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Part 4. Smart Grid Project for the Expansion of Electricity Distribution Infrastructure in the Dominican Republic

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Part 5. Support for Customer Protection in Digital Financial Services in Latin America and the Caribbean (LAC)

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Knowledge Sharing Program

2015 KSP - IDB Joint Consulting :

Smart City Technical Project Design and Implementation Plan for Valledupar and Villavicencio, Colombia

Part 1

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List of Abbreviation

Abbreviation	Full Description
ANSV	La Agencia Nacional de Seguridad Vial/The National Highway Traffic Safety Agency
ATMS	Advanced Traffic Management System
AVR	Automatic Voltage Regulator
BIS	Bus Information System
BMS	Bus Management System
CCTV	Closed Circuit Television
COT	Central Office Terminal
CPTED	Crime Prevention Through Environmental Design
CRC	Comisión de Regulación de Comunicaciones/Commission for Communications Regulation
DB	Data Base
DID	Digital Information Display
DANE	Colombia's National Administrative Department of Statistics
ELN	Ejército de Liberación Nacional/ National Liberation Army
EMIS	Emergency Management Integrated System
ESCI	Emerging and Sustainable Cities Initiatives
EWS	Emergency Warning System
FARC	Fuerzas Armadas Revolucionarias de Colombia/Revolutionary Armed Forces of Colombia
GPS	Global Positioning System
HF	High Frequency

Abbreviation	Full Description
HVAC	Heating, Ventilation, Air Conditioning
HW	Hardware
ICT	Information & Communication Technology
IFEZ	Incheon Free Economic Zone
IDB	Inter-American Development Bank
IOCC	Integrated Operations Command Center
IT	Information Telecommunication
ITS	Intelligent Transport System
KSP	Knowledge Sharing Program
MINTIC	Ministerio de Tecnologías de la Información y las Comunicaciones/Ministry of Information Technologies and Communications
MMI	Man Machine Interface
NIA	National Infrastructure Agency
NVR	Network Video Recorder
NW	Network
OBE	On Board Equipment
OECD	Organization for Economic Cooperation and Development
PND	Plan Nacional de Desarrollo /National Development Plan
PNTIC	Plan Nacional de Tecnología de la Información y Comunicación/National Plan for Information Technology and Communication
POT	Plan de Ordenamiento Territorial
PPP	Public Private Partnership
RFI	Request for Information
RT	Reomote Terminal
SETP	Sistemas Estratégicos de Transporte Público/Strategic Public Transportation Systems
SIC	Superintendencia de Industria y Comercio/Superintendence of Industry and Commerce
SITM	Sistema Integrado de Transporte Masivo/Integrated Mass Transit System
SMS	Short Message Service
SOP	Standard Operating Procedure

Abbreviation	Full Description
SW	Software
TOD	Time of Day
TRS	Trunked Radio System
TSCS	Traffic Signal Control System
TSM	Traffic Signal Management
UN	United Nations
UNASUR	Union of South American Nations
UPS	Uninterrupted Power Supply
USD	United States Dollars
USN	Ubiquitous Sensor Network
VDS	Vehicle Detection System
VHF	Very High Frequency
VM	Virtual Machine
VMS	Variable Message System

Summary

This research project focuses on two cities, namely Valledupar and Villavicencio in Colombia. Both are capital cities of the Cesar and the Meta Department, respectively. Valledupar and Villavicencio are the fastest growing cities in Colombia. However, they do not have enough basic infrastructure and public services to accommodate fast urban growth and situations caused by population influx. Such imbalance in supply and demand in turn creates many problems, such as traffic congestion in city center, high crime rate, and vulnerability towards natural disasters, among others.

The Knowledge Sharing Program (KSP) team conducted a site survey from August 25 to September 4, 2015 to define core services that should be included in each city's Integrated Operations Control Center (IOCC). The team worked with the cooperation of Colombia's Financial Institution for Territorial Development (Financiera de Desarrollo Territorial, Findeter), the two municipalities, and related organizations to collate data using a Request for Information (RFI). In addition, surveys were conducted with civil servants and citizens to identify main and current issues experienced by citizens in these cities. On the question of the most prioritized issues of the city, survey results showed that more than 70% of the respondents mentioned the need to prevent and solve crime, followed by systematic transportation system, and improved city's vulnerability against natural disasters. These were seen as factors that weakened city competitiveness.

Public security posed a continued threat to citizen safety, particularly as various problems arose between existing citizens and newly added citizens which are on the increase over the years. Unauthorized settlers who came from other cities remained jobless and involved in many violent crimes. In order to resolve the high rise of crime and its related social problems, the municipalities invested in and implemented crime reduction policies such as education, security facilities, environment improvement, and other related plans.

As for transportation issues, citizens were dissatisfied with narrow and uncovered roads, poor pavement management system, insufficient parking space, unreliable public transportation system, and illegal parking, which resulted in severe congestion. Especially, traffic congestion is a serious issue which causes additional social damage since it hampers swift response to emergency situations such as medical emergencies, fire, violent crime, or natural disasters. In addition, traffic congestion is a factor that hinders new and profitable businesses from entering a city, as smooth distribution network is a critical factor for ensuring efficient production and sales of goods or services. An

inadequate transportation environment therefore has negative impact on the economic and social development of society in a city, and for a nation.

In terms of environmental issues, Valledupar and Villavicencio are surrounded by high mountains and rivers, which make them highly vulnerable towards natural disasters, such as flood and hurricane, caused by heavy rainfall and high winds. Poor drainage often leads to widespread lowland flooding and this problem is very severe during the wet season. Power blackout and flash floods are some of the inconveniences experienced by people living in these areas.

After project analysis, the KSP Team highly recommends the construction of an IOCC for each city to systematically and efficiently react to urban problems. Having this integrated infrastructure will ultimately allow the cities to be highly competitive, as well as increase productivity, promote job opportunities and incomes, and raise its people's quality of life.

I Project Overview

1. Outline

In 2011, Colombia's Ministry of Strategy and Finance agreed to support developing countries in Latin America through an initiative with Inter-American Development Bank (IDB), called 'Emerging and Sustainable Cities Initiatives' through Knowledge Sharing Program (KSP). This led to the establishment of several KSP-IDB projects since 2011 and Smart City Projects with a focus on implementation of broadband and ICT (Information and Communications Technology) services. As of today, Smart City Projects for three cities have been conducted: Santa Ana in El Salvador, Montevideo in Uruguay, and Goiânia in Brazil. In these target cities, ICT environment research was conducted to facilitate Smart City construction and establishment. Among the above cities, basic design consulting work for an IOCC took place for Montevideo (Uruguay) and Goiânia (Brazil) in 2012, and also for a new target city Montego Bay (Jamaica) in 2013.

Upon recommendations made by Colombia's Financial Institution for Territorial Development (Financiera de Desarrollo Territorial, Findeter), consulting service was extended to establish IOCCs in two major cities in Colombia, namely Valledupar and Villavicencio, in 2015. For this undertaking, a Korean Smart City expert consulting engineering company specialized in Smart City services, Moon Engineering Co. Ltd. was tasked with conveying knowledge and expertise on city development, utilizing Korea's extensive experience of ICT.

The two subject municipalities selected for this project are emerging cities of Colombia with the fastest city growth rates. Hence, they are hub cities that have great developmental potential for commerce and service, tourism, and distribution networks. However, these cities face many challenges in traffic congestion, high crime rate, and proneness to natural disasters such as landslide and flood, particularly in city centers. These challenges make it very problematic for Valledupar and Villavicencio to acquire and meet critical standards of city competitiveness. Therefore, the implementation of IOCC is an essential strategy to promote efficient city management and continuous accumulation of critical data in order to transform these two emerging Colombia cities into sustainable hub cities.

2. Activities for Each Stage

2.1. Stage 1: Preliminary Study and Consulting Preparation

Basic preparation stage for prior studies and consulting involved conducting discussions with concerned stakeholders, i.e. The Export-Import Bank of Korea (Korea Eximbank), IDB, as well as each local government, to define project scope and establish research and work schedules. Literature review was conducted to first obtain an understanding of the cities' backgrounds. More preparation included selecting contents for a Request for Information (RFI), and preparing a survey for local citizens and related personnel in this project.

2.2. Stage 2: Diagnostic Study on the Municipalities

This stage included collecting information and recognizing status quo through official trips to local sites, carrying out current status research, conducting interviews with related organizations, and doing intensive on-site research to identify cities' development-related issues such as major crime, transportation, disaster related problems. With this gathered knowledge, the ensuing activity involved prioritizing functions and desired outcomes with the implementation of IOCC in each city.

Relevant research and data collection were carried out to compile a knowledge base covering related legal and regulatory frameworks and systems, such as road environment and traffic control systems, public transportation systems, crime rate, natural disaster, infrastructure construction, and other impact factors. Also, a survey was conducted with civil servants and citizens of the two target cities to identify difficulties they faced as city residents, and their ideas on desired improvements related to transportation, crime, and natural disaster occurrences.

2.3. Stage 3: Case Study and Interim Review

To gain a better idea for IOCC construction, the team undertook several site visits to target cities, and conducted country case analyses of previous IOCC construction (two Korean cases, and one Paraguayan case). The goal was to define and determine functions and scope for an initial solution to IOCC construction.

Based on the analyses' results, core Smart City services appropriate for target cities were then defined. An initial IOCC construction budget, with details of costs and schedules that take such definitions into consideration, was calculated. A second city site visit was deemed necessary in December 2015 because new mayors of the target cities were elected in October 2015, and the consulting team wanted to make sure that the views or priorities of the new mayors' teams were included in their IOCC planning.

2.4. Stage 4: Completion of Final Report

Following the research and analysis activities above, the team then defined and clarified the functions and scope of IOCC. Each facility or service was clearly stated in terms of budget, schedule

and duration, activities and execution plans, and overall organization. These results were then presented to stakeholders in Stage 5 of the project.

2.5. Stage 5: Capacity Building Workshop and Final Dissemination Seminar in the Municipalities

This stage involves capacity building workshop as well as final dissemination seminar.

First, to support capacity building of city officials, the workshop was organized to present successful Smart City cases to interested stakeholders. In January 2016, a group of six officials were invited to Korea for this training. These parties included officials from the Colombian target cities (two representatives from each city), one representative from Findeter, and one representative from IDB.

At the end of February 2016, the team organized a site visit to Valledupar and Villavicencio for a final dissemination seminar. For this seminar, stakeholders of this project were invited, including administrative officials from Findeter, government representatives of the two target cities, IDB, and other interested parties.

Ⅱ Diagnostic Studies

1. Current Status of Valledupar

1.1. Status of City

1.1.1. Outline

Valledupar is an inland city located in the north of Colombia, close to the border shared with Venezuela. Valledupar has an area of 4.264 km², central city area of 38.29 km², and a population of 453,215, according to statistics of 2015. A substantial proportion, i.e., 44% of the total population (1,028,890) of the Cesar department to which Valledupar belongs, resides here.

Figure II-1 | Valledupar: Location



Source: Google Map(http://www.google.com/maps/)

Major industries of this city include tourism, farming, agriculture, and mining. As for cultural events, every year at the end of April, the famed Vallenato Legend festival takes place in the city center.

1.1.2. Population

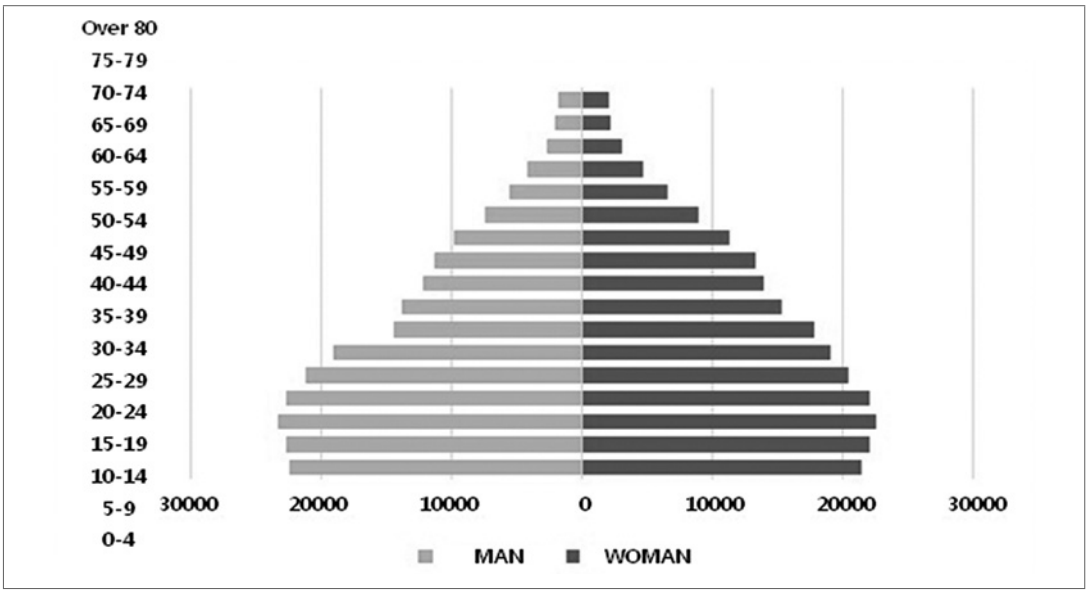
Statistical records of 2015 indicate Valledupar's population totals 453,215, with 200,939 males and 212,402 females. Average life span is 72.07 years old for male and 78.64 for female; the age group of 15-44 makes up 47.8% (197,446) of the total population.

Table II-1 | Valledupar: Age Distribution (2015)

Category	Less than 1 year old	1-4 years old	5-14 years old	15-44 years old	45-59 years old	Above 60 years old
Population (person)	8,601	34,598	88,710	197,446	54,153	29,687
Percentage (%)	2.08	8.38	21.48	47.80	13.11	7.19

Source: http://www.valledupar-cesar.gov.co/indicadores.shtml#poblacion

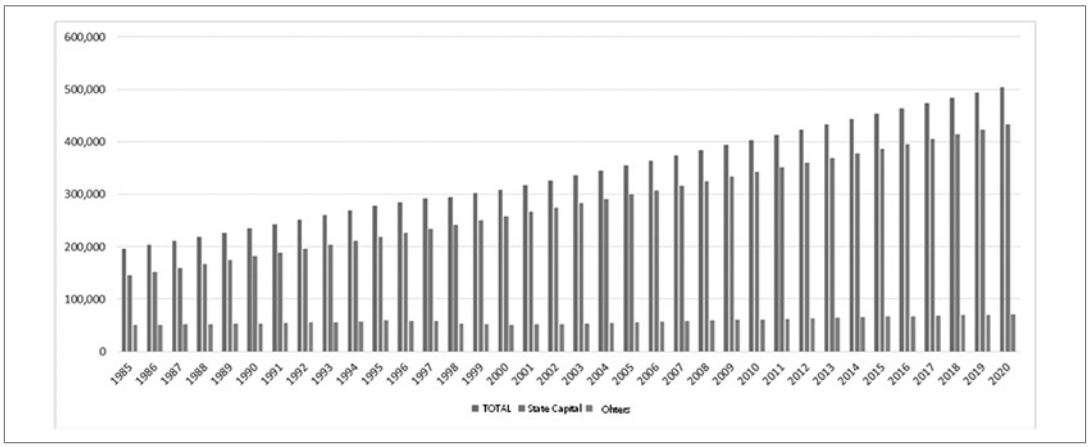
Figure II-2 | Valledupar: Population Distribution Pyramid



Source: Departamento Administrativo Nacional de Estsadistica Estadística(DANE) (2005)

Valledupar population has been on a continuous rise for the past 30 years. Population was 354,583 in 2005, while in 2015 population soared to 473,251, showing an increase of 27.8%. Statistical records indicate that the influx of people into the city is steadily increasing.

Figure II-3 | Valledupar: Population Increase Tendency (1985-2019)



Source: Departamento Administrativo Nacional de Estadística (DANE), (2005).

1.1.3. Climate

Valledupar is located near the equator with an average temperature of 28℃, and throughout the year temperature fluctuates between 23℃ and 35℃, with a yearly precipitation of 972 mm. Located near the Caribbean Sea, there are two wet seasons (May and October) and two dry seasons (December and July) and the city is greatly influenced by El Niño and La Niña. This city is affected by natural disasters like hurricane that bring about frequent thunderstorms, heavy rain, hail, thunderbolt and other dangers, which cause immense damages to residents.

Table II-2 | Valledupar: Average Monthly Temperature and Rainfall

Category	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Ave.
Max. temperature (℃)	34.7	35.6	35.9	35.6	34.0	34.2	35.4	35.1	33.8	32.6	33.2	33.6	35.1
Min. temperature (℃)	22.4	23.1	23.6	24.1	24.1	24.0	24.2	24.0	23.5	23.6	23.1	22.8	23.6
Precipitation (mm)	12	10	26	71	154	82	63	116	122	199	89	28	972

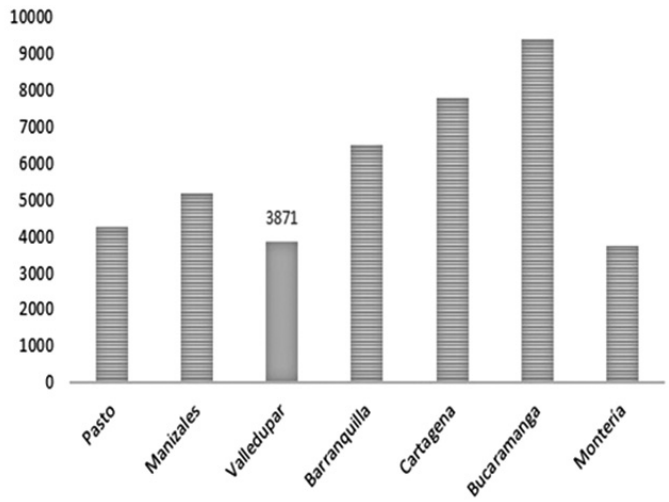
Source: World Meteorological Organization (WMO), Weatherbase 2008

1.1.4. Economy and Industry

There is no information on the city's gross domestic product (GDP) but according to 2012 the National Administrative Department of Statistics, the Cesar department's gross domestic product

amounted to USD 6.55 million, whereas that of Valledupar was USD 3.278 million. Valledupar's GNP was USD 3,870 million in 2012, which was somewhat lower than that of other cities in comparison in Figure II-4.

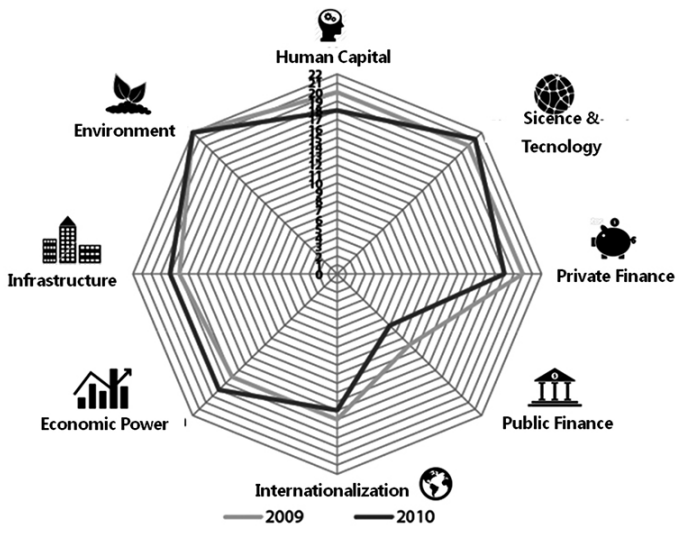
Figure II-4 | Colombian Cities by GDP



Gross Domestic Product (GDP) Comparison (2012)

Source: Colombia Departamento Administrativo Nacional de Estadística (DANE), (2012).

Figure II-5 | Valledupar: Competitiveness Indicators (Ranking)



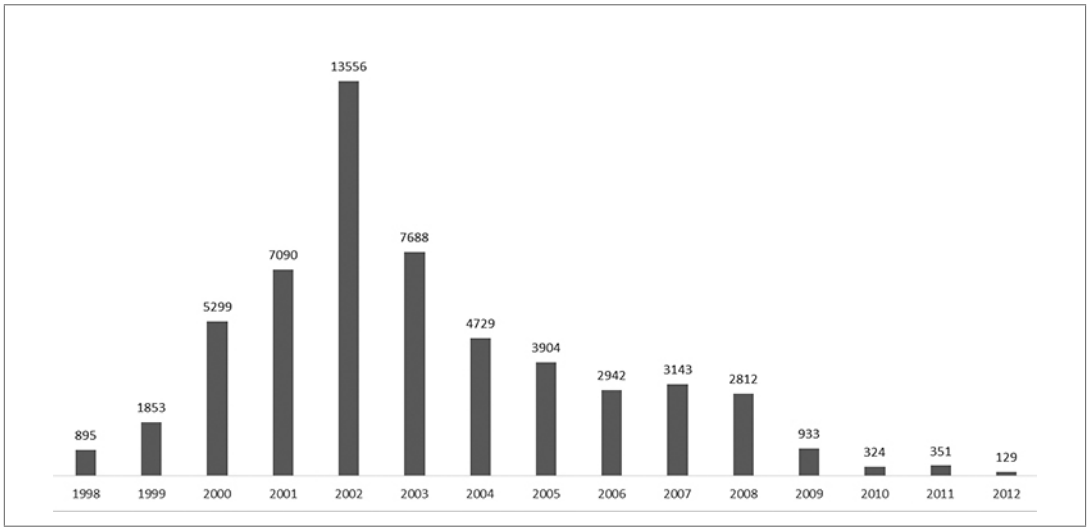
Source: Indicador Global de Competitividad de las Ciudades del Caribe Colombiano, 2009-2010.

Although Valledupar's global competitiveness index was very low in 2010, ranking 20th among all 22 cities, the city has been gradually improving in terms of city competitiveness. In addition to this, it is reported Valledupar has 157,000 possible sources of labor force, comprising self-employed (58.7%), special occupation (23.9%), civil servant (5.4%), housewife (4.1%), office worker (3%), and others (4.9%).

1.1.5. Social Phenomenon

The Caribbean region in the 1990s and 2000s suffered heavily from guerrilla and rebel forces, and Valledupar was greatly damaged both economically and socially. One of the consequences of guerrilla attacks was that Valledupar then became a retreat for refugees, a situation that escalated in 2002 with as many as 13,556 cases, as shown in Figure II-5 below. Eventually, the situation improved, with refugee cases reduced to 129 in 2012.

Figure II-6 | Valledupar: Number of Refugees per Year(1998-2012)



Source: Informe Nacional de Desplazamiento Forzado en Colombia (1985-2012).

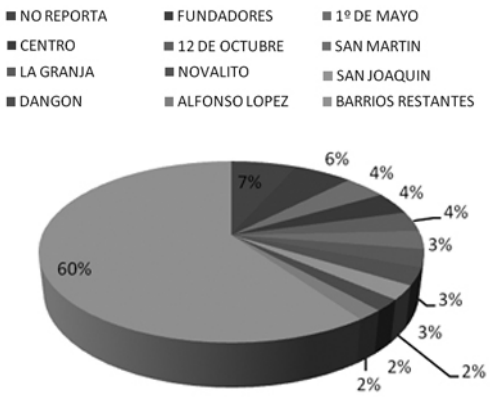
The two biggest problems in Valledupar are security and transportation. Security, particularly cases of homicides, remains the city's greatest challenge despite government policies aimed at reducing crime. Number of homicides rose from 24 cases in 2013 to 30 cases in 2014, and to 46 cases in 2015. Crimes involved firearms in crime prone areas, such as La Nevada (7%), Fundadores (6%), Primero de Mayo (4%), and Mareigua (4%).

In 2015, traffic accidents involved mainly motorcycle and pedestrian accidents; there were already 30 cases in the first half of 2015. Areas prone to traffic accidents were Fundadores (6%), Primero de Mayo (4%), and Centro (4%). These areas also recorded high rates of violent crime such as homicide, theft, robbery, and domestic violence.

Figure II-7 | Valledupar: Crime Hot Spots



Rate of violent crimes in each area



Rate of traffic accidents in each area

Source: Departamento de Policía Cesar (2012).

Valledupar is clearly a city in need of focused security and traffic accident control in order to improve quality of life and at the same time, improve city competitiveness for businesses and residents.

1.2. Status of Organizations

To research Valledupar's city status, the KSP team made two visits (1st visit from September 1-4, 2015; 2nd visit from December 10-11, 2015) to the city. An interview was arranged with personnel from the City Hall and related organizations. At the same time, the team conducted an in-depth ICT infrastructure status study.

Organizations involved in the ICT infrastructure research included the following: Transportation Control Center, Police Station Situation Room, Fire Department, Civil Defence, and Red Cross. The section below presents baseline data and results findings from interviews and field research on transportation, security, and disasters of Valledupar.

During the site visit, interviews with the Mayor of Valledupar and a review of 14 related organizations were carried out. The table shows the schedule and activities involved.

Table II-3 | Valledupar: Findings from Interviews with Relevant Organizations

Date	Organization in charge	Details	Consideration
October 1st	City Hall	• Major city issues are that of security and transportation	Implement security and transportation service
	Police	• Increase in violent crime (theft, robbery, homicide in order) • Plans to install camera and optic cable with assistance from the central government	Prevent overlapping investment
October 2nd	Civil Defense	• Disaster rescue and relief activities (Report call number 144) • Connections with other organizations utilize radio and telephone	Information link
	Fire Department	• Fire fighting, facility check-up, regional patrol • Goal is to reduce the dispatch time from 12 minutes to within 5 minutes	Information link
	Red Cross	• Information link with other organization via ICT technology is needed	Information link
	Environment Department	• Infrastructure to control water resource needs to be established • Implementing ICT technology to control river water level under review	Water level surveillance service under review
	Traffic Department	• Plans to double the number of buses by 2017 • Public transportation service implementation is under review	Public transportation service under review
	City Competitiveness Fortification Committee	• Pursuing industrial competitiveness improvement through acquiring agriculture, culture, tourism and resource development infrastructure	N/A
October 3rd	Waterwork business	• Private business • Facility is dated and is not being managed	N/A
	Waste disposal business	• Private business • Recycling takes place but it effect is dismal	N/A
	Gas supplier	• Private business • Gas supply facility remote surveillance system needed	N/A
	Electricity supplier	• Private business • Cooperation for electricity supply requested	N/A
	Communication business	• Private business • Concluded 232 city crime prevention CCTV installation agreement with the central government	N/A
October 4th	Commercial Department	• Assists private business and conducts educational business	N/A

Source: Compiled by KSP Research Team (2015).

1.2.1. Transportation

Field research and literature review show that Valledupar's severe transportation problems are caused by some main factors. These factors include uncontrolled increase in automobiles caused by population influx, insufficient or damaged roads, poor traffic signal system, and lack of public transportation, illegal parking, and overall poor transportation infrastructure planning. The table below shows current issues in transportation and ways in which these problems are expected to escalate and present more challenges to authorities in the coming years.

Table II-4 | Valledupar: Transportation Problems

Issue	Problem
Excessive traffic	• Increase in traffic due to population influx
Insufficient/damaged roads	• Continuous traffic congestion due to lack of road capacity for traffic
Lack of signal system	• Irrational signal system and changes in traffic load makes it impossible to react actively
Lack of public transportation	• Use of illegal transportation means (motorcycle, taxi)
Illegal parking	• Illegal occupation of the road causing traffic congestion and hindering emergency automobiles
Lack of transportation infrastructure	• Crossroads without any signals, poor crosswalk and route painting increases risk of accident

Source: Compiled by KSP Research Team (2015).

Figure II-8 | Valledupar: Traffic Situation



Poor road condition



Traffic light

Source: Compiled by KSP Research Team (2015)

The team conducted an ICT infrastructure review on the city's transportation systems, including analysis of its site equipment, situation room facility, communication network, center infrastructure, and connected links with other related organizations.

In Valledupar, a signal control system is used at 63 crossroads. However, the system is disorganized in that 53 crossroads use an old type signal controller whereas 10 crossroads use the new signal controllers. Old signal controllers are Argentinean brand CIMENS products, which are currently discontinued, and therefore repair and maintenance present major problems. New signal controllers are Spanish brand INDRA products with modern devices such as camera functions that can be used to monitor automobile counts.

Table II-5 | Valledupar: Problems of ICT Infrastructure for Traffic Control

Item	Status	Problem
Site Equipment	• Uses different brand signal controllers together • Automobile counting with fixed camera	• Difficult to link signal between crossroads • Difficult to recognize cause of traffic congestion
Situation room facility	• 42 inch LCD monitors under operation	• Lack of display screen when expanding system
Communication network	• Coaxial cable or wireless	• Difficult to maintain stable communication
Center infrastructure	• Lack of electricity, fire fighting, and assistance facility	• Breakdown caused by outside factors
Connection to other organizations	• Connect via radio or personal phone	• Difficult to convey situation quickly

Source: Compiled by KSP Research Team (2015).

Figure II-9 | Valledupar: Traffic Control Center



Situation Room



Equipment Room



Traffic signal controller – Old (CIMENS)



Traffic signal controller – New (INDRA)



Traffic control S/W



Traffic light

Source: KSP Research Team (2015).

1.2.2. Security

Field research and interview results show that Valledupar's major security issues are related to a rise in these aspects: violent crime, formation of crime ridden areas, and domestic violence.

Table II-6 | Valledupar: Security Problems

Issue	Problem
Population increase	• Increase in crime such as theft, robbery, and bodily harm due to influx of population from other regions
Formation of crime ridden area	• Violent crimes focused around poor neighborhood
Domestic violence	• Increase in violence towards women and children due to drug, drinking, etc

Source: Compiled by KSP Research Team (2015).

In Valledupar, CCTV control center is operated by the police. When citizens report a crime (no. 132), the agent registers and manages the report using their software (SECAD). Registered reports are conveyed to crime sites via radio (453-470 Mhz bandwidth 5 channel). Connections to other organizations can be made using a one-channel radio, telephone, or personal smart phone.

In 2006, a total of 56 cameras were installed using wireless networks, but the installation company failed to carry out proper maintenance work. Hence, this equipment is currently not functioning. In December 2015, government funding allowed the replacement and new installation of 209 cameras and 100 km optic cable to be set up in the city center. Newly installed camera specifications include 720 Pixel resolution with 30 surveillance video frame/sec, 15 storage video frame/sec, and a six-month storage period of video footage.

Table II-7 | Valledupar: Problems of ICT Infrastructure for Public Security Consolidation

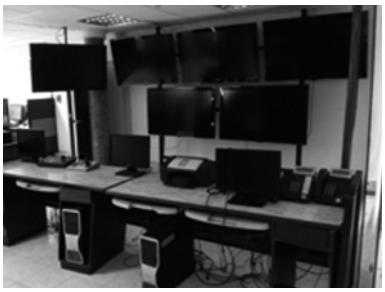
Item	Situation	Problem
Site Equipment	• Camera replacement and installation (209 branches)	• Continuous function management needed
Communication Network	• New installation of optic cable (100km)	• Need dualization for stable communication
Connection to other organizations	• Via radio or personal phone	• Difficult to convey situation quickly

Source: Compiled by KSP Research Team (2015).

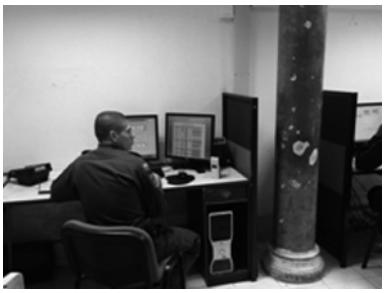
Figure II-10 | Valledupar: Situation Center of Police Station



Operational Board - New



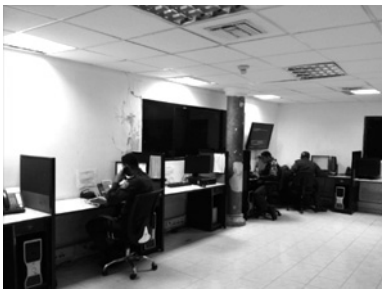
Operational Board - Old



Operation Control Board



Equipment Room



Call Center



On site CCTV

Source: Compiled by KSP Research Team (2015).

1.2.3. Disaster

Field research and interview results show that Valledupar's major disaster problems were flood, draught, mountain fire, landslide, earthquake, etc.

Table II-8 | Valledupar: Disaster Problems

Issue	Problem
Natural disaster	• Increased damage caused by flood/draught, etc, due to climate change • Difficult to react quickly to large scale disaster such as mountain fire/landslide/earthquake, etc

Source: Compiled by KSP Research Team (2015).

Figure II-11 | Valledupar: Area Vulnerable to Natural Disaster



Stream research



Flooded area

Source: Compiled by KSP Research Team (2015).

ICT Infrastructure review is conducted on three medical and emergency services, namely the Fire Department, Red Cross, and Civil Defense.

1) Fire Department

Valledupar currently has one fire department and plans to add two more. The Fire Department has 12 fire engines in total, of which seven engines were purchased after 2011 following the failure of the GPS navigation system.

Valledupar's Fire Department has four reporting lines (119) for public use, and two land lines are specially meant for receiving fire reports. A total of 67 radios are at hand with 2 wireless channels; one wireless channel is connected to the fire department, while the other connects to other related organizations. On getting a fire report, the fire department would contact the original caller to confirm the exact place of fire and location of the caller. Contents of fire reports are recorded by hand; only certification issuance and reports to senior officials are drafted using a word processing system. At this moment, there is no CCTV system for fire surveillance.

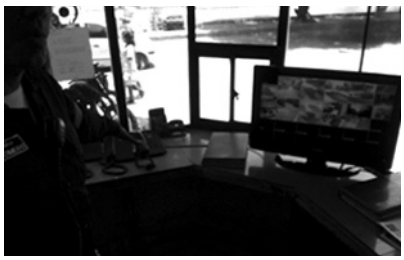
On analysis of these findings, the KSP Team recommends computerization of fire reports, real time information links with other organizations, and installation of fire fighting operations and surveillance using CCTV equipment. Implementation of these plans will improve the efficiency and reliability of fire fighting and prevention services in Valledupar.

Table II-9 | Valledupar: Problems of ICT Infrastructure for Firefighting

Item	Status	Problem
Site Equipment	• Land line (4) • VHF radio (67) • GPS installed navigation	• Relies on report to grasp situation • Difficult to share information other than audio communication
Connection to other organizations	• Via radio or personal phone	• Difficult to convey situation quickly

Source: Compiled by KSP Research Team (2015).

Figure II-12 | Valledupar: Fire Station



Call Center



Call Center



Report record



Radio



Fire engine - 1



Fire engine - 2

Source: Compiled by KSP Research Team (2015).

2) Red Cross

Red Cross is an organization that assists emergency rescue and provides medical services in emergency situations. A Red Cross unit is dispatched when other organizations such as City Hall, police or fire department sends in a request for help regarding following disasters like fire or flash floods. The Red Cross units have a radio to connect with other organizations, but this communication facility is now out-dated and no longer in use. Now, landline or personal phones are used as communication devices to stay in touch with parties in a disaster rescue or medical emergency.

Table II-10 | Valledupar: Problems of ICT Infrastructure for Emergency Medical Service

Item	Status	Expected Problem
Site Equipment	• Not operated	• ICT infrastructure is needed to share disaster information and react to emergency • Communication with emergency vehicle (ambulance) is needed
Connection to other organizations	• Via radio or personal phone	• Difficult to quickly inform emergency situation

Source: Compiled by KSP Research Team (2015).

Figure II-13 | Valledupar: Red Cross



Communication devices



Radio

Source: Compiled by KSP Research Team (2015).

3) Civil Defense

Civil Defense is a government organization set up to provide assistance for emergency rescue and evacuations in certain situations. Sometimes, there is a need to call on Civil Defense's help during major traffic accidents in the country.

Civil Defense operates its own call number, i.e. "144". Each of the regional communication units is operated by two agents (one for Tigo and another for Claro). There are seven radios in total and two wireless channels (one for internal use and another for connection to other organizations). There are not many facilities, and dispatches are sent out only upon request.

Table II-11 | Valledupar: Problems of ICT Infrastructure for Civil Defense

Item	Status	Problem
Site Equipment	• Emergency Call Number (144) • VHF Radio (7 units)	• ICT infrastructure is needed to share disaster information and react to situation
Connection to other organizations	• Via radio or personal phone	• Difficult to communicate situation quickly

Source: Compiled by KSP Research Team (2015).

Figure II-14 | Valledupar: Civil Defense



Call Center



Radio

Source: Drafted by oneself

There is much room for improvement in the services provided by emergency and medical emergency services in the city of Valledupar.

2. Current Status of Villavicencio

2.1. Status of the City

2.1.1. Outline

Villavicencio is a city located in central Colombia and is the capital of the Meta department. It is near the banks of River Guatiquía, which is 90km away to southeast from Bogotá, the national capital of Colombia. With a total city area of 1,300.8km², the city center takes up 28.6km² and 50.4% of the total population of Meta department (961,292) lives in Villavicencio. Major businesses include service, stockbreeding, agriculture, and transportation. This city is also known as 'Villavo', a name often used by locals.

Figure II-15 | Villavicencio: Location and Map

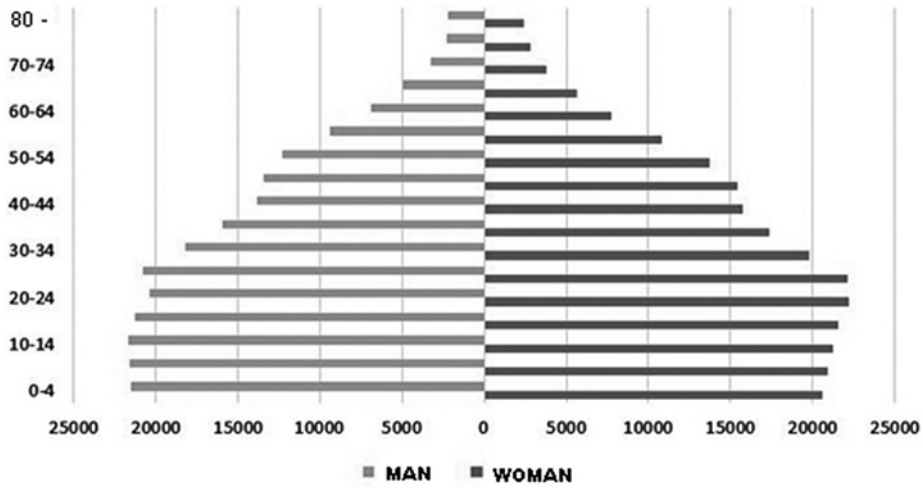


Source: Google Map (www.google.com/maps/)

2.1.2. Population

Villavicencio's population is 484,429 (2015 statistics) and comprises 48% male and 52% female. According to Colombia's National Administrative Department of Statistics (DANE), the city has more than 10,000 increases in population annually, which is a rate higher than the national average. Population distribution data show that the ratio of people under the age of 44 is relatively high, and thus the city is considered a very young city.

Figure II-16 | Villavicencio: Population Distribution Pyramid



Source: Departamento Administrativo Nacional de Estadística (DANE).

Table II-12 | Villavicencio: Population for the Past 10 Years

Category (year)	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Population (person)	400,485	400,485	410,726	421,074	431,476	441,959	452,472	463,093	473,718	484,429

Source: Departamento Administrativo Nacional de Estadística (DANE).

A possible reason for the recent increase in Villavicencio's population is linked to the Bogotá-Villavicencio road that connects the nearby capital Bogotá with the city. This improved transport route led to growth in mining and energy development (petroleum and gas), stockbreeding, and agricultural development in the Altillanura region.

2.1.3. Climate

Villavicencio is located near the equator with an average temperature of 28.4˚C and yearly temperature fluctuation between 20˚C and 38˚C, which is typical equator climate. Average monthly precipitation is 365 mm and its temperature is somewhat affected by the precipitation. Dry season is from December to March, and the wet season is between May and July.

Table II-13 | Villavicencio: Average Monthly Temperature and Rainfall

Category	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Ave.
Max. temperature (℃)	37.1	37.6	38.5	37.3	37.8	37.9	38.3	37.5	37.2	38.1	37.7	37.4	38.6
Min. temperature (℃)	20.9	20.8	22.9	20.6	20.4	21.5	21.6	21.7	20.5	21	21.4	20.7	20.8
Precipitation (mm)	64	129	227	526	627	522	439	416	396	470	411	157	365.3

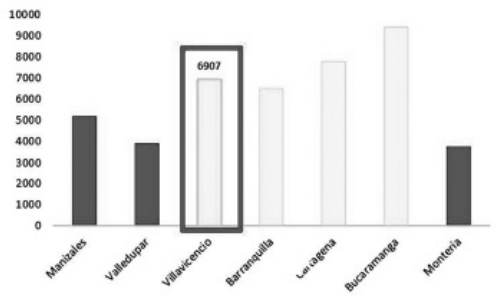
Source: Instituto de Hidrología, Meteorología y Estudios Ambientales de Colombia (IDEAM), 2012.

2.1.4. Economy and Industry

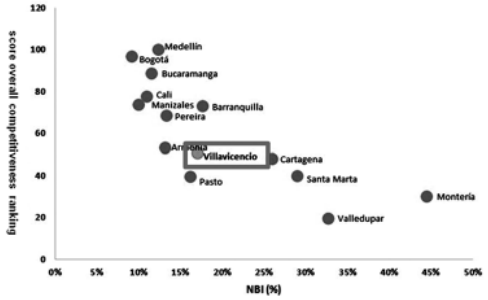
Villavicencio is the center of distribution and supply for an area that also covers the Orinoquía region. Though the city mainly produces petroleum and gas, jobs are created in non-productive areas of commerce and service, mainly energy, trade, construction, stockbreeding, agriculture and tourism.

According to the DANE, GDP of Meta department in 2012 was USD 18.64410 trillion, and that of Villavicencio, USD 31.259 trillion. In 2012, for example, Villavicencio's GNP was USD 6,907, which was more than that of other cities like Pasto, Montería, and Valledupar.

Figure II-17 | Villavicencio: City Competitiveness



A. Comparison of GDP in different cities (2012)



B. Global Competitiveness Index (2010) against Unsatisfied Basic Needs Index (NBI)

Source: Colombia's Financial Institution for Territorial Development (Findeter)

The main components of Villavicencio's GDP (that made up 16.8% of Meta region's GDP) were commerce, restaurant and hotel (14.7%), financial institutions, insurance and real estate (14.5%), social and personal service (10.39%), construction and transportation (8.27%), and production (6.17%). Unemployment rate in 2014 was 11.5% on the whole, whereas 57.68% of economically active population employed, mainly in city center. Related statistics revealed that the employed population consists of labourers (43%), self-employed (39.4%), civil servants (6.1%) and the remaining 11.5% were temporary workers, employers, or domestic workers.

Quality of life was measured using an index that took into account factors of economic environment, traffic and transportation, health, and education. Based on these factors, quality of life in Villavicencio was found to be lower than that of Cali and Medellín, and similar to that of Manizales, Santa Marta, and Pasto.

2.1.5. Social Phenomenon

According to a consulting report on human rights and immigration (CODHS, 2012), about 259,146 (approximately 70,039 households) refugees settled in Colombia in 2011. City secretariat data claimed Villavicencio was the 15th city to take in the highest number of refugees (65,988), which presumably led to a marked increase in city population, reaching 520,000 that year. Illegal settlement of refugees or displaced people focused in the suburbs, in sectors such as Relic, La Nohora, Kirpas, Nueva Colombia, Portales del Llano, and Popular. Such an unprecedented increase in population inevitably triggered problems in housing supply, environmental establishment, security, and provision of public services. In sum, the arrival of displaced people to Villavicencio caused various problems in the city, which in turn created demand on the city government to resolve socio-economic problems brought about by this unprecedented population increase.

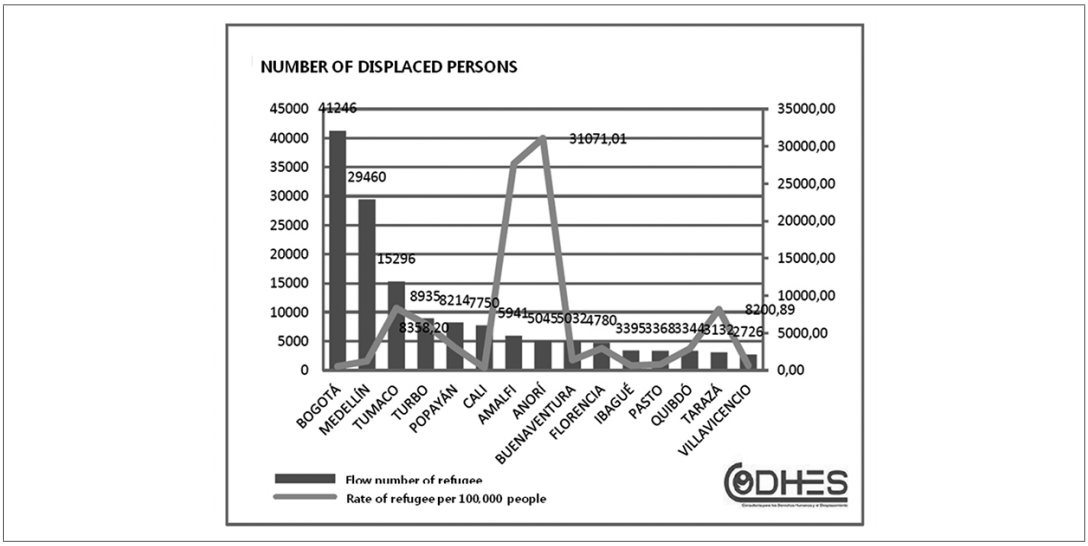
In recent years, it became glaringly obvious that poor transportation infrastructure and increase in registered automobiles are causing extreme traffic congestion. A steep increase in motorcycles

in particular led to a marked increase in road accidents, with motorcycle accidents taking up an alarming 61% (553 cases) of all 897 injuries in 2014. This alarming figure was followed by accidents involving special vehicles (140 cases), general vehicles and taxis (58 cases), bicycles (51 cases), and small trucks (35 cases). Death caused by motorcycles was also notably the highest (14 out of all 28 cases), followed by personal vehicles (5 cases), bicycles (5 cases), and pickups (2 cases). It was also notable that many such accidents occurred at certain roads and crossroads with poor traffic signal systems.

The situation became so bad in 2011 that Villavicencio was classified as the most unsafe city in Colombia that year. Homicide also was a major problem. With great efforts and planning, the city government managed to reduce general crime such as theft but homicide remained on the rise. For example, in 2013 there were 134 homicide cases per 100,000, but in 2014, this rose to 139. More than 50% of homicide crime was found to be revenge-motivated crimes amongst criminal organizations. In particular, citizens felt extremely anxious and unsafe due to prevalent drug trafficking, existence of drug addicts, and threat of kidnapping according to data from DANE (2013). Villavicencio Police had to manage 91 districts of the city which were divided based on population and risk level to fortify security, and among them, six districts required focused management.

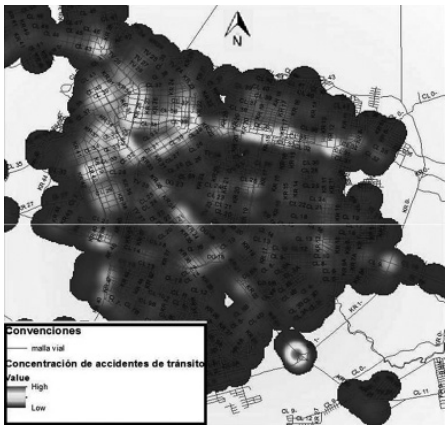
Poor transportation infrastructure and increase in registered automobiles cause traffic congestion. A steep increase in motorcycles especially led to accidents, taking up 61% of all 897 injuries in 2014 with 553 cases, followed by special vehicles with 140 cases, general vehicles and taxis with 58 cases, bicycles with 51 cases, and small trucks with 35 cases. Death caused by motorcycles are recorded to be 14 out of all 28 cases, followed by personal vehicles with five cases, bicycles with five cases, and pick-ups with two cases. Many traffic accidents occurred on certain accident prone roads and crossroads.

Figure II-18 | Municipalities Affected by Refugees (2011)



Source: Boletín de la Consultoría para los Derechos Humanos y el Desplazamiento Número 79 - Bogotá, Quito (2012).

Figure II-19 | Villavicencio: Traffic Accident Frequency and Crime Hot Spots



A. Frequency of traffic accidents

ZONA	BARRIOS	DELITOS PRINCIPALES
1. Porvenir	Porvenir Villa Humberto San Benito	Hurto a personas Lesiones personales
2. Reliquia	Reliquia Villa Suarez Morichal	Lesiones personales Violencia Intrafamiliar Homicidio
3. Barzal	Siete de Agosto Barzal Alto Barzal Bajo	Hurto a personas, comercio y motos Lesiones personales
4. Centro	Centro Villa Julia San José San Isidro	Hurto a personas, comercio Extorsión
5. Brisas del Guatiquía	Brisas del Guatiquía Santa Fe	Lesiones personales Homicidios
6. Ciudad Porfía	Ciudad Porfía	Homicidios Hurto a motos Violencia intrafamiliar

B. Priority security areas

Source: Villavicencio Secretariat, Establishment of Villavicencio Local Government Transportation Plans (2015).

2.2. Status of Organizations

To better understand Villavicencio's city status, the KSP team conducted two visits to the city (1st visit was from August 25-28, 2015, while the 2nd visit took place from December 8-9, 2015). At the same time, the team also conducted interviews with City Hall, the Mayor of Valledupar, and 12 related organizations. Which included six public services, namely Transportation Control Center, Police Station, Situation Room, Fire Department, Civil Defence, and Red Cross.

Table II-14 | Villavicencio: Findings from Interviews with Relevant Organizations

Date	Related Organization	Details	Consideration
August 25th	City Hall	General status Major city problems include that of security, transportation and disaster prevention	Security, transportation, disaster prevention service implementation under review
August 26th	Disaster Department	Operates disaster control center upon disaster Disaster prevention activities and management of river water level are required	Water level surveillance service under review
	Fire Department	Fire fighting, facility check-up, regional patrol Goal to reduce dispatch time to within 6 minutes	Information link
	Waterwork business	Private business Intake station water quality monitoring	N/A
	Cleaning business	Private business Recycling takes place but needs fortification	N/A
	Red Cross	Assists emergency medical service and medical service Acquiring equipment for medical practice is needed	Information link
	Civil Defense	Disaster rescue and relief work Many related works with the fire department	Information link
August 27th	Transportation Control Center	Transportation Control Center operates surveillance of traffic police, ambulance, and tow trucks based on their location Plan to add additional facility including traffic CCTV	Public transportation service under review
	Infrastructure Department	Road construction and maintenance and repair PPP method circulation road construction plans	N/A
	Crime Prevention Center	Increase in drugs and crimes due to influx of population from other regions Crime prevention CCTV are operated and additional installations are planned with government assistance	Information link
August 28th	City Hall Computer room	City Hall website operated Operation server and data management	Information link
	Air Force Rescue	Assists life saving and fire fighting	Information link
	Expected relocation venue of command and control center	Visited what is to be the new command and control center building Delivered opinion on the review	N/A

Source: Compiled by KSP Research Team (2015).

2.2.1. Transportation

Villavicencio is the capital city of Meta department; it is the hub of administration, finance, industry, service, and education where institutions, businesses and facilities are focused. Consequently, there is great influx of traffic into the city as well as sudden increase in registered automobiles, which very frequently leads to traffic congestion and increase in traffic accidents in the city center.

City roads are not improved from the way they were constructed a long time ago and have many aspects that hinder smooth traffic flow. Major issues include narrow roads that present risks when driving against heavy traffic, lack of parking space, illegal parking, short crossroad gap, and crossroads that lack sufficient turning radius for safe driving. 95% of roads have exceeded their durability life and therefore re-pavement of the roads is badly needed. However, shortage of city allocated budget meant poor road management, and no or little maintenance work is only taken up to restore damaged parts of roads. In general, overall road situation in this city is very poor.

Figure II-20 | Villavicencio: Traffic Situation



Narrow roads



Road congestion



Dangerous motorcycle driving



Illegal parking



Congestion in major shoulders



Poor road condition

Source: Compiled by KSP Research Team (2015).

Figure II-21 | Villavicencio: Status of Traffic Signs and Signal Controller



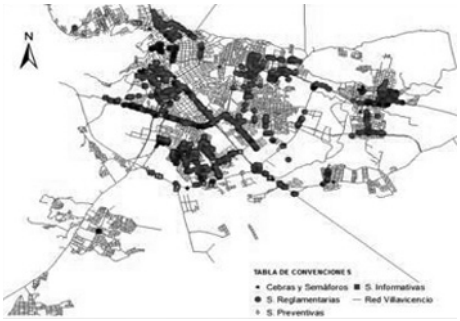
Traffic light controller on crossroad



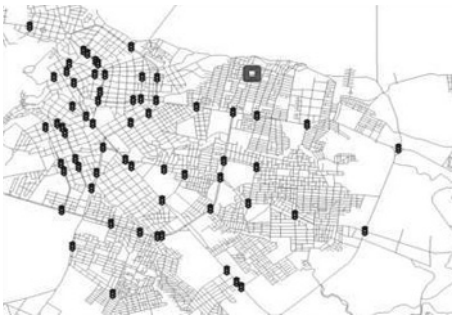
Inside of the traffic light controller

Source: Compiled by KSP Research Team (2015).

Figure II-22 | Villavicencio: Location of Traffic Signs and Signal Controller



Location of traffic signs



Location of Traffic Control Center and Traffic Light Controller

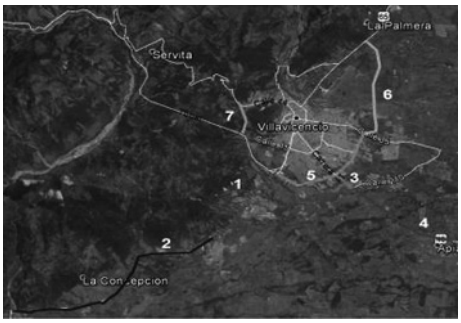
Source: Universidad Nacional de Colombia, 2013, Establishment of Villavicencio Local Government Transportation Plans.

In order to solve the problem of illegal parking that hinders traffic flow, Villavicencio is pursuing strict parking control, promotion of parking order improvement, and parking space acquisition projects that make use of city grounds. To improve the traffic flow in major shoulder roads, a regional road development project involving the improvement of existing roads, construction of outer circulation road is planned. Project planning for overall road improvement is also underway.

Figure II-23 | Villavicencio: Shoulder Parking Lot and Ring Road Development Plan



Shoulder parking lot

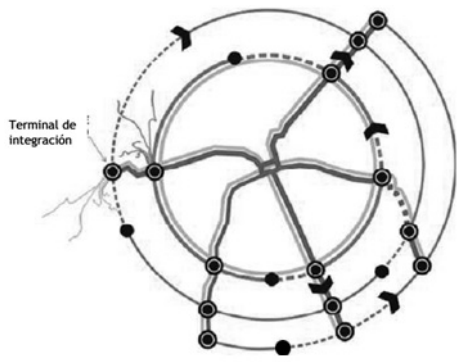


Ring road development plan

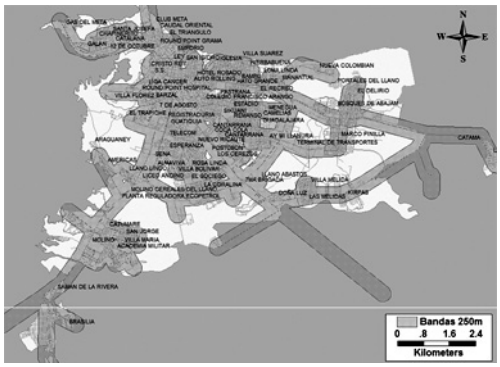
Source: Villavicencio Secretariat, 2015, Villavicencio General Information.

Public transportation takes up 31.2% of all transportation means, and there are problems that cause public transportation accessibility to be quite bipolarized. For example, some sections have too many overlapping bus lines whereas some areas have no bus line at all. This leads to low revenues for transportation businesses, which then provide very low quality service. This becomes a social cost, a burden to public transportation users. Plans are made to improve public transportation, acquisition of better public transportation convenience, improvement of user service, and adoption of a strategic public transportation system SETP (Sistema Estratégico Público Masivo) to guarantee business revenue. The plans include construction of an integrated terminal, line merge and modification, and improvement of road infrastructure.

Figure II-24 | Villavicencio: Public Transportation Improvement Plan Included in SETP



Integrated terminal construction plan



Public transportation line revision plan

Source: Universidad Nacional de Colombia, Establishment of Villavicencio local government transportation plans (2013).

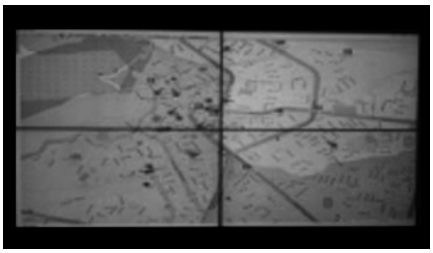
Villavicencio's Traffic Control Center is located on the 3rd floor of the Transportation Department. Its role is to assemble traffic status through communication with on-site traffic police via TRS

terminal that uses GPS to collect data of traffic movement and other location information; for example, it shows the terminal operational status (buses' arrivals and departures) and ambulance operational status. Emergency service vehicles like ambulances and tow trucks use the same TRS terminal to receive location information. The Traffic Control Center Operational Board uses maps to mark the location information of vehicles. For example, traffic police officers and tow trucks use this data to assist traffic situation control, such as during accidents and in the case of traffic violations.

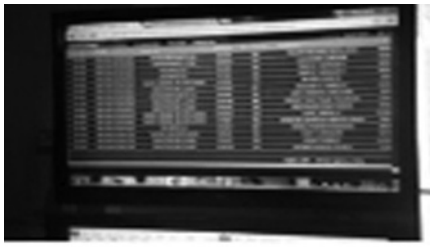
Figure II-25 | Villavicencio: Traffic Control Center



Traffic Control Center Situation Room



Traffic Control Center Operational Board



Bus arrival information display screen



Traffic Control Center operation server

Source: Compiled by KSP Research Team (2015).

In terms of operational organization, Traffic Control Center uses part of the Traffic Department office. Its office facilities are very basic, merely consisting of an Operational Board, a 1-meter high rack with communication facilities and server installation, an operator monitor and two tables with TRS terminal, and some chairs. It is unfortunate and undeniable that the Traffic Control Center is currently situated in an operation environment that is considered too basic to provide quality and reliable transportation services. To enable operational efficiency, this situation requires swift improvement in venue and facilities provisions.

Currently, the Traffic Control Center uses TRS terminal or landline to connect to other organizations, including crime prevention police force. However, this communication is restricted to only emergency purposes, rather than timely transportation information. To utilize transportation information in various areas such as firefighting, crime prevention, and emergency dispatch, great improvement for provision and connectivity of data and organizations is urgently needed. As of now, there is no operated traffic CCTV, but the city has plans to install 20 traffic CCTVs as part of its crime prevention CCTV construction project. In addition, there are plans to implement more

facilities: two traffic control vehicles, 20 fine issuance terminals, and a new signal controller that allows remote control to improve traffic administration work. However, there are no plans for the implementation of a system that controls traffic flow, or plans to improve the existing system.

Along with the transportation infrastructure enhancement project planned by the city, implementation of the newest ITS system will maximize the improvement of the traffic flow and the overall traffic operation management will be much more effectively handled. These improvements include the following:

1. Implementation of a Signal Control System that allows real time remote control and operation in consideration of traffic situation;
2. Implementation of traffic CCTV that allows recognition of traffic flow in major crossroads from the Traffic Control Center;
3. Implementation of ITS system that allows data collection, management, and control of traffic flow of major parts of the city and city's shoulders; and
4. Implementation of a viable bus operation management system (BIS/BMS) in line with the SETP project.

Additionally, it is critical to have a separate center to conduct traffic monitoring, system operation, data collection, and information provision in an integrated and real time manner.

The establishment of an IOCC is therefore highly and urgently recommended to efficiently utilize data for many purposes, among which are resourceful crime prevention and organized traffic administration. This IOCC will allow the city administration to establish integrated control and management over the entire city's service operations.

2.2.2. Security

For many years, Villavicencio was considered one of the top 20 crime-ridden cities in Colombia, with records of 139 homicides per 100,000 in 2014, and is the city where 50% of the nation's crimes take place. These crimes range from clashes between criminal organizations to domestic violence, theft, kidnapping, and drug trafficking. The continuous influx of population from other regions is seen as the overriding cause of the increase in crime, making public security a very important priority for the city administration.

From 2012 onward, the city embarked on and committed its resources to a general city safety plan. Security procurement measures worked to a certain extent, and in 2013 Villavicencio's city safety ratings improved and it moved to being the 10th most unsafe city in the nation. The city administration was duly and notably recognized for its efficient improvement in security.

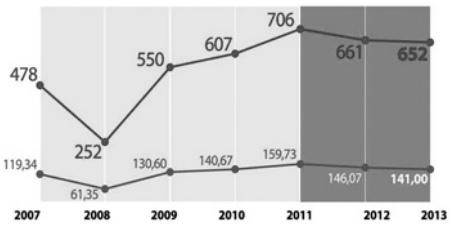
Currently, the city's police force classifies Villavicencio into 91 districts, by population and level hazard. Of these districts, six are designated priority areas of control. The police runs various programs suitable for each area's particular traits. At the same time, the city government and police are working together to focus special attention on disintegrating criminal organizations, which are major causes of social anxiety and all kinds of crimes.

There are as many as 126 crime prone areas in Villavicencio that have crime prevention CCTVs installed. However, many units are out-dated and maintenance and repair works are not carried out; hence, only 78 are currently operating. Maintenance and repair works of the crime prevention CCTVs were initially handled by the installation company, but after the warranty period, maintenance work was not carried out properly due to lack of budget and technical expertise.

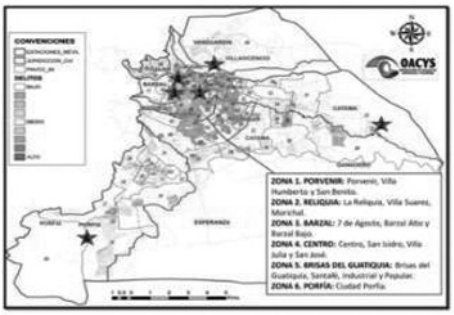
Figure II-26 | Villavicencio: Public Security

	2012	2013	Total
CAI Mobiles	0	6	**6**
Motorcycles	221	45	**266**
Vehicles	0	16	**16**
Security Cameras	98	28	**126**
Vallas quadrants	0	140	**140**

Investment in facilities for stronger government authority



Household theft tendencies



6 priority areas



Regional activity status

Source: Villavicencio Secretariat, Villavicencio General Information (2015).

In 2012, a total of 78 CCTVs for crime prevention were installed using a video control system from Indigo Vision. Of these, 36 are HD level products that support 1.3M pixels and the rest are SD level. Crime prevention CCTVs are installed at a height of either 2 meter or 14 meter, depending on location. CCTV closure has UPS installed, which allows 1-hour operation even during blackout and the speaker allows warning announcements from the center during emergency situations. However, the earlier crime prevention CCTVs installed in 2007 are without a speaker and only allows monitoring. Most crime prevention CCTVs are connected to command and control center using optic cable, and the installation and management of the optic cable is placed under the charge of contracted firms.

Figure II-27 | Villavicencio: Crime Prevention CCTVs



Crime prevention CCTV installation



Old and new crime prevention CCTV



Crime prevention CCTV controller



Crime prevention CCTV camera

Source: Compiled by KSP Research Team (2015).

Efficient and timely crime control must ensure simultaneous event control and history management. Currently the command and control center is limited in its capability to simultaneously control various emergency situations. All police vehicles have GPS installed and can be tracked, but there is no center system that can monitor and control their course of action. An innovative location-based system that includes an e-map will certainly lead to more effective and efficient crime control.

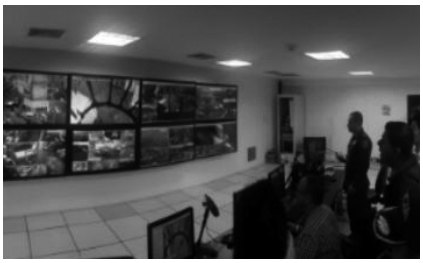
To that end, city safety and security prevention measures also need to be continued, including alignment of crime prone areas, fortification of security facilities to prevent crime, promotion and operation of crime prevention programs, support for criminal rehabilitation, and improved links with other security organizations tasked with lowering city crime rate.

In conclusion, to enable the efficient running of all these operations and plans, KSP Team suggested that remodelling the current building of the center would require an immense budget and needs to be located in a new building with facilities like specifically fitted Situation and Equipment Rooms that can support its functions and roles.

Figure II-28 | Villavicencio: Situation Room of Command and Control Center and Its CCTVs



Exterior of the center



Situation room



Operation control



CCTV control terminal screen



Equipment room



New center building

Source: Compiled by KSP Research Team (2015).

2.2.3. Disaster

The work and services of disaster control are managed by a variety of departments: Fire Department, Red Cross, Civil Defense, Air Force Rescue, and finally, a Disaster Control Department.

1) Fire Department

Fire Department is a privately run operation that is under contract with the Colombian government and local government; this fire department is run following a nationwide organization structure. Major tasks include fire fighting, checking fire facilities, neighborhood patrol, and fire safety education. There is only one fire department in Villavicencio, with 40 employees and 60 volunteer workers, and 16 fire vehicles.

Villavicencio's Fire Department operates a "119" report center that receives an average of 15,000 calls per day. However, many turn out to be prank calls. To prevent unnecessary dispatch upon false reports, all calls therefore need to be confirmed before making a dispatch. After receiving a report call, the process that follows is recorded by hand and Excel is used for post-management such as certification issue for insurance. The fire department uses analogue and digital TRS terminals, and another TRS terminal is for the purpose of collaborating with City Hall Disaster Control Center for reacting to large-scale disasters.

The Fire Department operates in eight densely populated areas and seven suburbs. Dispatch time now takes a maximum of 40 minutes owing to expansion of city, so the city has set up a goal to add four fire departments and reduce the dispatch time to within 6 minutes. The KSP Team and fire fighters discussed these goals as well as solutions for improving reporting system and GPS control, and constructing heat sensor CCTV for work efficiency were also discussed during site visits to the department.

Figure II-29 | Villavicencio: Fire Station



Call Center



Call Center



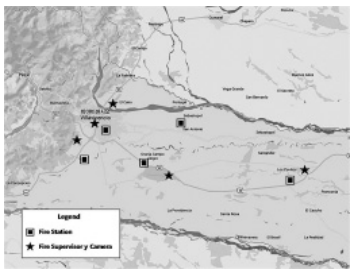
Record



Wireless Terminal



Fire Department Vehicle



Heat sensor CCTV location (planned), Villavicencio Fire Department

Source: Compiled by KSP Research Team (2015).

Additionally, acquisition of traffic information and traffic lights control to secure emergency dispatch routes, general reaction towards large-scale accidents or disasters, information integration and organic cooperation of related organizations are all required plans to improve the role and services of the Fire Department. These target goals are made possible with the construction of an IOCC that can efficiently manage all the above services.

2) Red Cross

Red Cross is an institute that provides assistance related to emergency medical service, general medical service and educational activities. Villavicencio Red Cross is in charge of all Meta department and is serviced by employees and volunteer workers. There are regional offices in 18 cities of Meta and these are connected only through the telephone.

An emergency call center is operated on the 7th floor of the Red Cross building (emergency number: 132), with a dedicated 132 phone and two landlines. A total of three terminals are used: two TRS terminals and mobile phones for work, and one TRS terminal connected with City Hall. Emergency calls are received during operation hours (07:00-18:00) at the center and also at the 1st floor reception after operation hours. Call details are recorded by hand on the log. An average number of 700 calls are received daily, with 50% being prank calls. Only one controller is responsible for receiving calls and processing them, and the workload is overwhelming. Out-dated TRS facilities have insufficient functionality and there are some physical locations that cannot be reached without improved equipment. Also, since all ambulances are located in one place, it normally takes more than six minutes for dispatches to arrive at the rescue or emergency site. Plans to add more ambulances situated at strategic locations are being reviewed.

The process management of the Red Cross emergency call center needs to improve. The most needed improvement to resources management such as manpower and computerization of work is related to the capability to initiate responsive action to calls for its services. IOCC will allow the municipality to have integrated information linkage.

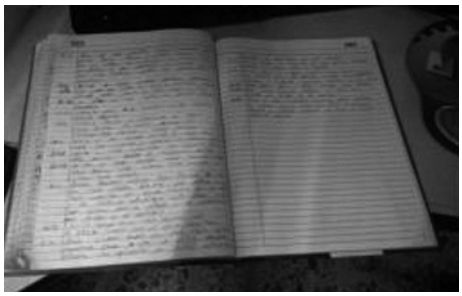
Figure II-30 | Villavicencio: Red Cross



Call Center



Terminal



Record



Red Cross ambulance vehicle

Source: Compiled by KSP Research Team (2015).

3) Civil Defense

Civil Defense is a national level government organization that provides assistance in services related to lifesaving, traffic accidents, emergency evacuation, fire fighting, and water supply problems. There are 250 Civil Defense members in the Meta region and 100 in Villavicencio. The city has 10 regular employees and the rest are mostly volunteer workers. In assisting traffic accidents and lifesaving, Civil Defense coordinates dispatches with City Hall's Disaster Control Center and often cooperates with the Fire Department.

The Civil Defense's call report number is "144" and details of all calls are handled manually by one controller. VHF terminals are used for city level communication while HF terminal is used for national level communication. There are seven VHF terminals at hand but present communication between Civil Defense mostly utilizes mobile phones. There is one TRS terminal for the purpose of communicating with City Hall's Disaster Control Center.

There is a need to construct a system for information linkage. With the construction of IOCC, it is possible to establish better cooperation and connectivity between organizations to ensure efficient rescue when needed.

Figure II-31 | Villavicencio: Civil Defense



Exterior



VHF terminal and HF terminal



Equipment storage



Civil Defense vehicles

Source: Compiled by KSP Research Team (2015).

4) Air Force Rescue

Air Force Rescue is a special rescue team (that operates under its team name 'Angel') in the second Air Force Combat. Its purpose is linked to providing emergency lifesaving and fire fighting assistance. This unit is responsible for four regions (including Meta), which makes up 20% of this nation.

Air Force Rescue operates a C2 Control Center to assist rescue team activities. This center employs trained soldiers who control operations with radar and GPS. Procedures for handling reports are established are legislated and hence this unit has a very efficient operation system. Assistance requests from other organizations such as Disaster Control Center and Fire Department are made through telephone via the C2 Control Center. Its facilities include emergency rescue helicopter and fire fighting equipment, but there is still a lack of rescue equipment for long distance patient transfer.

Air Force Rescue personnel recognize the importance of establishing measures to ensure quick and accurate information sharing among related organizations. However, although they are well equipped and have a smooth system for providing military aid to civil authorities, they often fail to provide timely assistance due to delayed assistance request from other organizations.

Establishing a system for handling quick assistance request and information sharing between Air Force Rescue and other service organizations is critical for improved service. The construction of

IOCC in the future will focus on establishing better cooperation and data connectivity between this unit and related organizations.

Figure II-32 | Villavicencio: Air Force Rescue Team



Emergency rescue helicopter



Inside the rescue helicopter

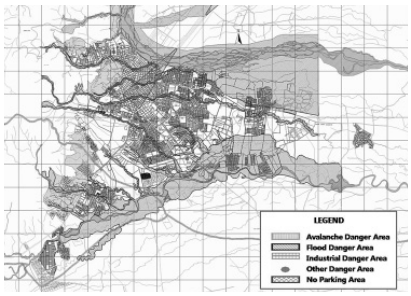
Source: Compiled by KSP Research Team (2015).

5) Disaster Control Department

The government of Colombia recognizes that the need for continuous control to prepare for disasters that frequently occur due to changes in climate. To promote sustainable development, 1523 Law was enacted in 2012 that stipulates the responsibility of government and businesses to react to citizens' needs to cope with disasters. The Disaster Control Department, one of the City Hall's organizations, operates the Disaster Control Center, taking a role of coordinator for the rescue activities of 25 related organizations. This department is in charge of disaster prevention patrol, disaster training, and education for citizens and provides needed equipment for restoration work in locations affected by disasters.

Disaster Control Department also categorizes city disasters into flooding, landslide, dangerous facility (electricity and gas piping) and other risks. For example, it makes regular patrol around 5,947 km of the city stream, which is designated as a Risk Management zone. In addition, the department monitors other disaster danger zones to prevent disasters, but the scope is too far and wide for manual control. Thus, a surveillance sensor and control system is needed and remote surveillance system should also be reviewed for early detection of flood and/or landslide.

Figure II-33 | Villavicencio: Data for Risk Management



Various risk control types



Danger zones under control

Source: Villavicencio Secretariat, Villavicencio General Information (2015).

Considering all this, the highest priority for a disaster control department is to be able to implement a system that guarantees efficient control work, swift reaction, and situation conveyance during disasters, as well as coordinated data sharing and action of all departments involved. Risk prevention and remote surveillance of disaster risk zones are also roles of paramount importance. The establishment of an IOCC to manage these roles will lead to more efficient disaster control and management for the city as well as for the nation.

Ⅲ Survey

1. Scope of Survey

The research covers a variety of critical issues: impact and issues of transportation, security and crime, and problems caused by disasters. Taking into account the context and stakeholders of target cities at all levels of the study, the research team visited the cities, consulted decision makers, analyzed civil organizations that provided services, and enquired about considerations for improved service provision.

The study took place from August 2015 to September 2015. Research decisions were made while acknowledging and accentuating the importance of the project in consideration of the geographical and cultural traits of the cities. For example, a preliminary survey draft was distributed to subject organizations and modified based on stakeholders' input and feedback. Since Spanish was the predominant language in Colombia, the survey was written and conducted in Spanish. Sample size for surveys conducted in each city was 100.

2. Data Elicitation Techniques

Survey items were drafted to focus on urbanization problems and disaster issues, according to the purpose of ESCI. In drafting survey questions, the team made reference to background knowledge of earlier smart cities projects, target cities' websites, and Findeter as sources of current information. Findeter (Financiera de Desarollo Territorial) is a public development bank that supports the phenomenon of decentralization, including urban development of territorial authorities.

Of particular relevance were references to experiences learned and technologies used in successful smart city cases like those in Korea and Paraguay. The team's survey preparation was also based on the 2013 KSP experience and report of Jamaica's Montego Bay urbanization project, as this project shared similar issues and considerations faced in Latin America and the Caribbean.

For this study, the research team first explained the purpose of the survey, obtained consent, and conducted a survey by distributing questionnaires to related organizations with the support and cooperation of the target city's administration and Findeter. In describing the project, the team clarified the Smart City Project goals, and initiated discussion with stakeholders on their

organizations' requests. The team then compiled a Status Analysis section that took into account roles and responsibilities of each organization, problematic issues mentioned, and considerations or recommendations for improvement of their services and roles.

In Valledupar, 15 organizations participated in discussing city development issues and providing vital data for the report. These organizations are: City Hall, Police Department (Control Center), Civil Defense, Fire Department, Red Cross, Cesar Environment Department (CORPOCESAR), Transportation Department (Transportation Center), City Competitiveness Improvement Committee, waterworks supplier, waste cleaning company, gas supplier, electricity supplier, key telecommunications business operators (such as UNE, TIGO, and CLARO), network circuit loaner, and Department of Commerce. There were a total of 88 respondents for this city.

In Villavicencio, 14 organizations participated in providing vital data for the report. These are: City Hall (general meeting), City Development Planning Department, Disaster Control Department, waterworks supplier (EAAV), cleaning business, Air Force Rescue, Red Cross, Fire Department, Civil Defense, Transportation Department, Infrastructure Department, Police Department Crime Prevention Center, City Hall Computer Room, Air Force Rescue, Future Police Integration Center Venue (on relocation into new building), and new Mayor (for interviews). There was a total of 67 respondents altogether.

Since the sample size for surveys and interviews are relatively small, there is the issue of generalizability of its results and conclusions. However, although a small sample-size study may limit the potential to generalize, there is support that their results may be used to contribute to knowledge and promotes action in the area of the circumstances studied. In fact, this is especially true as the purpose of this research is not to provide generalizable results but rather to "increase correspondence to reality" (Hidding 1998, as cited in Lee and Baskerville 2003). Combined with other research methods that provide rich data from multiple sources such as interviews, review of the literature, observations and site visits, results from surveys are carefully triangulated and are considered very useful and relevant, though not necessarily generalizable.

3. Survey Results

The sample size for surveys was 100 for each target city. In Valledupar, opinions were gathered from 88 respondents while in Villavicencio, 67 people responded to the city survey conducted there.

3.1. Valledupar Survey

Literature review reveals the major problems of Valledupar were traffic congestion, high crime rate, and natural disaster. This is further verified by findings of a survey on issues in regards to transportation, security, and disaster.

Table III-1 | Basic Information of Respondents in Valledupar

Total	Gender	Age distribution	Occupation	Address
88	Male: 76 Female: 12	• Under 20: 1 • 20-29: 25 • 30-39: 26 • 40-49: 26 • 50-59: 6 • Above 60: 4	• Worker: 21 • Civil servant: 60 • Student: 7	• City center: 86 • Suburbs: 2

Source: Compiled by KSP Research Team (2015).

The survey was designed and conducted to elicit citizens' opinions on the overall problems faced by residents in the city, and to gather their views on priorities of services. The survey respondents were civil servants, fire fighters, students, and city residents.

Table III-2 | Survey: Overall Evaluation (Valledupar)

Question	Details
1	• What are your priorities among transportation, crime prevention, and disaster prevention? 1) Very urgent 2) Urgent 3) Not so urgent
2	• What are your thoughts on transportation, crime prevention, and disaster prevention? 1) Very serious 2) Serious 3) A little problematic 4) No problem

Source: Compiled by KSP Research Team (2015).

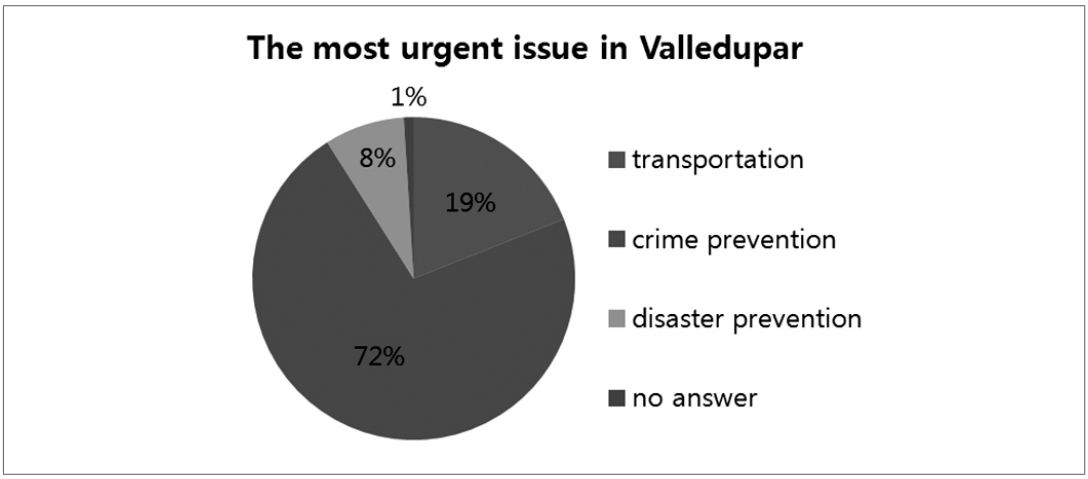
Question 1 and 2 asked about the most urgent and serious issues faced by Valledupar residents. As shown in the table below, Crime Prevention was mentioned as the most urgent issue that the city faces with 72% respondents saying that crime should be a priority for the city to resolve. The second and third most urgent issues were transportation (19%) and disaster control (8%).

Table III-3 | Overall Evaluation 1: Priorities in Urban Issues in Valledupar

Category	Most urgent	Urgent	Not so urgent
Transportation problem	17	38	29
Crime prevention	63	19	3
Disaster prevention	7	26	47
No answer	1	5	9

Source: Compiled by KSP Research Team (2015).

Figure III-1 | Overall Evaluation 1 : Priorities in Urban Issues in Valledupar



Source: Compiled by KSP Research Team (2015).

Survey results also showed that the citizens evaluate crime to be the most serious problem.

Table III-4 | Overall Evaluation 2: Seriousness of Urban Issues in Valledupar

Category	Very serious	Serious	A little serious	No problem	No answer
Transportation	34	36	13	1	4
Crime	66	17	2	0	3
Disaster	12	30	38	3	5

Source: Compiled by KSP Research Team (2015).

3.1.1. Transportation

In more detail, the results of survey for transportation sector are as follows.

Table III-5 | Survery: Transportation (Valledupar)

Question	Details
1	• Select the most often used transportation means in Valledupar.
2	• Evaluate the suggested transportation means in terms of road connection, safety, service intervals convenience, cost, and efficiency.
3	• Evaluate the seriousness of the issues below.

Source: Compiled by KSP Research Team (2015).

Transportation Survey 1 asked about their most often used transportation means, and their reasons for using or not using a particular means of transportation.

Table III-6 | Transportation 1: Most Often Used Transportation in Valledupar

Transportation means	Total	Ratio (%)
Car	23	26.14%
Mini bus	16	18.18%
Town bus	14	15.91%
Tourist taxi	7	7.95%
Route taxi	23	26.14%
Bicycle	24	27.27%
Motorcycle	16	18.18%
Other	15	17.05%

Source: Compiled by KSP Research Team (2015).

The most used transportation means was bicycle (27.27%), followed by cars and route taxis (26.14%), motorcycle and mini bus (18%), and town bus (16%). As shown in the results, public bus was not a regular means of travel because respondents found it unreliable and slow due to numerous stops. Additionally, problems with transportation were mainly the rise in traffic accidents involving bicycles. Cyclists on regular roads faced risks when traveling on narrow roads and when they disregard traffic signals and road regulations. Cyclists also caused problems to other road users as they often hindered drivers, reduced city center traffic speed, and brought about traffic congestion. Other problems included narrow roads and crossroads, lack of parking space, road damage, and poor road maintenance procedures.

Table III-7 | Transportation 2: Evaluation of Transportation Modes in Valledupar

Category	Very serious	Serious	Normal	Good	Very good	No answer
Car	13	44	12	6	4	9
Mini bus	24	28	8	10	1	17
Town bus	31	21	13	11	3	9
Tourist taxi	8	29	19	10	2	20
Route taxi	11	27	19	21	4	6

Source: Compiled by KSP Research Team (2015).

Transportation Survey 2 evaluated transportation means in terms of road connection, safety, service interval, convenience, cost, and efficiency. The respondents said that route taxis and their illegal parking were serious issues. Problems with taking town buses and mini buses had caused an increase in the use of illegal motorcycle taxis, which in turn created problems of traffic congestion and accidents.

Table III-8 | Transportation 3: Seriousness of Transportation Issues in Valledupar

Transportation Issue		Very serious	Serious	A little serious	No problem	No answer
General transportation	Traffic congestion	54	20	9	0	5
	Inefficient traffic light control	30	36	13	4	5
	Lack of real time transportation information	32	32	15	0	8
	Traffic accidents	49	28	5	0	5
	Speeding	39	28	14	0	7
	Traffic light violation	54	25	3	0	6
	Overload trucks	26	35	18	1	8
	Lack of parking space	46	29	7	0	6
Public transportation	Bus waiting time	44	23	14	2	5
	Lack of bus arrival information	43	20	15	3	7
	Illegal parking of route taxi	42	32	7	2	5
	Excessive route taxis	22	29	21	9	7

Source: Compiled by KSP Research Team (2015).

3.1.2. Security

Literature review research on the state of security in Valledupar reveals that the city suffered from various problems caused by rapid development of the city and inadvertent population increase. Drug cases and violent crimes caused especially by the influx of population from other regions were considered very serious issues. There was a marked increase in violence, especially domestic violence, caused by drug. The city made attempts to reduce crime rates by carrying out a number of policies related to enlightenment education, facility investment, and environment improvement. The following two surveys were conducted to collect citizens' opinion on security issues.

Table III-9 | Survery: Security (Valledupar)

Question	Details
1	• Evaluate the seriousness of crimes in Valledupar.
2	• Describe crimes that could take place in Valledupar other than those listed in Question 1.

Source: Compiled by KSP Research Team (2015).

Security Survey 1 asked the respondents to evaluate the seriousness of crimes. Response of citizens showed that violence/bullying was most serious, followed by drugs, theft, adolescent crime, robbery, and firearms threats. Result of Survey 1 in relation to security is as follows.

To find out more details on security issues, ranking of a series of nine crimes elicited citizens' opinions on security issues. The survey specifically asked respondents to evaluate the seriousness of crimes in Valledupar. Results showed that respondents ranked violence/bullying (80.7%), drug use (75%), and theft/robbery (68%) as very serious issues.

Table III-10 | Security 1 : Seriousness of Crime Issues in Valledupar

Crime	Very serious	Serious	A little serious	No problem	No answer
Violence / bullying	71	15	0	0	2
Households theft/robbery	50	29	4	1	4
Commercial theft/robbery	60	21	3	1	3
Pickpocketing in the streets	42	28	11	0	7
Pickpocketing in public places	24	30	23	3	8
Public facility damage	35	31	15	0	7
Adolescent crime	46	25	11	0	6
Drug use	66	15	1	0	6
Fire arms	39	31	12	0	6

Source: Compiled by KSP Research Team (2015).

Response to Security Survey Item 2 showed request for more proactive, swift reaction on behalf of the city police upon crime prevention. Many citizens also said that they would like to see additional installation of CCTVs in crime ridden, crime prone areas.

3.1.3. Disaster

Two survey items asked citizens about their awareness of disaster related city issues.

Table III-11 | Survery: Disaster (Valledupar)

Question	Details
1	• Evaluate the seriousness of disaster problems (natural disaster).

Source: Compiled by KSP Research Team (2015).

Drought was evaluated to be a very serious problem in disaster areas, according to 61.3% of the respondents. This was followed by flooding caused by lack of drainage facility in flood/heavy rain (54.5%), and also earthquakes.

Table III-12 | Disaster 1: Seriousness of Disaster Issues in Valledupar

Disaster	Very serious	Serious	Normal	Satisfactory	Very satisfactory	No answer
Earthquake	5	14	41	12	4	12
Lack of emergency rescue	6	9	20	17	32	4
Lack of drainage facility	11	37	23	6	7	4
Drought	27	27	21	4	4	5
Blackout	11	28	35	3	4	7

Source: Compiled by KSP Research Team (2015).

3.1.4. Other Concerns

There was an open-ended survey question that asked about possible city problems other than transportation, security, and disaster. There were not many responses for this open-end question, but respondents' concerns were mainly on environmental pollution (particularly from intake stations) and waterworks supply.

Table III-13 | Survey: Other Concerns (Valledupar)

Question	Details
1	• Please describe any concerns you have in areas other than transportation, crime, and disaster.

Source: Drafted by oneself

3.1.5. Conclusion (Valledupar)

Survey results showed that Valledupar citizens regarded security issue as the most serious problem, followed by transportation and disaster prevention.

In more detail, responses indicated that Valledupar residents found violence (including bullying) to be the most serious, followed by drugs, theft, adolescent crime, robbery, and illegal possession of firearms. It was very revealing to see what residents wanted from city administration in terms of solutions to the security problems they faced. Respondents said they would like to see more proactive, swift reaction on behalf of the city police when crimes had been committed. Many also said that they would like to see additional installation of CCTVs in crime ridden and crime prone areas.

For transportation, lack of parking space, traffic congestion, overloaded trucks, traffic light violation, and lack of real time transportation information were mentioned as serious problems. Respondents also ranked illegal parking of route taxis, excessive number of route taxis, lack of bus arrival information, and bus service interval as problematic for them.

As for disaster control and prevention, respondents ranked drought as the most serious problem they faced. They also said they suffered from flooding due to lack of city drainage facility when there is flood and/or heavy rain. Another concern mentioned was environmental pollution such as air quality and clean water supply.

The sample size of this survey may be insignificant when discussing the credibility and standard deviation of the survey results. However, survey findings provided credible baseline data particularly citizens' concerns that need to be addressed due to the severity and urgency of these problems. Hence, KSP Team took into account the above results with other sources such as advanced case, literative review, statistics and technical stability before making suggestions, on Smart City service in the target city.

3.2. Villavicencio Survey

A review of related literature revealed that major problems faced by Villavicencio residents were traffic congestion, high crime rate, and high occurrence of natural disasters (e.g., landslide, flood). To find out details of these problems, a survey was conducted to elicit citizens' views on issues relevant to transportation, security and disaster occurrences.

Table III-14 | Basic Information of Respondents in Villavicencio

Total	Gender	Age distribution	Occupation	Address
67	Male: 33 Female: 34	• Under 20: 0 • 20-29: 14 • 30-39: 27 • 40-49: 19 • 50-59: 7 • Above 60: 0	• Worker: 22 • Civil servant: 44 • Student: 1	• City center: 64 • Suburbs: 3

Source: Compiled by KSP Research Team (2015).

The objectives of the survey are to find out how citizens viewed the overall urban problems faced by the city and how their suggestions can help in the construction of Villavicencio IOCC and in the determination of needed services for a Smart City development project.

Table III-15 | Survey: Overall Evaluation (Villavicencio)

Question	Details
1	• What are your priorities among transportation, crime prevention, and disaster prevention for Villavicencio? 1) Very urgent 2) Urgent 3) Not so urgent
2	• What are your thoughts on Villavicencio's transportation, crime prevention, and disaster prevention? 1) Very serious 2) Serious 3) A little problematic 4) No problem

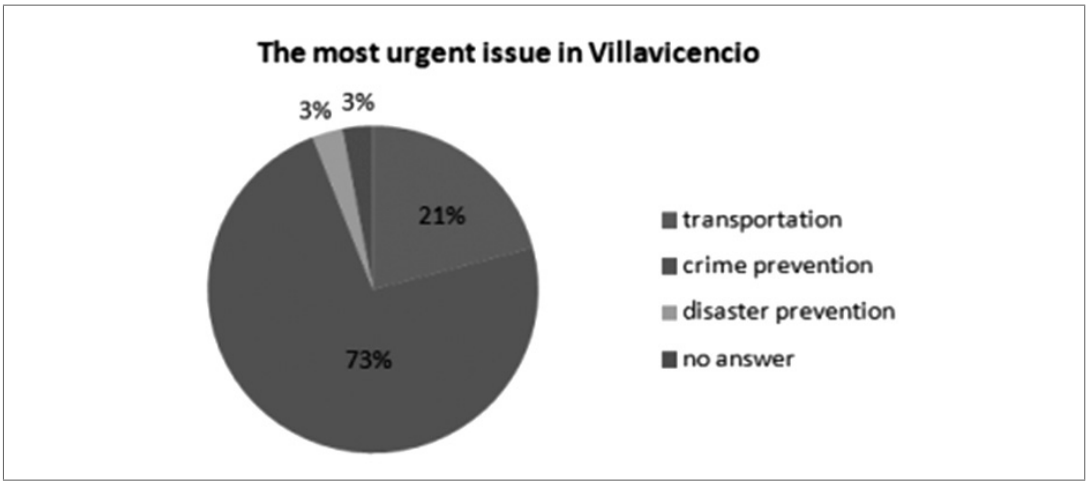
Source: Compiled by KSP Research Team (2015).

Table III-16 | Overall Evaluation 1: Priorities in Urban Issues in Villavicencio

Category	Most urgent	Urgent	Not so urgent
Transportation problem	14	30	18
Crime prevention	49	12	4
Disaster prevention	2	20	39
No answer	2	5	6

Source: Compiled by KSP Research Team (2015).

Figure III-2 | Overall Evaluation 1 : Priorities in Urban Issues in Villavicencio



Source: Compiled by KSP Research Team (2015).

Survey 2 asked the citizens on their take on the urgency of transportation, crime, and disaster; results showed that crime was recognized as a very serious issue.

Table III-17 | Overall Evaluation 2 : Seriousness of Urban Issues in Villavicencio

Category	Very serious	Serious	A little serious	No problem	No answer
Transportation	18	32	9	3	3
Crime	30	27	6	0	4
Disaster	4	25	29	2	7

Source: Compiled by KSP Research Team (2015).

3.2.1. Transportation

The existing literature on Villavicencio's traffic status shows that reasons for traffic congestion were narrow roads, unpaved roads, lack of parking space, illegal parking, inadequate public transportation, as well as poor road pavement management (i.e., cracks, breakage, and dent in pavements). To find out citizens' views on transportation, a survey was conducted using the three questions below to collect citizens' opinions on Villavicencio' current status.

Table III-18 | Survery: Transportation (Villavicencio)

Question	Details
1	• Select the most often used transportation in Villavicencio (more than 1 answer allowed)
2	• Evaluate the suggested transportation means in terms of road connection, safety, service interval, convenience, cost, and efficiency.
3	• Evaluate the seriousness of the issues below.

Source: Compiled by KSP Research Team (2015).

Table III-19 | Transportation 1: Most Often Used Transportation in Villavicencio

Transportation means	Total	Ratio (%)
Car	37	55.22%
Mini bus	9	13.43%
Town bus	13	19.40%
Tourist taxi	4	5.97%
Route taxi	18	26.87%
Bicycle	1	1.49%
Motorcycle	18	26.87%
Other	5	7.46%

Source: Compiled by KSP Research Team (2015)

In response to Survey 1, the majority of respondents said that their most often used transportation means was car (55.22%), followed by route taxi and motorcycle (26.87%).

Table III-20 | Tansportation 2: Evaluation of Transportation Modes in Villavicencio

Category	Very serious	Serious	Normal	Good	Very good	No answer
Car	11	23	12	5	2	14
Mini bus	8	24	8	3	0	24
Town bus	7	25	12	4	1	17
Tourist taxi	5	20	13	2	2	25
Route taxi	10	23	12	10	1	11

Source: Compiled by KSP Research Team (2015).

A common reason behind the low use of public transportation (i.e., bus) was that it took a long time due to its slowness and numerous stops. Too many private cars and lack of parking space as opposed to the number of route taxis also brought about Villavicencio's traffic jam. Increase in the number of motorcycles reduced traffic speed and caused many traffic accidents. In addition, a high number of complaints were about cars and route taxis. All of these reasons created traffic congestion and Villavicencio citizens' high dissatisfaction with overall transportation means in the city.

Table III-21 | Transportation 3 : Seriousness of Transportation Issues in Villavicencio

Transportation		Very serious	Serious	A little serious	No problem	No answer
General transportation	Traffic congestion	42	20	3	0	2
	Inefficient traffic light control	8	30	21	1	7
	Lack of real time transportation information	20	22	16	1	8
	Traffic accidents	19	30	15	0	3
	Speeding	11	32	16	1	7
	Traffic light violation	23	27	9	1	7
	Overload trucks	24	16	19	0	7
	Lack of parking space	26	21	12	2	6
Public transportation	Bus waiting time	9	21	23	4	10
	Lack of bus arrival information	11	21	18	6	11
	Illegal parking of route taxi	31	14	8	3	11
	Excessive route taxis	20	24	10	3	10

Source: Compiled by KSP Research Team (2015).

Survey 3 focused on the seriousness of issues in general and public transportation. To this question, respondents said that much improvement was needed in various aspects: traffic congestion (24%), lack of parking space (15%), overloaded trucks (14%), traffic light violation (13%), lack of real time transportation information (12%), and rate of traffic accidents (11%). For general transportation, citizens indicated that lack of parking space, traffic congestion, overloaded truck, violation of traffic lights, and lack of real time transportation information were problematic, in descending order. In terms of public transportation, citizens ranked issues like route taxis' illegal parking and their excessive number, lack of bus arrival information, and bus waiting time. To resolve such general and public transportation issues, citizens welcomed illegal parking control, more traffic police and CCTV camera installation.

3.2.2. Security

Villavicencio is a quick developing city which has experienced a great increase in population. This unintended situation brought about various problems including friction between existing citizens and new influx of population. Like Valledupar, Villavicencio was similarly affected in multiple ways from the massive influx of internally displaced people as these unauthorized settlers were considered the main cause of drug related and violent crimes.

With the rise in domestic and social violence caused mainly by drugs abuse, the city administration of Villavicencio was compelled to reduce the crime rate by carrying out a number of policies related to education, facility investment, and overall environment improvement. A survey conducted to gather opinions on security issues revealed the following results.

Table III-22 | Survey: Security (Villavicencio)

Question	Details
1	• Evaluate the seriousness of crimes in Villavicencio.
2	• Describe crimes that could take place in Villavicencio other than those listed in question 1.

Source: Compiled by KSP Research Team (2015)

Survey 1 asked respondents to evaluate the seriousness of crimes in Villavicencio. A total of 43 citizens answered that drug related crime was most serious, followed by violence/bullying (28 respondents), adolescent crime (26 respondents), street pickpocketing (26 respondents), theft and robbery (22 respondents), and damage of public property, e.g., fire alarm systems (7 respondents). Interestingly, a preliminary review of literature indicated possession of firearms was also an issue of concern, but survey respondents did not endorse this view and thought this issue was relatively less serious.

Table III-23 | Security 1: Seriousness of Crime Issues in Villavicencio

Crime	Very serious	Serious	A little serious	No problem	No answer
Violence / bullying	28	28	5	0	6
Households theft/robbery	22	26	13	1	5
Commercial theft/robbery	22	27	8	1	9
Pickpocketing in the streets	26	24	7	0	10
Pickpocketing in public places	13	21	21	0	12
Public facility damage	17	15	21	2	12
Adolescent crime	26	24	6	1	10
Drug use	43	13	5	1	5
Fire arms	16	27	12	1	11

Source: Compiled by KSP Research Team (2015).

Security Survey 2 (i.e., Describe crimes that could take place in Villavicencio other than those listed in Survey 1) did not recieve any responses. This was probably because the types of crimes listed in Survey 1 (based on knowledge gained from a detailed literature review) were considerably extensive already.

3.2.3. Disaster

The following question was asked to the citizens to recognize disaster related city issues.

Table III-24 | Survery: Disaster (Villavicencio)

Question	Details
1	• Evaluate the seriousness of disaster problems (natural disaster).

Source: Compiled by KSP Research Team (2015).

To this question, citizens answered that their most serious problem was lack of good drainage facility, and they suffered from flooding whenever there was heavy rainfall or during the wet season.

Table III-25 | Disaster 1: Seriousness of Disaster Issues in Villavicencio

Disaster	Very serious	Serious	Normal	Satisfactory	Very satisfactory	No answer
Earthquake	5	11	36	2	5	8
Lack of emergency rescue	4	17	29	9	2	6
Lack of drainage facility	15	30	15	3	1	3
Drought	5	18	28	5	2	9
Blackout	3	14	27	7	5	11

Source: Compiled by KSP Research Team (2015).

3.2.4. Other concerns

The respondents were asked an open-ended survey question to provide details on possible city problems other than transportation, security, and disaster. Only a few citizens provided their comments, pointing out environmental contamination issue.

Table III-26 | Survey: Other Concerns (Villavicencio)

Queestion	Details
1	• Please describe any concerns you have in areas other than transportation, crime, and disaster.

Source: Compiled by KSP Research Team (2015).

3.2.5. Conclusion (Villavicencio)

Survey results showed that security (73%) issue is the most serious problem in the city, followed by transportation (21%), and disaster (3%).

Among others, 64% of respondents found drug related crimes to be very serious, followed by violence/bullying (42.8%), adolescent crime (33.8%), and theft/robbery (32.8%). In terms of transportation, cars were most often used (55.22%), then route taxis and motorcycle (both 26.87%), town bus (19.4%), and mini bus (13.43%). Main grievances with traffic were congestion, narrow roads and crossroads, and poor road management. Also, in Villavicencio, disaster prevention and control of flooding was deemed as a problem that requires a prompt action from authorities, especially for drainage facility as this was seen by 67% of the respondents as a severe issue. Other disasters like drought and earthquake were also of concern to respondents.

The surveys reveal there were many city issues and problems shared by Valledupar and Villavicencio, and priorities for city competitiveness were similar in many aspects. According to the site analysis, review, and survey results, both cities' residents had similar concerns on security or crime prevention, ease of transportation, and disaster control.

In terms of survey results generalizability, the sample size is considerably small thus affecting the credibility and standard deviation of results. However, using a survey in this context is not aimed at achieving generalizability; rather, this method is selected because it "increases correspondence to reality" (Hidding, 1998, as cited in Lee and Baskerville, 2003). The survey is one of many research tools to elicit information from cities' residents. It is revealing to use survey results combined with interview data and other results to draw out citizens' concerns and issues.

The KSP Team's recommendations for establishing an IOCC and Smart City services are based not only on this survey's findings. The team rely also on multiple research methods that yield rich data for inquiry and analysis, such as interviews with multiple stakeholders, site observations, review of related literature, and case country comparisons.

Ⅳ Analysis of Legal and Policy Framework

1. Outline

It is critical to understand legal and institutional frameworks, as well as national and local policies in constructing an IOCC and supporting services of a Smart City. A preliminary research on Colombia's related legal system was thus conducted to gain a better understanding of current legal frameworks that are relevant to the project's goals. It is essential to be aware of possible legal issues that may arise during the construction and operation of the IOCC. Where deemed necessary, the KSP team will provide views and recommendations to facilitate IOCC establishment.

2. Relevant Legal Systems

First, legislative systems related to certain aspects of city development (e.g., security, transportation, disaster, information communication, and information protection) are reviewed. Then aspects that require improvement are analyzed for the provision of services found in smart cities and construction of IOCC in target cities to realize their Smart City mission.

Table IV-1 | Legal and Institutional Framework Related to Smart City

Area	Related law	Related issue
City Development	• National City Development Act	• Abide by land development plan of central government
	• National Development Plan Act	• Connection to master plan of central government
	• Micro Project Act	• Low income household stabilization and security procurement
	• Public-Private Partnership Act	• PPP projects
	• National Foundation Facility Act	• Connection to city infrastructure (transportation, electricity, and communications)
Security Procurement	• Anti-Terrorism/ Terrorism Act	• Government responsibility and crime prevention

Area	Related law	Related issue
Transportation Improvement	• National Transportation Safety Board Establishment Act	• IT based transportation safety policy establishment
	• Road Safety Promotion Act	• Provision of transportation information to automobiles and pedestrians
	• Traffic Act	• Automobile computerization, parking ban, and other regulations
	• Land Traffic Act	• Fine issuance standards
Disaster Control	• Volunteer Worker Act	• Volunteer emergency assistance system
	• National Disaster Accident Prevention Act	• Disaster Risk Management system operation regulations
	• Fire Officers Act	• Roles of fire officer, rescue activity personnel
	• Disaster Risk Control System Establishment Act	• Disaster Risk Management system and operation regulations
ICT Advancement	• Information, Communications and Technologies Act	• Regulations on mutual connection of networks
	• Outside Plant Routing Regulation	• Outside plant routing rights regulations
Information Protection	• Personal Information Protection Act	• Regulations on personal information protection
Local Government Governance	• Local Government Organization and Function Modernization Act	• Organization and function, responsibility regulations
Electricity Supply Improvement	• Electricity Supply Act	• Electricity supply and mutual connection

Source: Compiled by KSP Research Team (2015).

2.1. City Development Related Law

There are five laws or acts discussed in this section on legislation concerning city development.

2.1.1. National City Development Act (No. 388)

Under the National City Development Act (No. 388), a local government's city development plan named Plan de Ordenamiento Territorial (POT), must follow the 'Macro Project' enacted by the central government. POT is a city master plan that defines city system and permits construction projects. POT is selected by city mayor. And its planning is assisted by city's Planning Secretary.

In addition, POT must be connected to the master plan on city's general facility and mobility, public space, transportation, and public service. This means all planning tools must abide by procedures set out by local and central governments to avoid problems or adverse effects on environment, accessibility, transportation condition, waste control system, electricity supply system, waterworks and sewage systems, and public space.

1) Results of Review

This Act does not include any details on City service and IOCC construction. As such, partial revision of existing laws may be required as it should include plans as regards security and transportation such as collection and provision of transportation information for road traffic control, traffic signal control, disaster control plan, and infrastructure establishment.

2.1.2. National Development Plan Act (No. 1450)

Article 53-59 sepcify the needs of establishing plans for these areas: public land transportation for ICT infrastructure purposes (Article 53); joint possession of infrastructure for internal building communications network and service (Article 54); provision of information communications service accessibility (Article 55); network neutrality (Article 56); conditions for efficient electricity infrastructure utilization for communications service provision (Article 57); Internet society (Article 58); and information communications social volunteer worker enforcement (Article 59).

Inaddition, Article 84-86 state the importance of developing plans in terms of these aspects: intellectual transportation traffic (Article 84); intellectual traffic control center and transportation (Article 85); and detection of traffic violation using automation tool (Article 86). Article 84 requires establishment of plans for ITS to utilize computer and communications technology to collect, store, process and distribute information on transportation, operate conveyance and transportation, as well as fortify management and security of transportation plans. Article 85 requires establishment of plans for managing ITS control center, transportation related traffic, road safety, and control of traffic regulations compliance. Finally, Article 86 is concerned with detecting transportation violation using automation tools; punitive action, and administration procedures according to national transportation code regulations.

1) Results of Review

Colombia already has significant laws that form the foundation for Smart City service design as well as construction and operation of IOCC, such as information and communications infrastructure construction plan and intelligence transportation system development plan. There already are plans to operate administrative procedures such as detection of legal violations and fine issuance through automation facilities.

However, partial revision of the law is required for areas that are not included in the National Development Plan such as security procurement plan, disaster control plan, environment control plan, and ICT based infrastructure establishment plan.

2.1.3. Housing Supply Act (No. 1151 and 4260)

Colombia enacted a "Micro Project" policy as a law (i.e., the Micro Project Act) to assist low-income households to obtain housing in a large-scale land and housing development project.

In 2012, Colombia's central government stipulated the 2nd Micro Project and determined that 10 new city development areas would supply about 600,000 housing buildings. Candidate regions

include Barranquilla, Valledupar, Armenia, Quindío, Santa Marta, Villavicencio, Bello, Bucaramanga, Cúcuta, and Cali y Facatativa.

1) Results of Review

As emerging developing cities that saw rapid increase in population with city development, Valledupar and Villavicencio are included in the 2nd Micro Project. With support from the above project, it is expected that various social issues (e.g., high crime rate and lack of housing) will be reduced through resolving problems experienced by low-income households.

2.1.4. Public-Private Partnership (PPP) Act (No. 1467 and no. 1508)

The PPP Act (where PPP stands for Public Private Partnership) defines assistance and accordance through private business for projects conducted by the central or local governments.

This Act limits the implementation scope to cover only highway, port, railway facility, waterworks and sewage, public buildings such as schools, hospitals, libraries, and public housing construction.

The PPP Act also regulates the general stages applied to the preliminary validity of the Project and validity evaluation. It also has general rules for funding strategy and formation of Project Trust Fund & Equity of the Project. PPP covers a maximum of 30 years with a minimum project budget of around 2 million USD. Project promotion method is three-fold; first, private or joint investment under public leadership, second, joint investment under private leadership, and lastly, private investment under private leadership.

1) Results of Review

In a recent world economic forum, lack of infrastructure was identified as a major risk factor of Colombia. Compared to other countries, Colombia lacks electricity in quantity and quality; it requires acquiring competitiveness in its electricity area and has therefore included electricity business in its PPP plans. In the same manner, Smart City service and IOCC construction project can be added to PPP project scope, which thus necessitates a review of the current Public-Private-Partnership Act.

2.1.5. National Foundation Facility Act (No. 1682)

This act stipulates regulations that connect matters of land acquisition, environment conditions, infrastructure, and city convenience facility, i.e. transportation system, road, waterworks and sewage, electricity system. It stipulates regulations for National Infrastructure Agency (ANI) functions, which include acquisition and control of land necessary for foundational facility development and construction, and participation in public-private partnership for project development.

1) Results of Review

This particular law should be reviewed to include IOCC and information communications infrastructure as a national foundation facility. Additionally, the legal review should include acquisition of IOCC construction site, and regulations governing Site Equipment installation for Smart City service.

2.2. Security Procurement Related Law

This section focuses on a Security Procurement Act that protects the city against terrorism threats, and covers overt and covert operations or attacks.

2.2.1. Terrorism Prevention, Detection, Research, Economic Sanction Act (No. 1121)

This Act emphasizes the Colombian government's responsibilities in crime control to prevent terrorism. It also covers aspects of detection or surveillance and control of crime concealment. The latter refers to granting permission for the monitoring and sanctioning of economic connections, derived from terrorism funding sources or criminal activities.

1) Results of Review

This Act serves to protect Colombian citizens against overall crimes, such as terrorism attack prevention, detection, monitoring of research funding, budget sanctions, etc. If there is suspected activities involved with terrorism, security procurement measures such as the above mentioned are enacted and place into action. At the local government level, Smart City crime prevention service can act as a foundation level facility for terrorism prevention, detection, and surveillance. Hence, the current Act for terrorism prevention and terrorism related actions needs to include the role of local government's Smart City crime prevention service.

2.3. Transportation Improvement Related Law

There are four Acts associated with improvements to transportation services.

2.3.1. National Transportation Safety Department Establishment and Other Regulation Proclamation Act (No. 1702)

Article 1 defines establishment of an administrative organization under the Transportation Department named Agencia Nacional de Seguridad Vial (ANSV), for the purpose of maintaining special administration unit, law, administration and financial autonomy, and asset and national social order. Article 3 stipulates that ANSV is for national road plans, adjustment and road safety control. It assists systematic cooperation and supports efforts to realize transportation safety policy, monitoring and control strategy, planning and execution.

Article 9 defines ANSV's function for planning, regulation, information, control, and infrastructure. Its roles include the following:

- provides modeling for planning, preparation, execution, and evaluation of road safety policy and technology and information for research of cause and situation of traffic accidents;
- evaluates public and private organizations that operate traffic violation detection control system and utilizes the information created by such organizations to apply it to secure road safety;
- provides traffic safety related information to the citizens;

- establishes nation-wide activity plans with related authority, such as the police force, to monitor traffic safety, traffic regulation compliance and road safety procurement;
- utilizes information communication technology (ICT) as a solution to promoting traffic safety and enhancing traffic safety policy competitiveness;
- adjusts execution policy through automatic traffic violation control and semi-automatic control; and
- evaluates safety level of road infrastructure through traffic infrastructure inspection and safety check, and stimulates system design and its realization.

1) Results of Review

ANSV requires technology and function standards at the national level, such as the technical standards and function evaluation standards of Korean Intelligence Transportation System (ITS). Given the fact that it also regards generalities of transportation rule violation detection, there is a need to establish legal grounds for automobile control through unattended automation facility.

2.3.2. Colombia Road Safety Promotion Regulation Act (No. 1503)

This law defines general guidelines for governmental and local community's promotion of road safety. It assists in enforcing corporate or business social responsibility, promotion of traffic safety education, provision of traffic safety campaign training, and providing information on project research and development. Besides, it also promotes governmental, organizational and group efforts to conduct training on violation and awareness of traffic violation habits to pedestrians, passengers, and drivers using resources on driver education and road regulations. Road safety requires securing safety on the road for all persons (children, adults, elderly, disabled, etc.). Hence, road safety related information should be provided to automobile, motorcycle, bicycle drivers as well as the passengers, and pedestrians. Transportation safety training guidelines for all road users is provided.

1) Results of Review

Traffic safety education campaigns through VMS that is one of the Smart City services would be a good method that procures traffic safety.

2.3.3. Land Traffic Act (No. 769) and Traffic Act (No. 1388)

Major details of the Land Traffic Act (No. 769) are as follows: Article 54 requires all items related to automobiles to be computerized for registration while Article 76 deals with parking ban areas. Article 91 stipulates all public service drivers (ex, bus driver) to take on and let out passengers only at permitted places and that violation of such a rule should be punished with a fine. Article 93 controls driver's violation and allows issuing fine and canceling driver's license as means of such control. Articles 131-135 stipulate traffic rule violation related fine standards, attendance request, and fine issuance related items.

Major details of the Traffic Act (No. 1388) are as follows:

The Act, created according to the scope and principle of Land Traffic Act (No. 769) Article 1, stipulates mobility adjustment of pedestrian, user, passenger, driver, motorcycle, bicycle, traffic police, and automobile on public or private roads. Specifications on road boundary settings and traffic signs are also defined.

2.4. Disaster Control Related Law

There are four laws under this section on disaster control and prevention.

2.4.1. Disaster Risk Management Policy Adoption and Disaster Risk Management System Establishment Act (No. 1523)

Disaster Risk Management refers to danger reduction to ensure sustainable safety, welfare, and quality of life and disaster control for future risk management policy, plan, regulation, and actions. Disaster Risk Management includes standard prevention, control and disaster restoration, emergency control and danger reduction. This regulation oversees the selection of national disaster risk management policies and establishment of a national system for disaster risk management. It guards public, private, and local community to execute their respective responsibilities. It also encourages creating risk management process as a component of danger recognition, danger reduction, disaster control district, and disaster risk management.

At the same time, citizens who share the common responsibility of risk management are also guided to be cautious of personal facilities, to protect self and family, and to follow government authority regulations. Disaster risk management guidance in disaster treatment and assistance endorses two standard principles, i.e. fairness and protection.

1) Results of Review

This law defines the establishment and role of national disaster risk management organization and committee. Here, construction and operation of Smart City Service and IOCC require an integrated control environment, supplement of detailed items on surveillance on detailed disaster control, disaster surveillance and control facility installation operation. All the above will ensure a comprehensive national risk management system that connects central government and local governments.

2.4.2. Colombia Fire Officers Act (No. 1575)

Article 17 defines the role of Fire Department as an organization that prevents, manages and controls fire, with definitions on firefighting and harmful substance accident rescues. Article 20 sets out the conditions of establishing Fire Department while Article 28 as regards emergency services. It defines call and response actions regarding citizen rescue upon fire, explosion, harmful substance accidents, and related disasters.

1) Results of Review

Fire Department Operational Status research showed that fire officers and volunteer workers need to work based on teamwork. However, lack of fire facilities and shortage of fire officer manpower hinder such efforts. Revision of law to expand the number of fire officers and budget allocation is therefore required.

2.4.3. Emergency Treatment Volunteer Worker Sub-System Establishment and Encouragement of Civil Defense, Fire fighter, Red Cross Volunteer Worker Act (No. 1505)

This Volunteer Worker Act is the foundation of national volunteer workers and volunteer worker emergency assistance system. National volunteer workers are administered under regional Sub Systems; this is a group of volunteer workers who take interest in volunteerism to prevent events that cause damage to people and property. In other words, the national volunteer worker sub-system is part of the nation's system for disaster prevention and response.

Article 3 stipulates that the national volunteer work sub-system consists of four parties. These are first, officially recognized volunteer workers and Colombia Civil Defense; second, officially recognized volunteer workers and Colombia Red Cross; and third, officially recognized volunteer workers and fire fighters. The fourth group are other organizations that have been authorized by law to enforce disaster prevention.

Articles 11 through 15 require the government to assist volunteer organizations to act with pride through contracts with organizations linked to the national volunteer work sub-system and responsible to provide facilities required for rescue work.

1) Results of Review

Colombia is currently involved in volunteer-oriented Civil Defense, Fire Department, and Red Cross activities. However, since volunteerism has its own limitation, organizations must take into consideration methods to upgrade them to provide quality, nation-wide service in disaster and security areas.

2.4.4. Utility Supply for National Disaster Accident Prevention Act (No. 1506)

The law stipulates provision of minimum living utilities that affect citizens during disasters. This is achieved through the establishment of electricity, fuel gas network, water supply, sewage, and sanitary public service items.

Article 10 stipulates local government or utility (electricity, fuel gas, waterworks, sewage, and other public services such as toilet, etc.) supplier should prevent and react to disasters, as well as make effective evaluation. Risk management for utilities that can affect the people greatly should be carried out during disaster situations at the national level.

1) Results of Review

This law is significant because it systemizes utility suppliers of electricity, gas, waterworks, etc. This law can have profound impact on the lives of people to protect them with risk management measures against disasters.

2.5. Information Communication Related Law

This section discusses two Acts related to the advancement of ICT.

2.5.1. Information and Communication Technologies Act (ICT Act No. 1341)

This law is the foundation of national ICT policy such as Colombia information communication policy and regulation. It is also the foundation for establishing general regulation of ICT field and related government department and organizations (e.g., CRC, MINTIC, SIC).

The Ministry of Information Technologies and Communication (MINTIC) under Act 1341 enacted in Colombia, is the department responsible for the overall communication policy and Information Communication Technology (ICT) industry. MINTIC is in charge of a broad scope of roles such as designing, adopting and promoting of ICT policies, infrastructure, general accessibility, e-government, ICT training, broadband selection, trust and technical issues. One of its main objectives is to increase and facilitate access to citizens, making ICT facilities available to all.

MINTIC is pursuing a digital ecosystem establishment through a mutual reaction between four core elements, i.e., infrastructure, service, user and application, as the so-called 'Plan Vive Digital'. DNP is also in charge of planning, continuance, development and execution of existing policies.

Major basic principles include promotion of access and utilization of ICT, promotion of fair competition, assurance of efficient use of infrastructure and rare communication resources, user rights protection, investment encouragement, technology neutrality assurance, expansion of ICT access rights, assurance of maximization of government's use of ICT in service provision, etc. This law defines the role of government to include network mutual connection and mutual operation assurance, and basic facility connection assurance as special responsibilities of assuring competition, protecting user rights, increasing investment in communication sector, and efficient use of wireless frequency.

Article 50 advocates clear principles to ensure mutual connection. All communication businesses are to follow the principles of accepting mutual connection request on usage and connection of basic facilities and network, prevent non-discrimination, accept cost transparency and cost model, promote fair competition, prevent misuse of authority, and in general not allow mutual connection parties to have harmful effect on the network.

1) Results of Review

Colombia prepared the framework for communication policy and regulation with ICT Act. It is significant in that a broad scope system is systemized for the dispersion and development of ICT.

2.5.2. Outside Plant Routing Rights Regulation

Colombia operates regulations related to outside plant routing rights (RoW)[1] to fortify cooperation with local governments in CRC and MINTIC's construction of communication infrastructure. However, RoW related regulations operated by local government are not mandatory. Therefore CRC encourages policy compliance through management and surveillance on the proceedings of the policy in question.

In 2008, Colombia executed a regulation policy requiring all communication businesses to share their networks and to have 30% excess ducts in their installation as mandatory. Such regulation was implemented on private infrastructure since 2011 but strictly for the outside plant and pole, not including RoW, tower, and energy supply facility.

In June 2013, through discussions with the energy control department, all communication businesses were allowed to use transmission networks outside plant and poles upon infrastructure construction. Meanwhile, a usage fee cap was placed for the facility more than 30% so that the communication businesses could profit from the infrastructure construction.

1) Results of Review

First and foremost, it is proposed that an optical network to be constructed to resolve current fundamental issues of Colombia. This broadband will not only fulfill its original role but also supplement the mobile network. Significant flow of communication traffic is required to construct and operate Smart City Service and IOCC. Korean statistics for this usage in their Smart Cities experience show that communication traffic increases 20-30% every year. Increase in communication traffic inevitably leads to increase in operation and maintenance cost, which is considered a financial burden on the local government.

Therefore, it is imperative that the local government owns optic cable sufficient to take on future communication traffic required for the operation of Smart City Service and IOCC.

2.6. Information Protection Related Law

2.6.1. Personal Information Protection General Regulation Act (No. 1581)

Article 2 deals with sensitive or confidential information in public organizations, such as personal information and hospital records. Article 3 Clause 2 defines 'personal information' as one or more information that can identify a person.

Article 4 stipulates legality of personal information process, purpose of such processing, principle of liberty, accuracy, transparency, access limitation, security and confidentiality as principles for personal information processing. Article 5 requires assurance of preventing misuse of sensitive personal information such as race, ethnicity, political stance, philosophy, religious beliefs, hospital records, or any information that could lead to discrimination, and sensitive information such as labor union, citizen organization, membership, or promotion of political party.

1)RoW(Rights of Way):General regulation that is used internationally for constructing and expanding infrastructure

Article 8 determines the rights of personal information owner. Article 9 refers to permission of personal information owner. Article 10 concerns situations where permission is optional when personal information is required. Article 11 relates to provision of personal information. Article 12 concerns the responsibility to notify personal information owner, and Article 13 defines items regarding people that may provide information.

1) Results of Review

As new types of personal information are created upon operation of Smart City Service and IOCC, a specific definition of personal information defined by the current law is required. Law on personal information control and operation process linked to collection, storage, provision and disposal of such information requires revision. For instance, additional personal information should include personal video information.

2.7. Local Government Governance Related Law

2.7.1. Local Government Organization and Function Modernization Act (No. 1551)

This law is related to local government organization and functions designed to carry out local government responsibilities via an autonomous system.

1) Results of Review

Smart City Service and IOCC are two relatively new concepts to the current government or local government. This new form of citizen service is directly connected to works that are individually controlled by governmental organizations. Therefore, such integrated system requires an organization that is devoted to operating and maintaining the Smart City Service and IOCC. Certain parts of the law require amendments so that these revisions can be connected to existing issues in transportation, security, or disaster management.

2.8. Electricity Supply Improvement Related Law

2.8.1. Electricity Supply Act (No. 143)

Electricity Supply Act regulates general electricity supply system related to distribution of electricity supply and mutual connection.

1) Results of Review

On-site inspections in Villavicencio and Valledupar found that streetlights are on during the daytime as well. The same phenomenon happened in the capital city Bogotá. As such, energy saving measures and efficient management of electricity are required through revision of electricity related laws for electricity commonly consumed in the city, including streetlight. One way to determine success in constructing and operating Smart City is by cutting down operational costs. This allows for more efficient and systematic management where central and local governments can reduce electricity energy consumption.

3. Relevant Policies

Colombia established the National Development Plan (PND, or Plan Nacional de Desarrollo) during the 1st and 2nd Santos government. The plan has an impact on national development policy, security procurement policy, public transportation policy, and digital environment establishment policy.

The new mayor of the target city Valledupar, Augusto Ramírez, proposed measures to address housing issues, security procurement problems, improvement in public transportation, expansion of free Internet, and policies to create new businesses. In comparison, the new mayor of Villavicencio, Wilmar Orlando Barbosa, focused more on social, environmental, economy, and security issues and resolutions in his election policies.

This section reviews the above mentioned Smart City Service provision with a focus on local governments' policies on the current city issues on transportation, security and disaster.

Table IV-2 | Central and Local Government's Policies Related to Smart City

Policy review data		Overseeing organization	Related area	Local government relation
Central government policy	National Development Plan 2010-2014	Central government	Most significant plan	Local government development plan
	National Development Plan 2014-2018	Central government	Most significant plan	Local government development plan
	National Information Communication Technology (ICT) development plan	MINTIC	Communication infrastructure	
	Colombia's frequency distribution and utilization	MINTIC	Communication infrastructure	
	General information, communications, and technologies (ICT) service	MINTIC	Service policy	Local government service
	Information communications service fusion policy	MINTIC	Service fusion	
	Network neutrality policy	MINTIC	Communication policy	
	Peace treaty between Colombia government and FARC	Central government	Security procurement plan	

Policy review data		Overseeing organization	Related area	Local government relation
Valledupar local government policy	Land and housing development policy	Local government	Part of national development plan	Local government revision plan
	Security procurement policy	Local government	Crime prevention	Local government revision plan
	Public transportation system improvement plan	Local government	Transportation environment improvement	Local government revision plan
	Free Internet expansion	Local government	Communication service	Local government revision plan
	Creating new business, attract investment and expand employment	Local government	Creating new business	Local government revision plan
Villavicencio local government policy	Social policy	Local government	Public service improvement	Local government revision plan
	Environment policy	Local government	Environment improvement	Local government revision plan
	Economic policy	Local government	Economic vitalizations	Local government revision plan
	Security policy	Local government	security procurement	Local government revision plan

Source: Compiled by KSP Research Team (2015).

3.1. Central Government Policy

3.1.1. National Development Policy

The four goals of the National Development Plan 2010-2014 (PND 2010-2014) and National Development Plan 2014-2018 (PND 2014-2018) are as follows. First, it is aimed at strengthening security to stabilize the country. Second, it focuses on social development. The third aim is pertaining to vitalizations of local economy for stable and sustainable growth. Finally, the plan creates employment opportunities as an action to eradicate poverty. Realization of Smart City is believed to contribute to achieving vitalizations of local economy for stable and sustainable growth among the above policy goals.

3.1.2. Security Procurement Policy

The Colombian government is currently pursuing a peace treaty to end the civil war with rebel forces (FARC, ELN etc.) that entails terrorism, violence and other security threats. By 2018, it is

envisioned the government plans to add 6,100 CCTVs around the country for citizen safety, led by the Police Department.

3.1.3. Transportation Control Policy

The Colombian government implements a public transportation policy for large cities with population more than 600,000 and mid-sized cities with population of 250,000 to 500,000. Public transportation policy for large cities involves implementing curvy buses that run along central lanes using an integrated public transportation system (SITM). In addition, mid-sized cities are to implement strategic public transportation system (SETP) to expand the supply of general buses. The strategic public transportation system project includes automatic fare payment, bus control, integrated traffic lights control and construction of new bus stations. More specifically, general buses would deploy and operate automatic payment equipment, bus routes would be readjusted, transfer stations would be constructed, roads will be managed, environment friendly and high functioning automobiles will be implemented, central transportation information and control center will be constructed, and road and station infrastructure will be constructed as well. The above strategic public transportation system is in place with priority given to 12 mid-sized cities, including Valledupar and Villavicencio.

3.1.4. Digital Environment Formation Plan

The Colombian government established a nationwide policy to lead the IT industry via a new ICT policy entitled 'Vive Digital Plan 2010-2014'.

The goal of this policy is to create a digital ecosystem through mutual interaction of four core elements, i.e. infrastructure, service, user, and application.

Table IV-3 | Vive Digital Plan 2010-2014 Related to Smart City

Category	Details
Public organization Internet project	National Optic Network Development Plan(goal is to connect 777 local governments in 2013 and 1,078 in 2014)
Colombia e-government project	Implements e-government program to provide online services to the citizens
Vive Digital local project	Assistance program for local city ICT development

Source: Compiled by KSP Research Team (2015).

3.2. Valledupar Policy

There are five Smart City Service policies proposed by the new mayor of Valledupar, Augusto Ramírez, which are relevant and significant to this study. These are land and housing development policy, security procurement policy, public transportation system improvement policy, free Internet expansion and electricity cut back; and finally, creating new businesses, attracting investment and expanding employment policy.

3.2.1. Land and Housing Development Policy

As part of the National Development Plan 2014-2018 (PND 2014-2018), the central government is currently carrying out the Micro Project, actively supported by local governments. The new mayor made officially established promotion plan for developing land and housing for the poor for the next four years.

3.2.2. Security Procurement Plan

School education courses are set up to prevent domestic crime, such as pickpocketing, theft and robbery and violent acts. Technical facility to reduce crossroads pickpocketing and homicide can be enhanced when there is solidarity among the local community in daily activities.

3.2.3. Public Transportation System Improvement Plan

Valledupar has established a STEP plan abiding by the central government policy and is preparing a public transportation system improvement project. Local government seeks to improve city mobility through realizing a strategic public transportation system to make the plan more achievable. There are also plans to design a crossroad in two chronically congested areas.

3.2.4. Improved Education and Dispersion of Free Internet

Improvement in providing free access to Internet will encourage active use of information communication technology, which will in turn improve the quality of education. Hence, allowing free Internet connection in symbolic areas and vulnerable areas of the city is a strategic plan that should be followed through.

3.2.5. Creating New Business, Attracting Investment, and Expanding Employment

This strategy aims to achieve plan adjustment and economic development through a planning advice office. Besides, it also establishes strategies for entrepreneurship and fortification of education to develop new projects.

This strategy improves working conditions, attracts more domestic and foreign investment, and expands employment opportunities. Valledupar seeks to acquire competitiveness by attracting sustainable investment and expanding employment.

3.2.6. Results of Review

Valledupar is located at the geographical center of warehouse and distribution, with an airport to the south of the city and highways linking the north and south of the city. This strategic location makes it an ideal hub city that connects well to nearby cities. It is also a tourist city with the famed Vallenato Legend Festival every April, attracting more than 150,000 people each year.

However, this rapid growth and massive influx of population and urbanization brought on various security threats caused by transportation problem that hinders the city's growth. It is anticipated that once the chronic transportation congestion is relieved and city security is procured through

Smart City, private business investment will increase and employment expansion will follow.

3.3. Villavicencio Policy

In relation to Villavicencio's Smart City Service, Mayor Wilmar Orlando Barbosa has promised a four-fold policy related to the Smart City Service. The policy plans are to first, improve electricity security procurement; second, improve transportation environment to procure mobility; third, create more jobs in education and health areas; fourth, provide better public service.

3.3.1. Social Policy

Social policies include resolving housing issue, improving health program and social welfare, assisting cultural activities, assisting sports and leisure recreational activities, and improving public service. As part of the National Development Plan 2014-2018 (PND 2014-2018), the central government is engaging local governments to actively assist the Micro Project plan to resolve housing issue.

3.3.2. Environment Policy

The purpose of environment policy is to create general city pollution alleviation plan, housing environment improvement plan through land utilization plan, disaster prevention environment improvement through disaster prevention and improved control.

3.3.3. Economic Policy

The economic policy of Villavicencio includes improving mobility through road, facility and system enhancement as well as road safety and public transportation vitalizations. Villavicencio has implemented central government policy and established a public transportation service (STEP) plan. It is preparing a public transportation system improvement project. Highway that connects Villavicencio and Bogotá allowing for a greater number of loaded trucks for petroleum to pass through the city center on this highway, are causing serious traffic congestion. Local government is trying to resolve this problem by establishing plans to construct outer city bypass road.

There is also a plan to assist prospective working generation in agriculture and tourism industry to create more job opportunities. The city intends to form a sustainable city infrastructure by attracting investment, expand employment, and create new jobs.

3.3.4. Security Policy

The purpose of security policy includes procuring public safety and facility maintenance, adding security facility (CCTV, etc.), improving local community participation, and fortifying policy.

3.3.5. Results of Review

In conclusion, both Valledupar and Villavicencio are rapid emerging cities located at the center of economic activities. The rapid urbanization process has caused various security and transportation problems due to the influx of population that hinders city development, and causes massive traffic

and serious city traffic congestion. Establishing a Smart City with a center control facility is capable of resolving these cities' chronic urban development problems, to enable increase in investment and improvement in lives of its citizens.

V Case Studies

1. Outline

Regarding transportation, severe problems of illegal parking that cause traffic congestion can be resolved by installing traffic control CCTVs and speakers on the roads. These facilities can be effectively controlled from the IOCC, which will send out announcements traffic police dispatches to forbid illegal parking and resolve traffic problems. Crime can be also reduced by installing CCTV systems in crime prone or crime ridden places to detect crimes and arrest criminals. Futhermore, the fact that there is a CCTV system may warn off prospective criminals, thus helping the city to achieve the effect of Crime Prevention Through Environmental Design (CPTED). In terms of disaster control, various detection sensors will allow preliminary detection of disaster. Especially, sensors will accurately recognize the situation and evacuate citizens to minimize damage to human lives and property.

In this sense, the proposed IOCC and is expected to resolve current city problems of transportation, security, and disaster control, while also providing feasible solutions and technologies for city development. Particularly, real time data from connected devices of the IOCC will help quick and accurate decision making and response. When necessary, real time conveyance of critical data to related organizations will also be possible. In surveys conducted, respondents of both cities felt related organizations should have more cooperation with one another; this is mentioned both as a problem and a need for improvement.

IOCC is therefore proposed as a solution that can solve many emergent urban problems with minimum manpower through Smart City Service. With this in mind, the KSP Team aims to provide related solutions for IOCC to resolve current city issues based on experience and knowledge gained from literature review, site visits and observations, research methods as well as comparative city case analysis of smart city establishments in both developing countries and developed nations.

Exemplary Korean and Paraguayan cases are selected and analyzed for this project. So that Valledupar and Villavicencio can benchmark these success factors when adopting Smart City service and constructing the IOCC. It is difficult to identify one particular Korean city that has high level of resemblance with both target cities in all aspects such as area, population, industry structure, and climate. Hence, for the purpose of comparison, several cities were picked because they can partially

fit into modelling urbanization issues such as transportation, security, disasters, and environment problems facing the target cities.

1.1. Case Selection Criteria

There are two categories of Smart City. First, it can be regarded as a new city type Smart City if state-of-the-art facilities are implemented on a newly structured city such as Songdo, Incheon Free Economic Zone (IFEZ) in Korea. Second, it is called as an existing city type Smart City if advanced facilities are implemented on the existing city. This study focuses on the second category as both target cities are not new towns, but intend to transform their existing urban areas into Smart Cities based on ICT services.

In addition, to have an objective view, various other factors were took into consideration as mentioned in Table V-1. As a result, two Korean cases and one Paraguyan case were selected as the most appropriate cases that fit to compare with the target cities.

Table V-1 | Case Selection Criteria

Category	Korea 1 Gwanak-gu	Korea 2 Gwangyang-si	Asunción
Government model case award status	●	●	
City scope similarity status (Central city area scope)	(●)	●	●
Population scope similarity status	●		●
Over-population status	●		●
City and country complex city status (similarities in industry structure)		●	●

Source: Compiled by KSP Research Team (2015).

2. Korean Cases

As appropriate cases for target city environment, KSP Team of Gwanak District (Gwanak-gu) of Seoul, Korea's capital city, and Gwangyang City (Gwangyang-si), in South Jeolla Province (Jeollanam-do), because their area and population is similar to those of target cities. General status, center information, major performance, and success factors were reviewed in this part.

2.1. Gwanak-gu IOCC

2.1.1. General Status

Gwanak-gu has the area of 29.57 km² (4.9% of the whole Seoul city of 605.18km²) with 510,000 population, whereas the city area of Valledupar and Villavicencio are 38.29 km² and 28.6 km² respectively, and population 453,215 and 484,429 respectively. In other words, they are both very similar to Gwanak-gu in terms of city area and population density.

Table V-2 | General Information of Gwanak-gu

Category	Details	City Map
Area	• 29.57km²	
Administrative divisions	• 21 neighborhoods	
Population	• 513,186 (2014)	
Households	• 248,180 households (2014)	
Website	• www.gwanak.go.kr	

Source: Gwanak-gu Official Website.

2.1.2. Center Information

Gwanak-gu IOCC utilized a public building due to initial project plan and budget procurement issues. The 1st and 2nd floors are respectively used as library and welfare center, whereas the 3rd and 4th floors are both used as the IOCC. The control center is a relatively small one of 271.3m² and the detailed structure is as follows.

Table V-3 | Floor Area of Gwanak-gu IOCC

Floor	Area	Integrated Control Room	Meeting Room	Information Communication Room	Lounge, and other
3rd	148.5m²	90.2m²	23.3m²	-	35m²
4th	122.8m²	32.4m²	-	55.5m²	34.9m²

Source: Gwanak-gu Budget Computerization and Integrated Control Team, Sep 2015.

Figure V-1 | Gwanak-gu IOCC



Integrated Monitoring Room



Bird's-eye view

Source: Gwanak-gu Promotion Computerization Integrated Control Team (Sep 2015).

The operation of this center is run by 3 civil servants, 4 police officers, 1 maintenance worker and 12 monitoring personnel who work on the basis of two shifts per day. Currently, the Gwanak-gu Office operates control personnel through a service agency. However, the center plans to create more full time positions to enhance the of IOCC officers, who are the lookouts of the citizen's assets and safety.

Table V-4 | Operating Status of Gwanak-gu IOCC

Title	Organization	Personnel	Note
Civil servants	PR Computerization Department	1	• Manages maintenance and repair personnel
		1	• Manages controllers
	Transportation Training Department	1	• Operates illegal parking control system
Maintenance and Repair	Service Agency	1	• Maintenance and repair work
Controller	Service Agency	12	• 4 people, 1 group, 2 shifts/day
Police Department	Gwanak Police Department	4	• 1 person, 1 group, 2 shifts/day

Source: Gwanak-gu Promotion Computerization and Integrated Control Team (Sep 2015).

Table V-5 | Gwanak-gu IOCC's CCTV by Purpose

Service type	Details of the service and targetarea
Crime prevention	• Child protection, crime prevention
Intelligence	• Intelligent crime prevention and automobile tracking
Traffic control	• Illegal parking
Parking control	• Parking lot control, green parking
Environment control	• Unauthorized trash disposal
Facility control	• Office and park management
Cultural asset control	• Cultural asset protection
Disaster control	• Mountain fire surveillance, Prevent water disaster (flooding, overflow, etc.)
Multi-purpose service	• Multipurpose including crime prevention, traffic control, and nvironment protection

Source: Gwanak-gu Promotion Computerization and Integrated Control Team (Sep 2015).

There are 1,629 CCTV cameras in 931 regions and they are all connected through self-network.

Table V-6 | CCTV Operating Status of Gwanak-gu IOCC

Camera purpose	Number of sites	Cameras	Note
Park management	146	146	Facility management
Child protection	43	63	Crime prevention
Multi-purpose	294	339	Multi-purpose
Green parking	62	78	Facility management
Intelligent crime prevention	52	234	Intelligence type
Mobile police crime prevention	28	28	Crime prevention
Parking lot management	22	242	Facility management
Illegal parking	44	174	Illegal parking
Crime prevention (security)	156	203	Crime prevention
Around schools	24	56	Crime prevention
Unauthorized trash disposal	54	54	Environment control
Cultural asset protection	1	1	Facility management
Prevent water disaster	1	1	Disaster control
Town landscape	4	10	Facility management
Total	931	1,629	

Source: Gwanak-gu Promotion Computerization and Integrated Control Team (Sep 2015).

2.1.3. Major Achievements

Gwanak-gu IOCC has adopted different types of control system, system since 2012. They were designed to find out whether automobiles are violating parking regulations. With the effort, Gwanak-gu became the first city in Korea to implement intelligence system to curb illegal parking. It achieved 100,000 control performances during the period of 3 years, earning about 4.5 billion won in local tax revenue.

Table V-7 | Illegal Parking and Stop Detection Performance of Gwanak-gu IOCC

Control Year	Manual Control(*)		Manual +Automatic Control(**)		Automatic Control(***)	
	Number of control cases	Fine (1,000won)	Number of control cases	Fine (1,000won)	Number of control cases	Fine (1,000won)
2012	5,233	210,290	20,854	840,680	15,621	630,390
2013	5,605	226,275	15,546	625,700	9,941	399,425
2014	4,038	163,340	17,251	693,000	13,213	529,660
Total	14,876	599,905	53,651	2,159,380	38,775	1,559,475

* : Number of manual control cases (Multi-purpose CCTV)

** : Number of manual + automatic control cases (Multi-purpose CCTV + Illegal parking CCTV)

*** : Number of automatic control cases (Illegal parking CCTV)

Source: Gwanak-gu Promotion Computerization and Integrated Control Team (Sep 2015).

Besides, with the video information collected by Gwanak-gu IOCC, the police managed to reduce some of the city security problems. In the last 2 years, 1,242 cases provided video information upon police's request to assist in investigation and crime monitoring, of which 48 cases were solved. In addition, 21,321 illegal parking cases, 20,367 unauthorized disposal control cases, and 3 facility damage cases were detected. As a result, a total of 42,981 crime cases were resolved, contributing to the reduction of police manpower and subsequent cost cutting, citizen convenience, and safety protection. Detailed performances are shown below.

Table V-8 | Illegal Activity Surveillance Performance of Gwanak-gu IOCC

Control Year	Video provision	Video control	Control		Facility damage	Total
			Illegal parking	Unauthorized disposal		
2011	381	1	1,957	4,446	-	6,785
2012	861	47	19,364	15,921	3	36,196
Total	1,242	48	21,321	20,367	3	42,981

Source: Gwanak-gu Promotion Computerization and Integrated Control Team (Sep 2015).

The table below also shows crime control performance with the help of CCTV video information.

Table V-9 | Crime Detection Performance of Gwanak-gu IOCC (First half of 2015)

Category		Jan	Feb	Mar	Apr	May	Jun	Total
Homicide	Provision	-	-	1	-	1	1	3
	Control	-	-	-	-	-	-	-
Theft	Provision	1	2	1	2	2	3	11
	Control	-	-	-	-	-	-	-
Rape	Provision	1	1	1	-	1	1	5
	Control	-	-	-	-	-	-	-
Robbery	Provision	7	9	30	15	13	15	89
	Control	-	-	-	1	1	-	2
Violence	Provision	2	5	5	7	12	15	46
	Control	1	1	2	4	8	20	36
Etc.	Provision	13	10	20	15	15	20	93
	Control	7	4	1	3	10	14	39
Total	Provision	24	27	58	39	44	55	247
	Control	8	5	3	8	19	34	77

Source: Gwanak-gu Promotion Computerization and Integrated Control Team (Sep 2015).

2.1.4. Success Factors

There are three success factors of Gwanak-gu IOCC. First, The Chief of Gwanak-gu Office and other civil servants were highly motivated to promote the IOCC. This initiative was reflected in the active participation of the Office in the pilot projects of the central government related to Smart City. Second, organizations with diverse functions were integrated according to space and function. This is to minimize manpower and operational cost, while maximizing integration control effect. Optic communication network between site equipements and the IOCC was constructed at the initial stage of IOCC establishment to minimize constant operation costs, including communication bill. Finally, procurement budget from municipal government and manpower designation for continuous center operation are crucial. It is noted that stable operation can be managed through solution development, facility expansion, and swift repair.

2.2. Gwangyang-si Integrated Operations Control Cente

2.2.1. General State

Gwangyang-si's area is 458.89km² (75.8% of Seoul city area of 605.18km²) and the population is 150,000. In comparison, Valledupar and Villavicencio areas are 4,264 km² (38.29 km²) and 1,300 km² (city center 28.6 km²) respectively, where a population of 453,215 and 484,429 respectively. No Korean cities are exactly comparable with the two target cities. However, in terms of its status as a city-county complex city, Gwangyang-si is considered as a good example.

Table V-10 | General Information of Gwangyang-si

Category	Details	City Map
Area	• 458.89km²	
Administrative divisions	• 5 districts, 10 neighborhoods	
Population	• 153,233 (2014)	
Household	• 58,223 households (2014)	
Website	• www.gwangyang.go.kr	

Source: Gwangyang-si Official Website.

2.2.2. Center Status

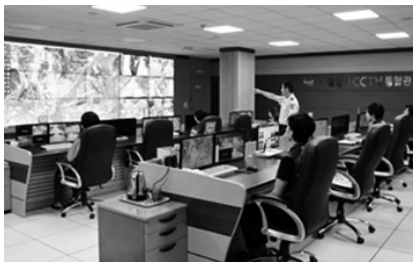
Gwangyang-si constructed a new building to operate the IOCC and it is a medium-sized center (689.53m²). Details of the composition are as follows.

Table V-11 | Floor Area of Gwangyang-si IOCC

Floor	Total area	Integrated Control Room	Meeting Room	Facility Room	Operation Room	Lounge
1st	689.5m²	150m²	100m²	40m²	30m²	369.5m²

Source: Gwangyang-si Official Safety Department (Jun 2015).

Figure V-2 | Gwangyang-si IOCC



Integrated Monitoring Room



Operation Control Board

Source: Gwangyang-si Official Safety Department (Jun 2015).

The Center is operated with 2 policemen and 21 monitoring control personnel on the basis of 3 shifts. Currently due to budget constraint, City Hall operates the control personnel through service agency. However, they intend to hire additional officers (full time) to make them more responsible for securing the citizen's assets and safety.

Table V-12 | Operating Status of Gwangyang-si IOCC

Category	Personnel	Work type	Note
Police civil servants	2	Shifts	• Control time : 24 hours • Control/person : 130 units
Control personnel	21	4 groups 3 shifts	

Source: Gwangyang-si Official Safety Department (Jun 2015).

1) Operational Service

Table V-13 | Gwangyang-si IOCC's CCTV by Purpose

Category	Service type	Service details and target area	Note
System Integration Service	Crime prevention	• Recognize license plate, everyday life crime prevention, adolescent crime-prone zone	-
	Child Safety Keeper	• Park, children protection area	-
	Environment surveillance	• Trash disposal surveillance	-
	Transportation control	• Traffic safety	-
System Connection Service	Transportation control	• Illegal parking	-
	Disaster control	• Disaster surveillance	In connection with general safety

Category	Service type	Service details and target area	Note
System Connection Service	Fire control	• Mountain fire surveillance	In connection with mountains
	Child Keeper	• Children in school grounds surveillance	In connection with elementary schools

Source: Gwangyang-si Official Safety Department (Jun 2015).

2) On-Site Facility Status

Gwangyang-si IOCC currently operates and manages 651 CCTVs, inclusive of 458 operated by the city and 193 by the elementary schools.

Table V-14 | CCTV Operating Status of Gwangyang-si IOCC

CCTV Purpose	Number of CCTV	Related Department
Crime prevention	129	• Police station, General affairs admin. department
Child safety	174	• Social welfare department, Traffic department
Garbage disposal monitoring	17	• Environmental department
Illegal parking	66	• Traffic department
Facility managment	23	• Environmental/Sports/Tourism/Citizen's life support department
Disaster monitoring	9	• Safety total management
Traffic safety	32	• Facility management department
Forest fire surveillance	8	• Mountains management department
Children's guard	193	• Elementary school
Total	651	

2.2.3. Major Achievements

1) Operation Performance

Gwangyang-si IOCC supported crime investigation with 821 CCTV video information viewing, 653 video information provisions to the police for the past 3 years. 318 crime attempts were prevented through CCTV video control.

Table V-15 | Crime Investigation Support Performance of Gwangyang-si IOCC

Category / Month	Number of CCTV video provisions			Prevention	Video control
	Total	View	Provision		
2013	380	234	146	154	83
2014	690	352	338	84	191
2015 first half	404	235	169	80	163
Total	1,474	821	653	318	437

Source: Gwangyang-si Official Safety Department (Jun 2015).

2) Arrests

City problems are resolved by cooperating with the police with the video information collected through Gwangyang-si IOCC. In the first half of 2015, theft, hit and run, rape, and robbery were reprimanded through cooperation with the police; and crimes such as automobile theft, car accident, theft, etc., were resolved through real time control. Through CCTV video control, Gwangyang-si helped in reducing the police manpower, enhancing citizen convenience and safety measures. Detailed performance is shown below.

Table V-16 | Crime Detection Performance of Gwangyang-si IOCC(First Half of 2015)

Arrests				Real time control		
Theft	Hit and run	Rape	Robbery	Car theft	Car accidents	Theft
1	1	1	1	1	1	1

Source: Gwangyang-si Official Safety Department (Jun 2015).

2.2.4. Success Factors

There are three noticeable success factors of Gwangyang-si IOCC. First, seeking measures to minimize operation cost; second, continuous maintenance of integrated control facility; and third, cooperation system between related organizations and departments.

1) Minimization of Operation Costs

The existing system consists of many departments (transportation, security, environment, disaster etc.) integrated in terms of event measurement in organizational, spatial, functional aspects to maximize the effects of integrated control.

2) Continuous Maintenance

City allocation budget enables manpower assignment for continuous operation of the center. This stable operation was further enhanced through solution development, facility addition, and swift repair work.

3) Connections and Cooperation System with Related Organizations

Gwangyang-si Office's connection with the police in the IOCC operation agreement led to the construction of quick and accurate cooperation system. Swift measurement system between police, fire department and other related organizations was created. The internal cooperation system between City Hall departments worked effectively for crime prevention, transportation, disaster, etc.

3. Paraguayan Case

Paraguay Asuncion Advanced Traffic Management System (ATMS) Construction Project was selected as the only foreign case that provides insights to Smart City conceptualization of the target cities.

3.1. Paraguay Asuncion Advanced Traffic Management System (ATMS) Construction Project

3.1.1. General Status

Asuncion, the capital city of Paraguay has an area of 117km². It is an administration and residential city with population of 710,000, similar to the size of Villavicencio. Main roads spread out from the city center, CENTRO with residential areas focused in the suburbs, which cause serious traffic congestion during rush hours.

Table V-17 | General Information of Asuncion

Category	Details	City Map
Area	• 117 km²	
Administration district	• 6 administration districts	
Population	• 714,267 (2010)	
Climate	• Yearly average temperature 23.3	
Precipitation	• Yearly precipitation 1,400mm	
Website	• www.mca.gov.py	

Source: Asuncion City Official Website

3.1.2. Road Status and Problems

Paraguay Asuncion transportation issues persist due to lack of road supply and transportation operation management system, irrational signal operation system, lack of citizen's transportation awareness, etc.

Table V-18 | Transportation Problems of Asuncion in the Past (2014)

Category	Problem	Solution
Road and attached facilities	• Lack of road supply • Decrease in speed and capacity due to damaged road • Poor maintenance of traffic lights and median strip	• Collect and provide real time transportation information • Provision of transportation information and bypass road • Remote monitoring of operation status
Transportation operation management system	• Lack of transportation management system • Repeated congestion due to focused traffic	• Collect communication information on major roads • Real time traffic demand management
Signal operation system	• Irrational signal operation system • Changes in traffic amount not reflected • No coupling operation between nearby crossroads • Increase in congestion due to lack of left turn capacity • Different signal term system of each crossroad • Lack of traffic light legibility • Various producers and outdated facilities	• Construct online traffic signal control system • Research traffic, operate signal for each crossroad Establish parameter, improve display • Establish TOD Plan for each crossroad
Traffic culture	• Poor yield attitude, frequent jay walking	• Implement traffic culture improvement campaign

Source: Paraguay Asuncion ATMS Construction Project Enforcement Design Report, KOICA, 2014.

3.1.3. Subject Roads

Paraguay Asuncion roads are spread out in 6X5 forms in a CBD (Central Project District) focused structure. Subject of the state-of-the-art transportation management system construction consists of major roads of Asuncion city, M.cal. Lopez and 7 more roads, with a total length of 37.6 km.

Figure V-3 | Roads Managed by Traffic Control System in Asuncion



Road name	Extension (Km)	Number of lanes
M.cal. Lopez	8.3	4 lane road
Espana	5.4	2 lane road
Del Chaco	2.9	4 lane road
Transchaco	4.7	6 lane road
Artigas	5.7	4 lane road
Felix bogodo	3.4	4 lane road
F.do de la Mora	4.7	4 lane road
Peru	2.5	4 lane road
Total	37.6	

Source: Paraguay Asuncion ATMS Construction Project Enforcement Design Report, KOICA, 2014.

3.2. Center Status

3.2.1. Center Scope

The exact location of the center is Av. Costanera, Asuncion, with a scope of 293.65 . The center includes the 1st and 2nd above ground floors, and the integrated control room is in a multi-stage structure.

Table V-19 | Floor Area of Traffic Control Center in Asuncion

Category	Area	Integrated Control Room	Equipment Room	Meeting Room	Etc.
1st floor	293.65m²	150m²	45.6m²	-	98.05m²
2nd floor	225.10m²		-	26m²	49.1m²

Source: Asuncion City Hall (Oct 2014).

Figure V-4 | Asuncion ATMS Traffic Control Center



Transportation Control Center Monitoring Room



Transportation Control Center Exterior

Source: Compiled by KSP Research Team (2015).

3.2.2. Center Operation Organization

Transportation Control Center is operated with 13 City Hall civil servants, one maintenance personnel and 9 monitoring control personnel who work in 1 group 3-shift system.

Table V-20 | Operating Status of Traffic Control Center in Asuncion

Service Type	Service details and subject area	Applied facility
Transportation information collection	• Transportation communication information and road video information collection service	CCTV, VDS
Transportation information processing	• Traffic signal control and repeated congestion management service	DB Server
Transportation information provision	• Accident occurrence information, road control information service	VMS, WEB

Source: Asuncion City Hall (Sep 2015).

3.2.3. Operational Service

Asuncion ATMS provides services to disseminate and manage transportation communication information via CCTV, VDS, DB Server, VMS and websites.

Table V-21 | Services of Traffic Control Center in Asuncion

Category		Unit	Construction quantity	Note
On site facility	TSCS	Crossroad	78	Signal controller+traffic light
	CCTV	Set	5	Pole height : 15M
	VDS	Set	24	Radar detector
	VMS	Set	6	12x16 rows, 8x12 rows
Total			113	

Source: Paraguay Asuncion ATMS Construction Project Enforcement Design Report, KOICA (2014).

3.2.4. Site Equipment Status

Paraguay Asuncion currently (as of September 2015) operates traffic signal controllers (TSCS), 5 CCTVs, 24 VDS and 1 VMS in 78 crossroads.

Table V-22 | Equipment Operating Status of Traffic Control Center in Asuncion

Category		Unit	Construction quantity	Note
On site facility	TSCS	Crossroad	78	Signal controller+traffic light
	CCTV	Set	5	Pole height : 15M
	VDS	Set	24	Radar detector
	VMS	Set	6	12x16 rows, 8x12 rows
Total			113	

Source: Paraguay Asuncion ATMS Construction Project Construction Supervision Report, KOICA, Mar 2015.

Figure V-5 | Asuncion ATMS Site Equipment



Traffic Signal Controller (TSCS)



Automobile Detector (VDS)



Variable Electric Sign (VMS)



Transportation Information Collection Camera (CCTV)

Source: Paraguay Asuncion ATMS Construction Project Construction Gallery, KOICA (Mar 2015).

3.3. Major Achievements

Post-evaluation of Paraguay Asuncion ATMS showed that the major roads that installed the service experienced 10-40% improvement of average speed.

Table V-23 | Improvement in Average Speed to Pass through Road in Asuncion

Subject road	Time	Road direction	Before system construction	After system construction	Improvement
Av. Espana	Morning	City-Suburb	19min 48sec	16min 39sec	119.02%
		Suburb-City	37min 00sec	32min 27sec	114.02%
	Afternoon	City-Suburb	51min 59sec	43min 53sec	118.46%
		Suburb-City	26min 01sec	23min 04sec	112.79%
M.cal. Lopez	Morning	City-Suburb	30min 20sec	18min 09sec	167.13%
		Suburb-City	43min 26sec	22min 10sec	195.94%
	Afternoon	City-Suburb	36min 59sec	24min 05sec	153.56%
		Suburb-City	31min 43sec	21min 41sec	146.27%

Subject road	Time	Road direction	Before system construction	After system construction	Improvement
Eusebio Ayala	Morning	City-Suburb	22min 15sec	18min 37sec	119.52%
		Suburb-City	26min 06sec	18min 20sec	142.36%
	Afternoon	City-Suburb	35min 32sec	26min 09sec	135.88%
		Suburb-City	22min 13sec	17min 23sec	127.80%
Fernando de la Mora	Morning	City-Suburb	24min 46sec	18min 37sec	133.03%
		Suburb-City	31min 53sec	19min 38sec	162.39%
	Afternoon	City-Suburb	32min 59sec	19min 42sec	167.43%
		Suburb-City	18min 42sec	16min 44sec	111.75%

Source: Paraguay Asuncion ATMS Construction Project Post-evaluation, KOICA (Sep 2015).

City aesthetics and visibility procurement, pedestrian safety, crossroad structure improvement and other improvements have been improved in city transportation.

Table V-24 | Improvement Effect of Asuncion's ATMS

Category	Before	After
City aesthetics and visibility		
Pedestrian safety		
Crossroads improvement		

Source: Paraguay Asuncion ATMS Construction Project Construction Gallery, 2015, KOICA.

3.4. Success Factors

Success factors of advanced transportation management system ATMS implemented in Asuncion, Paraguay, are analyzed to predict and eliminate possible implications for target cities to resolve transportation problems.

Table V-25 | Success Factors of Traffic Control Center Project in Asuncion

Item	Success Factors	Implications
City Hall's Active assistance	• Quick decision making of the city on determining person in charge, center site, additional budget input, etc. • Abide by construction schedule through quick work consultation with related organizations	• Active cooperation from City Hall and related organizations
Implement state of the art IT technology	• Minimize trial and error through implementation of certified IT technology • Maximize the credibility and utilization of transportation information by connecting with IT technology based automation system	• Implement certified technology • Need to implement IOCC for system connection
Input of professional consultant	• Conduct Project Management by inputting IT experts in each field of design/construction/supervision	• Designate professional consultant for project management
Technology transfer/ training	• Conduct technology transfer by inputting local manpower from the initial project stage • Provide all data in local language • Conduct regular technology seminar and training	• Requires technology transfer/training to ensure project continuity after the construction

Source: Compiled by KSP Research Team (2015).

3.5. Analysis of Findings

Asuncion is a Latin American city, similar to the two target cities in terms of city area and population. In the past, Asuncion faced similar transportation problems of excessive traffic, road infrastructure, irrational signals, illegal parking, lack of transportation infrastructure, etc. Hence, the city of Asuncion implemented a project for an advanced transportation system to resolve such transportation issues and successfully executed the above project.

Through this project, traffic was controlled through real time signal control while transportation information was collected and analyzed with detectors and CCTVs to improve the traffic speed about 10-40%. In this case, it was realized that IOCC must work as an integrated operation system, instead of individual operation system, in order to further enhance connection, sharing, and utilization of transportation information.

Other success factors that are imperative in the execution of the project are active assistance of City Hall, implementation of certified technology, input of experts, and assuring project continuity through technology transfer and training.

4. Comparison with Two Municipalities

Two Korean cases, i.e. Gwanak-gu and Gwangyang-si IOCCs, have greatly contributed to prevent crime in everyday life such as robbery, violence, trash disposal, disaster prevention, car theft, tax evasion automobiles etc. It protects citizen lives and assets through tracking and arresting criminals.

The case of Asuncion in Paraguay shows how the construction of ATMS and operation of Traffic Control Center worked in resolving the common transportation problem of Latin American cities. The integrated system helped to curb issues related to increase in traffic, lack of roads, irrational signal system, illegal parking, and lack of transportation infrastructure.

Korean and Paraguayan success cases show that in the construction, preparation and execution stage of Smart City, the will and drive of final decision makers, dedication of civil servants in charge, and personnel with expertise who can execute thorough preliminary preparation and implementation of certified ICT technology are critical factors of success.

Table V-26 | Critical Success Factors of Korean and Paraguayan IOCC Projects

Category		Korean cases		Foreign case
		Gwanak-gu	Gwangyang-si	Paraguay
Preparation and initiation	• Strong will and drive of the mayor	●	●	●
	• Dedication of civil servant in charge and self-help endeavor	●	●	●
	• Thorough preparation and implementation of certified ICT technology	●	●	●
Construction operation	• Connection and cooperation with related organization	●	●	●
	• Fortification of cooperation system	◑	◑	◑
	• Cut maintenance cost with low-power facility	●	●	◑
	• Construction of self information communication network	●	△	●
	• Obtain future expandability	●	●	●
Maintenance	• Minimization of operation cost	●	●	◑
	• Continuous training	●	●	●
	• Continuous maintenance	●	●	◑
	• Operation management technology transfer training	●	●	●
	• Acquire professional maintenance personnel	●	●	◑
Others	• Additional obtainments of local government tax revenue	●	△	△

Source: Compiled by KSP Research Team (2015).

Success cases in construction operation stage involve factors of connection and cooperation with related organizations, strong cooperation system, cutting maintenance costs with low-power facility, establishing self-information communication network, and procuring future expandability.

Ⅵ Proposal for Smart City

Establishing a Smart City means developing an intelligent and sustainable city to manage urban development and ease the challenges that come with development. This is particularly needed in emerging cities like Valledupar and Villavicencio that faced additional challenges, obstacles, and problems with unplanned population influx and inadequate city infrastructure.

In this chapter, the KSP research team will propose and strategize the smart city transformations of Valledupar and Villavicencio based on these phases: 1) provide a rationale for Smart City necessity supported by a status assessment of major issues and recommendations; 2) describe Smart City execution plan and implementation by outlining service selection, standards, and construction priorities; and 3) define Smart City establishment via its service, IOCC, and communication network infrastructure. The execution of each phase toward Smart City establishment and transformation is closely linked, and is influenced by many factors, priorities, and criteria that need to be first identified and described fully.

1. Necessity for Smart City

1.1. Major Issues

From August 2015 to September 2015, the research team conducted site visits to related organizations of the two selected target cities. The team also conducted interviews with persons in charge to identify and discussed in detail some of the critical factors that hindered city development, namely transportation, security, and disaster.

The top priority area that should be reviewed was security. The Police Department was in charge of security, but overall poor management and lack of maintenance had caused the existing CCTV system to be inoperable. Currently, a CCTV replacement and improvement project was underway under the target city police's lead, supported by the Colombian government's funding.

For transportation, city residents often encountered severe congestion during rush hours in major roads that flowed into the city center; additionally, traffic at major circular crossroads was particularly bad since automobile influx exceeded road capacity. The influx was controlled with traffic lights but the effect was minimal since the traffic signal system in place was outdated and

system non-functionality was caused by suspension of its maintenance. Integration of new and old signal controllers and implementation of a system required for collecting, processing, and providing transportation information were also in dire need.

As for disaster control, City Hall was operating a department to control disaster situations, but these authorities were lacking in facility and manpower. The local government needed to quickly establish better infrastructure and response systems required to connect with related service organization regarding action plans for improved disaster prevention, control, and management.

In conclusion, it seems that implementation and construction of city level IOCC that can make integrated control of various events in the city would be the solution for a systematic city management, prevention of overlapping system investment, and efficient future operation and maintenance.

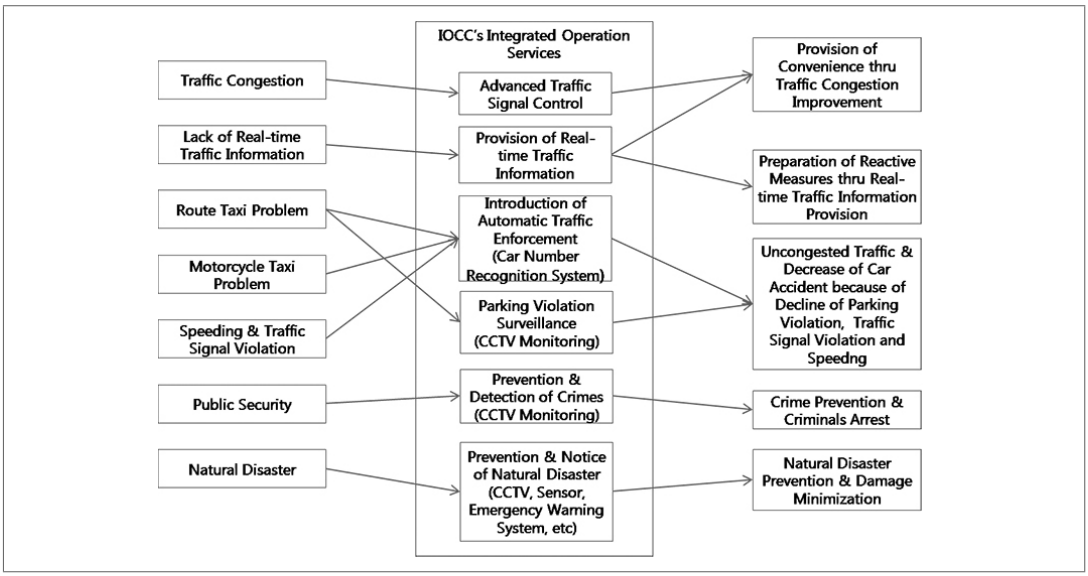
Table VI-1 | Major Issues and Required Solutions

Issue	Problems Identified	Needs and Solutions
Transportation	• Traffic congestion in city center's main roads • Congestion caused by insufficient roads and circular crossroad capacity • Dated traffic signal system currently under operation and lack of connectivity • Sudden increase in accidents caused by rise in number of illegal motorcycle taxis	• Implement real time transportation control system • Improve transportation system management for road and crossroad linear expansion • Improve traffic signal control system (TSCS) that allows real time control needs to be implemented • Expand public transportation (bus) services (improved reliability); eliminate illegal public transport services
Security	• Increased violent crimes such as homicide, theft, domestic violence. • Dated CCTV incapable of operation • Need to increase security in crime ridden areas • Need to improve surveillance with more operators	• Utilize information communication technology to implement security system for receiving report, dispatch, and enable prompt response • Replace dated system and provide new installation • Install CCTVs in crime ridden areas • Review intelligent CCTV solution such as motion detection, sound detection, alarm connection, etc.
Disaster	• Flooding of river areas during wet season • No dispersion of disaster situation • Poor connection and response system between related public service organizations	• Construct disaster DB to predict disaster and disperse situations • Transmit real time information via smart phone, Internet, etc. • Promptly share information with related organizations on disaster situation

Source: Compiled by KSP Research Team (2015).

The table summarizes the problems identified in each issue mentioned by city residents. The research team then drew implications of the needs and solutions to resolve the problems mentioned. Some solutions were derived from interviewees' responses; solutions were also based on analysis of the situations, knowledge of similar problems faced in urban development, and a review of best practices benchmarked in developing countries with Smart City solutions like Korea.

Figure VI-1 | IOCC: Solutions for Current Urban Issues



Source: Compiled by KSP Research Team (2015)

1.2. SWOT Analysis

In many new projects, a SWOT (Strengths, Weaknesses, Opportunities and Threats) analysis is particularly useful and strategic to recognize the gap between the current state and desired status, and to identify existing resources and prerequisites needed for improvement and transformation. For this project, the team conducted a SWOT analysis on the target cities targeted for Smart City execution using tools that included literature reviews, site research, visits to organizations, interviews and surveys.

Table VI-2 | SWOT Analysis For Smart City Implementation

• Well organized government level legal system • Strong will and support of Valledupar City Hall, related organizations, and civil servants	• Lack of city infrastructure and technology • Lack of IT professionals • Difficult to pursue project with existing city resources
Strengths	**Weaknesses**
• Provide opportunity to acquire city infrastructure to improve city competitiveness • Prospect of implementing IOCC that makes use of updated information communication for improvements in transportation, security, and disaster control	• Investment overlap with that for CCTV project which is currently pursued with government funding
Opportunities	**Threats**

Source: Compiled by KSP Research Team (2015).

2. Service Selection

To ensure that service provided by a Smart City fulfills its potential, a range of standards are needed to make sure that identified issues are addressed at different levels, i.e., from the decision-making at the city level to the functional interoperability of related organizations. The following section will review service of Smart City proposals for Valledupar and Villavicencio.

2.1. Selection Criteria

The following criteria were used to evaluate the most appropriate Smart City Service for target cities.

Table VI-3 | Smart City Service Selection Criteria

Selection criteria	Consideration	Details	Reference
Urgency	• Time of provision, importance, appropriateness	• Is the service an important one in consideration of the city's traits and should be constructed in priority before other services?	• Result of subject area review and SWOT analysis • Result of survey analysis • Result of policy and legal system analysis • Result of domestic and foreign case analysis
Public benefit	• Public convenience • (safety, utilization)	• Does the service provide public benefit that has high convenience and value for the citizens?	
Policy correspondence	• Correspondence of central and local governments' policy, consistency in vision and goal, legal environment	• Does the service accord with the central or city government's policy? • Have consistency in vision and goal? • I adequately supported by a legal environment?	
Possibility of technical realization	• Realization possibility, expandability of technology application	• Is there a case that have standardized the service with currently developed technology? In case of new technology, is it possible to realize the service in 1-2 years from now with technology that can be commercialized?	
Expected effect	• City operation efficiency, cost cutting, city promotion, and other impacts	• Is the service a differentiated one that can increase city operation efficiency, cut costs through integrated management, and improve the city's brand image?	

Source: Compiled by KSP Research Team (2015)

As in many other smart city cases, it was agreed that the proposed IOCC and communication network should act as the hub of collection, process/analysis, provision of information necessary for Smart City Service operation and management. It is very important that these functions should be aligned with and support the city's operation and management.

2.2. Selection Results

After discussion and review of collected data from research methods in this project, the KSP Team decided they would focus only on three main, recurring and urgent issues mentioned by stakeholders in Valledupar and Villavicencio, which are issues relevant to improvements in security, transportation, and disaster. Considering urgency issue as mentioned in Table VI, the team decided not to focus on environment and facility management. When selection was finalized, there were a total of six most appropriate Smart City Services as below.

Table VI-4 | Final Selection of Smart City Services

Service area	System	Reasons for selection
Transportation	• Real Time Traffic Signal control system • Real time road video collection system • Intelligent Transportation Information Collection System • Customized Transportation Information Provision System • Public Transportation Information Control system	• Based on subject area's environmental analysis and citizen survey results, transportation service improvement is seen as "most urgent". • After analysis of Korean and Paraguayan cases, the services that have the greatest impact were selected.
Crime prevention	• Intelligence Crime Prevention System • Criminal Vehicle Tracking system	• Based on subject area's environmental analysis and citizen survey results, security service improvement is seen as "Urgent" • Based on Korean case studies, the systems that have the great impact were selected.
Disaster prevention	• Integrated disaster surveillance system	• Construction and expansion of a system for surveillance, discovery, dispersion, and recovery of subject area's fire, flood, and other disasters is seen as "Urgent"
Common/ Shared Services	• Smart Portal Service System	• Smart City promotion, and guidance delivery is necessary as a window for communication with citizens • Smart Call Service future connections with other related organizations
Integrated Operation Control Center	• Building construction • ICT infrastructure • Operational Board (GIS based location control)	• It is required to consider sufficient Space Program for construction of the new IOCC building and future expansion that includes server room, technical room, situation room, meeting room, etc. • GIS operation is necessary to operate on-site service system for real time communication control with transportation, crime control, and disaster prevention.
Communication network	• Wired (self network) • Wireless (TRS) • WiFi service in public areas	• It is important to consider into self-sufficient network for new construction and expansion of future IOCC and on-site service system and provision of WiFi service in public areas.

Source: Compiled by KSP Research Team (2015)

2.2.1. Smart City Service

As mentioned earlier, Smart City Service offers nine types of services covering four areas: Common Administration, Transportation, Security, and Disaster Control or Management.

1) Outline

The Common Administration service is provided by a Smart Portal. This Smart City Service involves IOCC providing a variety of everyday information to citizens through the Web or smart phones. Smart Portal service contents generally include lifestyle information, weather, transportation, security, administration, education, local government announcements, etc., that are useful for citizens' daily living convenience.

Transportation information, for instance, through Smart City Service, provides communication information, accident and construction information, as well as transportation related policies. In addition, crime prevention information provides crime prevention activity information, crime prevention training, promotion and announcements. As for disaster control, information is given to disaster prone areas and where necessary, with recommended actions upon disaster, disaster information and promotion data. Information given out in a reliable and timely manner ensures swift evacuation and appropriate action of the citizens.

2) Transportation Service

The five kinds of transportation services are Real Time Traffic Signal Control System, Real Time Road Video Collection System, Intelligence Transportation Information Collecting System, Customized Transportation Information Provision System, and Public Transportation Information Control System.

a) Real Time Traffic Signal Control System

This service allows active response to changes in traffic by transferring existing signal control system to online standard traffic signal control system. The system operates traffic lights flexibly according to real time data; it allows efficient operation of crossroads and roads against constantly changing transportation situation and various unexpected events.

Benefits of using the IOCC are it enables real time monitoring of each crossroad and road signal operation status, and conducts special control such as turning them off/on remotely.

Table VI-5 | Function of Real Time Traffic Signal Control System

Main functions	
• Signal Control mode type - Fixed sight control/TOD control/ DOW control • Induction control - Half-induction control, fluctuating signal control • IOCC data based real time control - Collects transportation information from sites/ processes transportation information - Predicts transportation information and updates DB	• Interlocks and optimizes traffic flow • Signal control facility management - Detector for facility management and detection of signal operation, and facility operation situation • Connects related information - Information connection with local centers (firefighting, emergency medical treatment)

Information flow	Input	• Connection control information, vehicle control in special situation information, transportation control information, passing through vehicle information, transportation control request information
	Output	• Connection control information, transportation statistics information, signal control history information
Components	Center	• Signal control server, DB server
	Site	• Signal controller, Vehicle Detection System (VDS)

Source: Compiled by KSP Research Team (2015).

b) Real Time Traffic Video Collection System

This service involves installing CCTV in major city center crossroads to allow real time monitoring of the road situation. Upon unexpected events, the IOCC can enable immediate recognition and provides road utilization convenience to citizens through quick responsive measures.

This system is to be installed first on roads with heavy traffic or areas that repeatedly experience congestion for 24 hours. Its real time monitoring functions will ensure recognition of traffic flow and unexpected happenings. Upon congestion, transportation information such as road control information, bypass road information, etc., will be provided to citizens when the system operator quickly become aware of the situation. It also disperses related information upon emergencies such as traffic accident, etc., to related organizations, such as the Police Department and the Fire Department, to minimize traffic confusion and to protect citizens' lives.

Table VI-6 | Function of Real Time Traffic Video Surveillance System

Main function		
• Main road and crossroad monitoring (24-hour) - Traffic flow monitoring - Unexpected events monitoring		• System main function - Preset function, Day/Night Mode - Collected + text display, center remote control - Checks site facility status information and makes self-diagnosis
Information flow	Input	• Traffic flow information, unexpected events information,
	Output	• Video information, road information, unexpected events information, requesting handling of unexpected events
Components	Center	• Video collection/distribution server, video storage server, Operational Board
	Site	• CCTV camera

Source: Compiled by KSP Research Team (2015).

c) Intelligent Traffic Information Management System

This service collects traffic information of vehicles that go past the traffic detector installed on roads, such as volume, speed, occupancy, length, etc., and sends this data to the IOCC based on real time traffic control strategy. Traffic information collected by the detector is then transmitted to IOCC to be analyzed, processed, and operated in connection to Real Time Traffic Signal control system and customized traffic information provision system.

This system is to be installed and operated in places often prone to accidents and congestion, and will allow swift reaction to problematic traffic situations through real time information collection.

Table VI-7 | Function of Intelligent Traffic Information Management System

Main function		
• Information collection /control - Information DB - Vehicle-scan information (traffic amount, speed, share, lines in waiting) • Information processing - Processing, storage, evaluation		• Traffic information collection equipment control - Error detection and control
Information flow	Input	• Information on unexpected situations, road and main road situations
	Output	• Information on city and main road transportation and unexpected situations • Road communication information, traffic control and control information
Components	Center	• VDS Server
	Site	• Scanning device : VDS (non-laying)

Source: Compiled by KSP Research Team (2015).

d) Customized Traffic Information Provision System

This service utilizes various means to provide information based on transportation information that is collected real time. It is connected to other transportation systems such as Real Time Road Video Collection System, Intelligence Transportation Information Collecting System, etc., to provide various forms of transportation information such as communication status, warning/control, replace and bypass road, and guidance.

Real time traffic information utilizes huge billboards (VMS, or Variable Message System), Web, and smart phone apps for data dissemination. City drivers can use such provided information to search for optimum routes before driving and to select roads while behind the wheel (i.e., whether to use alternate routes or bypass roads). This will help to disperse traffic in chronically congested zones.

Table VI-8 | Function of Customized Traffic Information Provision System

<table>
<tr><th colspan="3">Main functions</th></tr>
<tr><td colspan="2">• Provides transportation information
- Guides replacement bypass road
- Provides unexpected event information
- Road control and provision of closure information
- Weather information, etc.
• Government promotion</td><td>• System remote control
- Facility status monitoring with web camera
- Remote surveillance with FMS function</td></tr>
<tr><td rowspan="2">Information flow</td><td>Input</td><td>• Transportation (traffic volume, speed), unexpected event information, surrounding road situation information</td></tr>
<tr><td>Output</td><td>• City and main road transportation information, unexpected event information
• Road communication information, transportation control and control information</td></tr>
<tr><td rowspan="2">Components</td><td>Center</td><td>• VMS server</td></tr>
<tr><td>Site</td><td>• Display equipment : VMS, WEB camera</td></tr>
</table>

Source: Compiled by KSP Research Team (2015).

e) Public Transportation Information Control System

This service recognizes real time bus location and operation status and conveys this data to control running schedule, schedule history, and establish communication with the driver, etc. It also can detect and punish driving violations, e.g., drivers who do not keep to operation lanes, or commit illegal driving acts.

Table VI-9 | Function of Public Transportation Inforrmation Control System

Main functions	
• Collects and provides route operation information • Collects bus operation status and real time location information - Sends bus and public vehicle location to IOCC • Calculates and provides bus arrival time and information (future) - Creates estimated arrival information for each operating route of each station - Provides estimated arrival information through information provision device of each station	• Public transportation information control system (future) - Public transportation route control system and calculation of optimum route • Bus management - Operation information and history management - Driver information provision

Information flow	Input	• Real time GPS location information for each vehicle • Operation plan information and service plan information
	Output	• Computerization of public vehicle and metro bus operation control • Service for drivers and passengers • Creates estimated arrival information (future) • Creates foundational data for public transportation control
Components	Center	• IOCC
	Inside vehicle	• Automobile Terminal (OBE) with GPS and wireless communication module attached • Display screen and navigation
	Station (future)	• Information provision device for passengers waiting • Shelter and other facility installation and passenger lounge
Requirements		• Collecting accurate location information in consideration of various route operation environment • Prior negotiation with transportation company for Automobile Terminal installation

Source: Compiled by KSP Research Team (2015).

3) Security Service

As for security control and prevention, two security services mentioned here are Intelligence Crime Prevention System, and Criminal Automobile Tracking System.

a) Intelligent Crime Prevention System

This service installs intelligence CCTVs in the city's crime ridden areas to prevent crime, identify critical data in the crime situation, and assists in the tracking and arresting of criminals through IOCC functions.

The Intelligent Crime Prevention System has functions of intelligence crime prevention and tracking such as two-way interactive communication channels, and warning announcements. These functions, along with the Crime Prevention System and CCTV, can automatically follow and track movements of suspects or targeted criminals.

IOCC can reduce crime through warning announcements; their function can allow citizens to activate the alarm device located on emergency sites, and to prevent further emergencies through real time two-way communication with the IOCC. The Center can also make rescue request, display crime scene on e-map, or deploy cast net surveillance using CCTVs located near crime sites, and thus is able to provide real time Service Function with information to related organizations such as police, medical or fire departments.

Table VI-10 | Function of Intelligent Crime Prevention System

<table>
<tr><th colspan="3">Main function</th></tr>
<tr><td colspan="2">• Crime ridden area monitoring (24 hours, 24/7/365 service)
- Crime ridden area monitoring, traffic flor monitoring, unexpected events monitoring
• Checks and responds to criminal situation
- Monitoring of nearby CCTV upon event occurrence
- Connects information to nearby police station upon event occurrence
- Confirms actions and measurements</td><td>• System main function
- Preset function
- Day/Night Mode
- Collected video + text display
- Checks site facility status information and self-diagnosis
- IOCC remote control and management</td></tr>
<tr><td rowspan="2">Information flow</td><td>Input</td><td>• Crime ridden area information, crime situation information
• Road information, unexpected situation completion information, city main road transportation information</td></tr>
<tr><td>Output</td><td>• Video information, rescue request information
• Road information, unexpected event occurrence information, request to handle unexpected event</td></tr>
<tr><td rowspan="2">Components</td><td>Center facility</td><td>• Intelligence crime prevention server, intelligence analysis server, video display server, DB server</td></tr>
<tr><td>Site facility</td><td>• CCTV camera, high functioning speaker, emergency alarm</td></tr>
</table>

Source: Compiled by KSP Research Team (2015).

b) Vehicle Tracking System

This service installs license plate recognition CCTVs on major roads and crossroads in the event that crime-related transportation may pass. The Center's function allows the identification of location and direction of such vehicles in real time, thereby allowing the police to track and make arrests upon spotting criminals' vehicles.

Table VI-11 | Function of Vehicle Tracking System

Main function		
• Implement an efficient, intelligent system for problematic vehicle control - Arrests wanted vehicle, control vehicle in default, maximize control work, convey situation in real time, track problematic vehicle's movement Automatic license plate recognition function - Automatic license plate recognition service, real time intelligence search service, real time monitoring and situation dispersion service		• System main characteristics - Real time, connected viewing of Police Department Crime Vehicle DB - Develop pure video analysis technology that does not require on site equipment - License plate recognition and video analysis technology without any limitation on site - Automated recognition through result notification, requiring minimum manpower - Check vehicle movement: display on map - Increase work efficiency: gives priority to dispatches - Can connect to existing CCTV or video control program
Information flow	Input	• Connected to local government's default collection (tax, fine) DB • Connected to the police (Central Police Department, State Police Department, City Police Department) theft/robbery vehicle DB
	Output	• Video information, license plate recognition information • Road information, license plate and location tracking information
Components	Center facility	• Crime vehicle tracking server, intelligence analysis server, video display server, DB server
	Site facility	• CCTV camera

Source: Compiled by KSP Research Team (2015).

4) Disaster Service

Disaster management includes measures and systems for control, surveillance, and prevention. The disaster control service is based on the Integrated Disaster Surveillance System.

a) Integrated Disaster Surveillance System

This service installs USN devices such as disaster surveillance CCTVs, as well as rainfall and water level sensors in disaster prone areas to detect fire, flood, landslide and other disasters through 24-hour surveillance monitoring. Upon disaster occurrences, the IOCC services are called upon to assist to protect citizens and minimize asset damage through preliminary detection of disaster, recognition of disaster damage, evacuation guidance, and warning announcements.

This service also allows real time monitoring of any pending disaster; it then sends off warning 1-2 hours before disaster occurrences and id prepared to fully responds to these events. Its facility is an Emergency Warning System (EWS), which can quickly deliver disaster warning news to the people.

Table Ⅵ-12 | Function of Integrated Disaster Surveillance System

<table>
<tr><th colspan="3">Main functions</th></tr>
<tr><td colspan="2">• Fire surveillance
- Real time fire surveillance
- Real time flooding/overflow surveillance
• Disaster prevention alarm and data transmission
- Delivers disaster information extensively via siren, audio warning, SMS, VMS, Internet and mobile phone, etc.</td><td>• Connections to related organizations
- Communication connection to related organizations and hotline construction
- Real time data transmission and work processing
- Disaster prevention related information, real time, expansive alarm
- Related organization facility and manpower location control (fire engine, ambulance, rescue team, etc.)</td></tr>
<tr><td rowspan="2">Information flow</td><td>Input</td><td>• Major region's water level measurement data, precipitation measurement data, landslide data, fire data
• Real time video information, rainfall information, and water level information of the disaster area
• Information transmission with related organizations and measurement data information</td></tr>
<tr><td>Output</td><td>• Fires alarm for flood / fire / landslide, etc. (provide bypass information if necessary (VMS))
• Fires siren or audio warning, provides information on Internet and smart phone</td></tr>
<tr><td rowspan="2">Components</td><td>Center facility</td><td>• Integrated disaster surveillance server, rainfall detection server, water level detection server, DB server</td></tr>
<tr><td>Site facility</td><td>• CCTV camera, high functioning speaker, warning light, rainfall detection sensor, water level detection sensor</td></tr>
</table>

Source: Compiled by KSP Research Team (2015).

5) Common Administration

a) Smart Portal Service

Smart Portal Service is a web service that provides various life related information and services for citizens through PC or mobile terminal. General provision of various information related to citizens' lives, weather, transportation, administration, education information, local government announcements will enhance the level of convenience for the citizens.

Table VI-13 | List of Smart Portal Service Functions

Area	Service	Service Details
Center introduction	Center information	• Center and service introduction, event registration functions
	Q&A	• FAQ viewing, Q&A functions
Transportation	Provides road information	• Provides communication information, unexpected news, construction notices, and event information
	CCTV video information	• Provides transportation CCTV video
	Public transportation information	• Provides bus route information, interval and operation information
	Parking/control information	• Controls illegal parking and provides public parking lot location information
Crime prevention	Life crime prevention information	• Provides emergency alarm, life crime prevention, and CCTV location information
	Automobile crime prevention information	• Provides automobile crime prevention and CCTV location information
Disaster	Disaster information	• Disaster occurrence information and disaster action guidance
	Disaster prevention facility location information	• Disaster prevention CCTV location information, disaster prevention sensor location information
Lifestyle and culture	Cultural events information	• Cultural events information viewing, event registration and related functions
	Provides local information	• Government office, medical institution, education facility
Website control	Website control	• Report error/inconvenience, FAQ, connection statistics
	Pop-up control	• Usage guide, menu/pop-up/banner control
System control	Admin control	• Admin information viewing, registration and related functions
	User control	• User information viewing, registration/edit/delete functions

Source: Compiled by KSP Research Team (2015).

2.2.2. IOCC

IOCC consists of hardware such as server, storage, network facility, and Operational Board, operation software that operates and controls them, and a security system that protects them from outside danger. It also requires sufficient space to install and operate all equipment and facility for operation of accessory equipment such as uninterrupted power supply device and thermo-hygrostat.

IOCC controls operations so that the composition system processes collect information and provides data to monitor composition system status, and connects with outside organizations

to exchange information. Information provided by IOCC is distributed to citizens and related organizations through various channels and by doing so, it acts like a control tower that oversees the whole Smart City.

IOCC contains essential hardware such as server, storage, network facility, Operational Board, as well as software that operates and controls the hardware. It also has a strong security system that protects these from outside threats.

There should be enough space to install and operate all above equipment and other facilities such as Accessory Equipment like UPS and thermo-hygrostat.

Table VI-14 | Main Components of IOCC

Category		Components
Hardware System	Hardware	• Main host, Servers, Disk Array, Network, DLP, Backup Device, PC, Interface Server, CCTV Streaming Server, Communication Server, etc.
	Commercial Software	• DBMS, Backup S/W, Cluster S/W, GIS S/W, Statistics & Reporting S/W, SMS/ NMS, etc.
	Network	• Backbone switch, L2 switch, Firewall, Routers, IPS, VPN, etc.
	Accessory Equipment	• UPS, Battery, Temperature/Humidity, Racks, etc.
Applicable Software System		• Intelligence Transportation Information System, Real Time Road Video Collection System, Real Time Traffic Signal Control System, Public Transportation Information Control System, Intelligence Crime Prevention System, Criminal Automobile Tracking System, Integrated Disaster Surveillance System
Center space		• Computer room, situation room, visitation room, office, etc.

Source: Compiled by KSP Research Team (2015).

2.2.3. Communication Network Infrastructure

Network infrastructure is basic infrastructure constructed to share information between site and center. It requires network credibility, data transmission stability, and future service expandability.

To function efficiently, a network infrastructure needs to have non-stop service provision, and allowance and stability should be constructed. Sufficient expandability is also required for future city growth and expansion which will entail demand for new services and increase in existing service system quantity.

Communication network topology can be categorized in Ring method, Point to Multi Point method, and Point to Point method. Each is applied selectively depending on communication capacity and size.

Construction of network infrastructure between Site Equipment and IOCC to realize Smart City applies the most advantageous method derived through comparative analysis of self communication

network and project contractor's leasehold communication network in the aspects of future expandability, construction convenience, economy, and maintenance.

Network infrastructure should be installed in consideration of facilities installed on site through Network Infrastructure Construction Plan. The city center should be built with optic communication network whereas suburbs should be constructed with wireless communication network, as required.

Communication network infrastructure is a basic infrastructure constructed to allow sharing of information between the site and center. Communication network should have superior credibility and stable data transmission should also be ensured. To do this, a communication network infrastructure reflecting nonstop service provision and percentage of allowance, stability, etc., should be constructed. It should provide expandability for future increase of system quantity as the city grows.

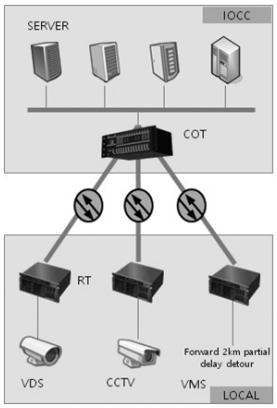
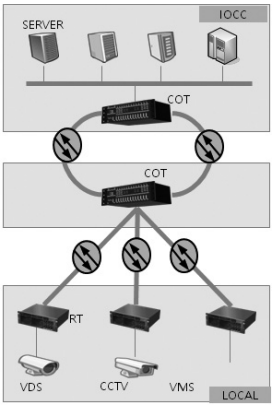
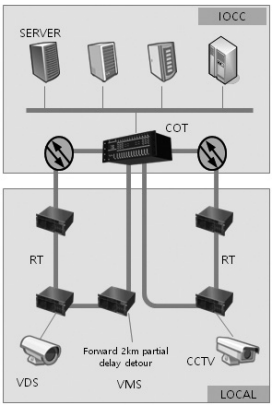
Table VI-15 | Considerations for Communication Network

Category	Basic outline	Considerations
Selection standard	• Analyze cost of self-owned network and leased network(wired) • Negotiate leased network with communication business	• Select a communication network after analyzing costs • Analyze operation cost when using leased network
Stability	• Establish error response strategy for non-stop service • Suggest a communication protocol between center and site • Protect information from outside invasion	• Immediate response to error through NMS • User certified standard protocol
Economics	• Select a communication network appropriate for the communication capacity • Suggest maintenance cost and circuit cost when using leased network	• Apply an economic communication network against communication capacity
Credibility	• Consider dualization of communication network • Provide consistent communication quality	• Review communication network topology (Ring type)

Source: Compiled by KSP Research Team (2015).

Communication network topology is mainly categorized in Ring type, Point to Multi Point type, and Point to Point type. They are to be selectively applied according to each communication capacity and scope. A review is conducted of the two cities' road type, distribution of installation location, system communication capacity, etc. The conclusion is 2-3 Ring type communication network topology should be applied around the center with other branches using Point to Point type as well. In the suburbs there is not much demand for the service and constructing an optic communication network would be economically irrational; a wireless communication network would be more advantageous.

Table VI-16 | Comparison of Communication Network Topologies

Category	Ring type	Point to Multi Point type	Point to Point type
Network structure			
Outline	• Communication network is formed in Ring type to collect data	• NODE is placed on site to collect data of two terminals	• Collects data by connecting the center and the site in a point to point method
Advantages	• Superior safety due to dualization • Service branch expansion is convenient	• Advantageous when there are many service branches • Easy maintenance	• Advantageous when there are not so many service branches
Disadvantages	• High price of equipment • Uneconomical when there are few branches in suburbs, etc.	• NODE construction cost occurs • Additional cost occurs upon service expansion	• Lots of Optic Cable will be consumed • Difficult to control the network
Application review	◎	X	◎

Source: Songdo U-City Enforcement Design Report, 2009, Incheon Free Economic Zone Authority.

Municipal Network and Leased Network are compared and analyzed in consideration of communication network infrastructure construction between Site Equipment and IOCC with the purpose of realizing Smart City in consideration of expandability, construction convenience, economics, and maintenance. Korea's Smart City used a communication company's leased network in the beginning but to cut yearly line lease cost, an additional communication network construction was planned and the network was switched to a municipal level arrangement.

Table VI-17 | Comparative Analysis between Self-Owned and Leased Network

Category		Municipal network	Leased network
Outline		• City Hall controls the installed optic cable and communication facility	• Borrows necessary number of lines from a communication business
Advantages Disadvantages		• Expansion and addition is easy since the City Hall owns the communication network • Excessive initial investment cost	• Advantageous in maintenance aspect • Monthly operation cost (line lease cost) occurs
Expandability		• Great expandability due to acquisition of reserve port and reserve capacity	• Difficult to expand when the communication business does not have enough capacity
Construction convenience		• Difficult, in occupying road at the construction stage, etc.	• Convenience, since a communication business' communication network is being leased
Economics	Construction cost	• High cost(cable, equipment construction cost occurs)	• Low cost (no initial investment cost)
	Operation cost	• Low cost (no monthly operation cost)	• High cost (monthly line lease cost occurs)
Maintenance		• Labor cost occurs for maintenance personnel	• Yearly maintenance cost occurs
Application review		◎	×

Source: Songdo U-City Enforcement Design Report, 2009, Incheon Free Economic Zone Authority.

2.3. Construction Outline

The construction plan of the selected site service system, its IOCC and communication network is suggested as follows. Construction would take place in three stages in consideration of resources and user scope for each area.

Table VI-18 | Considerations for Smart City Services Implementation

Construction Plan	Details
Construction in consideration of connections with other organization and regions	• Establish subject area's development plan in stages for city center, additional development, etc., and recognize expected effect
Construction in consideration of future technology development	• Reflect not only currently certified Smart City Service technology but also future applicable new technology impact on future execution designs • Consider application validity, expandability, correspondence of new technology, certification and establishment of acquisition plan • Analyze domestic and foreign ICT technology trends, national ICT policy, project requirements and create a short term/mid term/long term road map
Construction that ensures expandability and connectivity of each stage	• Analyze differences in demand such as increase/decrease in number of users, changes in user preferences, changes in service due to new technology development, etc., and establish a system design plan • Suggest a detailed design plan for software and hardware equipment, in consideration of future expandability and compatibility
Construction that minimizes operation cost for related system and facility, including IOCC	• Suggest means to cut operational costs such as total cost of operation, energy, operation man power, etc., through optimization of construction of the system (IOCC, including Communication network) Establish measures to minimize additional cost in a systematic manner
Construction in consideration of future revenue	• Utilize Smart City facility related to the on-site service system and IOCC • Establish measures that can create revenue in the future

Source: Compiled by KSP Research Team (2015).

Ⅶ Smart City Establishment Plan

Smart City Service offers nine types of services covering four areas: Common Administration, Transportation, Security, and Disaster Control or Management.

First, there is a common service administration known as Smart Portal Service. The second area is Transportation. There are five kinds of transportation services, namely Real Time Traffic Signal Control System, Real Time Traffic Video Collection System, Intelligent Traffic Information Management System, Customized Traffic Information Provision System, and Public Transportation Information Control System.

As for maintaining good security, the two security services are Intelligent Crime Prevention System, and Criminal Automobile Tracking System. Disaster management is based on using the Integrated Disaster Surveillance System.

IOCC construction plan is based on this process: first, it defines the function of IOCC, including collection, processing, integration, and connection of information. Then it suggests the location and equipment conditions related to IOCC construction as well as spatial design for situation room, facility room, technical room, etc. Lastly, it suggests hardware and software necessary to operate IOCC in order to provide Smart City Service.

1. Transportation Services

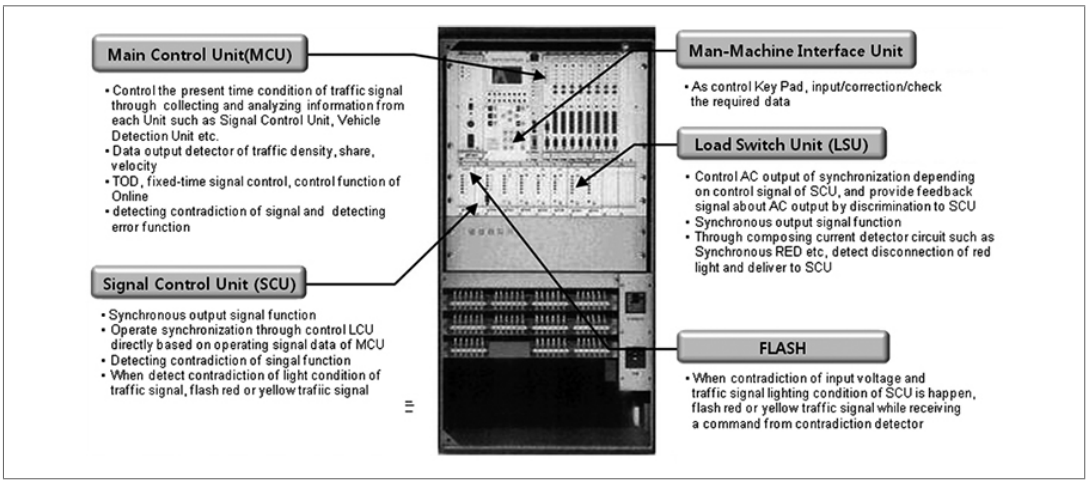
1.1. Real Time Traffic Signal Control System

1.1.1. Service Concept

Real Time Traffic Signal Control System consists of a signal control department and a signal drive department. The signal control department processes transportation situation information, controls algorithm, communicates with the Center, and makes MMI connections.

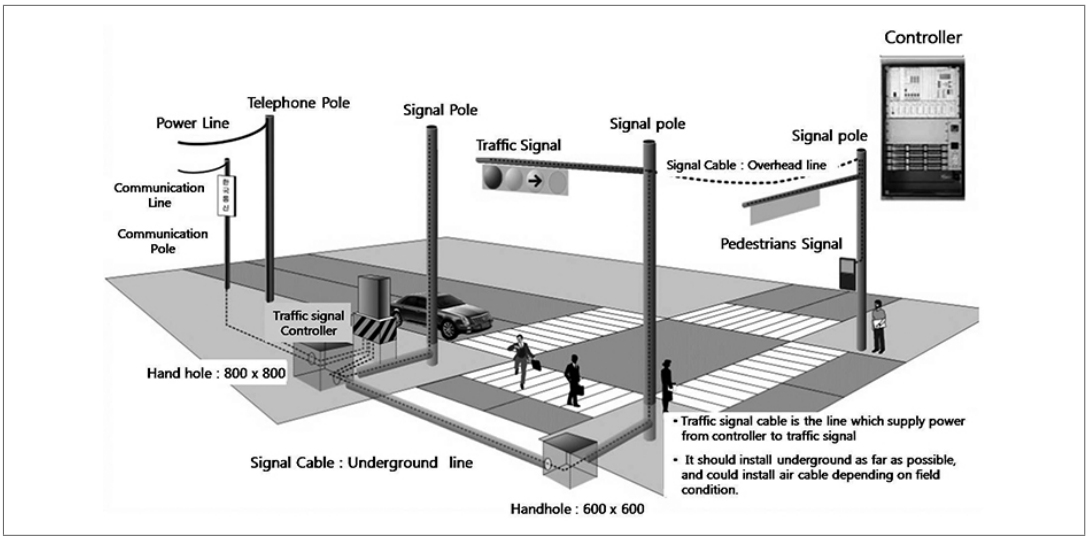
Expansion of additional functions is to be carried out through the signal control department. The signal drive department will take charge of Fail-Safe functions and traffic light drive functions for system stability.

Figure Ⅶ-1 | Forms and Functions of Traffic Signal Controller



Source: Asuncion, Paraguay, Advanced Traffic Management Systems (ATMS) Construction Plan, 2014, KOICA.

Figure Ⅶ-2 | Concept of Real Time Traffic Signal Control System



Source: Asuncion, Paraguay, Advanced Traffic Management Systems (ATMS) Construction Plan, 2014, KOICA.

1.1.2. Installation Plan

Real Time Traffic Signal Control System forms an online data communication system between the Center and site facilities to allow remote control. It will utilize various signal control techniques. It is recommended that the old signal controller be replaced with new signal controllers for more efficient controller connection.

Certain measures are required to protect the Real Time Traffic Signal Control System on-site installation from possible malfunctions because of abnormal. These measures include:

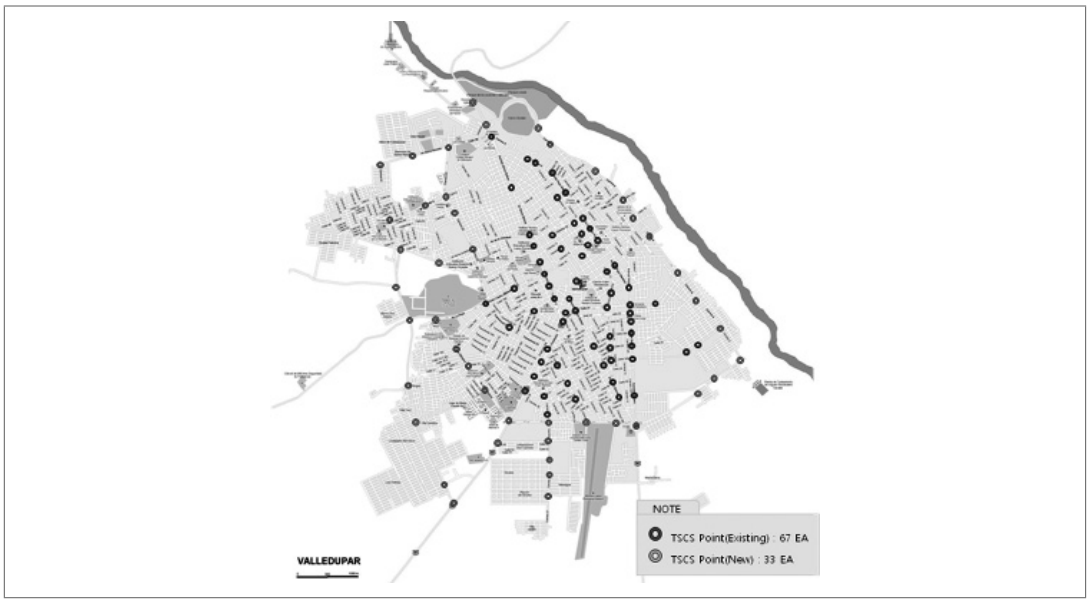
- Structures (pole) installed on site should be able to endure harsh weather conditions like typhoon, heavy rain, earthquake, etc.
- All facilities should be installed in locations that do not cause disruption to pedestrians.
- Controller installation height should take flooding risks into consideration.
- Automatic Voltage Regulator (AVR) should be used to provide stable power.
- Locking Screw should be used to prevent illegal disassembling of system components.
- Sign that cautions penalty for intentional damaging of signal controller should be posted.

1.1.3. Installation Plan and Construction Quantity

1) Valledupar

Review of the system shows that there are currently 67 signal controllers installed in the city of Valledupar. Some signal controllers in operation are old while others are new. Research also shows that most facilities are dated and replacement components in case of breakdown are in short supply. Aside from the 67 crossroads with controllers, 33 more crossroads are to install new traffic signal controllers to secure crossroad thoroughfare safety. At the same time, real time signal control is to be deployed to improve operation efficiency of major roads and crossroads in all of Valledupar, through the implementation of Signal Control System.

Figure VII-3 | Valledupar: Sites for Traffic Signal Control System



Source: Compiled by KSP Research Team (2015).

Construction quantity of Real Time Traffic Signal Control System to be installed in Valledupar is shown below.

Table VII-1 | Valledupar: Required Items for Traffic Signal Control System

Item	Specification	Unit	Quantity	Note
Traffic signal controller	Includes housing, foundation	Set	100	• CPU : more than 32bit
Traffic lights (for vehicles)	4 Aspect, LED	EA	400	• More than Ø300mm, includes protection metal
Traffic lights (for pedestrians)	2 Aspect, LED	EA	800	• More than Ø300mm, includes protection metal
Structure (for vehicles)	Includes foundation and battery	EA	400	• Ø200mm x 8m, Arm : 7m
Structure (for pedestrians)	Includes foundation and battery	EA	400	• Ø140mm x 6m
Hand hole	Special made	EA	100	• Concrete, combination lock

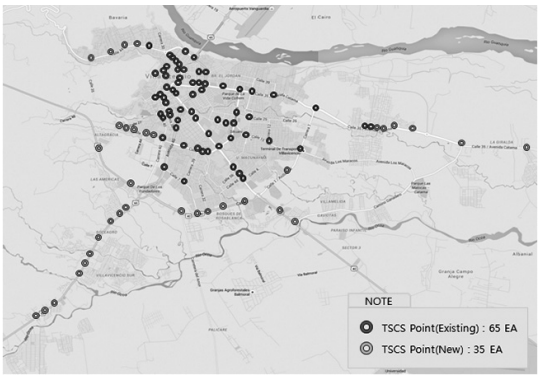
Source: Compiled by KSP Research Team (2015).

2) Villavicencio

Research shows that there are 65 signal controllers installed in Villavicencio. Some of the signal controllers in operation are old while others are new. Research also shows that most facilities are dated and supply components to be used in case of component breakdown are not available.

Aside from the 65 crossroads with controllers, 35 more crossroads will be equipped with new traffic signal controllers to secure crossroad thoroughfare safety. In addition, real time signal control is to be applied to improve operation efficiency of major roads and crossroads in all of Villavicencio, with the successful implementation of Signal Control System.

Figure VII-4 | Villavicencio: Sites for Traffic Signal Control System



Source: Compiled by KSP Research Team (2015).

In terms of service construction quantity, specifications of Real Time Traffic Signal Control System to be installed in Villavicencio are shown below.

Table VII-2 | Villavicencio: Required Items for Traffic Signal Control System

Item	Specification	Unit	Quantity	Note
Traffic signal controller	Includes housing, foundation	Set	100	• CPU : more than 32bit
Traffic lights (for vehicles)	4 Aspect, LED	EA	400	• More than Ø300mm, includes protection metal
Traffic lights (for pedestrians)	2 Aspect, LED	EA	800	• More than Ø300mm, includes protection metal
Structure (for vehicles)	Includes foundation and battery	EA	400	• Ø200mm x 8m, Arm : 7m
Structure (for pedestrians)	Includes foundation and battery	EA	400	• Ø140mm x 6m
Hand hole	Special made	EA	100	• Concrete, combination lock

Source: Compiled by KSP Research Team (2015).

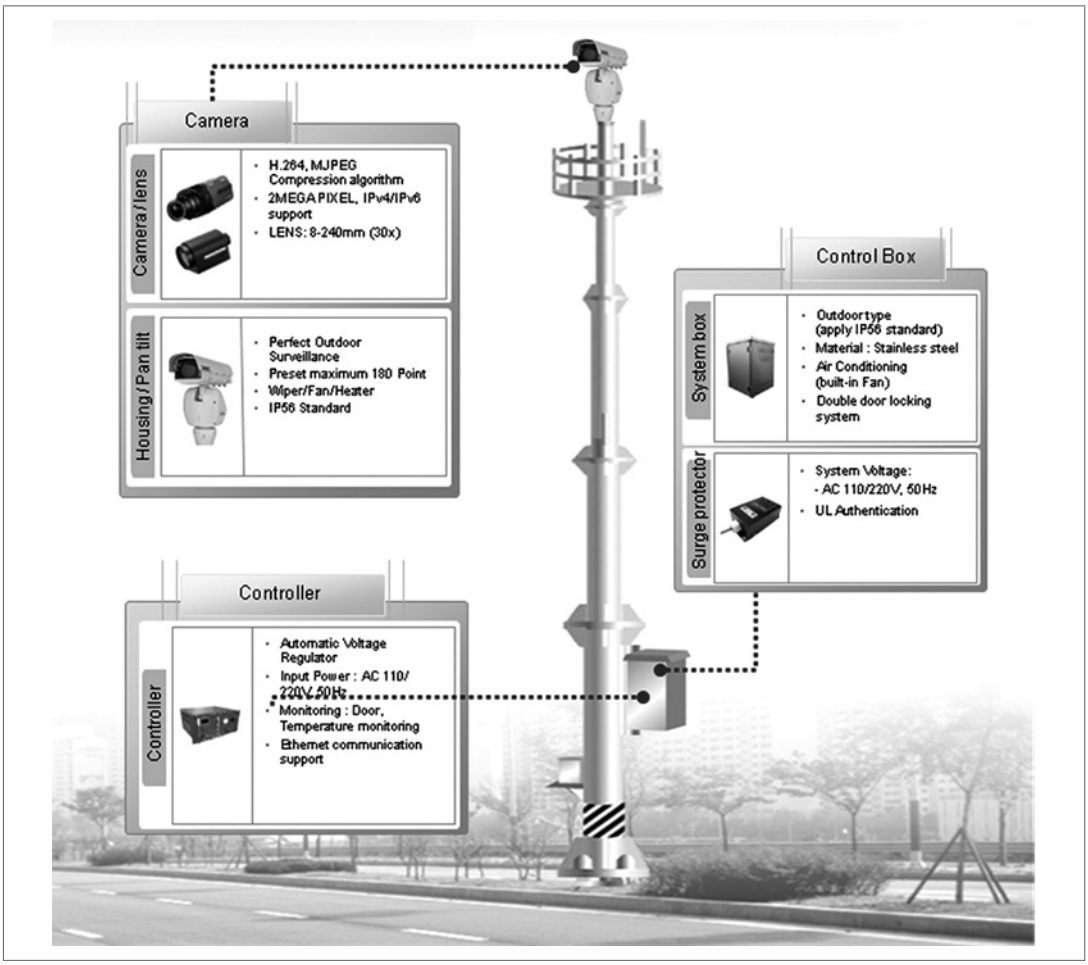
1.2. Real Time Traffic Video Collection System

1.2.1. Service concept

The CCTV system installed on site is used in outside environment, and therefore local climate (apart from the dustproof, insect-proof environment inside), should be considered. The system needs protection in the form of moist-proof, waterproof, and constant-temperature condition.

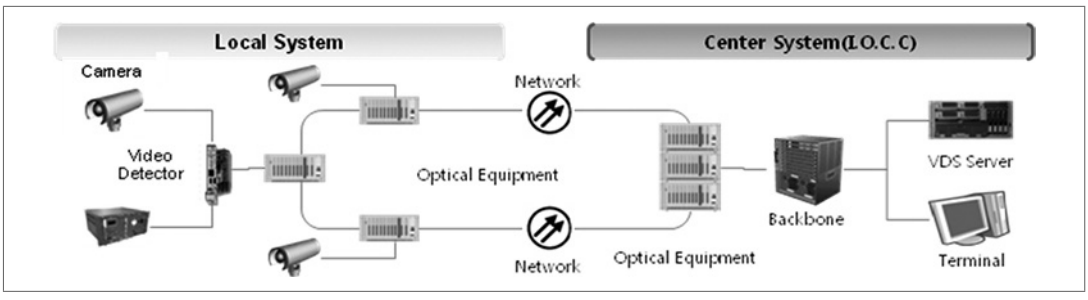
Also, equipment installed on site should have a motion detection function so that the System Admin is able to quickly detect and identify abnormalities via remote. A combination lock should also be attached for information protection and as a theft prevention measure.

Figure VII-5 | CCTV Components



Source: Paraguay ITS basic design report, 2013, KOICA.

Figure VII-6 | Concept of Real Time Traffic Video Surveillance System



Source: Paraguay ITS basic design report, 2013, KOICA.

1.2.2. Installation Plan

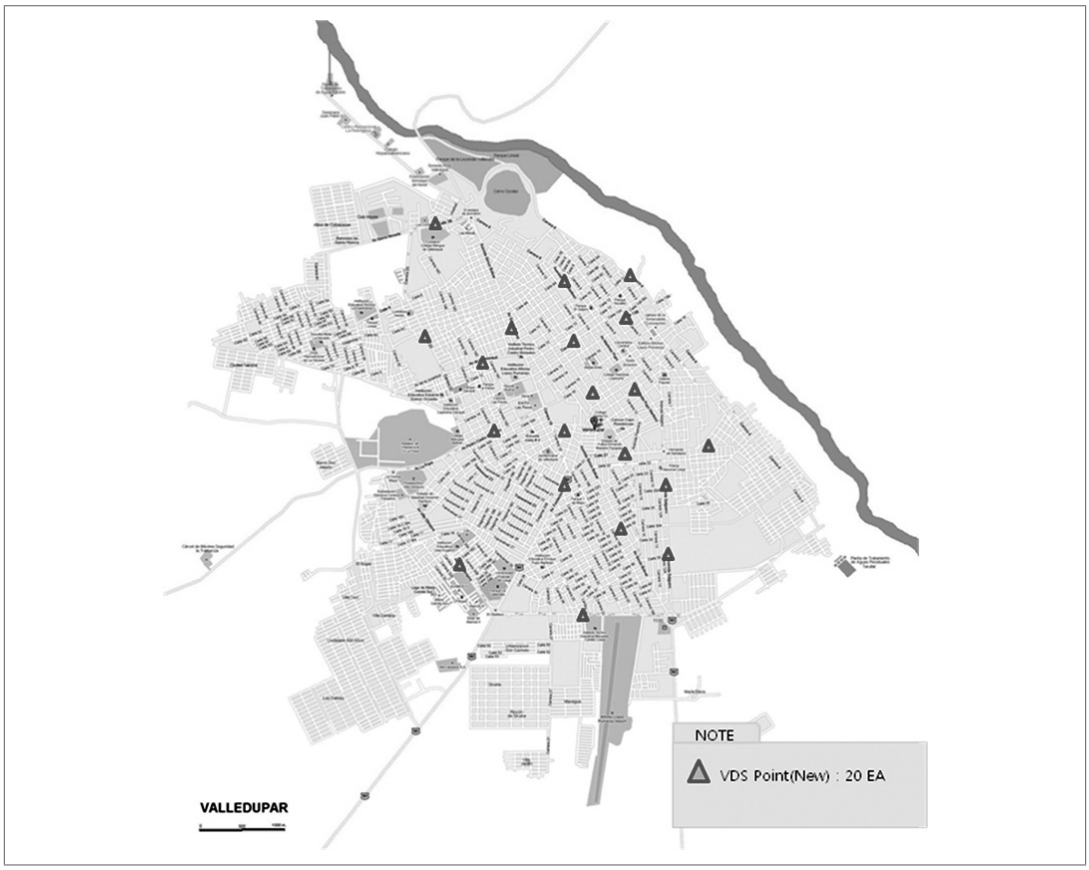
System Admin for Road Video Collection CCTV decides on a point that can ensure road view and installs camera poles taller than 15m to obtain views from this level. Measures to protect traffic information collection CCTV camera installed on site from abnormal conditions and environment should be considered in same way as Real Time Traffic Signal Control System.

1.2.3. Installation Plan and Construction Quantity

1) Valledupar

For this city, 10 sites of Valledupar's main crossroads in city center with heavy traffic are to be selected for installation of Real Time Traffic Video Collection System.

Figure VII-7 | Valledupar: Sites for Traffic Video Surveillance System



Source: Compiled by KSP Research Team (2015).

Construction quantity of Real Time Traffic Video Collection System to be installed in Valledupar is shown below.

Table VII-3 | Valledupar: Required Items for Traffic Video Surveillance System

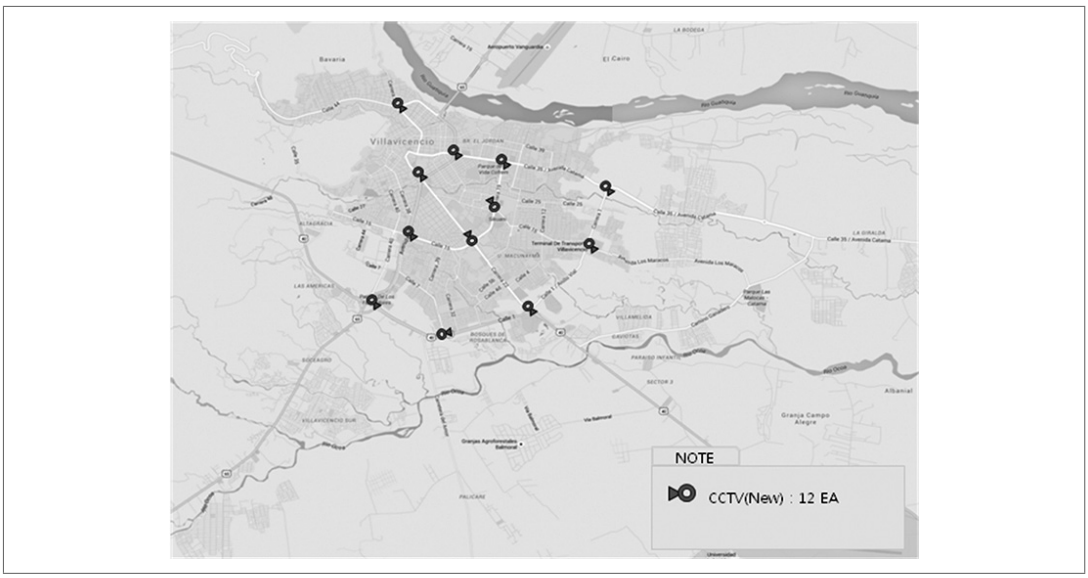
Item	Specification	Unit	Quantity	Note
CCTV Camera	2M pixel	Set	10	• HD-Supports IP, Day-night function
Zoom lens	More than 20x	EA	10	• More than 240mm, supports Preset
Housing	More than IP65	EA	10	• Built in pan heater, includes sun shield
Pan tilt	360 degree Endless	EA	10	• More than 30kg of max. load, supports Preset
Multi-function controller	Supports IP	EA	10	• Supports IP type communication
AVR	1KVA	EA	10	• 19″ rack type
Control housing	Stainless	EA	10	• Combination lock, pan attached, 19″ rack type
Structure	Special made	EA	10	• Above 15m, safety foothold, lightning rod
Hand hole	Special made	EA	10	• Concrete, combination lock

Source: Compiled by KSP Research Team (2015).

2) Villavicencio

In the city of Villavicencio, 12 sites of main crossroads in city center with heavy traffic are to be selected for installation of Real Time Road Video Collection System.

Figure VII-8 | Villavicencio: Sites for Traffic Video Surveillance System



Source: Compiled by KSP Research Team (2015).

Construction quantity of Real Time Road Video Collection System to be installed in Villavicencio is shown below.

Table VII-4 | Vllavicencio: Required Items for Traffic Video Surveillance System

Item	Specification	Unit	Quantity	Note
CCTV camera	2M pixel	Set	12	• Supports HD-IP, Day-night function
Zoom lens	More than 20x	EA	12	• More than 240mm, supports Preset
Housing	More than IP65	EA	12	• Built-in pan heater, includes sun shield
Pan tilt	360 degree Endless	EA	12	• More than 30kg of max. load, supports Preset
Multi-function Controller	Supports IP	EA	12	• Supports IP type communication
AVR	1KVA	EA	12	• 19″ rack type
Control housing	Stainless	EA	12	• Combination lock, pan attached, 19″ rack type
Structure	Special made	EA	12	• Above 15m, safety foothold, lightning rod
Hand hole	Special made	EA	12	• Concrete, combination lock

Source: Compiled by KSP Research Team (2015).

1.3. Intelligent Traffic Information Management System

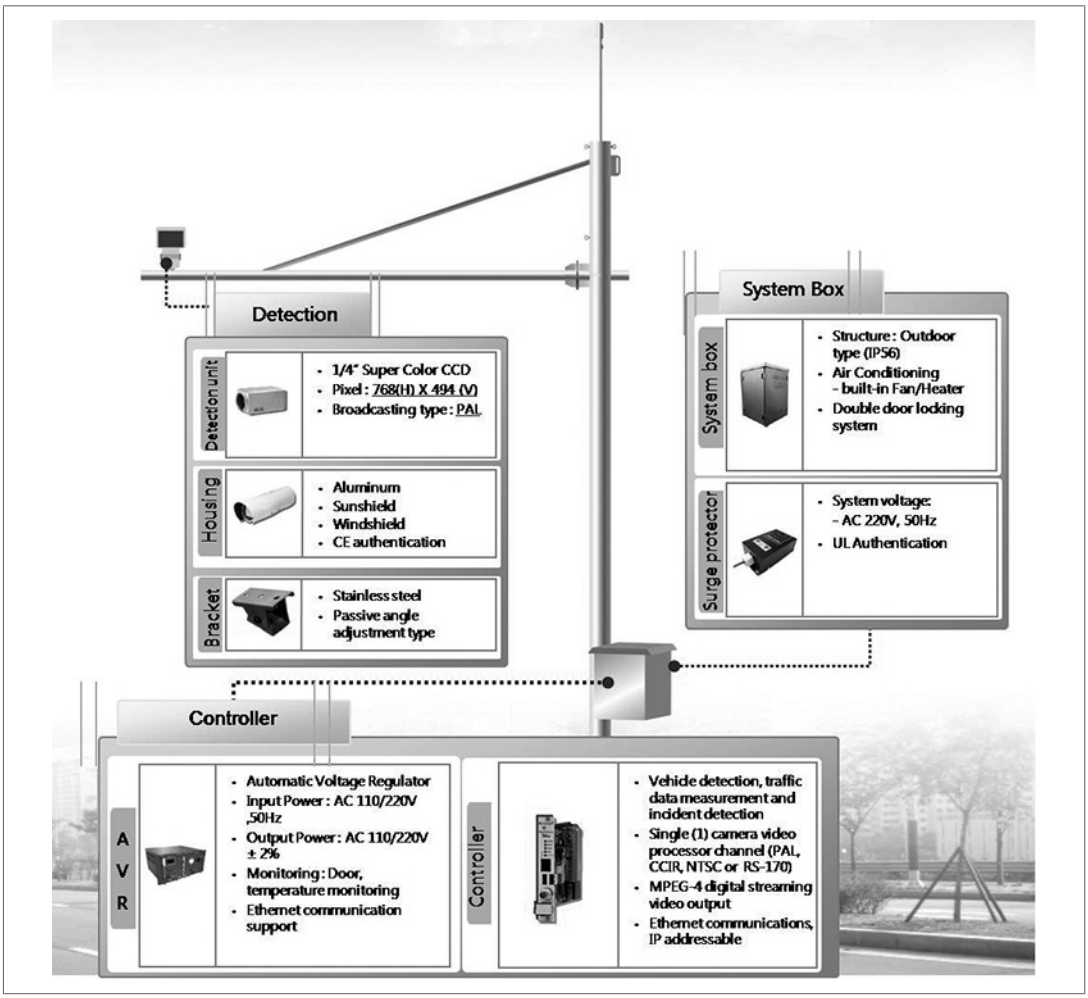
1.3.1. Service Concept

Optic Cable Communication network is used to enable real time transfer of transportation information collected by detector (non-laying) installed on site to be conveyed to IOCC. At the Center, this information will be used for other decision making.

Detector that collects transportation information should be a non-laying detector that is less affected by adverse road conditions, roadside trees, flooding, etc. As the detector is used outside, local climate effects, considerably different from the regular dustproof, insect-proof environment inside, should be considered. It requires shelter in the form of moist-proof, waterproof, and constant-temperature protection.

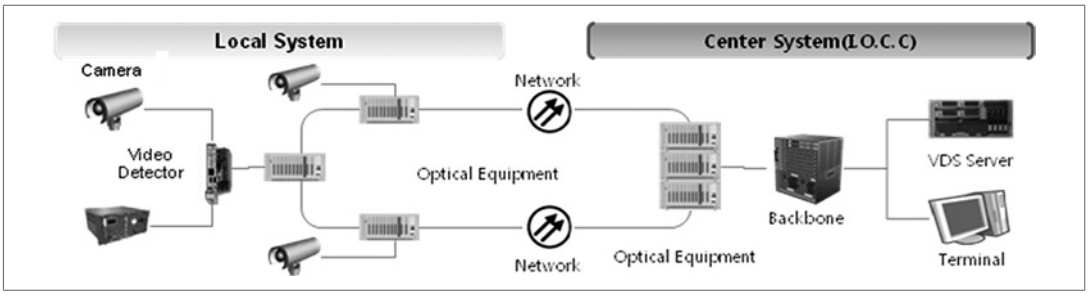
Additionally, the equipment installed on site should have a motion detection function so that the System Admin is able to quickly detect and identify abnormalities via remote access. The system should have a combination lock to ensure information protection and as a theft prevention measure.

Figure VII-9 | VDS Components



Source: Compiled by KSP Research Team (2015).

Figure VII-10 | Concept of Intelligent Traffic Information Management System



Source: Paraguay ITS basic design report, 2013, KOICA.

1.3.2. Installation Plan

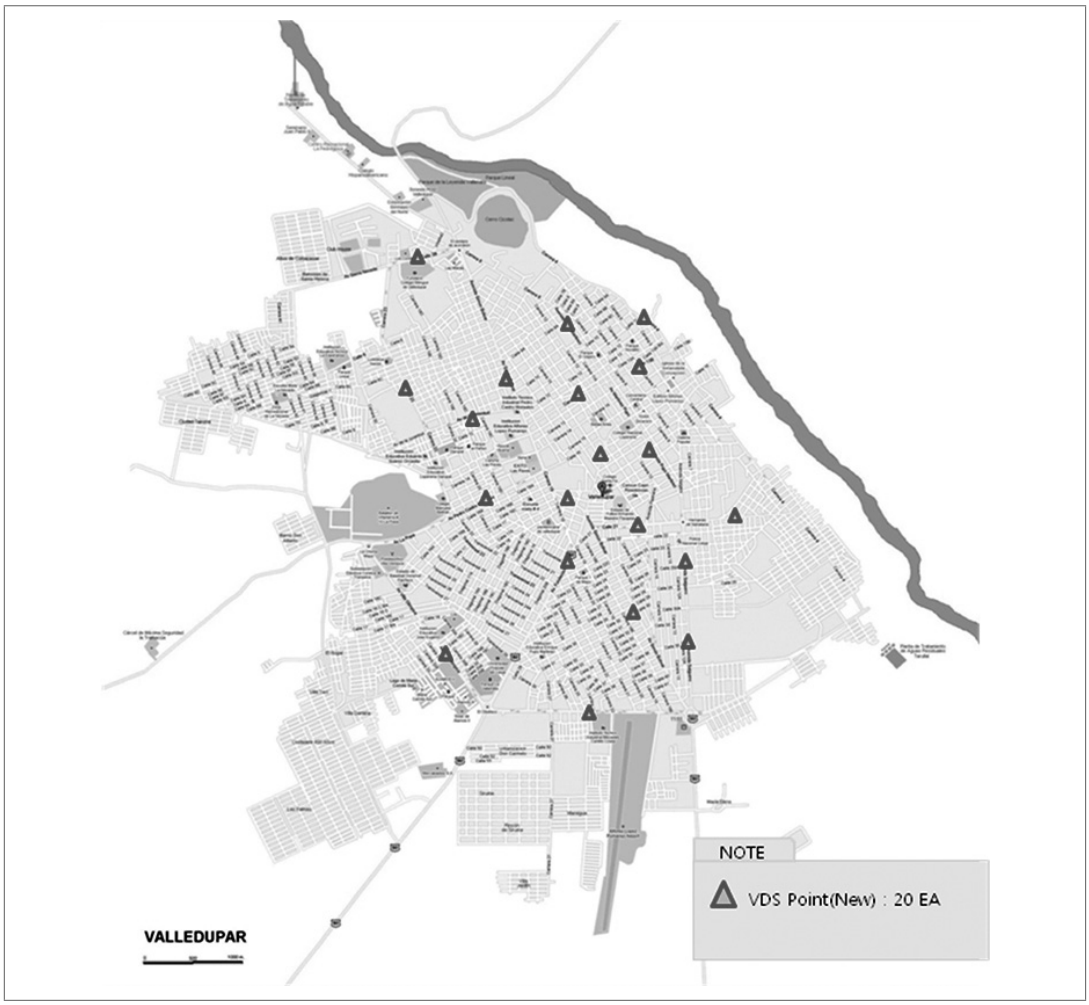
Detectors can be installed as separate structure or use street light structure. Measures to protect detectors installed on site from abnormal activities from the outside or environmental changes should be considered in the same way as Real Time Traffic Signal Control System.

1.3.3. Installation Plan and Construction Quantity

1) Valledupar

Intelligent Traffic Information Management System shall be installed in 20 sites of side streets, and is expected to disperse traffic of roads with heavy traffic as well as congested traffic on main roads in the city center.

Figure VII-11 | Valledupar: Sites for Traffic Information Management System



Source: Compiled by KSP Research Team (2015).

Construction quantity of traffic information management system to be installed in Valledupar is shown below.

Table VII-5 | Valledupar: Required Items for Traffic Information Management System

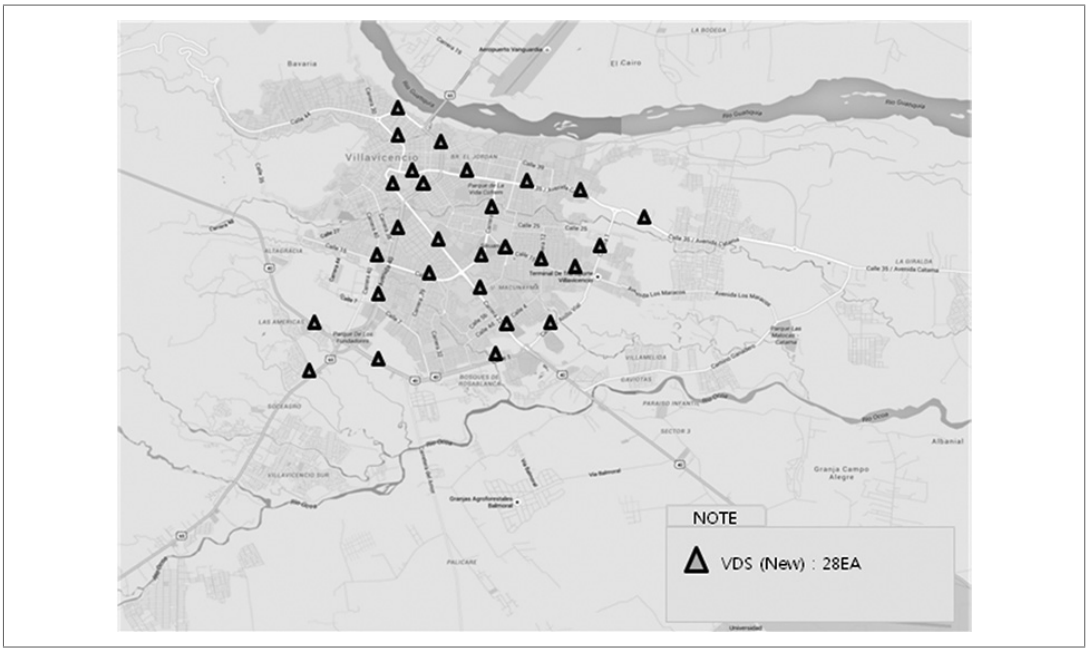
Item	Specification	Unit	Quantity	Note
Detector Module	Non-laying	Set	20	• Includes bracket and housing
Detector Cable	7m	EA	20	• AWG 24 8C
Control device	1KVA	EA	20	• 19″ rack type
Control housing	Stainless Steel	EA	20	• Pan attached, includes combination lock
Structure (Pole)	Special Made	EA	20	• Hot dip, includes battery/lightning protection
Hand hole	800 x 800 x 800	EA	20	• Concrete, includes combination lock

Source: Compiled by KSP Research Team (2015).

2) Villavicencio

In this city, Intelligent Traffic Information Management System shall be installed in 28 sites of side streets. This system should be able to disperse traffic of roads with heavy traffic and of main roads in city center areas.

Figure VII-12 | Villavicencio: Sites for Traffic Information Management System



Source: Compiled by KSP Research Team (2015).

Construction quantity of intelligence traffic information management system to be installed in Villavicencio is shown below.

Table VII-6 | Villavicencio: Required Items for Traffic Information Management System

Item	Specification	Unit	Quantity	Note
Detector Module	Non-laying	Set	28	• Includes bracket and housing
Detector Cable	7m	EA	28	• AWG 24 8C
Control device	1KVA	EA	28	• 19″ rack type
Control housing	Stainless Steel	EA	28	• Pan attached, includes combination lock
Structure (Pole)	Special Made	EA	28	• Hot dip, includes battery/lightning protection
Hand hole	800 x 800 x 800	EA	28	• Concrete, includes combination lock

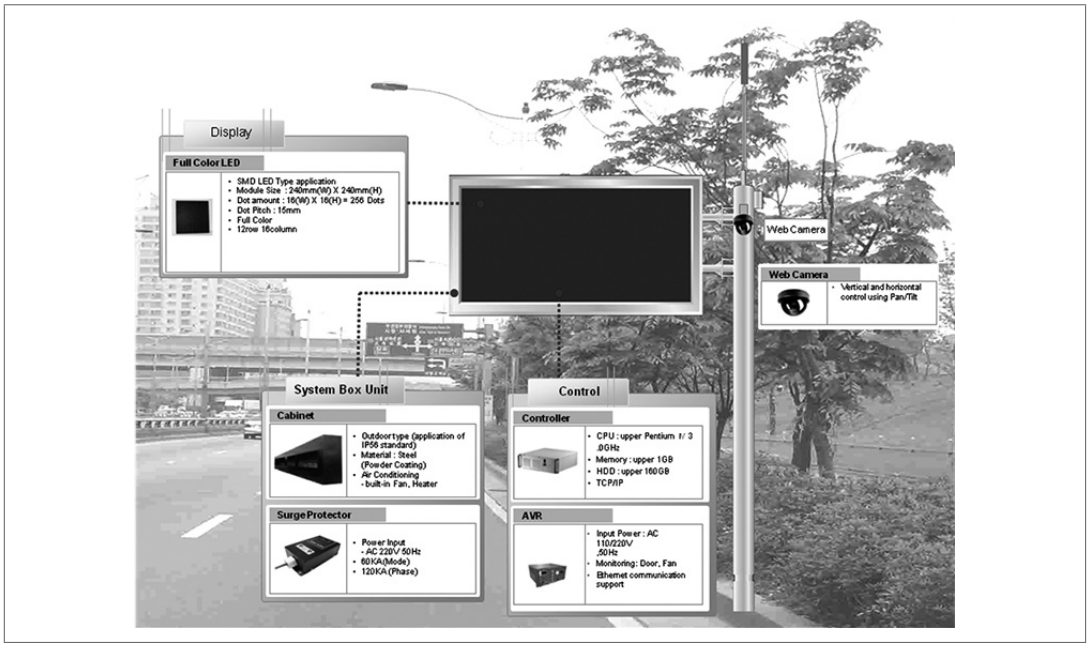
Source: Compiled by KSP Research Team (2015).

1.4. Customized Traffic Information Provision System

1.4.1. Service Concept

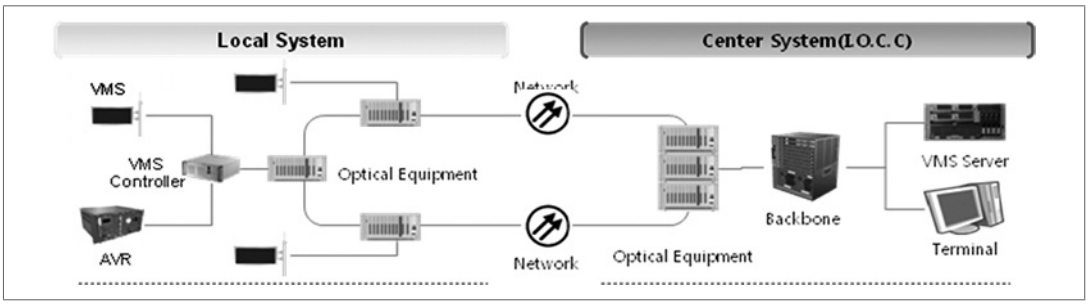
A huge display screen (VMS) shall be installed on site to display traffic information sent from IOCC in real time. Display size shall be determined depending on the road width.

Figure VII-13 | VMS Components



Source: Paraguay ITS basic design report, 2013, KOICA.

Figure VII-14 | Concept of Customized Traffic Information Provision System



Source: Compiled by KSP Research Team (2015).

System Admin should be able to write and edit information on the display screen. This information should be displayed according to message list input/edit and schedule. The IOCC should be able to control and monitor the displayed information, and in case of error system, the Center can reset and correct a display via remote.

The system should have remote control functions such as automatic brightness adjustment function, self-diagnosis and restoration function. In consideration of convenient maintenance, a parallel LED module should be used since this will not affect other modules should errors occur.

1.4.2. Installation Plan

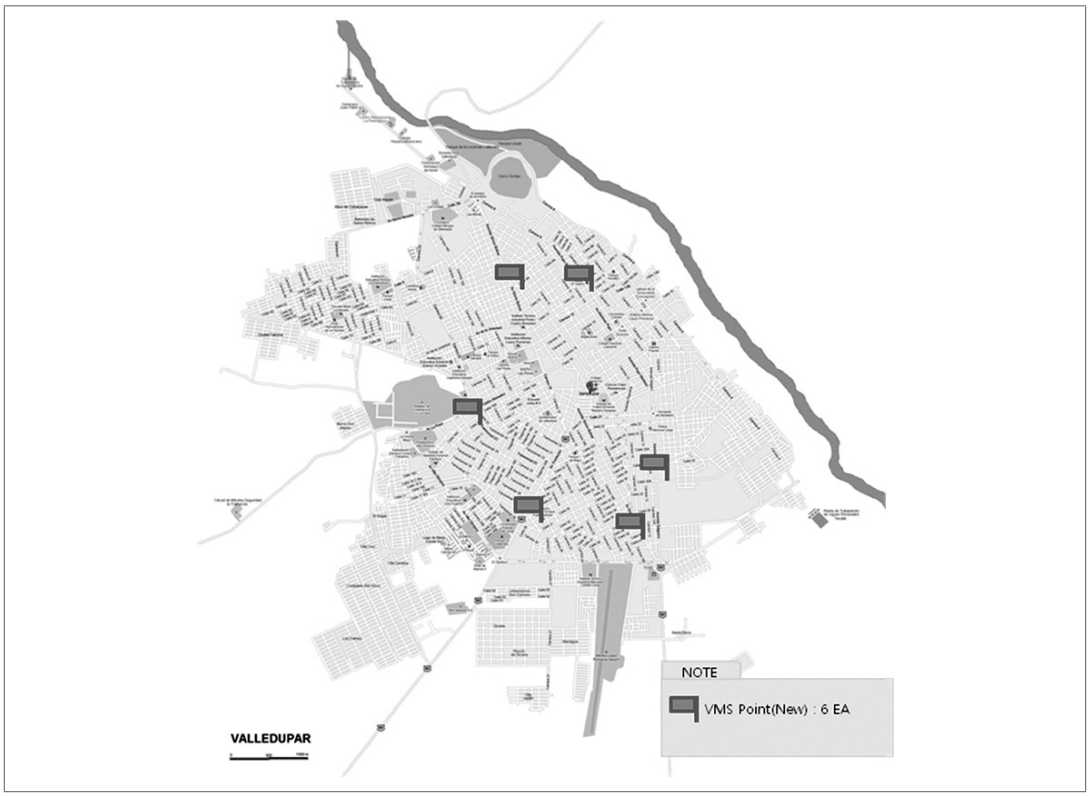
Installation should be made in places that have no hindrance of view by roadside trees or other similar obstacles. Areas that are routed with high-tension wires, communication cables, etc. should be avoided, where possible. Measures to protect the Customized Traffic Information Provision System installed on site from damage, whether intentional or otherwise should be considered in the same way as Real Time Traffic Signal Control System.

1.4.3. Installation Plan and Construction Quantity

1) Valledupar

Customized Traffic Information Provision System should be installed on entry and exit roads as well as on main roads of the city. In sum, installation can be made in a total of six sites in Valledupar, specifically north and south entry roads, and main city roads.

Figure VII-15 | Valledupar: Sites for Traffic Information Provision System



Source: Compiled by KSP Research Team (2015).

Construction quantity of traffic information provision system to be installed in Valledupar is shown below.

Table VII-7 | Valledupar: Required Items for Traffic Information Provision System

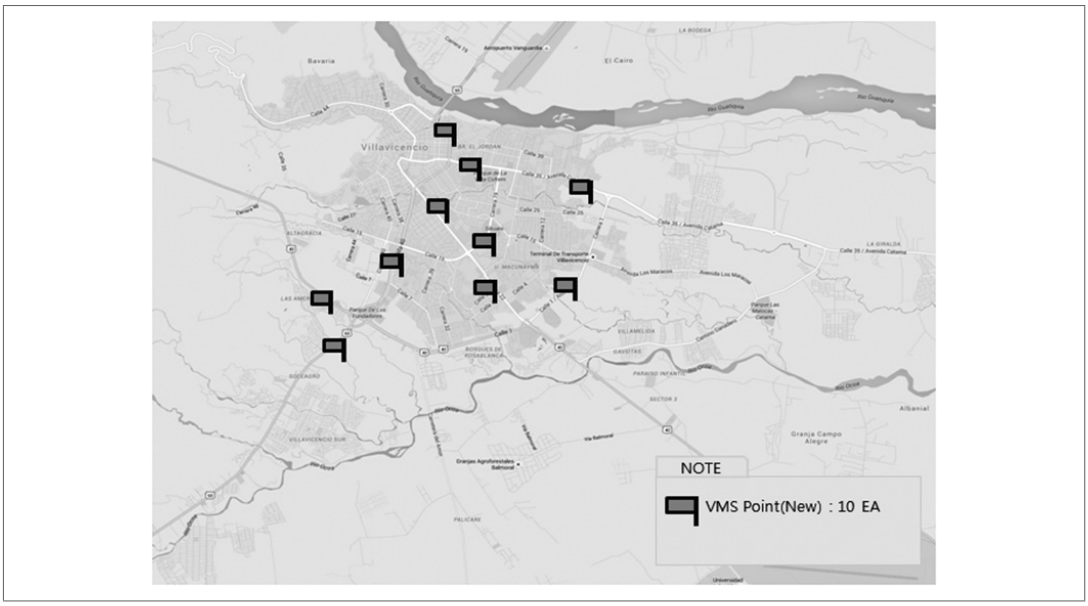
Item	Specification	Unit	Quantity	Note
LED Module	Full Color, module type	Set	6	• Includes Power Supply and case
Main Controller	HDMI 1.3a	EA	6	• 19″ rack type
Sub Controller	1 in 1 out	EA	6	• 19″ rack type
Display PC	Pentium	EA	6	• Includes monitor, mouse, keyboard
Web Camera	More than 2M Pixel	EA	6	• Includes dome type zoom lens/pan tilt
Control housing	Stainless Steel	EA	6	• Pan attached, includes combination lock
Structure (Pole)	Special Made	EA	6	• Hot dip, includes battery/lightening rod
Hand hole	800 x 800 x 800	EA	6	• Concrete, combination lock

Source: Compiled by KSP Research Team (2015).

2) Villavicencio

It is recommended that Customized Traffic Information Provision System be installed on entry and exit roads and on main roads of the city. Therefore, installation will be made in a total of 10 sites in Villavicencio – on north and south, west entry roads and main city roads.

Figure VII-16 | Villavicencio: Sites for Traffic Information Provision System



Source: Compiled by KSP Research Team (2015).

Construction quantity of customized traffic information provision system to be installed in Villavicencio is shown below.

Table VII-8 | Villavicencio: Required Items for Traffic Information Provision System

Item	Specification	Unit	Quantity	Note
LED Module	Full Color, module type	Set	10	• Includes Power Supply and case
Main Controller	HDMI 1.3a	EA	10	• 19″ rack type
Sub Controller	1 in 1 out	EA	10	• 19″ rack type
Display PC	Pentium	EA	10	• Includes monitor, mouse, keyboard
Web Camera	More than 2M Pixel	EA	10	• Includes dome type zoom lens/Pan tilt
Control housing	Stainless Steel	EA	10	• Pan attached, includes combination lock
Structure (Pole)	Special Made	EA	10	• Hot dip, includes battery/lightening rod
Hand hole	800 x 800 x 800	EA	10	• Concrete, combination lock

Source: Compiled by KSP Research Team (2015).

1.5. Public Transportation Information Control System

1.5.1. Service Concept

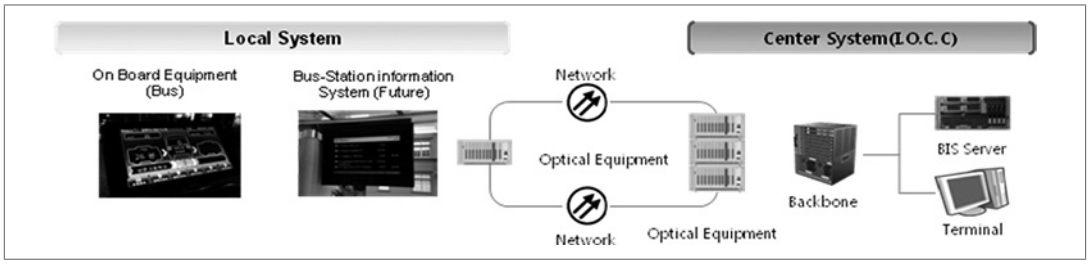
Public Transportation Information Control System is a system that collects and processes real time operation information data from IOCC and via a terminal installed inside the site vehicle. The terminal installed inside the site vehicle uses GPS and wireless communication module to collect and send the data to IOCC. The message received from IOCC is then displayed on Automobile Terminal (OBE: On Board Equipment) screen, and provide road users with higher convenience and access to information such as route change, etc.

Figure VII-17 | Concept of On-Board Equipment Components



Source: (http://www.idomin.com/news/articleView.html?idxno=323027

Figure VII-18 | Concept of Public Transportation Information Management System



Source: Compiled by KSP Research Team (2015).

1.5.2. Installation Plan

The initial goal of this project is for the local government to control public transportation vehicles' operation and to computerize various foundational data. In principle, information management service should be constructed after travel routes are sorted out and a more stabilized operation of public transportation culture has set in. Authorities also need to take into account that prerequisite for constructing an efficient information management service requires first and foremost improvements on foundation facility of a city's stations, public transportation route improvements,

and other aspects that affect the system's operational efficacy.

Also, technologies provision needs to be made. For example, in order to allow OBE and the Control Center to send and receive information, a wireless network needs to be in place. The simplest method is to use GSM or WCDMA type commercial network, where the local government could borrow the data network from a commercial business. In this case, OBE should have a GSM or CDMA type data interface. If commercial network is unavailable, a separate WiMax network or Trunked Radio wireless network should be constructed.

1.5.3. Installation Plan and Construction Quantity

Construction quantity of customized transportation information provision system to be installed in Valledupar is shown below.

1) Valledupar

Table VII-9 | Valledupar: Required On Board Equipment

Item	Specification	Unit	Quantity	Note
Automobile Terminal (OBE)	7-inch, GPS built-in wireless communication module	Set	100	• Includes automobile attachment bracket

Source: Compiled by KSP Research Team (2015).

2) Villavicencio

Similarly, construction quantity of customized transportation information provision system to be installed in Villavicencio is shown below.

Table VII-10 | Villavicencio: Required On Board Equipment

Item	Specification	Unit	Quantity	Note
Automobile Terminal (OBE)	7-inch, GPS built-in wireless communication module	Set	100	• Includes automobile attachment bracket

Source: Compiled by KSP Research Team (2015).

2. Security Services

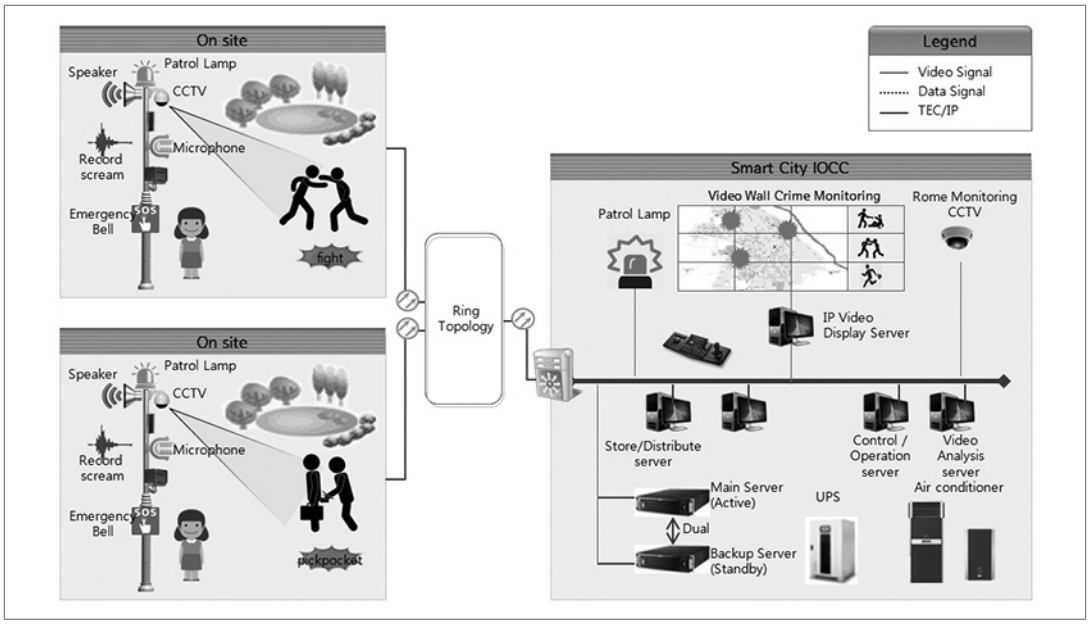
2.1. Intelligent Crime Prevention System

2.1.1. Service Concept

Intelligent Crime Prevention System comprised Site Equipment which includes a high functioning rotating and fixed camera, high functioning speaker, emergency alarm, warning light, network that connects Site Equipment and IOCC, together with IOCC Server and Software.

A detailed Block Diagram is shown below.

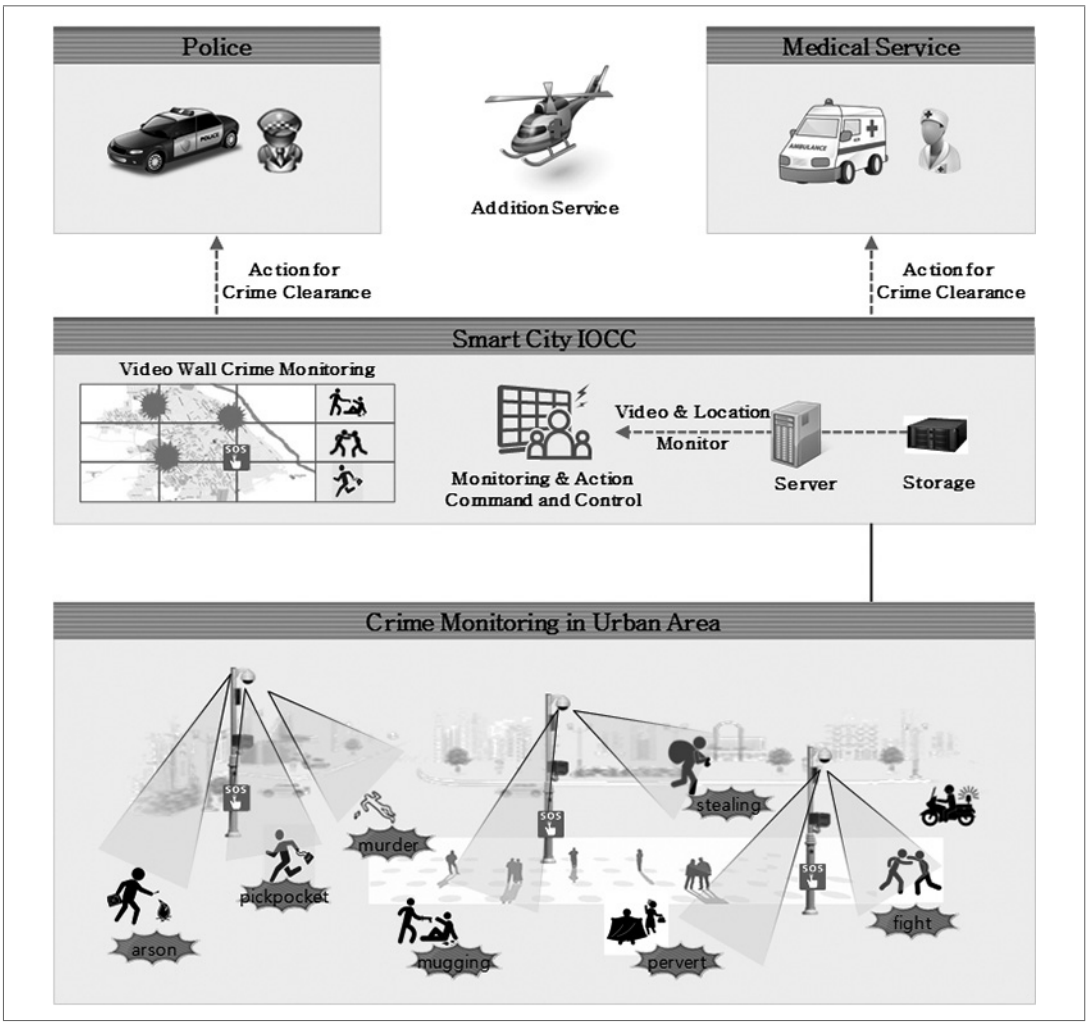
Figure VII-19 | Concept of Intelligent Crime Prevention System



Source: Compiled by KSP Research Team (2015).

Crime Prevention System information flow is based on on-site crime prevention video and other information. When a crime occurs and detected, IOCC refers and requests to handle situation to police, army, rescue team, so that quick actions are taken according to situation. In emergency and when necessary, alarm siren is rung and warning announcement is made to protect citizens from criminals.

Figure VII-20 | Operational Flow of Intelligent Crime Prevention System



Source: Compiled by KSP Research Team (2015).

Real time crime surveillance is made possible with CCTV. When a crime occurs nearby, CCTV can be utilized. IOCC can produce integrated analysis of the on-going situation on-site and take prompt action to safeguard the rights of the citizens.

IOCC can prevent crime through warning announcement. Upon emergency, on-site emergency alarm can be rung by the citizens and prevent emergency through a real time two-way communication with IOCC.

2.1.2. Installation Plan

Intelligence Crime Prevention System is to be connected to the existing CCTV in operation. Newly installed intelligence CCTVs in main crime-ridden areas act as crime prevention cameras. Site

Equipment conditions require on-site Integrated Disaster Surveillance System to be protected from external hazards and threats:

- Structure (pole) installed on site (foundation construction that holds up the pole and structure) should endure hurricane, wind, heavy rainfall, earthquake, etc.
- Structure (pole) height should be chosen and installed among/within 9m/15m/25m according to appropriate usage purpose.
- All facilities should be installed in locations that do not disturb pedestrians.
- Structure (pole) and control housing should be installed in stainless steel, which does not rust.
- Structure (pole) and control housing should be grounded to protect the equipment from thunderbolt (direct thunder, induced thunder).
- Height of controller housing where the controller is installed in should take flooding risks into consideration.
- Control housing should have waterproof and dustproof function to be protected from wind, dust, and heavy rain.
- Control housing should have a locking device so that only authorized personnel can open it.
- Automatic Voltage Regulator (AVR) should be used to provide stable power.
- Sign that cautions penalty for intentional damaging of signal controller should be posted.

2.1.3. Installation Plan and Construction Quantity

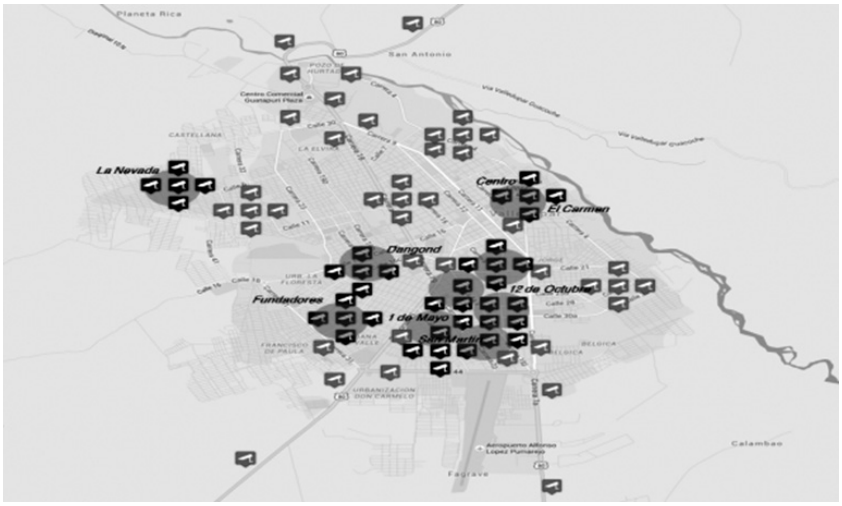
1) Valledupar

Crime Prevention System installed in 78 sites in three stages, mainly in areas that have frequent violent crimes such as homicide, theft, and violence. Location wise, tourist sites and city center are at risk where frequency of pickpocket and robbery is relatively high. Installation of CCTVs at major crossroads can be used to trace criminals' escape route to track and arrest criminals.

Strategic location to install CCTVs is determined by first considering factors related to previous crime surveillance, detection, track and arrest of crime-ridden areas. After the system is in place, surveillance will take place 365 days a year, 24 hours a day.

The best location to install on-site Intelligence Crime Prevention System CCTV is shown as follows.

Figure VII-21 | Valledupar: CCTV Locations for Crime Prevention System



Source: Compiled by KSP Research Team (2015).

Most of the 46 homicide cases took place in 2015 involved firearms. Areas that often suffered such violent crimes were La Nevada (7%), Fundadores (6%), Primea de Mayo (4%), and Mareigua (4%).

Construction quantity of Intelligence Crime Prevention System is shown below.

Table VII-11 | Valledupar: Required Items for Crime Prevention System

Item	Specification(function)	Unit	Quantity	Note
CCTV camera	2M Pixel (Includes zoom lens, housing, pan tilt)	SET	78	• Supports HD-IP, Day-Night function • Composition : 1 rotating type, 3 fixed type
emergency alarm	Special made	EA	78	• Includes microphone
Speaker	More than rated output of 36W	EA	78	• Includes AMP
Multi-function Controller	Supports IP	EA	78	• Supports IP type communication
AVR	1KVA	EA	78	• 19″Rack Type
Control housing	Stainless	EA	78	• Cmbination lock, pan attached, 19″ Rack Type
Structure	Special made	EA	78	• Above 15m, safety foothold, lightning rod
Hand hole	Special made	EA	78	• Concrete, combination lock

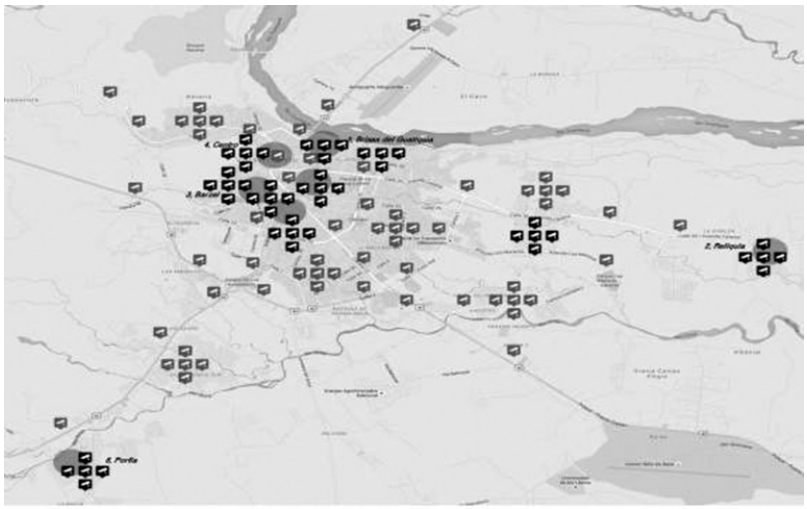
Source: Compiled by KSP Research Team (2015).

2) Villavicencio

It is proposed that Intelligent Crime Prevention System will be installed in 70 sites in three stages, mainly in areas that recorded highest frequency of violent crimes, i.e., homicide, theft, and violence. At tourist sites and city center where pickpocketing and robbery often take place, CCTVs can be used effectively to track and arrest criminals round the clock. Consideration for CCTV installation location was made based on previous crime rate and surveillance at crime-ridden areas.

Location of Intelligent Crime Prevention System CCTV to be installed on-site is shown below.

Figure VII-22 | Villavicencio: CCTV Locations for Crime Prevention System



Source: Compiled by KSP Research Team (2015).

Quantity of construction of Intelligent Crime Prevention System is shown below.

Table VII-12 | Villavicencio: Required Items for Crime Prevention System

Item	Specification(function)	Unit	QTY	Note
CCTV Camera	2M Pixel (Includes zoom lens, housing, pan tilt)	SET	70	• Supports HD-IP, Day-Night function • Composition : 1 rotation type, 3 fixed type
Emergency alarm	Special made	EA	70	• Includes microphone
Speaker	More than rated output of 36W	EA	70	• Includes AMP
Multi-function Controller	Supports IP	EA	70	• Supports IP type communication
AVR	1KVA	EA	70	• 19″Rack Type
Control housing	Stainless	EA	70	• Combination lock, pan attached, 19″Rack Type
Structure	Special made	EA	70	• Above 15m, safety foothold, lightning rod
Hand hole	Special made	EA	70	• Concrete, combination lock

Source: Compiled by KSP Research Team (2015).

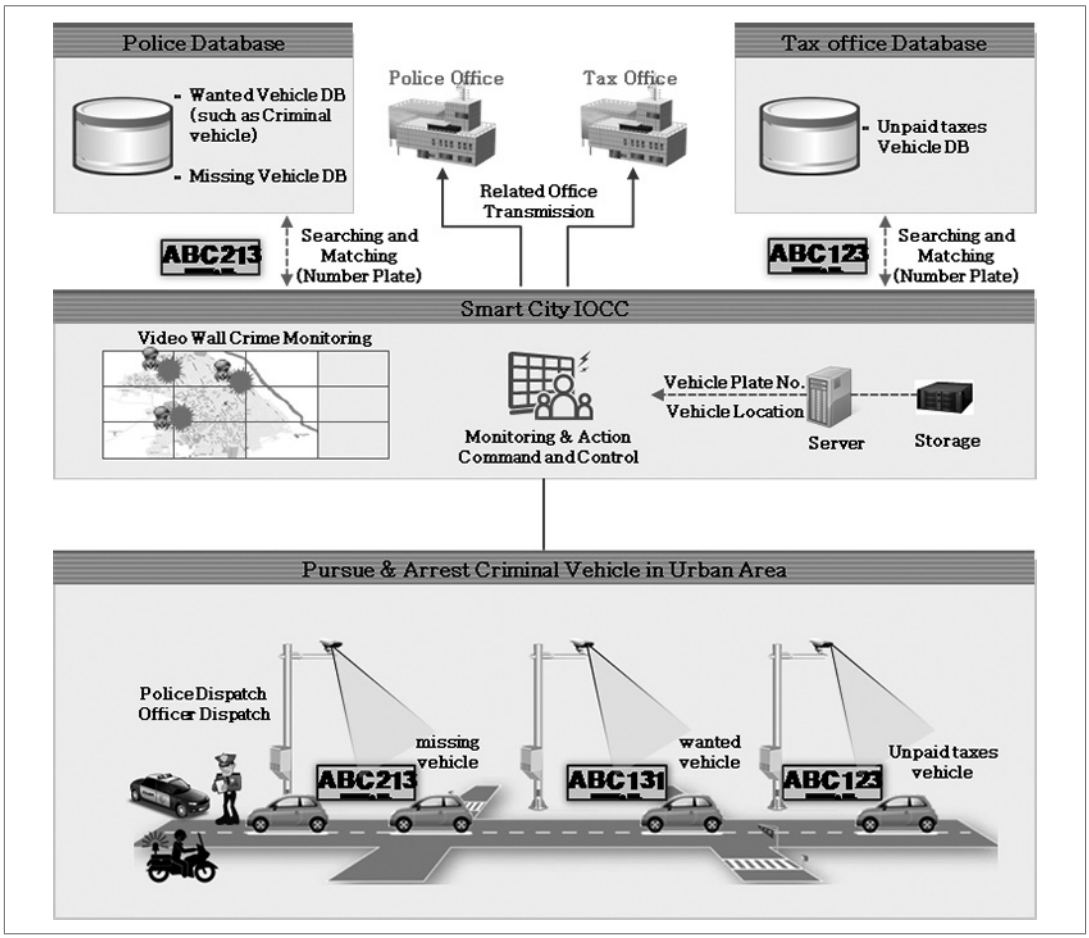
2.2. Criminal Automobile Tracking System

2.2.1. Service Concept

Criminal Automobile Tracking System comprises the following components of Site Equipment: high functioning rotating and fixed cameras, network that connects Site Equipment and IOCC, IOCC server, software, police department and local government crime vehicle DB.

Criminal Automobile Tracking System consists of Site Equipment and center system. This Block Diagram is shown as follows.

Figure VII-23 | Concept of Automobile Tracking System



Source: Compiled by KSP Research Team (2015).

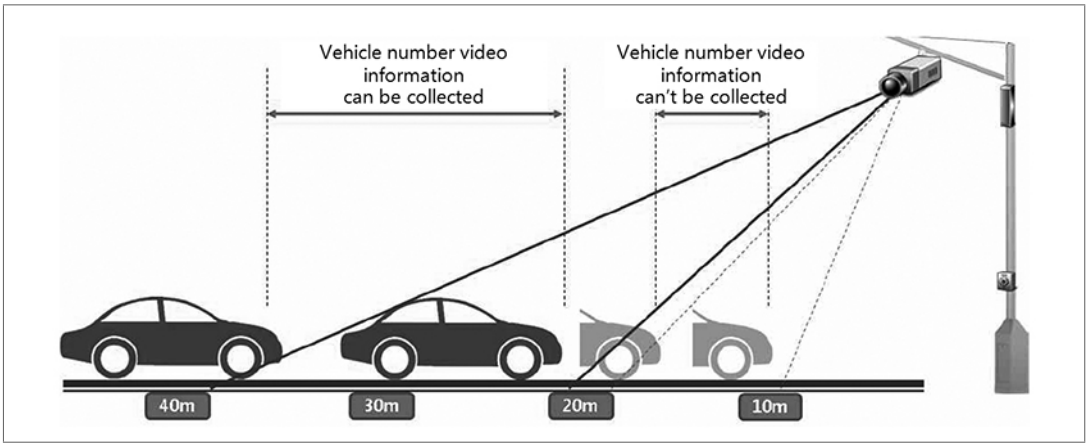
2.2.2. Installation Plan

The general conditions for the installation of Criminal Automobile Tracking System camera pertaining to camera position, direction, and angle are as follows.

- Vehicles' license plate's collectable angle should be obtained.
- Upon CCTV installation and selection, camera type, direction, angle, height, etc. should be sufficiently considered to allow reliable recording of license plates.
- Fixed type camera should be installed on the upper but lower part of the arm so that camera can be operated with the same angle as that of the crime prevention camera.
- If the up down recording angle of the camera is too wide, it will be difficult to make accurate recognition due to not enough license plate recognition range and too short amount of vehicle exposure time.

- If the left right recording angle of the camera is too wide, license plates will be tilted and will not be recognized properly.
- Even if the camera's up down recording angle is appropriate, if the installation height is too high the recording video gets too wide an angle and will not be able to recognize license plates.
- Video collection range for different camera recording angles is shown below.

Figure VII-24 | Distance Required for License Plate Recognition



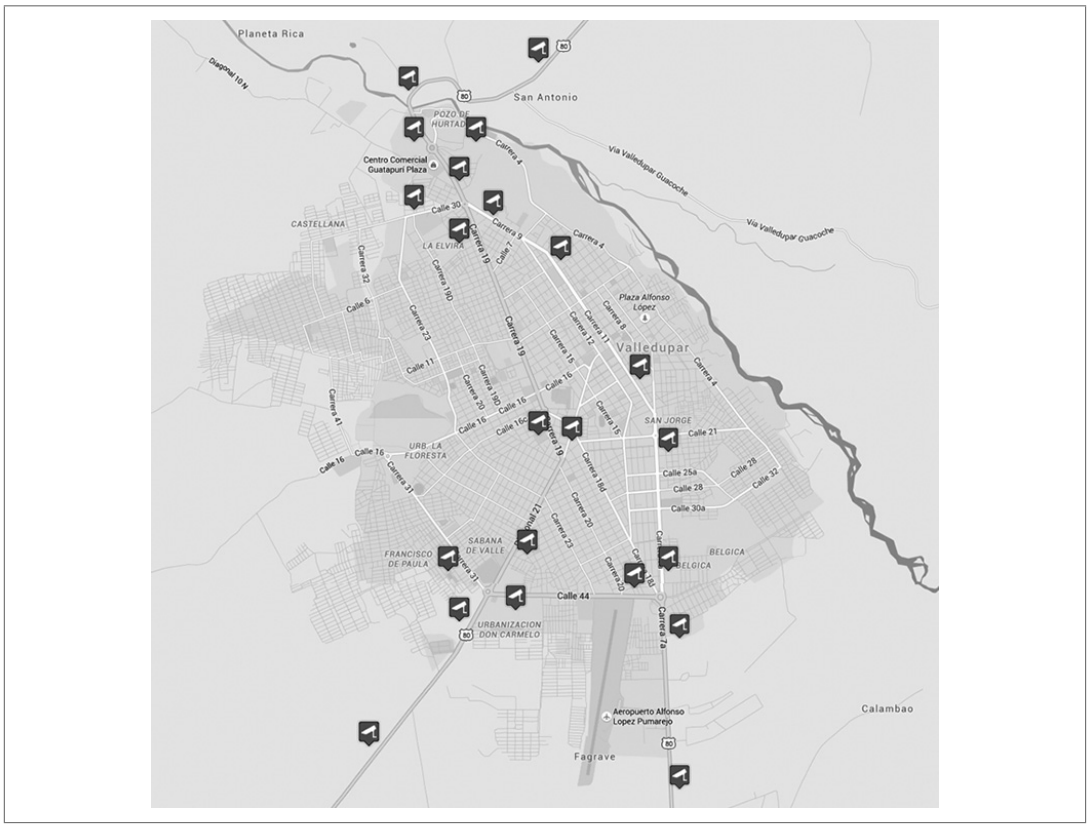
Source: Gwanak-gu Promotion Computerization and Integrated Control Team.

2.2.3. Installation Plan and Construction Quantity

1) Valledupar

Criminal Automobile Tracking System shall be installed in 56 sites in three stages, to detect and stop detected crime vehicles as a crime prevention measure. The figure below illustrates the location of Criminal Automobile Tracking System CCTV to be installed on-site.

Figure VII-25 | Valledupar: CCTV Locations for Automobile Tracking System



Source: Compiled by KSP Research Team (2015).

Quantity of construction of Criminal Automobile Tracking System is shown below.

Table VII-13 | Valledupar: Required Items for Vehicle Tracking System

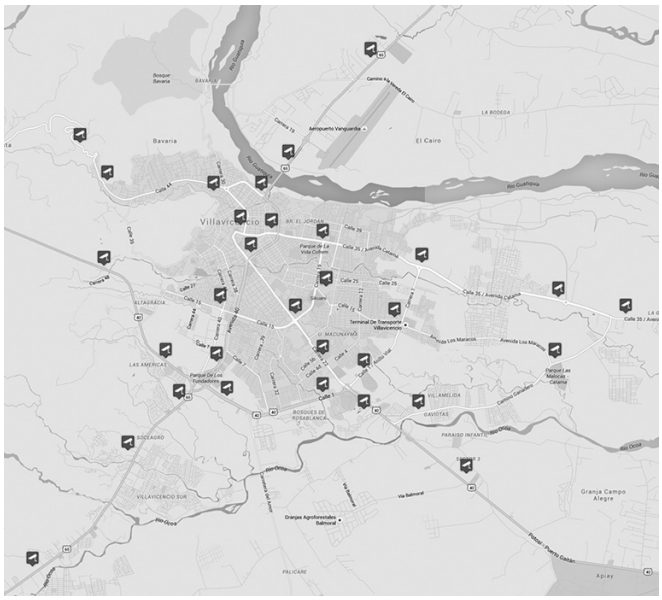
Item	Specification(function)	Unit	Quantity	Note
CCTV camera	2M Pixel (Includes zoom lens, housing, pan tilt)	Set	56	Supports HD-IP, Day-Night function Composition : 1 rotating type, 3 fixed type
Multi-function Controller	Supports IP	EA	56	Supports IP type communication
AVR	1KVA	EA	56	19″Rack Type
Control housing	Stainless	EA	56	Combination lock, pan attached, 19″Rack Type
Structure	Special made	EA	56	Above 15m, safety foothold, lightning rod
Hand hole	Special made	EA	56	Concrete, combination lock

Source: Compiled by KSP Research Team (2015).

2) Villavicencio

Criminal Automobile Tracking System shall be installed in 60 sites in three stages, mainly on main city entrance and exit roads and crossroads, this will enable detection and location recognition of crime vehicle. Location of Criminal Automobile Tracking System CCTV to be installed on site is shown below.

Figure VII-26 | Villavicencio: CCTV Locations for Automobile Tracking System



So.urce: Compiled by KSP Research Team (2015)

Table VII-14 | Villavicencio: Required Items for Vehicle Tracking System

Item	Specification(function)	Unit	Quantity	Note
CCTV camera	2M Pixel (Includes zoom lens, housing, pan tilt)	Set	60	Supports HD-IP, Day-Night function Composition : 1 rotating type, 3 fixed type
Multi-function Controller	Supports IP	EA	60	Supports IP type communication
AVR	1KVA	EA	60	19″Rack Type
Control housing	Stainless	EA	60	Combination lock, pan attached, 19″Rack Type
Structure	Special made	EA	60	Above 15m, safety foothold, lightning rod
Hand hole	Special made	EA	60	Concrete, combination lock

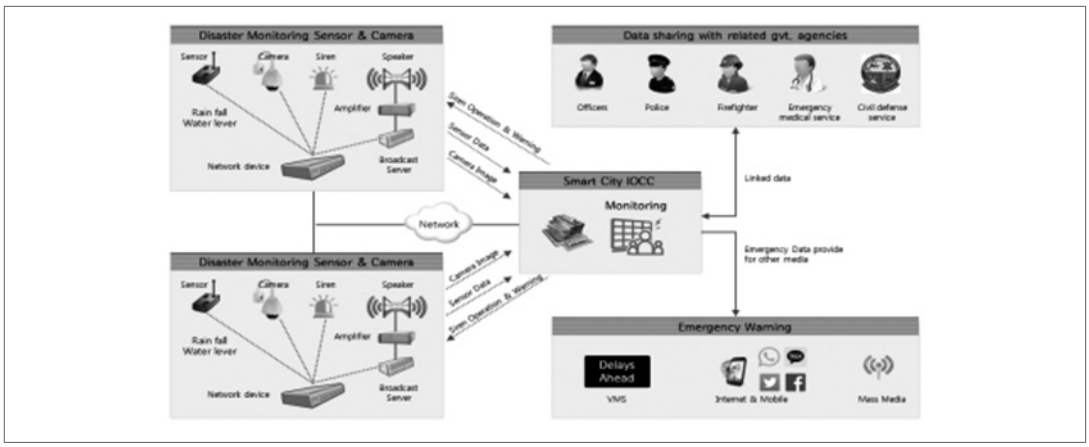
3. Disaster Service

3.1. Integrated Disaster Surveillance System

3.1.1. Service Concept

Integrated Disaster Surveillance System comprises of Site Equipment which includes high functioning rotating and fixed camera, high functioning speaker, water level detection sensor, and rainfall detection sensor, network that connects Site Equipment and IOCC, and IOCC server and software. Integrated Disaster Surveillance System includes Site Equipment and center system and its detailed Block Diagram is shown below.

Figure VII-27 | Concept of Integrated Disaster Surveillance System



Source: Compiled by KSP Research Team (2015).

Emergency danger situations are notified through automatic water level increase and stream overflow observation done with Disaster related USN sensor (water gauge, rain gauge, etc.) and a communication network that allows detecting water level and transmitting information.

Also, when monitoring personnel is out of his/her place during the 24-hour disaster CCTV control, abnormalities input into CCTV video via water level sensor, flow meter, etc. are automatically detected and notified to person in charge via SMS or alarm system to prevent disasters and accidents. A smarter disaster control is indeed possible.

When disasters such as flood, fire, landslide, traffic accident, etc. occur, citizens' lives and assets can be protected through disaster warning, evacuation guidance, and rescue activities using CCTV and various state of the art detection sensors. In other words, real time rainfall is measured and water level of chronically flooding area can be predicted to minimize damages caused by flood. Upstream rainfall detection information is also used to set off flood warning and alarm to secure sufficient evacuation time (golden time).

3.1.2. Installation Plan and Construction Quantity

Due to climate change, people who live on the stream bank or on the downstream suffer gravely from hurricane and flood which are costing them of their lives and assets. Such stream overflow and flood damages have been reoccurring every year but reports are made only when people notify the City Hall after the disaster has already taken place. Thus, a real time automatic measurement and alarm system that uses USN sensor (water gauge, river gauge) and disaster surveillance CCTV is in urgent need. Disasters are categorized into fire, flood, and landslide and each disaster's characteristics and surrounding environment should be considered to optimize the location of surveillance camera and alarm system before installation.

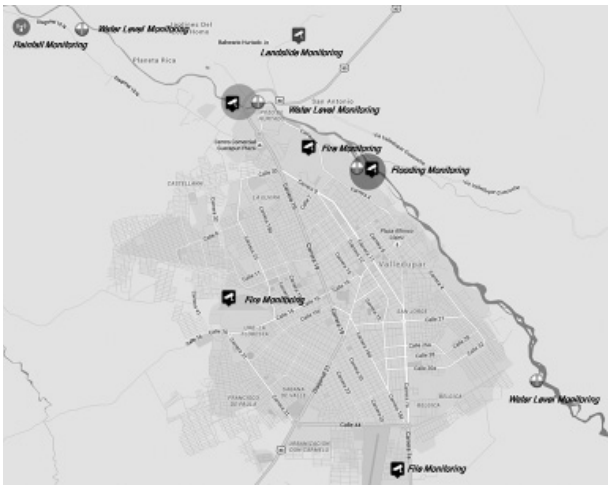
1) Valledupar

Integrated Disaster Surveillance System shall be installed in 12 sites in 3 stages, mainly in areas where disasters such as fire, flood, river overflow, landslide, etc. occur frequently.

In the case of Valledupar, stream overflow and flood damages have been reoccurring every year but reports are made only when people notify the City Hall after the disaster has already taken place. A real time automatic measurement and alarm system that uses USN sensor (water gauge, river gauge) and disaster surveillance CCTV is in desperate need.

Climate change has brought flood every year and cause suffering to citizens who live on the stream bank or on the downstream, costing them of their lives and/or assets. Valledupar disaster surveillance shall be categorized into fire, flood, and landslide, and each disaster's characteristics and surrounding environment should be considered to optimize the location of surveillance camera and alarm system before installation. Location of disaster surveillance CCTV and sensor to be installed on site is shown below.

Figure VII-28 | Valledupar: CCTV and Sensor Locations for Disaster Surveillance



Source: Compiled by KSP Research Team (2015)

Construction quantity of Integrated Disaster Surveillance System is shown below.

Table VII-15 | Valledupar: Required Items for Disaster Surveillance System

Item	Specification(function)	Unit	Quantity	Note
CCTV camera	Rotating 2M Pixel	SET	12	• Supports HD-IP, Day-Night function
Emergency alarm	Special made	EA	12	• Includes microphone
Speaker	More than rated output of 36W	EA	12	• Includes AMP
Water level detection sensor	Water Level Sensor	EA	10	• Includes controller, housing, structure
Rainfall detection sensor	Rain Meter Sensor	EA	6	• Includes controller, housing, structure
Multi-function Controller	Supports IP	EA	12	• Supports IP type communication
AVR	1KVA	EA	12	• 19″Rack Type
Control housing	Stainless	EA	12	• Combination lock, pan attached, 19″Rack Type
Structure	Special made	EA	12	• Above 15m, safety foothold, lightning rod
Hand hole	Special made	EA	12	• Concrete, combination lock

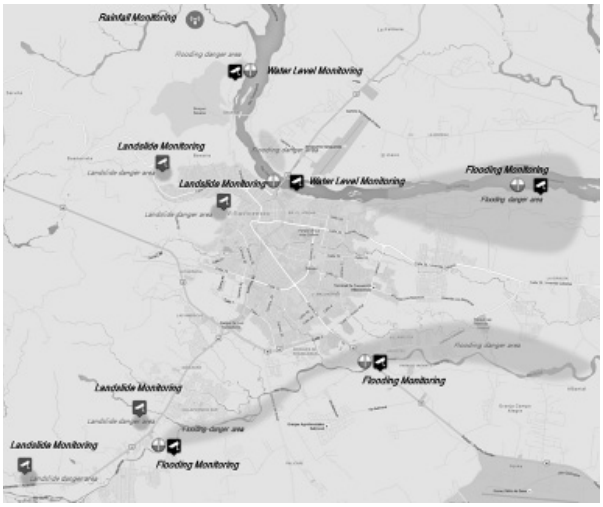
Note) Disaster warning announcement is made through nearby speaker upon disaster to evacuate citizens. Small VMS can be installed in flood, overflow prone areas such as bridge entrance and exit to guide disaster information when necessary.

Source: Compiled by KSP Research Team (2015).

2) Villavicencio

Integrated Disaster Surveillance System shall be installed in 10 sites in 3 stages mainly in areas where disasters such as fire, flood, river overflow and landslide occur frequently.

Figure VII-29 | Villavicencio: CCTV and Sensor Locations for Disaster Surveillance



Source: Compiled by KSP Research Team (2015).

Construction quantity of Integrated Disaster Surveillance System is shown below.

Table VII-16 | Villavicencio: Required Items for Disaster Surveillance System

Item	Specification(function)	Unit	Quantity	Note
CCTV camera	Rotating 2M Pixel	SET	10	• Supports HD-IP, Day-Night function
Emergency alarm	Special made	EA	10	• Includes microphone
Speaker	More than rated output of 36W	EA	10	• Includes AMP
Water level detection sensor	Water Level Sensor	EA	8	• Includes controller, housing, structure
Rainfall detection sensor	Rain Meter Sensor	EA	6	• Includes controller, housing, structure
Multi-function Controller	Supports IP	EA	10	• Supports IP type communication
AVR	1KVA	EA	10	• 19″Rack Type
Control housing	Stainless	EA	10	• Combination lock, pan attached, 19″ Rack Type
Structure	Special made	EA	10	• Above 15m, safety foothold, lightning rod
Hand hole	Special made	EA	10	• Concrete, combination lock

Note) Disaster warning announcement is made through nearby speaker upon disaster to evacuate citizens. Small VMS can be installed in flood, overflow prone areas such as bridge entrance and exit to guide disaster information when necessary.

Source: Compiled by KSP Research Team (2015).

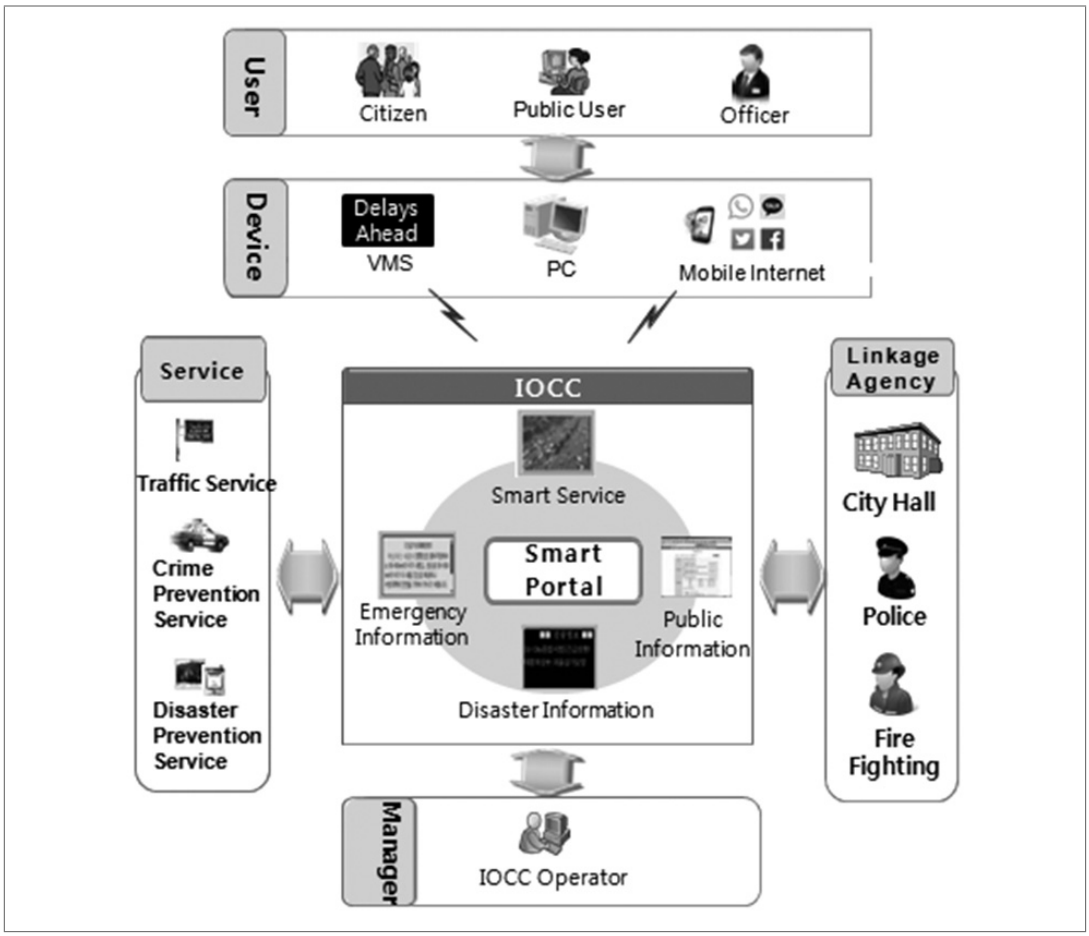
4. Common Administration Services

4.1. Smart Portal Service

4.1.1. Service Concept

The conceptual design of the Smart Portal System is as follows:

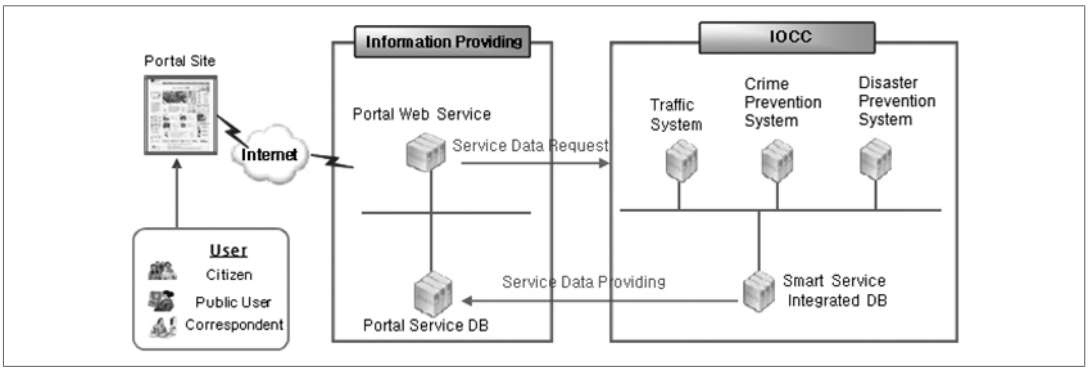
Figure VII-30 | Concept of Smart Portal Service



Source: Compiled by KSP Research Team (2015).

The Smart Portal System's hardware components use separate web servers, e.g., a WAS server for stable operation. A single server for each function is designated for higher efficiency. Application software and commercial software suited for each system are selected to form and provide a smooth running website service.

Figure Ⅶ-31 | Principles of Smart Portal Service



Source: Compiled by KSP Research Team (2015).

4.1.2. Installation Plan

The installation plan involves following four procedures, as presented here:

1) Web Style Guide

The Smart Portal website is designed following a consistent design policy. Maintenance of consistency and efficiency improvement are ensured for future website maintenance and editing.

2) User Oriented Service

Quick and accurate information is provided to the user to ensure user's convenience in using the portal website. Errors and inconveniences are to be immediately reported and the Portal Administrator is trained to quickly respond to reports and to take remedial action.

3) Personal Information Protection

Portal website has functions that recognize and provide these services: membership enrolment, change of member information, ID and password search service, etc. All these functions adhere to regulations on personal information protection policy.

4) Web Accessibility

To allow anyone to access and use the portal website easily in any kind of environment, all web pages are to follow and realize web standardization, browser compatibility, and web accessibility related guideline. For example, standards used will follow web policies under these regulations: America's Rehabilitation Act Article 508, W3C DOM 2.0; World Wide Web consortium's document object model standard (W3C DOM 2.0); Style definition standard for web document components (CSS 1.0); Homepage language usage standard (HTML 4.01 or XHTML1.0); Protocol standard used on Internet to transfer document (HTTP 1.1); and Expandability mark-up language standard (XML 1.0) as well as extensible style language standard (XSL 1.0)

4.1.3. Installation Plan and Construction Quantity

Specifications for the construction of Smart Portal Service System that will be installed in target cities are shown below.

Table VII-17 | Required Servers for Smart Portal Service

Category	Specification	Unit	Quantity	Note
Web server	Linux Server	Set	1	Rack type
WAS server	Linux Server	Set	1	Rack type

Source: Compiled by KSP Research Team (2015).

5. IOCC

5.1. IOCC Construction

5.1.1. Condition of IOCC Location

- IOCC has to have great accessibility so that pedestrians and cars have no problems in approaching and entering.
- There needs to be foundational facility for construction, such as waterworks, sewage, electricity, communication, etc.
- It should be located in a safe location away from disasters such as fire, flooding, earthquake, landslide, and other non-natural disasters associated to risks with gas storage, electric furnace and chemical plant, welding site, wooden building, etc.
- Areas around railway, congested highway, and airport should be avoided. It should be located in an area where there is no communication hindrance for wireless antenna installation.
- Buildings should be placed so that IOCC can become an energy efficient building. All building form and bearings should also be set to meet such standards.

Figure VII-32 | Example of IOCC



IOCC Monitoring Room



IOCC Exterior

Source: Compiled by KSP Research Team (2015).

5.1.2. IOCC Components

IOCC should be constructed to satisfy the level above TIA-942 (Telecommunication Infrastructure Standard for Data Center) Tier-2.

IOCC is a venue that constructs, operates, and controls IT system and infrastructure required in executing overall city management functions such as transportation, crime prevention, disaster prevention, 24 hours a day, 365 days per year.

Its main components are as follows.

Table VII-18 | Major Components of IOCC Infrastructure

Category	Details	Note
Building	• Fire prevention plan, flood damage prevention plan, earthquake proof structure design	• Ceiling height higher than 5m • Area per person larger than 6m²
	• Efficient work space design	
	• Assistance facility such as parking, etc.	
Power, heating/air-conditioning, etc.	• 2-3 systematization of power, self development facility, uninterrupted facility	
	• Temperature, humidity and air freshness control	
Security	• Enter and exit control of people and system	
	• Camera surveillance, building control	
Communication machine room	• Earthquake-proof structure Rack/Cabinet, power, communication and other various cable wiring	
	• Internal safe for data storage	

Source: Compiled by KSP Research Team (2015).

5.1.3. Space Design

1) Design Outline

IOCC consists of 24-hour operated situation room and computer equipment, UPS, IT equipment room where thermo-hygrostat and other equipment can be installed in meeting room, visitation room, training room, and maintenance room. IOCC situation room should be efficiently designed to allow simultaneous monitoring of both transportation information and various CCTV videos. It should also be designed in a manner that assures refreshing, efficient work of the employees, even after long hours.

2) Space Composition

Required spatial composition for IOCC is suggested as below, after considering the functionality of IOCC equipment, Admin's comfort, efficiency, and economics.

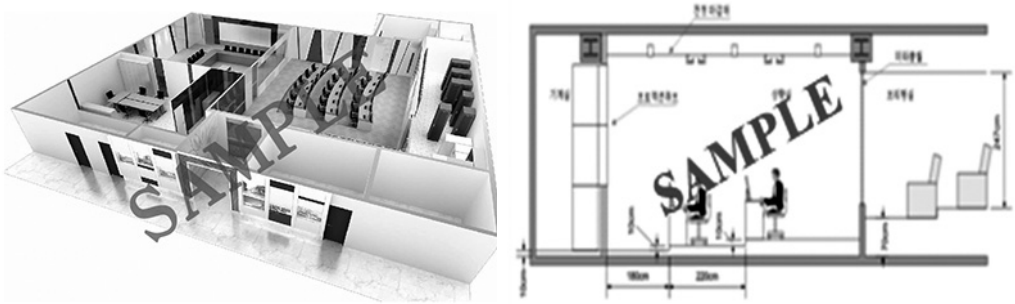
Table VII-19 | Spatial Structure of IOCC

Item	Unit	Area (m²)	Note
Chief of Center Office	Number of persons	30	• Includes working space and secretary room
IT facility room	Rack	200	• Server, rack, UPS, thermo-hygrostat
Control machine room	Rack	80	• Operational Board operation server, broadcasting equipment
Training room (Grand meeting room)	Number of persons	90	• Table, chair, projector, etc.
Situation room	Worker	200	• Manger(1), Admin of each area (transportation, crime prevention, disaster prevention, reserve)
Call center	Number of persons	50	
Visitation room/meeting room	Number of persons	90	• Training room(60), meeting room(30)
Operation room (administration room)	Number of persons	80	
Maintenance room	Number of persons	50	• LAB room
Electricity facility		280	• UPS room, transformer room, dynamo-room
Library and lockers	-	100	• Document storage, warehouse
Night duty and lounge	Number of persons	120	• Worker lounge
Office	-	300	• Center residency institute office
Common area		710	• Corridor, stairs, etc., uses 30% of exclusive use space
Total		2,380	

Source: Compiled by KSP Research Team (2015).

There should be no hindrance when situation room Admin views the Operational Board display. Situation room height should be as high as possible so that chairs should be placed like stairs (higher than about 5m).

Figure Ⅶ-33 | Example of IOCC Spatial Composition and Situational Room



IOCC composition (Example) Situation room composition (Example)

Source: Compiled by KSP Research Team (2015).

5.2. IOCC Operation Hardware

5.2.1. Hardware Composition

1) Hardware Composition Plan

IOCC hardware suggests overall system establishment plan in three stages. Stage 1 is a pilot project that constructs basic, mandatory system that must be constructed for IOCC operation and system required for services implemented in Stage 1; Stage 2 and Stage 3 constructs systems required for additional service and expansion.

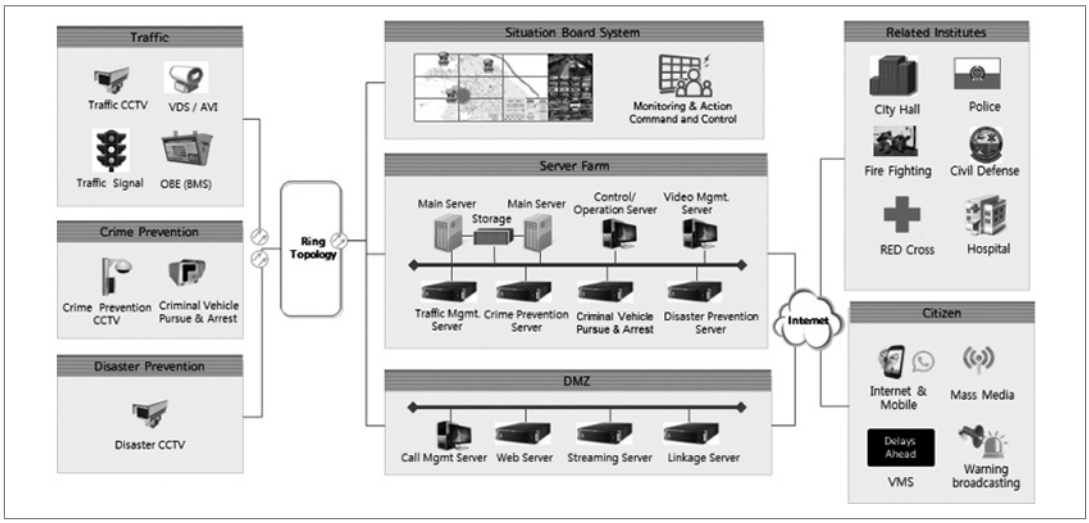
Hardware system consists of hardware equipment such as main server, information collection server, information provision server, communication server and communication facility. Commercial Software includes DBMS, Cluster S/W, Backup S/W, GIS S/W, NMS/SMS, etc., and other devices that are required to operate them, center network facility and UPS, and accessory equipment like thermo-hygrostat, etc.

Main server and backbone, etc., the main system, should be dualized so that they can be operated 24 hours a day, 365 days a year without stopping and provide reliable and stable service. It should be able to expand its functions without replacing equipment or implementing additional equipment upon future expansion of site facility and capacity increase.

Hardware system construction should take the following into consideration.

- Dualization: For cluster on main server, backbone, communication facility, etc., to prepare for errors
- Expandability: Expansion is convenient without System Composition changes; can be prepared against future capacity increase caused by external factors
- Availability: Create equipment that can restore main server as fast as possible when a logical data error occurs.

Figure VII-34 | Example of Hardware Structure



Source: Compiled by KSP Research Team (2015).

2) Server and Storage Device Implementation

Table VII-20 | IOCC Servers and Other Equipments

Equipment name	QTY	Main function	Note
Main server (DB server)	1 Set	• Stores collected data, statistics analysis data	HA composition
Backup device	1 Set	• External disk data automatic backup equipment LTO Tape, etc.	
VDS server	1 Set	• Collect transportation data from VDS	
VMS/backup server	1 Set	• Display message on road and backup	
Signal control server	1 Set	• Center signal control server	
Video storage server	1 Set	• Saves video collected on site	Transportation, crime prevention, disaster
Video distribution server	1 Set	• Transmits video to Operational Board, Operation terminal, outside related organization	Transportation, crime prevention, disaster
Streaming server	1 Set	• Displays video information online	Transportation, disaster
Intelligence video analysis server	1 Set	• Video analysis of surveillance area, video storage and event occurrence	Crime prevention
Vehicle tracking system	1 Set	• Recording and tracking of license plate	

Equipment name	QTY	Main function	Note
BMS server	1 Set	• Collection of bus operation information and bus location information and processing server	
GIS server	1 Set	• Space information control and GIS development tool assistance	
Disaster control server	1 Set	• Disaster information collection and control server	
SMS/NMS/FMS server	1 Set	• Monitoring of status of all servers and Communication network in center, understand the status of all facilities	
Integrated control server	1 Set	• Operational Board Integrated Control	
Command system server	1 Set	• Situation control and dispatch control	
Outside connection server	1 Set	• Communication connection between related centers	
Web server	1 Set	• Intraweb, Internet	
Call center server	1 Set	• Report handling and control	
SAN device	1 Set	• Storage device communication switch	Dualization
Storage	1 Set	• DB and video data storage device	30 days storage

Source: Compiled by KSP Research Team (2015).

3) Network and Security Equipment Implementation

Table VII-21 | IOCC Network and Security Devices

Equipment name	Quantity	Main function	Note
Backbone switch	1Set	• Center internal communication basic switch	Dualization composition
L4 Switch	1Set	• Switch with Internet traffic road balancing function	Dualization composition
L2 Switch	1Set	• Internal equipment connection switch	
Router	1Set	• Exterior equipment connection router	
Firewall	1Set	• Illegal break-in prevention equipment	Dualization composition
IPS	1Set	• Break-in detection system	

Source: Compiled by KSP Research Team (2015).

5.2.2. Server System Capacity Estimation

1) Valledupar Server System

a) Basic Data Quantity

Basic data required to estimate optimum capacity of the main server is described in the following table; it includes site equipment to be installed in Valledupar and items and quantities of logical data.

Table VII-22 | Valledupar: IOCC Server System

Category	Item	Unit	Quantity	Note
Site facility	VDS	ea	20	
	VMS	ea	6	
	CCTV	ea	558	• Transportation, crime prevention, disaster prevention
Logical data	Node	ea	100	• Signal controller installation crossroad
	Link	ea	400	• Number of nodes * 4
	ITS Standard link	ea	100	• Crossroad
	Information provision link	ea	100	• Unit link for information provision service
Related organization	Standard connection	ea	6	

Source: Compiled by KSP Research Team (2015).

b) Server Capacity Estimation Result

(i) Main Server (DB server)

TPM-C model was applied to estimate the capacity of main server where Database Management Software (DBMS), online transaction application, and batch processing are all operated on. Main server standard requires a CPU over 2.4GHz 4Core, memory larger than 32GB, HDD with function greater than two 300GB.

(ii) General Data Storage

Storage is a saving device that saves basic data required for system operation, data collected from site facility, analysis and statistics data. Storage capacity estimation standards and the results are as follows.

Table VII-23 | Valledupar: IOCC Database Storage

Item	Raw data(Byte)	Collection cycle	Storage period	Total size(MB)
VDS traffic	600	30 sec	1 year	1,316,250
VDS status	100	30 sec	1 year	4,285
CCTV status	100	30 sec	1 year	119,542
VMS message	6,000	5 min	1 year	3,856
VMS status	100	30 sec	1 year	1,285
1 min traffic	400	1 min	1 year	329,063
5 min traffic	400	5 min	1 year	131,625
15 min traffic	400	15 min	3 years	131,625
30 min traffic	400	30 min	3 years	65,813
1 hour statistics	400	1 hour	3 years	16,453
Master data			Permanent	5,000
Index(80% of Data Table)				1,699,837
Total/Year				3,824,634

Source: Compiled by KSP Research Team (2015).

(iii) Video Storage

Video storage is a physical saving device that saves digital CCTV video data collected from CCTVs on site. Storage size required to store HD level video data for 30 days is approximately 549.98TB. Therefore there needs to be about 600TB of storage capacity for CCTV video storing.

- Video data size of 1 HD level CCTV: 16.2GB (Storage standard: 720*480, 30 frames, 1 day)

- Size of all CCTV camera video data: 16.2 GB * 558EA * 30Days = 271.19TB

Table VII-24 | Valledupar: IOCC Video Data Storage

Item	Estimated value(TB)	Importance	Note
Data domain	271.19	100%	• 1 CCTV video data/day=16.2GB (720x480 resolution, 30 frame standard)
File system overhead	325.43	20%	• Minimum additional overhead
Array raid mode	423.06	30%	• RAID 5 and Hot spare 30%
System reservation ratio	549.98	30%	
Estimation result	600		• 600TB

Source: Compiled by KSP Research Team (2015).

2) Villavicencio Server System

a) Basic Data Quantity

Basic data required to estimate optimum capacity of the main server is described in the following table. It includes site equipment installed in Villavicencio and items and quantities of logical data.

Table VII-25 | Villavicencio: IOCC Server System

Category	Item	Unit	Quantity	Note
Site facility	VDS	ea	28	
	VMS	ea	10	
	CCTV	ea	542	• Transportation, crime prevention, disaster prevention
Logic data	Node	ea	100	• Signal controller installation crossroad
	Link	ea	400	• Number of nodes * 4
	ITS standard link	ea	100	• Crossroad
	Information provision link	ea	100	• Unit link for information provision service
Related organization	Standard connection	ea	6	

Source: Compiled by KSP Research Team (2015).

b) Server Capacity Estimation Result

(i) Main Server (DB server)

TPM-C model was applied to estimate the capacity of main server where Database Management Software (DBMS), online transaction application, and batch processing are all operated on. Main server standard requires a CPU over 2.4GHz 4Core, memory larger than 32GB, HDD with function greater than two 300GB.

(ii) General Data Storage

Storage is a device that saves basic data required for system operation, data from site facility, analysis and statistics data. Storage capacity estimation standards and results are as follows.

Table VII-26 | Villavicencio: IOCC Database Storage

Item	Raw data(Byte)	Collection cycle	Storage period	Total size(MB)
VDS traffic	600	30 sec	1 year	1,316,250
VDS status	100	30 sec	1 year	5,999
CCTV status	100	30 sec	1 year	116,115
VMS message	6,000	5 min	1 year	6,427
VMS status	100	30 sec	1 year	2,142
1 minute traffic	400	1 min	1 year	329,063
5 minute traffic	400	5 min	1 year	131,625
15 minute traffic	400	15 min	3 years	131,625
30 minute traffic	400	30 min	3 years	65,813
1 hour statistics	400	1 hour	3 years	16,453
Master data			Permanent	5,000
Index(80% of Data Table)				1,701,208
Total/Year				3,827,719

Source: Compiled by KSP Research Team (2015).

(iii) Video Storage

Video storage is a physical saving device that saves digital CCTV video data collected from CCTVs on site. Storage size required to store HD level video data for 30 days is approximately 549.98TB. Therefore there needs to be about 600TB of storage capacity for CCTV video storing.

- Video data size of 1 HD level CCTV: 16.2GB (Storage standard: 720*480, 30 frames, 1 day)

- Size of all CCTV camera video data: 16.2 GB * 542EA * 30Days = 263.41TB

Table VII-27 | Villavicencio: IOCC Video Data Storage

Item	Estimated value(TB)	Importance	Note
Data domain	263.41	100%	• 1 CCTV video data/day=16.2GB (720x480 resolution, 30 frame standard)
File system overhead	316.09	20%	• Minimum additional overhead
Array raid mode	410.92	30%	• RAID mode composition
System reservation ratio	534.19	30%	
Estimation result	600		• 600TB

Source: Compiled by KSP Research Team (2015).

5.2.3. Operational Board

Operational Board is a system that efficiently monitors real time transportation information, accident control, crime prevention and disaster prevention control and that displays necessary information for such operation and control. Based on an e-map, Operational Board installs a multi-cube so that integrated information such as location information, communication information, surprise information, CCTV video, signal operation status, site facility movement and breakdown status, etc., can be displayed.

Operational Board installs a video display optimized in consideration of display method, resolution, brightness, convenient maintenance, and expandability. Operation scenario is to be written up to allow control of all situations and plan an effective display.

As the center works 24 hours a day, 365 days a year, stability, credibility, expandability, and convenience in maintenance should all be taken into consideration.

5.2.4. Additional Facilities

Accessory Equipment of IOCC should be put in place after analyzing sufficient capacity for center facility and equipment operation. This involves the following processes:

- A stable power facility should be constructed to protect the system from instant blackout and power accidents.
- Dualization should be done in principle; emergency power should be supplied even when power supply is suspended.
- Construct air conditioning facility to ensure 24 hour refreshing and efficient working space.
- Thermo-hygrostat should be composed in consideration of spatial area and heat created in facility room and work space.
- State-of-the-art firefighting facility constructed for quick extinguishing and early actions against fire.

Table Ⅶ-28 | Required Facilities for IOCC

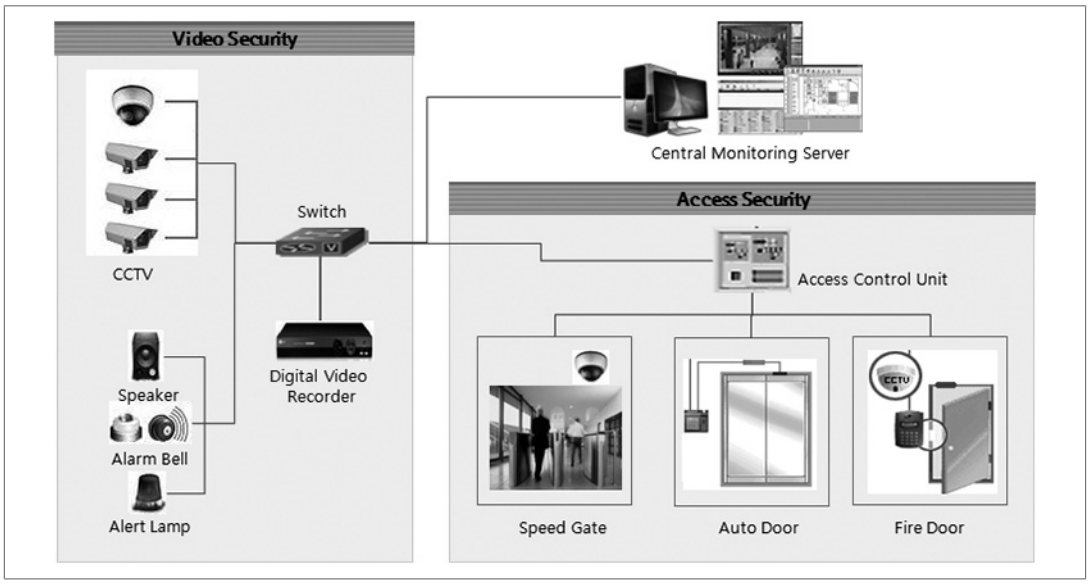
Equipment name	Quantity	Main function	Note
UPS	1Set	• 100 KVA(1Set), 3-phase 4-wire 380/220V • Blackout compensation time longer than 60 minutes, UPS	Includes battery
Generator	1Set	• 3phase 200KW air-cooling(includes silencer) • Install fuel supply tank (can be driven for four consecutive hours)	
Thermo-hygrostat	1Set	• 30RT 1Set	Facility room, situation room
Fire extinguishing facility	1Set	• Uses environment friendly fire extinguisher (uses HFC-23 extinguisher) • Automatic fire detection facility	
Resource control facility (FMS)	1Set	• Real time facility monitoring • Temperature/humidity control, leakage surveillance, fire prevention, energy surveillance	Includes RTU

Source: Compiled by KSP Research Team (2015).

5.2.5. Access Control System

IOCC security facility categorizes subject of security into access security and video security. Each room such as main entrance and situation room, etc., should be applied with security level to establish Access Control System while a video security system should also be operated to secure video footage on people accessing.

Figure VII-35 | Concept of Access Control System



Source: Compiled by KSP Research Team (2015).

Table VII-29 | Components of IOCC Access Control System

Equipment name	Major composition	Note
Operation system	• Operation PC, access control operation SW, digital video recorder	
Site facility	• Access Control Unit, R/F Card Reader, finger print reader, electronic door lock, speed gate, dome camera, fire monitoring unit	

Source: Compiled by KSP Research Team (2015).

5.2.6. Commercial Software

Commercial software required for development, operation, management and security of various systems operated at IOCC is shown as follows.

Table VII-30 | Required Commercial Software for IOCC

Equipment name	QTY	Main function	Note
DBMS	1 Set	• Relation type database control system • Supports multi processer, convenient backup and operation control	Dualization
Cluster software	1 Set	• Clustering to provide nonstop main server service	HA composition
GIS engine	1 Set	• C/S environment's space information provision service • Web GIS engine	
Backup software	1 Set	• Database and server data backup	
SMS	1 Set	• Integrates subject system's composition, function and error events • Reports error and function of the controlling server • Provides function and error monitoring information in real time	
NMS	1 Set	• Supports standard protocol for SNMP and RMON 1 & 2 • Information provision on main function items (CPU, memory, SWAP, In/Out bps, Interface In/Out bps	
FMS	1 Set	• Real time facility monitoring • Temperature/humidity control, leak surveillance, fire prevention, energy surveillance	
Vaccine	1 Set	• Vaccine software for server • Vaccine software for PC	
Development tool	1 Set	• Development tool for traffic control application software development	
Video control software	1 Set	• Control software for Operational Board operation	
WEB/WAS	1 Set	• WEB/WAS Software	
Traffic signal control software	1 Set	• Traffic signal control server application	
CTI software	1 Set	• CTI application program	

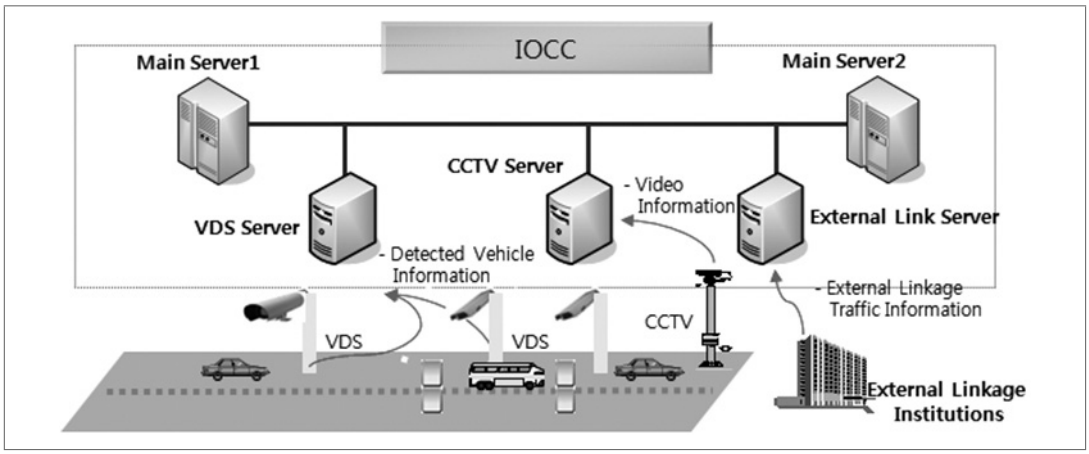
Source: Compiled by KSP Research Team (2015).

5.3. IOCC Operation Software

5.3.1. Traffic Information Collecting System

A system that collects and processes traffic information collected through Automobile Detector, CCTV, outside related organizations, etc. This plays an important role in allowing IOCC to provide transportation information.

Figure VII-36 | Concept of Traffic Information Collecting System



Source: Compiled by KSP Research Team (2015).

Traffic Information Collecting System function and control entity is as follows.

Table VII-31 | IOCC Software: Traffic Information Collecting System

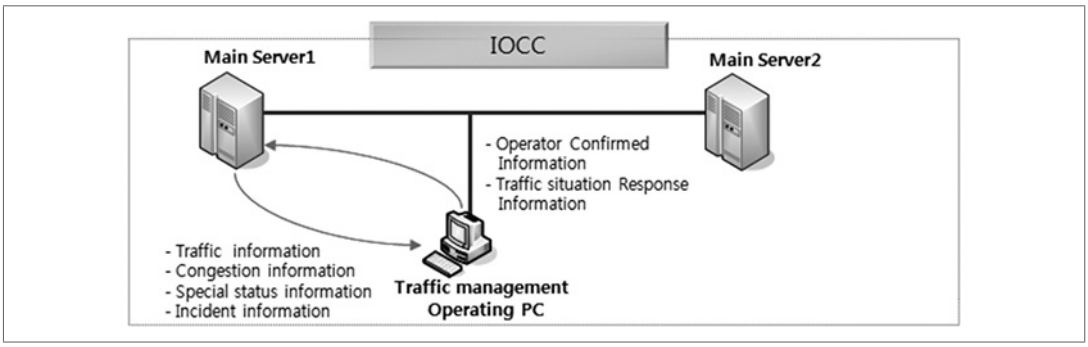
Category	Item	Details
VDS	Detector data collection	• Collects traffic, speed, and share information collected from video detector on a regular basis
	Erroneous information filtering	• Corrects erroneous data that exceeds certain range
CCTV	Video information collection	• Collects video information on road traffic situation through on site CCTV
Outside connections	Related organizations' transportation information collection	• Collects closely related organizations' transportation information on a regular basis

Source: Compiled by KSP Research Team (2015).

5.3.2. Traffic Information Processing System

This system analyzes data collected through Traffic Information Collecting System to determine road congestion, unexpected events, and special situations, etc. Unexpected events especially need to be dealt with quickly to maintain certain traffic speed and secure mobility.

Figure Ⅶ-37 | Concept of Traffic Information Processing System



Source: Compiled by KSP Research Team (2015).

Definition of traffic information processing situation control system function and control entity is as follows.

Table Ⅶ-32 | IOCC Software: Traffic Information Processing System

Category	Item	Details
Central server	Smoothing detector data	• Use smoothing algorithm on corrected data at the collection system for processing
	Creating transportation information	• Creating point communication information, road communication information, information provision section communication information
	Congestion control	• Use communication information for automatic congestion detection and handle congestions
	Special situation control	• Control construction/event information input by Admin beforehand (construction/event notification)
	Unexpected event control	• Automatic detection and dealing with unexpected events on continuing roads only
	Statistics processing	• Statistics processing of point, road communication information and sudden events/congestion
Traffic situation control	Basic data control	• Adding/editing/deleting section information, various parameter information
	Transportation information viewing	• Views point and road communication information/statistics information
	Traffic situation control	• Receives and responds to unexpected situation, congestion, special situation

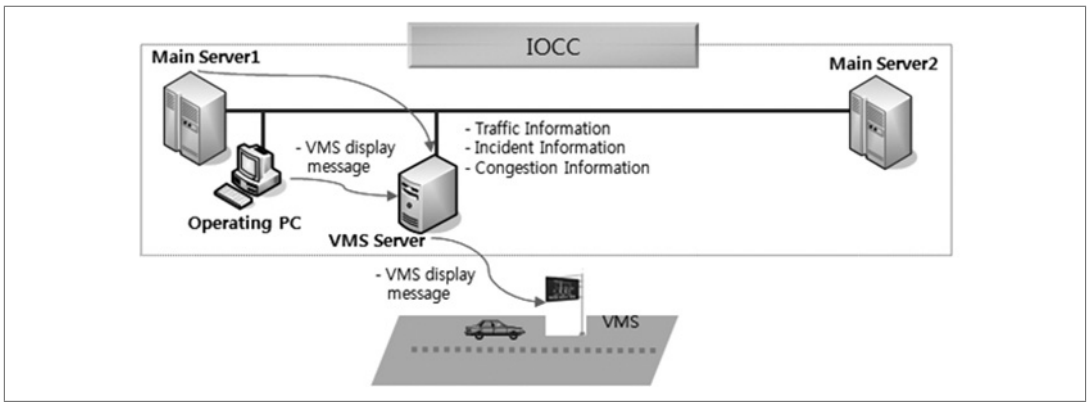
Source: Compiled by KSP Research Team (2015).

5.3.3. Information Provision System

1) VMS System

VMS System provides traffic situation ahead or information on unexpected situations and congestion, etc., to drivers to prevent accidents, induce smooth traffic flow, and provide opportunities to choose different routes.

Figure VII-38 | Concept of VMS System



Source: Compiled by KSP Research Team (2015).

Definition of VMS System function and control entity is as follows.

Table VII-33 | IOCC Software: VMS System

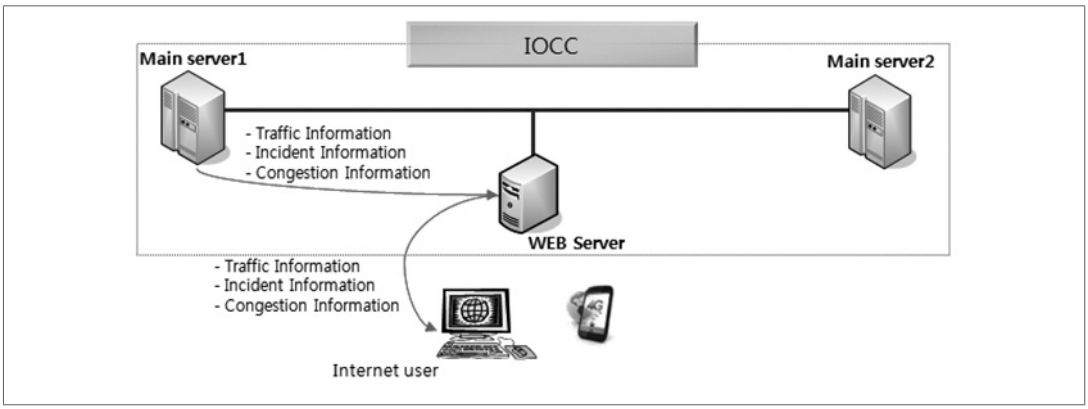
Category	Item	Details
VMS information provision	Viewing transportation information	• Regularly views transportation information viewing for each information provision section that is provided by individual VMS
	Creating VMS message	• Uses viewing result to create VMS message which will be shown on VMS message library the Admin has set
	Manual message edit	• Message editing function that allows Admin to check unexpected situation, weather information, etc. and display on VMS
	VMS basic data control	• Controls basic data such as VMS provision section, VMS library, VMS symbol, VMS schedule, VMS control parameter, etc.

Source: Compiled by KSP Research Team (2015).

2) Internet Information Provision System

Internet Information Provision System provides information like traffic situation (communication status, unexpected events, congestion, special situation) and public transportation information to citizens through Internet to help them easily understand the transportation status.

Figure Ⅶ-39 | Concept of Internet Information Provision System



Source: Compiled by KSP Research Team (2015).

Table Ⅶ-34 | IOCC Software: Internet Information Provision System

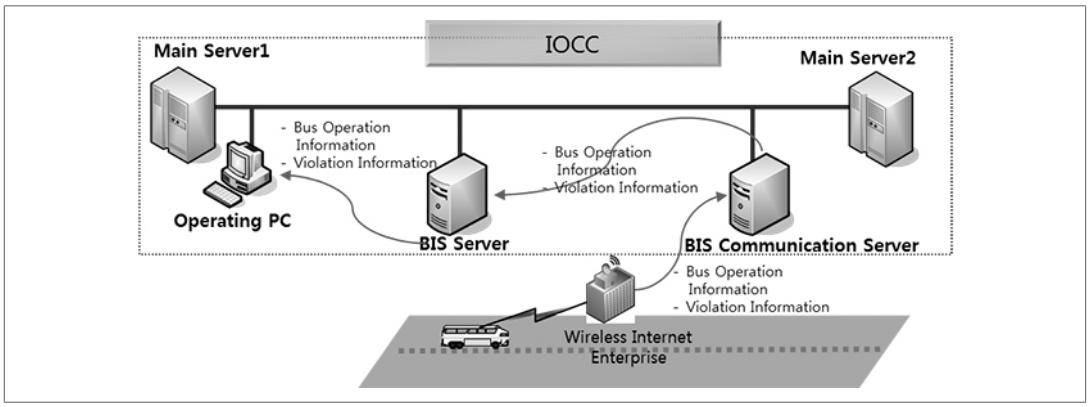
Category	Item	Details
Internet information provision	Information demand	• Regular viewing of transportation information of each Internet provision section
	Transportation information viewing	• Viewing and renewal of transportation information (unexpected situations, congestion, communication status, etc.)
	Public transportation information viewing	• Viewing and renewal of public transportation information
	Parking information viewing	• Viewing and renewal of parking information of parking lots in the city
	Transportation information provision	• Provision and display of transportation information (unexpected situations, congestion, communication status, etc.)
	Public transportation information provision	• Provision and display of public transportation information
	Parking information provision	• Provision and display of information

Source: Compiled by KSP Research Team (2015).

5.3.4. Public Transportation Management System

Public Transportation Control System makes it easy for road users to understand and control bus route and station information to assist rational establishment of transportation policies. It also monitors and controls violations that take place during bus operations to assist in establishing traffic order.

Figure VII-40 | Concept of Public Transportation Management System



Source: Compiled by KSP Research Team (2015).

Definition of Public Transportation Control System function and control entity is as follows.

Table VII-35 | IOCC Software: Public Transportation Management System

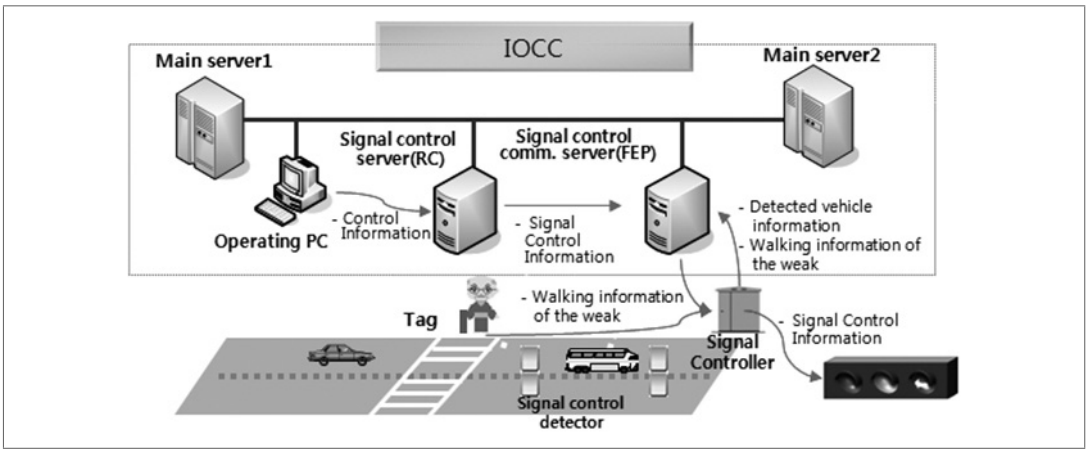
Category	Item	Details
Public transportation control	Operation control information collection	• Collects operation control information (equipment condition, operation speed, etc.) from terminal in the bus
	Bus information control	• Views composition details of all routes and certain routes and redefines information of changed routes on its course and stations
		• Views composition details of all stations and certain stations and redefines information of changed stations
	Driver information provision	• Provides distance information(distance length, distancing time), operation information(operation time, operation distance, etc.), transportation information(congestion information, unexpected event information) to driver's terminal
	Bus operation administrative measure assistance	• Main function of bus operation administrative measure assistance is systematic control of interval and speeding information, etc., using statistics data

Source: Compiled by KSP Research Team (2015).

5.3.5. Traffic Signal Control System

This system detects traffic flow that passes the crossroads with crossroad status information (signal cycle, traffic, lines in waiting) and congestion level (quiet, nearly saturated, saturated, over saturated) to control signal controller interval and adjust the period of green light.

Figure Ⅶ-41 | Concept of Traffic Signal Control System



Source: Compiled by KSP Research Team (2015).

Signal Control System function is as follows.

Table Ⅶ-36 | IOCC Software: Traffic Signal Control System

Category	Item	Details
Real time signal control	Automobile detection information collection	• Regularly collects amount of traffic, speed, and share information collected by signal detector
	Controller data collection	• Collects crossroad signal operation status information
	Creating signal control variable	• Uses the collected transportation information to create variable value of saturation, lines in waiting, etc.
	Determination of signal control plan	• Creates and operates signal control plan using values such as display, signal cycle, offset, etc.,
	Processing Admin requirement	• Processes intervention command where Admin directly intervenes in control
	Signal plan transmission	• Sends signal control plan(display, cycle, offset) to signal controller
	Signal control monitoring	• Monitoring of crossroad display, cycle, status information collected by second
Mobility handicapped safety	Mobility handicapped recognition	• Recognition of mobility handicapped who use the crosswalk tag
	Crosswalk time extension	• Calculates maximum crosswalk crossing time and extends up to that point
Bus first signal control	Bus first signal control	• Uses the created signal control variable to control signals such as display, signal cycle, etc., on bus only signal

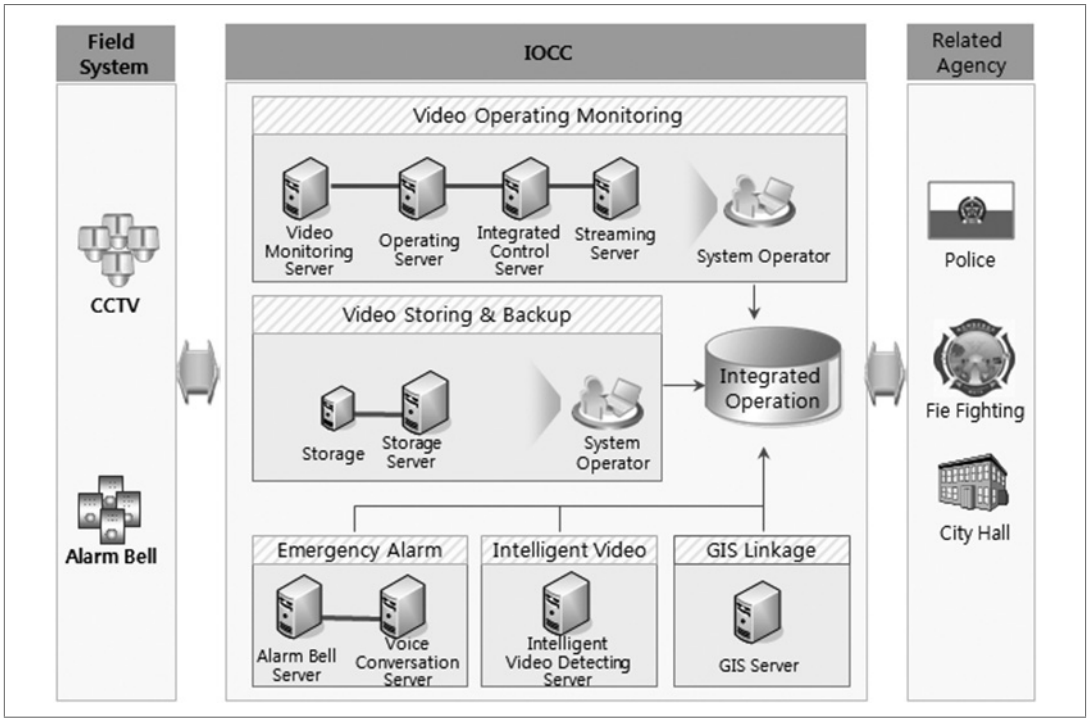
Source: Compiled by KSP Research Team (2015).

5.3.6. Crime Prevention System

1) Service Concept

Center composition of Crime Prevention System operated by IOCC includes video sever that displays high resolution surveillance video sent from on-site CCTV and also consists of video operation server, video storage and backup server, emergency alarm server, intelligence video server, and GIS connected server.

Figure VII-42 | Concept of Crime Prevention System



Source: Compiled by KSP Research Team (2015).

Each unit server S/W of City Integration Information Center Crime Prevention System has several functions that operate according to each unit module composition.

Table VII-37 | IOCC Software: Crime Prevention System Servers

Item	Details
Video surveillance server	• Real time video information display, orderly transition setting and provision, screen division setting and provision
Video operation server	• Camera control, stored video information playback, real time video surveillance, sequential transition and screen division
Integrated control server	• Operational Board display setting and operation, controls setting information and alarm DB
Video steaming server	• Collection and transmission of video information in real time, user and connection SW control
Intelligence video surveillance server	• Sets video detection pattern, video analysis and warning occurrence
GIS connection server	• Connects and displays map, displays camera location and controls correction, marks emergency alarm location and controls corrections
Emergency alarm server	• Controls emergency events, emergency alarm and displays camera location, controls transmission of emergency alarm
Video storage server	• Collects real time video information, transfers SAN switch video, saves big capacity storage
Audio communication server	• Designates group and controls individual designation, audio communication with site

Source: Compiled by KSP Research Team (2015).

Crime Prevention System function is as follows.

Table VII-38 | IOCC Software: Crime Prevention System

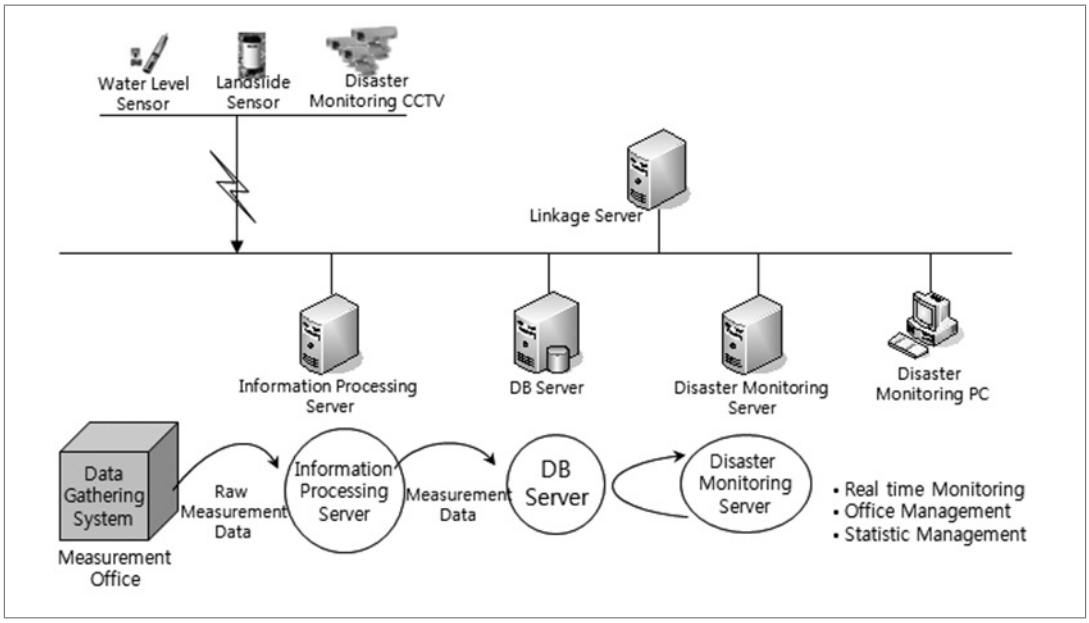
Category	Item	Details
Video control	Intelligence video detection	• Analyzes object movement pattern in the video and makes automatic abnormality detection
	Video storage	• Saves and backup related video information
	Video/audio communication	• Video and audio two-way communication in Crime Prevention System and emergency alarm
Event control	Receives/delivers emergency alarm	• Receives emergency alarm signal with network transmission equipment and delivers it to integrated control room
	Event collection	• Receives event from integrated controller S/W, saves in database, and delivers alarm information to other servers
	GIS map display	• Uses GIS map information to display alarm situation and the map
	Notification of related organization notification/ processing result	• Disperses situation to related organization using wired/wireless infrastructure, receives processing result, records as event and stores it

Source: Compiled by KSP Research Team (2015).

5.3.7. Disaster Prevention System

Disaster Prevention Monitoring System is a surveillance system that makes real time surveillance and analysis of water level and measurement information collected from water level instrumentation. Its functions are to collect credible data and real time video data surveillance from surveillance camera for early detection of disaster and tracking of disaster location.

Figure VII-43 | Concept of Disaster Prevention System



Source: Compiled by KSP Research Team (2015).

Disaster Prevention Monitoring System function is as follows.

Table VII-39 | IOCC Software: Disaster Prevention System

Item	Details
Data collection and processing	• Data is collected from water level/rainfall instrumentation and is processed as unit information for surveillance and analysis.
	• Surveillance camera video is collected and processed for real time fire surveillance.
Monitoring post control	• Controls monitoring post location, image information and status information.
Real time surveillance	• Surveillance of real time density status and standard violation status, etc., for each monitoring post.
	• Monitoring of real time surveillance video.
Statistics control	• Controls statistics information of each monitoring post, measurement item, and period.
Measurement data control	• Controls data including calibrating data with abnormal numbers and generating statistic data.
	• Transforms real time surveillance video into images and saves/manages them.
Floor prediction	• Predicts time of overflow, quantity of overflow, and expected area of overflow, etc.
Confirmation of fire location coordinates	• Uses two surveillance camera location coordinates and camera angle to read fire location coordinates.

Source: Compiled by KSP Research Team (2015).

6. Communication Network

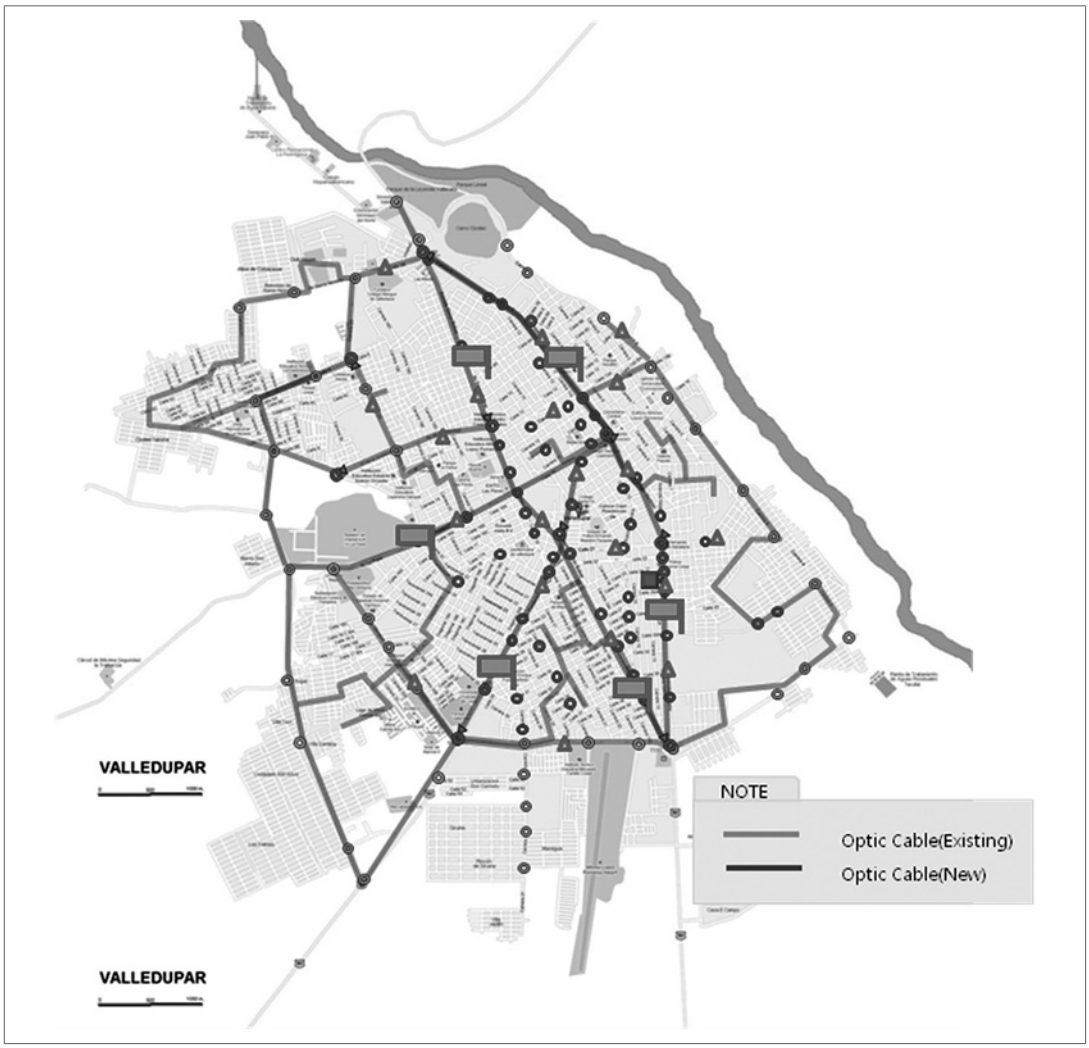
6.1. Construction Plan

6.1.1. Valledupar

Communication network infrastructure is constructed based on the location of the facility installed on site. In the city center, it will be constructed based on optic communication network and in the suburbs based on wireless communication network.

Valledupar Police Department constructed a 100km optic communication network in 2015. In view of this, the communication network for future realization of Smart City can utilize this optic communication network constructed by the Police Department and can expand to more areas of use that need additional connectivity.

Figure VII-44 | Valledupar: Optic Network Installation Plan



Source: Drafted by oneself.

Table VII-40 | Valledupar: Required Items for Communication Network

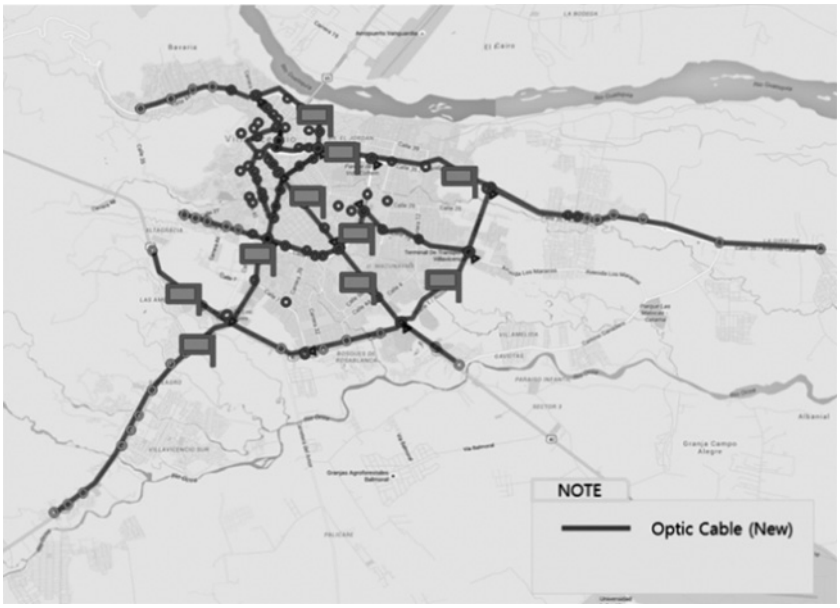
Item	Specification	Unit	Quantity	Note
Optic Cable	More than8 CORE	KM	75	• Police Department Optic Network expansion
COT (Center Optical Terminal)	More than 24ch	SET	100	• Dualization composition, NMS support
RT (Remote Terminal)	More than 1ch	SET	200	• Dualization composition, NMS support

Source: Compiled by KSP Research Team (2015)

6.1.2. Villavicencio

Villavicencio does not have its own optic communication network but the city has plans to construct a 100km optic communication network section. But since the plan is in its planning stage, a new construction plan for optic communication network should now be considered. When the city constructs its own optic communication network, this venture should be reflected on the design so that its construction does not overlap with the Smart City establishment plan.

Figure VII-45 | Villavicencio: Optic Network Installation Plan



Source: Drafted by oneself.

Table VII-41 | Villavicencio: Required Items for Communication Network

Item	Specification	Unit	Quantity	Note
Optic Cable	More than 8 CORE	KM	150	• Police Department Optic Network expansion
COT(Center Optical Terminal)	More than 24ch	SET	100	• Dualization composition, NMS support
RT(Remote Terminal)	More than 1ch	SET	200	• Dualization composition, NMS support

Source: Compiled by KSP Research Team (2015).

VIII Project Execution Plan

1. Outline

Colombia Smart City establishment planned for Valledupar and Villavicencio is a project and undertaking that entails multiple planning stages and numerous processes involving strategic execution of planned activities.

The entire project encompasses three main stages, with an execution plan of 68 months. During this period, the Project Design Team collaborated with stakeholders to accomplish project deliverables or outputs within stated timelines. For each execution stage, project activities were documented, with milestones set as targeted goals or action plans.

Stage 1 (32 months) involves consulting work that takes into account defining Smart City basic design, outlining IOCC construction design and construction, and identifying Smart City service that would benefit or serve the interest of citizens of selected cities. The current plan is for the newly constructed IOCC of the Smart City establishment to provide a total of seven (7) services. In detail, four services are related to Transportation Improvement, two services aimed at Security Procurement, and one service for improved Disaster Management.

If the local government (i.e., municipalities of Valledupar and Villavicencio) may provide for the building construction of IOCC, the IOCC construction will not be excluded from the Smart City Project's implementation plan.

Stage 2 (18 months) takes up planning work related to service installation. This work involves four additional transportation service expansion installation, two security service expansion installations, one disaster service expansion installation, and a supplementary and new provision of Smart Portal Service as a common public service for all citizens' added convenience.

Lastly, Stage 3 of the project (18 months) is aimed at work that enforces and expands on services (namely transportation, security, disaster, common public service) mentioned in Stage 2. To realize the goal of improved information sharing and informed decision making on transportation issues, a new service, i.e., Public Transportation Information Control Service is added to the list of Smart City services.

2. Prerequisite Tasks and Conditions

In addition to conducting a study of target cities' status and potential for urban development, the KSP research team reviewed successful Smart City establishments in advanced countries (particularly of the U-Integrated Operation Center of Anyang, in Korea) to identify essential prerequisites for a similar success case in these two cities of Colombia. Based on success cases of Korea's experience and other countries', the project team conducted an appraisal to determine prior requirements and critical success factors needed for the successful establishment of Smart City in Colombian cities.

2.1. Strong Will of the Local Government (e.g., Municipalities, Mayor)

This key facotr is undeniably the most prominent in appraising Smart City success cases in Korea and Paraguay. The will, resolve, and political determination of government at all levels – national, local or municipality (e.g., its mayor) is a critical motivator for project initiation, progress, and most importantly, sustainability. In Colombia, KSP projects were forwarded by the strong will of the current mayors to pursue urban development. As key components of a project, execution plans for Smart City Service and IOCC similarly require strong will of the mayors of target cities and supportive consensus of primary stakeholders concerned.

2.2. Smart City as a Complement to Local Government's Plan

Ideally, Smart City construction and service strategy need to be established as a local government's initiative. In the target cities, Smart City construction and service provision related plans should be included in the local government's city development plan; for example, communication infrastructure plan is incorporated when establishing Intelligence Transportation System (ITS) implementation plan for efficient transportation information collection and provision, traffic signal control management. Similarly, a foundation infrastructure construction plan to control road traffic should also be incorporated at the city planning and environmental development stage.

With local governments' efforts and support, Smart City initiatives should lead to enhanced cooperation with related organizations, for example, improved transportation plans are linked to enhanced security, disaster prevention, or environmental development schemes.

2.3. Speedy Execution of Follow-Up Project's Basic Design

The KSP Project uses a Conceptual Design to determine the necessity and execution of a project. For actual execution, a Basic Design process is required to determine fundamental aspects such as Site Equipment installation location, quantity, and budget. Smart City construction depends on whether the follow-up project is pursued within appropriate time frame. A prevalent reason for projects not moving forward from conceptual design to construction is because they very often missed the timing needed to pursue follow-up projects.

In this instance, a follow-up project needs to be executed soon. Therefore, preparation needs to be made now to ensure well-timed execution and processes such as prompt review of related system and procedures, and budget procurement and approval.

2.4. Securing Project Continuity (Manpower/Technology Standards)

Smart City Service and IOCC construction project is a long term project involving three main stages. Securing project continuity is a critical success factor for project sustainability and ultimately project accomplishment.

To secure project continuity, a few processes need to be in place. Conceptual Design should be reflected in its Basic Design, and bidding documents should be drafted appropriately. It is also important to select contractors who have the expertise and experience to actually execute the Smart City construction plans.

In this instance, as a 3-stage project, Stages 1 and 2 should have continuity, as with Stages 2 and 3. The Korea's experience is a lesson learned; in the early stage of its Smart City construction, Stage 1 system was not compatible with that of Stage 2, thus failing to provide service in the most optimal way possible.

Therefore, to secure project continuity, it is important to select a Consultant or Consultant Team that can oversee the whole project well, and to select a suitably qualified and experienced Construction Contractor to secure needed technology standards and compatibility criteria.

2.5. IOCC Site Selection and Construction

IOCC, which is considered the heart of Smart City, is a critical building that collects information from Smart City Site Equipment, uses this information to help System Admin make informed decisions on how to control and monitor the city, and processes information to provide services in a timely manner to related organization and citizens.

Therefore, the location of IOCC should be protected from damage of any kind, (e.g., via terrorism, cyber-attacks, natural disasters such as flood and earthquake), should have stable electricity supply, and definitely should be safe from any form of sabotage or threat (e.g., loss of data or convenience to users). The IOCC must also adhere to a spatial plan that allows installation of enough Operational Boards to control and monitor the city.

IOCC's construction requires a minimum period of one year from design to construction completion. Deliberations and decision whether to remodel an existing building that can be used as IOCC, or to construct a new IOCC building should be determined by stakeholders before the Basic Design stage.

2.6. Construction Approval

First of all, if a new IOCC building is to be constructed, speedy processing is required for construction permit and related procedural matters to eliminate possibility of project hindrance. Permits for excavation, waterworks and electricity supply, provisions for engineering and road occupancy required for the installation of Site Equipment, revised usage of existing structure and facility, and related procedures should all be executed before the start of construction work. Labor

conditions for the construction (in other words, night work) should be reviewed and approved if time is of essence. Preliminary cooperation is therefore needed from related organizations such as local government, court of law, police, or fire department. With good planning, there should be no reason or justification to hold back the project's construction and completion plans.

2.7. Economic Concerns in Design and Procurement

Cost-effective design is important for Smart City, particularly in consideration of construction cost, operation cost, and maintenance cost. For example, if too much budget allocation goes into state-of-the art technologies in Smart City Service provision, it will be problematic to afford sustainable service in the long term. Contemporary design developments show that reducing construction cost will increase operation and maintenance costs; similarly, if intelligence functions and construction cost increase, operation and maintenance costs are reduced. The Project Team has to achieve a balance in making sound financial decisions concerning the economics of design, procurement, maintenance, and sustainable upkeep.

2.8. Overlapping Investment Avoidance

Each target city has started to pursue various developments in transportation, security, and communication infrastructure even before the KSP project, and will continue to have developments during and after the project. With this in mind, it is critical to make use of existing equipment and other provisions when implementing Smart City Service, and to prevent overlapping investments at design and planning stages. This was a lesson learned from Korea's experience where during the early stage of Smart City construction, procurement cost was very high, thereby creating a problem of overlapping investment in facilities that were already in place and still in good operational condition.

One of the functions of Smart City, therefore, is to carry out integrated control monitoring of individually operated transportation, security, and disaster services from a single venue or control point, i.e., through IOCC.

2.9. Legal Provisions for Smart City

2.9.1. Smart City Law Enactment

It can be said that so far, Korea is the only country that has enacted Smart City related legislation, which accounts for one of the reasons why Korea is regarded internationally as an innovative leader in Smart City development.

At the time it established Smart Cities, Korea experienced many challenges (now viewed by others as trial and error situations) in Smart City planning and construction stages as it did not then have related laws or technology standards to follow. To deal with this state of affairs, the Korean government had the Ministry of National Development and also Ministry of Information and Communication work together to enact a Smart City related law in 2008. Local governments

followed suit and enacted local government laws (ordinances) that pertain to development of Smart Cities, which are used to this day. Colombia's central government and target cities' local governments should follow these country cases and also prepare a systematic legal foundation for activities related to Smart City, and to ensure they remain sustainable cities.

Legislation for establishing Smart City should encompass all stages of planning, construction, operation, and maintenance (i.e., sustainability). Smart City Service and IOCC plan, construction and operation organization, budget support, are especially important areas. Enactment of laws associated with main Smart City Service (e.g., transportation, security, disaster control or prevention, environment conservation, technologies and medical service provisions), related organizations' contribution and stipulation of a mutually beneficial cooperation system should also be accorded priority.

2.9.2. Smart City Law Amendment/Alignment: Personal Information Protection Law

The Colombian government already operates a Personal Information Protection Law, but the existing law is not entirely satisfactory when it involves collecting personal information using unmanned equipment (CCTV, GPS, etc.) in a Smart City environment.

Above all, increased use in personal information collection now calls for a more rigorous personal information protection system, and detailed specifications of operation management to promote personal information protection with Smart City services. This generates new legislative demands, and includes putting into place the following measures, under specified circumstances:

- Detailed procedures of personal information processing, such as government collection purposes and utilization, information acquisition items, information application and control period, is now required
- Personal information control methods such as internal control system for personal information, personal information controller designation, is required
- Consent to gather opinions from related organizations and residents of subject area is required before installing CCTV
- Related law on personal video information storage period, method of storage, provision condition, and data discarding method, needs to be revised to suit new circumstances of usage.

2.10. Operational Procedure Establishment

A systemic operation plan for Smart City IOCC and Smart City Service needs to be established. Upon encountering disasters such as security breach or terrorism, Standard Operation Procedure (SOP) for allied support and connected action plans between Police Department, Fire Department, Army and other security control management units is activated. This is made possible when decision making regarding dispatches for crimes, fire, disasters etc. and related government agencies' functions is seen as a principal and significant undertaking of IOCC.

2.11. Organization Structure

IOCC construction and Smart City Service provision require a dedicated Task Force at local government sector level to assist and provide support for Smart City planning, operation, and control. These are key features of a strong organization structure:

- Related organizations should be participating in this Task Force;
- Each sector's leader should be identified at construction stage, including IOCC Center Chief;
- Operation and technology capability training is required, with roles centered around the construction stage manager; and
- A specific maintenance manager should be assigned at Operation and Maintenance stages to ensure sustainable management.

2.12. Capability Building: Technology and Expertise

Smart City does not only provide service; to operate efficaciously in a modernized city, Smart City operation and maintenance technology is very much a key success factor. Developed and developing nations are trying to promote sustainable urban growth and businesses, as well as create jobs through sustainable city development within Smart City initiatives.

Smart City operation is a technical arena that requires experience and technological know-how in various aspects: foundation technology, design technology, realization technology, operation technology, and maintenance technology. Acquisition of maintenance technology know-how and experience is especially important; no matter how superior the modern service is, it will be no use if errors cannot be resolved when the service is being used. Therefore, the Colombian central government and local governments should train related organization personnel and also partner with universities to upgrade technology training and to foster expertise sharing.

2.13. Secure Future Expandability

Smart City should be a sustainable city, and any sustainable city should have future expandability. Future expandability requires having both physical expandability and infrastructure expandability.

Physical expandability requires preparing for future service increase through providing sufficient space for expansion of IOCC and network infrastructure. Infrastructure expandability requires enacting more communication methods and construction related technology standards, standardization of communication signals and interface, standardization of protocols, and standardization of data format so that information can be shared and utilized regardless of location and time, or with any device. Security procurement can also be considered infrastructure expandability.

3. Budget Plan for Each Municipality

3.1. Valledupar Budget

3.1.1. Total Budget

Project budget for Smart City Service realization and IOCC construction is expected to be USD32,195,953. Total budget is broken down to $6,217,391 for center construction, $19,176,525 for service construction (center system, site equipment, and network construction), $1,534,122 for operation maintenance, $500,000 for training, $3,809,088 for consulting and project control, and $958,826 for shipping and insurance. Total budget breakdown of Valledupar Smart City construction project is as follows.

Table VIII-1 | Valledupar: Total Project Budget Estimation (Unit: USD)

Category	Quantity	Unit	Subtotal
1. Center construction	1	SET	6,217,391
2. Service construction (A+B+C)	1	SET	19,176,525
A. Center system	1	SET	8,629,965
B. On-site service equipment (a+b+c)	1	SET	8,325,256
a) Transportation	1	SET	5,043,152
b) Security	1	SET	2,952,243
c) Disaster	1	SET	329,861
C. Network construction	1	SET	2,221,304
3. Operation maintenance (O&M)	1	SET	1,534,122
4. Training (training assistance and technology transfer)	1	SET	500,000
5. Consulting and project control (CIP)	1	SET	3,809,088
6. Shipping and insurance	1	SET	958,826
Total		SET	32,195,953

* Reserve, tax/custom and service fee are additionally required. However, project budget should be determined according to IDB standards.

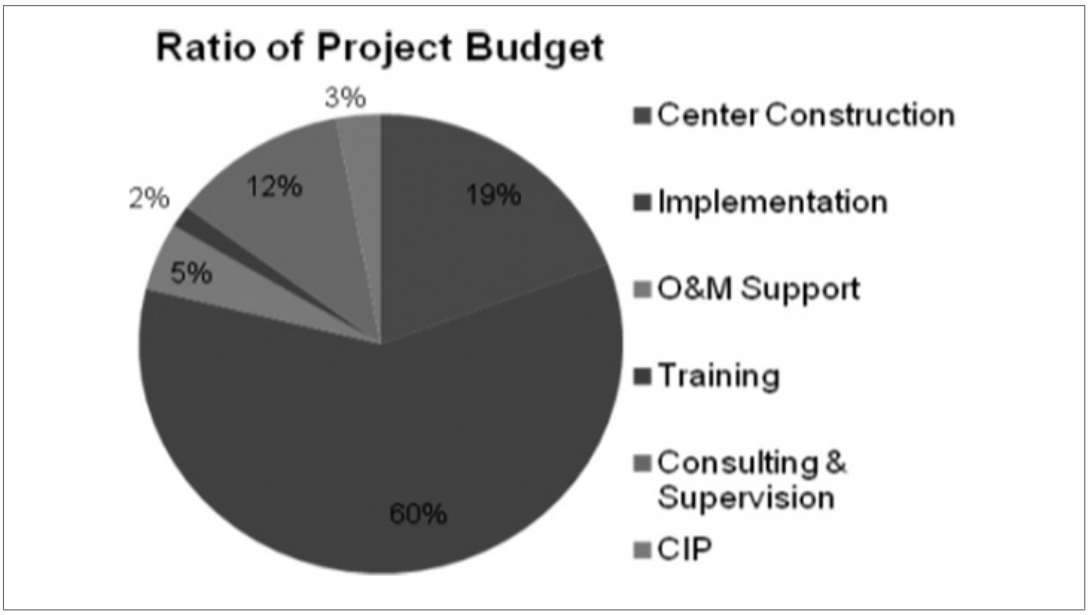
** If Valledupar takes responsibility for the above cost, this amount should be excluded from project budget.

Source: Compiled by KSP Research Team (2015).

Specific project execution method and budget should be pursued through a KSP follow-up project. This Project will be based on a Feasibility Study (F/S) with basic design to determine many factors of Stage 1 project, which include installation location, quantity, budget, and drafting of bidding

documents. Budget ratio for each item is as follows: Center construction: 19%; Smart City Service construction (Center system, Site Equipment, Network construction): 60%; operation maintenance cost: 5%; training cost: 2%; consulting and project control cost: 12%; and shipping and insurance cost: 3%. Composition ratio of each item in Smart City Construction Project's total budget is shown below.

Figure VIII-1 | Valledupar: Composition of Total Project Budget



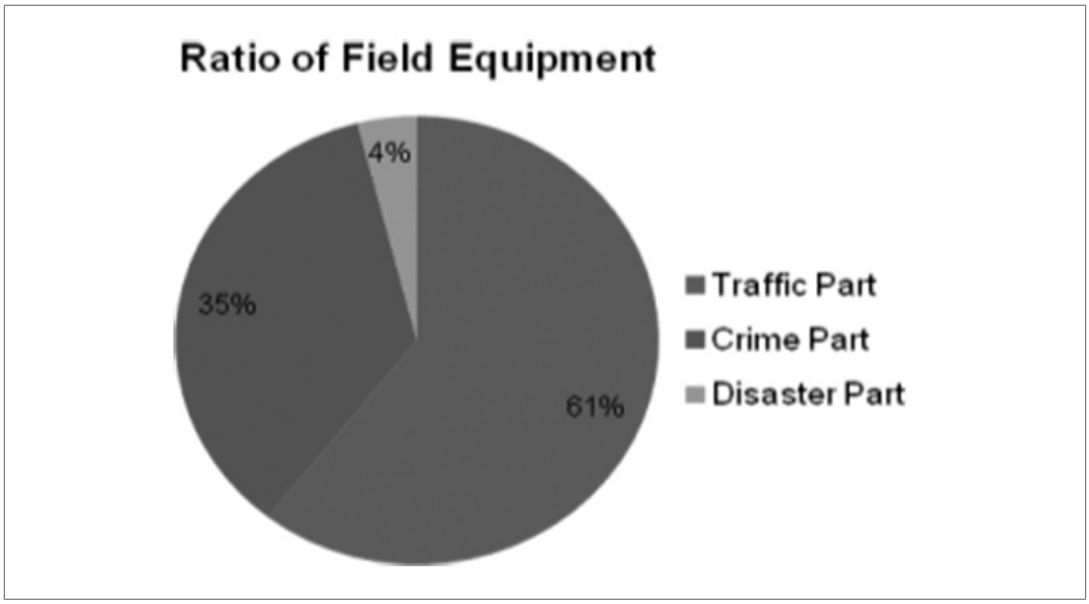
Source: Compiled by KSP Research Team (2015).

Service construction cost refers to costs for center system server, network and security facility, Operational Board facility, additional facilities, access control, commercial software, and software development.

Site Equipment comprise many facilities, which include Smart Portal Service, Intelligent Traffic Information Management System, Real Time Traffic Video Collection System, Real Time Traffic Signal Control System, Customized Traffic Information Provision System, Public Transportation Information Control System, Intelligent Crime Prevention System, Crime Automobile Tracking System, and Integrated Disaster Surveillance System. Site Equipment budget composition ratio is as follows: Transportation (61%); Security (35%); and Disaster (4%).

For Valledupar, the composition ratio for Smart City construction project total budget is as follows:

Figure VIII-2 | Valledupar: Composition of Site Equipment Budget



Source: Compiled by KSP Research Team (2015).

3.1.2. Budget Breakdown by Stage

The total budget of Valledupar Smart City construction is USD $32,195,953. This Project is executed in 3 stages: Stage 1 budget is $14,227,75 (or $8,010,361 when excluding IOCC construction), Stage 2 budget is $13,709,672, and Stage 3 budget is $4,258,529.

Table VIII-2 | Valledupar: Budget per Project Phase (Unit: USD)

Category	Phase 1	Phase 2	Phase 3	Subtotal
1. Center construction	6,217,391	-	-	6,217,391
2. Service construction (A+B+C)	5,182,139	10,988,448	3,005,938	19,176,525
A. Center system	2,344,409	4,212,565	2,072,991	8,629,965
B. On-site service equipment (a+b+c)	2,259,513	5,464,013	601,730	8,325,256
a) Transportation	1,582,609	3,347,500	113,043	5,043,152
b) Security	574,487	1,940,278	437,478	2,952,243
c) Disaster	102,417	176,235	51,209	329,861
C. Network construction	578,217	1,311,870	331,217	2,221,304
3. Operation maintenance	414,571	879,076	240,475	1,534,122
4. Training (training assistance and technology transfer)	250,000	150,000	100,000	500,000
5. Consulting and project control	1,904,544	1,142,726	761,818	3,809,088
6. Shipping and insurance	259,107	549,422	150,297	958,826
Total	14,227,752	13,709,672	4,258,529	32,195,953

Source: Compiled by KSP Research Team (2015).

3.2. Villavicencio Budget

3.2.1. Total Budget

Project budget for Smart City Service realization and IOCC construction is expected to be USD $33,176,049.

Total budget is broken down to $6,217,391 for center construction, $19,942,226 for service construction (center system, Site Equipment, network construction), $1,595,378 for operation maintenance, $500,000 for training, $3,923,943 for consulting and project control, and $997,111 for shipping and insurance.

Total budget breakdown of Villavicencio Smart City construction project is as follows.

Table VIII-3 | Villavicencio: Total Project Budget Estimation (Unit: USD)

Category	Quantity	Unit	Subtotal
1. Center construction	1	SET	6,217,391
2. Service construction (A+B+C)	1	SET	19,942,226
A. Center system	1	SET	8,880,696
B. On-site service equipment (a+b+c)	1	SET	8,840,226
a) Transportation	1	SET	5,593,313
b) Security	1	SET	2,853,217
c) Disaster	1	SET	278,652
C. Network construction	1	SET	2,221,304
3. Operation maintenance (O&M)	1	SET	1,595,378
4. Training (training assistance and technology transfer)	1	SET	500,000
5. Consulting and project control	1	SET	3,923,943
6. Shipping and insurance (CIP)	1	SET	997,111
Total		SET	33,176,049

* Reserve, tax/custom and service fee are additionally required. However, project budget should be determined according to IDB standard

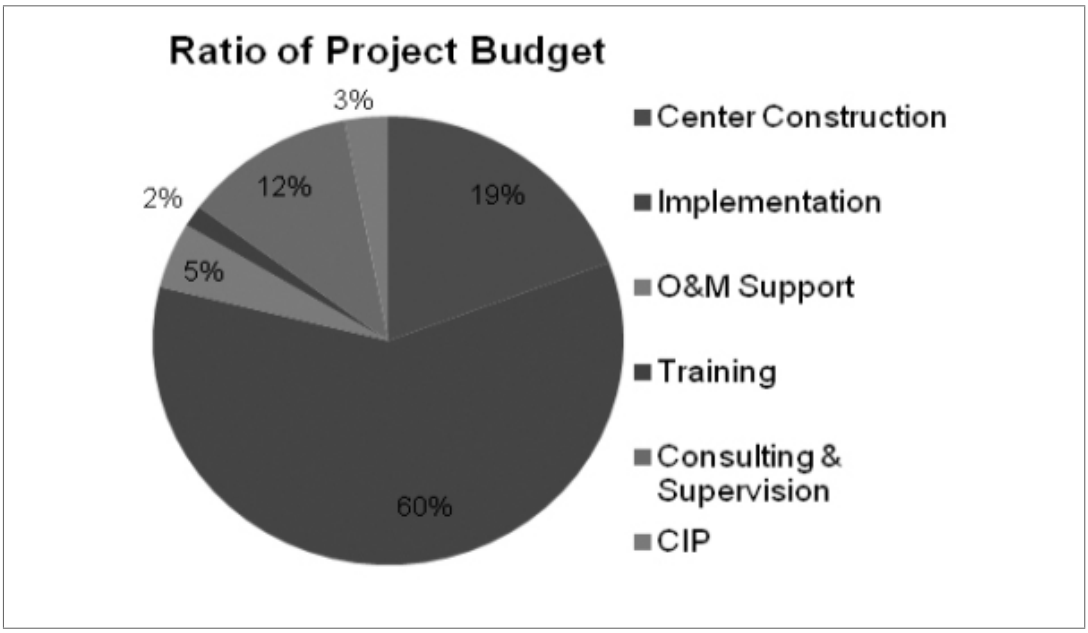
** If Villavicencio takes burden of the above cost it should be excluded from project cost

Source: Compiled by KSP Research Team (2015).

However, specific project execution method and budget should be pursued through KSP follow-up project's Feasibility Study (F/S), which develop a basic design to determine installation location of Stage 1 project, quantity, and budget and drafting of bidding documents. Budget ratio for each item is as follows: Center construction (19%), Smart City Service construction which includes Center system, Site Equipment, network construction (60%), operation maintenance cost (5%), training cost (2%), consulting and project control cost (12%), and shipping and insurance cost (3%).

The composition ratio of each item in Smart City Construction Project's total budget is shown as follows.

Figure VIII-3 | Villavicencio: Composition of Total Project Budget



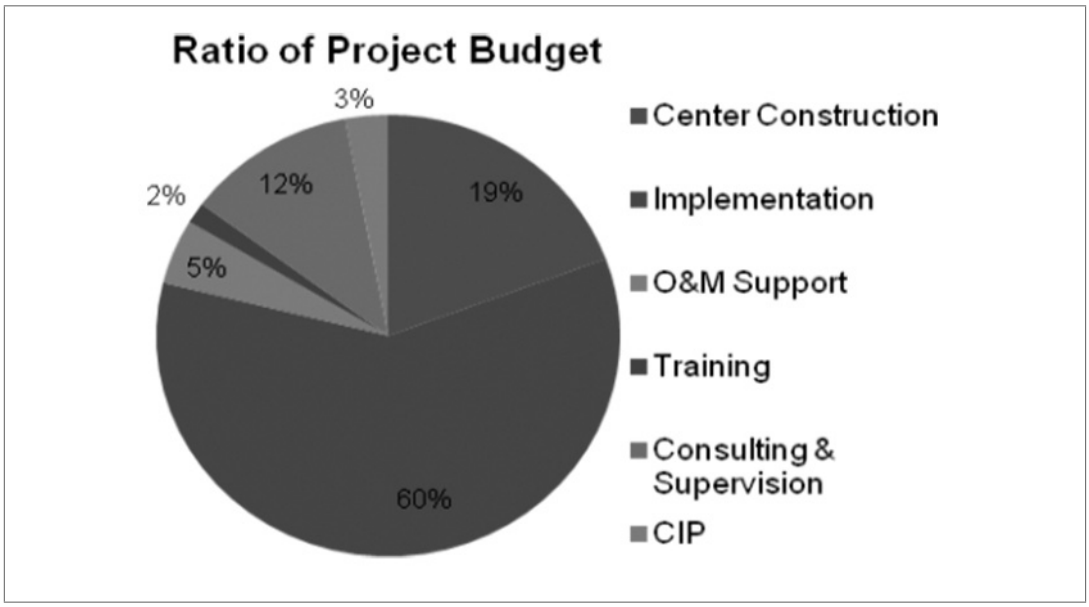
Source: Compiled by KSP Research Team (2015).

Service construction cost comprises costs for center system server, network and security facility, Operational Board and facilities, access control, commercial software, and software development.

Site Equipment refers to Smart Portal Service, Intelligent Traffic Information Management System, Real Time Traffic Video Collection System, Real Time Traffic Signal Control System, Customized Traffic Information Provision System, Public Transportation Information Control System, Intelligent Crime Prevention System, Crime Automobile Tracking System, and Integrated Disaster Surveillance System. Site Equipment budget composition ratio is as follows: Transportation (61%), Security (35%), and Disaster Management (4%).

Component ratio of Smart City construction project total budget, by item, is shown as follows.

Figure VIII-4 | Villavicencio: Composition of Site Equipment Budget



Source: Compiled by KSP Research Team (2015).

3.2.2. Budget Breakdown by Stage

Total budget of Villavicencio Smart City construction is USD $33,176,049. Project is executed in 3 stages. Stage 1 budget is $16,219,597 (or $10,002,206 if excluding IOCC construction), Stage 2 budget is $12,233,997, and Stage 3 budget is $4,722,455.

Table VIII-4 | Villavicencio: Budget per Project Phase (Unit: USD)

Category	Phase 1	Phase 2	Phase 3	Subtotal
1. Center construction	6,217,391	-	-	6,217,391
2. Service construction (A+B+C)	6,894,013	9,652,048	3,396,165	19,942,226
A. Center system	2,424,670	3,970,200	2,485,826	8,880,696
B. On-site service equipment (a+b+c)	3,667,300	4,571,196	601,730	8,840,226
a) Transportation	2,595,704	2,999,609	113,043	5,593,313
b) Security	989,130	1,426,609	437,478	2,853,217
c) Disaster	82,465	144,978	51,209	278,652
C. Network construction	802,043	1,110,652	308,609	2,221,304
3. Operation maintenance	551,521	772,164	271,693	1,595,378
4. Training (training assistance and technology transfer)	250,000	150,000	100,000	500,000
5. Consulting and project control	1,961,971	1,177,183	784,789	3,923,943
6. Shipping and insurance	344,701	482,602	169,808	997,111
Total	16,219,597	12,233,997	4,722,455	33,176,049

Source: Compiled by KSP Research Team (2015).

4. Project Scope and Action Plan

4.1. Total Project Scope and Construction Schedule

This project is centered on Smart City construction for a whole city. In its project plans, facilities such as IOCC, Site Equipment, network accessibility, and other features of Smart Cities, will be constructed for a variety of purposes: protect citizens' rights and assets, secure their safety, and ensure convenience and overall higher quality of life through provision of improved administration, transportation, crime prevention, and disaster management services.

4.1.1. Smart City Construction Stage and Scope

For Smart City construction, its stages and scope are as follows:

Table VIII-5 | Work Scope per Project Phase

Category	Composition	Phase 1	Phase 2	Phase 3
Center construction	Center construction	Center construction complete	-	-
Center facility	Server	Service server installation	Expansion installation, dualize important equipment	Expansion installation
	Network and security	Network and security facility installation	Expansion installation, dualize important equipment	Expansion installation
	Operational Board	Operational Board(3 x 3) installation	Additional (3 x 3) installation	-
	Accessory Equipment	Accessory Equipment installation	Expansion installation	-
	Access control	Access control installation	-	-
	Commercial S/W	Service commercial S/W installation	Expansion construction and function improvement	S/W Upgrade
	S/W development	Service S/W development	Expansion construction and function improvement	S/W Upgrade
Site Equipment	Transportation	Intelligence Transportation Information Collecting System	-	-
		Real Time Road Video Collection System	Expansion construction	-
		Real Time Traffic Signal Control System	Expansion construction	-
		Customized Transportation Information Provision System	Expansion construction	-
		-	-	Public Transportation Information Control System
	Crime prevention	Intelligence Crime Prevention System installation	Expansion construction	Expansion construction
		Criminal Automobile Tracking System installation	Expansion construction	Expansion construction
	Disaster	Integrated Disaster Surveillance System installation	Expansion construction	Expansion construction

Category	Composition	Phase 1	Phase 2	Phase 3
Network infrastructure	Optic Cable	Optic Cable installation	Add more Optic Cables	Add more Optic Cables
	COT/RT	Network COT/RT installation	Add COT/RT	Add COT/RT
	Electricity supply	Electricity supply for facilities	Electricity supply for additional facilities	Electricity supply for additional facilities

Source: Compiled by KSP Research Team (2015).

4.1.2. IOCC Space Plan

IOCC has many facilities, which include a 24-hour situation room with computer equipment, communication equipment room where UPS and other equipment can be installed, meeting room, visitation room, training room, and maintenance room. This Center should be constructed with adequate amenities for relaxation and recreation purposes, especially by employees who need to work extended shifts in the Center.

1) IOCC's Space Composition Plan

IOCC has a Space Composition Plan that takes the following into account: first, unified integrated situation control space composition; second, space allocation for situation control tasks; and third, reserve space in consideration of future expandability.

Unified integrated situation control space composition requires separation of entrance for each function and role, a controlled area, and appropriate control work space. Space allocation for situation control tasks should provide convenience facilities for controllers to enable them to work a 24-hour nonstop operation. It should also provide enough space so that a control worker can comfortably move around his workplace.

On this issue, IOCC needs a minimum of 5m floor height for efficient equipment installation, operation, and integrated control work.

2) IOCC: Spatial Division Plan

The proposed IOCC's Space Division Plan is shown as follows.

Table VIII-6 | Spatial Composition for IOCC

Item (Category)	Specification (Composition)	Area(m²)
Situation room	Situation monitoring and control	200
Visitation room	VIP room and observation room	60
Call center	Call center equipment	50
Grand meeting room	Meeting room and training center, capacity of more than 30 people	90
Center Chief Office	Center Chief's personal work space and secretary room	30
Operation office	Center operation and maintenance	80
Meeting room	Administration meeting room	30
Library	Document storage room	50
Storage room	Warehouse	50
LAB room	Test Room, Repair Room	50
Control room	Situation room equipment	80
Communication room	Computer equipment, communication equipment	200
UPS	UPS and battery	40
Transformer room	Center power supply transformer	100
Generator room	Center facility generator	140
Night duty and lounge	Workers' lounge	120
Office	Center residence office	300
Common area	30% of exclusive space is allotted for corridor, stairs, etc.	710
Total		2,380

Source: Compiled by KSP Research Team (2015).

The above construction and division areas might be changed depending on decisions to use an existing building to house the IOCC, or to select a new site and carry out construction work for an innovative IOCC. This is a decision to be made in the follow-up project's basic design stage involving a feasibility study.

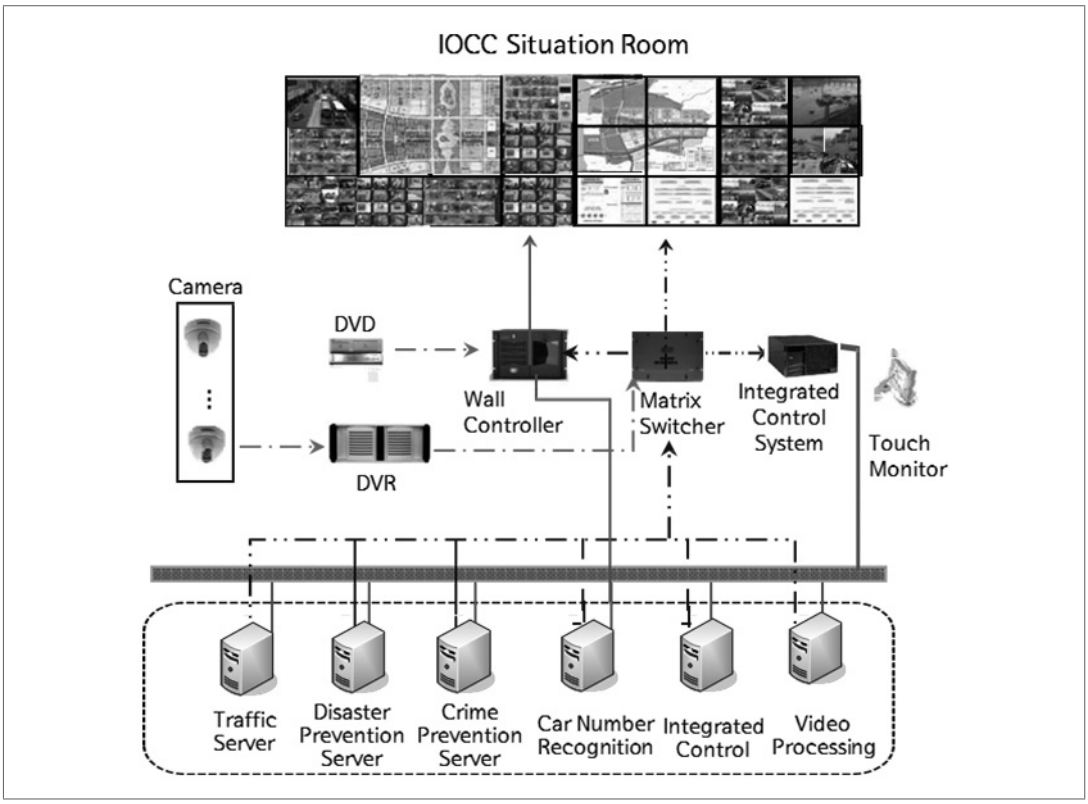
4.1.3. IOCC Operational Board

The IOCC Operational Board carries out efficient monitoring of real time transportation information, accident control, crime prevention, as well as disaster prevention. The Board controls and displays necessary information for immediate response upon event occurrences.

1) Service Concept

The conceptual design of IOCC's Operational Board is shown below.

Figure VIII-5 | Concept of IOCC Wall Board



Source: Compiled by KSP Research Team (2015).

2) Operational Board Composition Plan

Using an E-map, the Operational Board displays integrated information such as location information, communication information, unexpected event information, CCTV video, site facility movement and breakdown status. The Operational Board shall install optimized video equipment that have facilities like display method, resolution, brightness, maintenance convenience and expandability.

When needed, an Operation Scenario is drafted and effectively displayed to ensure control of all events that require monitoring. Since center work is carried out 24 hours a day, 365 days a year, features of a comfortable work environment such as stability, credibility, expandability, and maintenance convenience should all be taken into consideration in its construction plan.

IOCC's Operational Board Composition Plan is as follows:

Table VIII-7 | Required Items for IOCC Wall Board

Item	Specification	Unit	Quantity
LED DID	LED DID 55 inch	EA	16
Digital Matrix	CCTV video display	EA	2
CCTV Control PC	Field CCTV Control	SET	1
Integrated control server	Situation room facility integrated controller	SET	1
Wall controller	Operational Board e-map control device	SET	1
Touch panel	User UI equipment	SET	1
Center interior	Center Interior	SET	1

Source: Compiled by KSP Research Team (2015).

4.1.4. IOCC Facility

The table below shows a list of items and history of IOCC components, which include hardware, network, software and accessory equipment.

Table VIII-8 | Hardware, Software, Network, and Ohter Equipments for IOCC

Item(Category)	Specification(Composition)	Unit	QTY	
Main server	Main Server	DB server (2)	EA	2
Transportation server	Traffic signal control	Signal communication server, signal control server	EA	2
	Transportation control server	Collection server, provision server, VDS server	EA	1
	Transportation video server	Situation room equipment integrated controller	EA	1
	Public transportation server	Operational Board e-map control device	EA	1
Crime prevention server	Crime prevention server	User UI equipment	EA	1
	Vehicle tracking server	CCTV video display	EA	2
Disaster server	Disaster video server	Site CCTV control	EA	1
	Disaster control server	Situation room facility integrated controller	EA	1
Operation server	Integrated control server	Operational Board e-map control device	EA	1
	Operation control server	User UI equipment	EA	1
Call center server	Call server	Integrated call center facility integrated controller	EA	1

Item(Category)	Specification(Composition)	Unit	QTY	
Storage device	Storage	Smart City Service information storage device	EA	1
	SAN Switch	Interface between DB server and storage	EA	2
Network and security facility	Backbone switch	Backbone network switch, router	EA	2
	L4 & L2 switch	L4 switch (4), L2 switch (12)	SET	1
	F/W & IPS	F/W (2), IPS (2)	SET	1
Commercial software	DBMS	DBMS(2), Cluster SW (2)	EA	4
	Control S/W	GIS engine (2), backup (1), SMS(1), NMS(1), FMS(1)	EA	6
	Development S/W	Development tool (1), video control SW (1), WEB/WAS (2), signal control (1), CTI (1)	SET	1
	Security vaccine	Server (50), PC(200)	SET	1
Development software (Application)	TMS & BMS	Transportation collection/processing/provision/ Operation terminal	SET	1
	Disaster control	Disaster control application SW	SET	1
	Portal	Portal application SW	SET	1
	Command control	Command control application SW	SET	1
	Vehicle viewing	Vehicle viewing application SW	SET	1
	Call center	Call Center application SW	SET	1
	Connection server	Connection server application SW	SET	1
	Statistics analysis	statistics analysis application SW	SET	1
Accessory Equipment	Electricity	UPS(1), generator (1)	EA	2
	A/C and fire fighting	thermo-hygrostat (1), Automatic fire fighting facility (1)	EA	2
	Access control	Fingerprint reader (1), RF Card Reader (1)	EA	2
	Others	Facility control system, broadcasting facility	EA	2

Source: Compiled by KSP Research Team (2015).

4.1.5. Service Site Equipment

Site Equipment Installation Plan for Smart City Service in Valledupar is shown as follows.

Table VIII-9 | Valledupar: System Installation Plan

Sub System	Site Equipment	Unit	phase 1	phase 2	phase3	Subtotal	
Transportation service	Intelligence Transportation Information Collecting System	VDS	SET	8	12	-	20
	Real Time Road Video Collection System	CCTV	SET	4	6	-	10
	Real Time Traffic Signal Control System	TSCS	SET	30	70	-	100
	Customized Transportation Information Provision System	VMS	SET	2	4	-	6
	Public Transportation Information Control System	OBE	SET	-	-	100	100
Crime prevention service	Intelligence Crime Prevention System	CCTV	SET	16	52	10	78
		Emergency alarm	SET	16	52	10	78
		Warning announcement	SET	16	52	10	78
		S/W	SET	1	1	1	3
	Criminal Automobile Tracking System	CCTV	SET	10	36	10	56
		S/W	SET	1	1	1	3
Disaster service	Integrated Disaster Surveillance System	CCTV	SET	4	6	2	12
		Rain gauge Sensor	SET	2	4	-	6
		Water level gauge Sensor	SET	2	6	2	10
Railway, pipe (including construction work)	Optic Cable (24C)	Optic Cable	Km	40	90	20	150
	Center Office Terminal Optical transmission device/switch (10km)	COT	SET	3	5	2	10
	Remote Terminal Optical transmission device/switch (10km)	RT	SET	46	114	40	200

Source: Compiled by KSP Research Team (2015).

Site Equipment Installation Plan for Smart City Service in Villavicencio is shown below.

Table VIII-10 | Villavicencio: System Installation Plan

Sub System	Site Equipment	Unit	phase 1	phase 2	phase3	Subtotal	
Transportation service	Intelligence Transportation Information Collecting System	VDS	SET	12	16	-	28
	Real Time Road Video Collection System	CCTV	SET	4	8	-	12
	Real Time Traffic Signal Control System	TSCS	SET	50	50	-	100
	Customized Transportation Information Provision System	VMS	SET	4	6	-	10
	Public Transportation Information Control System	OBE	SET	-	-	100	100
Crime prevention service	Intelligence Crime Prevention System	CCTV	SET	25	35	10	70
		Emergency alarm	SET	25	35	10	70
		Warning announcement	SET	25	35	10	70
		S/W	SET	1	1	1	3
	Criminal Automobile Tracking System	CCTV	SET	20	30	10	60
		S/W	SET	1	1	1	3
Disaster service	Integrated Disaster Surveillance System	CCTV	SET	3	5	2	10
		Rain gauge Sensor	SET	2	4	-	6
		Water level gauge Sensor	SET	2	4	2	8
Railway, pipe (including construction work)	Optic Cable (24C)	Optic Cable	Km	55	75	20	150
	Center Office Terminal Optical transmission device/ switch (10km)	COT	SET	3	5	2	10
	Remote Terminal Optical transmission device/switch (10km)	RT	SET	70	100	30	200

Source: Compiled by KSP Research Team (2015).

4.2. Construction Schedule

4.2.1. Expected Project Duration and Schedule

Expected duration for the whole project is 68 months. Stage 1 (pilot project for Smart City Service provision and IOCC construction) lasts 32 months. This is a significant period that includes IOCC construction. Stage 2 takes up 18 months, while Stage 3 lasts 18 months. Details for the Project Schedule, by stages, are presented below.

Table VIII-11 | Smart City Project Schedule

Task	Tasks (Activities)			Project period (month)		
				Phase 1 (M32)	Phase 2 (M18)	Phase 3 (M18)
Consulting service	Smart City basic design			6	2	2
	Smart City bidding document drafting			3	2	2
	Smart City contractor selection evaluation assistance			3	2	2
	Smart City project control (purchase assistance)			12	12	12
	IOCC construction design			6	-	-
	IOCC construction bidding document drafting			3	-	-
	IOCC construction contractor selection evaluation assistance			3	-	-
Construction	IOCC construction			8	-	-
Project	Implementation	Center system	Server purchase/ installation	6	6	6
			Center network and security facility	6	6	6
			Operational Board	4	4	4
			Accessory Equipment (including interior)	6	6	6
			Access Control System	2	2	2
			Commercial S/W purchase	6	6	6
			Development S/W purchase	8	8	8
			Smart portal service	-	6	6

Project	Implementation	Site system	Intelligence transportation information collection system	6	6	6
			Real time road video collection system	6	6	6
			Real time traffic signal control system	6	6	6
			Customized transportation information provision system	6	6	6
			Public transportation information control system	-	-	6
			Intelligence crime prevention system	6	6	6
			Crime vehicle tracking system	6	6	6
			Integrated disaster monitoring system	6	6	6
		Network infrastructure	Network facility	4	4	4
			Optic Cable	6	4	4
			Power supply	2	2	2
	Test (Unit, general test)			4	4	4
	Training			4	4	4

Source: Compiled by KSP Research Team (2015).

4.2.2. Stage 1 Project Period

Stage 1 project period would take 32 months, and included consulting service (security design, bidding document, contractor selection evaluation assistance, and project control), construction (Center system, site system, and network infrastructure), test (Unit, general test) and training. Stage 1 consulting service consists of Smart City Service construction consulting and IOCC building construction consulting service.

Table VIII-12 | Project Period (Phase 1)

Task	Task details			Project period (month)															
				Period	M 4		M 8		M 12		M 16		M 20		M 24		M 28		M 32	
Consulting service	Smart City basic design			6					■	■	■									
	Smart City bidding document drafting			3							■	■								
	Smart City contractor selection evaluation assistance			3									■	■						
	Smart City project control (purchase assistance)			12											■	■	■	■	■	■
	IOCC construction design			6	■	■	■													
	IOCC construction bidding document drafting			3				■	■											
	IOCC construction contractor selection evaluation assistance			3					■	■										
Construction	IOCC construction			8							■	■	■	■						
Project	Implentation	Center system	Server purchase/installation	6												■	■	■		
			Center Network and security facility	6												■	■	■		
			Operational Board	4													■	■		
			Accessory Equipment (including interior)	6											■	■	■			
			Access Control System	2													■			
			Commercial S/W purchase	6												■	■	■		
			Development S/W purchase	8												■	■	■	■	
			Smart portal service	-																
		Site system	Intelligence transportation information collection system	6												■	■	■		
			Real time road video collection system	6												■	■	■		
			Real time traffic signal control system	6												■	■	■		
			Customized transportation information provision system	6												■	■	■		
			Public transportation information control system	-																

Task	Task details			Project period (month)										
				Period	M 4	M 8	M 12	M 16	M 20	M 24	M 28	M 32		
Project	Implentation	Site system	Intelligence crime prevention system	6										
			Crime vehicle tracking system	6										
			Integrated disaster monitoring system	6										
		Network infrastructure	Network facility	4										
			Optic Cable	6										
			Power supply	2										
	Test (Unit, general test)			4										
	Training			4										

Source: Compiled by KSP Research Team (2015).

4.2.3. Stage 2 Project Period

Stage 2 project period is determined to be 18 months and would include consulting service (security design, bidding document preparation, contractor selection evaluation assistance, and project control), construction (Center system, site system, and network infrastructure), test (unit, general test) and training.

Stage 1 is assigned six months as a basic design period. Stage 2 is determined to continue for two months to add supplementary features to Stage 1 project's design.

Table VIII-13 | Project Period (Phase 2)

Task	Task details			Project period (month)									
				Period	M2	M6		M10		M14		M18	
Consulting service	Smart City basic design (security design)			2	▨								
	Smart City bidding document drafting			2		▨							
	Smart City contractor selection evaluation assistance			2			▨						
	Smart City project control (purchase assistance)			12				▨	▨	▨	▨	▨	▨
	IOCC construction design			-									
	IOCC construction bidding document drafting			-									
	IOCC construction contractor selection evaluation assistance			-									
Construction	IOCC construction			-									
Project	Implentation	Center system	Server purchase/installation	6						▨	▨	▨	
			Center Network and security facility	6						▨	▨	▨	
			Operational Board	4							▨	▨	
			Accessory Equipment(including interior)	6				▨	▨	▨			
			Access Control System	2							▨		
			Commercial S/W purchase	6					▨	▨	▨		
			Development S/W purchase	8					▨	▨	▨	▨	
			Smart portal service	6					▨	▨	▨		
		Site system	Intelligence transportation information collection system	6					▨	▨	▨		
			Real time road video collection system	6					▨	▨	▨		
			Real time traffic signal control system	6					▨	▨	▨		
			Customized transportation information provision system	6					▨	▨	▨		
			Public transportation information control system	-									

Task	Task details			Project period (month)									
				Period	M2	M6		M10		M14		M18	
Project	Implentation	Site system	Intelligence crime prevention system	6						▨	▨	▨	
			Crime vehicle tracking system	6						▨	▨	▨	
			Integrated disaster monitoring system	6						▨	▨	▨	
		Network infrastructure	Network facility	4						▨	▨		
			Optic Cable	4					▨	▨			
			Power supply	2							▨		
	Test (Unit, general test)			4								▨	▨
	Training			4								▨	▨

Source: Compiled by KSP Research Team (2015).

4.2.4. Stage 3 Project Period

Stage 3 project duration is 18 months and included time for consulting service (security design, bidding document preparation, contractor selection evaluation assistance, and overall project control review), construction (Center system, site system, and network infrastructure), test (unit, general test), and training.

Six months are allocated for basic design period of Stage 1. As with Stage 2, two months are allocated to Stage 3 project for the team to make supplementary design changes on the results of Stage 1 and Stage 2 project design.

Table VIII-14 | Project Period (Phase 3)

Task	Task details			Project period (month)											
				Period	M2		M6		M10		M14		M18	
Consulting service	Smart City basic design (security design)			2	▨									
	Smart City bidding document drafting			2		▨								
	Smart City contractor selection evaluation assistance			2			▨							
	Smart City project control (purchase assistance)			12					▨	▨	▨	▨	▨	▨
	IOCC construction design			-										
	IOCC construction bidding document drafting			-										
	IOCC construction contractor selection evaluation assistance			-										
Construction	IOCC construction			-										
Project	Implentation	Center system	Server purchase/installation	6							▨	▨	▨	
			Center Network and security facility	6							▨	▨	▨	
			Operational Board	4								▨	▨	
			Accessory Equipment (including interior)	6					▨	▨	▨			
			Access Control System	2								▨		
			Commercial S/W purchase	6						▨	▨	▨		
			Development S/W purchase	8						▨	▨	▨	▨	
			Smart portal service	6						▨	▨	▨		
		Site system	Intelligence transportation information collection system	6						▨	▨	▨		
			Real time road video collection system	6						▨	▨	▨		
			Real time traffic signal control system	6						▨	▨	▨		
			Customized transportation information provision system	6						▨	▨	▨		
			Public transportation information control system	6						▨	▨	▨		

Task	Task details			Project period (month)										
				Period	M2		M6		M10		M14		M18	
Project	Implentation	Site system	Intelligence crime prevention system	6						▨	▨	▨		
			Crime vehicle tracking system	6						▨	▨	▨		
			Integrated disaster monitoring system	6						▨	▨	▨		
		Network infrastructure	Network facility	4						▨	▨			
			Optic Cable	4					▨	▨				
			Power supply	2							▨			
	Test (Unit, general test)			4									▨	▨
	Training			4									▨	▨

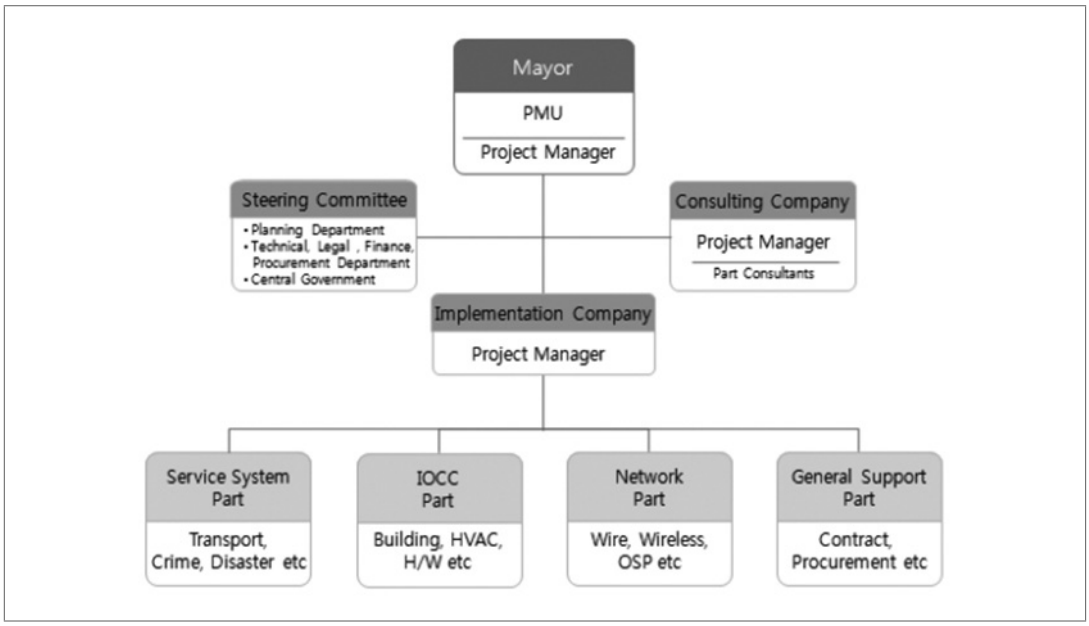
Source: Compiled by KSP Research Team (2015).

5. Organizational Structure

5.1. Construction Organization

The Project's construction organization comprises a Task Force Team (PMU: Project Management Unit), staffed by personnel working in offices of the target city's mayor. As shown in the diagrams below, the organizational structure has many levels, starting at the planning level with a steering committee to control various execution related issues/risks, Smart City related site service system, and functions related to IOCC and communication network.

Figure VIII-6 | Organizational Chart of IOCC Project Implementation Team



Source: Compiled by KSP Research Team.

The above is a tentative organizational structure. It is recommended that when Colombia Findeter and target cities' local governments decide on pursuing construction, a more specific organization structure should be worked out and finalized.

Followimg is a summary of each unit organization's roles and areas of responsibility.

Table VIII-15 | Roles and Responsibilities of IOCC Project Implementation Team

Unit organization	Role and Responsibility	Note
Mayor	• Overall responsibility and rights of project promotion • Establish an organic cooperation system with project unit organization by designating PMU components including Smart City site service system related transportation, police, fire department, Civil Defense, Red Cross, etc., and PM • Input operation manpower after construction is complete • Focused management of IOCC building construction (*)	• (*) Secure IOCC residency area and building
Steering Committee	• Adjust differences between central government and local government • Adjust law, system, budget purchase, contract related decision making • Adjust other issues and risk factors upon occurrence	• Result of adjustment should be reported t and approved by the mayor
Consulting Company	• Draft basic design and bidding document/paper (RFP) for construction project • Assist selection process by reviewing construction business bidding paper, making evaluation, etc. • Carry out overall supervision consulting including enforcement design for construction, construction, training, test drive, operation transfer, etc. • Carry out technology transfer consulting through local operation manpower capacity building workshop (**), etc.	• (**) Executed by each area, centered around future operators
Implementation Company	• Draft enforcement design for construction subject • Construct and test site service system, transfer operation training • Construct and test IOCC (interior, HW, SW, HVAC, etc.) transfer operation training • Network construction and test, transfer operation training • Free of charge/cost charged assistance of operation and maintenance after construction is complete (***)	• (***) Free of charge for 1 year, with charge for 2 years

Source: Compiled by KSP Research Team (2015).

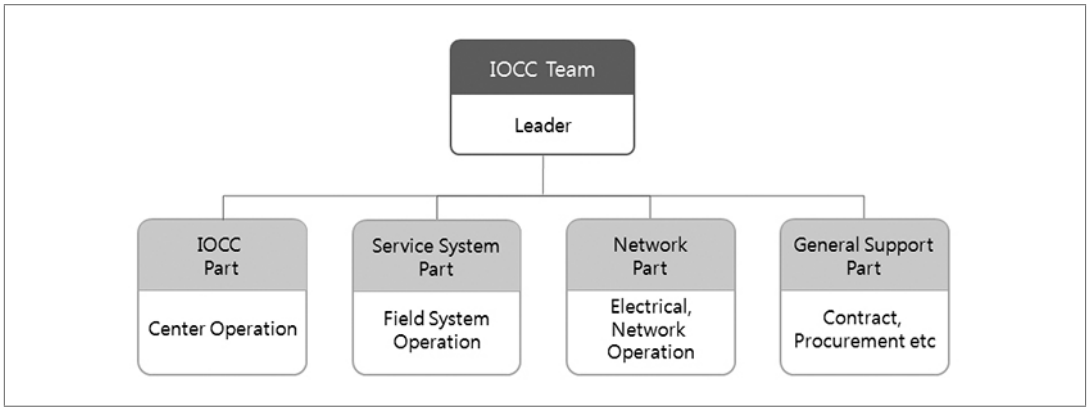
5.2. Operation Organization

The most important consideration when operating the site service system, i.e., IOCC and Network after construction, is that the facility has the capacity to run all year around, 24 hours a day. This is because these functions support core services that protect the lives and assets of the target city's citizens.

Ideally, operation organization should commence with an initial direct top-down organization, with an IOCC operation team under it, and supported by the operations of IOCC, which are service, network, and general support site service systems. Expected manpower needs consist of manning 8 hour 3 shifts as standard work hours, for a 24 hour x 365 days operation.

The operation organization structure is depicted in the diagram as follows.

Figure VIII-7 | Organizational Chart of IOCC Operation Team



Source: Compiled by KSP Research Team (2015).

Names and designations of personnel in charge, including the team manager, should be shown on the above operation organization diagram. This is aimed at enforcing and instilling a higher sense of responsibility, accountability, as well as transparency of roles to the general public. Such details can be changed depending on necessity, using the following reference indicating current manpower needs, specifications, and delegation of duties.

Table VIII-16 | Required Manpower for IOCC Operation Team

Unit organization	Required manpower for each role	Calculation grounds
IOCC Operation Team	• Team manager (1)	• Director level, under direct supervision of the mayor
IOCC Part	• Monitoring personnel for each site service system (18)	• Transportation (2), Crime prevention (2), disaster prevention (1) and common (1), 7 hour 3 shifts/day standard
	• Center system and facility operator (8)	• Electricity such as HW, SW, DB, NW, HVAC, UPS, etc. (2 each)
	• Construction company's maintenance contract manpower of each field (*)	• (*) Electricity including interior such as HW, SW, DB, NW, HVAC, UPS, etc.
Service System Part	• Construction company's maintenance contract manpower of each field (**)	• (**) Transportation, Crime prevention, disaster prevention and common area
Network Part	• Construction company's maintenance contract manpower of each field (***)	• (**) Communication, electricity, etc.
General Support Part	• General team assistance such as budget establishment and maintenance contract control, etc. (2)	• Budget and planning(1), purchase and contract control(1)

Unit organization	Required manpower for each role	Calculation grounds
Total required manpower	• Target City's IOCC Operation Team (29)	• Operation maintenance control contractor manpower excluded

Source: Compiled by KSP Research Team (2015).

6. Maintenance Plan

6.1. Outline

It is imperative to ensure nonstop operation after construction is complete so that maximization of stability, reliability, and accessibility of service is maintained. In order to do this, the construction company should be obligated to execute transfer control to IOCC operation team after construction is complete, and provide a minimum of one year free-of-charge maintenance and two years of maintenance for a cost. To ensure stable operation, one expert for each field from the construction company should be designated during the maintenance period to reside in each part of the operation organization or assist dispatch on site. The consulting firm should cooperate with the target city's construction organization and operation organization and mediate smooth execution of all procedures throughout the maintenance period, from construction and operation control transfer stages.

6.2. Maintenance

Requirements of stable operation maintenance are shown in the below table. There are preliminary prevention servicing items and post-servicing items.

Table VIII-17 | Type of System Maintenance and Repair

Category	Prevention servicing	Post-servicing
Concept	• Services daily, weekly, or monthly, according to already determined cycle and inspection items	• Service for system or facility emergencies such as error and breakdown
Purpose	• Goal is nonstop and zero-error operation	• Minimize damage caused by error
Expected effect	• Maximization of system related equipment and facility operation efficiency	• Quick restoration of erroneous system and facility

Source: Compiled by KSP Research Team (2015).

Several maintenance measures for stable operation are also suggested for reference.

Table VIII-18 | Suggestions for System Maintenance

Category	Suggestions
Secure stability	• Establish preliminary improvement measures to resolve operational problems or issues • Maximize system operation efficiency by maintaining system basic setting environment through preliminary prevention inspection
Guarantee service quality	• Maximize system availability and service quality by minimizing similar errors through utilization of knowledge DB on system function error/disability type analysis and solutions

Source: Compiled by KSP Research Team (2015).

7. Training Plan

This project is based on the understanding that use of latest ICT technology, cooperation with various industries, and training on related fields are all very important success factors for future efficient construction and operation.

To ensure smooth future operation and work organization, the Project Team recommends well designed training for construction organization personnel. Upon construction completion, target city's government and construction company participants at different levels will be invited to Korea for training to ensure systematic technology transfer and capacity building workshop for optimal performance.

7.1. Capacity Building Workshop in Korea

The key purpose of capacity building workshop in Korea is to offer hands-on experience of managing site service system, IOCC, and network by working with a system that is actually implemented and in operation. This kind of applied and practical training will maximize accessibility to operations' demands and create a better understanding of fusibility of the system and facilities to be constructed.

Recommended participants for the capacity building workshop include target cities' policy decision makers, field technicians who will participate in the construction and operation, as well as local construction company management and field personnel.

The training process should be executed according to training goals and dedicated personnel, for example, categorized by field technology acquisition course and policy decision making course. In the table below, contents of the training, period, and number of participants are suggested options; details shall be determined and confirmed upon construction agreement's concluding stage, and after discussions with the consulting company and target city PMU.

Table VIII-19 | Capacity Building Workshop in Korea

Course name	Training details	Training period	Number of subjects
Field technology acquisition course	• IOCC server, storage, backup facility installation and operation • IOCC Operational Board surveillance field operation • Site service system facility installation and operation • Network installation operation control • DBMS and system SW installation operation control • Application system installation operation control	10	14
Policy decision making course	• IOCC construction plan establishment • IOCC application case introduction and benchmarking • Smart City construction case introduction and benchmarking • Smart City related law, system introduction and benchmarking	5	5

Source: Compiled by KSP Research Team (2015).

7.2. Local Training

The consulting firm dispatched from Korea will provide guidance and training in aspects such as system and facility construction, operation, and measures against errors, for each area mentioned below. This kind of localized training will be carried out for a month for local target city's construction organization to support future construction and operation, guide operation organization government's participants, and discuss course of action with local construction company personnel.

Table VIII-20 | Local Training Course

Category	Training details
Training course composition	• Course is categorized according to the level of training subject – beginner, intermediate, advanced. • Various training manuals (for HW, SW and users) are prepared in local language • Lecturers comprise professionals from HW, SW construction and supply businesses • Topics include system and facility maintenance procedures and restoration procedures of each error type
Training course operation	• Training purpose is set, suggested and course is operated after categorizing subjects /participants that may consist of admin, manager, user and maintenance company contract manpower, etc., to maximize the effect and outcome of training
Training lecturer composition	• Lecturers of training course are selected from Korea's IOCC construction professionals and experts in each field including vendors who participate in the construction including system developer, project planning admin, and field work trainers

Source: Compiled by KSP Research Team (2015).

8. Consulting Service

8.1. Outline

Consulting service plays a core role in assisting target cities' construction organization and operation organization to achieve the desired goals of target cities' Smart City site service system and IOCC, network, and other construction and future operation courses.

Therefore, the consulting firm must deliver and meet demands according to its assigned roles. One key role is to focus on technology transfer; another just as important key role is to ensure that Smart City construction project brings about active support of citizens at all levels. Sustainability and continuous development must be another deliverable for consulting services provided.

8.2. Service Details

Categorized as Stage 3, consulting service involves carrying out general Project Management consultation, as shown in the table below.

Table VIII-21 | Scope of Consulting Service

Stage category	Scope of work	Main output
Stage 1- design and purchase assistance	• Site research and requirement recognition • Basic design for project scope calculation • Bidding paper drafting (RFP, specification, etc.) to select suitable and qualified construction contractor	• Research report • Basic design, BoM, BoQ • RFP
Stage 2- construction contractor selection assistance	• Assist construction bidding business proposal evaluation • Assist contract according to priority negotiation and business selection result	• Bidding business' proposal evaluation report
Stage 3- Supervision	• Review construction enforcement design and supervise construction • Inspect facility purchase and check system installation status • Check test operation and training plan execution result/ outcomes	• Supervision report for each quarter

Source: Compiled by KSP Research Team (2015).

Since this particular KSP project does not include the basic design output for detailed project budget calculation which is derived through fusibility study survey, it is recommended that KSP Team be put in charge of conducting Stages 1, 2, and 3 for efficacious implementation of this project.

Ⅸ Conclusion and Recommendations

The KSP team could look for the practical problems and /or issues of taget cities and Colombian governmental urban development strategy through this KSP project. Also, the consensus on importance of Smart City's project execution has been formed by sharing the advanced Korean cases analyses and holding the capacity building workshop for Colombian government officials in Korea. In this context, KSP team kindly provides several suggestions for the Smart City's effective implementation including IOCC with transportation, public security and disaster etc.

Firstly, the close cooperation of stakeholders between local and central government shall be the most important for this project of Smart City's implementation to be effectively conducted. Specially, it needs a strong willingness of Findeter and target cities' government and the establishment of execution organization for this Smart City project is also important.

Secondly, a more specific IOCC Construction Plan needs to be established. Based on the findings and analysis of this KSP project, IOCC project is recommended to be carried out over the period of approximately six years, in three stages. Specific project plans including transportation, public safety and disaster etc should be established for speedy and successful construction of Stage 1. Therefore, for these plans additional consultation project including basic design, quantity calculation and bidding documents should be suggested by the KSP team..

Thirdly, it is necessary to adjust and integrate institutional and legal systems in order that relevant institutions can effectively respond to the issues related to mobility, security and natural disasters by using the major smart services of the IOCC.

Fourthly, existing transportation and crime related plans should be integrated for cost-effective IOCC construction. Current public transportation procurement and crime prevention infrastructure construction projects initiated by the local governments are especially closely related to the Smart City project, and these should be seriously considered when establishing enforcement design to minimize new and perhaps unnecessary information communication costs.

Lastly, the core objectives of Smart City's implementation are to guarantee the safe and happy life for all citizens and the expected effects must be quantitively proven by cost benefit analysis. Therefore, the most important thing is that the already proven services and systems for target cities should be designed and applied as well.

In conclusion, for the IOCC project to function successfully in the Latin American region, all procurement and administrative decisions need to be made by fully dedicated personnel with relevant and rich experience in this area so that set targets can be met with as few challenges as possible in execution and implementation. Also, the strong execution intention and leadership of target cities' government with the closest cooperation among relevant institutions and stable financing support shall be absolutely necssary for this successful Smart City implementation, dealing with many relevant stakeholders.

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Knowledge Sharing Program

2015 KSP - IDB Joint Consulting :

Consultancy for the Development of a Route Optimization Study in Solid Waste Collection in Barbados

Part 2

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List of Abbreviation

Abbreviation	Full Description
APTS	Automatic Pipeline Transport System
B/C	Benefit / Cost
BSDP	Barbados Sustainable Development Policy
BWC	Barbados Waste Code
C&D	Construction and Demolition
CI	Commercial and Institutional
EHD	Environmental Health Department
EIRR	Economic Internal Rate of Return
EPD	Environmental Protection Department
EPR	Extended Producer Responsibility
ERR	Economic Internal Return Rate
GCF	Green Climate Fund
GOB	Government of Barbados
GPS	Global Positioning System
GW	Green Waste
ICI	Industrial, Commercial and Institutional
IDB	Inter-American Development Bank
IRR	Internal Return Rate
ISWMP	Integrated Solid Waste Management Programme
KERC	Korea Environment & Resources Corporation

Abbreviation	Full Description
KEXIM	Export-Import Bank of Korea
KMOE	Ministry of Envirinment of Korea
KSP	Knowledge Sharing Program
KWEA	Korea Minicipal Waste Engineering Association
LFG	LandFill Gas
MED	Ministry of Environment and Drainage
MHT	Man Hour per Tom
MSW	Municipal Solid Waste
NPV	Net Present Value
ODA	Official Direct Assistance
PAHO	Pan America Health Organization
PET	PolyEthylene Terephthalate
PMCU	Project Management Coordination Unit
R&S	Rock and Soil
RDF	Refuse Derived Fuel
RFID	Radio Frequency IDentification
SBRC	Sustainable Barbados Recycling Center
SLC	Sudokwon Sandfill Site Management Corporation of Korea
SRF	Solid Refuse Fuel
SSA	Sanitation Services Authority
WTO	World Trade Organization
4Rs	Reduce, Reuse, Recycle, Recovery

Summary

Increased consumption, construction and other development activities has resulted in increased rates of waste and recyclable generation in Barbados and Barbados is putting a lot of effort and resources in improving the collection, disposal and management of solid waste in order to better serve residents and visitors. The Ministry of Environment and Drainage (MED) of Barbados, Inter-American Development Bank (IDB) and Export-Import Bank of Korea (KEXIM) agreed to proceed with a KSP-IDB Joint Consulting Project to study route optimization and to determine the improvement points for the solid waste collection and management process in Barbados.

This report provides the details of the results of the Consulting Project called the "Consultancy for the Development of Route Optimization Study in Solid Waste Collection in Barbados". During the first mission trip for the Project, the KSP Consultants conducted As-Is Analysis of the current status and environment of solid waste collection, disposal and management in Barbados. From the As-Is Analysis and analysis of case studies in Korea, the KSP Consultants determined improvement points for solid waste collection, disposal and management in Barbados in terms of process improvements, system improvements, and equipment improvements.

A Dissemination Seminar was conducted in Barbados with the key stakeholders in order to present the findings of the report and to discuss the improvement points in more detail. The Dissemination Seminar was attended by the representatives from the IDB, Project Management Coordination Unit (PMCU), Sanitation Services Authority (SSA) and Environmental Protection Agency. The suggestions and comments raised during the Dissemination Seminar were incorporated into the final report and presented during the Capacity Building Workshop (CBW) which was also held in Barbados. Representatives for nine (9) neighboring Caribbean countries were invited to attend the CBW to present their current status and future plans for solid waste collection and management in their respective countries as well as discuss future needs and plans for the whole Caribbean region.

I Project Overview

1. Project Background and Objectives

1.1. Project Background

Since 2004, the Ministry of Strategy and Finance of Korea had been initiating and sponsoring the KSP (Knowledge Sharing Program) with the Export-Import Bank of Korea as its execution agency. Every year more than 10 KSP Consulting Projects are executed in various underdeveloped countries in diverse fields and industries where Korea's knowledge and experience in the diverse fields and industries are shared with the recipient countries in order to help the recipient countries leap-frog to the next level of advancement without going through the pains and mistakes that might arise through trial-and-error processes. The economies of the recipient countries will also be able to grow and prosper through the knowledge gained from the KSP Consulting Projects.

In Barbados, increased consumption, construction and other development activities had resulted in increased rates of waste and recyclable generation. In 2008, Barbados constructed the Sustainable Barbados Recycling Center (SBRC) to properly manage the collection and disposal of waste. Barbados is putting a lot of effort and resources into improving the collection, processing, disposal and management of solid waste in order to better serve residents and visitors. The Ministry of Environment and Drainage (MED), IDB and KEXIM agreed to proceed with a KSP-IDB Joint Consulting Project to study route optimization and to determine the improvement points for the solid waste collection process and systems in Barbados.

In 2014 Inter-American Development Bank (IDB) sponsored the Caribbean Conference on Solid Waste Management in Jamaica and the Conference was attended by the representatives from some countries in the Caribbean and Central America. Presentations were made by individual countries to explain the current status and future plans for solid waste management in their countries. To continue the practice, IDB and KEXIM (Export-Import Bank of Korea) agreed to conduct a similar conference in Barbados in 2015 as a Capacity Building Workshop where representatives from some neighboring countries along with Barbados were able to present the current status and future plans for solid waste collection and management in their respective countries. In addition, IDB and KEXIM shared the results of this Consulting Project, including the Best Practices and case studies in Korea, with the representatives from the other neighboring countries who attended the Capacity Building

Workshop in order for all participants to share ideas and direction for advancements in processes and systems related to solid waste collection in the region.

1.2. Project Objectives

The Consulting Project's main objective was to conduct a route optimization study for solid waste collection in Barbados. Currently in Barbados, there are a number of problems that are arising due to inefficient solid waste collection such as stacking of solid waste waiting to be picked up, illegal dumping of solid waste, and others. The Consulting Project proposed solutions and alternatives to solving the current problems and issues related to solid waste collection and management in order to make the solid waste collection and management activities more efficient and standardized.

2. Scope of Works

2.1. Main Areas of Focus

- Solid waste collection process is not a stand-alone process that can be analyzed and managed independently; therefore, recycling process and solid waste disposal process will be included in the overall analysis and study.
- Hazardous waste collection was not included in this study where "hazardous waste" is defined as 1) characteristic waste which are materials that are known or tested to exhibit one or more of the following four hazardous traits: ignitability, reactivity, corrosivity, and/or toxicity and 2) listed hazardous wastes which are materials specifically listed by regulatory authorities as a hazardous waste which are from non-specific sources, specific sources, or discarded chemical products.
- This study concentrated on residential waste with some consideration of commercial waste while industrial waste was not covered..

2.2. Project Implementation Plan

The Consulting Project was executed in four stages : Preparation and As-Is Analysis Stage, Case Study and Recommendation Stage, Dissemination Seminar Stage, and Capacity Building Workshop Stage.

Table I-1 | Stages of Execution

Stage	Duration	Activity	Deliverables
1	2015. 8. 1 ~ 10. 15	• Preparation and As-Is Analysis Stage : Research of relevant materials : Preparation of Mission Trip : Finalization of Project Implementation Plan : Inception Mission to Barbados (Oct. 8 ~ Oct. 15)	• Inception Report/ Project Implementation Plan • Mission Plan • Mission Report

Stage	Duration	Activity	Deliverables
2	2015. 10. 16 ~ 11. 15	• Case Study and Recommendations Stage : Study of Best Practices and case study of solid waste collection in Korea : Determination of improvement points and recommendations for solid waste collection in Barbados : Invitation of participants to Capacity Building Workshop in Barbados	• Interim Report
3	2015. 11.1 ~ 11.30	• Dissemination Seminar Stage : Presentation of final finding of the study to all stakeholders in Barbados : Preparation of Workshop and mission trip : Execution of Seminar in Barbados (Nov. 16 ~ 18)	• Mission Plan • Mission Report
4	2015. 12. 1 ~ 12. 30	• Capacity Building Workshop Stage : Planning and preparation of Workshop : Execution of Workshop in Barbados (Dec. 7 ~ Dec. 11)	• Materials for • Workshop • Mission Plan • Final Report

2.3. Detailed Activities

2.3.1. Preparation and As-Is Analysis Stage

The main purpose of the Preparation and As-Is Analysis Stage was to properly prepare for and efficiently execute the Inception Mission Trip such that the on-site activities could be executed effectively without missteps and the As-Is status and environment was properly researched and analyzed to meet all the requirements and expectations of the stakeholders.

The following activities were performed during this stage:

- Understanding the objective, scope, target and direction of consulting services,
- Identifying and defining the roles and responsibilities of all the stakeholders,
- Identifying and defining the roles and responsibilities of all project members,
- Preparation of draft Project Implementation Plan which will the document to be used for discussion during initial conference call between Consultant, KEXIM, IDB, and PMCU (Project Management Coordination Unit) of the MED of Barbados,
- Defining the exact scope and requirements of all the stakeholders
- Preparation of revised Project Implementation Plan detailing the exact scope, activities, duration, deliverables, project management plan, resources to be deployed,
- Document-based analysis of the current status and environment in host country,

- Preparation of the Inception Mission Plan (to be delivered two weeks prior to the mission, tentatively on Aug. 13, 2015),
- Preparation and distribution of questionnaires (included in Mission Plan),
- Go on Inception Mission (Oct. 8 ~ Oct. 15),
- Initial meetings and interviews of key personnel and project counterpart,
- Interviews and meetings with all relevant agencies and departments,
- Obtain data, reports and other documents related to the past and present solid waste production, collection, disposal and management,
- Research and analyze policies, laws and regulations related to solid waste collection,
- Research and analyze current processes, systems, equipment, and manpower related to solid waste collection,
- Analysis of ISWMP (Integrated Solid Waste Management Program), and
- Visit Mangrove Pond Landfill.

2.3.2. Case Study and Recommendation Stage

The main purpose of the Case Study and Recommendations Stage was to research and study the Best Practices and case studies of solid waste collection in Korea. Using the results of the As-Is Analysis and the case study of Korea, improvement points and recommendations were made related to solid waste collection and management in Barbados.

The following activities were performed during this stage:

- Research and analysis of Korea's Best Practices and case studies in solid waste collection and management in Korea (policies, systems, services, included),
- Interview and have meetings with regional government offices related to solid waste collection in Korea,
- Interview and have meetings with companies that are involved in solid waste collection in Korea,
- Based on the As-Is Analysis and case study in Korea, determine improvement points and recommendations to improve the solid waste collection and management in Barbados, and
- Perform study of route optimization program in Barbados for solid waste collection.
- Determine improvement points for solid waste collection and disposal process and system based on As-Is Analysis and case studies in Korea.
- Determine additional manpower, equipment, and system requirements to implement the route optimization program.
- Perform feasibility study and economical analysis of implementing the route optimization program for solid waste collection.

2.3.3. Dissemination Seminar Stage

The main purpose of the Dissemination Seminar Stage was to present the final results of the Consulting Project to all stakeholders in Barbados.

The following activities were performed during this stage:

- Plan and preparation of the Dissemination Seminar,
- Execute the Dissemination Seminar in Barbados (Nov. 16 ~ Nov. 18) in accordance to the requirements of all stakeholders, and
- Present the final results of this Consulting Project during the Dissemination Seminar.

2.3.4. Capacity Building Workshop Stage

The main purpose of the Capacity Building Workshop Stage was to invite experts in solid waste collection from Barbados and other neighboring Caribbean countries to Barbados in order to share knowledge concerning solid waste collection and to obtain comments concerning the route optimization program proposed to Barbados. The suggestions and comments received during the Workshop were used to finalize the results of the Consulting Project. The Workshop was jointly planned and executed with IDB and the funds for the execution of the Workshop were sponsored by both KEXIM and IDB.

The following activities were performed during this stage:

- Planning and preparation of Capacity Building Workshop : activities, lectures, programs, discussion points,
- Preparation of the schedule and study materials for the Workshop,
- Execute the Workshop to the satisfaction of the invited guests on Dec. 7 ~ Dec. 11; 11 participants from neighboring countries will be sponsored by KEXIM while IDB will sponsor the meals and venue, and the participants from Barbados will be sponsored by PMCU where minimal costs will be associated with participants from Barbados.
- During the Workshop, Best Practices and case studies in Korea will be presented and shared with all participants,
- During the Workshop, representatives from other neighboring countries will share their current status and future plans in solid waste collection, and
- During the Workshop, the final results of this Consulting Project will be shared with all participants in order to receive their comments and suggestions, and
- Prepare Final Report to be delivered by Dec. 30, 2015

2.4. Consulting Team

The Consulting Team was a consortium between three organizations: namely Dongbu Inc. who was the main member with numerous international consulting experiences, Korea Waste Association who is the leading authority in Korea for solid waste collection, and GDC who is a consulting company specializing in feasibility study and economic analysis.

Table I-2 | Consortium Members

Main Member	Partner Member	Partner Member
Dongbu Inc.	Korea Waste Association	GDC Consulting
Extensive experience in international consulting and KSP projects	Extensive knowledge in solid waste collection and management	Extensive experience in conducting feasibility study and economic analysis
• Project management • Communication with KEXIM, IDB and PMCU • Quality management	• As-Is analysis and recommendations related to solid waste collection and management	• As-Is analysis and economic analysis of policies and financial impact of route optimization

Table I-3 | Roles and Responsibilities of Consultants

Role	Name	Responsibilities	Experience
PM (Project Manager)	Park, SangWook	• Overall project management • (resource, delivery, quality) • Main contact for project	• Ph.D. • 7 overseas consulting projects
Waste Technology	Min, Dal Ki	• As-Is analysis and development of route optimization program	• Ph.D. (Environment) • 17 projects related to waste
	Kim, Hak Joo	• As-Is analysis and recommendations of solid waste collection	• Master (Environment) • 7 projects related to waste
	Sung, Nak Kuen	• As-Is analysis and recommendations of solid waste collection	• Bachelor (Environment) • 16 projects related to waste
	Lee, Jung Heon	• As-Is analysis and recommendations of solid waste management	• 12 projects related to waste

Role	Name	Responsibilities	Experience
Policy and Financial Analysis	Lee, Kyung Wan	• Feasibility Study of implementing the route optimization program	• 4 overseas and feasibility study projects
	Lee, Kye Chun	• Financial and economical analysis of implementing the route optimization program	• Masters (Financial analysis) • 12 financial analysis projects
Policy and Financial Analysis	Lee, Seung Yong	• As-Is analysis and recommendations on policies related to solid waste collection and management	• Bachelors (Environment) • 8 overseas projects
Project Support	Kim, Ho Chang	• Plan and execute Capacity Building Workshop • Research of Best Practices	• 12 overseas projects (6 projects with workshops)

3. Expected Results

The following were the expected results of the Consulting Project:

- With Barbados as the key reference site and since Barbados is one of the leading countries in the Caribbean in terms of solid waste collection and management, improvement points and advanced systems and processes proposed in this Consulting Project could also be expanded and adapted to other neighboring countries in order to raise the overall level of solid waste collection and management throughout the Caribbean.
- The results of the Consulting Project could be used as the basis for future projects in solid waste collection, disposal and management. Barbados will be able to apply for IDB, GCF (Green Climate Fund) or other ODA (Official Direct Assistance) funds as a follow up project from the results of this Consulting Project.

Ⅱ Analysis of Current Status

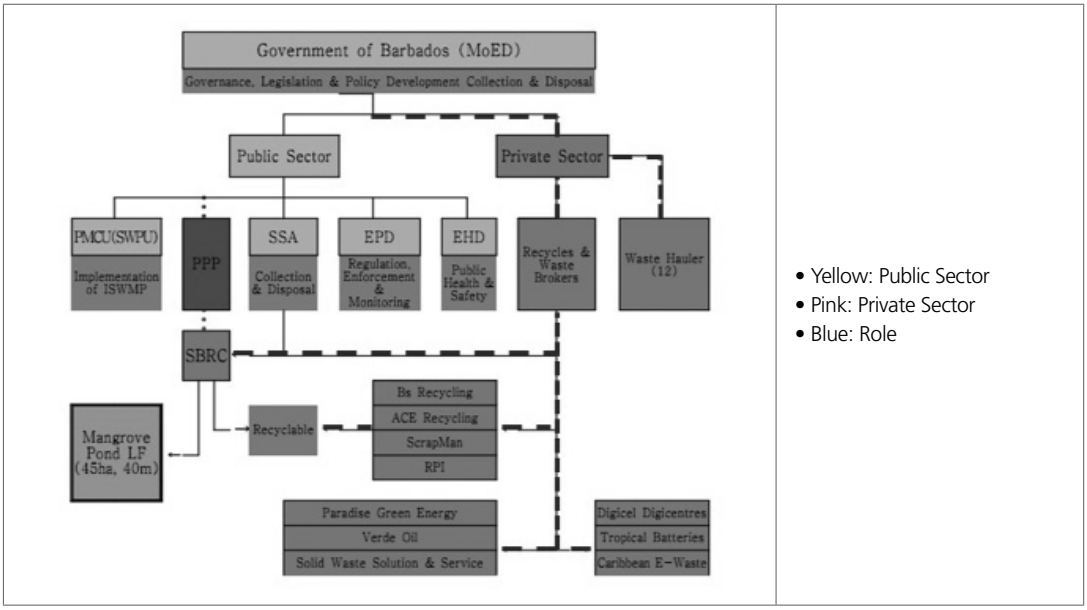
1. Law and Policy in Barbados

1.1. Organization

The main organization concerning solid waste management in Barbados is the Ministry of Environment and Drainage (MED) and the MED is responsible for developing and executing the law, regulation and policies related to solid waste collection, disposal and management. Under the MED, there are three main departments who are involved in solid waste management and they are the Project Management Coordination Unit (PMCU), Sanitation Services Authority (SSA) and the Environmental Protection Department (EPD) (Please refer to Figure II-1 on the next page). PMCU is responsible for the implementation of the Integrated Solid Waste Management Programme (ISWMP) and they are the main counterpart organization for this Consulting project. SSA is a quasi-government agency responsible for the collection and disposal of solid waste. EPD is responsible for the regulation, enforcement and monitoring of the laws related to solid waste collection, disposal, and management. The Environmental Health Department (EHD) works in conjunction with the EPD; however, EHD is not part of the MED but under the Ministry of Health. The Sustainable Barbados Recycling Center (SBRC) is a PPP (Public Private Partnership) where the SSA reimburses SBRC for some of the services SBRC provide such as 1) automatic weighing of collection trucks as the trucks enter and leave SBRC, 2) acting as a transfer station where wastes are unloaded and separated prior to the delivery to the landfill, and 3) recycling of the waste that are unloaded by the collection trucks.

There are around 12 private companies involved in solid waste collection and management and the three largest are Simpson Trucking and Skip Services, Jose and Jose, and Garbage Master. There are also some companies involved in recycling paper, plastic, glass, metal, etc. and the three largest are B' Recycling, Ace Recycling and Scrap Man. Other than the recycling companies, all the private haulers also take their collected solid waste to the SBRC to be processed and reside disposed of at the landfill.

Figure II-1 | Organizational Chart of Solid Waste Management in Barbados



1.2. Solid Waste Related Law and Policy

The main laws related to solid waste is the "Waste Management Act"(draft version) and the "Licensing Relations" related to the execution of the law. Other related laws are the Sanitary Service Act, Health Service Act, Town and Country Planning Act, Marine Pollution Act and the Coastal Zone Management Act.

The main policy related to solid waste is the Integrated Solid Waste Management Programme (ISWMP) which was started in 1993. There were many revisions and amendments to the ISWMP since 1993 and it is also a major part of the government-wide Barbados Sustainable Development Policy (BSDP) which was launched in 2004.

Solid waste characterization studies are also performed every ten years (1994 and 2005) and Barbados is currently undergoing the latest study where the draft version of the study was received and was reviewed. In the "National Strategic Plan of Barbados 2005~2024", Major Target 4 deals with "Strengthening the Physical Infrastructure and Preserving the Environment" where solid waste management is outlined as one of the key issues that the Government of Barbados (GOB) will be focusing on for the next 25 years.

Later, with the emergence of national waste management as an international environmental issue, Barbados established the 1993 Health Sector Development Plan and the ISWMP is currently being implemented as part of this Plan. The ISWMP focuses on various stakeholders from both the public and private sectors working together to change the existing bad practices of illegal disposal of wastes, to minimize the disposal of solid waste, to promote recycling, and to provide guidance to

convert solid wastes into resources. By presenting a long term vision for solid waste management for the next 20 years, the goal of the ISWMP is to develop a modern and sustainable management system that is efficient and reliable in order to effectively manage the solid waste disposal throughout Barbados and protect the environment.

The objectives of the ISWMP can be categorized into three parts. The first objective is to reduce the disease and environmental contamination from wastes resulting from illegal disposal and existing bad disposal practices. The second objective is to improve the sanitation standards of Barbados by developing and providing an efficient and reliable solid waste management system, and the third objective is to provide programs to promote awareness and educate the public in order for the citizens of Barbados to manage the environment on their own. The participation of the private sector stakeholders in the solid waste management system, and the reduction of volume and toxicity of the solid wastes are also included in the third objective (PAHO, 2003).

The ISWMP is composed of physical elements and non-physical elements. Physical elements are the facilities such as the landfills, solid waste management depots, and large waste disposal facilities. The solid waste disposal depots should include transfer stations, materials recovery facilities, chemical waste storage facilities, and composting facilities. Additionally, improving the roads to effectively transport the wastes to the disposal facilities are also included in this element (PAHO, 2003).

The non-physical elements of the ISWMP are reinforcing the solid waste management system by establishing organizational and advisory groups, who can implement all aspects of the solid waste disposal process and can supervise the status of progression of the ISWMP. Developing policies and laws related to improving solid waste disposal, increasing public awareness and providing educational programs on the importance of solid waste management for various stakeholders such as employees of major governmental agencies, semi-governmental organizations and private waste collection companies are all considered to be non-physical elements as well. Furthermore, looking for more economical ways to recoup the solid waste management expenses are also included in this category (PAHO, 2003).

Table II-1 | Summary of ISWMP

Category	Details
Program Name	Integrated Solid Waste Management Program (ISWMP)
Start Date	Temporary Stat Date : 1993 Actual Start Date: 1995
Execution Agency	Project Management Coordination Unit (PMCU)
Objective	- Development of a modern and sustainable solid waste management system that is efficient and reliable. - Vision for solid waste management for the next 20 years.

Category	Details
Composition	- Improve the landfills - Establish solid waste management depots and large waste disposal facilities - Improve the road conditions - Reinforce the solid waste management system - Develop policies and laws for solid waste management - Promote public awareness and operate educational programs on the importance of solid waste management - Find ways to economically recoup the solid waste management expenses

Source: PAHO. (2003). Country Analytical Report Barbados. PAHO

2. Current Status of Solid Waste Collection in Barbados

2.1. Classification of Waste

The Waste Management Act does not clearly define the classification of waste; however, generally the waste is classified as 1) Municipal Solid Waste (MSW), 2) Industrial, Commercial and Institutional (ICI) or Commercial and Institution (CI), 3) Construction and Demolition (C&D) waste, and 4) Rock and Soil (R&S). Another way to classify waste is by using the content of waste such as 1) garbage or MSW, 2) Green Waste (GW), 3) C&D and 4) R&S. The "Characterization Study 2005" classified waste as 1) Residential Refuse 2) Residential Yard Waste, 3) Commercial Refuse, 4) Commercial Yard Waste, 5) Bulky Waste, 6) Hazardous Waste, 7) Special Liquid Waste, and 8) Imported Waste. The definition of waste is currently being undertaken in the revised policy.

Since there is no classification of waste defined in the Waste Management Act, there is also no waste code (number) associated with the different waste classifications. Waste code is very important in the management of waste; therefore, the waste codes defined in the characterization studies are currently being used to manage the different types of waste. We can see a continuous increase in the number of classifications of waste (thus, the number of waste codes) from the initial characterization study performed in 1995 which had 34 classes to the latest study performed in 2015 which has 52 classes. Currently, codes 1~8 classifies paper and cardboard, codes 9~13 classifies glass, codes 14~21 metal, codes 22~28 plastic, codes 29~30 textile, codes 37~42 construction waste, codes 43~48 special care waste and codes 49~52 other waste. The different codes define the different methods of recycling and processing of the waste which is a very efficient coding system. The waste codes can also be used as keys to identify the different types of waste in a computer system.

2.2. Production of Waste

Usually the increase in waste production is linked with the increase in population and the increase in income. However, in Barbados, there is minimal increase in population; therefore, the yearly increase in waste production is linked to the increase in GDP. Before 2001, the yearly increase in waste production was only 3%; however, from 2001 to 2010, the yearly increase rose to over 11%

which is directly linked to the large increase in GDP during this period. Then after 2010, the yearly increase has fallen back to the 3% level.

The sum of MSW production and GW production was 150 tons per day in 2001, then in 2010 the amount increased to 400 tons per day and in 2014, the amount has increased to 450 tons per day. 450 tons per day translates to 1.68 kg of waste produced per person every day. The average waste production for advanced countries is about 1 kg per person per day so Barbados's waste production is much higher than the average and we can assume two main reasons for this higher amount. One is because tourism is one of Barbados' main industries and the second is due to the large amount of GW produced.

The total sum of all waste produced, including MSW, GW, C&D and R&S, is about 1,000 tons per day (300 tons per day for MSW, 150 tons per day for GW, 150 tons per day for C&D, and 400 tons per day for R&S). Table II-2 shows the amount of waste received by SBRC for the last 5 years. You can see that the total amount of waste received by the SBRC has increased continuously for the last 5 years. The waste collected by SSA accounts for about 21.7% of the total (78,703 tons out of a total 360,526 tons) and you can notice that the amount of waste collected by SSA stays rather constant between 77,000 tons to 83,000 tons per year for the last 5 years which means that the population is not increasing very much. The main increase in the total amount of waste comes from the private haulers, meaning that the increase in waste production is due to increase in tourism and businesses.

Table II-2 | Waste received by SBRC for the last 5 years (in tons)

Year	Collector		Total
	SSA	Private	
2010	50,780	157,855	208,635
2011	81,105	162,488	243,593
2012	77,195	220,214	297,209
2013	83,921	271,114	355,035
2014	78,703	281,823	360,526

2.3. Composition of Waste

Table II-3 shows the composition of MSW and ICI waste in the latest "Characterization Study 2015". For MSW, 36% are organic waste with paper, textile and plastic accounting for 15%, 11%, and 10%, respectively. For ICI, 48% are organic waste and 35% are C&D and these two types of waste account for 83% of all ICI. Paper, plastic, textile and organic waste account for 92% of the overall waste production by households and the remaining 8% are glass and metal waste.

Table II-3 | Composition of Waste (2015)

Category	MSW	ICI	Combined	
Paper	14.9 %	3.6 %	10.28 %	92 %
Plastic	9.5 %	5.0 %	7.70 %	
Textiles	10.9 %	1.7 %	7.16 %	
Organics	36.4 %	47.7 %	41.00 %	
Glass	3.0 %	1.5 %	2.40 %	8 %
Metal	3.9 %	1.9 %	3.07 %	
C&D	9.8 %	35.0 %	20.09 %	
special care waste	0.2 %	0.2 %	0.20 %	
other waste	11.4 %	3.4 %	8.10 %	
Total (%)	100 %	100 %	100 %	

2.4 Waste Management

The general waste management process is as follows:

Generation → Storage (on-site) → Collection → Transportation → Processing

Usually, task of collection and the task of transportation are separated and executed by different companies or organizations. In this case, collection can be performed using large non-compactor trucks and the waste delivered to transfer stations where the waste is separated and compacted for delivery. However, in Barbados, due to the small size of the country, both collection and transportation are carried out by the same company or organization using compactor trucks. Also, there are no in-between transfer stations handling the waste separation prior to delivery to the SBRC. SBRC can be considered the only transfer station prior to the delivery to the landfill.

In Barbados there are no requirements for separation of recyclable waste versus non-recyclable waste. The only separation of waste done at the households are the separation of containers made of glass, polyethylene terephthalate (PET), or metal since these containers can be brought to recycling centers for exchange of money (based on the Returnable Containers Act). These recyclable wastes account for about 20% of the total waste generated at the households (about 60 tons per day).

The generated wastes are placed in plastic bags (designated trash bags or regular plastic bags provided at the markets) and placed at the curb for pick-up. The plastic bags can just be piled on the curb or placed in individual trash bins which can be purchased. The 60 to 100 liter trash bins are made of plastic with holes drilled at the bottom to remove liquid, which are generated by the waste. The trash bins make the waste collection easier for the loaders. Other than households, skips

can be used to store plastic bags or other trash generated by commercial businesses or apartments. The Figure below shows the storage on-site of the generated waste in Barbados.

Figure II-2 | Waste Storage On-Site



(a) Bag and Bin



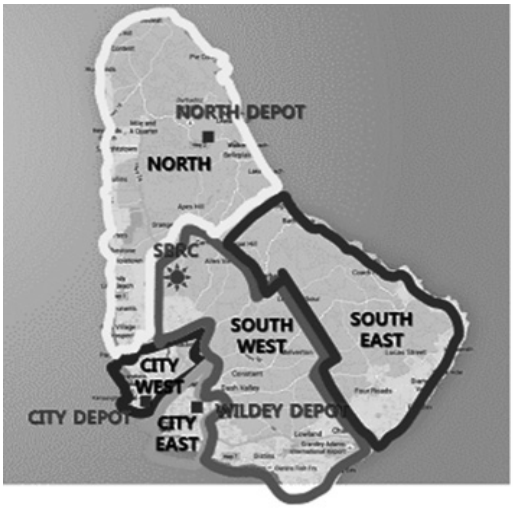
(b) Skip Container

2.5 Waste Collection

The SSA divides Barbados into 5 major regions for waste collection. The regions are City West, City East, South West, South East and North (shown in Figure II-2 below). Bridgetown, where 42% of the total amount of waste is generated is divided into two separate regions, City West and City East. In Barbados, there are 3 major depots where collection trucks are parked and distributed from. The Wildey Depot is the main depot with about 40 trucks (operational or not). There is a depot in Bridgetown at Reed Street with 1 compactor truck and 1 skip truck. Finally, there is a small depot in the North at Greenland with 3 trucks.

Table II-4 shows the amount of waste collected by region in 2014. There were only 4 regions in 2014 where the South was divided into two regions this year.

Figure II-3 | Regions for Waste Collection



Depot	Driver	Loader
South East	10	20
South West	11	22
North	11	22
City West	16	32
City East	11	22
Commercials	6	12
Total	65	130

Table II-4 | Waste Collection by Region (2014)

Category	Region				Total
	City West	City East	South	North	
No. of trip	2,822	3,950	4,014	3,523	14,309
Tons received	14,565	15,601	23,213	18,267	71,646
Ton/trip (average)	5.16	3.95	5.78	5.19	5.00

The residents bring out their waste to the curb and place the plastic bags on the curb or put the plastic bags into 60 to 100 liter trash bins. Barbados is currently using a house-to-house, "alley service" method of collection. In larger apartments or buildings, skip container based "block service" method of collection is being used. In the city, street cleaners roll along large garbage cans to place sweep the streets as well as collect garbage from trash bins or directly from the streets. Figure II-4 shows the type of collection equipment used by SSA.

Figure II-4 | Waste Collection Equipment



(a) Street Cleaning



(b) Lorry Loader



(c) Compactor Truck



(d) Open Truck



(e) Skipped Truck

Comparing waste management status of Barbados with the current waste management status of Seoul, Korea, the land area of Barbados is about 71% of the land area of Seoul; however, Barbados only has 2.6% of Seoul's population, 5.3% of Seoul's waste generation, 5.0% of persons associated with waste collection and 3.5% of the number of waste collection equipment (please refer to Table II-5 below).

Table II-5 | Comparison of Barbados and Seoul

Category			Barbados	Korea	Seoul
Land area (square meter)			430	100,368	605
Population (1,000 person)			268	51,710	10,143
Province/District			11 province	8 M-city & 8 province	25 district
Waste generation (tons/day)			450	48,728	8,559
Collection & Transportation	Public Sector	Manpower	300	34,014	6,018
		trucks	64	11,446	1,868
	Private Sector (Number of companies)		12	4,035	143

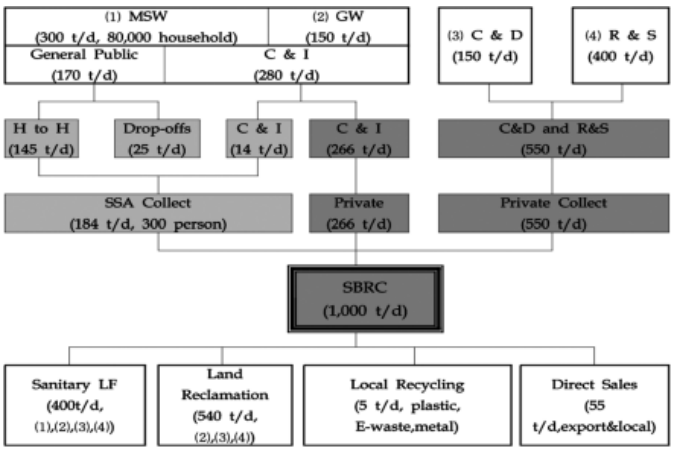
Category		Barbados	Korea	Seoul
Public Facility	Incinerator	0	182	5
	Landfill	1	221	1
Budget (USD per year)		28M (overall)	4,110M	679M

2. 6. Waste Processing

The waste processing in Barbados has a very simple structure. Recyclable goods collected at the private recycling companies and the SBRC are mostly exported to China or to South America. Most of the MSW generated are buried in the Mangrove Pond Landfill without incineration.

Figure II-4 shows the waste collection, disposal and management process in Barbados depending on the classification of waste. About 1,000 tons of waste are collected and delivered to the SBRC every day (MSW 300 tons/day, GW 150 tons/day, C&D 150 tons/day, and R&S 400 tons/day). SSA is responsible for collecting about 180 tons of waste per day and the remaining 800+ tons of waste are being collected by private companies. Most of the 1,000 tons of waste collected per day either go to the landfill to be buried (400 tons/day) or is being used for land reclamation (540 tons/day). The remaining 60 tons of waste are being recycled; therefore, about 6% of the total amount of waste is being recycled which is very low compared to Korea where about 60% of the waste is being recycled. Recycling is important because it diverts a large amount of waste going to the landfill.

Figure II-5 | Waste Processing in Barbados



- Yellow: Public Sector
- Pink: Private Sector

3. Problems and Issues

The two biggest problems and issues in waste collection in Barbados are 1) collection trucks and 2) roads. In case of collection trucks, the biggest problem is that the trucks and facilities are old and outdated. There should have been a continuous purchasing of at least a small number of trucks every year or every two years; however, in Barbados, large number of trucks were purchased in 1999, 2005 and 2013 without replenishing fleet in other years. Since the trucks are old and overworked, there are constant mechanical failures mainly in the gear, brake, compactor and transmission. Since 1991, a total of 88 trucks were purchased; however, currently there are only 41 trucks that can be used and out of these 41, only 15 trucks were operational during our mission trip. The remaining trucks were in the shop waiting for replacements and minor repairs. Some trucks were completely unusable and some were outside the shop being worked on for major repairs by outsourced private companies. The percentage of operating trucks was far below 50% while in Korea, the percentage of operating trucks was maintained to levels above 85% at all times. Table II-6 shows the defect ratio of equipment.

Table II-6 | Defect Ratio of Equipment

Year of Make of Equipment	Operating	Repair		Total
		Minor	Major	
1991		1		1
1992			1	1
1994			1	1
1996			1	1
1998			1	1
1999	6	3	2	11
2000			1	1
2001			1	1
2002			1	1
2003			2	2
2005	15	5	11	31
2006	3			3
2007	3	2	2	7
2008	3	1		4
2009			2	2

Year of Make of Equipment	Operating	Repair		Total
		Minor	Major	
2010	2	1	3	6
2013	9	2	3	14
TOTAL	41	15	32	88

The other major problem is in the road infrastructure of Barbados where a lot of the roads are narrow and hard to access by waste collection trucks. There are a lot of roads with dead-ends and no turn-around points; thereby, forcing waste collection trucks to back into the dead-end roads for pickup or make hard almost impossible turns to drive out of roads. Low hanging trees or electric wires also pose problems to drivers and parked cars sometimes make it impossible to reach houses in streets with narrow roads. Other problems that arise are that sometimes persons dump their waste into other person's garbage lots or skips in order to avoid payment for excessive discharge. Table II-7 shows the troublesome issues related to waste collection.

Table II-7 | Troublesome Issues related to Waste Collection

Structural Aspects	Non-structural Aspects
• Low electric wire • Road trouble • Narrow road • Dead-end alley (cul-de-sac) • Road constructing • Obstacles(floating wood) in storm	• Difficulty to the block collection service • Road trouble • Heavy traffic jam • Illegal car parking • Incorrect usage of free dischargers to the bins of paid dischargers

Ⅲ Case Study on Korea's Experiences

1. Korean Waste Management Laws and Policies

1.1. Development of the Waste Regulations

The Waste Management Policy of Korea which started with the 'Garbage Cleaning Law' of the 1960s has developed continuously through the establishment and amendment of the related laws and regulations. There was a dual waste management policy before 1986 because residential waste was managed under the 'Garbage Cleaning Law' while industrial waste was managed under the 'Environmental Protection Law'.

It is difficult to say that both the 'Garbage Cleaning Law' and the 'Environmental Protection Law' can be considered real waste management policies, as they only pertained to the cleaning and disposing of the wastes instead of managing them effectively and systematically.

However, with the establishment of the 'Waste Management Law' in the late 1980s, waste management became a single policy, and various waste management policies and regulations were established and implemented afterwards.

1) Establishment of the 'Garbage Cleaning Law' (1961~1986)

Established in December 1961 and abolished in December 1986, the 'Garbage Cleaning Law' focused mainly on thoroughly collecting and disposing of household garbage and human excrements in the cities. This was closely related to the social situation at the time where the neglected garbage and excrements damaged the views of the residential environments and public spaces, and the odors became a serious problem. Meanwhile, the 'Garbage Cleaning Law' was amended in 1973 to include not only household garbage and human excrements but other wastes as well.

2) Establishment of the 'Environmental Protection Law' (1978~1986)

As the result of the increasing awareness for environmental contamination problems as the result of the increase in industrial wastes from industrialization, the 'Environmental Protection Law' was established in December 1977 and enforced in January 1978. With the implementation of this law, the waste management policy in Korea became a dual policy where residential wastes such as

garbage and human excrements were managed under the existing 'Garbage Cleaning Law', while the industrial wastes were managed under the new 'Environmental Protection Law'.

Meanwhile, with the birth of the Korea Environmental Office in 1980 after the establishment of the 'Environmental Protection Law', Korea's environmental policies became more assertive. In other words, if the existing policies were considered more passive by focusing mainly on disposing (cleaning) the wastes that were produced by households and industries, the policies after the establishment of the Environmental Protection Law became more assertive, seeking for directions to maintain a clean environment.

Furthermore, in order to reflect the social situation of increasing importance for environmental problems, the Environmental Protection Law included more assertive solutions such as the evaluation on the pollutants' effect on environment, the environmental standards and contaminant levels for pollutants instead of preventing and improving the environmental pollutions.

3) The 'Waste Management Law' Era (1986~1992)

'Waste Management Law' was established in December 1986 to address the problems that were caused due to continuous increase of waste generation and the rising public awareness for the safe treatment and proper management of waste in Korea. Korea's waste management policy really developed with the establishment of the "Waste Management Law". Under the new 'Waste Management Law', the dual policy of 'Garbage Cleaning Law' (residential waste) and 'Environmental Protection Law' (industrial waste) became a single policy, and the concept of 'waste recycling' was included to accommodate the awareness in and the interest to practice recycling.

Then in 1991, a newly amended 'Waste Management Law' was publically announced to include such policies as waste reduction and recycling, waste collection and disposal deposits, follow-up management of the waste disposal facilitie. This was closely related to the need at that time for a policy that went beyond the simple waste disposal/cleaning concept to systematically and efficiently managing the waste from the production, collection, transportation, incineration, landfill and recycling stages (Hyung-Gi Ahn, 2010).

4) Law Separation Era (1993~present)

Since 1993 until now, the unified Waste Management Law was segmented and revitalized into recycling and resource recirculation as well as actively promoting the installation of waste disposal facilities by incorporating a variety of laws and regulations. In this regard, the 'Resource Saving and Recycling Law' was established in 1992 and enforced from 1993. This law separated waste reduction and recycling from the existing 'Waste Management Law' in order to promote recycling. Accordingly, the recycling policies and regulations such as reduction of packing materials, regulations on disposable products, waste disposal deposits and fees, and encouragement of recycling industries were enforced.

Additionally, the 'International Waste Transport and Disposal Law' was established in 1992 and enforced from 1994 to fulfill the Basel Treaty. Accordingly, the 'Waste Disposal Facility Installation and Local Support Law' was separated from the 'Waste Management Law' in 1995. The purpose

of this law is to prevent the NIMBY (Not In My Backyard) situation towards waste facilities such as incinerators by the local residents by giving them support to solve and mediate any social complications that may arise.

Laws for specific wastes were established in 2003 and 2007. These included the 'Construction Waste Recycling Law' of 2003 and the 'Electric Appliances, Electronic Products, and Automobile Resources Recirculation Law' of 2007. In particular, the 'Electric and Electronic Products, and Automobiles Resource Recirculation Law' was introduced for the resource recirculation concept and the product resource recirculation evaluation.

Meanwhile, the 'Standardized Garbage Bag System' and the 'Forbidding of Food Garbage Accumulation and Landfill Ban' were enforced in 1995 and 2005 respectively to reduce waste, promote separate collection through recycling, and recover resources.

1.2. Main Waste Laws

The main waste laws of Korea began with the 'Waste Management Law' in 1986 and developed through the 'Resource Saving and Recycling Law' and the 'International Waste Transport and Disposal Law' in 1994, the 'Waste Disposal Facility Installation and Local Support Law' in 1995, and then the 'Electric Appliances, Electronic Products, and Automobile Resources Recirculation Law' in 2007.

Table III-1 | Main Waste Laws

Year of Establishment	Name of Law	Details
1986	• Waste Controls Act	- Suppress waste production - Usage of eco-friendly disposable methods
1992	• Act on the Promotion of Saving and Recycling of Resources	- Suppress waste production and promote recycling - Promote recirculation of resources
1994	• Act on the Control of Cross Border Transportation of Hazardous Waste and • Their Disposal	- Regulate the importing, exporting and transiting of wastes to fulfill the 'Basel Treaty on the Restriction of International Transport and Disposal of Hazardous Wastes' - Prevent environmental contamination from international transportation of wastes and promote international cooperation
1995	• Act on the Promotion of the Installation of Waste Disposal Facilities and Assistance in Adjacent Areas	- Secure land for waste disposal facilities and support local residents - Build waste disposal facilities without problems and improve the welfare of the residents

Year of Establishment	Name of Law	Details
2007	• Act on the Resource` Circulation of Electrical and Electronic Equipment and Vehicle	- Promote the recycling of electric appliances, electronic products and automobiles by suppressing the use of hazardous wastes, making for easy re-usage, and appropriate recycling - Construct a resource recirculation system for efficient resource usage

Source: Anh. (2010). *Improvement Direction of the Waste Management Policy – Construction of an Inter-Governmental Cooperative Governance System*. Korea Local Government Society Bulletin", Vol. 22, No. 4

With the amendment of the 'Waste Management Law' in 1995, waste was divided into residential waste and commercial waste. The 'Waste Management Law' was amended in 2007 to introduce the 'Electronic Transfer and Takeover System', and made it obligatory to report the details of the wastes in order to strengthen and simplify the management process, and make it transparent. Accordingly, each time a business produces, collects, transports, recycles or disposes of wastes, all data relating to the transfer and takeover of the process has to be inputted in the electronic information processing program. Furthermore, if a business exports or imports wastes, information such as type, quantity, and disposal plans have to be reported to the Minister of Environment. Therefore, if one type of waste is imported or exported, the type, quantity, and disposal plans of the concerned waste must be reported to the Minister of Environment.

The 'Waste Management Law' was amended again recently and publically announced in July 2015, to be enforced in July 2016. The main purpose of the amendment was to manage the waste systematically and activate the recycling to develop the concerned industries and technologies. The main amendment of the 'Waste Management Law' is the systematic management of the wastes depending on the source, composition, and toxicity, while promoting the development of the new waste recycling technologies.

In order for a smooth enforcement of this amended law, the Ministry of Environment established guidelines for a more detailed waste classification, advanced and improved recycle management structure, and recycling environment evaluation, and plans to do maintenance on the enforcement ordinances and regulations.

1.3. Waste Management Plan

1.3.1. Comprehensive National Waste Management Plan

In 1993, the Ministry of Environment established the 'Comprehensive National Waste Management Plan (1993~1995)'. As the result of this plan, the 'Resource Saving and Recycling Law' was enforced (1993), the 'Waste Disposal Facility Installation and Local Support Law' was established (1995), and the 'Standardized Garbage Bag System' was implemented (1995).

However, this plan was amended due to the numerous internal and external changes which had an effect on the waste management conditions and policies. Two reasons for this are the 'Standardized Garbage Bag System' and the global environmental change. First of all, for one year after the initial implementation of the 'Standardized Garbage Bag System' in January 1995, residential waste was reduced by 27% and recycling increased by 35%, bringing about the need for a waste management plan to respond to this. Furthermore, there was also the need for change in the central government's policies towards the local governments who were closing themselves off after the election of the local government heads.

Globally, there was reorganization in the world order of gradual integration of environment and economy with the World Trade Organization (WTO) at the center, and Korea saw increasing need to change its environment. Additionally, as the result of the 1972 London Treaty on the prevention of ocean pollution from disposal of wastes and other matters, Korea had increasing need for new measures in preparation for the ocean disposed waste ban in the near future.

Therefore, the Ministry of Environment amended the 'Comprehensive National Waste Plan' which was established under the policy goal of 'building an infrastructure for the resource recirculation economy' as the basic plan on waste management, and established the '1st Comprehensive National Waste Management Plan (1996~2001)'. Then the '2nd Comprehensive National Waste Management Plan (2002~2011)' was confirmed in March 2003 to fixate the policy goal of a resource recirculation waste management system where the first plan was developed further to reduce the total quantity of the wastes, recover resources and recycle as much as possible, and dispose of inevitable wastes in an eco-friendly, safe and hygienic way. 'The 3rd Comprehensive National Waste Management Plan' is currently being finalized.

The policy goal of the 1st Plan was 'establishing a sustainable resource recirculation economy infrastructure' and three main focus areas were selected to achieve the goal of promoting resource recovery to protect nature and providing the citizens with a more pleasant living environment. The three focus areas are:

- Waste Minimization. Efforts would be made to develop policies in stages to minimize the production, distribution and consumption of the wastes during the entire life cycle of a product.
- Resource Recovery. An integrated recycling system would be constructed to promote resource recovery and increase the efficiency of the waste resource distribution.
- Safe Waste Management. A plan is needed to find ways to prevent environmental pollution and effectively manage harmful wastes.

Additionally, the 1st plan presented five main strategies for clarifying the roles and responsibilities of each economic group, integration and efficiency of the waste management system, minimization of wastes at each stage of a product's life cycle, promotion of regional competitiveness based on the characteristics of that region, encouragement for more public participation and establishment of a 'Green Spending' culture.

With the goal of achieving a sustainable resource recovery society or a Zero Waste Society, the '2nd Comprehensive National Waste Management Plan (2002~2011, amended in 2007)' presented six strategies. "Zero Waste" or "Zero Discharge Waste" defined as a state where zero waste is incinerated or buried but 100% of the waste is either re-used or recycled. It is an ideal or theoretical state only and almost impossible to achieve in reality. The six strategies are waste risk management, waste resource recovery, waste reduction, waste disposal facility installation and advanced management, waste management internationalization and cultivation of the recycling industry, and the construction of a customer-oriented waste management system.

The '3rd Comprehensive National Waste Management Plan (2012~2021)' is currently being finalized to include the construction of a competitive system by regions, technology development to promote waste recycling, and conduction of a national statistical study on wastes.

1.3.2. Basic Resource Circulation Plan

The In 2011, the Ministry of Environment established the '1st Basic Resource Recirculation Plan (2011~2015)' to build an upcycling basis for waste resources in accordance with the 'Resource Saving and Recycling Law' with the objective of realizing the 'Low Carbon Resource Recirculation Society'. 'Upcycling' is changing the wastes into a new material or product that is higher in value qualitatively or environmentally (Ministry of Environment, 2015). Accordingly, all wastes are considered upcycleable resources, that is to say, they can be recirculated 100%, and such acknowledgement is the basic precondition for the realization of the low carbon recirculation society (Ministry of Environment, 2015).

This plan which contains five strategies, was established together with the various Korean ministries such as the Ministry of Public Administration and Security, Ministry for Food, Agriculture, Forestry and Fisheries, Ministry of Knowledge Economy, and the Ministry of Land, and Transport and Maritime Affairs. The five strategies are changing to a resource recirculation society structure, realizing an improved value resource recirculation (4Rs: reduce, reuse, recycle, recover energy), building an integrated waste disposal infrastructure, cultivating the resource recirculation industry and technology development, and providing the basis for implementation such as a national resource recirculation evaluation.

Meanwhile, this plan serves as the guideline for promoting government-wide resource recirculation to present the concerned governmental ministries with mid and long term goals and strategies for waste resource upcycling and green growth.

1.4. Waste Management System

1.4.1. Extended Producer Responsibility (EPR)

The main 'Extended Producer Responsibility (EPR)' was enforced in January 2003 in accordance with the amended 'Resource Saving and Recycling Law'. The goal of EPR is to strengthen the responsibilities of the waste producers to reduce wastes and promote recycling by inducing eco-friendly ways in all stages of waste management from product design, manufacturing, distribution, consumption, to disposal.

In accordance with this system, the producers have to fulfill their responsibilities depending on the number of product deliveries they receive and the obligatory quantity by products annually announced by the government. Those producers who do not fulfill their obligations are charged the 'recycle tax' which is less than 1.3 times the cost to collect and recycle a product. The producers are also required to pay an allotted fee to the Recycle Business Co-operative.

Table III-2 | Products Included in EPR

Classification	Items
Products	- Home appliances (TVs, refrigerators, washing machines, mobile phones) - Batteries (mercury, silver-oxide, nickel, cadmium) - Tires, lubricants, florescent lights
Packaging	- Paper packs, glass bottles, metal cans, and synthetic resin material used for holding or packaging food and drinks, agricultural products, fishery products, meat products, detergents, cosmetics, pharmaceuticals, and butane gases

Source: KMOE, KERC. (2005). Extended Producer Responsibility. KMOE, KERC

Meanwhile, the fulfilling of the obligatory recycling amount can be executed in either of three methods. The first method is for the producer to recycle them himself, and the second method is for the producer to hire a recycling company for the job. The third method is for the producer to join the Recycling Business Co-operative and pay the allotted fee. If a producer chooses to fulfill the recycling obligation using either the first or the second method, then there is an incentive given to the producer where a deduction is provided for the amount of payment of the allotted fee. The amount of deduction is proportional to the recycling amount multiplied by a deduction factor determined by the Ministy of Environment.

1.4.2. Standard Garbage Bag System

The 'Standard Garbage Bag System' was enforced in January 1995. The targets for this system are household garbage and wastes from small businesses that have the similar composition to the recyclable residential wastes.

This is a system where the waste producer pays a fee for the wastes they throw out, thus reducing waste and increasing recycling. The fee is collected through the sale of special garbage bags or stickers designated by each local government for the wastes. Accordingly, the levying of the garbage fee changed from a fixed amount based on property tax or building area, to be proportional to the waste output (through usage of the 'standard garbage bags').

According to this system, waste has to be disposed of at a specific area using the standardized garbage bags but if these special bags are not used and the offender is identified, a fine of less than 1 million won (U$850) is charged. However, the standardized garbage bags are not required and collected free of charge for recyclable wastes if they are disposed of in accordance with the guidelines of the local governments. For those large wastes that cannot be disposed of in the

standardized garbage bags, households need to be call the local district office and ask for removal of the waste with some payment. The payment amount and an invoice is issued by the local district office and the households need to go to any bank to make the payment (invoice is needed for payment).

1.4.3. Sharing Expenses System

The 'Sharing Expense System' was introduced in 1993 to suppress the production of wastes from the product manufacturing stages as well as to prevent waste. This system charges a waste disposal fee to the manufacturer or importer of products, supplies or containers that contain harmful materials or are difficult to recycle, causing problems in waste management. These products include containers for insecticides and hazardous products, antifreeze, gum, disposable diapers, cigarettes, and plastics.

The "sharing expense fee" is included in the special accounts for environmental improvement and used for the promotion and activation of recycling. The purpose of the fee is to purchase and store recyclable resources, support recycling businesses and install waste disposal facilities, research and develop technologies to effectively recycle and reduce wastes, and support the local governments in the collection and recycling costs of the wastes.

1.5. Summary and Implications

In reviewing the development trends of Korea's waste management policies based on the contents discussed, it is apparent that as time went on, development took place in Korea in the order of 'garbage cleaning - waste reduction - safe handling of wastes and waste management reinforcement - recycling and resource recirculation'. In other words, from cleaning or reducing wastes, the policies gradually progressed and developed into efficiently and effectively managing and using recyclable wastes, to improving the usage value or adding new value to the wastes as if the wastes were also resources as well.

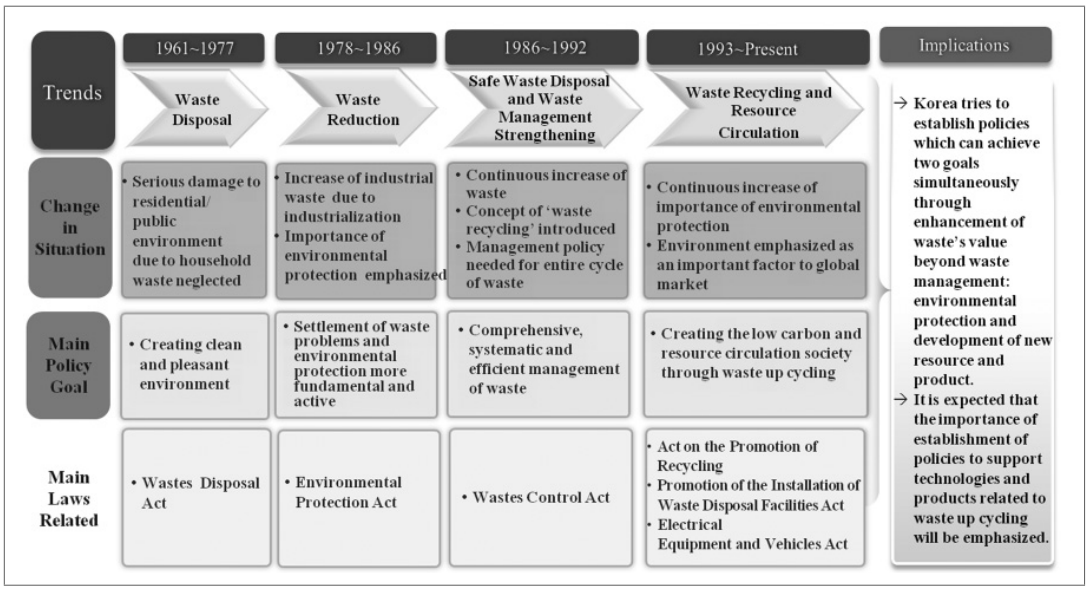
In the past before the industrialization era, when Korea's main concern was 'how not to go hungry' and livelihood was the most important thing for the people, residential wastes were almost neglected. However, with the continuous increase in population and livelihood activities became more vigorous, the wastes produced also grew drastically and the previously neglected wastes not only damaged the views of the residential environments but also public spaces such as roads as well, while the serious odors became an important social issue. Hence, the 'Garbage Cleaning Law' was established in 1961 to dispose the wastes to provide a pleasant living environment, becoming the starting point for waste disposal.

However, with the increase of industrial wastes resulting from industrialization which was taking place in the late 1970s, industrial wastes became a separate category under the 'Environmental Protection Law' of 1977. In addition, with the increasing wastes resulting from industrialization leading to environmental pollution problems, and the rise in awareness of the importance in environmental protection, political weight began to move from just cleaning up the garbage to

slowly reducing the amount of waste to fundamentally and actively solving the waste issues and seeking ways to protect the environment.

Through the establishment of the 'Waste Management Law' in the late 1980s, the waste management policy entered a full-scale progressive stage. With the importance of safe treatment and reinforcement of waste management becoming more apparent as the result of the continuously increasing wastes, policies for residential wastes and industrial wastes integrated as one comprehensive structure. Furthermore, a new concept of 'recycling' was introduced in the 'Waste Management Law' by changing the thinking of wastes as simply being 'useless garbage that need to be removed' to 'materials that can be used again'. This thought process became the starting point for drawing up a policy to systematically and efficiently manage all the stages of waste management from waste production, collection, transportation, incineration, landfill and recycling.

Figure III-1 | Development Trends of Korea's Waste Management Policies



Meanwhile, the waste management policy from the 1990s until the present has focused on increasing not only recycling based on the 'Resource Saving and Recycling Law', the 'Electric Appliances, Electronic Products, and Automobile Resources Recirculation Law', and the 'Standardized Garbage Bag System', but also on building a 'Low Carbon Resource Recirculation Society' through 'Waste Upcycling'. It can be said that the increasing awareness on the importance of environmental protection within Korea had a large impact on such trend, but the global trend of focusing on national competitiveness and world order as well as 'environment' and 'economy' centering around the World Trade Organization (WTO) also had a considerable affect.

'Waste Upcycling' is one step further in development beyond 'waste recycling'. In other words, it is adding a new design or process to a waste to add value qualitatively and environmentally and

recreating a new material or product. When waste upcycling actively takes place, not only will waste reduction and recycling be achieved, but also will secure the necessary resources to manufacture a new product effectively from the point of view of costs and productivity. Furthermore, new industries can be created and developed centering on waste upcycling.

In order for these effects to be actually displayed, there is a need for a policy to back up the waste upcycling. Accordingly, it will be interesting to see the outcomes of the '1st Basic Resource Recirculation Plan (2011~2015)' established by the Korean government in 2011 by emphasizing the importance of waste resource upcycling and the follow up policies developed afterwards. Also, during the follow up policy establishment processes, it will be important to seriously consider the efficient management of the wastes as well as the upcycling technologies and policies supporting product development, bearing in mind the upcycling process itself.

1.6. Comparison of the Waste Management Policy for Barbados and Korea

The waste management policy of Korea started with the 'Garbage Cleaning Law' in 1961 to clean up the garbage of the cities, and influenced by industrialization, the 'Environmental Protection Law' was enforced in 1978 to manage the industrial wastes, looking for ways to actively improve the environmental pollution. Additionally, with the enforcement of the 'Waste Management Law' in 1986 to efficiently manage the increasing wastes, the 'Garbage Cleaning Law' and the 'Environmental Protection Law' were integrated into one.

'The Health Services Act (law to promote and preserve health)' of Barbados started to manage the wastes in 1969, and with the gradual increase in population and development of the tourism industry, the 'Integrated Solid Waste Management Programme (ISWMP)' was enforced in 1993 to improve Barbados's weak area of solid wastes.

Both Korea and Barbados integrated the relevant waste policies in 1986 and 1993 respectively in order to efficiently manage the wastes, but Korea opens the 'Law Separation Era' in 1993 by establishing separate laws for each waste product. That is to say, the focus of Korea's waste management policy is in suppressing the production of wastes and promoting resource recirculation through recycling, and thus various waste systems that were previously regulated by the traditional Waste Management Law were separated into the Resource Recycling Law and the Individual Recycling Law (Chae, 2009).

Korea currently not only has policies to increase waste recycling, but also established the '1st Basic Resource Recirculation Plan (2011~2015)' to realize the 'Low Carbon Resource Recirculation Society'. In order to achieve the low carbon resource recirculation society, the policy makers in Korea are aware that all wastes are resources that can be upcycled 100%. Barbados also has established the 'Barbados Sustainable Development Policy (BSDP)' and 'The National Strategic Plan of Barbados 2005~2015)' to establish the basic principles for sustainable development.

Both Korea and Barbados have developed policies and legal structures for solid waste management differently in accordance with the social, cultural, economic, and geographical

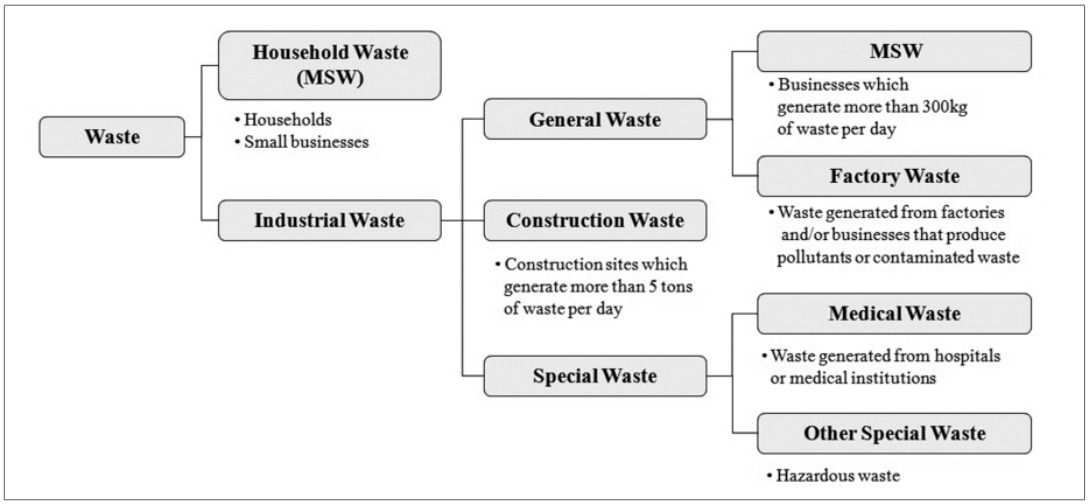
environments of each country. If Korea strengthens the legal system of the necessary areas through segmentation of Korea's relatively multi-complex industrial structure, various international stakeholders and rapid growth, Barbados has a relatively simple industrial structure to manage the solid wastes integrally. However, both countries are striving for a resource recycling and resource recirculation society for sustainable development.

2. General Status of Waste in Korea

2.1. Definition and Classification of Waste

In Under Article 2 of the "Waste Management Law", waste is defined as 'materials that are no longer needed in people's lives or business activities'. Also, residential wastes are wastes other than the business wastes, while business wastes are wastes produced by air, water quality, noise and vibration discharging facilities and businesses designated by the presidential decree. Designated wastes are those such as waste oil and waste acid that can pollute the surrounding environments or those that can be harmful to the body such as medical wastes and determined by the presidential decree.

Figure III-2 | Classification Structure



The classification of the wastes can be categorized largely into residential wastes and workplace wastes, where residential wastes are those other than the workplace wastes, and workplace wastes can be classified into three types – general workplace wastes, construction wastes, and designated wastes. Here, general workplace wastes are classified as workplace wastes and discharging facilities wastes, and designated wastes are classified as medical wastes and designated wastes other than the medical wastes. In other words, workplace wastes are those that are discharged more than 300kg per day or more than 5 tons as the result of a series of constructions or work (excluding construction

companies), and discharging facilities wastes are wastes produced by air, water quality, noise and vibration discharging facilities, end waste water treatment facilities, public sewage treatment facilities, human excretion treatment facilities, public animal excrement treatment facilities, and waste disposal facilities. Construction wastes are wastes from construction companies producing more than 5 tons from construction work.

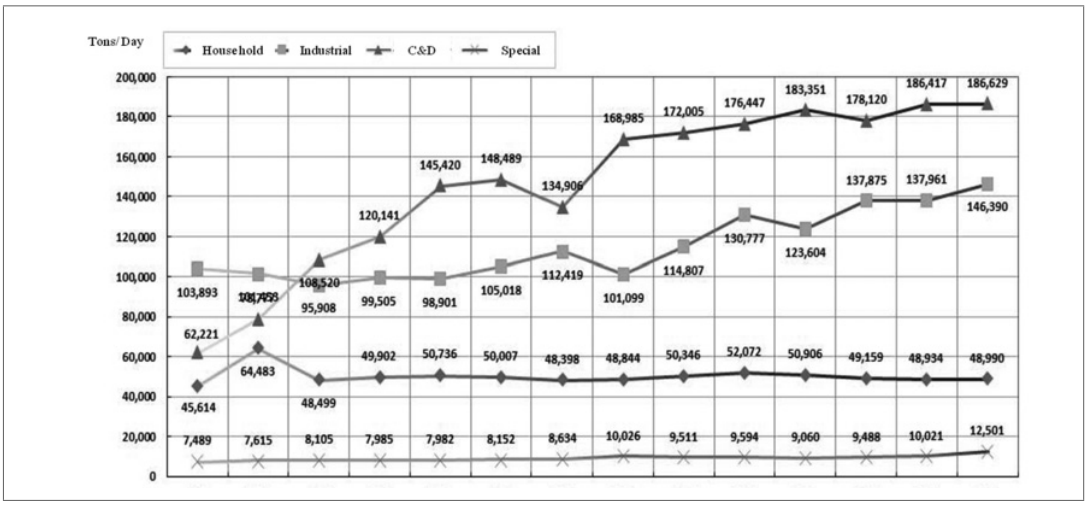
2.2. Waste Generation and Disposal

2.2.1. Waste Generation

Under the "Waste Controls Act" the Korean government conducts research every year to determine the source of the produced wastes, types and principal treatment agents, treatment methods, and treatment status, and a national statistical waste research every five years to use as the basic data for policy establishment.

Waste quantities from 1999 until 2012 continued to increase starting in 1999 from 219,217 tons/day, and increasing close to twice the amount in 2012 at 394,510 tons/day. Looking at the compositions, there was no big change in the residential wastes and designated wastes, but the composition of the general workplace wastes increased by about 1.4 times, while construction wastes increased by approximately 3 times. When looking at the waste status ratio in 2013, construction waste was approximately 47%, general workplace wastes was 37%, residential wastes was 12%, and designated waste was about 3%.

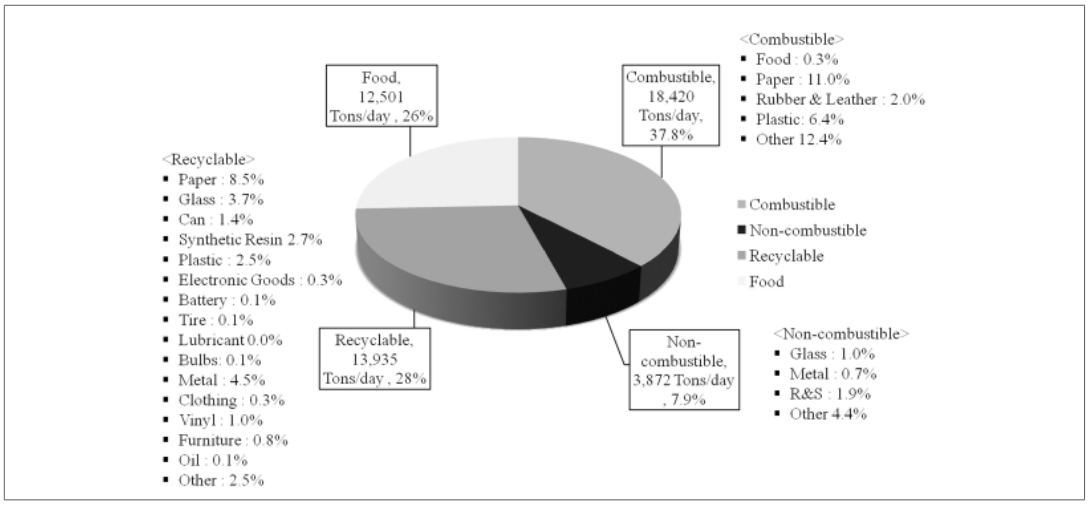
Figure III-3 | Waste Generation for the last 15 years



Source: KMOE. (2015). *2014 Environmental White Paper*. KMOE

In looking at the composition of the residential wastes based on the 2013 results, combustible was largest with 18,420 tons/day (38%), recyclable was 13,935 tons/day (28%), food was 12,501 tons/day (26%), and incombustible was 3,872 tons/day (8%).

Figure III-4 | Composition of Residential Waste



Source: KMOE (2014). 2013 Nationwide Waste Generation and Disposal Status. KMOE

2.2.2. Waste Disposal

Looking at the residential wastes by disposal methods for 1999, out of the total of 45,614 tons/day, landfill was largest with 52%, incineration was 38%, recycling was lowest with 10%, but in 2012, out of the total residential waste of 48,990 tons/day, landfill was rapidly reduced to 16%, and recycling rapidly increased with 59%. From 2005, with the ban of burying food wastes and waste separation expanded, recycling increased while influencing the reduction of incineration and landfill.

As the result of the standardized garbage bag system, recycling policy, and waste resource energy conversion implemented from 2000, Korea's waste disposal structure is changing from a simple landfill-oriented system to a resource recirculation system that prioritizes the recirculation of waste resources.

Figure III-5 | Disposal of Residential Waste



Source: KMOE. (2015). 2014 Environmental White Paper. KMOE

2.3. Waste Disposal Companies and Facilities

2.3.1 Waste Disposal Companies

If a waste is disposed or recycled in Korea, permission is required under the 'Waste Controls Act'. The waste disposal business can be categorized into collection and transport, middle disposal, final disposal, and recycling. For the construction waste disposal companies, they need permission for the middle disposal process. There are a total of 12,534 approved waste disposal companies comprising of 6,573 collection and transport companies, 262 middle disposal companies, 55 final disposal companies, 5,146 recycling companies, and 498 middle processing (construction waste) companies. "Middle disposal" and "middle processing" companies are categories only used in Korea which refers to companies performing incomplete processing such as simple shredding, sorting, chemical treatment, etc.

Table III-3 | Waste Disposal Companies

Category	Collection & Transport	Middle Disposal	Final Disposal	Recycling	Middle Processing	Total
Household	1,473					1,473
Emission Facility	2,983	184	38	4,577		7,782
Construction & Demolition	1,495				498	1,993
Special Waste	464	63	17	569		1,113

Category	Collection & Transport	Middle Disposal	Final Disposal	Recycling	Middle Processing	Total
Medical Waste	158	15				173
Total	6,573	262	55	5,146	498	12,534

Source: KMOE. (2014). *2013 Nationwide Waste and Disposal Status*. KMOE
KMOE. (2014). *2013 Designated Waste and Disposal Status*. KMOE

2.3.2. Waste Disposal Facilities

The waste disposal facilities built and operated by the local governments in Korea are landfills, incineration facilities, food waste recycling facilities, recycling selection facilities, and solid fuel product manufacturing facilities. There are a total of 690 facilities comprising of 233 landfills, 184 incineration facilities, 53 food waste facilities, 66 recycling selection facilities, and 164 others.

Table III-4 | Waste Disposal Facilites by Municipalities

Classification	Landfill	Incineration	Food	Selection	Other	Total
Seoul		5	5	10	26	46
Busan	1	3		2	12	18
Daegu	1	1				2
Incheon	5	9	4	3	5	26
Gwangju	1	1	1	1	5	9
Daejeon	1	1	1		4	7
Ulsan	2	2	1	1	1	7
Sejong	1	1		1		3
Gyeonggi	9	24	13	9	36	91
Gangwon	24	16	1	2	9	52
Choongbuk	13	10	2	4	2	31
Choongnam	16	10	6	5	3	40
Jeonbuk	15	2	1	5	8	31
Jeonnam	58	51	5	7	22	143
Gyeongbuk	38	24	4	6	12	84
Gyeongnam	28	17	7	8	17	77
Jeju	10	7	2	2	2	23
Total	223	184	53	66	164	690

Source: KMOE. (2014). *2013 Nationwide Waste and Disposal Status*. KMOE

2.4. Residential Waste Manpower and Budget

2.4.1. Residential Waste Manpower and Equipment

The collection and disposal of residential wastes can be handled directly by the local governments or consigned to private professional companies in Korea. It is reported that as of 2013, the total number of people handling the collection and disposal of residential wastes are 34,014 people, 11,445 collection trucks, 7,321 handcarts, and 545 heavy equipments.

Table III-5 | Residential Waste Manpower and Equipment

Classification	Persons	Trucks	Handcarts	Heavy Equipment
Total	34,014	11,445	7,321	545
Local Governments	18,577	4,903	5,154	408
Professional Companies	15,425	6,540	2,107	108
Self-Operated Companies	12	2	60	29

Source: KMOE. (2014). *2013 Nationwide Waste and Disposal Status*. KMOE

2.4.2. Residential Waste Budget

The budget needed to install a residential waste disposal facility, operate the trucks, purchase equipment, pay consignment, and operate the facilities as of 2013 was approximately 3.1 trillion won ($U2.65 billion) and approximately 4 trillion won (U$3.42 billion) in 2014. Out of the total, consignment fee was the largest with 1.2 trillion won (U$1.03 billion), 84 billion won (U$718 million) for labor, and 35 billion won (U$299 million) for facility operations.

Table III-6 | 2013 Residential Waste Expenditures

Facility Installation	Labor	Truck Operation	Equipment Purchase	Consign-ment	Facility Operation	Other	Total
297,424	840,043	67,246	29,985	1,273,340	349,189	259,995	3,117,223

Source: KMOE. (2014). 2013 Nationwide Waste and Disposal Status. KMOE

Table III-7 | 2014 Residential Waste Budget

National Expense	Local Expense	Municipal Bond	Total
165,210	3,248,620	66,054	4,110,786

Source: KMOE. (2014). 2013 Nationwide Waste and Disposal Status. KMOE

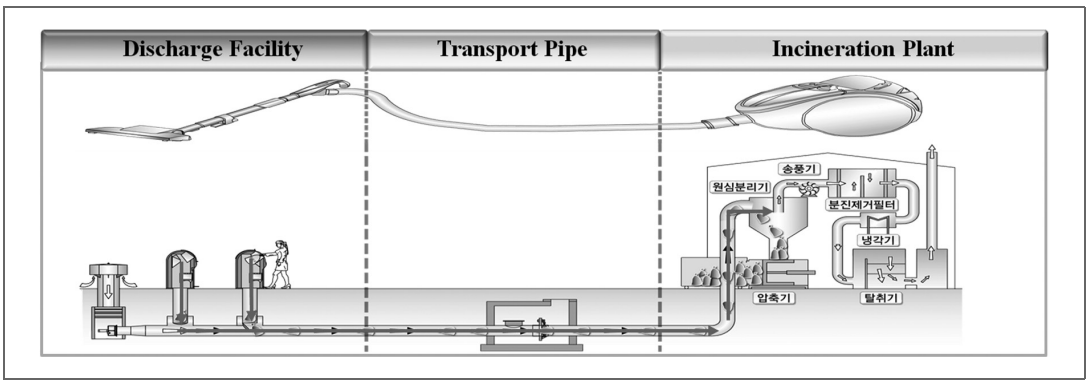
3. Case Studies in Korea

3.1. Automatic Pipeline Transport System

In the general case, residential waste are placed in standard garbage bags and discharged in pre-specified locations near the house for curb side service. The main problems for this general process is odor, unpleasant view, flies and other insects, cats which are major causes of claims by residents in the area. A new process and system is currently being implemented in a few areas in Seoul such as the Eunpyung region where an Automatic Pipeline Transport System (APTS) is constructed and being used to solve the above mentioned problems. Test cases were started in 1990 and now in 2015, newly constructed apartment complexes all are equipped with the APTS.

The Figure below show the conceptual idea behind the APTS where residents in the apartment complexes would bring their residential waste to fixed location trash bin and using their pre-assigned RFID cards, residents would open the trash bins with their RFID cards and deposit their waste in the bins. The bins are directly connected to nearby incineration plants via an underground (or above ground) pipelines which uses vacuum suction to automatically transport the deposited waste to the incineration plant where the waste are burned for energy. The APTS eliminates the need for collection trucks and residents can discharge waste at any time of the week without delay.

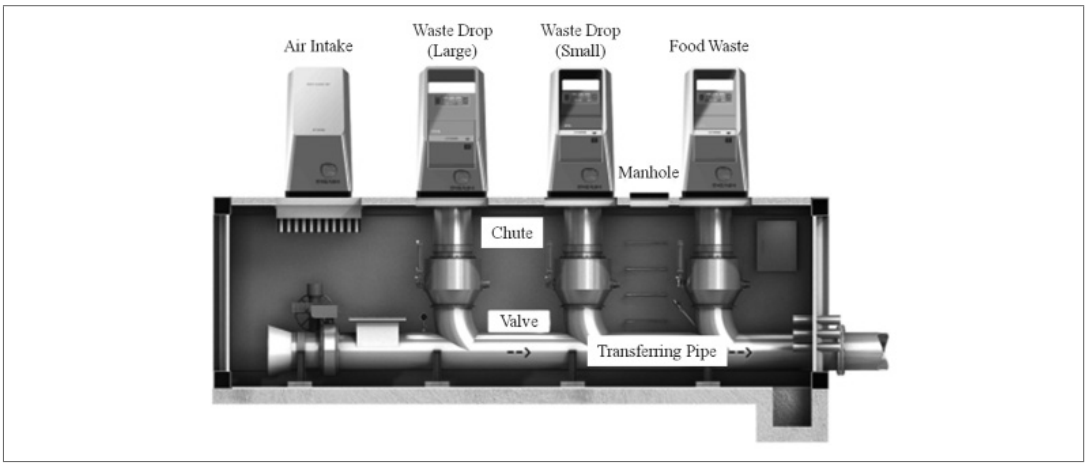
Figure III-6 | Automatic Pipeline Transport System



Source: KWEA. (2013). Automatic Pipeline Transport System. KWEA

The Figure below show two designs of trash bins used for the APTS.

Figure III-7 | Trash bins for the APTS



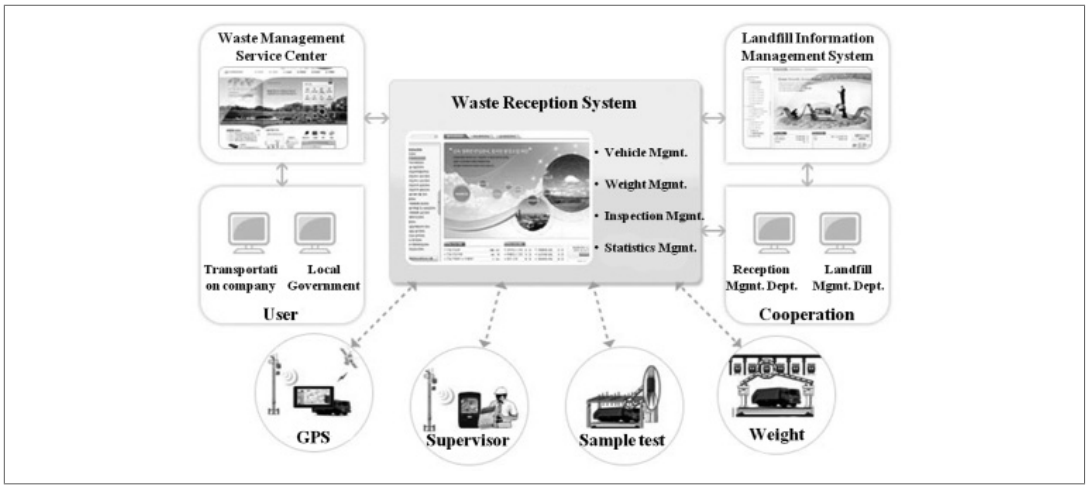
Source: KWEA. (2013). Automatic Pipeline Transport System. KWEA

3.2. Allbaro System

Up to the year 2000, all data related to waste collection and disposal were manually recorded and stored. The collection companies recorded collection activities using daily work sheets and disposal companies recorded all disposal activities using a daily log. The manual process was inefficient in using unnecessary time, manpower and effort to perform tasks that could were menial and labor extensive.

In 2001, a computer system called "Allbaro" was implemented in order to automate the data collection, storage, and retrieval process associated with waste collection and disposal data. All collection companies, transportation companies, transfer stations, disposal companies would input daily collection, transportation and disposal data into the Allbaro system online where all waste related data was managed centrally which could be accessed and shared by all stakeholders. Allbaro is the only automatic waste management system in the world that is used by all stakeholders throughout the whole nation. Currently, over 350,000 companies and organizations are using the system and every year over 10 million data activities are processed by the system. The system keeps track of over 128 million tons of waste each year..

Figure III-8 | Waste Information Management System (Allbaro)



Source: Allbaro System. https://www.allbaro.or.kr. Oct. 2015

3.3. Medical Waste RFID System

In 20015, in order to properly monitor and manage medical waste which might be hazardous or contagious, the Ministry of Environment issued standardized plastic bins specifically for the storage and transport of medical waste. These plastic bins were tagged using RFID tags in order to track the progress of the waste from the initial discharge to the final disposal.

Figure III-9 | Plastic bins for medical waste with RFID tags



3.4. Use of GPS-based System for Budgeting Purposes

In Korea, almost all the collection and transport activities are outsourced to private waste haulers and in order to accurately determine the necessary budget to contract with the private companies, the local governments estimates the following parameters needed for the collection and transport activities: 1) cost of manpower, 2) cost of truck operations, 3) operational expenses, and 4) management costs. All the other parameters can be estimated using past data; however, in order

to estimate the cost of truck operations, we need to know the exact routes taken by the trucks in performing the collection and transport. A GPS-based tracking system can be used to monitor and track the actual routes of the collection trucks operated by the private waste haulers. The Figure below shows one example of such a system used by a local government agency in Korea.

Figure III-10 | Example of the GPS-based Tracking System



3.5. Residential Waste and Disposal

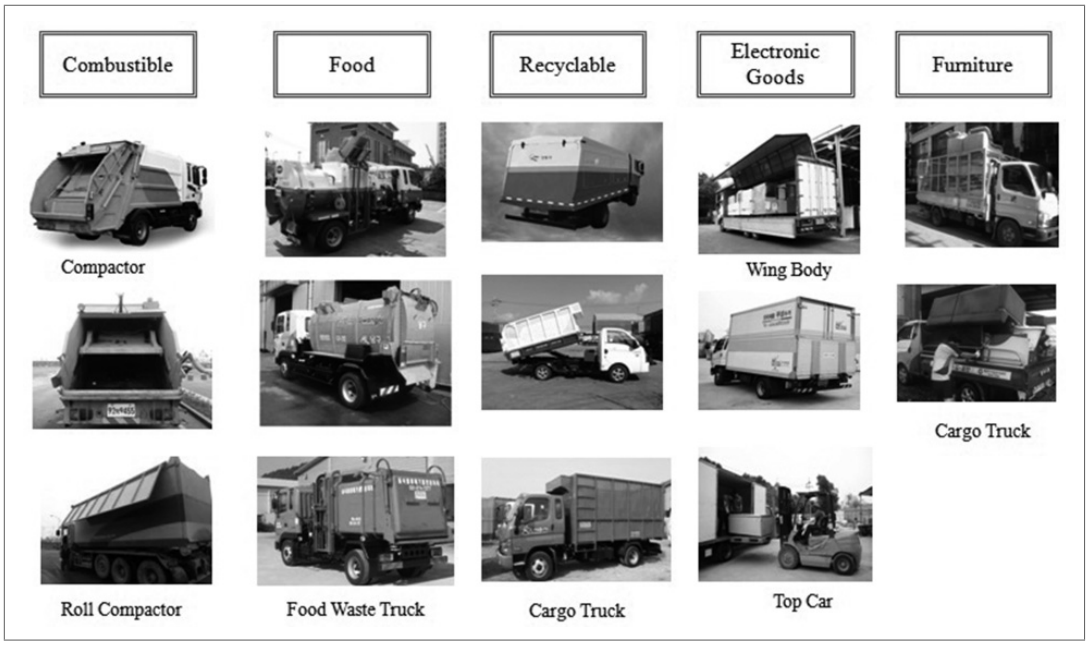
3.5.1. Separation and Disposal of Residential Waste

Residential waste is separated at the point of discharge depending on the composition of the waste. Combustible wastes and incombustible wastes are separated and discharged in their respective standardized garbage bags. There are no special criteria for recyclable wastes, but they are discharged in transparent bags that make it easy to confirm the contents inside the transparent bags. Large garbage is classified as used furniture and used household appliances, where stickers have to be purchased at the local district offices and put on the discharged furniture before they can be collected, while the discharged household appliances are collected free of charge if they are properly reported to the local district office.

3.5.2. Types of Trucks for the Collection and Transportation of Residential Wastes

The trucks for collecting and transporting of residential wastes differ depending on the type of garbage. Combustible wastes are generally transported by compressor trucks, and if the distance between the collection site and disposal depot is far, they are sometimes transferred to an "arm-roll" truck at a transfer station and before being transported to the disposal depot.

Figure III-11 | Types fo Trucks



Food wastes are transported with tank-lorries made exclusively for this purpose and these trucks are equipped with mechanical devices on the front or side of the trucks to load the special food waste containers. Recyclable wastes are mostly transported in cargo trucks that can unload in 'dumping' style. These trucks usually have high sides and an open-top. However, the recent trend for the recyclable waste trucks is renovating them by closing off the top for safety and for environmental reasons. Bulky wastes, such as used household appliances, are transported with "Wing-Body" trucks that open sideways or topside, while cargo trucks with open tops are used for furniture.

3.5.3. Residential Waste Disposal Methods

In general, residential wastes are disposed of by incineration, landfill, re-utilization or recycling. There are currently approximately 500 incineration facilities in Korea, where most of the medium and large incineration facilities recycle the heat to produce hot water or electricity (waste-to-energy plants). The incineration facilities are managed in accordance with the installation, management, and inspection standards of the Waste Management Law, and the emitted gas is managed strictly by the air quality standards of the Law. The Stoker-type incinerators are mostly used in Korea because of their efficiency and proven technology. However, various other types such as the Fluidized Bed, Rotary Kiln, Gasification, and Plasma were all considered with few currently in operation.

There are about 290 landfills in Korea, where 220 are public facilities. The landfill facilities are operated in accordance with the installation, maintenance and follow-up standards for dikes, shield skirts, leachate treatment sites, underground water control, gas pileup facilities, etc. accordance to

the Waste Management Law. The largest landfill is the Metropolitan Landfill which is in the vicinity of Seoul and handles the wastes generated in Seoul, Incheon and the Gyeonggi Province.

Food wastes are mostly handled by the three facilities comprised of the Compost Facility, the Fodder Facility, and the Anaerobic Digestion Facility. With the establishment of the Landfill Prohibition Law in 2005, the food waste treatment facilities increased to 280 nationwide, and they are being managed by the Waste Management Law together with the incineration facilities and the landfills.

Recyclable wastes consist of glass bottles, metal cans, plastics, papers, vinyls, and styrofoams that can be reused or recycled. They are transported to the recyclables sorting facility in their mixed state at the time of the collections, and then separated into various materials by people or machines. There are some 200 public and private sorting facilities in Korea, and the separated materials are then auctioned and sold to various recycling companies.

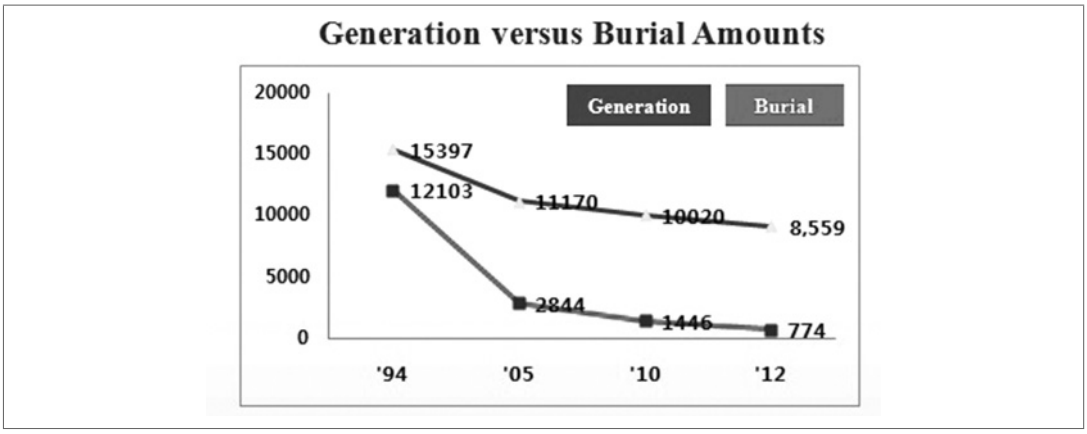
The SRF (Solid Refuse Fuel) Facility is an energy recovering facility that emerged as the substitute for the incineration facilities. SRF is also called the RDF (Refuse Derived Fuel) in the past. The SRF Facility produces solid refuse fuel in 'pellet' or 'fluff' form by crushing, grinding, drying and shaping the combustible wastes, and these wastes are used as natural fuels in cogeneration plants, cement kilns, and industrial boilers after the contaminants are removed and heat is increased.

3.5.4. Residential Waste Management in the City of Seoul

1) Residential Wastes and Disposal

Seoul, the Capital City of the Republic of Korea, has an area of 605km2, and a population of approximately 10.40 million people. It is a large city with 25 administrative districts and generates an average of about 8,559 tons (as of 2012) of residential wastes daily, with each person generating 0.8kg a day. With the Standardized Garbage Bag System implemented in 1994, the residential wastes decreased by 40% compared to 2012, and landfill was reduced to 94%.

Figure III-12 | Trend in Waste Generation and Burial in Seoul



Source: Yu. (2015). *Policy on Waste Management in Seoul*. City of Seoul

Based on the 2012 residential wastes, general garbage was 3,078 tons (36%), food waste was 3,072 tons (35.9%), and recyclable waste was 2,409 tons (28.1%). From this amount, 2,304 tons (42%) were incinerated, 774 tons (14.1%) were landfilled, and 5,481 tons (43.9%) were recycled, making recycling the most used method for waste treatment.

2) Residential Waste Collection and Disposal System

Residential waste is separated into general waste and recyclable waste, and general waste is collected by the local governments and transported to the incineration facilities and landfills. There are five incineration facilities in Seoul, and only one landfill, the Metropolitan Landfill. Recyclable wastes are collected by both the local governments and private recycling waste collection companies. The local governments transport to the recyclables sorting center where they are auctioned off after the EPR registration, while private collectors work directly with the recycling companies. Food wastes are collected by the local governments and directly contracted with recycling companies in Seoul and its vicinity.

3) Residential Waste Collection and Management Infrastructure

The collection and transportation of residential wastes and the management of street sweeping for the city of Seoul are differentiated. In the case of collecting and transporting, most of the local district offices work independently by contracting the jobs to third parties while operating with the income from the selling of standardized garbage bags. There are 3,018 sanitation workers cleaning from 19:00 until 05:00 daily.

Table III-8 |Residential Waste Collection and Management Infrastructure in Seoul

Category	Collection & Transportation	Street Sweeping
Responsible Party	Contractor	Local District Office
Number of Sanitation Workers	3,018 people	2,559 people
Cleaning Time	19:00 ~ 05:00	05:00 ~ 15:00
Operation	Independent	Local District Office

Source: City of Seoul. (2015). *Report on Resource Circulation.* City of Seoul

The street sweeping is handled by the local district offices with 2,559 workers cleaning from 05:00 until 15:00 every day.

There are a total of 1,953 trucks for collecting and transporting general household and food wastes in Seoul. General wastes are usually collected by compression trucks, cargo trucks and "arm-roll" trucks, while food wastes are collected by specially designed and manufactured food-waste collection trucks.

3.5.5. City of Busan's Formation of the Eco-Friendly Energy Town

1) Residential Wastes and Management

Busan is 769km2 in area with a population of about 3.56 million people, and divided into 16 administrative districts. Based on the 2014 figures, there were 3,258 tons/day of residential wastes generated composed of 1,030 tons of general wastes, 780 tons of food wastes, and 1,448 tons of recyclable wastes. From these wastes, 1,448 tons were recycled, 961 tons were incinerated, 69 tons were landfilled, and 780 tons of food was recycled, making recycling the highest treatment method.

Table III-9 | Waste Generation and Treatment in Busan

Year	Generated (tons/day)				Treated (tons/day)				
	Total	General Wastes	Total	General Wastes	Total	General Wastes	Total	General Wastes	Total
2014	3,258	1,030	780	1,448	3,258	1,448	961	69	780
2013	3,174	1,004	759	1,411	3,174	1,411	771	233	759

Source: City of Busan. (2015). *Report on Resource Circulation*. City of Busan

2) Residential Waste Treatment Facilities

The collection and management infrastructure of Busan's residential wastes are summarized in Table 22 with 3,047 people for collection and 1,044 trucks for cleaning. In terms of facilities, there are one landfill, two incineration facilities, one SRF facility, 15 recycling facilities, 116 recycling centers, seven food recycling facilities, and 394 waste treatment companies.

Table III-10 | Residential Waste Collection and Management Infrastructure in Busan

Category	Manpower and Facilities
Cleaning Manpower	• 3,047 sanitation workers
Cleaning Trucks	• 1,044
Landfill	• Area: 748,000m2, Capacity: 24,494,000m3
Incineration Facilities	• 2 (Myeongji, Haeundae) 510 tons/day
SRF Facility	• SRF Production Facility: 900 tons/day, Boiler Facility: 500tons/day, Power: 24.8MWh
Recycling Facilities	• 15 Sorting Centers, 116 Recycling Centers
Food Recycling Facilities	• 7 (2 public, 3 private, 2 local government) 964 tons/day
Waste Treatment Companies	• 394 (356 collect & transport, 38 mid-process, 2 final process)

Source: City of Busan. (2015). *Report on Resource Circulation*. City of Busan

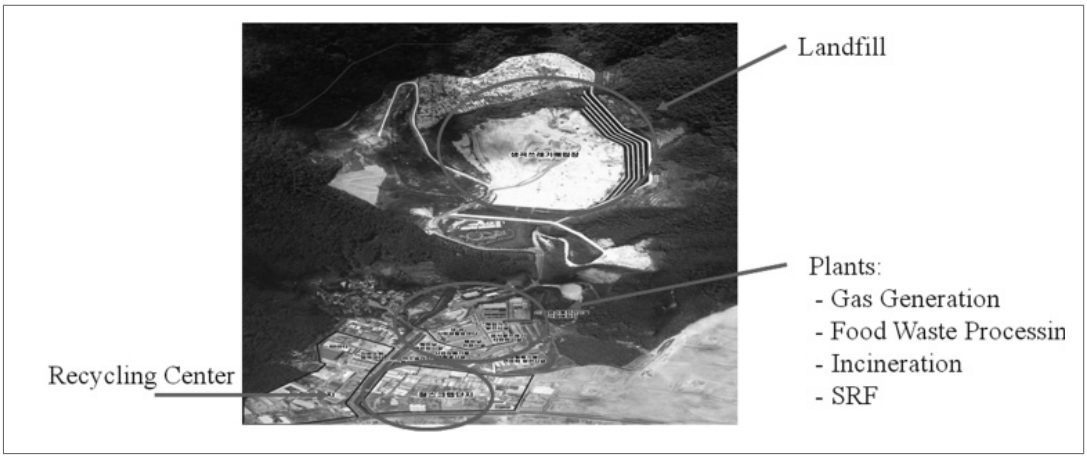
3) The Busan Eco-Friendly Energy Town

The infrastructure for Busan's residential waste disposal system is concentrated around the Saengok Landfill in Gangseo-gu, and the facilities mutually link together and reuse the energy generated from the waste treating process. The City of Busan is currently building an eco-friendly energy town to this infrastructure by adding a Specialized Resource Recirculation Complex.

The 'Eco-Friendly Energy Town' is a project that will solve the environmental and energy problem simultaneously by installing avoiding facilities like the landfill, sewage treatment plant, and incineration facility in one location and providing the local residents with actual benefits. The City of Busan plans to not only provide the residents with jobs, energy supply and improved welfare, but also expand their project into a culture and tourism business to overcome the general view of avoiding unpleasant facilities.

The LandFill Gas (LFG) generated from the Saengok Landfill produces 4MWh of electricity from the generator facility built with private investment and records an annual income of KW2 billion ($1.7 million), while the food recycling facility produces 2MWh of electricity from collected digestion gas. The SRF facility produces SRF from 900 tons of waste daily and the boiler facility uses this to generate 24.8MVh of electricity, bringing in KW15.9 billion ($13.6 million) in profits annually. Additionally, the Sewer Sludge Recycling Facility, the Recycling Center, the Recyclable Sorting Facility, the Vinyl Recycling Facility, and the Vinyl SRF Facility are also being used as eco-friendly facilities to recycle resources and collect energy, and the earnings from the Eco-Friendly Energy Town are being used for the local community after discussions with the local resident task force committee. Furthermore, the Special Resource Recirculation Complex that is being formed as part of the Governmental Assistance Policy is scheduled to be completed in December 2015, with the hope of attracting 77 private steel scrap and waste recycling companies, and creating some 3,000 jobs. The Complex plans to build the foundation for the recycling industry by creating a synergy effect of mutually linked companies of the recycling industry in one concentrated area.

Figure III-13 | Busan Eco-Friendly Energy Town



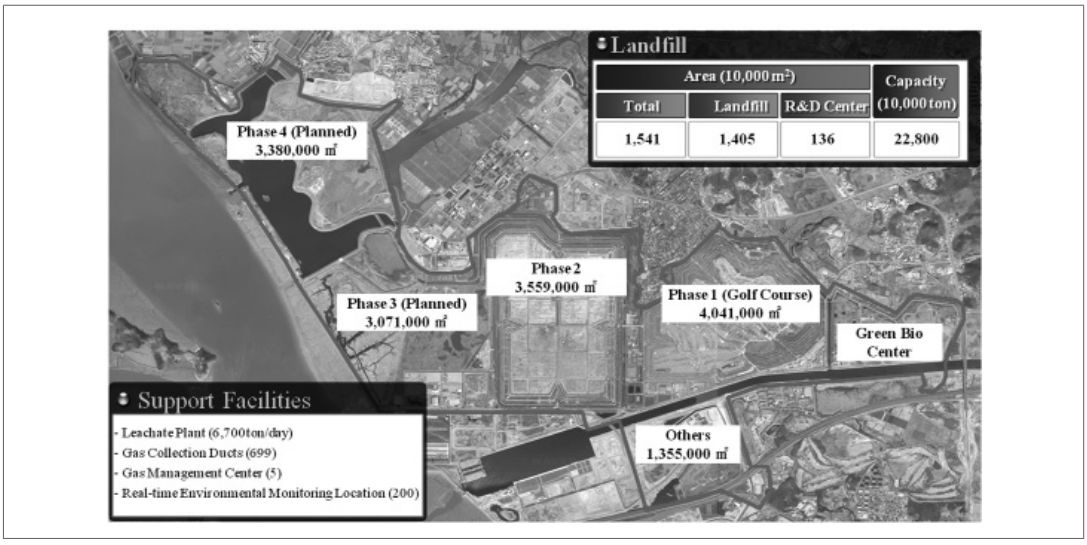
Source: City of Busan. (2015). *Best Practice: Busan Eco-Friendly Energy Town*. City of Busan

3.5.6. The Metropolitan Landfill and Plans for the Futuristic Theme Park

1) Metropolitan Landfill Facility

The Metropolitan Landfill was formed in 1992 and located in Seo-gu, Incheon to treat the residential and construction wastes generated in Seoul, Incheon and part of the Gyeonggi Province. It has an area of 15,410,000 m2 with the capacity of 228 million tons. It is comprised of four zones, with Zone 1 currently being used as a golf course after the area was filled completely. Zone 2 is currently in use, with Zones 3 and 4 remaining in reserve.

Figure III-14 | Current Status of Metroplitan Landfill



Source: SLC. (2015). *Development of Eco-Friendly Energy Town*. SLC

2) Eco-Friendly Metropolitan Landfill Energy Town

The Metropolitan Landfill is managed by the Metropolitan Landfill Site Management Corporation that was established by the Korean government to handle the wastes from the initial two cities and one province. In the beginning, the Corporation was planned to manage the landfill site only, but with the change in the waste policies and the times, it is now managing a variety of energy facilities additionally.

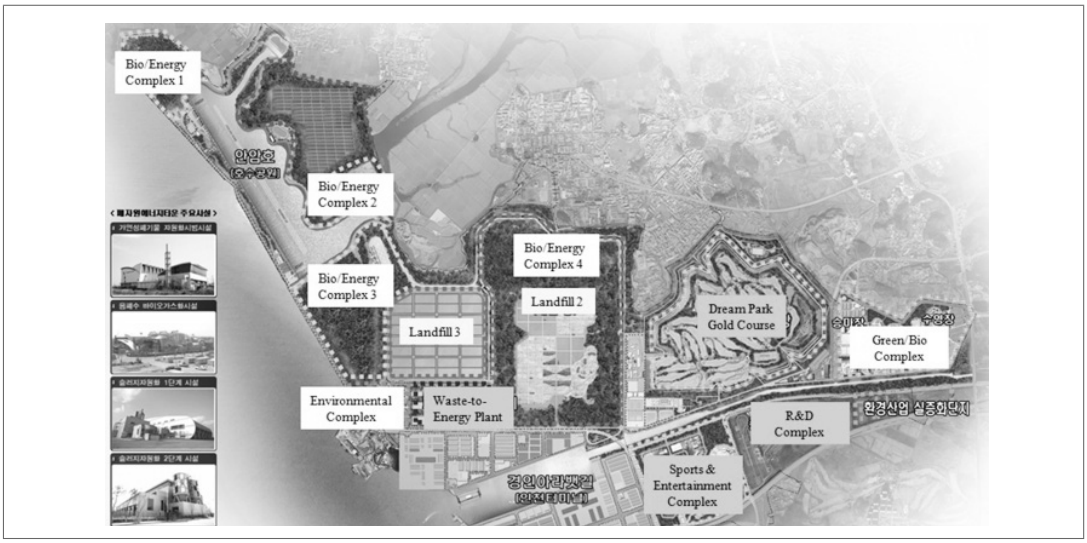
In accordance with the government's changed policy to reduce wastes and recycle more, the inflow of wastes to the Metropolitan Landfill was drastically reduced after 1994 from 11.7 million tons to 3.45 million tons in 2013, almost below 1/3. Taking into consideration the recent increase in oil prices and the basic conditions for utilizing energy, the formation of an eco-friendly energy town was planned from the end of the 1990s. The eco-friendly energy town was formed because there were infrastructures for the new towns and industrial complexes to supply heat and electricity near the vicinity of the Metropolitan Landfill, and there were a lot of combustible and organic wastes coming into the landfill that could be utilized for energy.

The Metropolitan Landfill Eco-friendly Energy Town uses the LFG from the landfill to produce 50MWh of electricity, the largest amount of its kind in the world, and operates a 200 ton/day SRF facility, with 25,000Nm3 of bio gas (methane content of more than 60%) from anaerobic digestion of the food waste water. In addition, the Town is equipped with a sewer sludge dry fuel facility (1,000 tons/day), a bio gas automobile fuel facility (10 m3/minute), a bio circulation forest, a resource recirculation research center and training facility, an international exhibition hall and convention facility.

3) Plans of the Metropolitan Landfill Futuristic Theme Park

The Metropolitan Landfill plans to go beyond its status of being the largest landfill and eco-friendly energy town, to form a global theme park and resort of the future. The goal of this project is to contribute to the activation of Incheon's economy and national development by forming a multi-resort complex with a variety of contents including environmental, touristic, leisure, recreational, cultural, amusement, and commercial.

Figure III-15 | Plan for Future Them Park



Source: SLC. (2015). *Development of Eco-Friendly Energy Town*. SLC

The multi-resort theme park will be developed on 5,4000,000 m^2 of land which includes the Zone 1 landfill and will house a Park & Resort Area, Golf & Healing Area, and an Urban Entertainment Center (an urban cultural facility).

The Park & Resort will be 870,000 m^2 in area comprised of a theme park, a water park and condominiums for both the young and the old to enjoy together, while the Golf & Healing area will be 3,000,000 m^2 and incorporate the golf course that is already in use with a healthcare town with state-of-the-arts medical equipment to be built. The Urban Entertainment Center will be 1,300,000 m2 and will house a shopping mall, outlets and hotels.

The Metropolitan Landfill hopes to take the second leap in development with the formation of the futuristic theme park, taking into consideration the regional advantages and conditions of the times.

Ⅳ Recommendation

1. Recommendation for Number of Operational Trucks

1.1. Evaluation Method for Collection Efficiency

1.1.1. MHT (Man Hour per Ton)

MHT is the man hour needed to collect one ton of waste, that is to say, the amount of time needed for one man to collect one ton of garbage. This number changes depending on the location of the garbage bin, distance, type and shape of the garbage bin, and the ability and type of the collection truck. In other words, the MHT is the direct variable that represents the collection efficiency.

According to Dr. Tchobanoglos in "Waste Treatment and Disposal", the garbage bag collection method involving the disposable garbage containers was the most efficient with 0.9 MHT, the usual street collection was 1.6 MHT, and the 'set out', 'set out & set back', and 'back yard carry' where the sanitation workers had to go indoors several times to bring out the wastes were the most labor-intensive with 2.6 MHT. Normally, based on the level o MHT equal to 1.0, collection efficiency is considered good if it is below this number, and poor if it is above. However, this MHT value is the official time-expense estimation of the sanitation workers, so the number can be reduced if the waste generation is coordinated amongst households.

Table IV-1 | General MHT Dependent on Type of Container and Location of Collection

Category	Plastic Bags	Movable		Fixed		
Outdoors	Indoors	Outdoors	Indoors	Outdoors	Indoors	Fixed
Actual Collection	0.12	0.24	0.63	0.73	1.01	1.16
Other *	1.23	1.23	1.23	1.23	1.23	1.23
Total	1.35	1.47	1.86	1.96	2.24	2.38

※ In "Other", the time in-between collections, time to and from transfer stations, and time for unloading at the transfer station are all included.

Source: Min, et al. (2003). Waste Disposal Engineering. Sae-Hwa Publishers

Table IV-2 | MHT Value for Collection Service

Collection Method		Characteristics	Remark
Bin Collection	Alley Collection	• Households located inside an alley bring their garbage bins to the collection truck on the street when they hear the collection bell and take the empty bins back.	1.6 MHT
	Curb Collection	• The collection truck empties the garbage bins located on the curb on a designated day and the owners take their empty bins back.	
	Block Collection	• The collection truck passes by on a designated route at a designated time signaling or ringing a bell, and the households bring their garbage bins to the collection truck. It is the same as the 'bell ringing' collection.	
	Set Out	• The collector comes into the houses to take the garbage bins out to the collection truck and the owners bring their empty bins back.	2.6 MHT
	Set Out – Set Back	• Similar to the 'Set Out' method, but the empty garbage bins are brought back by the collector.	
	Back Yard Carry	• The collector comes into the house to collect wastes from a fixed garbage container (more than 35 liters and less than 20kg).	
Poly Bucket		• Container collection method for industrial wastes.	0.9 MHT
Bag Collection		• For medium and small cities. Waste is collected in bags. Cost savings.	
Dust Box Method		• Boxes are installed on the street per tens of households and the collection truck takes them.	
Chute Method		• Chutes are installed on the walls of apartments or buildings.	
Container Collection		• Waste is stored on the lowest floor after being collected by the Chutes.	

Source: Min, et al. (2003). *Waste Disposal Engineering*. Sae-Hwa Publishers

1.1.2. The Time-Motion Study

The Time-Motion Study is a research done on the time it takes for the collection trucks or carts to leave the depot until they return with a full load. In this case also, the value changes depending on the location of the garbage bin, the distance, the type and shape of the garbage bin, the ability and type of the collection truck, the type of residence and the distance between the collections. Like the MHT value, the collection time is determined depending on the type and location of the garbage bin, and the actual collection time is used to influence the overall collection time. Therefore, it can be understood that in order to reduce the collection time, it is advisable to install movable rather than fixed garbage bins, outdoors instead of indoors, and the best collection method is the 'Bag' method like the standardized garbage bags.

The Time-Motion Study can be explained as follows, and this data is used to determine the collection efficiency factor:

- services/day/truck : number of houses per day per truck
- services/man/hr : number of houses per man per hour
- tons/day/truck : collection volume per day per truck
- tons/man/hr : collection volume per man per hour

Table IV-3 | Time-Motion Study Dependent on Type of Container

Category	Plastic Bags	Movable		Fixed		Wall Attachment
		Outdoors	Indoors	Outdoors	Indoors	
Actual Collection Time	3.7	7.4	19.6	22.7	31.4	35.9
Travel Time During Collection	4.8	4.8	4.8	4.8	4.8	4.8
Travel Time To Transshipment Depot	15.2	15.2	15.2	15.2	15.2	15.2
Unloading Time at Transshipment Depot	12.8	12.8	12.8	12.8	12.8	12.8
Other	5.4	5.4	5.4	5.4	5.4	5.4
Total	41.9	45.6	57.8	60.9	69.6	74.1

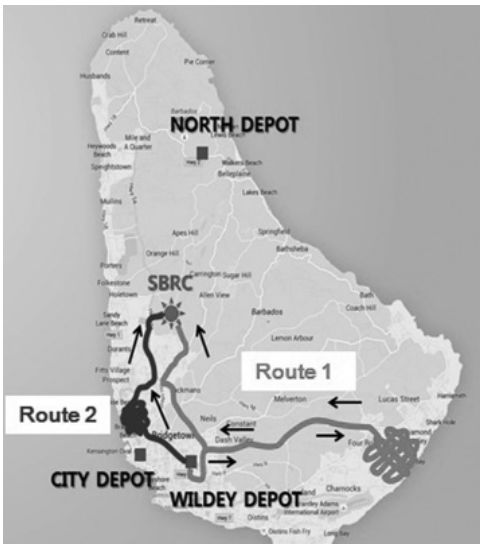
1.2. Time-Motion Study in Barbados

1.2.1 Route Selection for the Time-Motion Study

In terms of waste disposal collection, Barbados is divided into five regions of North, South East, South West, City East, and City West. Taking into consideration the distance between the regions, two depots, the Wildey Depot in the south and the North Depot in the north are in operation for the garbage trucks. While the Wildey Depot is responsible for collecting wastes from four out of the five regions of South East, South West, City East and City West, the North Depot is only responsible for the North region.

For the Time-Motion Study, two routes of South East and City West were selected from the Wildey Depot. Route 1 used the ML 271 collection truck with the capacity of 14.25 tons. The ML 271 left the garage at Wildey Depot, collected the wastes at South East's Mangrove Ocean City Foul Bay, unloaded at the SBRC Landfill and returned to the Depot. Route 2 used the ML 278 collection truck with the capacity of 5.92 tons. The truck left Wildey Depot for the Bridge Town Farm Road at City West to collect the wastes, unloaded at the SBRC Landfill and also returned to the Depot.

Figure IV-1 | Time-Motion Study Routes



▷ Route 1 [ML 271 truck]

Wildey Depot (garage) ⇒ South East Region (four roads ⇒ Mangrove Ocean City Foul Bay) ⇒ SBRC (landfill) ⇒ Wildey Depot (return to garage)

▷ Route 2 [ML 278 truck]

Wildey Depot (garage) ⇒ City West Region (near Bridge Town Farm Road) ⇒ SBRC (landfill) ⇒ City West Region (return to site)

1.2.2. Main Parameters of the Time-Motion Study

The measured values for the two routes are showed in Figure IV-1 (above). A compactor truck with a driver and two loaders were involved in the Study. While most of the countries use high performance small trucks for collection and large container-type trucks for transportation, Barbados uses small compactor trucks for both collection and transportation. This is because the overall waste transportation distance in Barbados is short.

For Route 1, the collection site was 14km (19 minutes) from the Depot, and a total of 10.66 tons of waste was collected from 372 pickups, travelling 14km (299 minutes) within the collection region. The collected wastes were taken to the landfill and then the truck returned to the Depot. Leaving from the Depot and returning back after the collection took a total of 395 minutes and the distance traveled of 67km. In the case of Route 1 travelled by the ML 271 truck, the time for one collection was 6.6 hours, and it was the route that had the 1 trip/day collection frequency so it is recommended that a large truck be used for the long distances.

In Route 2, the travel distance was 5km (11 minutes) from the Depot to the collection site, and a total of 4.72 tons of waste was collected travelling 4km (111 minutes) within the collection site, making 105 pickups. The collected wastes were taken to the landfill and then the truck returned to the collection site to collect the second batch of collection for the day. Leaving from the Depot and returning back after the collection took a total of 173 minutes, and the total distance traveled was 28km. For Route 2 where the compact short distance truck ML 278 was used, the time for one collection was 2.9 hours, and it is the route with the collection frequency of 2 or 3 trips/day.

Figure IV-2 | Parameters for the Time-Motion Study



1.2.3. Major Results of the Time-Motion Study

All major deducible results of the Time-Motion Study are presented in Figure IV-2 (above). The MHT, the most important numeric value in this study, was 1.84 man hour/ton which was slightly higher than the average for the outdoor movable or alley collection methods but indicated that a comparably efficient collection was taking place. However, the time it takes to collect one ton of waste was reduced by more than 1.4 times the standard collection, indicating that the loaders were very efficient.

As Route 1 and Route 2 were performed one outside the city center and one in the downtown (concentrated) area using either a large truck or a compactor truck respectively, the results of the Time-Motion Study is somewhat different. In the case of the city center where there is a densely concentrated population, the time it took to collect one ton of waste was less than outside the city center, but the volume per collection and time per collection was more than outside the city center.

Table IV-4 | Analysis of Time-Motion Study in Barbados

Index		Route 1	Route 2
No. of Operators		1 driver + 2 loaders	1 driver + 2 loaders
Vehicle	Type	compactor truck	compactor truck
	Capacity	14.25 tons	5.90 tons
Distance (km)	Travel	53 ㎞	24 ㎞
	Collect	14 ㎞	4 ㎞
	(Total)	67 ㎞	28 ㎞
Operation Time (hr/cycle)	Traveling	1.60	1.03
	Collecting	4.98 (Ⓣ 1.40 Ⓒ 3.58)	1.85 Ⓣ 0.40 Ⓒ 1.45)
	(Total)	6.58	2.88
No. of Pick-ups		372	105
Loads		10.66 ton	4.72 ton
Actual Loading to Truck Capacity Ratio		0.748	0.800
Operating Time Per Ton		0.617 hr/ton	0.610 hr/ton
Collection Time Per Ton	Total	0.467 hr/ton	0.392 hr/ton
	Net	0.336 hr/ton	0.307 hr/ton
Collecting Efficiency (MHT)		1.85 man·hr/ton	1.83 man·hr/ton
Collection/Pick-up	Per Pick-up	28.65 kg/pick-up	44.95 kg/pick-up
Collection Time/Pick-up		0.80 min/pick-up	1.06 min/pick-up
Net Collection Time/Pick-up		0.58 min/pick-up	0.83 min/pick-up
Operation Time/Collection Time		1.321	1.557

※ Ⓣ Travel Time within the Collection Region, Ⓒ Actual Collection Time

Table IV-5 | Time Required to Collect One Ton of Waste by Bin-type

Moveable Bins		Fixed Bins		Wall Attachments Indoors
Outdoors	Indoors	Outdoors	Indoors	
45.6 min./ton	57.8 min./ton	60.9 min./ton	69.6 min./ton	74.0 min./ton

1.3. Estimation of the Required Number of Collection Trucks

It is possible to estimate the total number of trucks needed for waste transport in Barbados using the annual waste collection results or the results from the Time-Motion Study directly, and to determine the appropriate number using the complex economic feasibility evaluation.

The total waste collected in Barbados for 2014 was 184 tons/day, and in order to estimate the required number of trucks to collect this volume, several preconditions must be met. In other words, it will be assumed that the total waste collection is 200 tons/day, work hours are five days/week at eight hours/day, and the collection trucks will be used for waste collection and transportation only.

◇ Assumption
work 8 hrs/day & 5 days/week
need to collect 200 tons of waste per day
(which is about 10% over the current average of 184 tons per day)
# of trucks = trucks used only for collection & transportation

1.3.1. Calculation using the 2014 Barbados Waste Management Results

When reviewing the 2014 cleaning operations data for Barbados, it was recorded that the trucks made about two trips a day to the landfill bringing in five tons per trip. Accordingly, it was stated that 20 trucks were used to do this daily. Taking into consideration that Barbados currently operates 53% of its trucks, it can be estimated that 38 trucks are needed.

Number of trucks needed optimally

= 200 ton/day ÷ [5.00 ton/trip × 2 trips/truck]

= 20 truck/day

Actual number of trucks needed using the defect ratio

= 20 trucks ÷ 53%

= 38 trucks/day

1.3.2. Calculation using the Results of the MHT Directly

The waste collection trucks work 8 hours a day with a team of three people per truck and the planned collection of 200 tons per day. So if the MHT value is adjusted accordingly, the number of trucks needed is 16. If the current truck defect rate of Barbados (53%) is considered, then 30 trucks are needed.

To collect 200 tons/day,

MHT = 1.84 man·hrs/ton

= 368 man·hrs/200 tons

= 46 men·8 hrs/200 tons

≒ 16 (3 men) x (8 hrs)/200 tons

= 16 trucks·day/200 tons

Actual number of trucks needed using the defect ratio

= 16 trucks ÷ 53%

= 30 trucks/day

1.3.3. Calculation Reflecting the Economic Feasibility

This method is applied when planning for the number of trucks needed during the initial stages of operation or when planning to buy medium or large quantities of trucks during regular operations. This method is used to determine how many and what capacity trucks need to be purchased. However, instead of deciding the capacity through planning, it is expertly determined using the road structure and collection situation in many instances. Therefore, this method is suggested as a general recommendation instead of explaining the current situation of Barbados.

In order to decide on how many and what capacity trucks are needed, it is necessary to apply the method on a variety of trucks. First of all, a table is made with random volumes on the vertical using the results of the Time-Motion Study or the annual operation results for Barbados, where 2, 4, 6, 8…, 18, 20 tons of waste volume is selected. In Table IV-6, 0.77 was used as the actual volume by averaging the load ratio of Table IV-4. Next, the total driving time of Table 4-4 is proportionally considered and collection frequency for one day (8 hours) is calculated for each truck capacity. Therefore, the actual load volume multiplied by collection frequency will be the collection capacity per truck.

The overall collection volume is estimated as $10.78N_2 + 12.32N_4 + 13.86N_6 + 15.40N_{10} + 10.78N_{14}$. In Table 4-6, the 8-ton and 12-ton trucks appear to have less collection volume overall compared to the other trucks with the same collection frequency, so they seem to be inefficient, while the trucks with a capacity for more than 16 tons appear to have less than one collection per day, so they need to be utilized for other special purposes rather than for regular waste collections. Taking into consideration the current waste collection situation in Barbados, it appears that the trucks needed are the 2-tonners, 4-tonners, 6-tonners, 10-tonners and 14-tonners.

Table IV-6 | Step 2 - Determining the Total Collection Weight

Truck Capacity (tons)	Actual Loading Weight(*1) (tons)	Trip Per Day(*2) (trips/day)	Waste Collected (tons/day)	Required Truck Quantity	Total Waste Collected
2	1.54	7	10.78	N_2	$10.78N_2$
4	3.08	4	12.32	N_4	$12.32N_4$
6	4.62	3	13.86	N6	$13.86N_6$
8	6.16	2	12.32	low efficiency	-
10	7.70	2	15.40	N10	15.40N10
12	9.24	1	9.24	low efficiency	-
14	10.78	1	10.78	N14	10.78N14
16	12.32	below 1	12.32	special purpose	-
18	13.86	below 1	13.00	special purpose	-
20	15.40	below 1	13.00	special purpose	-

(*1) using the average of about 77%
(*2) based on 8 hrs (1 day) ÷ operation time (hr/cycle) by the results of the time-motion study [see Table IV-4]

For Step 2, the total volume of waste collected by the different capacity trucks in Step 1 must be over 200 tons per day. For this purpose, the following equation must be analyzed, and the result will be presented with numerous values. The maximum value for N is the total number of the various volume trucks used per collection. The number of trucks needed by load capacity to collect 200 tons a day is 18 2-tonners, 17 4-tonners, 15 6-tonners, 13 10-tonners, and 18 14-tonners.

$10.78N_2 + 12.32N_4 + 13.86N_6 + 15.40N_{10} + 10.78N_{14} \geq 200\text{tons/day}$

many solutions are suggested

In the last step, the total cost per truck per day is calculated by using the number of trucks needed per capacity in Step 2 and multiplying the daily cost of the truck (BD/day). The daily cost of the truck is calculated by adding the operation cost of the truck (BD/day) such as purchase price depreciation, repair costs, and fuel costs, taking into consideration the durability life of each truck. The lower the expense the more economical, so using trucks with various capacities is the most economical method.

Table IV-7 | Step 3 – Calculating the Total Cost & Selecting the Truck Capacity and Quantity

Alternative No.	(1) Required Truck Quantity					(2) cost(*1) ($BD/day)					Sum ($BD) ∑[(1)×(2)]	Priority
	N_2	N_4	N_6	N_{10}	N_{14}	N_2	N_4	N_6	N_{10}	N_{14}		
1	18	0	0	0	0	C_2	C_4	C_6	C_{10}	C_{14}	18C2	14321
…											…	…
11	12	1	1	1	1						$12C_2+C_4+C_6+C_{10}+C_{14}$	8234
…											…	…
111	8	0	2	2	2						$8C_2+2C_6+2C_{10}+2C_{14}$	1543
…											…	…
1111	4	3	1	1	4						$4C_2+3C_4+C_6+C_{10}+4C_{14}$	12
…											…	…
11111	0	0	0	0	18						$18C_{14}$	432
…											…	…

(*1) cost = purchase price ($BD/day) + operating cost ($BD/day)

2. Recommendations for Waste Management

2.1. Vehicle Defect

In looking at the defect ratio situation for waste collection equipment in Barbados, there are a total of 66 trucks purchased within the last 10 years where 10 of these are in need of repairs and 21 are damaged beyond operation, making the total of 31 trucks inoperable. This makes the defect ratio for the trucks purchased within 10 years to be 47%, making only 53% operable for waste collection. This is the most serious problem for Barbados's waste management, so the following improvements are recommended:

- There needs to be a special policy for vehicle maintenance and repair.

  (easy access to parts, specialization and privatization of vehicle repair services, local residency in Barbados of mechanics from truck manufacturers)

- The required number of trucks needs to be secured.

- A fixed number of trucks must be purchased regularly every year according to a plan.

- The durability life of the trucks should be determined so their usage can be legally stopped after their lifecycles expire, meaning that a phase-out plan is needed to eventually phase out old trucks so that the total number of trucks is not distorted.

Table IV-8 | Defect Ratio of Collection Trucks

Year		1991	1992	1994	1996	1998	1999	2000	2001	2002	2003	Total	
In Use							6					6	
Repairs	Minor	1					3					4	15
	Major		1	1	1	1	2	1	1	1	2	11	
Total		1	1	1	1	1	11	1	1	1	2	21	

Year		2005	2006	2007	2008	2009	2010	2013	Total	
In Use		15	3	3	3		2	9	35	
Repairs	5	5		2	1		1	2	10	31
	11	11		2		2	3	3	21	
Total		31	3	6	4	2	6	14	66	

2.2. Other Waste Management

The roads in the Barbados city center is arranged in a grid with many one-way streets, and the intersections are roundabouts, making it easy for the garbage trucks to travel. However, the local roads are double lanes only with narrow tree-type layouts, and since many houses are located in dead-end alleys off the main roads, access for the garbage trucks are quite difficult.

As the structural characteristics of the roads determine the waste collection method, the Curb Service and Alley Service currently used in Barbados is considered to be very reasonable. It appears that with the exception of the deficient vehicles, waste management of Barbados is appropriate and well executed, with the following improvements for reference.

Table IV-9 | Comparison of Collection Methods

Indix		Type of Collections				
		Curb	Alley	Set Out-Set Back	Set Out	Back Yard Carry
Resident Cooperation	Bins Brought	○	required	×	×	×
	Empty Bins Taken Back	○	required	×	○	×
Collection Plan with the Residents' Cooperation		○	×	×	○	×
Problems in Landscape Image	Exposure and Leakage	high	high	low	high	low
	Garbage Bins can be seen	○	×	×	○	×

Indix	Type of Collections				
	Curb	Alley	Set Out-Set Back	Set Out	Back Yard Carry
Work is Easy for the Sanitation Workers and Attractive to Scavengers	○	very familiar	×	×	×
Prone to Upsets	○	○	×	○	×
Number of Workers for Efficiency	1~3	1~3	3~7	1~5	3~5
Crew Time	low	low	high	mid	mid
Injury Rate of Worker during Garbage Loading and Unloading	low	low	high	mid	high
Trespassing Complaints	low	low	high	high	high
Cost for Size and Workers and Work Time	low	low	high	mid	mid

Source: Min, et al. (2003). Waste Disposal Engineering. Sae-Hwa Publishers

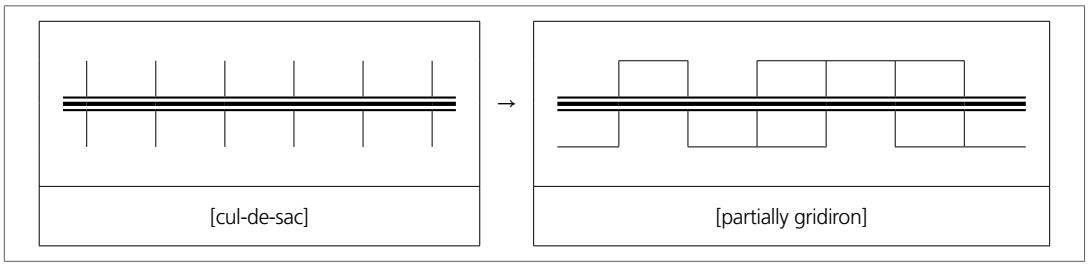
2.2.1. Methods to Improve the MHT Efficiency

The problem with the road structures of Barbados is that they are only double lanes and many dead-ends. In other words, the roads outside the city center is developed in the tree line-type structure and the houses are built parallel along the roads in alleys with dead-ends. The narrow roads are the cause for traffic jams or traffic stops resulting from illegal parking, but on the other hand, the advantage of these roads is that garbage collection can be done from both sides of the road simultaneously.

Currently, the garbage trucks leave the alleys driving backwards due to the dead-ends. The road structure that are the obstacles for waste collection need to be improved with urban planning, but if the dead-ends can be linked together to make a flow traffic road, garbage collection will be easier. The following recommendations can be presented to help with this problem:

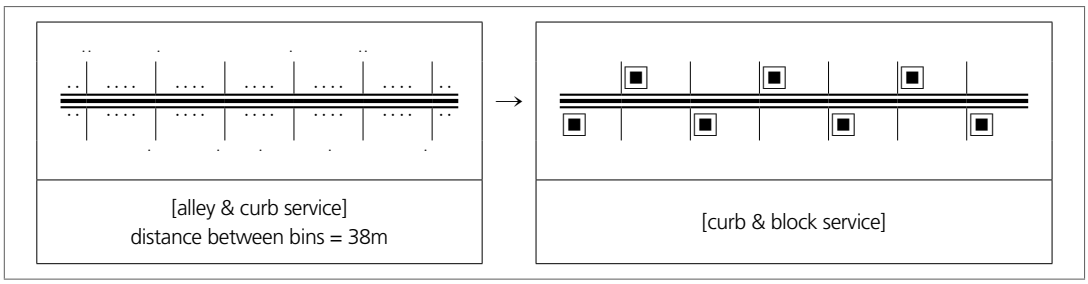
- The dead-end streets can be linked together for flow traffic to make it easy for garbage collection (See figure below).
- The residents living on the dead-end streets can bring their garbage voluntarily to the curbs of the main roads for collection.
- The collection trucks can be equipped with small mobile carts and these carts are used for the collection.

Figure IV-3 | Type of Roads



Barbados used the alley and curb collection services. By looking at the Time-Motion Study, the average distance between garbage bins are 38m, so as one of the ways to increase collection efficiency, the distances between the bins can be increased and larger bins can be used.

Figure IV-4 | Suggestions on Improvements in Roads



Furthermore, if the collection route is transcribed in the order of the district names, it should be changed into drawings and graphics to make it easy if the loaders change, so the new loaders can memorize the collection routes better. To date, the trucks in Barbados are not equipped with GPS navigators so it seems like the graphic route maps are needed, and when the trucks get equipped with GPS, the collection routes can be displayed on the screens rather than the drawings.

2.2.2. Street Sweeping and Collection Improvement for Narrow Alleys

Currently, street sweeping in Barbados is done by workers with wheeled garbage bins (60 120L), and narrow alleys in the city center are cleaned by small tracker-shaped lorry loaders. In the case of Korea, automatic water-charged vehicles or rear cars are used for street sweeping. The rear cars are more stable compared to the wheeled bins and are easy to use, with the advantage of having the ability to link to bicycles or motorcycles for power.

Figure IV-5 | Equipments for Street Cleaning



[waste bin & lorry loader] [manual or automatic rear-car]

2.2.3. Systemization and Computerization of Waste Management

It appears that Barbados needs to construct a database on wastes for a more advanced waste management system in the future. In order to construct the database, concerned laws must define what waste is, establish a classification system, and select the classification codes to serve as the basis for the computerization. Afterwards, in order to determine the flow of the waste management system, the waste generation, transportation, treatment and disposal process need to be computerized. The GPS or RFID can be used partially for this purpose.

- Construction of the database for wastes including the definition, establishment of the waste system and cataloged (Barbados Waste Code, BWC)
- Selection of the Classification Codes
- Computerization of the waste generation, transportation, treatment, and disposal process (computerization, Just-in-Time Record System)
- Regular conduction of statistical surveys on wastes
- Application of the GPS and RFID systems and optimization of routes

2.2.4. Waste Collection

Improvements for the waste collection are as follows:

- Collection bags and bins need to be standardized for easy and efficient collection.
- Existing defect ratio of trucks needs be improved by using various types of collection trucks
- Instead of just using collection region information as route information, the actual road routes

used by the collection trucks should be mapped out onto a map for better visual management and checking of route coverage.

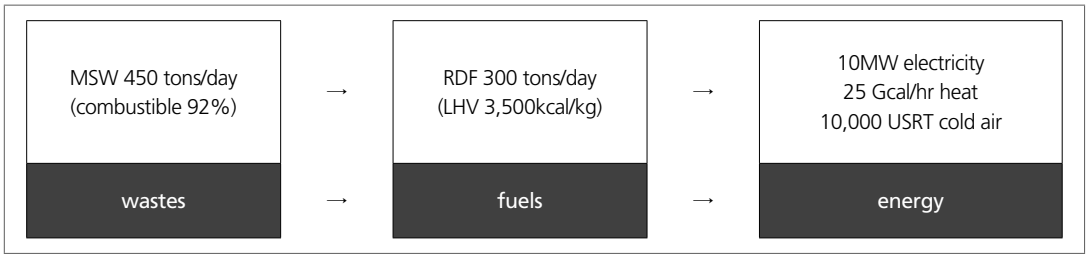
- It will be difficult to improve on the current collection routes because the drivers have currently optimized their driving routes to be the most optimum according to the region of their pick-up. Therefore, a GPS-based tracking system is not needed in order to optimize the collection routes.
- Automatic Pipeline Collection System could be considered the in the city center with a high population density in order to improve the waste administration and collection efficiency
- RFID-based tracking system for medical waste could be considered in order to track the whole collection and disposal process of medical waste.

2.2.5. Waste Treatment and Disposal

Improvements for waste treatment and disposal are as follows:

- The re-using and recycling can be optimized with realized policies.
- Automated sorting devices should be installed at the disposal or recycling transshipment depots to efficiently promote the 3Rs.
- Reclaim the methane gas from the existing landfill
- The burying amount can be minimized and the life durability of the landfill can be extended by digging and reorganizing the existing landfill.
- The Waste-to-Energy Policy should be established. In the case for Barbados, it is possible to produce 450 tons/day of 92% combustible MSW and 300 tons/day of RDF (Refuse Derived Fuels). With heat (100 tons/day x 3 incinerators) treatment, it will be possible to produce 10MW of electricity, 25 Gcal/hr of heat, and 10,000 USRT of cold air.

Figure IV-6 | Waste-to-Energy Planst Process



3. Economic Feasibility Analysis

3.1. Method of Analysis

In this section, the economic feasibility analysis of the purchasing 15 additional collection trucks is performed using benefit-cost analysis. For this purpose, social benefit and cost of the purchase are estimated, and the economic feasibility is analyzed using Net Present Value (NPV) Method, Economic Internal Return Rate (EIRR), and Benefit/Cost ratio (B/C ratio).

The NPV method is the most widely used technique for economic feasibility analysis. NPV is the sum of present value (PV) cash inflows subtracted by the sum of present value (PV) cash outflows. When the NPV value in the formula is greater than 0, the project is considered as economically feasible. Economic Internal Rate of Return (EIRR) or Internal Rate of Return (IRR) provides a discount rate that equals the sum of present value cash inflows and the sum of present value cash outflows. As a decision criterion to economic feasibility, the EIRR of an investment alternative needs to be greater than social discount rate (social discount rate in the analysis is 12%). Benefit/Cost Ratio shows the ratio of the benefit value of a project relative to its cost value. Since the NPV values are influenced by the volume of investment, B/C ratio is used complementary. When a B/C ratio is larger than 1, the investment alternative is economically feasible.

In addition sensitivity analysis was also performed to analyze the sensitivity of the investment relative to changes in the discount rate, the overall costs, and the overall benefits.

3.2. Assumptions Used for the Analysis

3.2.1. Inflation Rate

We used the average Barbados inflation rate compiled by the IMF from 2012 to 2014 as the inflation rate that will be applied to the estimation of the various future values for the economic feasibility analysis.

Table IV-10 | Inflation Rate of Barbados

(Unit: %)

Year	2013	2014	2015	3 -Year Average
Inflation Rate	1.823	1.868	1.199	1.630

Source: IMF. (2015). *World Economic Data*. IMF

3.2.2. Period of Analysis

We assumed that 5 collection trucks will be purchased every year for 3 years starting 2016 for a total of 15 new trucks being purchased within the three year period. The reason for the purchase of 15 new trucks is assumed from the recommendations for the number of operational trucks (Section IV.1) where the minimum number of required trucks was calculated as being over 30 trucks and currently there are only about 15 trucks that are operational at this moment for the SSA.

The start of the benefits obtained from the purchasing of new collection trucks was assumed to be from 2017 which is one year after the initial purchase in 2016. The total period for the benefits to arise was assumed to be 10 years after the initial purchase. Salaries for drivers and loaders, cost of gasoline, and maintenance costs for the trucks were assumed to occur every year after the purchase of the new trucks; the total period of the economic feasibility analysis is 13 years from 2016 to 2028.

3.2.3. Discount Rate

We applied 12% as the discount rate for the economic feasibility analysis because 12% is the standard discount rate used by the Export-Import Bank of Korea for all their financial analysis of developing countries.

3.3. Cost Analysis

3.3.1. Cost Components

The following are the costs associated with the purchase of new collection trucks:

- Cost of purchasing 15 compactor trucks (5 in 2016, 5 in 2017 and 5 in 2018)

- Operational and maintenance costs per truck

3.3.2. Cost Details

1) The cost of purchasing 15 trucks is

- Year 2016 cost = 5 x USD 250,000 = USD 1,250,000

- Year 2017 cost = 5 x USD 250,000 x inflation = USD 1,270,375

- Year 2018 cost = 5 x USD 250,000 x inflation = USD 1,291,082

2) Cost of operation and maintenance for 13 years is,

- Year 2016 cost = 5 x USD 16,500* x 50% (6 month) = USD 41,250

- Year 2017 cost = 10 x USD 16,500* / year x inflation = USD 167,690

- Year 2018 to Year 2028 cost = 15 x USD 16,500* / year x inflation

- the maintenance cost is based on the data received from the SSA.

3.3.3. Cost Table

The following two Tables show the yearly flow of money needed to cover the costs of purchasing 15 new collection trucks for the next 13 years. The total present value of all the costs is USD 4,430,000.

Table IV-11 | Yearly Costs (Future Value)

(Unit: 1,000 USD)

Costs	2016	2017	2018	2019	2020	2021 ~ 2028	TOTAL
Purchasing of Trucks	1,250	1,270	1,291	-	-	-	3,811
Operation & Maintenance	41	168	256	260	264	1,941	2,929
Total	1,291	1,438	1,547	260	264	1,941	6,740

Table IV-12 | Yearly Costs (Present Value)

(Unit: 1,000 USD)

Costs	2016	2017	2018	2019	2020	2021 ~ 2028	TOTAL
Purchasing of Trucks	1,116	1,013	919	-	-	-	3,048
Operation & Maintenance	37	134	182	165	150	714	1,382
Total	1,153	1,147	1,201	165	150	714	4,430

3.4. Benefit Analysis

3.4.1. Benefit Components

The following benefits are expected to arise with the purchase of 15 new collection trucks:

- Prevention of decrease in tourism due to environmentally unhealthy and visually unclean situations that might be caused by deficiencies in waste collection from key tourist attractions, and
- Reduction in salary from not working over-time in week-ends

3.4.2. Benefit Details

1) The money savings arising from the prevention of the decrease in tourism can

be used as a benefit for purchasing new collection trucks because there was a case in Napoli, Italy where tourism income dropped significantly in 2008 due to problems in waste collection and street cleaning.

The benefit obtained in terms of prevention of the decrease in tourism can be calculated using the following formula:

benefit = (number of new trucks) x (average yearly income from tourism) x
(percentage of decrease in tourism with shortage of one truck) x
(1 + inflation rate)

where

percentage of decrease in tourism with shortage of one truck was assumed to be 0.01% and average yearly income from tourism was assumed to be USD 1.098 Billion (www.wttc.org).

: Year 2017 benefit = 5 x USD 1.098 B x 0.01% = USD 549,000

: Year 2018 benefit = 10 x USD 1.098 B x 0.001% x inflation
= USD 1,116,000

: Year 2019 to Year 2028 benefit = 15 x USD 1.098 B x 0.001% x inflation

2) With more collection trucks, SSA personnel do not have to work on weekends which translates to savings in over-time payments.

The benefit obtained in terms reduction in over-time salary can be calculated using the following formula:

benefit = (number of new trucks) x (average daily salary of SSA workers) x
(number of workers per truck) x (number of days of over-time per year)
x 1.5 x (1 + inflation rate)

where

average daily salary of SSA workers was assumed to be USD 100 per day (USD 24,000 yearly income from data received from SSA which is equal to the per capita GDP of Barbados in 2014, www.indexmundi.com) and the number of days of over-time was assumed to be 4 days per month.

: Year 2017 benefit = 5 x USD 100 x 3 x 1.5 x 48 days = USD 108,000

: Year 2018 benefit = 10 x USD 100 x 3 x 1.5 x 48 days x inflation
= USD 219,000

: Year 2019 to Year 2028 benefit = 15 x USD 100 x 3 x 1.5 x 48 days x inflation

3.4.3. Benefit Table

The following two Tables show the amount of yearly benefits obtained from purchasing 15 new collection trucks for the next 13 years. The total present value of all the benefits is USD 9,520,000

Table IV-13 | Yearly Benefits (Future Value)

(Unit: 1,000 USD)

Benefits	2017	2018	2019	2020	2021	2022~ 2028	TOTAL
Prevention of Decrease in Tourism	549	1,116	1,701	1,729	1,757	10,952	17,804
Reduction in Salary	108	219	329	334	340	2,120	3,451
Total	657	1,335	2,030	2,063	2,097	13,072	21,255

Table IV-14 | Yearly Benefits (Present Value)

(Unit: 1,000 USD)

Benefits	2017	2018	2019	2020	2021	2022~ 2028	TOTAL
Prevention of Decrease in Tourism	438	794	1,081	981	890	3,788	7,973
Reduction in Salary	86	156	209	190	172	733	1,547
Total	524	950	1,290	1,171	1,062	4,521	9,520

※ discount rate of 12% used

3.5. Results of the Economic Feasibility Analysis

The following Table summarizes the results of the economic feasibility analysis with total benefits being USD 9,520,000 and total costs being USD 4,430,000. The NPV was USD 5,990,000 which is greater than 0, B/C Ratio was 2.15 which is greater than 1.0 and finally the IRR was 43.77% which is greater than 12.00%. Therefore, the results show that it is economically feasible to purchase the 15 new collection trucks.

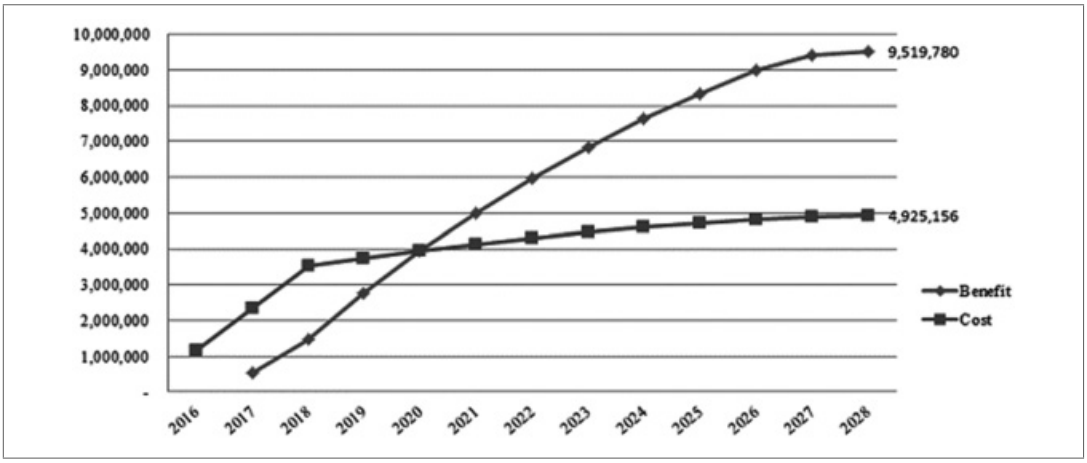
Table IV-15 | Results of the Economic Feasibility Analysis

(Unit: 1,000 USD)

Analysis	Total Benefit	Total Cost	NPV	B/C	IRR
Feasibility Standard			0	1.0	12.00%
Analysis Results	9,520	4,430	5,090	2.15	43.77%

The following graph shows the plot of the benefits versus costs for this analysis.

Figure IV-7 | Benefit – Cost Graph



3.6. Sensitivity Analysis

The NPV, B?C Ration, and IRR were calculated for cases when the overall cost is increased or decreased by 10% and 20% and at the same time the overall benefit is also increased or decreased by 10% and 20%. The Table below shows the results for the different cases of variations.

Table IV-16 | Results of Sensitivity Analysis

(Unit: 1,000 USD)

Variations		NPV	B/C	IRR
Fixed Cost	Fixed Benefit	5,090	2.15	43.77%
Cost Increased by 20%	Fixed Benefit	4,204	1.79	34.65%
Cost Increased by 10%		4,647	1.95	38.84%
Cost Decreased by 10%		5,533	2.39	49.68%
Cost Decreased by 20%		5,976	2.69	56.96%

Variations		NPV	B/C	IRR
Fixed Cost	Benefit Increased by 20%	6,994	2.58	54.35%
	Benefit Increased by 10%	6,042	2.36	49.10%
	Benefit Decreased by 10%	4,138	1.93	38.34%
	Benefit Decreased by 20%	3,186	1.72	32.78%
Cost Increase by 20%	Benefit Increased by 20%	2,300	1.43	25.03%
Cost Increase by 10%	Benefit Increased by 10%	3,695	1.76	33.80%
Cost Decrease by 10%	Benefit Decreased by 10%	6,485	2.63	55.51%
Cost Decrease by 20%	Benefit Decreased by 20%	7,880	3.22	69.86%

We can determine from the results of the sensitivity analysis that even with the variations in costs and benefits increased or decreased up to 20%, the results of the economic feasibility study stands because the NPV was always greater than 0, B/C Ration was always greater than 1, and the IRR was always greater than 12.00%.

V Conclusions and Suggestions

The general assessment of services provided by the Sanitation Services Authority (SSA) of Barbados related to waste collection, disposal and management is that they are currently doing a very good job in all areas of waste collection, disposal and management. SSA's drivers and loaders are very hard working and the managers are dedicated in providing the best possible service to the citizens with the limited resources they have available to them. The collection routes are very efficient and it will be hard to improve on their current collection efficiency.

The areas that need improvements and upgrades are 1) more effective means of maintenance of collection trucks, 2) purchase of additional collection trucks to replace old model trucks that are not functioning to capacity, 3) mapping out actual collection routes on a map, 4) construction of a leachate treatment facility, 5) construction of a waste-to-energy plant to incinerate most of the combustible solid waste prior to burial, 6) increased recycling at the source in order to reduce the amount of waste, 7) designing of a waste code specific to Barbados, 8) development of a waste database to facilitate data management and retrieval, 9) development of a computer program for waste management, 10) research and analysis on setting up intermediary transfer stations throughout the island, 11) standardizing trash bins and garbage bags to facilitate collection, and 12) developing metrics to measure the performance of collection, transportation and disposal of solid waste.

The results of this Consulting Project can be used to better plan for future activities in waste collection, disposal and management in Barbados. Barbados is one of the leading countries in waste collection and management in the Caribbean and hopefully the lessons learned through this project can be transferred to other countries in the Caribbean. Our final proposal is for the Caribbean countries to form an association related to waste management throughout the Caribbean so that countries can share each other's knowledge and expertise as well as collectively strategize concerning the future directions pertaining to waste management in all Caribbean countries.

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List of Abbreviations

Abbreviation	Full Description
AASHTO	American Association of State Highway and Transportation Officials
ASR	Alkali-Silica Reaction
AP	Asphalt Pavement
BMS	Bridge Management System
CP	Concrete Pavement
DIS	Digital Imaging System
DLP	Digital Laser Profiler
DMI	Distance Measuring Instrument
EDCF	Economic Development Cooperation Fund
FOMAV	Fondo de Mantenimento Vial
FWD	Falling Weight Deflectometer
GDP	Gross Domestic Product
GPR	Ground Penetrating Radar
Hi-PMS	Highway-Pavement Management System
HPCI	Highway Pavement Condition Index
IC	Índice de Mantenimiento o Conservación
IDB	Inter-American Development Bank
IRI	International Roughness Index
KSP	Knowledge Sharing Program
LCC	Life Cycle Cost

Abbreviation	Full Description
LCCA	Life Cycle Cost Analysis
LTPP	Long Term Pavement Performance Program
MIDAS	Multi Infrastructure Distress Analysing System
MTI	Ministerio de Transporte e Infraestructura (Minister of Transport and Infrastructure)
PCI	Pavement Condition Index
PCN	Pavement Condition Number
PIARC	Permanent International Association of Road Congresses
PMS	Pavement Management System
POA	Plan Operativo Anual
RD	Rut Depth
SCN	Sealant Condition Number
SDA	Surface Distress Area
SDL	Surface Distress Length
SF	Safety Factor
SIGMAVIAL	Sistemas Integrados de Gestión del Mantenimiento Vial
SMA	Stone Mastic Asphalt Pavement
SN	Skid Number
SRT	Skid Resistance Tester
U-BIROS	Ubiquitous-Bridge Inspection Robot System
WB	World Bank

Summary

When it comes to transport infrastructure as one of the key driving forces of economic development of a country, appropriate management of existing assets is as critical as construction of new infrastructure stock. Particularly in Nicaragua, around 80% of the roads nationwide are in poor condition, so efficient management of road assets has become an urgent policy direction of the government. With a view to providing support for Nicaragua's efforts to improve its transport infrastructure, the Inter-American Development Bank (IDB) has pushed forward a number of infrastructure projects. In support of sustainable economic development of Nicaragua, the Ministry of Strategy and Finance of Korea has undertaken a joint consulting project in collaboration with the IDB as part of its Knowledge Sharing Program (the "KSP") aiming to share Korea's experience in the introduction and operation of the road assets management system with the Nicaraguan authorities for the sector.

In Nicaragua, road pavements are managed jointly by the Ministry of Transportation and Infrastructure (Ministerio de Transporte e Infraestructura, MTI) and the FOMAV (Fondo de Mantenimiento Vial). The MTI is responsible for the maintenance, improvement, and reconstruction of the road network of fair grade or below, whereas the FOMAV takes charge of routine maintenance of roads in fair or better condition through improvement activities. The FOMAV also adjusts road assets to maintain each year within the annual budget in consultation with the MTI. In this project, we have worked mainly with the FOMAV as the primary partner organization and contacted the MTI in regards to bridge matters as the FOMAV is not engaged in bridge management.

Most of the roads managed by the FOMAV are paved in .asphalt. In terms of maintenance method, surface treatment, patching and overlay were used depending on damage type. Field survey found, however, that in some cases, severely damaged sections were not repaired because of financial constraints and it would be necessary to increase the thickness of the pavement layer, improve asphalt mix design, and apply modified asphalt. Although Hawkeye 1000 is in use for pavement condition survey, the equipment still remains at a trial phase now. The field survey has been completed for only about 500km segment thus far, and improvements should be made to the equipment to gain necessary data for decision making. Furthermore, the closed-end (Client/Server, C/S) pavement management system called SIGMAVIAL can conduct a comparison of maintenance costs only, while the pavement condition index used for the system appears not to reflect local pavement conditions appropriately.

Bridge inspection and maintenance is carried out by the Transport Infrastructure Survey Department and the Road & Bridge Diagnosis and Evaluation Department under the supervision of the Road Management Division of the Planning Office at MTI, but research shows that there are no separate laws or guidance in place governing their operations. The MTI runs a bridge management system, NICASAP, developed under Denmark's international development cooperation program, DANIDA, in 2001 for the management of bridge statistics and inspection data. This system provides general information on bridges, search for bridge inspection data, and bridge condition analysis. Findings from the field survey on bridge management status revealed that bridges in the country are relatively in good condition, despite long service years and absence of regular maintenance. Still, bridge deck damage due to expansion joint stripping, deck plate efflorescence as a result of absence of drain piping, steel girder corrosion caused by painting scaling, bridge deck surfacing damage due to pot holes, bridge bearing damage caused by scaling and leakage were among major problems.

Consisting of the road pavement and bridge sector, this project went through field surveys and analyses, comparison of both countries to find areas for improvement, improvement recommendations and a proposal of improvement roadmap in order. For this project, the Korea Expressway Corporation (KEC) formed a consortium with Pyunghwa Engineering and Consultants (PEC), held a inception meeting in Nicaragua to discuss the project action plan with the Nicaraguan road authorities and the IDB, and conducted research regarding the operation and management status of Nicaragua's road pavement and bridge management system. In addition, the KEC consortium invited the FOMAV officials to Korea for road management related lectures and field trips to associated facilities, followed by an interim workshop to give presentation of findings from the field surveys and exchange ideas with respect to the direction of this project. Afterwards, the KSP Consultant came up with a necessary action plan and a phased roadmap for the improvement of the road management system in Nicaragua, taking results of the field surveys and collected data and opinions into account. Outcomes of the project were shared with road related agencies at the final debriefing in Nicaragua, and an industry-academic joint technology seminar was held to share Korea's experience in projects of this kind and expertise with government officials and engineers of Nicaragua.

I PROJECT OVERVIEW

1. Background and Objectives

In developing countries like Nicaragua, construction and rehabilitation of roads and bridges is the first priority to improve their transport infrastructure. Amid the growing interest in efficient management of the infrastructure assets, discussions about the need to introduce a Pavement Management System (PMS) and Bridge Management System (BMS) have continued. As roads in good condition remain at 20% of the entire road network in Nicaragua, the IDB has provided support for Nicaragua's efforts to improve its road assets in a series of infrastructure projects.

The Ministry of Strategy and Finance of Korea and the Export-Import Bank of Korea (the "Korea Eximbank") have agreed to assist the Nicaraguan government and the IDB in their endeavor to enhance road management capacity of the country and undertaken this joint consulting project as part of its Knowledge Sharing Program (the "KSP") in collaboration with the IDB. This project aims to share Korea's experience in the introduction and operation of the road assets management system, propose a PMS/BMS framework customized to Nicaragua's needs and thereby support the nation's sustainable economic development.

2. Scope

This project evaluates roads and bridges in Nicaragua and diagnoses their problems, assesses Korea's experience in introducing and managing the PMS/BMS, examines the applicability of the Korean PMS/BMS via comparative analysis of both countries, and finally proposes a PMS/BMS framework tailored to Nicaraguan situations. In an effort to promote effective knowledge sharing, Nicaraguan working-level officials were invited to Korea for capacity building workshop, and KSP dissemination seminars were held in Nicaragua to share outcomes of the project.

3. Expected Results

If successfully completed, this project is expected to contribute to the enhanced road management capacity of Nicaragua and reduced road operation and management costs. Outcomes of this project will help improve infrastructure management system significantly, if they are incorporated into the system development in conjunction with loans and grant aid projects and international cooperation programs.

Ⅱ PAVEMENT MANAGEMENT SYSTEM (PMS)

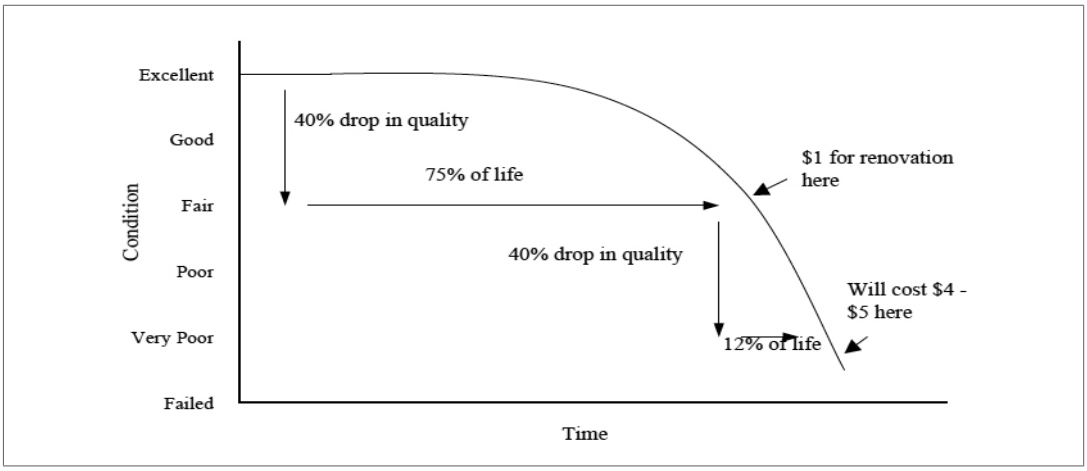
1. PMS Introduction

1.1. Concept of Maintenance

Pavement maintenance is divided into preventive maintenance and corrective maintenance; preventive maintenance takes place before structural damage occurs in order to preserve pavements and prevent functional degradation based on a Life Cycle Cost Analysis (LCCA), while corrective maintenance aims at addressing functional and structural damage of pavement. Especially, increase in road construction has driven the surging increase in total road length and maintenance costs at the same time, which raises the need of a reasonable and systematic decision concerning maintenance timing and methods. A Pavement Management System (PMS) is a means that assists the management of large-scale road pavements in a scientific manner.

Road pavements are damaged due to fatigue caused by repetitive traffic loading, which leads to the degradation of functional and structural performance of roads. Therefore, preventive maintenance conducted in a timely manner may delay pavement damage, but if left for too long without any intervention, the damage worsens over time, resulting in the rise of the total LCC. If pavement damage happens to roads with a high traffic volume, costs borne by users will rise accordingly. This shows how important timely maintenance is.

Figure 2-1 | Relationship between Road Pavement Damage and Maintenance

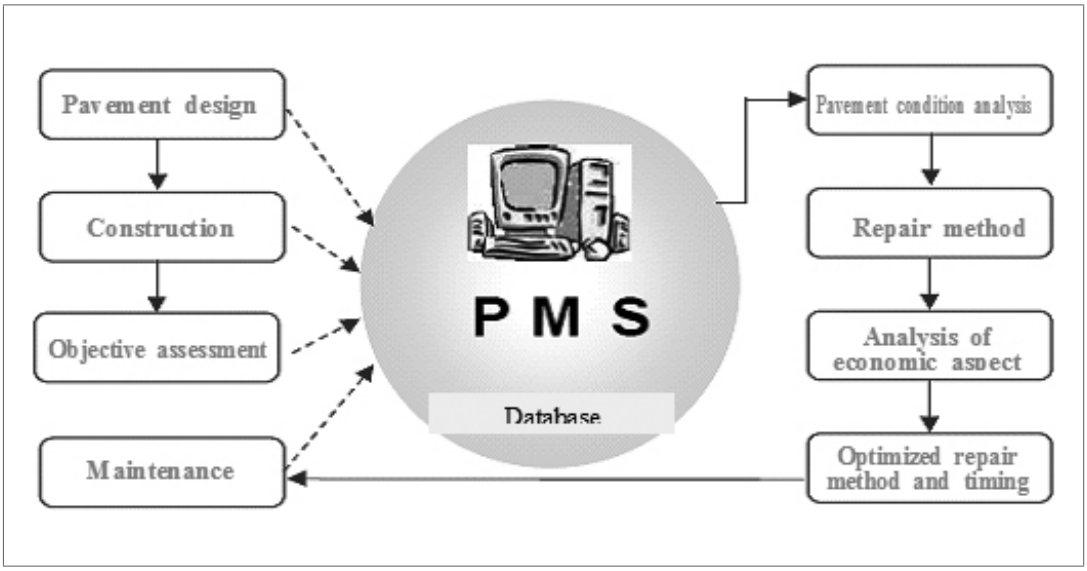


Source: Purdue University (2015), https://engineering.purdue.edu/

1.2. Configuration and Features of PMS

A PMS aims to help perform pavement condition survey, evaluation and analysis, selection and implementation of maintenance methods, and data accumulation in an objective and rational way. By assisting most timely maintenance of pavement, the system ultimately lengthens life span, saves maintenance costs and improves road pavement design techniques.

Figure 2-2 | Configuration of PMS



Source: Hwang Seong-do, Road Pavement Survey and Management (2006).

With the adoption of a PMS, it is possible to manage road pavements systematically and provide maintenance practitioners with data to judge pavement condition objectively and accurately. The PMS should have the following features:

1) Provision of general current information on road pavement: pavement structure, maintenance history

2) Road pavement damage status : surface defects, structural bearing capacity, etc.

3) Proposal of maintenance alternatives

4) Suggestion of mid- and long-term maintenance strategies

5) Verification of pavement and maintenance designs

6) Link to other road management systems.

Pavement condition survey tackles structural, functional, and safety aspects of the pavement system. It examines whether the pavement stably resists traffic or environmental loading in structural terms, while checking from functional perspectives if vehicles can drive on the pavement in a comfortable and safe manner. Finally, the survey also assesses if braking of vehicles can be properly done safely without skid.

2. PMS in Nicaragua

2.1 Overview of Pavement Management and Maintenance

As shown in Table 2-1, asphalt pavement represented 9.72% of the total road length in Nicaragua as of 2014, block pavement 4.87%, and concrete pavement 0.55%, respectively, reaching 15.14% of paved roads combined. This means that unpaved roads account for 84.86%, 29.71% of which are not available during wet season.

Table 2-1 | Roads in Nicaragua (as of 2014)

(Unit: km)

Department	Asphalt	Block pavement	Concrete	Length of paved roads	Gravel roads	Unpaved	All season (dry/wet)	For dry season only	Total
NUEVA SEGOVIA	43.70	127.72	0.76	172.18		147.57	819.18	819.75	1958.67
MADRIZ	61.88	86.93	0.57	149.37	1.23	61.58	504.54	452.82	1169.54
ESTELI	71.06	60.89		131.94	1.70	262.57	518.00	352.99	1267.21
CHINANDEGA	249.09	71.46	1.59	322.15	15.00	207.36	377.41	489.78	1411.68

Department	Asphalt	Block pavement	Concrete	Length of paved roads	Gravel roads	Unpaved	All season (dry/wet)	For dry season only	Total
LEON	212.72	95.47	35.17	343.36	1.17	200.35	338.43	1132.62	2015.92
MANAGUA	328.19	106.11	34.24	468.54	0.25	103.19	259.13	646.17	1477.28
MASAYA	105.23	98.48	10.04	213.75	0.38	5.22	116.42	304.62	640.39
GRANADA	71.51	25.25		96.70		49.31	106.58	263.16	515.74
CARAZO	107.60	30.25	0.44	138.29		15.86	129/37	575.16	868.67
RIVAS	119.90	118.57	0.86	239.33		147.66	278.76	310.60	976.36
BOACO	142.07	67.41		209.47		202.71	590.56	229.38	1232.12
CHONTALES	199.41	107.09		306.49		255.10	616.08	230.06	1377.74
JINOTEGA	75.99	74.31		150.30		363.08	1292.34	487.45	2293.16
MATAGALPA	328.22	54.73	4.03	386.97		409.77	1654.37	498.94	2950.05
RIO SAN JUAN	149.90	0.76	2.02	152.68		116.83	248.28	165.57	683.34
RACN	0.26	9.30	30.80	40.36	2.00	537.35	1168.40	174.31	1922.42
RACS	79.52	40.61	11.36	131.50		441.08	776.78	37.85	1387.20
TOTAL	2346.22	1175.28	131.88	3653.38	21.72	3496.59	9794.60	7171.21	24137.49
%	9.72	4.87	0.55	15.14	0.090	14.49	40.58	29.71	100

Source: FOMAV statistics (2015).

Table 2-2 | Road Classifications by Function in Nicaragua

(Unit: km)

Surface type/ function	Asphalt	Block pavement	Concrete	Gravel road	Unpaved	All seasons (dry/wet)	For dry season only	Total
Primary trunk road	1.18	1034.94	44.58					1080.70
Trunk road	73.42	571.29	35.02		333.30			1013.02
Secondary trunk road	372.82	474.46	11.97	1.48	333.01	8.34		1202.08
Collector road	483.32	125.95	15.34		1535.23	509.15	68.26	2737.25
Local road	244.54	139.60	24.96	20.24	1295.05	9277.10	7102.95	18104.45
TOTAL	1175.28	2346.22	131.88	21.72	3496.59	9794.60	7171.21	24137.49
%	4.87	9.72	0.55	0.09	14.49	40.58	29.71	100

Source: FOMAV statistics (2015)

Table 2-3 | Statistics of National Road Network, General Road Network & Road Network Under the MTI-FOMAV Partnership

Pavement type	National road network (km)	General road network (km)	Road under the 2015 partnership (km)
Asphalt	2,346.22	2,298.88	2,086.76
Block Pavement	1,175.28	797.54	888.27
Concrete	131.88	54.34	46.53
Unpaved	20,484.12	5,269.94	650.67
Total	24,137.50	8,420.70	3,672.23
Share in the national road network (%)		34.89	15.21%
Share in the general road network (%)			43.61%

Source: FOMAV statistics (2015)

2.2. Pavement Management and Maintenance Status

2.2.1. Relevant Laws and Guidelines

In Nicaragua, the Road Maintenance Fund (FOMAV) is a government agency launched to preserve the country's maintainable national road system with guaranteed technical and administrative independence. It aims to contribute to the enhanced national competitiveness and socio-economic development of the country by preserving road assets nationwide. Since its budget comes from taxes paid by road users, the agency is operated in the principles of efficiency, efficacy, and transparency to ensure responsible execution of the budget.

1) Operations

In accordance with the laws behind its creation, FOMAV carries out activities to preserve nationwide maintainable roads in partnership with the Ministry of Transportation and Infrastructure (Ministerio de Transporte e Infraestructura, MTI) on a yearly basis. "Maintainable roads" refers to the entire inland road network for public purposes, and roads in 'Very Good,' 'Good,' and 'Fair' conditions only are managed and maintained by FOMAV. Details of its maintenance activities are as follows:

- Scope of road pavement (Scope of FOMAV services): Asphalt, block, unpaved and concrete roads
- Day-to-day management: Routine maintenance activities encompassing minor pavements repair, drainage system management, and cleaning of passage
- Regular management: Road surface treatment or repair through overlay and recycling.
- Road safety: Vertical/horizontal signals, bus stops, and black spot management, and road safety campaigns

2) Laws behind its creation

FOMAV was created under the following laws:

- The FOMAV Creation Law (Law No. 355): Passed the National Assembly in 29 June 2000.Published in the government newspaper (157) in August 2000.
- The Law No. 572 and 355 Amendments: Published in the government newspaper (249) on 26 December 2005 (249)
- The Law on the Creation of Special Tax (Law No. 574): Published in the government Newspaper (250) on 27 December 2005.
- The Law No. 706 and 355 Amendments: Published in the government newspaper (243) on 23 December 2009

As documented above, the FOMAV Creation Law was enacted in 2000, but financing means for the FOMAV operations was not determined until the 2005 amendment came into effect. This led the National Assembly to pass the current financing plan under which imposes a tax on fuel in 2005.

The country's Ministry of Finance and Public Credit (MHCP) transfers revenue from the fuel tax to FOMAV every year so that FOMAV can perform road maintenance duties with the funds. Therefore, the agency started to finance its operations on its own in 2006.

3) Financial resources

Financial resources for maintenance activities of FOMAV come from a special tax imposed on oil (diesel and gasoline). The oil tax rate was US$ 0.06/gallon at first, which gradually rose to US$ 0.16/gallon in 2009. Currently, 20% of the financial resources for its operations are transferred to local governments for road maintenance activities in their jurisdiction. The special oil tax rate is planned to be increased up to 20% in the future.

Table 2-4 | FOMAV Oil Tax Rates

Date	15 Dec 2005	1 Dec 2006	1 Dec 2007	1 Dec 2008	1 Dec 2009
Rate (USD/gallon)	0.06	0.08	0.12	0.15	0.16

Source: FOMAV data (2015).

Table 2-5 | Uses of FOMAV Financial Resources

Item	2010	2011	2012	2013	2014	Average
Administration cost (%)	3.20	3.88	3.92	3.92	3.79	3.71
Operating cost (%)	72.09	71.05	71.00	70.14	60.38	68.93
Inspection cost (%)	4.72	5.07	5.08	6.10	5.08	5.21
Transfers to local governments (%)	20.00	20.00	20.00	20.00	20.00	20.00

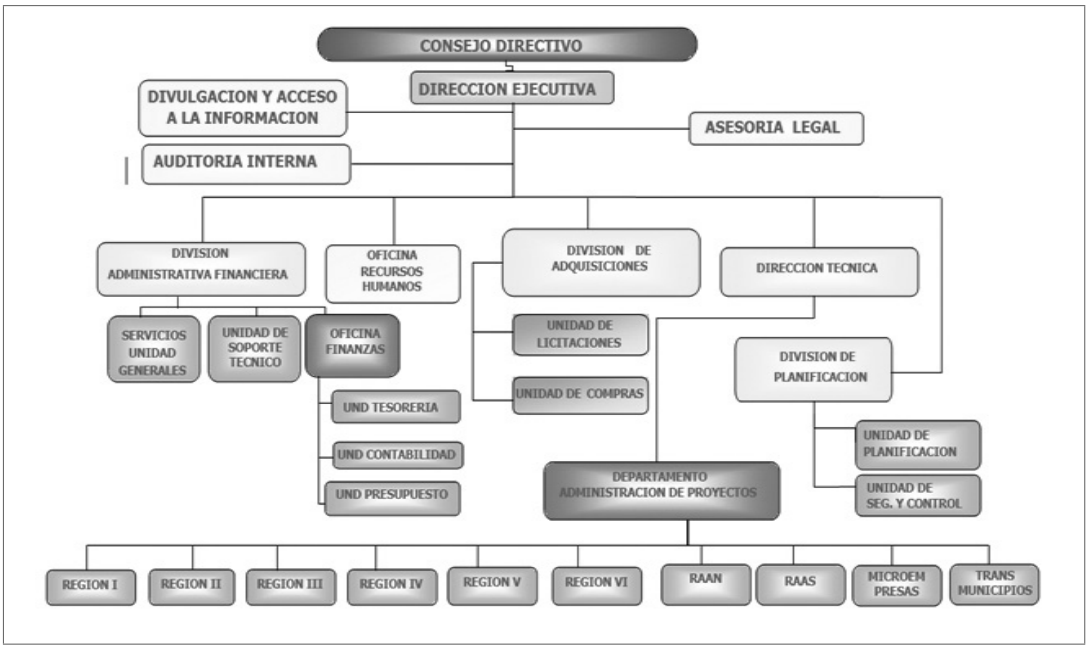
Source: FOMAV data (2015).

2.2.2. PMS Organization and Activities

FOMAV was organized as per provisions in Article 290 of the Law on Administrative Organization, Competition, and Procedures, and the FOMAV administrator puts into practice decisions of its board of directors as specified in Article 355 of the FOMAV Creation Law and Article 572 of its Amendment. As of 2015, head of FOMAV takes charge of implementing policies and decisions of the board of directors and supervise and coordinates its operations with a view to ensuring efficiency of road management practices and activities. Division of Technology takes on the planning and implementation of road maintenance and is responsible for qualitative and quantitative management of projects. In 2014, it managed and supervised the maintenance project of a 3,282 km maintainable road section. Division of Finance and Administration controls overall management and coordination of financial resources for the agency's operations, and in 2014, the division managed

and operated a budget of the Annual Operative Plan (Plan Operativo Annual, POA) amounting to C$1.028 billion for the year.

Figure 2-3 | Organization of FOMAV



Source: FOMAV, Memoria de Labores (2014).

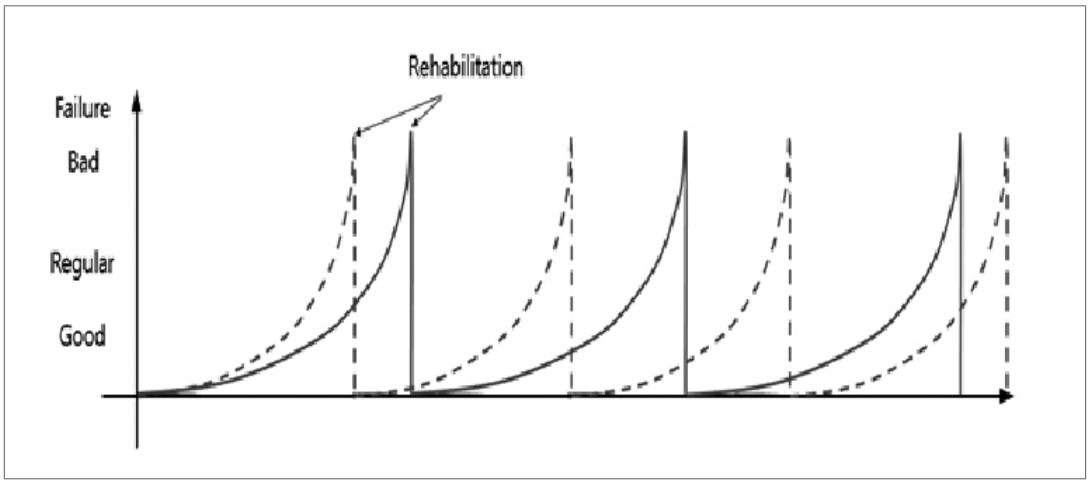
The Division of Procurement is responsible for contracts and bids related to construction, supervision, assets and services under Law No.737. In 2014, the division signed 104 contracts with various requirements and formats, including public bids, private consultancies, optional contracts, and international and domestic bids. Legal Division provides legal support to ensure that the FOMAV activities are carried out in the framework of the current laws, and Public Relations Division is responsible for diverse mass media (e.g. TV, radio, and newspaper), distributes promotion materials, visits project sites, manages SNS and websites, and stages public awareness campaigns related to transport.

2.2.3. Nicaraguan Pavement Management System

1) SIGMAVIAL

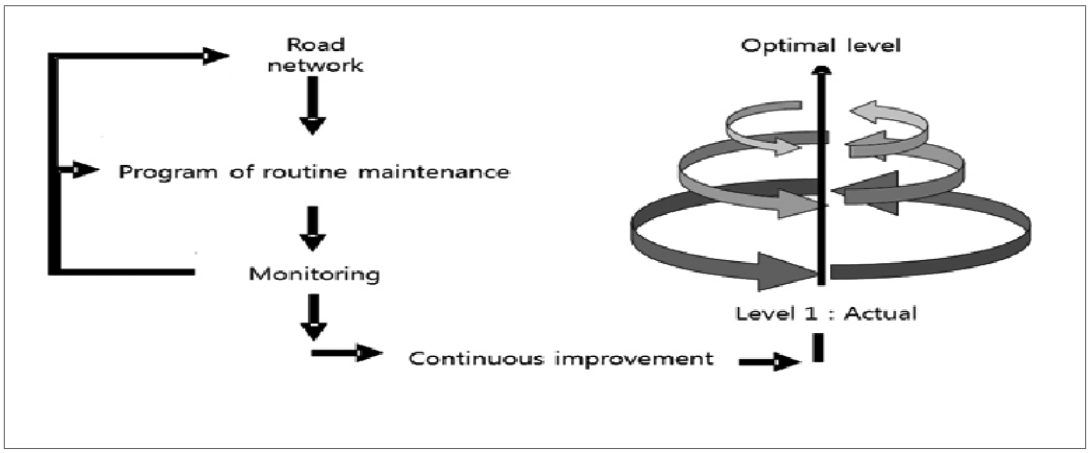
Sistemas Integrados de Gestión del Mantenimiento Vial (SIGMAVIAL) is extremely important to properly preserve and maintain the national and provincial road networks and improve management mechanism. SIGMAVIAL provides information for the government to make decisions on the preservation of road networks to ensure sustained and appropriate road management. In Nicaragua, SIGMAVIAL is used to automate and optimize the maintenance process for the purpose of increasing life cycle of all the components of roads, saving money and making efficient input.

Figure 2-4 | Change in Pavement Condition by Maintenance



Source: Informe Final - Anexo 5: Manual de Usuario del SIGMAVIAL - Consultoría: "Desarrollo de un Sistema Integral de Gestión del FOMAV" (2013), FOMAV

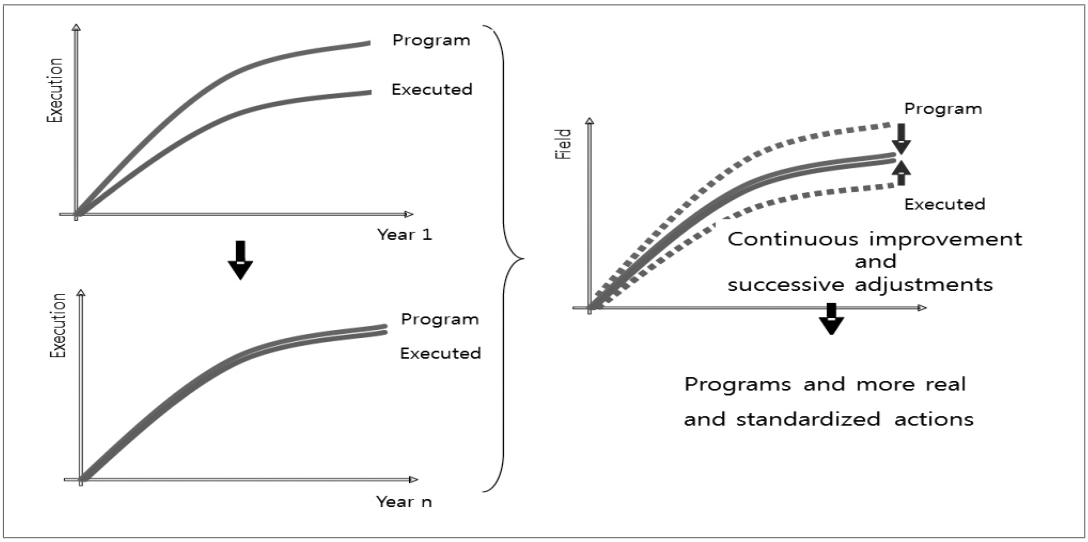
Figure 2-5 | Optimization Process



Source: Informe Final - Anexo 5: Manual de Usuario del SIGMAVIAL - Consultoría : "Desarrollo de un Sistema Integral de Gestión del FOMAV" (2013), FOMAV

As illustrated below, it is necessary to adjust results via maintenance optimization process based on collected and processed data to enhance efficient use of SIGMAVIAL. This means that continuous improvements should be made to narrow the gap between actual service performance and estimations regarding various maintenance methods for the road network, by improving cost adjustment related standards or performance relate estimation methods.

Figure 2-6 | Adjustment of The Difference between Actual Performance and Estimation of Repair Method



Source: Informe Final - Anexo 5: Manual de Usuario del SIGMAVIAL - Consultoría: "Desarrollo de un Sistema Integral de Gestión del FOMAV" (2013), FOMAV.

2) Advantages of SIGMAVIAL

In order to establish the process for road network management and repair, SIGMAVIAL puts together computer systems to enhance timing, quality, scope of uses, and efficiency of existing IT system and thereby coin a road network maintenance framework for the management of development platform and database. The road network consists of the following:

A. Routes and sections

B. Inventory (road geometric structure, longitudinal and transverse drain, road shoulder, vertical-horizontal signal, security system, etc.)

C. In addition, considerations for road network maintenance include:

D. Unit cost, estimation model, repair, execution and operation based on the condition of the section, etc

E. Designation of region and season

F. Parameters of pavement condition and conservation index

G. Maintenance programming characterized by:

- Maintenance scheduling to the level of section, region or nation
- Repair scheduling at the level of section, region or nation without restricted budget (ideally 100%)

- Repair scheduling at the level of section, region or nation via adjustment of condition indexdue to restricted budget and approval of POA depending on condition index
- Generation of maintenance simulation numbers in the road network as set by the user

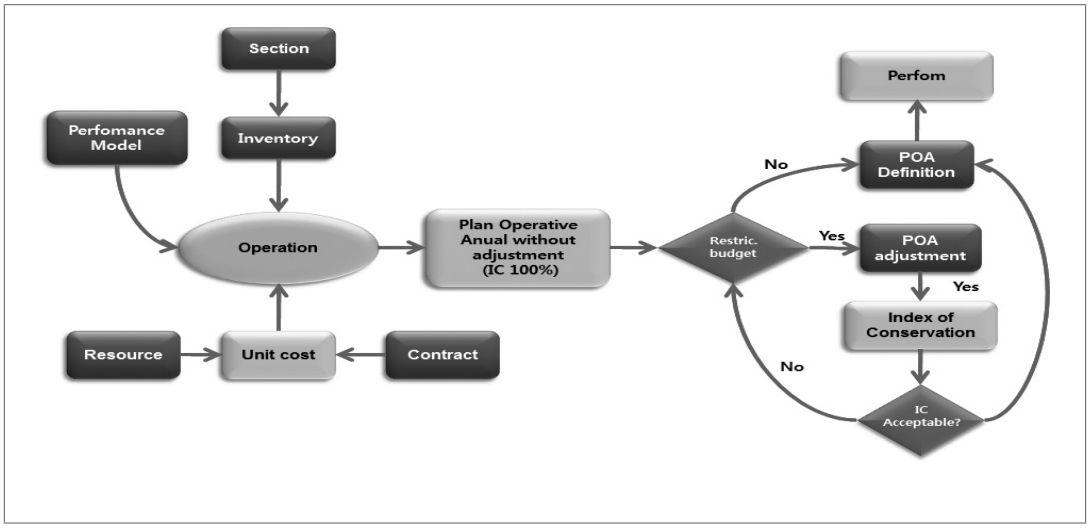
H. Input of external contracts or internal management and execution of monitoring and maintenance

- Physical and financial contracts or prior contracts
- Execution of physical and financial schemes by the relevant department

I. GIS as one of the components of SIGMAVIAL

J. Integration of information provided offline by camera built in survey equipment.

Figure 2-7 | SIGMAVIAL Process



Source: Informe Final – Anexo 5 : Manual de Usuario del SIGMAVIAL Consultoria : "Desarrollo de un Sistema Integral de Gestion del FOMAV" (2013), FOMAV

2.2.4. Survey Equipment

In 2015, Nicaragua introduced Hawkeye 1000 to carry out pavement condition surveys. Hawkeye, pavement survey equipment made by Austrian company ARRB Group, is categorized into two types: 1000 series and 2000 series. The 1000 series is equipped with a profiler and a distance measuring instrument and can take photos of pavement with the front embedded camera to check pavement condition. The 2000 series has 17 lasers to measure roughness and rutting and has many cameras, which allow cracks to be analysed automatically via 3D road surface survey. In addition, interlocked to data monitoring program, the equipment provides automatic updates of pavement conditions.

Figure 2-8 | FOMAV's Hawkeye 1000 series



Source: Taken by the KSP Consultant (2015)

2.3. Field Survey

2.3.1. Field Survey Sections

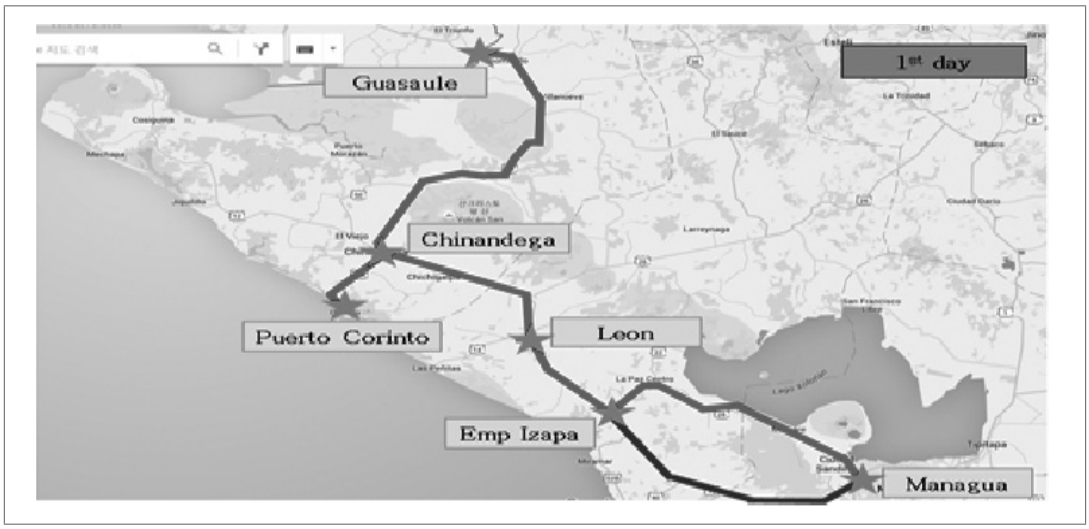
The field survey took place from 4th to 5th of September 2015 in Nicaragua to examine pavement conditions of the national road network and evaluate types and causes of pavement damage. Sections covered were in the north-south road network of dense-graded asphalt pavement, concrete pavement and block pavement by type. The first field survey was conducted along the northern road network of 200 km from Managua to Guasaule bordering Honduras. The next day, the survey was performed for the southern segment of 150 km from Managua to Sapoa until the border to Costa Rica. Table 2-6 provides survey sections, pavement types and characteristics of each section covered by the field survey in Nicaragua.

Table 2-6 | Summary of Field Survey

Date	4 Sep. 2015	5 Sep. 2015
Section	Guasaule-Managua	Managua - Sapoa
Date	4 Sep. 2015	5 Sep. 2015
Section	Guasaule-Managua	Managua - Sapoa
Length	200 km	150 km
Pavement Type	Asphalt pavement (AP) and concrete pavement (CP)	Asphalt pavement (AP) and concrete pavement (CP)
Remarks	- Two overlays onto existing pavement. - 5-cm modified asphalt paved for the first time. - Overload vehicle control system in place in Nicaragua. - Severe pot holes found in northern region.	- Concrete pavement constructed for the first time. - Four types of maintenance methods applied depending on surface distress type.

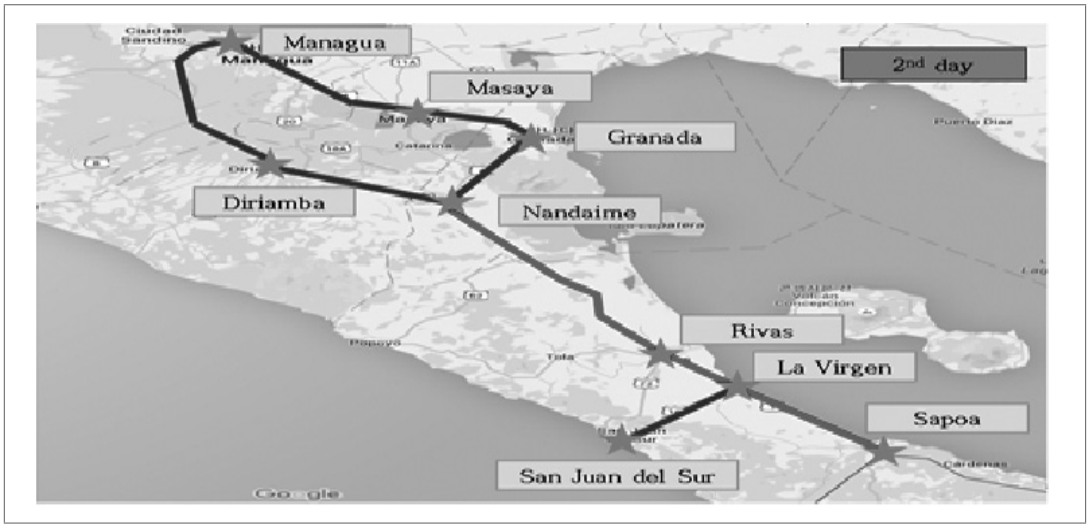
Source: Compiled by KSP Consultant (2015)

Figure 2-9 | Location of Field Survey (4 Sept 2015)



Source: Compiled by KSP Consultant (2015)

Figure 2-10 | Location of field survey (5 Sept 2015)



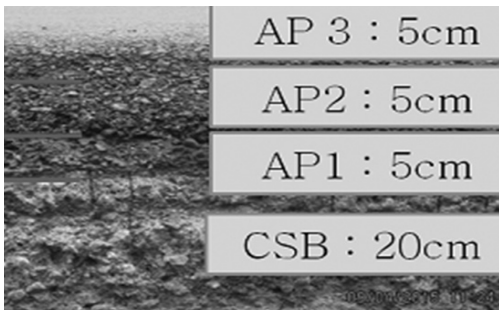
Source: Compiled by KSP Consultant (2015)

2.3.2. Overlay Section

- Section: Chinandega-Puerto Corinto
- Pavement type: Dense-graded asphalt pavement over cement treated base, followed by two overlays

This section is an example to show Nicaragua's pavement crosss sections. Initially, dense-graded asphalt mix was paved (5 cm) on the cement treated base (20 cm). Two successive overlays (5 cm + 5 cm) increased the thickness of the asphalt pavement. Korea has a similar case; in 1970, asphalt pavement was constructed as deep as 7.5 cm, and later five overlays took place, resulting in the increase of the thickness of the ashalt pavement.

Figure 2-11 | Field Survey (repeated overlays)



Layers of pavement



Repeated overlays in Korea (in the Gyeongbu Expressway)

Source: Taken by KSP Consultant (2015)

2.3.3. Modified Asphalt Pavement Section

- Section: Leon-Chinandega
- Pavement type: Modified asphalt pavement (5 cm)

As in Figure 2-12, this section has soft soil to which modified asphalt pavement was applied for the first time to enhance durability of the pavement. Expansive soil in lower layers results in weakening pavement during wet season, and cut-off walls were installed on both sides of the road to prevent rainwater from coming in to lower layers of pavement.

Figure 2-12 | Modified Asphalt Mix Pavement Section



Modified asphalt pavement



5 cm-overlay

Source: Taken by KSP Consultant (2015)

2.3.4. Road Maintenance and Repair Methods

• Section: all sections

• Pavement type: Asphalt pavement (5 cm)

Findings from survey and analysis of maintenance and repair methods for asphalt pavement revealed that sealing was used as a first repair means to prevent invasion of rainwater through linear cracks, seal coating was conducted next to prevent spread of cracks / occurrence of potholes, patching was performed as a third repair method in the sections with potholes, and finally overlay was applied to sections where the pavement was heavily damaged. This shows that FOMAV carries out appropriate repair activities by damage phase in order to use limited maintenance budget in an efficient manner.

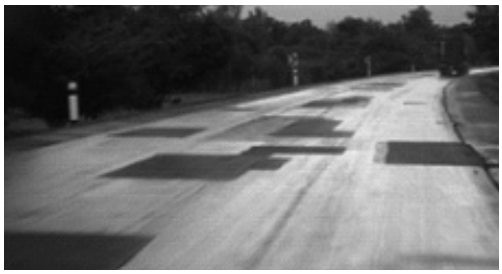
Figure 2-13 | Maintenance and Repair Methods for Asphalt Pavement



Sealing of linear cracks



Seal coating



Patching



Overlay

Source: Taken by KSP Consultant (2015)

2.3.5. Asphalt Pavement Equipment

• Section: all sections

• Pavement type: Asphalt pavement (5 cm)

The results from survey/analysis of asphalt pavement equipment show that in Nicaragua, emulsion was applied to enhance the interlocking with the existing layer, prior to asphalt pavement. General asphalt paving machine is used, and a comination of tire roller and tandem roller is in use for compaction. However, a 3-machine combination is recommended to obtain sufficient compaction ratio (96%). The best comination is composed of macadam roller, tire roller, and tandem roller.

Figure 2-14 | Asphalt Paving Equipment



Emulsion application equipment



Asphalt paving equipment



Tire roller



Tire roller

Source: Taken by KSP Consultant (2015)

2.3.6. Overload Vehicle Control Section

• Section: Chinandega-Puerto Corinto

Much traffic of heavy vehicles to and from ports pass this section where overload check points are in place to regulate access of overload vehicles that cause pavement damage. More checkpoints are considered necessary to root out overloading.

Figure 2-15 | Overload Vehicle Control



Overload vehicle



Overload vehicle



Overload check point



Vehicle Weight Monitoring System (VWMS)

Source: Taken by KSP Consultant (2015)

2.3.7. Pavement Damage Status

• Section: All sections

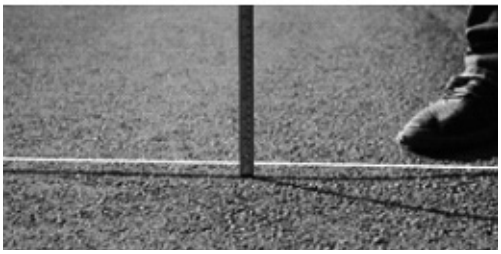
• Pavement type: Asphalt pavement

Recently repaired pavements appeared to be in good condition, but lots of cracks and pot holes were found in older pavements. Heavy vehicles are crossing the median to avoid pot holes in two-lane roads, which poses a threat to road safety. Major types of pavement damage include cracks, pot holes, and rutting. Some segments of the road suffer from longitudinal cracks along the road, which is considered due to strains in lower layers. Results of the field survey revealed that asphalt pavement needs to be deeper in order to enhance durability of asphalt pavement in Nicaragua. It is also necessary to improve asphalt mix design or apply modified asphalt to reduce pot holes.

Figure 2-16 | Types of Pavement Damage



Pot holes



A vehicle crossing the median to avoid a pot hole



Pavement rutting



Pavement rutting



Lower layer rutting



Lower layer rutting



aLongitudinal crack 1



Longitudinal crack 2

Source: Taken by KSP Consultant (2015)

2.3.8. Concrete Pavement

• Section: Managua - Diriamba

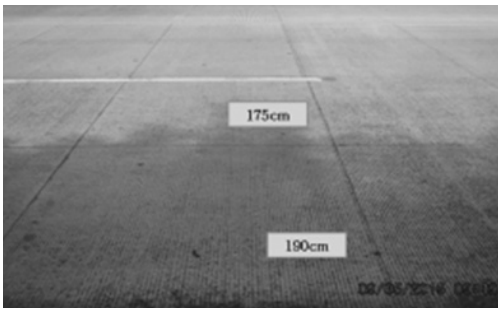
• Pavement type: Concrete pavement (15 cm)

This 1 km long section remained in good condition, as it was constructed in suburban areas as a pilot project in March 2015. Also, the concrete pavement was as deep as 15 cm and the spacing of joints was 1.75 m (thinner pavement layer and shorter joint spacing than in Korea). Joints were sealed with silicon and in good condition free of foreign substances. As it is easy to obtain cement in Nicaragua where there are many volcanic terrains, concrete pavement will be expanded further in the future.

Figure 2-17 | Concrete Pavement



Concrete pavement 1



Concrete pavement 2

Source: Taken by KSP Consultant (2015)

2.3.9. Problems Detected in the Field Survey

Problems with the pavement condition of road networks in Nicaragua found as a result of the field survey are categorized into four; First, it was hard to obtain detailed tracking records on the surveyed sections (construction data, frequency and timing of repair, pavement condition before repair, and traffic volume), second, cracks and pot holes in deteriorated pavements appeared to become a threat to road safety, and third, the field survey revealed that depth of asphalt pavements should increase in order to enhance their durability and it would be necessary to improve asphalt mix design or apply modified asphalt to mitigate pot holes. Fourth, a scientific PMS is needed to prioritize and implement repair works for old pavements within budget.

3. PMS in Korea

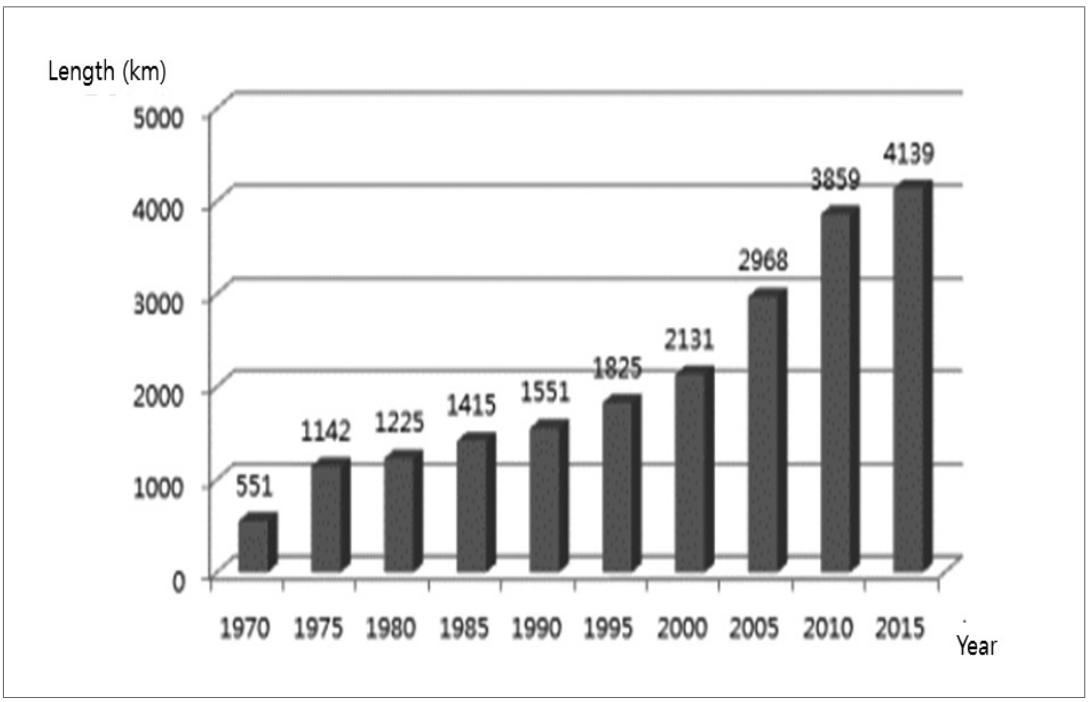
3.1. Overview of Highway Pavement Management

3.1.1. Managed Pavements

1) Increase in pavement length

In 1968, the 30 km Seoul-Incheon expressway was opened as the first of its kind in Korea, and as the Gyeongbu Expressway as long as 428 km linking Seoul and Busan opened in 1970, the country heralded its age of expressways. Continued expansion of expressways since then has achieved a 4,139 km national expressway network today. The expressway network has played a pivotal role in driving the nation's economic growth as one of the key infrastructure assets. Korea Expressway Corporation (KEC) manages a 3,817 km road section of it, except for routes managed by the private sector. Early in the 1990s, in particular, the total length of the managed expressways stood at 1,500 km, which has increased over 2.5 times as a result of efforts to accommodate growing traffic since the 2000s. Given that expressway construction projects have been promoted continuously under the expressway network development plan to build seven north-south routes and nine east-west routes, length of managed roads is likely to rise up to 6,000 km in the long run.

Figure 2-18 | Expressway Length by Year (As of 31 Dec 2014)



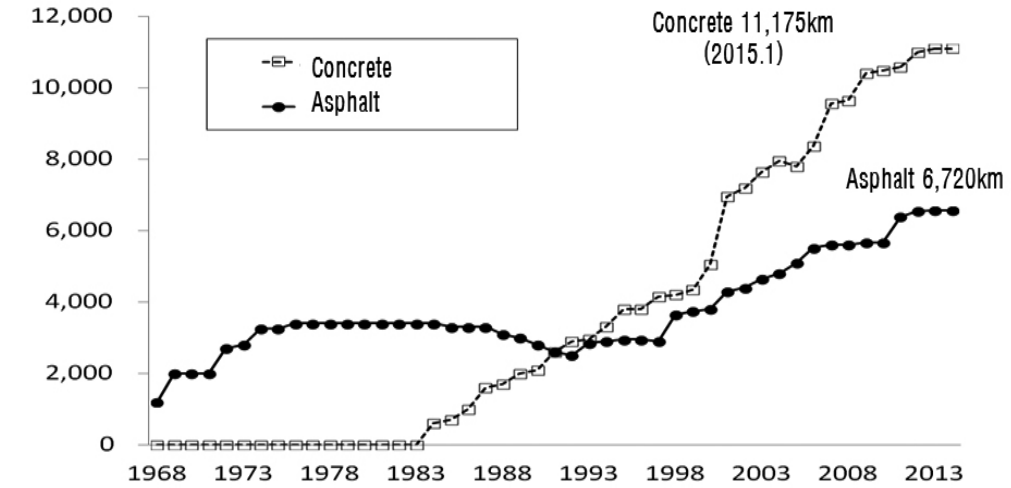
Source: The 2015 Yearbook of Road Statistics (2015), Republic of Korea Ministry of Land, Infrastructure and Transport (http://www.rsis.kr/).

2) Road statistics by pavement type

Highway pavements were constructed with asphalt until early in the 1980s. Concrete pavement was applied to the 88 Olympic Expressway in 1984, as it is less expensive and requires less maintenance for a certain period of time. Since then, concrete payment has become the major pavement type of choice for expressways. Currently, out of the 3,817 km road section managed by the KEC, 2,495 km is paved with concrete, accounting for 65% of all.

Figure 2-19 | Length by Pavement Type

Classification	Total	Concrete	Asphalt	Remarks
Length (km)	3,817 (17,895)	2,495 (11,175)	1,322 (6,720)	(for 1-lane roads)
Ratio (%)	100	65	35	



Source: The 2015 Yearbook of Road Statistics (2015), Republic of Korea Ministry of Land, Infrastructure and Transport (http://www.rsis.kr/).

3) Pavement condition by age

For asphalt pavements, regular overlays have been applied depending on pavement condition, while early concrete pavements become older, exceeding their design life of 20 years. Even though concrete pavements have been maintained by means of partial repair or cutting overlay with asphalt pavement using concrete-based materials, pavement aging and deterioration caused by the increased use of de-icing agent in winter have sped up damage of pavements. As there is a growing need for full-scale improvement of aged sections, efforts are being made to develop a phased improvement plan for such sections.

Table 2-7 | Number of Pavements by Age (Unit: km/1-lane road)

Classification	Total	5yrs or less	6-10yrs	11-20yrs	20yrs or older
Total	17,895	5,237 (29%)	5,666 (32%)	6,034 (34%)	958 (5%)
Concrete	11,175	2,002 (18%)	3,172 (28%)	5,043 (46%)	958 (8%)
Asphalt	6,720	3,235 (48%)	2,494 (37%)	991 (15%)	-

Source: The 2015 Yearbook of Road Statistics (2015), Republic of Korea Ministry of Land, Infrastructure and Transport (http://www.rsis.kr/).

4) Overlay repair by year

Decisions are made on the basis of pavement condition survey results to select pavements for annual maintenance work, and overlays are performed for the one-lane road section as long as 200km, which will likely continue to grow, as the total length of deteriorated sections is steadily on the rise. As far as non-cutting overlay is concerned, the height of the medians and road shoulder drain dikes drops as much as the thickness of the overlaid pavement, so overlay usually comes after cutting. However, overlay may be possible without cutting depending on site conditions.

Table 2-8 | Overlay by Year (Unit: km/1-land road)

Average	2011	2012	2013	2014
197	147	204	220	217

Source: KEC Statistics (2014), KEC.

3.1.2. Annual Pavement Maintenance Budget

Pavement maintenance budget used by the KEC comprises the asset-class improvement budget and the consumables-class routine maintenance budget. Due to the increase in length of managed roads and service life over the recent five years, pavement maintenance budget has continued to grow 66.5%: from USD 90 million in 2011 to USD 150 million in 2015. The increase in the length of aged concrete pavements, among others, has fuelled a remarkable growth in concrete pavement maintenance budget, which is likely to further rise over time.

Table 2-9 | Changes in Pavement Maintenance Budget

(Unit: USD 100m)

Classification		2011	2012	2013	2014	2015 (est.)
Total		0.92	0.96	1.51	1.32	1.54
Improvement	CP	0.27	0.32	0.47	0.40	0.58
	AP	0.12	0.16	0.23	0.23	0.24
	Bridge pavement	0.28	0.21	0.38	0.28	0.40
Routine maintenance		0.26	0.27	0.42	0.41	0.32

Source: The 2015 Yearbook of Road Statistics (2015), Republic of Korea Ministry of Land, Infrastructure and Transport (http://www.rsis.kr/).

Given the 2014 CP maintenance budget, specifically, partial repair to correct spalling at joint as a major CP distress represented the largest share at 47%, followed by overlay in AP at 35%; these two types of maintenance accounts for the majority. In addition, diamond grinding to improve roughness and joint repair as preventive maintenance measure for joints used around 18% of the budget.

Table 2-10 | Concrete Pavement Maintenance Budgets (2011-2015)

(Unit: USD 100m)

Total	Overlay	Partial repair	Diamond grinding	Joint repair
2.04	0.73(35%)	0.96(47%)	0.11(6%)	0.24(12%)

Source: Korea Expressway Corporation Information System (2015), Korea Expressway Corporation.

Regarding AP maintenance, overlay accounts for the largest share of 81%, and approach slab deflection improvement constitutes 19%. As far as bridge deck pavement maintenance is concerned, bridges with badly deteriorated slab have been maintained with concrete-based materials, and less badly deteriorated bridges with AP, respectively. About 68% of the budget is used for maintenance with concrete-based materials. Besides, undefined capital improvement budget is used for routine maintenance covering patching of pot holes and cracks happening from time to time at pavements.

Table 2-11 | Asphalt Pavement and Bridge Pavement Maintenance Budgets (2011-2015)

(Unit: USD 100m)

AP			Bridge pavement		
Total	Overlay	Repair of structure connections	Total	Concrete	Asphalt
0.97	0.78 (81%)	0.19 (19%)	0.56	1.07 (68%)	0.49 (32%)

Source: Korea Expressway Corporation Information System (2015), Korea Expressway Corporation.

3.1.3. Pavement Management Organization

The KEC has five headquarters (HQs) and 19 Divisions and Offices at Head Office, and the R&D HQ is a body under the direct supervision of Head Office and controls five R&D related organizations including the KEC Research Institute, or KECRI. There are other direct control centres including the Construction Offices responsible for the implementation of construction of expressways and seven Regional HQs and 52 Branch Offices for the management of expressways in use. Among units and divisions in charge of pavement management are the Road Pavement Team at Traffic Management HQ and the Pavement Laboratory of the R&D HQ. Regional HQs and Branch Offices conduct maintenance of pavements.

Figure 2-20 | Pavement Management Organization

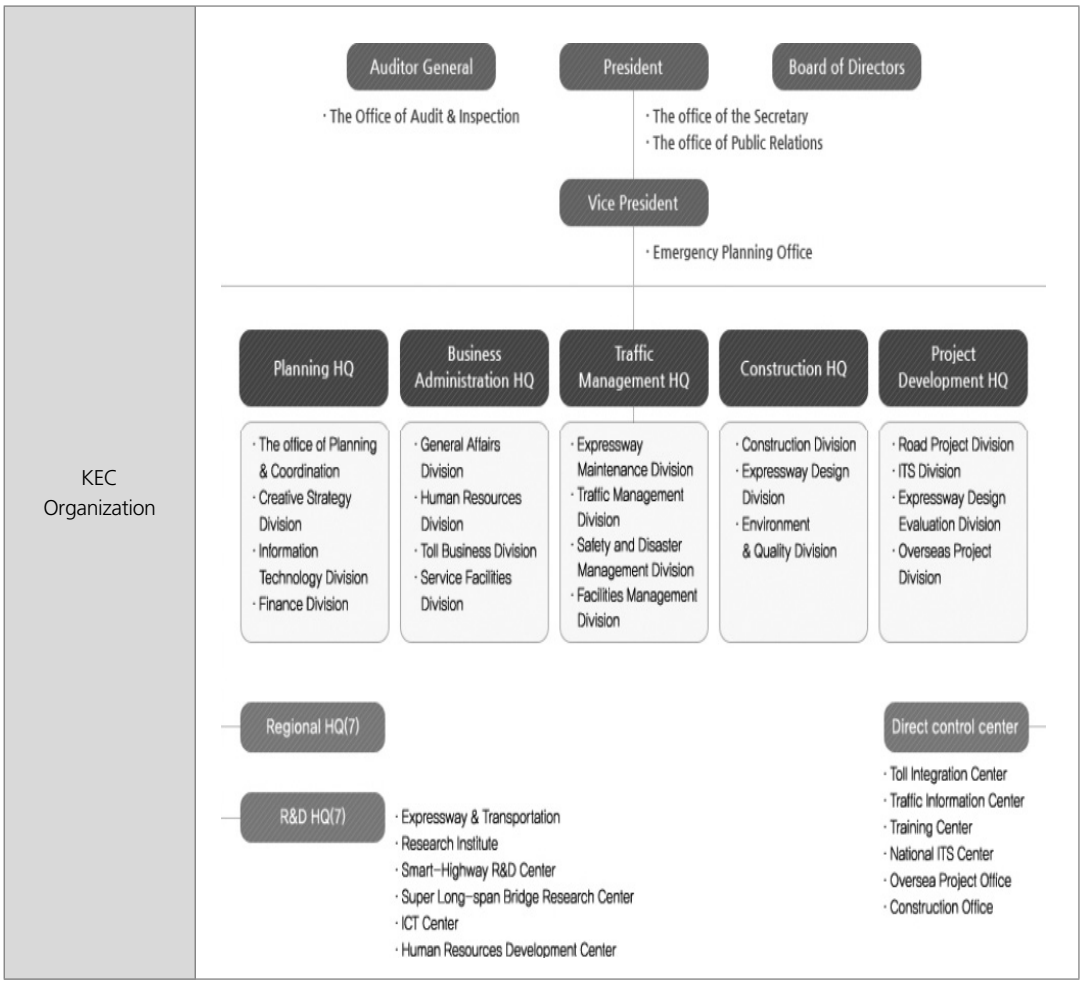
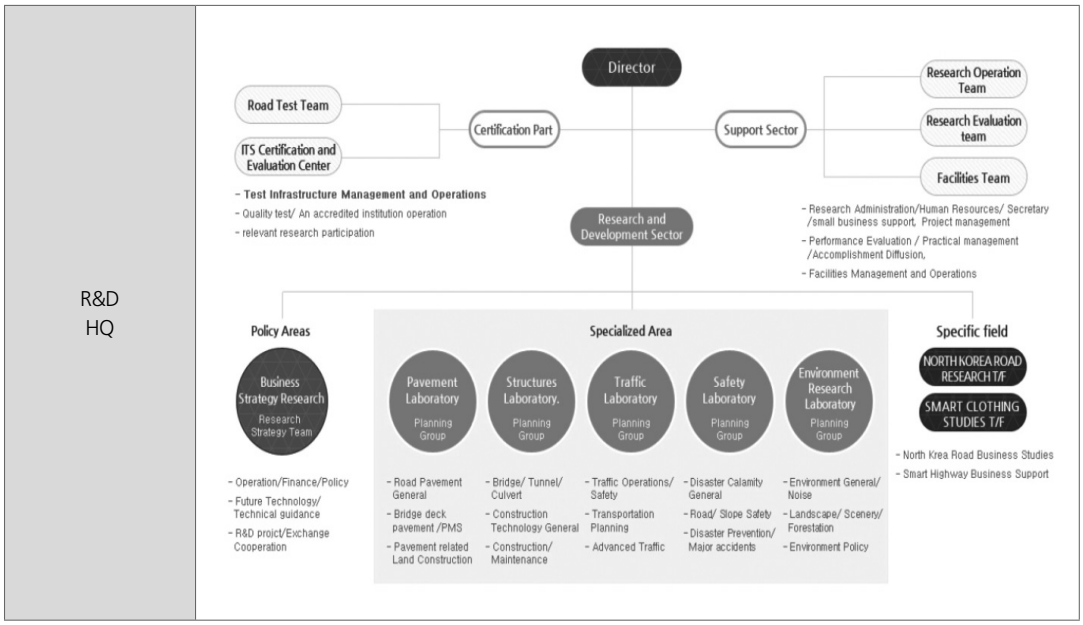


Figure 2-20 | Pavement Management Organization (continued)



Source: Korea Expressway Corporation

3.2. Pavement Management System

3.2.1. PMS Related Manuals

Data input management is critical to enhance the usability and reliability of the PMS. Since different staffers enter construction and maintenance data into the system and staffers in charge may change in some cases, it is necessary to put in place a standard input method. The PMS User Manual and the System Management Guide' have been formulated to serve this purpose. The former describes how modules of the PMS work and how to use them in order to assist the personnel to use the system better. The latter sets out how to manage input of inspection and maintenance data.

Although the manuals and guidelines are distributed to the personnel of all the offices, there still may be a lack of understanding on details. To solve this issue, an annual 2-day-and-3-night PMS training is given to the personnel. The training consists of lectures on PMS operation theory and practice for maximum effects. In order to continue to update the manuals and guidelines, participants discuss and diagnose problems with the current operation and give feedback to find solutions during the training.

3.2.2. Pavement Maintenance and Repair Related Manuals

Quality standards of pavement maintenance works are established under the framework of the Expressway Construction Guide Specification, which sets out quality standards for both construction and maintenance by work type. In addition, the KEC publishes the Handbook on the Pavement Management and Maintenance Practices incorporating specifications, standards, and guidelines to assist on-site pavement maintenance activities. The Handbook contains PMS, pavement condition survey and analysis methods, maintenance planning standards, administrative matters covering pavement construction project awards and completion, defect management, and detailed maintenance methods by distress type to boost convenient uses.

As explained above, annual pavement management training covers related education plus education on the pavement management at large to help the pavement management personnel to foster expertise in this field. A separate textbook titled "The Expressway Pavement Management Standard Textbook (the "Textbook")' is used for this training. This Textbook contains mainly key issues of the Handbook as well as a checklist and methods of pavement management and maintenance useful for the personnel. These manuals are revised through regular feedback.

Table 2-12 | Pavement Maintenance and Repair Related Manuals

Expressway Construction Guide Specification	Handbook on the Pavement Management and Maintenance Practices	Standard Highway Pavement Management Textbook
This guide specification provides all sorts of specifications for expressway design/ construction.	This handbook sets forth management standards and repair methods for the road pavement management upon construction.	This textbook is for pavement manager training that covers pavement management standards and ways of data entry/utilization.

Source: Compiled by KSP Consultant.

3.3. Pavement Management Methodology

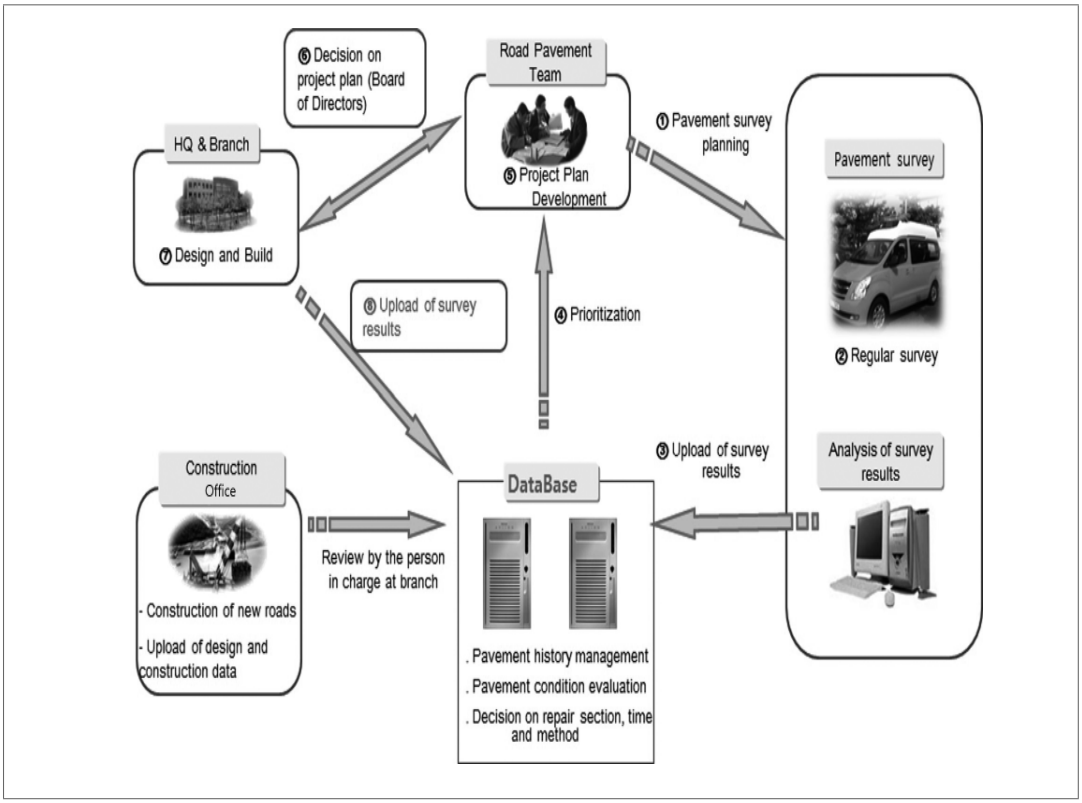
3.3.1. Pavement Management Process

Design and construction data are highly important to manage pavements efficiently. As a body to perform construction, improvement, and expansion of expressways, Construction Offices of KEC upload pavement design and construction data to the Construction Information System (Hi-Construction) prior to the completion of each project, and as a pavement manager, each Branch Office examines if the data are entered correctly and develops a database. Once entered to the Hi-Construction, the data are automatically transferred to the pavement management system (Hi-PMS) and used as basic pavement maintenance data.

Pavement management is carried out by evaluating pavement conditions via annual pavement survey and analysis and thereby prioritizing repair sections and methods. The Road Pavement Team at Head Office establishes a plan for the next year within the budget with the approval of the board

of directors. Under this business plan, the Head Office and Branch Offices implement maintenance works including design and construction and enter results to the PMS to keep track of pavement maintenance activities. This data is used for pavement design and construction management as well as LCCA.

Figure 2-21 | Pavement Management Procedure



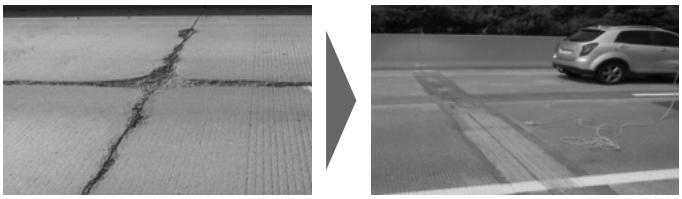
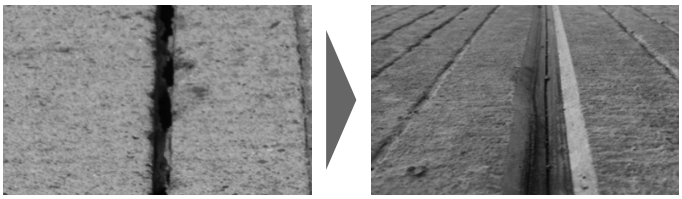
Source: Handbook on the Pavement Management and Maintenance Practices (2012), Korea Expressway Corporation.

3.3.2. Major Pavement Repair Methods

1) Concrete pavement repair methods

The most common type of damage found in concrete pavement in Korea is joint spalling, which is a phenomenon where pavement slab is broken into pieces from vertical and horizontal joint corners. In general, spalling occurs when inappropriate construction and maintenance of joints leads to invasion of incompressible materials into the joints and, in turn, excessive stress appear due to the slab expanded as temperature rises or when repeated traffic loading accelerates damage.

Figure 2-22 | Major Concrete Pavement Repair Methods

Partial repair	• Application: spalling at joints 
(Cutting) overlay (T=8-10cm)	• Application: overall damage due to aging 
Full re-pavement (T=30cm)	• Application : alkali-aggregate reaction 
Diamond grinding	• Application: surface wear and poor roughness 
Sealant re-application	• Application: sealant damage 

Source: Handbook on the Pavement Management and Maintenance Practices (2012), Korea Expressway Corporation.

Especially, where de-icers are heavily used in winter, calcium chloride and de-icing salt cause chemical deterioration and cyclic freezing-thawing worsens damage. In this case, partial repair is largely carried out.

Figure 2-23 | Partial Repair of Concrete Pavement



Removal of damaged segment | Clearing | Modified concrete pavement

Source: Handbook on the Pavement Management and Maintenance Practices (2012), Korea Expressway Corporation.

Where overall improvement is necessary due to spread of concrete pavement damage, overlay of asphalt pavement is hired in SMA (Stone Mastic Asphalt) pavement method which is resistant to compressive force and shear force due to interlocking mechanism of aggregates.

In the case of an alkali aggregate reaction section or overall concrete pavement damage caused by blow up, the entire concrete pavement is cut off before full-depth repair with asphalt pavement. Besides, as a preventive maintenance, sealant re-application and sealing of cracks are used to prevent joint spalling damage.

2) Asphalt pavement maintenance methods

For asphalt pavements, damage types like rutting and cracking in a broad area of 20% or more are repaired by overlays and local damage by partial patching. Damage like pot holes poses a threat to driving and requires a prompt repair and therefore, cold-mixed asphalt is used to carry out a quick patching rather than hot mixed asphalt. However, cold mixed asphalt is less durable than hot mixed asphalt, and therefore, in recent years, hot mixed asphalt grows to be used for emergency repair using a movable asphalt concrete mixer. In an effort to prevent pavement damage by preventive maintenance, sealing of cracks and cold joins are used.

Figure 2-24 | Major Asphalt Pavement Repair Methods

Cutting- overlay	 • Application: major damage area	

Figure 2-24 | Major Asphalt Pavement Repair Methods (continued)

Patching	 • Application: minor damage area
Emergency patching	 • Application: partial damage area
Cold joint & crack sealing	 • Application: joint damage area

Source: Handbook on the Pavement Management and Maintenance Practices (2012), Korea Expressway Corporation.

3.4. Pavement Management System (PMS)

In an attempt to tackle issues like changing pavement management conditions and sharp rise in management budget effectively, the KEC started to develop a PMS suitable for expressways in 1993 and completed the development of a Hi-PMS (Highway Pavement Management System) at the end of 2003 after trial operations and improvements and has been using for its operations. Anyone at the KEC can access Hi-PMS as an intranet-based information system.

3.4.1. PMS Developments

1) PMS history

In Korea, the KECRI introduced a PMS to the country through a PMS research in 1993, and the PMS has been used in practice since 2000. Table 2-13 summarizes PMS improvements made thus far.

Table 2-13 | Summary of PMS Improvements in Korea

Year	Improvement
1993-1996	Adopted HPCI (KECRI) - Regression equations developed following panel rating (roughness, cracking, rutting)
2000-2003	Surveyed pavement conditions and developed and operated PMS (Expressway Maintenance Division)
2004	HPCI improvement (1st) - Site conditions like roughness, rutting, and surface distress considered (per 100m)
2006	HPCI improvement (2nd) - HPCI calculation (per 100m → per 10m) - Project section selection method 100m segment (HPCI 3.2 or less) → 300m segment (HPCI 3.0 or less)
2010	HPCI improvement planning - HPCI calculation method improved including weighted value adjustment
2011	Panel rating - Panel survey: comparison of measurements by equipment at regional offices and evaluations by expert investigation Hard to apply repair and improvement grades due to broad range of HPCIs (Grade 3 or less) of sections subject to preservative maintenance and improvement projects => improved from Grade 5 to Grade 7.
2012	Distance measured with distance measuring instrument (DMI) ▷Improved location reliability for the survey sections using GPS data.

Source: Expressway Pavement Condition Survey and Analysis Report (2014), Korea Expressway Corporation.

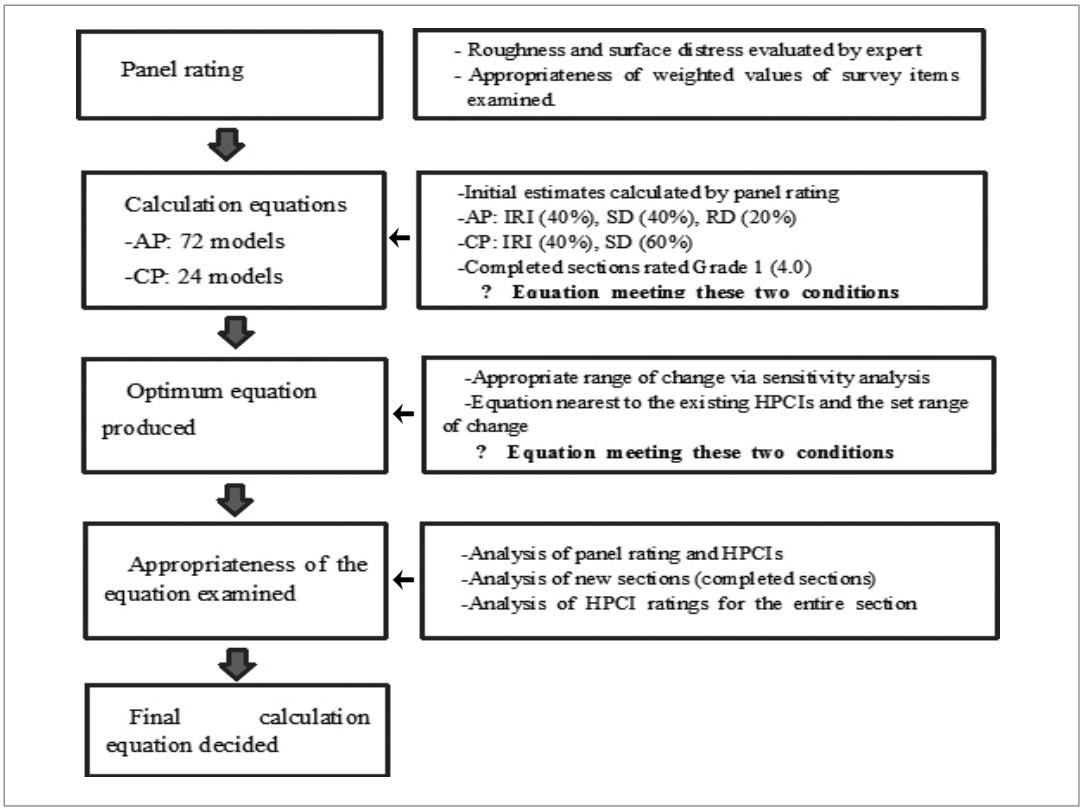
Continued changes in HPCI as above are because it has the following problems. First, weighted pavement condition evaluation items (roughness and surface distress) failed to reflect site conditions fully. In other words, weighted value for IRI was higher, and damage effect was lower. Although improvement of paving equipment and ascon material enhanced overall IRI, damage sped up spread of damage in old pavements, freezing-thawing, and deterioration. It is necessary to increase weighted value of pavement damage that affects safety of customers.

Second, it is hard to compare pavement conditions to select project sections by 2-year cycle pavement evaluation. There is no system in place to implement and supplement evaluation of HPCIs of sections improved by overlay and other methods. It is difficult to monitor partially repaired pavements and therefore give feedback of HPCI. This is why adjustment of HPCIs of repaired and improved pavements is required following pavement survey.

Third, in some cases, new pavements failed to attain Grade 1 (HPCI > 4.0). In general, even new pavements with a 1.6 or less IRI and having no surface distress rated Grade 2 (Grade 1: HPCI > 4.0) at HPCI of 3.96. Consequently, it is necessary to adjust the index so that new pavements with a 1.6 or less IRI and having no surface distress are rated Grade 1. It is hard to apply repair and improvement grades

due to the broad range of HPCIs (Grade 3 or less) of sections subject to preservative maintenance and improvement projects. As routine maintenance and improvement projects are classified by the range of HPCIs, it is necessary to clarify budget spending and project implementation methods for repair and improvement works such as partial repairs and overlays by sub-categorizing HPCIs. To solve these problems, the HPCI calculation equation was improved in the following process:

Figure 2-25 | HPCI Calculation Improvement Flowchart



Source: Expressway Pavement Condition Survey and Analysis Report (2014), Korea Expressway Corporation (2014).

2) Developments of highway pavement condition index (HPCI) calculation

At an early stage, foreign standards for HPCI calculation applied to domestic pavements in Korea, but they were not enough to fully reflect Korea-specific pavement condition. Efforts have been continued to produce HPCI calculation formula fit to Korean situations since 2004 when field survey data were collected. The current HPCI has gone through three revisions to enhance the correlation between actual pavement condition and HPCI, before being applied to PMS.

Table 2-14 | Developments of HPCI Calculation Methods

Year 1996
• Asphalt: HPCI = 4.564 – 0.348×IRI- 0.36×RD-0.01×(5+Tc'+AREA)0.5 Where, IRI = International Roughness Index (m/km), RD = Rut Depth (cm) TC' = Temperature crack (m/km), AREA' = Fatigue cracking and patching (m2) • Concrete: HPCI = 7.35 – 4.65×log(1+IRI)- 1.06×log(10+10/BC')-0.32×log(10+10/BP') IRI = International Roughness Index (m/km), B = imaging width of the equipment C' = Crack (m/(B×100)㎡), P' = Patching (m2/(B×100)㎡) - Developed first in 1996. - Evaluators drove on the representative pavement sections and measures correlations of roughness and surface distress, etc. through a regression analysis.
Year 2004
• Asphalt: HPCI = HPCI = 5 - 0.78×IRI0.7 - 0.5×RD1.5 - 0.65×log(1+SDA) Where, IRI = International Roughness Index (m/km), RD = Rut Depth (cm) SDA = Surface Distress Area (m2) • Concrete: HPCI = 5 - 0.84×IRI0.7 - 0.48×log(1+2.5×SDL) Where, IRI = International Roughness Index (m/km), SDL = Surface Distress Length (m) - Expert panel rating revealed that due to lack of HPCI-pavement condition correlation, rating index based on actual data was designed (HPCI was measured per 100m section.) - In a 5-point scale, IRI, rutting, and surface distress were considered, with values of individual items deducted from 5 points.
Year 2006
• Asphalt: HPCI = 5 - 0.78×IRI0.7 - 0.5×RD1.5 - 0.65×log(1+SDA×10) Where, IRI = International Roughness Index (m/km), RD = Rut Depth (cm) SDA = Surface Distress Area (m2) • Concrete: HPCI = 5 - 0.84×IRI0.7 - 0.48*log(1+2.5×SDL×10) Where, IRI = International Roughness Index (m/km), SDL = Surface Distress Length (m) - Local damage hugely affected the 100m section (rated poorer than in reality), so HPCI was calculated per 10m, from which 100m average was calculated.
Year 2011
• Asphalt: HPCI = 5 - 0.54×IRI0.8 - 0.75×RD1.2 - 0.9×log(1+SDA) Where, IRI = International Roughness Index (m/km), RD = Rut Depth (cm) SDA = Surface Distress Area (m2) • Concrete: HPCI = 5 - 0.8×IRI0.7 - 0.85×log(1+2.5*SDL) IRI = International Roughness Index (m/km), SDL = Surface Distress Length (m)
- Improved HPCI calculation to enhance the correlation between panel survey and HPCI.

Source: Korea Expressway Corporation (2014), Expressway Pavement Condition Survey and Analysis Report

3) Changes in HPCI ratings

HPCI ratings of asphalt pavement and concrete pavement conditions have improved from 5 grades to 7 grades since 2011.

Table 2-15 | Improvement in HPCI Rating for Asphalt Pavement (5 → 7 grades)

5 Grade-System (before 2011)					
Grade	HPCI	IRI	RD	SD(㎡)	SD(%)
1	4.0 or over	1.5 or less	2㎜ or less	7.2㎡ or less	2% or less
2	3.5-4.0	1.5-2.5	2-6.5mm	7.2-18㎡	2-5%
3	3.0-3.5	2.5-3.5	6.5-12.5mm	18-36㎡	5-10%
4	2.0-3.0	3.5-5.0	12.5-15mm	36-54㎡	10-15%
5	2.0 or less	Over 5	Over 15mm	Over 54㎡	Over 15%

7 Grade-System (from 2011)					
Grade	HPCI	IRI	RD	SD(㎡)	SD(%)
1	4.0 or over	1.5 or less	4㎜ or less	0㎡	0%
2	4.0-3.5	1.5-2.0	4-7㎜	1.0㎡or less	0.3%
3	3.5-3.25	2.0-2.5	7-10㎜	1.0-18㎡	0.3-5%
4	3.25-3.0	2.5-3.0	10-13㎜	18-36㎡	5-10%
5	3.0-2.5	3.0-3.5	13-16㎜	36-52㎡	10-15%
6	2.5-2.0	3.5-4.0	16-20㎜	52-72㎡	15-20%
7	2.0 or less	4.0 or over	20㎜or over	72㎡or over	20% or over

Source: Expressway Pavement Condition Survey and Analysis Report (2014), Korea Expressway Corporation.

Table 2-16 | Improvement in HPCI Rating for Concrete Pavement (5 → 7 grades)

5 Grade-System (before 2011)					
Grade	HPCI	IRI	RD	SD(㎡)	SD(%)
1	4.0 or over	1.5 or less	2㎜ or less	7.2㎡ or less	2% or less
2	3.5-4.0	1.5-2.5	2-6.5mm	7.2-18㎡	2-5%
3	3.0-3.5	2.5-3.5	6.5-12.5mm	18-36㎡	5-10%
4	2.0-3.0	3.5-5.0	12.5-15mm	36-54㎡	10-15%
5	2.0 or less	Over 5	Over 15mm	Over 54㎡	Over 15%

Table 2-16 | Improvement in HPCI Rating for Concrete Pavement (5 → 7 grades) (continued)

7 Grade-System (from 2011)				
Grade	HPCI	IRI	SD(㎡)	SD(%)
1	4.0 or over	1.5 or less	0㎡	0%
2	4.0-3.5	1.5-2.0	1.0㎡or less	0.3%
3	3.5-3.25	2.0-2.5	1.0-18㎡	0.3-5%
4	3.25-3.0	2.5-3.0	18-36㎡	5-10%
5	3.0-2.5	3.0-3.5	36-52㎡	10-15%
6	2.5-2.0	3.5-4.0	52-72㎡	15-20%
7	2.0 or less	4.0 or over	72㎡or over	20% or over

Note: Calculation basis of concrete surface distress changed from linear (m) to plane (㎡).

Source: Expressway Pavement Condition Survey and Analysis Report (2014), Korea Expressway Corporation.

3.4.2. Pavement Condition Survey

1) Survey levels

Highway pavement survey is categorized by network level, project level, and research level. Network level survey aims to assess overall properties of pavements such as surface distress, rutting, and IRI, and project level and research level survey is carried out for selected pavements as necessary for the intended purpose.

Table 2-17 | Expressway Pavement Evaluation

Level	Objective	Item
Network Level	Rate pavement condition of the entire network	Functions
Project Level	Identity causes for distress of the section and take actions	Bearing capacity, skid resistance, etc.
Research Level	Conduct studies including Long-Term Pavement Performance (LTPP)	Function, bearing capacity, etc.

Source: Expressway Pavement Condition Survey and Analysis Report (2014), Korea Expressway Corporation.

2) Survey cycles

Until 2007, road pavement condition ratings at a network level were conducted for individual sections every 2 to 4 years depending on traffic volume and service life. Since 2008, the entire pavement section has been rated at a two-year interval to increase the reliability of data collected. In addition, regardless of the criteria for survey cycles, a separate end of warranty inspection is conducted to discover defects two years after the completion of construction.

Table 2-18 | Highway Pavement Condition Survey Cycle

Until 2007			Since 2008
Traffic Volume		Interval	Interval
10,000 vehicles or over		2 yrs	Every 2 yrs for all sections
Below 10,000 vehicles	10 yrs or over service life	3 yrs	
	Less than 10 yrs service life	4 yrs	

Source: Expressway Pavement Condition Survey and Analysis Report (2014), Korea Expressway Corporation

3) Survey items

Pavement condition survey is performed with a focus on 12 items for asphalt pavements and 13 items for cement concrete pavements, respectively.

Table 2-19 | Highway Pavement Survey Items

Category	Asphalt pavement (12 items)		Cement concrete pavement (13 items)	
IRI	IRI		IRI	
Rutting	Rut depth (cm)		-	
Surface distress	• Fatigue cracking • Block cracking • Joint damage • Reflection Cracking • Longitudinal crack • Transverse crack	• Patching • Bleeding • Pot hole • Other	• Corner cracking • Durability Cracking • Longitudinal crack • Transverse crack • Ascon patching • Partial repair	• Punch-out • Scaling • Longitudinal spalling • Transverse spalling • Other
Joint			Sealant stripping	

Source: Expressway Pavement Condition Survey and Analysis Report (2014), Korea Expressway Corporation

4) Expansion of survey units

Although it is advantageous to make survey intervals as short as possible given varying characteristics of distress even among adjacent sections, a 10 m interval is desirable because too short intervals may result in too much data, leading to low efficiency.

5) Survey equipment

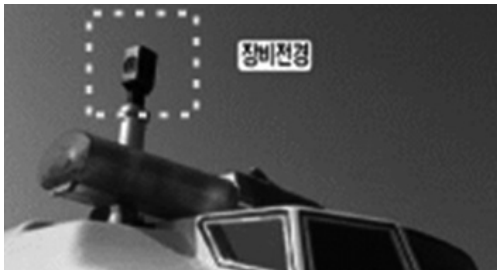
The MIDAS (Multi Infrastructure Distress Analysing System) was developed in Korea and has been used since 2012. Its performance has been verified with ARAN made by Roadware Group, Canada. Driving at 80 km/h, MIDAS can take panoramic photos and surface photos and measure RDs and IRIs at the same time and is easy to locate and adjust in link to Distance Measuring Instrument (DMI). Also, the 360° camera mounted outside of the vehicle can take panoramic photos of roads under survey, which are saved for every 10 m segment, so it is possible to identify all directions of pavements under survey.

Table 2-20 | Survey Equipment

Period	Equipment	Item	Photo
2003- 2011	ARAN 4900C (Roadware, Canada)	IRI, rutting, panoramic photos, and surface photo	
2012- present	MIDAS II & III (developed in Korea)	IRI, rutting, 360° panorama, surface photos	

Source: Expressway Pavement Condition Survey and Analysis Report (2014), Korea Expressway Corporation

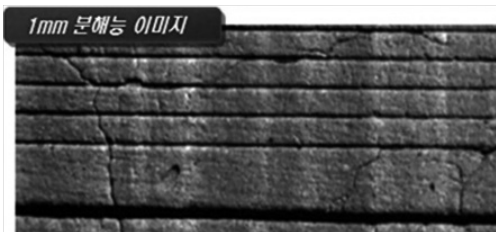
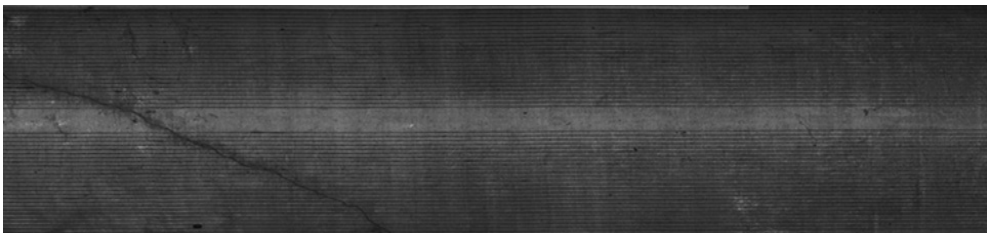
Figure 2-26 | Panorama

Equipment	Panorama
	

Source: Expressway Pavement Condition Survey and Analysis Report (2014), Korea Expressway Corporation.

As shown in Figure 2-27, the rear laser light and camera take surface photos at a speed ranging 0 to 110 km/hr and up to the 4.1 m width and the 10 m length. Also, with this system, it is possible to take photos of uniform brightness on a real-time basis. Surface photos capture up to 1 mm cracks. As surface photos are provided in JPG files, it is easy to store data in common hard-disk, CDs or DVDs for the future use.

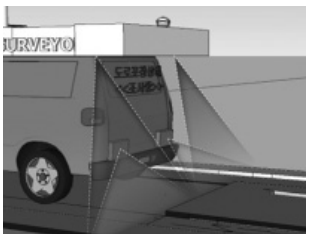
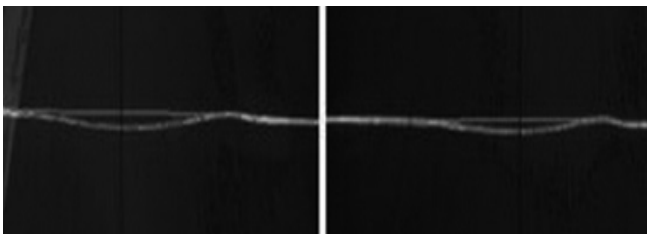
Figure 2-27 | Pavement Surface Imaging

Measuring system	Enlarged photo (1 mm crack)
	
Cracked surface photo (L=10 m)	
	

Source: Expressway Pavement Condition Survey and Analysis Report (2014), Korea Expressway Corporation

Rut Depth Measuring System is designed to measure curves of surface by shedding optical lines on the surface with laser light and the infrared camera and capturing curves of the lines in the form of images. The system measures rut depth every 2 m of road surface segments for the maximum width of up to 4.1 m and ±1 mm precision level.

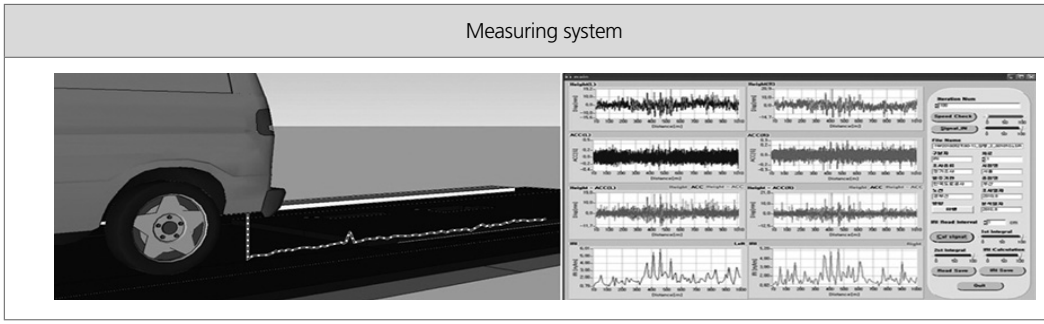
Figure 2-28 | Rut Depth Measurement

Measuring system	Curved image
	

Source: Expressway Pavement Condition Survey and Analysis Report (2014), Korea Expressway Corporation.

IRI is measured with a laser sensor and an accelerometer placed at the rear of the vehicle. IRI measuring system is composed of a laser sensor and an accelerometer and is able to calculate IRI real time. Measurements take place at an interval of 50 mm. Two units are mounted at both wheels, one for each, making it possible to measure at both wheels on both sides of the road.

Figure 2-29 | IRI Measurement



Source: Expressway Pavement Condition Survey and Analysis Report (2014), Korea Expressway Corporation.

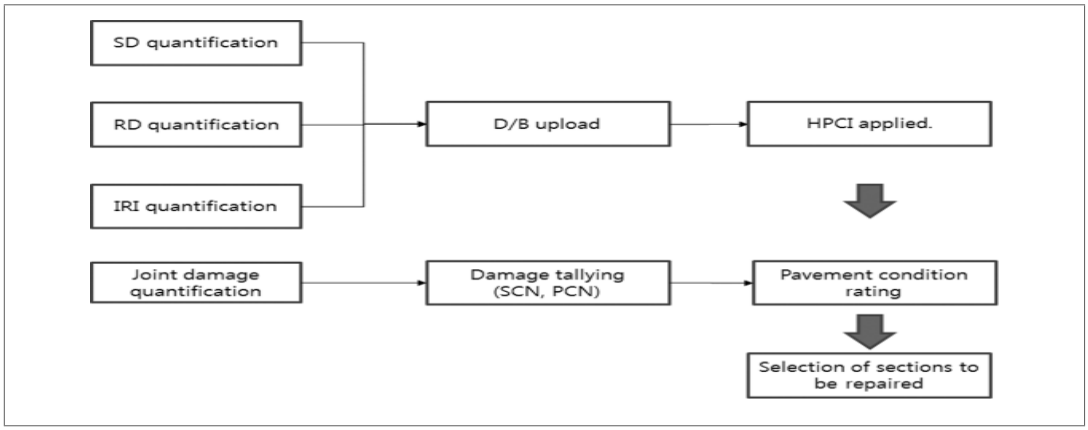
3.4.3. Analysis of Pavement Condition Survey Results

1) Quantification of results

The survey results undergo individual qualification process to produce HPCI, SCN (Sealant Condition Number) for joint damage, and PCN (Pavement Condition Number), for every 100 m segment, as the basis for project section determination. SCN and PCN are an index that indicates the soundness of CP joint sealant and spalling of CP around joint, respectively, and they are calculated on a 100 m basis.

- SCN damage rate = number of damaged joints / number of joints × 100(%)
- PCN damage rate = spalling area / paved joint area × 100(%)

Figure 2-30 | Quantification of Survey Results



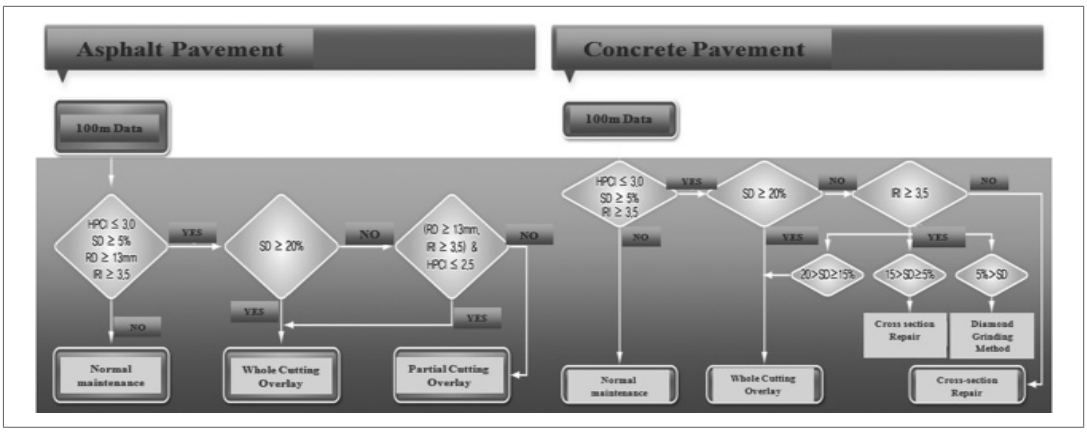
Source: Expressway Pavement Condition Survey and Analysis Report (2014), Korea Expressway Corporation.

HPCIs are a comprehensive index for distress items with different levels of roughness, surface distress, and rut depth. The index is recalculated if the importance of distress items changes due to changing road management environment. The calculation equations have been revised three times so far.

2) Selection of project sections

Prioritization of sections is carried out, considering weighted values on the basis of HPCI, SD, RD, IRI, service life, and traffic volume. To enhance improvement effects, neighbouring pavement sections requiring intensive repair work are set aside as sections of intensive inve stment. From pavement condition survey results, pavement ratings are determined, on the basis of which repair prioritization proceeds. Repair methods are chosen, taking qualification data such as HPCI, SD, RD, and IRI into consideration.

Figure 2-31 | Repair Method Selection



Source: Handbook on the Pavement Management and Maintenance Practices (2012), Korea Expressway Corporation.

Table 2-21 | Prioritization Process

1. Selection of repair sections	• Select sections by repair method - Improvement: cutting overlay, cross-section repair, and repair of joints - Routine maintenance: patching and repair of cracks • Unit section: 100m • Conditions to decide repair methods - Improvement for Grade 5 or lower/ routine maintenance for • Grade 4 or higher
2. Prioritization	• Decide prioritization indicators. - Prioritize HPCI, SD, RD, IRI, service life, and traffic volume after giving weighted value by indicator. - Prioritize repair methods.
3. Selection of intensive investment pavements	• Prioritization intensive improvement pavements by section and branch • Decide intensive investment ratios

Source: Handbook on the Pavement Management and Maintenance Practices (2012), Korea Expressway Corporation.

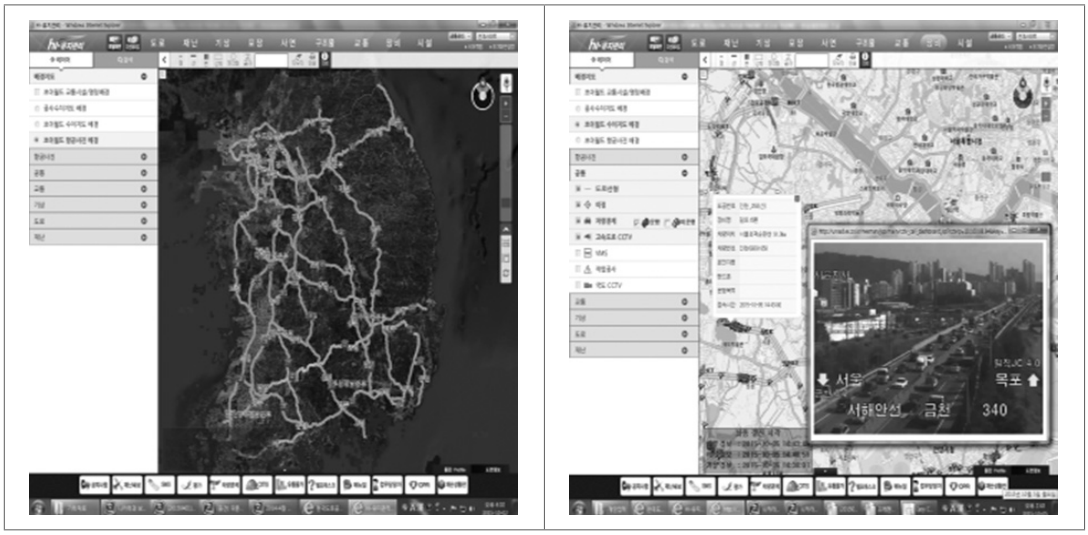
3.4.4. Hi-PMS

1) Highway Management System (Hi-PMS)

The Highway Management System (Hi-Management) is comprised of a set of systems for Road Management, Disaster Control, Hi-PMS, Slope Management, BMS, Transportation Management, Equipment Management, and Facilities Management. All staffers at KEC can share and use information via its web-based intranet in real time. The Road Management System provides road linear information and information on maintenance project awards, Disaster Control assists the staffs in managing de-icing works and data on flood and storm in real time by providing weather information and forecasts. The Transportation Management System is a system that manages traffic accident data, and real-time traffic information is managed in a separate system by ITC Centre. Besides, the Slope Management System that manages all cut slopes along the national highway network, BMS that manages bridges and tunnels, Facilities Management System for the management of structures, and Equipment Management System for equipment operation are also in operation.

As illustrated in Figures 2-35 and 2-36, the Main Menu of Hi-PMS displays CCTV images by geographical area, traffic information, and maintenance vehicle operation and provides basic management information on a real-time basis.

Figure 2-32 | Hi-PMS Main Menu



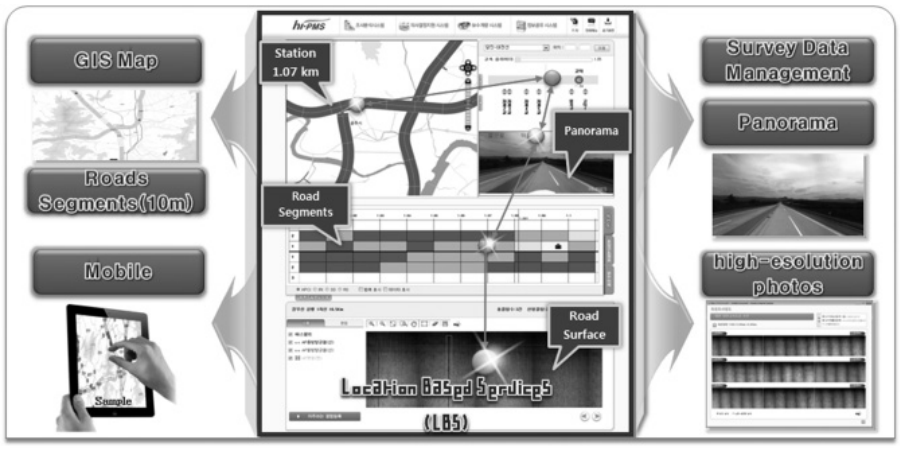
Source: PMS (2015), Korea Expressway Corporation.

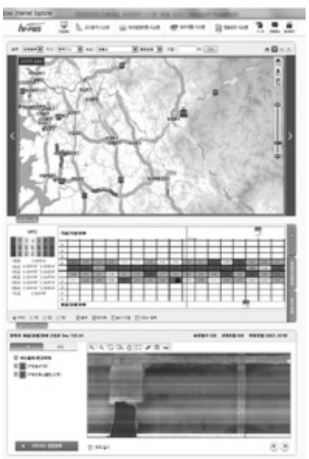
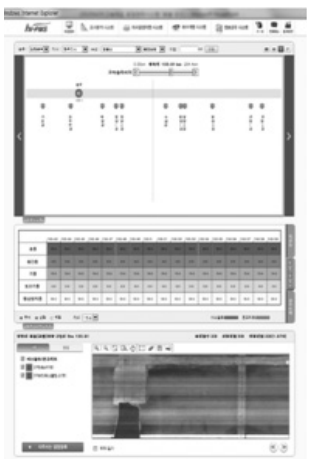
2) Hi-PMS by module

KEC set up the Hi-PMS in 2012 to help users to see which routes are in good or bad pavement condition at a glance from pavement condition ratings (seven grades) of the expressways nationwide in colours displayed on GIS Map on Main Menu. When necessary, users can check further

information on pavements at any location or section covering pavement structure and maintenance records, retrieve front and rear and surface photos of the section, and conduct on-site pavement management activities via mobile devices like smart phones, tablets, and PCs.

Figure 2-33 | Hi-PMS Flowchart and Main Menu



Pavement condition info	Pavement structure info	360° panorama photos and survey record
		

Source: PMS (2015), Korea Expressway Corporation.

The Hi-PMS consists of GIS Map-based Main Menu and four systems: Survey and Analysis System, Decision-Making Support System, Repair and Improvement System, and Information Sharing System. First, with the Survey and Analysis System, it is possible to retrieve construction data covering construction project periods, designers, constructors, and inspectors, pavement management data such as length of pavements managed, pavement types, and pavement materials by managing

party, and results of 100 m-based pavement surveys. Second, the Decision Support System assists prioritization of repair sections; if prioritization conditions are entered, repair priorities are determined, considering survey results. Third, the Repair and Improvement System assists in managing pavement construction projects done by Regional Offices and Branches and plays an important role in durability and LCC analysis by construction method based on pavement history. Maintenance performance data is managed by inputting maintenance locations, construction methods, costs, volumes, and depth. Also, the pavement maintenance personnel of Branches carries out regular inspections on a half-yearly basis and special inspections, if necessary, and inspection date and distress type and area are entered as pavement tracking data. Finally, the Information Sharing System serves to provide information needed for pavement maintenance and supports for the staff to have easy access to data by sharing damage-specific maintenance standards, pavement management manuals, and pavement management guidelines.

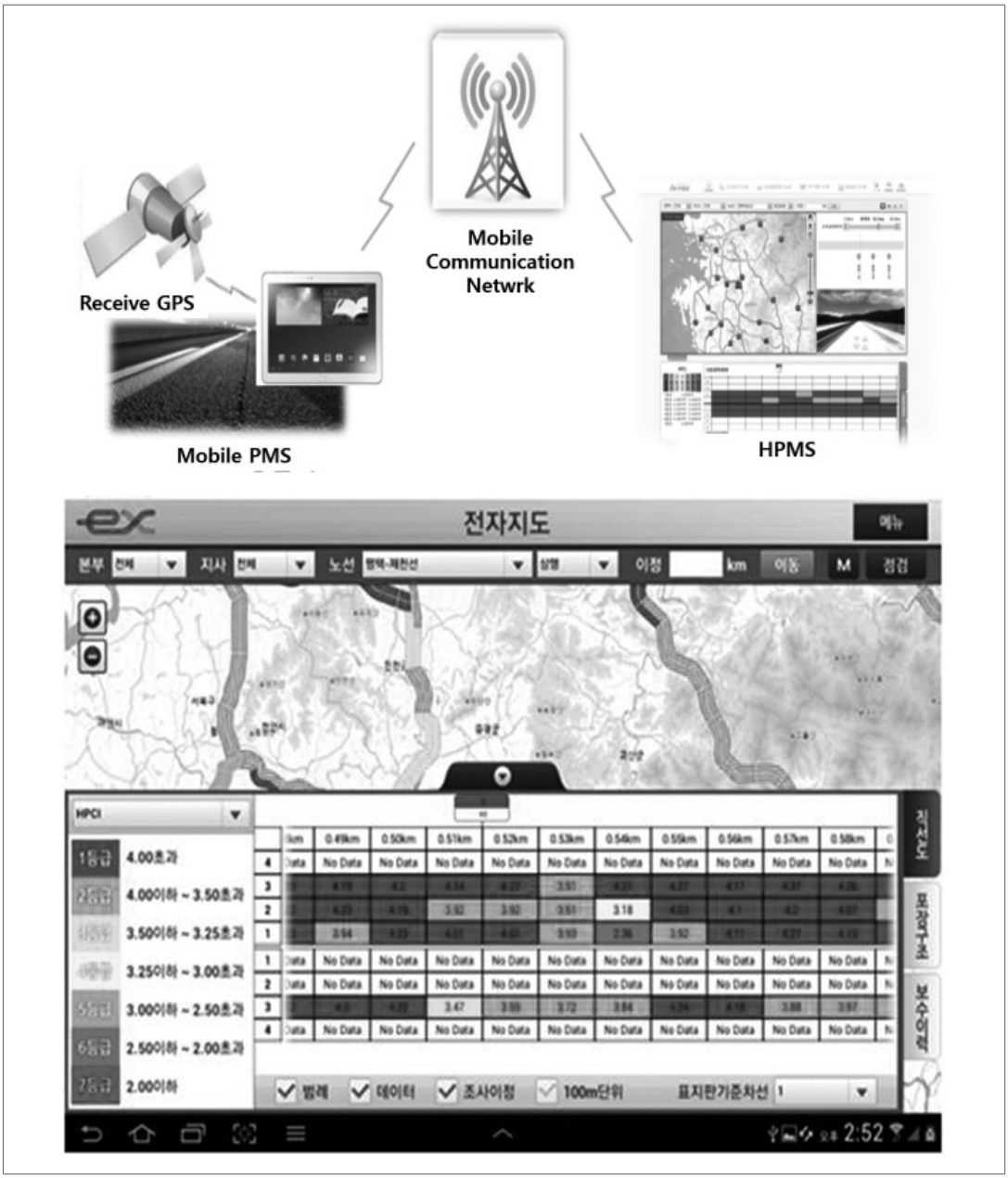
3.4.5. Application and Effects of Hi-PMS

Data from the Hi-PMS is utilized for diverse purposes including prioritization of repair works for the next year. Construction data, maintenance history, and pavement condition ratings in the Hi-PMS are used for an LCC analysis to identify the most appropriate method for Korea's climate and traffic, of which results are the basis for the selection of types or construction methods during pavement design. Construction and maintenance data and pavement condition survey results are stored in the server so that all the staffs can access and use this data easily and keep permanently for future use.

To enhance the effect of data utilization, it is important to build up reliable database among others. As massive data are input by different staffers at different offices, input methods may vary. For example, when inputting data on adjacent patching segments, some may choose longer sections covering adjacent sections, while others may make an input for every spot of repair. To narrow this gap, a standard input method should be established. The KEC experienced many trials and errors at early stages of the introduction of PMS in the past, but now standard input method is in place. In addition to this, training and education are provided for the personnel in charge of the input as part of effort to minimize errors.

Data on the Hi-PMS are accessible via mobile devices, giving easy access on site. To retrieve data on site, one can find real-time GPS based pavement condition data from the Main Menu.

Figure 2-34 | Mobile PMS

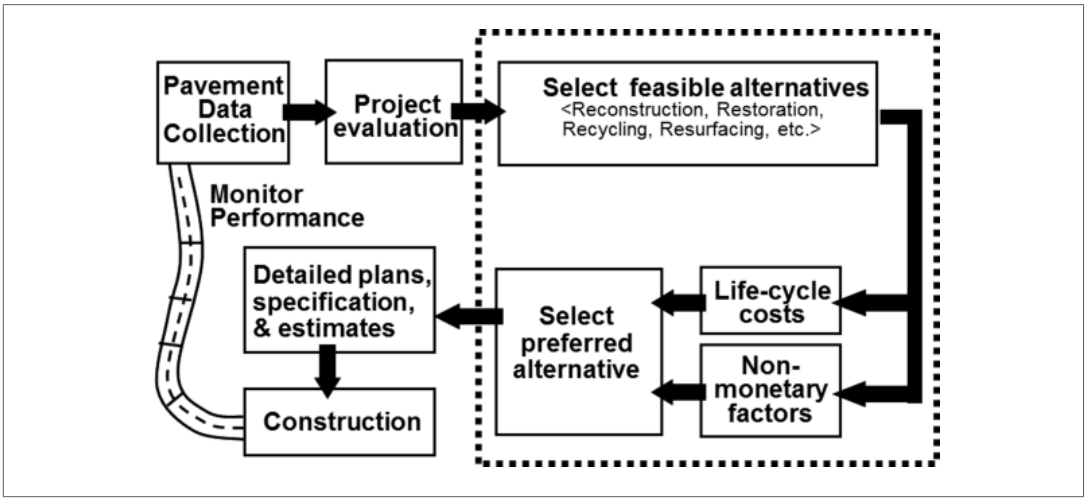


Source: PMS (2015), Korea Expressway Corporation.

4. Comparative Analysis

The PMS of both countries goes through a repetitive process as in Figure 2-39 to collect necessary data and chose the most feasible alternatives with monetary and non-monetary considerations in mind, and finally come up with detailed standards and plans. We performed an item-specific comparative analysis considering the following PMS flowchart.

Figure 2-35 | PMS Flowchart



Source: HMA Pavement Evaluation and Rehabilitation-Training Course No. 131063 (2015), NHI

4.1. Comparison of Pavement Management Systems and Organizations

4.1.1. Standards and Training System

FOMAV manages road pavements in accordance with the Central American Pavement Management Manual, which is more of a guide specification than a manual and is very clear and concise. Since the manual conforms to the U.S. standards or accepts standards of other Central American countries, test standard for materials or quality evaluation standards may not be in line with Nicaragua's management or environment conditions.

Meanwhile, the KEC revises its specifications, manuals, and guidelines for road pavement maintenance as necessary to reflect reality. When a new construction method is developed, a specification setting forth standards for associated materials, construction and quality control is attached. With respect to quality control, inspection items and criteria are specified in detail for AP, CP, and bridge pavement. In addition, construction supervision company representatives work on site by section during the construction, but upon construction completed, KEC has its personnel carry out quality surveillance and decides incentives or nonconformances on the basis of the quality inspection results. The KEC also operates HRD Center as a training unit, which offers professional training programs in the field of design, materials, construction and equipment with the aim of

cultivating technical expertise and enhancing field understanding necessary for road management operations.

It is advisable for FOMAV to build capacity to decide if maintenance materials and methods are properly prepared and applied before, during or after the construction, referring to the practices in Korea. Despite supervision by an agent, project owner-led quality control activities are necessary to ensure reliable on-site management. It is also imperative to develop expert-level training programs and systems that help broaden the knowledge of field engineers.

Table 2-22 | Comparison of Other Areas

Area	FOMAV	KEC
Pavement maintenance manual	• AASHTO and SIECA standards apply with necessary modifications	• Offering categorized specifications, manuals, and guidelines.
Quality control	• Supervised by Inspection Company. • Necessary to check the capacity of Inspection Company.	• Process for contracting, preparation, construction and evaluation in place. • Quality assessment by both Inspection Company and the KEC.
Training program	• Lacking in training programs.	• Having a training center in place (HRD Center) • Offering training programs for design, materials, construction, and equipment.

Source: Compiled by KSP Consultant

4.1.2. Pavement Management Organization

FOMAV has been in operation since 2006 and its personnel total 57: 4 for management, 15 for support, 13 for technical affairs, and 25 for administrative affairs, and the number of technical staff for road management constitutes simply 22% of the total. As Nicaragua has no local road management bodies, responsible engineers travel long distances to manage roads nationwide. Financial resources for maintenance activities of FOMAV come from a special tax imposed on fuel (diesel and gasoline). The initial tax rate was US$0.06/gallon, which gradually rose to US$0.16/gallon in 2009, and is expected to further climb to US$0.20/gallon. Managed sections were as long as 3,672 km in 2015, only 500 km of which has been covered by the PMS. To achieve financial independence, FOMAV plans to increase managed sections to approximately 5,900 km, which, however, means the rise in the length of unpaved sections to manage, so there is an urgent action regarding this issue.

In Korea, KEC is responsible for the construction and maintenance of expressways from 1970. There are 32 personnel dedicated to the PMS at Head Office, and each of the seven Regional HQs nationwide has three PMS staff, and two employees from each of the 52 Branch Offices engage in pavement maintenance related operations. Also, 15 researchers holding PhD or master's degree work at the Pavement Laboratory at KECRI, a think-tank specializing in the development of pavement management and maintenance technology. The KEC managed a 3,817 km national

road network as of 2014, which is likely to reach 49,964 km by 2020. Korea's expressway pavement maintenance is funded by toll incomes. The pavement maintenance budget of USD 150 million in 2015 will likely continue to rise due to growing length of old pavements.

Taking KEC's practices into account, FOMAV should make every effort to perform its responsibilities seamlessly as prescribed in the future. Firstly, the road manager should prepare a plan for stable financing by finding diverse additional sources of tax revenue including a tax rate hike. Also, considering projected increase in length of managed roads and expansion of operations, FOMAV should enlarge the current organization. Beginning with major hub cities, branch offices should be established, with KSP Consultant staffed with sufficient numbers of the relevant personnel.

Table 2-23 | PMS Organizations

Category	FOMAV	KEC
Responsible organization	• FOMAV in operation since 2006. • Board of Directors, Division of Technology, Division of Finance & Administration, Division of Acquisition, Legal Advisory Team, PR Office, etc. • 57 personnel (4 for management, 15 for support, 13 for technical affairs & 25 for administrative affairs)	• KEC: Founded in 1969. • Head Office: 1 office & 3 teams • 7 Regional HQs & 52 Branch Offices • Pavement management & technology development unit in place (Pavement Lab, KECRI)
Personnel	• No local organizations in place. Engineers are dispatched every week to supervise operations of contractors	• Pavement management personnel at Head Office: 32 • 125 local pavement management personnel: 3 per Regional HQ & 2 per Branch Office • Pavement Lab at KECRI: 15
Maintenance administration process	Ministerio de Hacienda y Credito(Ministry of Finance and Credit) notifies FOMAV of estimated tax every August→with the estimate tax, FOMAV agrees with MTI upon project sections for the next year (to the extent that budget allows)→Every September, FOMAV sends business plan for the next year to the finance division → The finance division signs a contract with the winning bidder for the project and conducts audit of previous contracts →FOMAV board of directors approves maintenance plan submitted by Head of FOMAV.	(Head Office) Pavement survey → select pavements to repair → prioritize by construction method (based on survey results, traffic volume, and years of service) → set up business plan → finalize business plan at the board of directors → allocate budgets to relevant teams and divisions (Regional HQs & Branch Offices) design and award repair projects according allocated budgets → supervise and manage construction → complete construction → register repair results into the system

Table 2-23 | PMS Organizations (continued)

Category	FOMAV	KEC
Financial resources	• Fuel tax: 0.16$/gal, which is to be raised to 0.20$/gal • FOMAV budget allocation HQ (80%), Branch (20%)	• Funded by collecting tolls and rents of service area facilities (no fuel tax imposed). • Of the 2015 total pavement management budget of KRW 1,565.5 billion, around KRW 191 billion used for pavement maintenance. • Pavement management budget for 2016: KRW 208 billion
Length of managed sections	• 3,672 km (in 2015), 500 km of which is managed by PMS. Expected to increase to 5,900km. • AP: 2,086 km, Con'c: 46km, block: 88 8km, unpaved: 650 km • Length of unpaved sections to manage likely to rise, raising the need of urgent action for this.	• 3,817km (in 2014) and 49,964 km (by 2020) • All the managed sections are fully (100%) paved. (AP:6,720 km/lane, Conc:11,175 km/lane)

Source: Compiled by KSP Consultant (2015)

4.2. Pavement Condition Survey Vehicles and Comparison of Specifications

4.2.1. Pavement condition survey vehicles and specifications

MIDAS used by the KEC and Hawkeye-1000 used in Nicaragua to evaluate pavement conditions are compared in Figure 2-40. Hawkeye 2000 is added to compare with existing vehicles

Figure 2-36 | Comparison of Pavement Condition Survey Vehicles

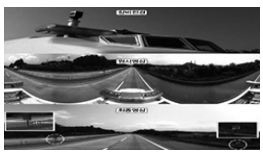
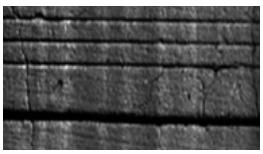
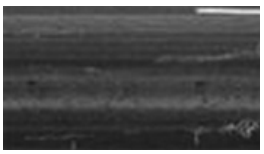
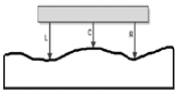
Classification		Hawkeye-1000 DUO	Hawkeye-2000	
Manufacturer		ROADKOREA	ARRB, Australia	ARRB, Australia
Year of Adoption		2012& 2014 (used for PMS by KEC)	- (used for PMS in Nicaragua)	
Photo				
Price		$500,000	-	-
I T E M	Panorama	Survey sensor: 360° camera Definition : 1,600×1,200 (6 sets) 	Survey sensor: 1 set of panorama camera Definition : 1,200×960 	Survey sensor: 1 set of panorama camera +2 sets of side camera Definition : 1,200×960 (3 sets) 

Figure 2-36 | Comparison of Pavement Condition Survey Vehicles (continued)

ITEM				
	Surface photo	Survey Method: Line scan (laser-based) Definition : 3,450×10,000 Resolution: able to detect cracks of 1 mm or smaller 	N/A	Survey Method: 3D laser unit (2 sets)+ Line scan camera (1 set) Definition : 1,200×960 Resolution: able to detect 0.5 mm-deep cracks (auto) 
	IRI	Survey sensor: Laser & accelerometer survey interval: 50mm Resolution: 0.1 mm or less	Survey sensor: Laser & accelerometer survey interval: 25 mm Resolution : 0.1 mm or less	Survey sensor: Laser & accelerometer survey interval: 25 mm Resolution: 0.1 mm or less
	rutting	Survey sensor: Line laser & camera Transverse scope: Max. 4.1 m Longitudinal survey interval : 2 m Transverse survey interval: 2 mm	Survey sensor: 3 sets of laser (2 sets of Both-Side Wheel Path + 1 set of Center) Transverse scope: Max. 4.1 m Longitudinal survey interval: 25 mm Transverse survey interval: 750 mm 	

Sources: ROADTECH. (2015). http://www.rdth.co.kr/. Arrb. (2015). Hawkeye 1000 Series. https://www.arrb.com.au/Equipment.

FOMAV adopted pavement condition survey vehicles for the first time in 2015, but there is no standard in place for regular measurements of pavement surface condition. The Nicaraguan road management organization has built up experience and expertise from 500 km-section pilot operations. Hawkeye 1000 is used for profiling, distance measuring, and photocopying of pavement conditions, while a specific procedure to take into consideration results of analysis on such data in decision making process for maintenance has not been established yet. Milestones are placed every 1 km on road sides to indicate sections for road management.

In Korea, the Pavement Laboratory at the KEC gives regular training to its staff, which aims to help the personnel maintain expertise to the required level and has a group of continuously trained and highly experienced equipment operators and analysis personnel. In addition to this, as pavement condition changes year after year, complete inspection of entire routes takes place every two years. Data obtained from such complete inspection become the basis for quantitative evaluation to calculate asphalt and concrete pavement condition, or HPCI, and prioritization of repair works is made according to condition rating criteria. Milestones are placed every 0.2 km on road sides to indicate sections for road management. GPS-based 360° photography is used to take pictures of facilities, and discrepancies in distance can be adjusted remotely to gain a correct understanding on maintenance sections and their locations.

Table 2-24 | Comparison of Pavement Condition Survey Vehicles

Classification	FOMAV	KEC
Vehicle	Hawkeye 1000	MIDAS
Expertise of Survey Personnel	• Lacking in expertise of vehicle operation, distress measuring and judgment to some degree, as it is at an early stage of adoption of the vehicle.	• Regular training given by the Pavement Laboratory serves to maintain expertise of the personnel. • Having continuously trained, highly experienced vehicle operation and analysis staff.
Survey cycle	• Not decided. 500 km survey in operation now.	Survey of all routes every 2 years.
Data obtained	• Profile and distance measuring. Pavement condition photography	• IRI, rut depth, 360° photos (per 10m), surface photography, distance measuring, and image analysis tool used to calculate distress and rutting.
Reflection of evaluation results	• Specific procedure not established yet.	• Analysis results used to quantify pavement condition (HPCI) and update Hi-PMS. • Prioritization of repair works according to pavement condition rating criteria.
Distance management	• Working with the responsible department regarding MTI digital distance measuring system. • The responsible department calculates exact location of post, and FOMAV has the winning bidder start construction.	• GPS-based 360° photography is used for the continuity of data, and the 360° photography allows for adjustment of discrepancies in distance.

Source: Compiled by KSP Consultant (2015)

Given the activities of KEC in Korea mentioned above, the most urgent actions taken by FOMAV are; Survey cycles and methods should be defined first to take an objective view of road pavement damage. FOMAV should formulate relevant internal regulations and survey manuals, establish the ground for regular evaluation and management, and provide training for survey and analysis staff to minimize errors caused by subjective judgment. It seems also necessary to adopt or improve survey vehicles to collect more data objectively and hire additional survey vehicle professionals, considering the work scope and capabilities for the future.

4.2.2. Quantification of Pavement Survey

Once data are obtained from pavement condition survey, quantitative evaluation on pavement conditions of the sections surveyed should be conducted. FOMAV uses pavement condition index, or IC, which indicates overall condition of a pavement through components such as pavement, drainage, structures, signal/safety, and traffic volume. The index has many non-pavement elements,

making it inappropriate to show conditions of pavement only. Since the index was developed by borrowing many aspects from cases of other countries, rather than taking the Nicaraguan situations into consideration. This indicates that it is necessary to develop a pavement condition index tailored to Nicaragua, as IC has limitations as a road pavement repair standard.

As discussed above in detail, lessons from Korea's HPCI development process may serve as an invaluable reference for Nicaragua to develop its pavement condition index. As mentioned above, pavement condition is quantified in HPCI rating system with seven grades in Korea, and proper repair methods are presented for HPCI Grades 5, 6, and 7. The HPCIs were developed by a group of pavement experts via panel rating after driving on road pavement. The indexes have undergone continuous improvements and adjustments since the functionality focus for pavements changed over time. At first, the KEC had many doubts concerning the development of the index because HPCIs obtained from pavement condition survey vehicles were different from priorities, which the field personnel believe should be given to sections to be repaired. After a series of improvements and extensive efforts, however, the HPCIs are in agreement with evaluations by field staff and in use as an index that represents road pavement conditions of the entire national expressway network in Korea.

Table 2-25 | Comparison of Pavement Condition Indexes

Category	FOMAV	KEC
Pavement Condition Index	• Pavement condition index (IC) found in SIGMAVIAL but having no enough explanation. • Inappropriate for pavement condition evaluation due to lots of non-pavement elements. • Unlikely to reflect Nicaragua's road pavement conditions well because it relies heavily on foreign cases. • Having limitations as repair standard. • Necessary to come up with an index tailored to Nicaragua.	• Pavement condition quantified into HPCIs of 7 grades. • Proper repair alternatives presented for Grades 5, 6, and 7 of HPCI. • Many pavement experts calculated and adjusted the index via panel rating. • Extensive efforts made to match HPCIs calculated by survey vehicle and repair section priorities judged by the field personnel.

Source: Compiled by KSP Consultant (2015)

Therefore, FOMAV should integrate sporadic pavement condition data and develop a single comprehensive index to push forward efficient management of road network and appropriate execution of maintenance budget. This may be a fundamental basis for reasonable prioritization of maintenance sections.

4.3. Rationale behind the decision on maintenance methods

Upon qualification of pavement condition survey results, a program is used to select repair alternatives for sections to be repaired. FOMAV hires SIGMAVIAL, a program developed in Argentina. The program is a Client/Server system allowing access to a small number of authorized personnel. As the server is placed at FOMAV now, access is possible only within the agency but not on site even if any event requiring access to the system takes place. As listed in the table above, the system provides key features such as section information, road and pavement related inventory, and performance modeling, allows the user to choose from construction cost calculation options and available financial resources, and has a prioritization module based on available budgets of FOMAV. As described earlier, however, SIGMAVIAL provides no quantitative index for pavement condition, making it hard to verify the validity of prioritization. Furthermore, since possible alternatives are compared simply in a comparative analysis on initial construction costs without taking life cycle of pavements into account, relatively less expensive construction methods may be chosen as an alternative. Besides, the program is designed primarily for simple analysis, and therefore it is hard to gain section-specific pavement cross-section data, traffic volume, performance change prediction data and various statistics.

KEC has Hi-PMS in place, a web-based system using electronic map. The Hi-PMS should be seen as more of an integrated system which aims to manage road pavements nationwide than a program. This system is accessible via a PC in office as well as a Smartphone and a tablet PC on site so as to help deal with field issues promptly. With this system, it is possible to manage the entire cycle of pavement maintenance covering section-specific pavement condition data obtained from survey and analysis, decision-making system for prioritization of projects, pavement performance change prediction modeling, repair history and information on new construction methods of each section, information on related manuals, standards, and policies, pothole statistics and data, and a wide range of information on contracting and budget execution. The KEC operates regular training programs in an attempt to rule out individuality of users and ensure uniformity in data input and system operation.

Given Korea's experience as above, FOMAV is in need of an improved system to manage the nation's current and future road network on an dfficient basis. Instead of a simple analysus program, the system should be an integrated management system which allows for data search and entry, data analysis, prioritization, road network management, and provision of related documents as an open-ended system to help more users gain access to diverse information.

Table 2-26 | Repair Alternative Selection Program

Classification	FOMAV		KEC	
Program	SIGMAVIAL		Hi-PMS	
System type	- Client/Server system allowing access for a small number of authorized personnel.		Web-based system using e-map	
Key features	Section info	Section length, related info, etc.	Survey & Analysis	• Pavement condition data: transfer history & basic data • Pavement condition survey and analysis data: pavement survey findings, data on pavement condition defect ratio • Data on analysis of bridges and backfilling parts
	Inventory	• Road geometrical structure, horizontal and transverse drainage, road shoulder, vertical and horizontal signals, security system, etc.	Decision making	• Project prioritization, mid- & long-term investment plan, pavement aging prediction model
	Performance model	• Pavement change prediction equation	Repair & improvement	• Repair data, data on newly adopted construction methods, and plan for repair of special damage sections.
	Maintenance cost	• Contract type, available resources, unit cost	Information sharing	• Standard for repair of damaged pavement, Pavement management manual, management guidelines and policies
	Cost limitation	• Define priorities considering cost limitation. • Adjust pavement condition index (I.C). • Select alternatives based on the "cost<budget" logic.	Pothole management	Potholes found, emergency repair materials, statistics & analysis
Miscellaneous	• Optimal construction method selected for the section with a limited budget. • Life Cycle Cost Analysis feature not included. • Having no evaluation index. • Accessible at FOMAV only.		• Traffic volume info, detailed pavement info, maintenance history, pavement condition index (HPCI (7 grade system) – AP, Conc), CCTV footage, road linear info, distance info, etc. • Accessible from PC, smart phone, and tablet. • Training given to ensure uniform input format.	

Source: Compiled by KSP Consultant (2015)

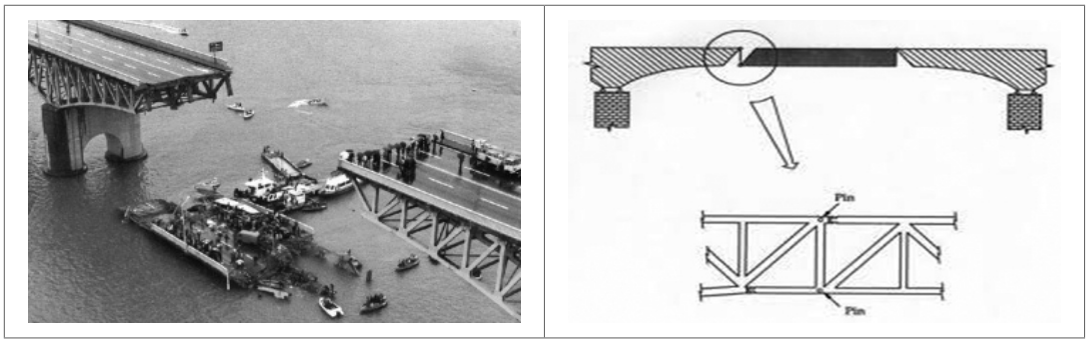
III BRIDGE MANAGEMENT SYSTEM (BMS)

1. BMS Overview

Bridges are deteriorated and damaged due to increasing traffic over time. Bridge management refers to not only preventive efforts to delay such deterioration and damage well in advance, but also repair and reinforcement activities to restore to the original functionality after damage occurs. In a broad context, this encompasses all associated procedures ranging from bridge design to construction and maintenance, while in a narrow sense, this term means operations including day-to-day cleaning and maintenance after inspection. The key objective of bridge management is to perform bridge maintenance and repair during the design or while in use so as to make a bridge perform to the full as intended, and to ensure safety by taking appropriate and timely action.

Bridge management is divided into demanded maintenance in which repair and reinforcement is made as necessary due to damage or defect and preventive maintenance aiming to prevent and delay the occurrence of damage or deficiency by means of diverse actions. Considering the nature of bridges, if an accident takes place, this may lead to heavy casualties. Therefore, rather than demanded maintenance, preventive maintenance is viewed as more important to ensure the safety of bridge users. Many reports have defined preventive maintenance; the United States Minnesota Department of Transportation defines it as a strategic program designed to stop minor damage and delay progressive failure consisting of activities to extend the service life and enhance service level for users, even if not improving load-carrying capacity of a bridge dramatically. Unlike pavements, bridges are made up of many members, and deadly damage of a member may become a cause of irreparable casualties. In this respect, preventive maintenance of bridge is considered more important than that of pavement. Its importance was well proven in the collapse of the Seongsu Bridge crossing the Han River in Seoul, the capital city of Korea, which accounted for 17 deaths and 32 injuries. The accident happened as joints of the truss bridge were broken and the bridge deck fell into the river, showing how critical preventive maintenance of bridge is.

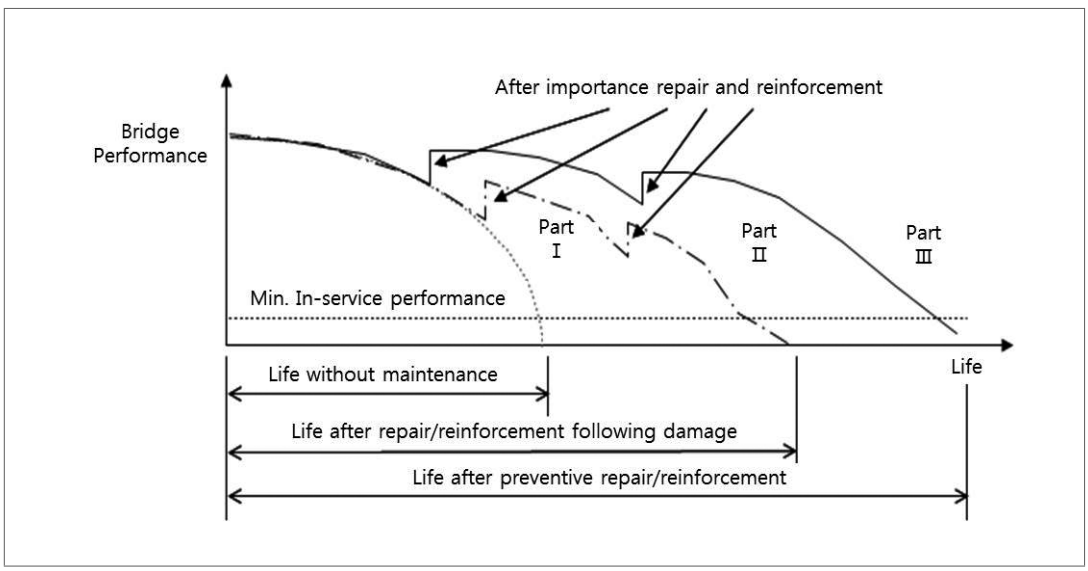
Figure 3-1 | Collapse of Seongsu Bridge and Causes



Source: Son Gi-jong, Disaster Control System Establishment Strategy in Korea with a focus on the collapse of the Seongsu Bridge (2014).

More details about extended life of a bridge by preventive maintenance are provided in Figure 3-2; without maintenance work, bridges are deteriorated in performance along Path I, and the performance of those repaired and reinforced by demanded maintenance after damage happens drops along Path II. However, once repair takes place before damage occurs under preventive maintenance mechanism, bridge performance would decrease along Path III and the degree of extended life of a bridge may vary by the level of preventive maintenance activities. As a consequence, bridge maintenance activities focus on preventive aspects, which provide significant economic benefits by extending the life of the bridge and by making maintenance works far less costly than repair and reinforcement following damage.

Figure 3-2 | Time-dependent bridge performance degradation

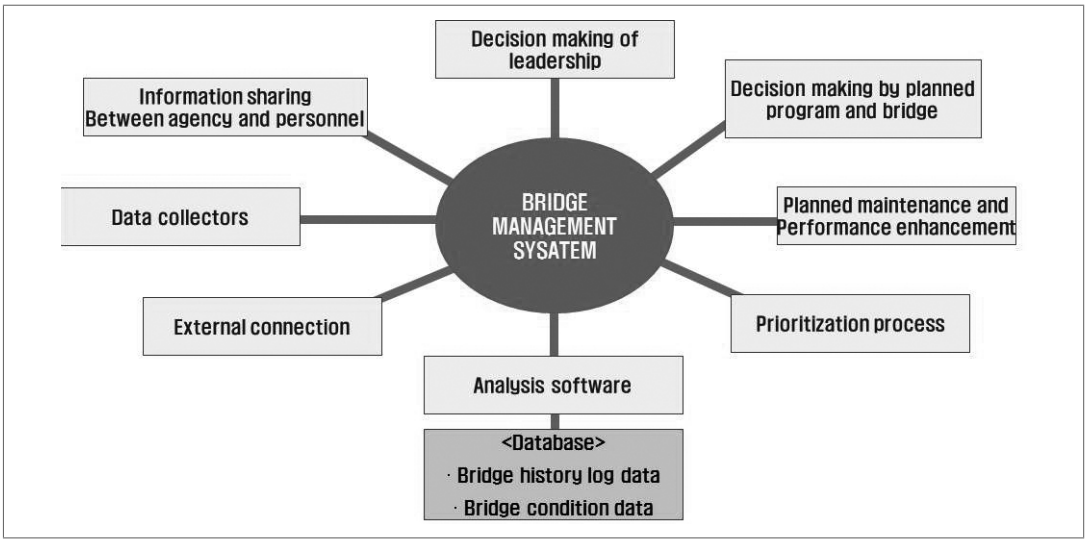


Source: A Study on Preventive Maintenance of Bridge (2005), KEC.

A number of members make up a bridge, and if any of them is damaged, this poses a serious threat to the bridge users. Consequently, thorough prior inspection of the members and thereby assessments and actions are required. It is also necessary to establish criteria to determine which of the damaged members should be repaired first, and to choose economically beneficial and optimal repair methods. In recent years, newly built bridges are growingly larger in scale, raising the need of an efficient, comprehensive computerized bridge management system (BMS).

A BMS can collect and process extensive information on a number of bridge members, but requiring managers to enter data for an integrated system management. Generally, a BMS consists of several modules – database module for entry and display of all information, inspection module for the entry of bridge inspection data and condition ratings, repair/reinforcement module for entry and display of repair/reinforcement history data, and decision making module for appropriate budget allocation and execution. Instead of being a full-featured system from the beginning, the BMS may be configured as necessary to meet needs of the users. Basic components of a BMS are as in Figure 3-3.

Figure 3-3 | Basic components of BMS



Source: A Study on HBMS Decision System Improvement (2003), KEC.

2. BMS in Nicaragua

2.1. Statistics of Bridges

2.1.1. General Statistics of Bridges

The number of managed bridges in Nicaragua amounts to 2,888, and there are 14 bridge types including concrete bridge, composite bridge, and box bridge.

Table 3-1 | Bridges by Structure Type

Classification	Type		No	Length (m)	Ratio	
					Number of bridges	Length
1	Wood bridge (Puente de Madera)		97	1,400.92	3.4%	3.8%
2	Stone bridge (Puente de Mampostería)		11	39.10	0.4%	0.1%
3	Concrete arch bridge (Puente Arco de Concreto)		9	291.18	0.3%	0.8%
4	Corrugated steel bridge (Puente Arco Metal corrugado)		60	347.85	2.1%	0.9%
5	Steel bridge (Puente Metálico)		12	721.20	0.4%	2.0%
6	Temporary bridge (Puente Provisional)		15	620.80	0.5%	1.7%
7	Concrete bridge (Puente de Concreto)		536	7,192.49	18.6%	19.5%
8	Suspension bridge (Puente Colgante)		3	179.20	0.1%	0.4%
9	Composite (Puente Mixto)	Wood+Concrete(Madera/Concreto)	2	7.70	0.1%	0.1%
		Wood+steel (Madera/Acero)	15	149.10	0.5%	0.4%
		Concrete+steel (Concreto/Acero)	550	13,150.77	19.0%	35.6%
		Steel+Concrete (Acero/Concreto)	1	100.15	0.0%	0.3%
10	Combined bridge (Puente Combinado)		6	59.40	0.2%	0.2%
11	Box bridge (Caja Puente)		444	2,324.16	15.4%	6.3%
12	Combined arch bridge (Arco y Puente combinado)		4	48.20	0.1%	0.1%
13	Culvert (Alcantarilla)	Box (Caja)	21	170.25	0.7%	0.5%
		Concrete (Concreto)	698	4,608.22	24.2%	12.4%
		Steel (Acero)	106	606.47	3.7%	1.6%
		Plastic (Plástico)	50	339.25	1.7%	0.9%
		Mixed (Mixta)	33	252.39	1.1%	0.7%
14	Ford bridge (Puente Vado)	Concrete pipe (Tubos Concreto)	112	2,364.92	3.8%	6.4%
		Arch concrete pipe (Arco y Tubos Concreto)	3	96.20	0.1%	0.3%
		Steel pipe (Tubos Acero)	18	155.20	0.6%	0.4%
		Plastic pipe (Tubos Plástico)	67	1,349.70	2.3%	3.6%
		Plastic & concrete pipe (Tubos Plástico y Concreto)	1	10.50	0.1%	0.1%
		Plastic & steel pipe (Tubos Plástico y Acero)	1	12.30	0.1%	0.1%
		Concrete (Concreto)	13	308.10	0.5%	0.8%
Total			2,888	36,905.72	100%	100%

Source: MTI Yearbook of Bridge Statistics (2015).

1) Concrete steel composite bridge (Estructura Mixta Losa de Concreto sobre Vigas de Acero)

Representative type of bridge, there are 550 concrete steel composite bridges in Nicaragua stretching 13.15 km, the largest share at 34.85%. Most of them are 100 m or over long. Compared to other bridge types, the construction costs more, but it is easier to design and build this type of bridge, making them more common.

2) Concrete bridge (Puente de Concreto)

There are 536 concrete bridges, placing in second place in number. With a total length of 7.19 km, they account for 19.5% of all bridges in the country. Due to the difficulty of design, they are less widely used.

3) Culvert (Alcantarilla)

Culverts are built as a round passage for drainage purpose. Those using a rectangular passage tube are classified as box bridge (Caja Puente). Used mainly for small rivers, and there are 887 culverts with a total length of 5.8 km, accounting for 15.73%. They are made of concrete, steel, and plastic materials.

4) Box bridge (Caja Puentes)

Like culverts (Alcantarilla), they are built as drainage and basically made of concrete. Compared to culverts (Alcantarilla), they are excellent in water flow and structurally stable. There are 444 box bridges with a total length of 2.3 km, accounting for 6.3% of all bridges in Nicaragua. Each bridge is around 26m long.

Figure 3-4 | Bridges by Type



Concrete steel composite bridge | Concrete bridge | Culvert | Box bridge

Source: Taken by KSP Consultant (2015).

5) Ford bridge (Puentes Vados)

Because they are less expensive and not complicated to build, ford bridges are preferably considered for wider river sections. There are 215 ford bridges with a 4.2 km total length, accounting for 11.6%. The representative bridge of this type is El Recreo, with a 111.0 m total length, the longest in Nicaragua. This bridge was built in 2012. In general, each ford bridge is around 50m long. bridge, making them more common.

6) Wood bridge (Puentes de Madera)

Wood bridges are the oldest type of bridge type and become less used with the advancement of technology. Their service life is short, and they are less durable and highly vulnerable to environmental impacts. In Nicaragua, there are 97 wood bridges with a 1.4 km total length, accounting for 3.4% of all. Wood bridges are not used on major public roads and need to be replaced by other types of bridge in the future.

Figure 3-5 | Ford Bridge and Wood Bridge



Ford bridge



Wood bridge

Source: Taken by KSP Consultant (2015).

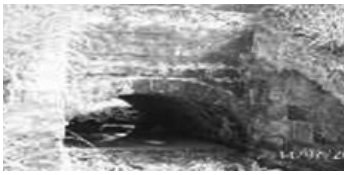
7) Other types of bridge

Other types of bridges found in Nicaragua include stone bridge (Puentes de Mampostería), concrete arch bridge (Puentes Arco de Concreto), corrugated steel bridge (Puente Arco Metal corrugado), suspension bridge (Puente Colgante), composite bridge (Puente Mixto), Combined bridge(Puente Combinado), combined arch bridge(Arco y Puente Combinado), and box culvert combined bridge(Caja y Alcantarilla combinado). Figure 3-5 shows photos of representative bridges of each type, along with the number of bridges and length.

Figure 3-6 | Other Bridges Types



Puentes de Mampostería
(11 bridges with 39.10m total length)



Puente Arco de Concreto
(9 bridges with 29.1.18m total length)



Puente Arco Metal corrugado
(60 bridges with 347.8m total length)



Puente Colgante
(3 bridges with 179.2m total length)



Puente Mixto Madera/Acero
(15 bridges with 149m total length)



Puente Mixto Concreto/Madera
(2 bridges with 7.7m total length)



Puente Combinado
(6 bridges with 59.4m total length)



Arco y Puente Combinado
(4 bridges with 48.2m total length)



Caja y Alcantarilla combinado
(21 bridges with 170.25m total length)

Source: "PUENTES EN LA RED VIAL NACIONAL AÑO 2014" (2015), MTI.

2.1.2. Statistics of Bridges by Route

In Nicaragua, there are three major managed routes: 01DA0804000-71WG13 00000, NIC, and NN. Among them, the country's main corridor is NIC route, which covers 2,201 managed bridges (70%). Bridges by route are as in Table 3-2.

Table 3-2 | Bridges by Route

Route	Mgmt no	No bridges	Length (m)	Ratio	
				No of bridges	Length
01DA0804000- 71WG1300000	1 - 403	403	4,470.17	14.0%	12.1%
NIC route	404 - 2,424	2,021	27,132.80	70.0%	73.5%
NN route	2,425 - 2,888	464	5,302.75	16.0%	14.4%
Total		2,888	36,905.72	100%	100%

Source: MTI Yearbook of Bridge Statistics (2015).

2.1.3. Key NIC Routes and Bridges

In NIC, there are 12 major routes including NIC-1, NIC-2, and NIC-4 that are interconnected, centring on the capital city Managua. In these routes alone, 754 bridges of 10.10 km length are managed, representing 26% of all bridges (or 27.35% of total length). Bridges in NIC routes Subject to management are listed in Table 3-3, which indicates that most of the bridges are located on NIC-1-TP, NIC-7-TP, and NIC-25 routes. Representative types of bridges in service on the major routes are concrete culverts (Alcantarilla de Concreto), box bridges (Caja Puente), concrete bridges (Puente de Concreto), and concrete/steel composite bridges (Puente Mixto Concreto/Acero), constituting 90.1%, or 679 bridges (9.19 km length at 91.1% of the total length).

Table 3-3 | Bridge Types by Major Route

Classification	Route No.	No of bridges	Length (m)	Ratio	
				No of bridges	Length
1	NIC-28	30	220.80	4.0%	2.2%
2	NIC-12A-TP	81	976.2	10.7%	9.7%
3	NIC-24B	71	1.089.15	9.4%	10.8%
4	NIC-2	62	856.65	8.2%	8.5%
5	NIC-18B	4	17.9	0.5%	0.2%
6	NIC-4-TP	22	239.1	2.9%	2.4%
7	NIC-11B	7	33.3	0.9%	0.3%
8	NIC-11A-TP	10	63.2	1.3%	0.6%
9	NIC-1-TP	138	1,840.6	18.3%	18.2%
10	NIC-7-TP	160	2,654.75	21.2%	26.3%
11	NIC-25	103	1,477.75	13.7%	14.6%
12	NIC-26	66	624.48	8.8%	6.2%
Total		754	10,093.88	100.0%	100.0%

Source: MTI Yearbook of Bridge Statistics (2015).

Table 3-4 | Bridge Types by Major Route

Classification	Structure type	No of bridges	Length (m)	Ratio	
				No of bridges	Length
1	Steel Culvert Bridge	17	74.00	2.3%	0.7%
2	Concrete Culvert Bridge	191	1272.03	25.3%	12.6%
3	Mixed Culvert Bridge	7	68.20	0.9%	0.7%
4	Arch Combined Bridge	3	43.70	0.4%	0.4%
5	Box Bridge	205	1,133.95	27.2%	11.2%
6	Box Culvert Combined Bridge	6	61.30	0.8%	0.6%
7	Corrugated Steel Bridge	32	191.20	4.2%	1.9%
8	Concrete Bridge	209	3,709.62	27.7%	36.8%
9	Stone Bridge	6	26.55	0.8%	0.3%
10	Steel Bridge	3	334.80	0.4%	3.3%
11	Steel+Concrete Composite Bridge	1	100.15	0.1%	1.0%
12	Total	74	3,078.38	9.8%	30.5%
Total		754	10,093.88	100.0%	100.0%

Source: MTI Yearbook of Bridge Statistics (2015).

2.2. Bridge Management Practices

2.2.1. Relevant Laws and Guidelines

Nicaragua has no bridge management related laws in place, and the Central American Bridge Risk Management Manual (Manual Centroamericano de Gestión del Riesgo en Puentes) published in 2010 and the bridge management system NICASAP Manual developed with the aid of Denmark in 2001 apply to bridge management practices. Key components of the manuals are presented below.

1) Central American Bridge Risk Management Manual

The Central American Bridge Risk Management Manual consists of eight chapters, and key issues of bridge management are presented in Chapter 4. 'Normas para la Gestión del Riesgo en Puentes (Bridge Risk Management Standards),' Section 4.5. 'Operación (servicio) y Mantenimiento (O&M: Operation (Use) & Maintenace)'. Contents of the Central American Bridge Risk Management Manual and key issues of bridge management therein are summarized in Figure 3-7.

Figure 3-7 | Contents of the Central American Bridge Risk Management Manual

Chapter 1. Presentación (Introduction)
Chapter 2. Antecedentes(Background)
Chapter 3. Objectivos del manual(Objective)
Chapter 4. Normas para la gestión del riesgo en puentes
(Bridge Risk Management Standards)
Chapter 5. Metodología recomendada (Recommended Methods)
Chapter 6. Estudio de impacto ambiental, un instrumento para mitigar y reducir daños al ambiente(Environmental Damage Mitigation Measures, environmental impact assessment (EIA))
Chapter 7. Factores de seguridad vial(Road Safety Factors)
Chapter 8. Bibliografía (References)



Source: FOMAV (2015)

According to the manual, maintenance budget is allocated depending on the importance of each bridge, and field surveys are conducted in accordance with the Survey Form provided in the Manual so that bridges can be maintained for the intended service life in good condition. In this manual, bridge management consists of four stages described below.

First, routine maintenance activities such as repair of handrails, drainage cleaning, riverbed cleaning before wet season, installation of longitudinal/transverse signs, and painting of bridges are carried out at least once a year. Second, preventive maintenance is necessary to prevent damage of components of a bridge and preservative maintenance must include preventive maintenance. Third, preservative maintenance must comply with the steps set forth in the 'Central America Section 100-Bridge Manual,' which sets out effective methods to reduce vulnerability of bridges during natural disasters, and such methods are considered to be friendly to people, the community, work process, and the environment of the entire structure.

Finally, bridge inspection is necessary prior to maintenance activities. If a field survey is made for the bridge in advance and provides basic information like name, location, size, type, and components of the bridge, inspection may be simpler. In order to evaluate all the bridges appropriately in the same inspection scheme, inspectors must use an inspection form containing all the inspection items of bridge components. This form should be simple and clear to prevent description from being different from actual evaluation results. Also, data on this form should be categorized and concise. The form comprises eight steps and at each step the rater must provide detailed description of the evaluation. The eight steps are as below:

- (Step 1) Basic Information: bridge name, route name, location, plain and linear, etc.
- (Step 2) General Information: length, route, pavement width, bridge type, design load, traffic, etc.
- (Step 3) Information on Materials and Evaluation Items: information on materials, height, and width, and cracks in slabs, bridge bearing, piers, and walls, deficiencies such as lack of rebar and screws, etc.
- (Step 4) Results of Substructure Evaluation: cracks in abutments and piers, scour, etc.
- (Step 5) Results of Superstructure Evaluation: cracks in bridge deck pavement, girder, and protective wall, pot holes, exposed rebar, etc.
- (Step 6) Non-structural Elements: sectional deficiencies in expansion joint, and handrail, painting damage, etc.
- (Step 7) Substructure characteristics: bridge substructure characteristics (rivers, valleys, etc.) and shape of places near abutment.
- (Step 8) Other: evaluation cycle, presence of artificial lighting and drainage near the bridge, etc.

* (Other) Final comments of the inspectors are given.

2) NICASAP Bridge Management Manual

In 2001, NICASAP was developed as a bridge management system of Nicaragua by consultants working at Road Department of DRD as part of a technical cooperation project led by DANIDA, and the NICASAP manual was released together. The manual is comprised of five chapters covering general information, inventory, inspection principle, routine maintenance and cleaning, and prioritization. In this manual, bridge evaluation is discussed in Chapter 2, Inspection Principles and bridge management in Chapter 3 Routine Maintenance, respectively.

2.2.2. Organizations and Responsibilities of Bridge Management

There are two pavement and bridge management organizations in Nicaragua: the MTI and FOMAV. Either of them is not under the control of the other, and they operate as an independent entity, but some of the MTI–managed bridges are transferred to FOMAV for management and maintenance. Specifically, MTI as a major pavement management agency is responsible for rehabilitation and reconstruction of bridges in deteriorated and poor condition, while FORMAV is responsible for the management of bridges in"Good" or better condition.

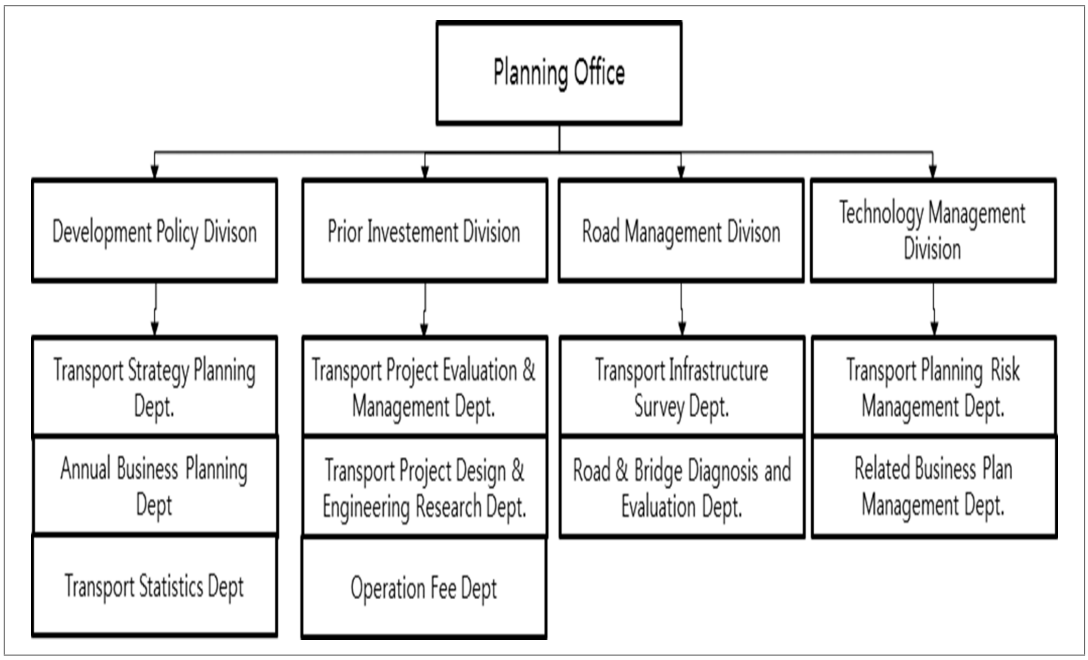
1) Organization and responsibilities of FOMAV

We have already explained how FOMAV is organized in Chapter 2. Major roles of FOMAV are related to road pavement management, and the agency has no organization and personnel for bridge management as of 2015, but it seems that FOMAV is expected to expand its operations to bridge management in the future.

2) Organization and responsibilities of the MTI

MTI has seven Offices under the General Affairs Office. Among Divisions engaging in bridge management are the Road Management Division of the Planning Office and Road Maintenance Division of the Road Office. The Planning Office consists of four Divisions, and the Road & Bridge Diagnosis and Evaluation Department under the control of the Road Management Division is responsible for bridge management activities. The personnel are five: three at HQ and two on site to manage around 2,800 bridges in the MTI-controlled road network by visual inspection. The two inspectors check about 20 bridges weekly; this means it is absolutely necessary to increase the number of bridge inspection personnel.

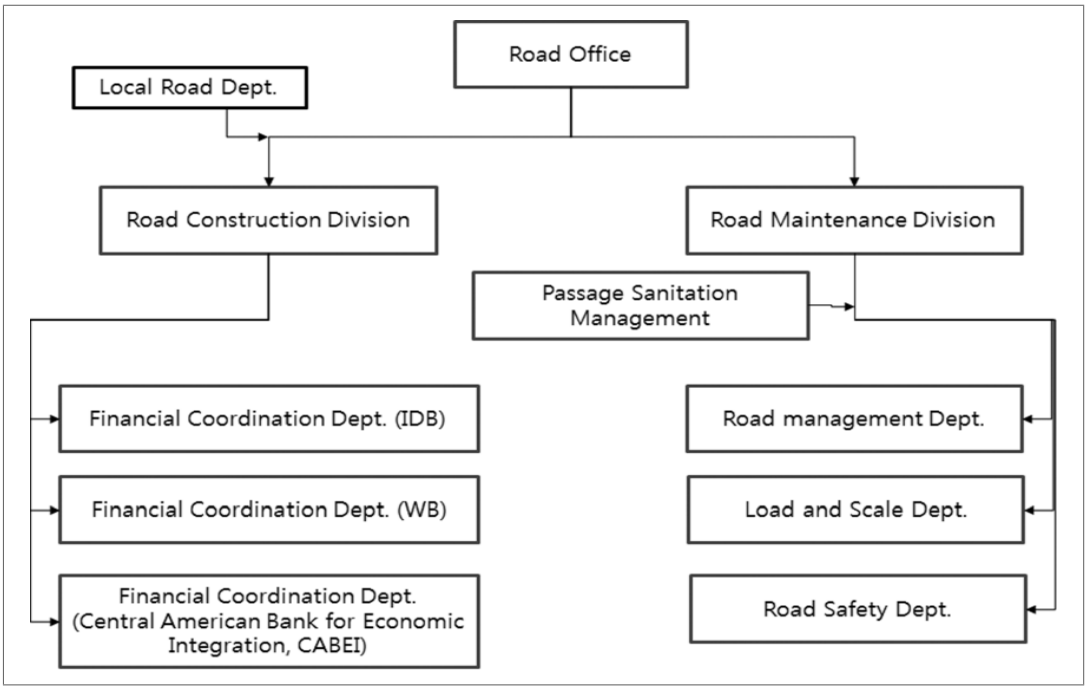
Figure 3-8 | Organization of Planning Office at MTI



Source: MTI (2015)

The Road Office is comprised of two Divisions; the Road Maintenance Division performs bridge management. Specifically, the Division consists of the Road Management Department, the Load/Scale Department, and the Road Safety Department. The Road Management Department is in charge of maintenance of roads and bridges, the Load/Scale Department is engaged in overload vehicle control, and the Road Safety Department management is responsible for road safety facilities.

Figure 3-9 | Organization of Road Office at MTI



Source: MTI (2015)

2.2.3. Bridge Management Practices in Nicaragua

Of bridge types, concrete bridge (Puente de Concreto: 20%) and steel-concrete composite bridge (Puente Mixto Concreto/Acero: 35%) account for about 55% combined, and concrete aqueduct bridge (Alcantarillas de Concreto) constitutes around 12%. Serial numbers are given to the entire 2,828 bridges for management purposes. In addition, bridge related data of MTI shared with FOMAV include:

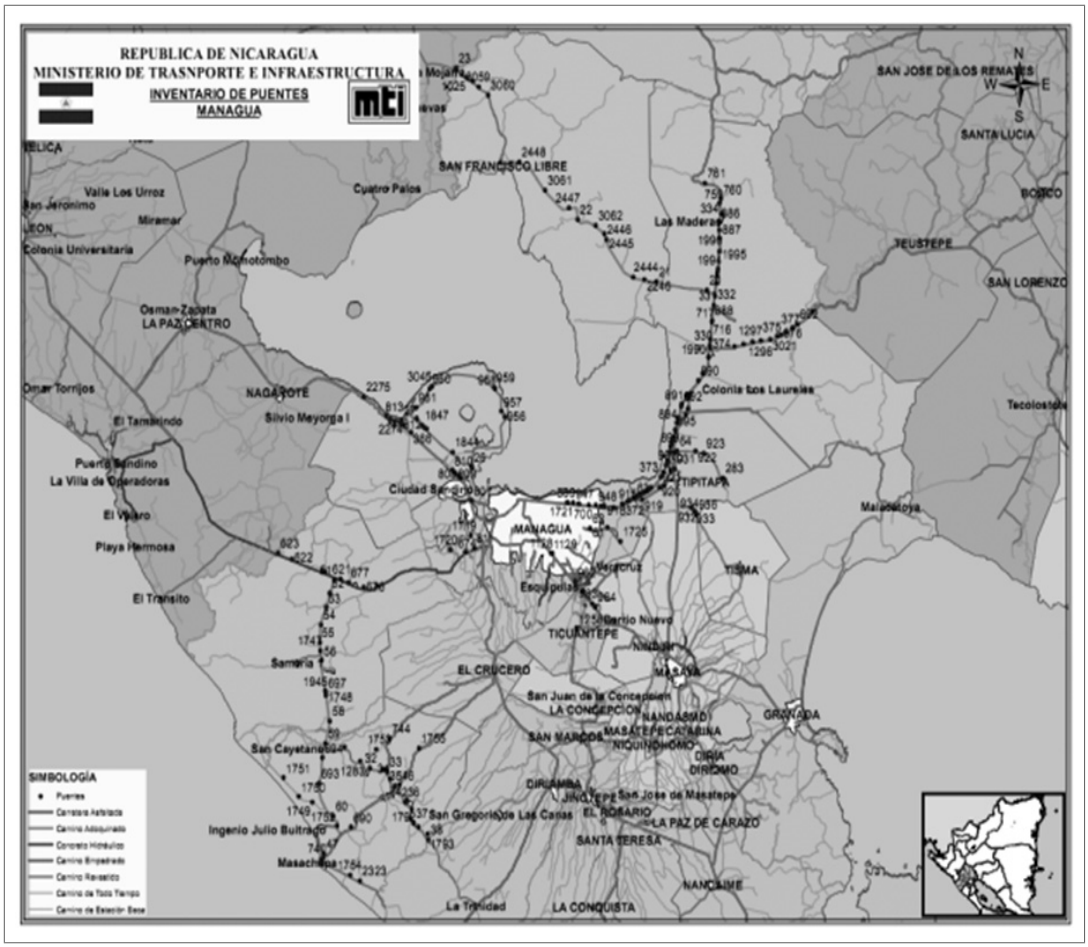
1) Listado de Puentes 2014 Red Vial Nacional de Nicaragua

2) Inventario por Registro Puentes 2014 Red Vial Nacional de Nicaragua

3) Mapas Departamentales Inventario de Puentes 2014 Red Vial Nacional de Nicaragua

As serial numbers are given to bridges in the 17 departments in Nicaragua, it is possible to locate each bridge. In particular, as shown in Figure 3-10, FOMAV enters bridge specific-location data and basic information on Google Earth for the purpose of understanding bridge statistics rather than bridge management.

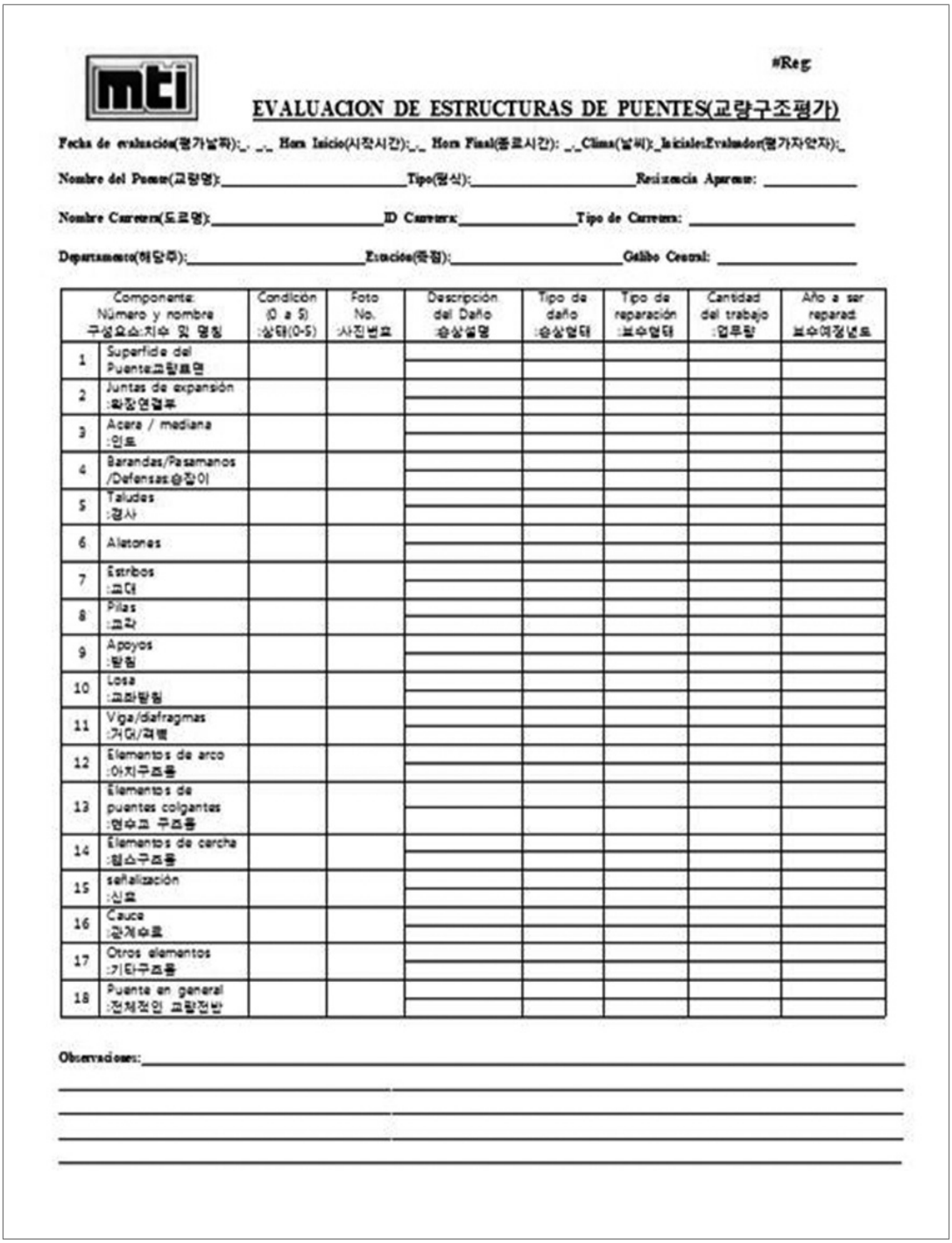
Figure 3-10 | 2014 Map of bridges in major routes in Nicaragua



Source: MTI (2015)

Bridge inspection is not by FOMAV as it does not have an entity to do this, but by the MTI, instead, in accordance with the NICASAP Manual and without specific inspection cycles or condition rating principles. Common inspection method is visual inspection of which findings are documented in an evaluation form. Inspectors rate bridges in a six-grade scale ranging from 0 (Best) to 5 (Worst). Also, bridges are evaluated in 18 checklists as in Figure 3-11.

Figure 3-11 | MTI Bridge Evaluation Form



#Reg:

EVALUACION DE ESTRUCTURAS DE PUENTES(교량구조평가)

Fecha de evaluacion(평가날짜):_. _._ Hora Inicio(시작시간):_._ Hora Final(종료시간): _._Clima(날씨):_Iniciales Evaluador(평가자약자):_

Nombre del Puente(교량명):_____Tipo(형식):_____Resistencia Aperura: _____

Nombre Carretera(도로명):_____ID Carretera:_____Tipo de Carretera: _____

Departamento(해당주):_____Estación(측점):_____Gálibo Central: _____

	Componente: Número y nombre 구성요소:치수 및 명칭	Condición (0 a 5) :상태(0-5)	Foto No. :사진번호	Descripción del Daño :손상설명	Tipo de daño :손상형태	Tipo de reparación :보수형태	Cantidad del trabajo :업무량	Año a ser reparad 보수예정년도
1	Superficie del Puente:교량표면							
2	Juntas de expansión :확장연결부							
3	Acera / mediana :인도							
4	Barandas/Pasamanos /Defensas:손잡이							
5	Taludes :경사							
6	Aletones							
7	Estribos :교대							
8	Pilas :교각							
9	Apoyos :탄점							
10	Losa :교좌탄점							
11	Viga/diafragmas :거더/격벽							
12	Elementos de arco :아치구조물							
13	Elementos de puentes colgantes :현수교 구조물							
14	Elementos de cercha :트스구조물							
15	señalización :신호							
16	Cauce :하계수로							
17	Otros elementos :기타구조물							
18	Puente en general :전체적인 교량전반							

Observaciones:_____

Source: MTI (2015)

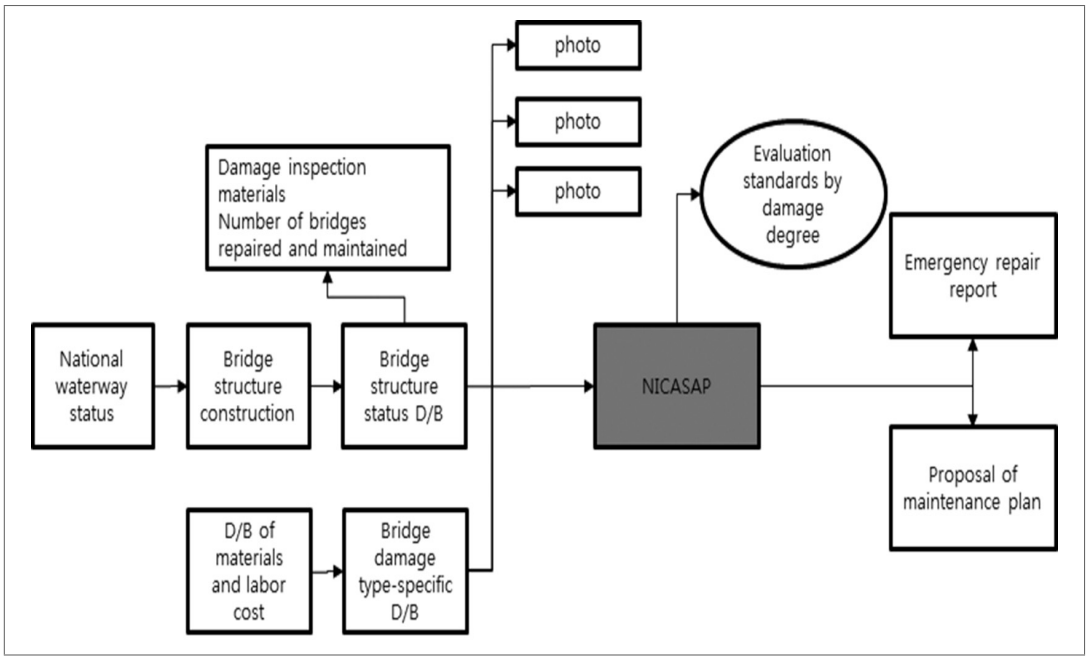
2.2.4. Bridge Management System in Nicaragua

1) Overview

Since FOMAV has no bridge management unit, MTI bridge management system was examined. The system is called NICASAP, which was developed in a consulting project led by the Road Department of the DRD of Denmark in 2001 as part of the DANIDA technical cooperation program, as discussed earlier. NICASAP was put into effect in three phases: training (Oct 2001 - Jun 2003), system application (Dec 2003- Sept2004) and enhancement (Nov - Dec 2006).

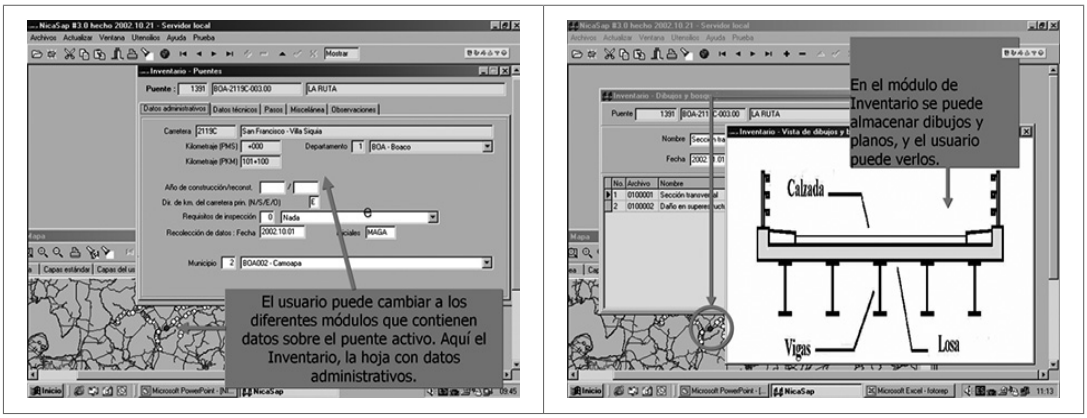
NICASAP provides basic bridge information, allows for entry of safety inspection data, and supports budget allocation and inspection reporting, but no updates have been made since its development. It has four functions: i) bridge inspection and diagnosis data collection; ii) analysis of structure condition in accordance with structure evaluation standards; iii) information on maintenance costs; and iv) development of routine and emergency maintenance plan based on bridge inspection data. The system is configured and operated as in Figures 3-12 and 3-13.

Figure 3-12 | NICASAP Process Flowchart



Source: MTI (2015)

Figure 3-13 | NICASAP Operation Menu



Source: MTI (2015)

2) Key features of NICASAP

An interview with the personnel and program demonstrations at the MTI to gain an understanding on key features of NICASAP revealed that it consists of five modules: 'the Statistics Module, the Basic Inspection Module, the Prioritization Module, the Routine Maintenance Module, and the Administrator Module.

First, the Statistics Module contains general information on bridges in Nicaragua and provides data on bridge locations, departments, shifts, data input date, inspection equipment needed, inspection date and inspector in the Operation Information category and data on span structure, minimum span range, maximum length and width in the Technical Information category. In addition, 'Transverse Condition' contains data on design loads, load-carrying capacity, and overhead clearance, and 'Location Information' retains regional information and administrative divisions. GPS coordinates of bridges are uploaded onto the 'Observation Information.' Taken together, the data covers detailed information of bridges in the country.

Second, the Basic Inspection Module shows inspection dates, temperatures, upcoming inspection dates, and daily traffic in the Inspection category and has the Detailed Components category where inspection findings are input into about 11 inspection item input fields. Data are gathered on-site in an inspection form in line with the 18 inspection item input fields of NICASAP and input into the system against the form. Also, this module supports photo inputs and print out of reports.

Third, the Prioritization Module is configured to house data on repair spots and costs of bridges repaired and unit repair prices by work type for reference. According to the personnel, however,

Features of this module are almost not used in reality and considered for reference only. Fourth, the Routine Maintenance Module contains data on cleaning, repair and improvement methods by deficiency type, and approaches to bridges, making them useful references looked up before day-to-day maintenance activities. Fifth, the Administrator Module is the administrator feature of NICASAP

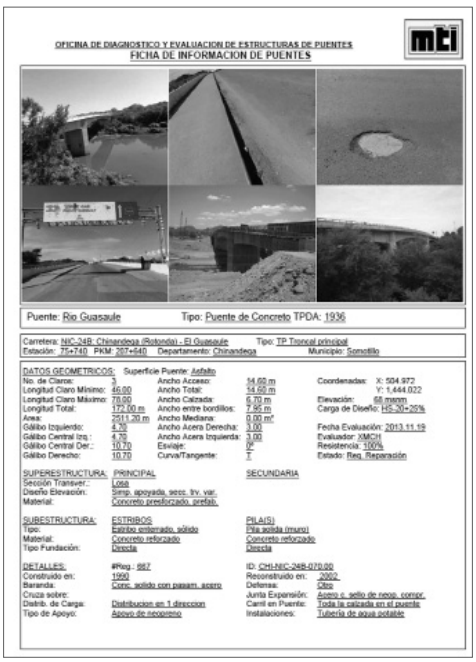
designed to enable creation and revision of items of the modules, data updates, and statistic data production.

The field survey found that NICASAP provides effective bridge statistics and inspection function, but it does not offer drawings of various structures, and locations of bridges are expressed in coordinates only, so they are not viewed on the electronic map. Besides, although designed to comply with the current bridge inspection and pavement condition evaluation standards of Nicaragua, the Basic Inspection Module is considered necessary to be modified in the future, if changes are made to the bridge inspection methods and evaluation standards.

When it comes to system operation, a single MTI employee is in charge of inputting and managing all the data in NICASAP. Since the system is C/S (Client Sever) based, not web-based, it is impossible to work it at other computers than that of the responsible employee. The data are stored in CDs, and therefore, upon future increase in the number of bridges and management staff, it seems necessary to change into a web-based system accordingly.

At the MTI, there is an Excel-based program compatible with NICASA developed by the MTI. This program enables printout of frequently viewed materials from NICASAP. As mentioned above, the program is linked to NICASAP, so users can view related information on the display simply by typing in the name of a bridge in the search box. According to the MTI personnel, this program has been heavily used in practice.

Figure 3-14 | MTI Program Printout



Source: MTI (2015)

To sum up, Nicaragua's bridge management system NICASAP is managed by a single staffer and is operated at the staffer's computer only, which are among disadvantages of the system. However, as the system has been long managed by one employee, the employee has an in-depth understanding on the program, and data are significantly well organized. As far as features are concerned, core features of the system, that is, bridge statistics inputs and inspection data inputs are effectively configured and organized. Still, there seems to be a need of converting to a web-based system and of adding a function that shows drawings and locations of bridges on the electronic map at the basic bridge information input field.

2.3. Field Survey

During the field survey in Nicaragua, 22 bridges on three section to the north, south, and east from the capital city Managua were surveyed with the following results;

2.3.1. 1st Field Survey Section: Managua-Leon-Chinandega-Guasaule

On the first day of the field survey, bridges on NIC-28, NIC12A, NIC-24A and NIC-24B routes in the northern road network stretching to the border of Honduras were examined. This road network connects the capital city Managua and the country's largest port city Leon and plays a pivotal role in the international logistics of the Pacific Highway.

Table 3-5 | Overview of Roads in The 1st Field Survey Section

Route No.	Section	Length (km)	Department	Remarks
NIC-28	Las Piedrecitas-Los Brasiles	11.12	Managua	Northern section
	Los Brasiles-Nagarote-La Paz Centro	40.18	Managua-Leon	
NIC-28/ NIC12A	La Paz Centro-Izapa-Leon	34.98	Leon	2 roads Multi-section
	Leon-Chinandega	40.31	Leon-Chinandega	
NIC-24A	Chinandega-Corinto	20.0	Chinandega	West section
NIC-24B	Chinandega-Guasaule	75.74		North road
Total length		222.33		

Source: Compiled by KSP Consultant (2015)

Bridges that were evaluated on that day belong to concrete steel composite bridge, corrugated steel bridge, and concrete bridge. In particular, Rio Guasaule Bridge was a PSC box girder branch built in FCM method.

Table 3-6 | Overview of 1st Field Survey of Bridges

No	Route No (station)	Name of bridge	Upper-structure	Length (m)	Width (m)	Overhead clearance (m)/ transverse	Design load	Completion	Inspection date (result)
1	NIC-28 (19+990)	Los Cabros	Puente Mixto Concreto/ Acero (Plate Girder)	35.5	13.5	8.2 / over a river	HS-20 +25%	1963	28 May 2012 (maintenance needed)
2	NIC-28 (48+445)	Nagarote	Puente Arco Metal corrugado (Corrugate Plate)	9.0	14.0	3.6 / over a waterway	HS-20-44	-	28 May 2012 (good)
3	NIC-12A (112+015)	Los Llanos	Puente Mixto Concreto/ Acero (Plate Girder)	32.4	10.0	8.6 / over a river	HS-20 +25%	1999	28 Nov 2012 (maintenance needed)
4	NIC-24B (133+955)	El. Guarumo (R.Acome)	Puente de Concreto (PSC T-Beam)	2@33 =66	10.0	9.6 / over a river	HS-20-44	1982	10 Feb 2011 (maintenance needed)
5	NIC-24B (207+640)	Rio Guasaule	Puente de Concreto (PSC Box Girder-FCM)	3span =372	9.6	4.3 /over a river	HS-20 +25%	1990	19 Jan 2011 (maintenance needed)
6	NIC-24A	Paso Caballos	Puente de Concreto PSC-Beam	7@30 =210	9.3	Sea bridge	Designed by USA	Around 2013	

Source: Compiled by KSP Consultant (2015)

Figure 3-15 | Photos of 1st Field Survey of Bridges



Los Cabros Bridge



Nagarote Bridge



Los Llanos Bridge



El. Guarumo(R.Acome) Bridge



Rio Guasaule Bridge



Paso Caballos Bridge

Source: Taken by KSP Consultant (2015)

Among the defects and deficiencies found in this road network were foreign substances deposited around the bearing, stripping and damage of expansion joint system, no drainage in place, bridge side deterioration and corrosion under the steel girder and pot holes in bridge deck pavement. Considering the year of completion and insufficient bridge management, however, the bridges were in good condition overall.

Figure 3-16 | Major Damage Cases in Managua-Guasaule (border to Honduras) Section



Foreign substances deposited around the bearing



Stripping/damage of expansion system



No drainage in place



Bridge side deterioration



Steel girder Corrosion (Llanos)



Bridge pavement pot hole (Guarumo)

Source: Taken by KSP Consultant (2015)

In connection with service life of the bridges, Los Cabros bridge has been used for 52 years (built in 1963), Rio Guasaule Bridge for 25 years (built in 1990), and the others for 15 to 13, respectively. It is necessary to carry out a comprehensive safety evaluation of the bridges including replacement of damaged expansion joints and durability study in consideration of service life. The following shows survey findings by item:

Table 3-7 | Survey Findings of The Managua-Guasaule (border to Honduras) Section

Survey component	Result
Appearance	• In good condition based on visual inspection.
Bridge deck pavement	• Relatively in good condition, but pot holes evident on Guarumo Bridge which need to be repaired immediately.
Bridge bearing	• Lots of foreign substances deposited around the support. • Without a bearing block, space between lower girder and bridge seat is narrow, and if bearing is replaced, there is no room for hydraulic jack installation. • Paso Caballos Bridge (built in 2009), the newest among the surveyed bridges, has no bearing block.

Survey component	Result
expansion joint	• For rubber types, rubber seal disappeared in most cases, but both Guasaule Bridge in border to Honduras and sea-crossing bridge Paso Caballos in NIC-24A are in good condition.
Bridge deck drainage	• Mostly without a well, but drain pipes are in place. However, Guasaule and Paso Caballos Bridge have a well. • No drainage in place or drain pipes are short, causing deterioration of girders by moisture. Drainage construction and extension needed.
Steel girder	• Painting in good condition, but Llanos Bridge suffering from ongoing corrosion.
Concrete surface	• All the bridge side protective walls considerably deteriorated.

Source: Compiled by KSP Consultant (2015)

2.3.2. 2nd Field Survey Section: Managua-Namdaime-Peñas Blancas/ Granada-Masaya

On the second day of the field survey, bridges on NIC-2 and NIC-4 routes in the southern road network leading to the border of Costa Rica (Peñas Blancas) were examined. This road network is a part of the Pacific Highway like the first field survey section and plays a pivotal role in the international logistics.

Table 3-8 | Overview of The 2nd Field Survey Section

Route No.	Section	Length (km)	Department	Remarks
NIC-2	Semáforo 7 Sur-El Crucero	15.86	Managua	Managua-Border to Costa Rica
	El Crucero-Jinotepe-Nandaime	40.87	Managua-Carazo -Granada	
	Nandaime-Rivas-La Virgen-Peñas Blancas	82.29	Granada-Rivas	
NIC-4	Nandaime-Granada-Masaya	60.0	Granada	
Total length		199.02		

Source: Compiled by KSP Consultant (2015)

On the second day, eight bridges were evaluated, and their types were box bridges, concrete steel composite bridges, and culverts. Interestingly, Las Lajas Bridge is a truss bridge, which is hard to find in Korea.

Table 3-9 | General Information of 2nd Field Survey of Bridges

No	Route No (station)	Name of bridge	Upper Structure	Length (m)	Width (m)	Overhead clearance (m)/ transverse	Design load	Completion	Inspection date (result)
1	NIC-02 (73+ 190)	Rodeo Grande	Puente de Concreto (RC T-Beam)	11.4	9.5	7.7 /over a waterway	HS-20-44	1951	2012.02.21 (Maintenance needed)
2	NIC-02 (80+ 420)	Rio Ochomogo	Puente de Concreto (PSC Beam)	2@30 =60	10.5	9.1 /over a river	HS-20 +25%	2000	2012.02.22 (Good)
3	NIC-02 (118+ 520)	Las Lajas	Puente Metálico (TRUSS)	50	12.5	3.0 /over a river	HS-20 +25%	1996	2012.07.23 (Good)
4	NIC-02 (145+ 170)	La Conga	Puente de Concreto (RC T-Beam)	10.5	9.5	4.0 /over a waterway	HS-20-44	1958	2012.07.24 (Maintenance needed)
5	NIC-02 (143+ 030)	El Caserío No.2	Metal corrugado (Corrugate Plate)	7.7	9.5	4.3 /over a waterway	HS-20-44	-	2012.07.24 (Good)
6	NIC-02 (139+ 090)	Río Ostayo	Puente Mixto Concreto/ Acero (Plate Girder)	48.5 (3span)	11.0	4.7 /over a river	HS-20-44	1958	2012.07.24 (Good)
7	NIC-02 (135+ 120)	Río Nacascolo	Puente de Concreto (3span RC Slab)	31.0 (3span)	10.0	3.5 /over a river	HS-20-44	1958	2012.07.24 (Good)
8	NIC-04 (48+ 100)	El. Escudo	Caja Puente (Box culvert)	4.4 (2@Box))	12.5	1.0(depth of soil) /over a waterway	HS-20-44	-	2012.01.27 (Maintenance needed)

Source: Compiled by KSP Consultant (2015)

Figure 3-17 | Photos of 2nd Field Survey of Bridges



Rodeo Grande



Rio Ochomogo



Las Lajas 1



Las Lajas 2



La Conga



El. Caserío No.2



Río Ostayo



Río Nacascolo



Río Nacascolo

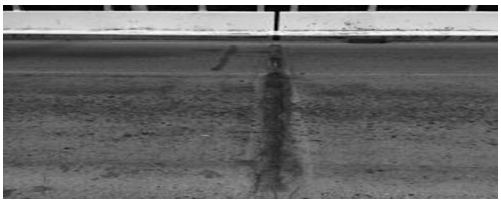
Source: Taken by KSP Consultant (2015)

This road network has no bearing blocks without any room for girder for future maintenance. Among other major types of damage are stripping and damage of expansion joint system, no drainage in place, bridge side deterioration, and cocoons under the slab.

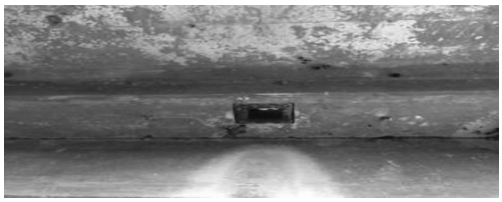
Figure 3-18 | Major Damage Cases of Managua-Peñas Blancas (border to Costa Rica) Section



No bearing block in place



Expansion system stripping/damage



No drainage in place



Bridge side deterioration



Girder/slab reinforcement (2 bridges)



Lots of cocoons under the slabs/girders/piers

Source: Taken by KSP Consultant (2015)

In connection with service life, Rodeo Grande Bridge has been used for 64 years (built in 1951), La Conga/Rio Ostayo/Rio Nacasolo Bridge for 57 years (built in 1958), and Las Lajas Bridge for 19 years (built in 1996), respectively. Most of the bridges were very old, so it is necessary to repair or replace damaged expansion joints with a steel type in a quick manner. Given their long service life, a comprehensive safety evaluation via a durability analysis is considered necessary.

Table 3-10 | Managua-Peñas Blancas (border to Costa Rica) Section Field Survey Findings

Survey Item	Result
Appearance	• In good condition based on visual inspection.
Bridge deck pavement	• Relatively in good condition.
Bridge bearing	• Lots of foreign substances deposited around the bearing. • Without a bearing block, space between lower girder and bridge seat is narrow, and if bearing is replaced, there is no room for hydraulic jack.
Expansion joint	• For rubber types, rubber seal disappeared in most cases.
Bridge deck drain	• Mostly without a well, but drain pipes are in place. Drainage is not in place or drain pipes are short, causing deterioration of girders by moisture. Drainage construction and extension needed.
Section reinforcement & cracks (2 bridges)	• Rodeo Brande and La Conga Bridges are of the same structure (RC T-Beam) and length (about 11 m/span), with section reinforcement made to abutments under the slab. • Lots of cracks under the slab.
Poor cleaning & maintenance (2 bridges)	• Rio Ostayo (Plate Girder) and Rio Nacascolo (3-span RC Slab) have never been maintained thus far and have lots of cocoons under the slabs, girders and piers. Clearing is urgent.
Concrete surface	• All the bridge side protective walls considerably deteriorated.

Source: Compiled by KSP Consultant (2015)

2.3.3. 3rd Field Survey Section: Managua-Juigalpa-Puerto Díaz (NIC-1-7-37)

On the last day, NIC-1, NIC-7 and NIC-37 routes to the east from Managua were investigated and some bridges were reconstructed or being constructed. In this road network, eight bridges were surveys, some of which should have been classified as a culvert rather than a bridge in the Korean standard. Also, some bridges were built in truss type in this network.

Table 3-11 | Roads of The 3rd Field Survey Section

Route No.	Section	Length (km)	Department	Remarks
NIC-1	Managua-Tipitapa-San Benito	38.0	Managua	
NIC-7	San Benito-Teustepe-Juigalpa	99.0	Managua-Boaco -Chontales	
NIC-37	Juigalpa-Puerto Díaz direction	20.0	Chontales	Unpaved road
Total length		157.0		

Source: Compiled by KSP Consultant (2015)

Table 3-12 | General Information on The 3rd Field Survey of Bridges

No	Route No (station)	Name of bridge	Upper Structure	Length (m)	Width (m)	Overhead clearance (m)/ transverse	Design load	Completion	Inspection date (result)
1	NIC-01 (13+ 430)	Monte Fresco No.1	Caja Puente (3@Culvert)	11.8	26	1.3 /over a waterway	HS-20 +25%		2011.12.05 (Maintenance needed)
2	NIC-01 (21+ 708)	Tipitapa (upper/lower part separated)	Puente Mixto Concreto/Acero (Plate Girder)	30.5(R)/ 30.4(L)	9.5	4.0 /over a river	HS-20-44	2000	2011.12.05 (Maintenance needed)
3	NIC-07 (35+ 100)	San Benito	Caja Puente (2@Culvert)	2@ Culvert =7.0	18.5	3.2 /over a waterway	HS-20 +25%		2011.12.05 (Maintenance needed)
4	NIC-07 (41+ 800)	Alcantarilla 4x60	Alcantarilla de Concreto (Circle Pipe)	Φ1.5m @4=10	16.0	1.5 /over a waterway	HS-20 +25%		2011.07.12 (Maintenance needed)
5	NIC-07 (46+ 180)	Las Banderas	Puente Metálico+ Puente de Concreto (TRUSS+PC Beam)	Truss+ 3@30	12.3	9.0 /over a river	HS-20-44	Rebuilt in 2013	Completed in 1944/ Rebuilt in 2013
6	NIC-07 (101+ 118)	Tecolostote (New+old +Foot-bridge) :separated following reinforcement of existing bridge	Old:Puente Metálico (TRUSS)+Puente Mixto Concreto/ Acero (Plate Girder)/foot bridge	100 (Plate Gir.+Truss+ Plate Gir.) /foot bridge (Plate Gir.)	7.4	7.5 /over a river	HS-20-44	1945	New bridge built to make a bypass. Bridge reinforcement underway
			New: Puente Mixto Concreto/Acero (Plate Girder)	3-span				Rebuilt in 2013	Used (1-lane)
7	NIC-07 (121+466)	Cuisala	Puente Metálico (Truss)	50	7.4	7.5 /over a river	HS-20-44	1945	2011.08.08 (Maintenance needed)
8	NIC-37B (142+970)	Las Limas	Puente Mixto Concreto/Acero (Plate Girder)	3span = 37	4.0	5.2/Cuisala over a river	HS-20-44		2014.05.06 (Maintenance needed)

Source: Compiled by KSP Consultant (2015)

Figure 3-19 | Photos of 3rd Field Survey of Bridges



Monte Fresco No.1



Tipitapa



San Benito



Alcantarilla 4x60



Las Banderas



Tecolotote(1/4)
(new+old+foot bridge)



Tecolotote(2/4)
(new bridge)



Tecolotote(3/4)
(new bridge+old truss bridge)



Tecolotote(4/4)
(old bridge under reinforcement+foot bridge)



Cuisala(1/2)



Cuisala(2/2)



Las Limas

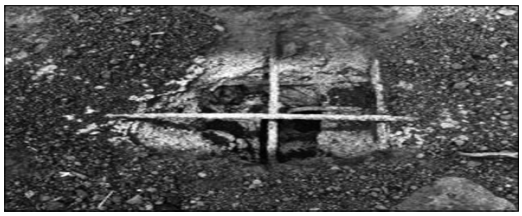
Source: Taken by KSP Consultant (2015)

Major defects and deficiencies in this road network include soil deposits due to lacking water flow section, punching holes in slabs, no bearing block in place, corrosion under the steel girder, expansion joint faulting, and poor treatment of precast panel joints.

Figure 3-20 | Major Damage Cases of Managua-Juigalpa-Puerto Díaz (NIC-1-7-37) Section



Soil deposits: lacking water flow section/flooding during wet season



Punching hole in the slab



No bearing block in place



Corrosion under the girder



Traffic causing severe noise due to expansion system faulting



Precast panel: failure of joint treatment

Source: Taken by KSP Consultant (2015)

Although the reconstructed bridges in this road network were designed and constructed with bridge maintenance taken into account, older bridges are still suffering from diverse damage patterns. Among others, slab punching holes in Tipitapa Bridge, expansion system of Cuisala Bridge, and precast joints, handrails, and expansion system of Las Limas should be promptly repaired and reinforced.

Table 3-13 | Analysis of Damage Cases of Managua-Peñas Blancas (border to Costa Rica) Section

Survey component	Result
Appearance	• Waterway culvert Monte Frecco Bridge is flooded during wet season as upstream soil deposits cause lack of flow area. So, water flow capacity evaluation followed by proper actions needed. • Slabs, girders, abutments, and piers of some of the bridges are suffering deterioration. But, recently rebuilt bridges are in very good condition.
bridge deck pavement	• Tipitapa Bridge contains punching holes in the slab, which need to be repaired quickly. In the case of Las Limas Bridge on NIC-37 route, bridge deck was replaced with precast plate, but joints were not connected, causing greater impacts of driving, which spread to girders. • Other rebuilt bridges are in very good condition
Bridge bearing	• Foreign substances deposited around the bearing of some bridges. • Without a bearing block, space between lower girder and bridge seat is narrow, and if bearing is replaced, there is no room for hydraulic jack.
Expansion joint	• For rubber types, rubber seal disappeared in most cases. • Due to sealant stripping and faulting, the expansion system of Cuisala Bridge causes serious impact noise while vehicles travel, requiring quick replacement. • Las Limas Bridge has no expansion system at abutments.
Bridge deck drainage	• In the case of recently rebuilt bridges, catch basins are installed and drain pipes are well connected, but Tipitapa Bridge's drain line is short, causing corrosion of steel girder.
Old bridge reinforcement	• In the case of Tecolostote Bridge, a new bridge (1-lane: Plate Girder) was built as a detour for vehicles, and a reinforcement work of the older bridge (TRUSS+Plate Girder) is underway.

Source: Compiled by KSP Consultant (2015)

Some of the bridges in this road section were rebuilt in 2013 by JAICA. Steel expansion joint system is used for these bridges, and the bearing block is tall enough to maintain (H=30cm). In addition, to prevent foreign substances coming in to the catch basin, steel bars have been installed on the catch basin cover, and the drainage was extended to the lower girder. In addition, steel chain and concrete block have been installed to prevent the collapse of upper girder during a quake. The

above mentioned improvements should be applied to other bridges to raise durability of bridges and increase service life.

Figure 3-21 | Managua-Juigalpa-Puerto Díaz(NIC-1-7-37) section improvements



Expansion system and sealant in good condition



Bearing block in place (H=30 cm)



Quake-caused bridge collapse prevention system: steel chain



Drainage extended up to lower girder



Quake-caused bridge collapse prevention system: concrete block



Steel bar to prevent foreign substances

Source: Taken by KSP Consultant (2015)

2.3.4. Problems Found from the Field Survey

The problems detected as a result of the field survey of bridges in Nicaragua can be summarized in three categories; Firstly, without any established classification system, both bridges and culverts are managed as bridge, making it hard to focus on the management of bridges, and secondly, as

bridge inspection cycles and methods are not formulated systematically, inspection and repair/reinforcement of bridges have not been carried out appropriately. Furthermore, there is no available means to manage inspection and repair/reinforcement history. In consideration of these problems, it appears that Nicaragua needs a well-designed, scientific bridge management system.

3. BMS in Korea

3.1. Overview of Highway Bridge Management

There are 8,542 highway bridges nationwide in Korea, according to the statistics of August 2015. This figure only covers bridges in the expressway routes managed by the KEC, such as the Gyeongbu Expressway and the Namhae Expressway. The total length (one-direction) of the bridges is 477km, accounting for 12.4% of the total 3,841km expressway network, a ratio that is also on the rise.

3.1.1. Status of Bridge Management

1) Statistics by Service Life

Average service life of expressway bridges reaches 13.1 years; bridges below 10 years of service life amount to 3,042 (35.6%), those between 10 and 20 years of service life to 3,961 (46.4%), those between 20 and 30 years of service life to 1,369 (16.0%), and those of 30 years or over in service life to 170 (2.0%), respectively.

Table 3-14 | Bridges by Service Life

Total	Below 10 yrs.	10-20yrs.	20-30 yrs.	30yrs. or over
8,542 (100%)	3,042 (35.6%)	3,961 (46.4%)	1,369 (16.0%)	170 (2.0%)

Source: Korea Expressway Corporation Structure Information System (2015)

2) Statistics by length and structure

By length, expressway bridges consist of 5,683 bridges shorter than 100m accounting for 66.5%, 2,505 bridges longer than 100m and shorter than 500m at 29.3%, 294 bridges between 500 and 1,000m in length at 3.5%, and 60 bridges longer than 1,000m at 0.7%.

Table 3-15 | Bridges by Lengthe

Total	Below 10 yrs.	10-20yrs.	20-30 yrs.	30yrs. or over
8,542 (100%)	5,683 (66.5%)	2,505 (29.3%)	294 (3.5%)	60 (0.7%)

Source: Korea Expressway Corporation Structure Information System (2015)

In regards to superstructure, PSC I girder bridge constitutes the biggest share of 2,568 (30.0%), followed by Rahmen bridge at 2,466 (28.9%), steel box girder bridge at 1,484 (17.4%), PF beam bridge, PSCB girder bridge, and IPC girder bridge in order. Special-structure bridges include cable-stayed bridges (2), truss bridges (2), and arch bridges (11).

Table 3-16 | Bridges by Superstructure

Total	PSC I girder bridge	Rahmen bridge	Steel box girder bridge	PF beam bridge	PSCB bridge	IPC bridge	Other including special structure bridges
8,542 (100%)	2,568 (30.0%)	2,466 (28.9%)	1,484 (17.4%)	422 (4.9%)	331 (3.9%)	329 (3.9%)	942 (11.0%)

Source: Korea Expressway Corporation Structure Information System (2015)

Figure 3-22 | Special Highway Bridges



Cable-stayed Bridge – Seohae Bridge



Truss bridge – Hojeo Bridge



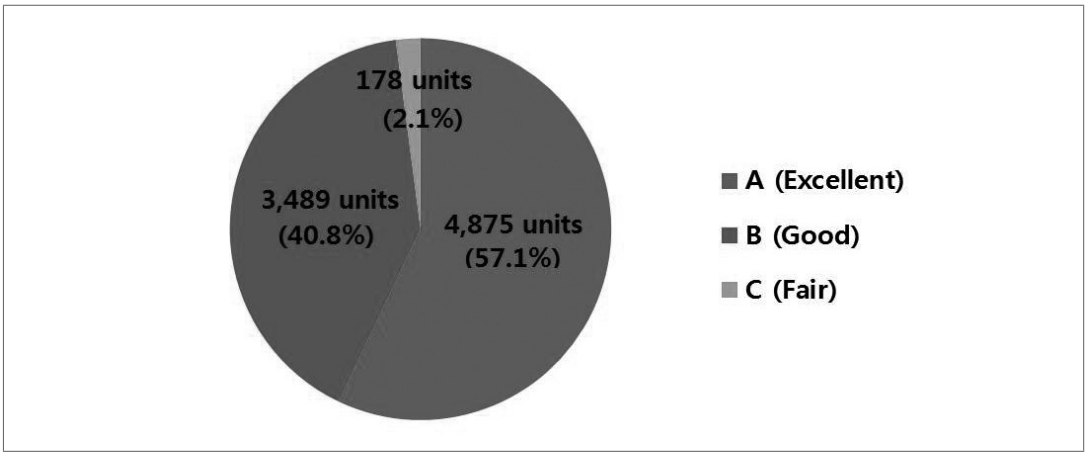
Arch bridge – Juklimoncheon Bridge

Source: Korea Expressway Corporation Structure Information System (2015), KEC

3) Statistics by safety rating

An estimated 4,875 highway bridges at 57% or so among the 8,542 bridges in total are rated the best condition Grade A (Excellent), the 3,489 bridges (40.8%) are rated Grade B (Good) requiring minor repair, and the remaining 178 bridges (2.1%) are in Grade C (Fair) requiring repair of principal components or minor reinforcement of secondary components. There are no Grade D (Poor) and Grade E (Very Poor) bridges, which require urgent repair and reinforcement of principal components or need to be excluded from service immediately and reinforced or rebuilt due to serious defects in principal components.

Figure 3-23 | Safety Ratings for Highway Bridges

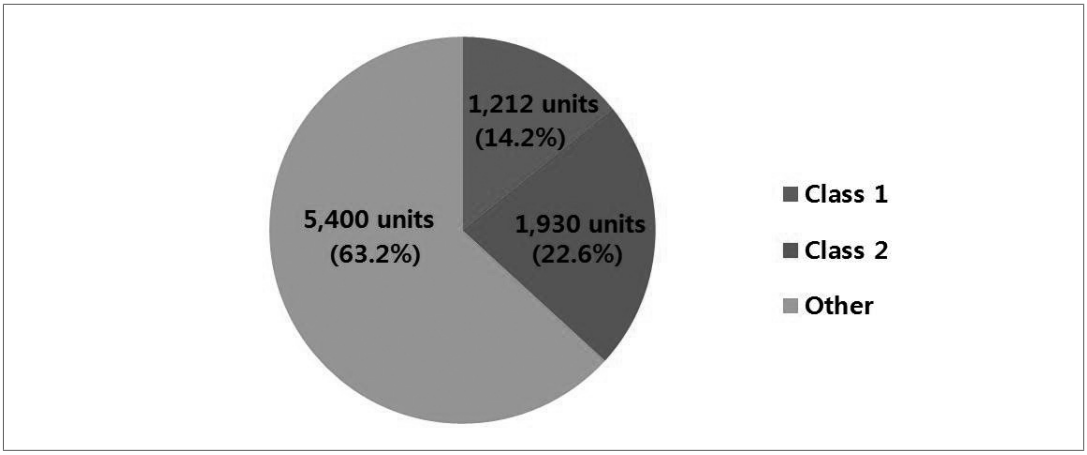


Source: Korea Expressway Corporation Structure Information System (2015).

4) Classifications of highway bridges

Highway bridges in Korea are made up of 1,212 bridges of Class 1 Infrastructure (14.2%), 1,930 bridges of Class 2 Infrastructure (22.6%), and 5,400 bridges of Other Infrastructure (63.2%). Pursuant to the Special Act on Safety Control for Public Structures, Class 1 Infrastructure refers to 500 m or over long bridges, special bridges like suspension bridges, cable-stayed bridges, and arch bridges, or bridges with spans up to 50 m or over (except for short-span bridges) Class 2 Infrastructure means bridges with a length of 100 m or over which do not fall into Class 1 plus short-span bridges with span ranges up to 50 m or longer. Other bridges than Class 2 belong to Other Infrastructure.

Figure 3-24 | Classifications of Highway Bridges



Source: Korea Expressway Corporation Structure Information System (2015).

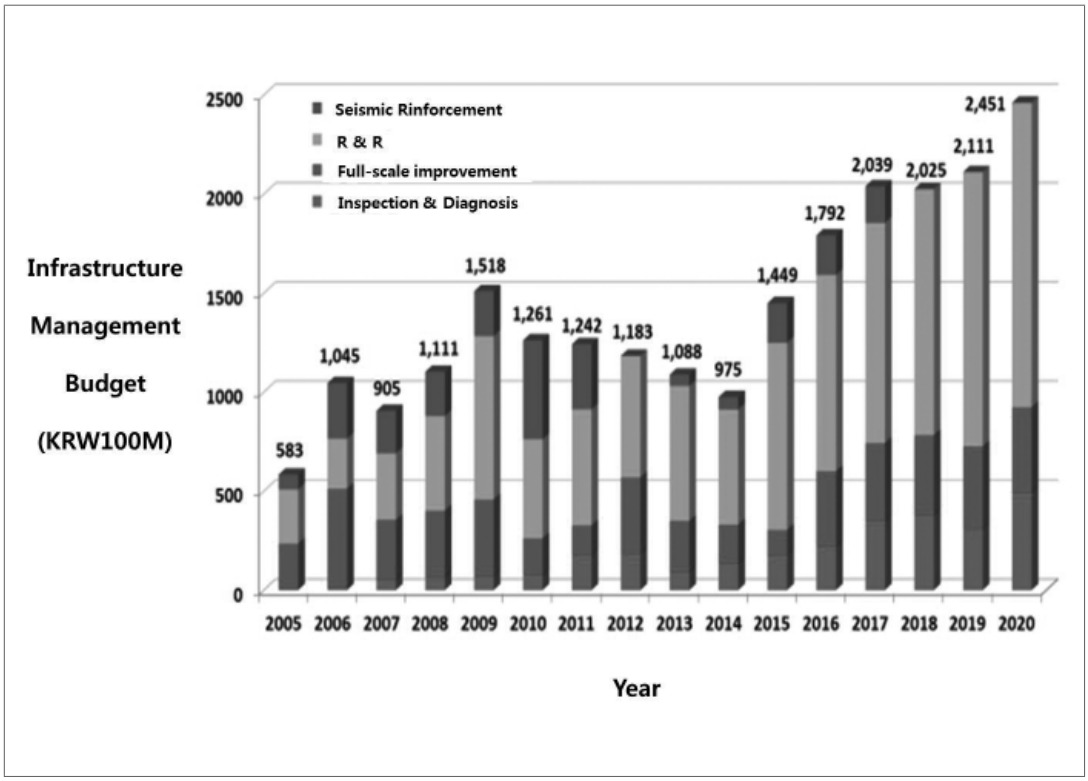
3.1.2. Bridge Maintenance Budget

Bridge management budget is subdivided into four categories in terms of uses: inspection and diagnosis, full-scale improvement, repair and reinforcement (R&R), and seismic reinforcement. Specifically, budget for inspection and diagnosis covers precise safety diagnoses and detailed end of warranty inspections, which are carried out by an outside safety diagnosis service provider, Full-scale improvement budget is for demolishing and rebuilding of bridges falling short of the standard or those with insufficient flood elevation for safety reasons. R&R budget is to be spent on repairing and reinforcing distressed members like bridge deck pavements and expansion joints detected in a safety inspection to enhance safety. Seismic reinforcement budget is used to reinforce bridges without seismic capacity.

1) Changes in bridge maintenance budget

Maintenance budget for structures has grown around 2.5 times over the past 10 years; the budget was KRW144.9 billion in 2015, compared to KRW58.3 billion in 2005. This indicates that the number of structures to be managed and that of deteriorated ones are on the rise and consequently more money is required for their management.

Figure 3-25 | Annual Budget for Infrastructure Management over The Past 10 Year and Estimates for The Future



Source: KEC Structure Information System (2015).

By catrgory, repair and reinforcement of structures, specifically for bridge deck pavement improvement and replacement of expansion joint system, makes up the largest of the budget. Aging of bridges and increased deicing agents usage during winter season accelerate deterioration of bridge deck and pavements, requiring the largest amount of R&R budget. Expansion joint system is another member to which increasingly growing budget is allocated. Expansion joint is another element that consume unneglectable portion of maintenance budget. Spendings on substructural element including abutment and bearing are also increasing because of leak in expansion joint system that accelerates deteration. With the growth of managed bridges and long-span bridges, diagnosis and inspection is claiming a bigger share of the budget and first priority is given to this sector in the budget investment planning process to ensure the safety of bridges. Mid- and long-term plans for investment in full-scale improvement and seismic reinforcement have been developed, under which project are performed on a yearly basis.

2) Bridge management budget for 2015 and predictions

Bridge management budget in 2015 was KRW144.9 billion, made up of KRW98.1 billion (68%) for R&R, KRW17.6 billion (12%) for inspection and diagnosis, KRW14.8 billion (10%) for seismic reinforcement, and KRW14.4 billion (10%) for full-scale improvement. Given the

Growing number of managed structures and deteriorated ones, it is predicted that R&R and diagnosis and inspection budgets will continue to grow. Since investment in seismic reinforcement and full-scale improvement projects is thought to decrease due to reduced needs thereof upon completion of such projects, more funds will be allocated to R&R.

Table 3-17 | Infrastructure Management Budget for 2015 (KRW100M)

Total	R & R	Inspection & Diagnosis	Seismic Reinforcement	Full-Scale Improvement
1,449 (100%)	981 (68%)	176 (12%)	148 (10%)	144 (10%)

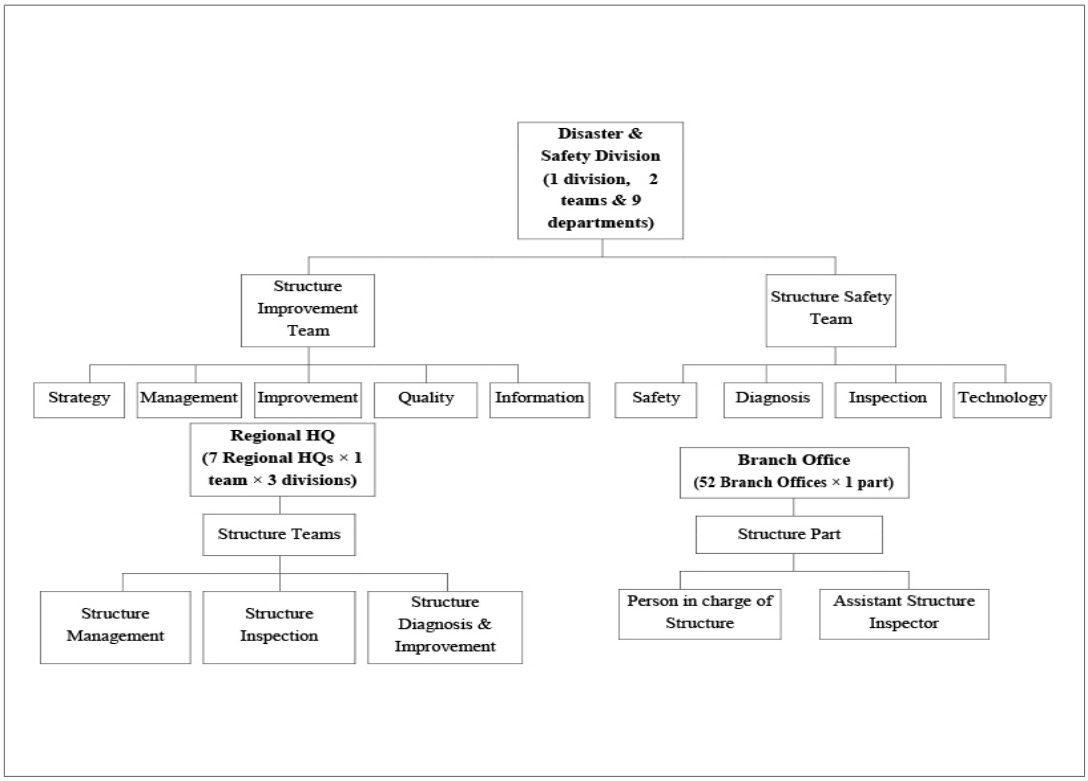
Source: Operations of Safety & Disaster Management Division (2015), KEC.

3.1.3. Bridge Management Organization

The Bridge (structure) management personnel amount to 189 in total; 21 from one division and two teams of Head Office, 54 from seven teams of Regional HQs, and 114 from 52 Branch Offices throughout the country. The two teams of Head Office - the Structure Improvement Team and the Structure Safety Team - are responsible for establishing a structure management plan, managing budgets, and formulating related standards; the Structure Improvement Team deals with major bridge improvement, seismic reinforcement, bridge deck pavement management, defect management, IT system operation and improvement, and Structure Safety Team is in charge of prevention of damage from de-icing chlorides, safety inspection and precise safety diagnosis, scientific structure inspection, and technical exchanges at home and abroad.

Regional HQs take charge of bridge management in their jurisdiction, acts for Head Office, and manage bridge operations done by Branch Offices under their control. They also take part in important inspections (in-depth inspections) conducted by Branch Offices and providing technical assistance. Branch Offices are supervised by Regional HQs; every Regional HQ controls seven to nine Branch Offices, and there are 52 Branch Offices nationwide whose major duties include bridge safety inspection, repair and reinforcement oversight, and uploading of various inspection data. At the forefront of inspection and routine maintenance of bridges, Branch Offices have the best understanding on the conditions and vulnerable issues of the bridges they managed and therefore bridge conditions may depend on their bridge inspection and maintenance activities.

Figure 3-26 | Bridge Management Organizations



Source: Operations of Disaster & Safety Division (2015), KEC.

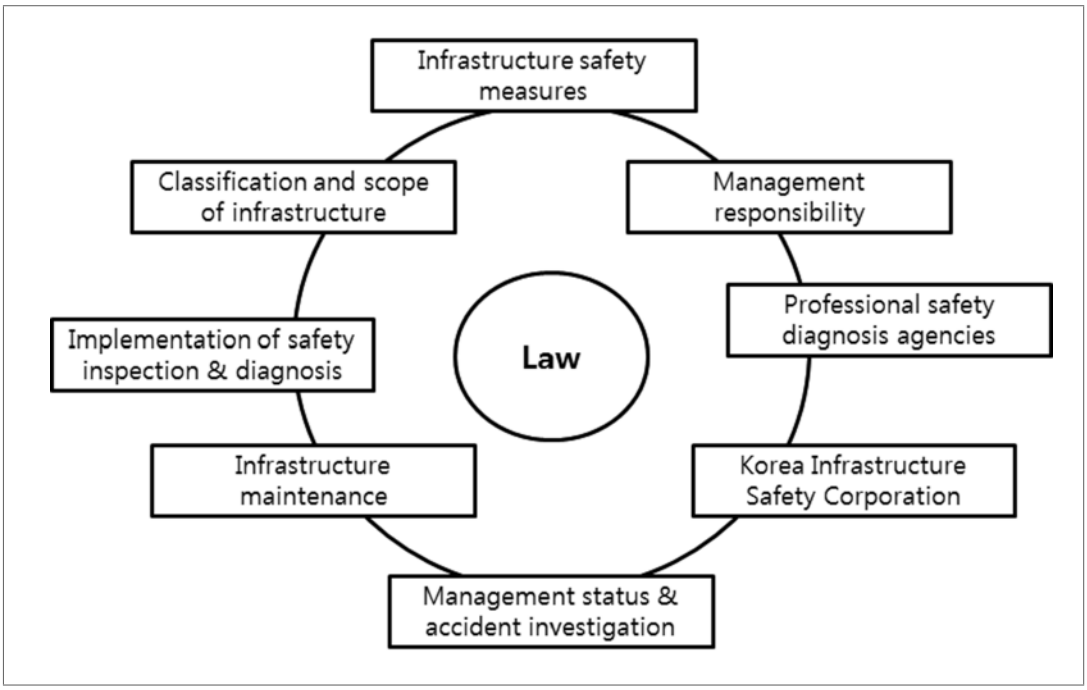
3.2. Bridge Management Laws and Guidelines

3.2.1. The Special Act on Safety Control for Public Structures

The Special Act on Safety Control for Public Structures came into effect in the 1990s amid the urgent need of safety regulations for existing infrastructure as public facilities including Seongsu Bridge and Sampoong Department Store collapsed in series. This law aims to prevent disaster and

enhance the efficacy of infrastructure (bridges, tunnels, slopes, etc.) through safety inspection and proper maintenance, and ultimately ensure the safety of the public and contribute to the welfare of citizens.

Figure 3-27 | Key Agendas of the Special Act on Safety Control for Public Structures



Source: Textbook of Expressway Management Training (2013), KEC

3.2.2. The Framework Act on the Management of Disasters and Safety

Subject to the Framework Act on the Management of Disasters and Safety, the head of the disaster control executing agency is required to designate, manage and maintain infrastructure assets and areas (special management facilities, etc.) which are considered highly vulnerable to disasters or managed continuously to prevent disasters. Infrastructure assets to be managed are 10-year or older bridges with lengths ranging from 20 m to 100 m, excluding those in Class 1 and 2 Infrastructure under the Special Act on Safety Control for Public Structures. Special management facilities are required to be surveyed from October to November every year and reported to higher authorities by December.

3.2.3. Other Bridge Related Laws

Among other laws relating to bridges are the Earthquake Disaster Countermeasure Act and the Construction Technology Promotion Act. In accordance with the Earthquake Disaster Countermeasure Act, serviceable bridges having no seismic design are required to be designed and reinforced to resist earthquake. The Construction Technology Promotion Act sets forth provisions for initial inspection before completion of bridge construction, inspecting authorities, and payment.

3.2.4. Infrastructure Management Rules

The Infrastructure Management Rules are a set of regulations on highway infrastructure (bridges, tunnels, and culverts) management performed by the KEC with the aim of ensure functionality and safety of infrastructure and prevent and take prompt actions against disasters. The rules cover infrastructure management planning (management objectives, safety ratings, major infrastructure assets subject to observation, business planning, etc.), safety inspection and precise safety diagnosis (types of safety inspection, regular inspection, in-depth inspection, precise safety diagnosis, etc.), classification and performance of maintenance works, and infrastructure information system.

3.3. Bridge Management Methods

Bridge management along expressways begins with inspection and diagnosis, followed by determination of state ratings, repair and strengthening of bridges, and history tracking, among which safety inspection of bridges is at the core of bridge management. Also, intervals of and methods of the inspection vary by bridge type. This is in accordance with the relevant law - The Special Act on Safety Control for Public Structures.

3.3.1. Inspection Types and Methods

Safety inspections are categorized largely into regular inspection, in-depth inspection (including in-depth end of warranty inspection), emergency inspection (damage inspection and special inspection), and in-depth end of warranty inspection. Precise safety inspections are performed to take quick and proper repair and strengthening measures upon failures and deficiencies detected in various safety inspections. Safety inspection is like a regular medical check-up for the human body. Just as we become healthy again through medical treatment even if health issues are detected in a physical examination and medical check-up, bridges, if found damaged or failed in a safety inspection and diagnosis, regain original functionality via repair and strengthening. A safety inspection team consists of two persons, in general; one focuses on inspection, and the other works to secure the safety of the inspector. The sections that follow describe each type of inspections and diagnoses.

1) Regular inspection

Regular inspection is carried out by an experienced, skilled person to the extent of a careful visual inspection (excluding safety rating) to detect serious defects at an early stage as a preliminary inspection for all sorts of inspections/diagnoses. All bridges are subject to a regular inspection in a cycle of every six months for Class 1 and 2 bridges and other bridges for specific management and every year for other bridges, under the responsibility of head of Branch Office for the section. If in-depth inspections and precise safety diagnoses are carried out in the same year, one regular inspection is omitted.

Table 3-18 | Inspection Subject and Frequency

Classification	Frequency	Method
Class 1 & 2 Infrastructure	Twice a year	Carried under the responsibility of branch head
Other Infrastructure (for specific management)	Twice a year	
Other Infrastructure	Once a year	

Source: A Sourcebook of Structure Maintenance Practices (2012), KEC.

A regular inspection specifically examines the overall external condition to detect the presence and development of damage, the state of repaired and strengthened elements and cross-sections, drainage condition, bridge deck pavement condition, and damage of expansion joints among others through a visual inspection using tools such as telescope and mirror.

Table 3-19 | Inspection Items and Equipment for Regular Inspection

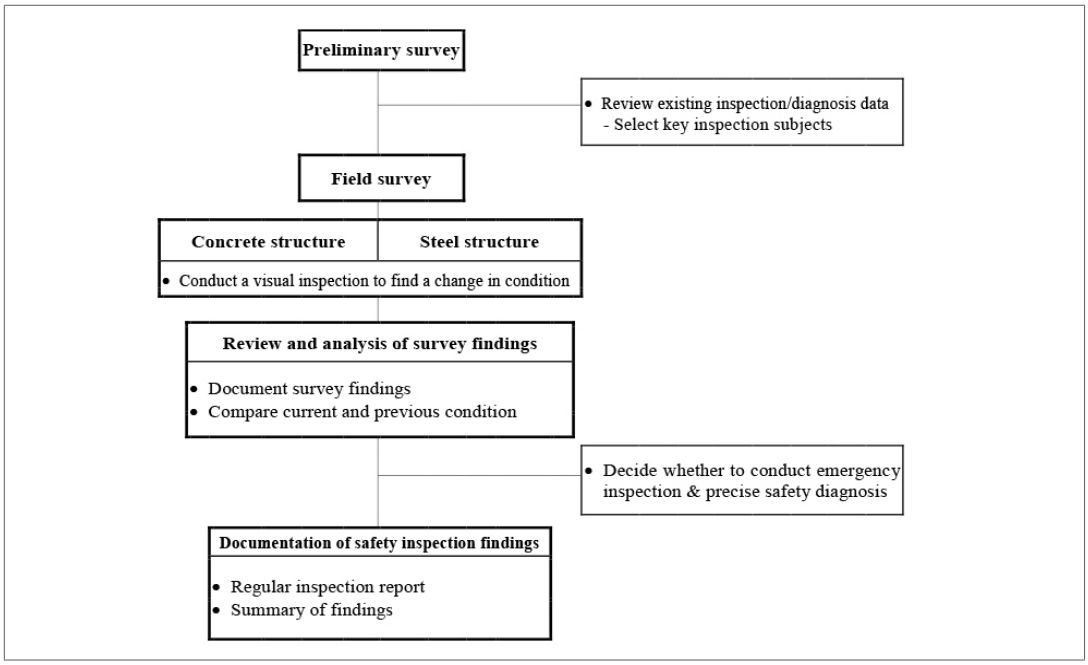
Component	Item	Equipment
Entire members of structure (superstructure & substructure)	• Simple visual inspection - overall exterior condition - presence and development of damage, defect, and deterioration - external condition of repaired and strengthened elements and cross-sections - drainage and bridge deck pavement condition following rainfall - damage of expansion joints and abnormal sound - identification of areas requiring precise inspection - damage of bridge components caused by vehicle crash - scour and settlement due to change in river bed	telescope camera writing instruments tape measure hammer flashlight

Source: Detailed Guideline for Safety and In-depth Inspection (2010), Korea Infrastructure Safety & Technology Corporation

With respect to regular inspection procedures, existing inspection/diagnosis data are reviewed first to establish a thorough plan for preliminary survey including selection of intensive inspection areas, followed by a field survey to compare current and previous conditions.

Finally, further inspection needs like precise safety diagnosis are determined, and safety inspection findings are documented.

Figure 3-28 | Regular Inspection Flowchart



Source: Detailed Guideline for Safety and In-depth Inspection(2010), Korea Infrastructure Safety &Technology Corporation.

2) In-depth inspection

In-depth inspection is carried out by experienced, skilful professionals to accurately evaluate the current conditions of structures, identify changes from the initial or previously documented conditions and thereby decide whether to meet current use requirements. Bridges subject to in-depth inspection are Class 1 and 2 Infrastructure, and inspection cycles differ by condition ratings - every two years on average. Inspections of this kind are performed under the joint responsibility of head of Regional HQ governing the region and head of Branch Office responsible for the section. If defect inspection and precise safety diagnosis are carried out in the year, one in-depth inspection is omitted.

Table 3-20 | Inspection Subject and Frequency for In-depth Inspection

Classification	Frequency	Responsible person
Class 1 & 2 Infrastructure (bridges & tunnels)	Grade A (every 3 yrs)	Head of Branch
	Grade B & C (every 2 yrs) Grade D & E (every year)	Head of Regional Office

Source: A Sourcebook of Structure Maintenance Practices (2012), KEC.

In addition, compared to regular inspection, more precise visual inspection and simple measuring systems and inspection vehicles are used for in-depth inspection, along with inspection equipment when necessary.

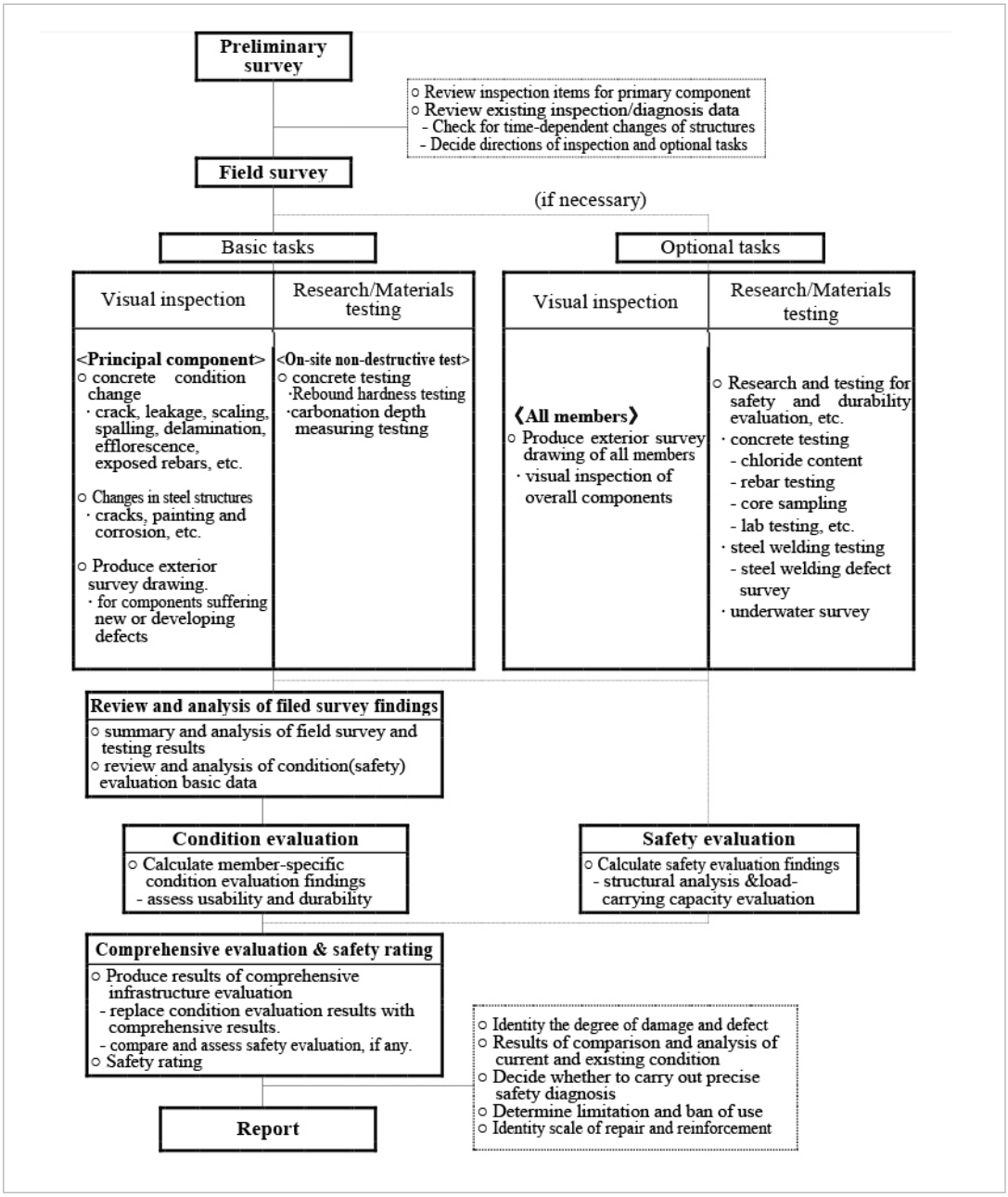
Table 3-21 | Items and Equipment for In-depth Inspection

Component	Item	Equipment
Superstructure	• Visual inspection - Bearing condition of superstructure and overall appearance - Bridge deck pavement, drainage, and handrails - Deck crack, stripping, leakage, and efforescence - Damage and joint gap of expansion joints - Girder deflection, cracking, strain, corrosion, --connecting condition, etc. • Simple measuring - Strength testing via rebound hardness method - Carbonation testing	• Schmidt Hammer • Bore scope Mirror • Bore scope • Hammer • Camera • Flashlight • Writing instruments • Inspection equipment
Substructure	• Visual inspection - Overall exterior condition - Damage, deterioration, and function of bearing - Damage, defect, and deterioration of abutment and pier - Erosion and scour of foundation and pile • Simple measuring - Strength testing via rebound hardness method - Carbonation testing	

Source: Detailed Guideline for Safety and In-depth Inspection (2010), Korea Infrastructure Safety &Technology Corporation..

For in-depth inspection, preliminary survey and field survey are performed to assess conditions of infrastructure and determine safety ratings and if necessary, decision is made on whether to carry out further inspections including in-depth safety diagnosis, as presented in Figure 3-29.

Figure 3-29 | In-depth Inspection Flowchart



Source: Detailed Guideline for Safety and In-depth Inspection (2010), Korea Infrastructure Safety &Technology Corporation.

3) Emergency inspection

Emergency inspection is conducted to the level of in-depth inspection when bridge damage occurs and urgent examination of the situation is required. By purpose, it is divided into damage inspection and special inspection; the former aims to check for the degree of deficiency in bridge Caused by a disaster or accident and thereby to decide the need of urgent restriction or prohibition of the use of the bridge. The damage inspection also judges the urgent need, scale and work scope of repair and reinforcement and evaluates safety, as necessary. On the other hands, special inspection takes place when deficiency has happened or is likely to happen or when it is necessary to determine whether or not the use of a structure should be resumed. By special inspection, bridge inspection time is decided depending on how severe the deficiency is. In the event of any deficiency considered adverse to the safety of a structure, emergency inspection should be initiated without delay after report is made to the responsible person. According to the inspection results, appropriate actions should follows.

4) Detailed end of warranty inspection

For Class 1 and 2 Infrastructure assets of which warranty period for key elements is soon to be expired, an detailed end of warranty inspection is carried out to boost responsible construction by the contractor and raise the durable life of the assets and entrusted to an outside safety diagnosis service provider under the responsibility of head of Regional HQ no later than 14 days before the relevant warranty period expires.

Table 3-22 | Inspection Subject and Frequency for In-depth Inspection

Classification	Warranty Period			
	Key component		Other	
	10yrs	7yrs	5yrs	2yrs
Bridge	50m or over span 500m or over length	Below 500m of length	-	Bridge deck pavement, joints, handrails, etc.
Tunnel	RC or steel parts	-	Other	-

Source: A Sourcebook of Structure Maintenance Practices (2012), KEC.

5) Precise safety diagnosis

Precise safety diagnosis aims to detect physical and functional defects of road assets and suggest repair and reinforcement methods by examining, measuring, and evaluating structural safety and causes for defects for prompt and appropriate actions. Precise safety diagnosis is performed for Class 1 bridges under the Special Act on Safety Control for Public Structures. First precise safety diagnoses are conducted by an outsourced safety diagnosis service provider 10 years after the completion of construction. Subsequent diagnoses take place by safety class by means of diverse tests and structural analyses on a 4-6 year basis.

Table 3-23 | Criteria for Precise Safety Diagnosis Execution

Class	Time				Agency
Class 1	• Regularly or when necessary. - Frequency: every year after 10 years pass following completion • On a regular basis depending on safety rating, thereafter.				Safety diagnosis service provider (outsourced)
	Safety Rating	Grade A	Grade B&C	Grade D&E	
	Frequency	Every 6 yrs or more	Every 5 yrs or more	Every 4yrs or more	
Class 2	if necessary				
Other	if necessary				Internally

Source: Detailed Guideline for Safety and In-depth Inspection (2015). MOLIT.

Whereas in-depth inspection examines if a bridge continues to fulfil current service requirements through visual inspection and simple measuring and testing with test equipment, precise safety diagnosis aims to collect data necessary for condition rating and safety evaluation of infrastructure assets with more in-depth visual inspection and a variety of measuring and test equipment (MTE) to discover defective members which cannot be easily detected by in-depth inspection. In short, the purpose of precise safety diagnosis lies in assessing the condition of a bridge more accurately and thoroughly than in-depth inspection. In-depth inspection and precise safety diagnosis are compared as in Table 3-24.

Table 3-24 | Activities of In-depth Inspection and Precise Safety Diagnosis

Category	In-depth Inspection	Precise Safety Diagnosis
Data collection & analysis	• As-built drawing, structural calculation, special specification, etc. • Shop drawings, repair and work plans • Various test and instrumentation data, • repair/reinforcement history, etc.	• Same as left.
Field s urvey	• Visual inspection of infrastructure assets or key members and preparation of visual inspection drawing. • Simple onsite material test.	• Visual inspection of all members and preparation of visual inspection drawing. • Overall onsite material test for the bridge.
Evaluation method	• Condition rating.	• Condition rating, safety evaluation, and overall assessment.
Repair/ reinforcement method	• No repair/reinforcement method recommended.	• Repair/reinforcement method recommended.
Report preparation	• CAD drawing and report preparation.	• Same as left.

Source: Detailed Guideline for Safety and In-depth Inspection (2015). MOLIT.

5) Qualification and training of engineers responsible for safety inspection and precise safety diagnosis

The personnel in charge of safety inspection and precise safety diagnosis must be a professional engineer qualified in accordance with relevant laws who has completed 70 hours or longer of safety inspection or precise safety diagnosis training in the field recognized by the Minister of Land, Infrastructure and Transport. In addition, those who perform inspection under the supervision of the lead engineer must be an entry or higher level professional civil engineer.

Table 3-25 | Qualifications of Engineers Engaged in Safety Inspection and Precise Safety Diagnosis

Classification	Qualification Requirements
Regular Inspection	• Entry or higher level of professional engineer in civil construction under the Construction Technology Promotion Act
In-depth Inspection & Emergency Inspection	• Advanced or higher level of professional engineer in civil construction under the Construction Technology Promotion Act
Precise Safety Diagnosis	• Special or higher level of professional engineer in civil construction under the Construction Technology Promotion Act

Notes:
- Special level engineer: An engineer
- Advanced level engineer: A qualified engineer who has engaged in construction projects for seven years or longer. A qualified industrial engineer who has engaged in construction projects for 10 years or longer.
- Intermediate level engineer: A qualified engineer who has engaged in construction projects for four years or longer. A qualified industrial engineer who has engaged in construction projects for seven years or longer.
- Entry level engineer: A qualified engineer or industrial engineer.

Source: The Special Act on the Safety Control of Public Structures (2015), ROK Ministry of Government Legislation.

Besides, the KEC establishes mid-term and annual training plans to cultivate management capacity of the personnel mentioned above, under which it offers basic, intermediate-high and advanced-high training courses tailored to individual needs.

Table 3-26 | Structure Personnel Training

Course	Personnel	Contents of Training	Contents of Training
OJT of structure personnel	Structure personnel of HQs/ Branch Office	- Structure information system - Structure inspection and diagnosis	Once a year (for 5 days in Feb)
Precise safety diagnosis training (outsourced)	Inspection personnel of Head Office/HQs/Branch Office	Precise safety diagnosis of bridges and tunnels	6 to 7 times a year (for 10 days from Jan to Nov)
Structure management expert training (e-learning)	Structure personnel of Head Office/HQs/Branch Office	Safety inspection, diagnosis and structure management at large	12 times a year (every month)
Completion of Construction Office Structure Information System Input Training	Responsible personnel of Completion of Construction Office /HQ/Branch Office	How to input and transfer data of new structures into structure system	Once a year (for 3 days, when necessary)
Structure inspection personnel training	Structure inspection personnel of Branch Office	Basic structure-related theories, safety inspection methods and practices	Once a year (for 3 days early in the year)

Source: A Sourcebook of Structure Maintenance Practices (2012), KEC.

3.3.2. Inspection Equipment and Facilities

Basic tools and equipment used for various safety inspections include ladder, high place operation car, and bridge inspection vehicle for the inspector to approach the bridge, tools such as brush and grinder to clean equipment and bridge surface, inspection hammers, bore scope mirrors, telescopes, rulers, and flashlights, as well as measuring and survey equipment. Approach equipment is most important in providing mobility to help the inspector to examine every bridge member safely. The most widely used equipment in Korea is a high place operation car, which lifts the inspector up to see the component of interest. In case where a high place operation car cannot be used because it is impossible to set up the platform at the bottom of the bridge due to unfavourable conditions or the bridge is too high to approach, a bridge inspection vehicle is a solution, which helps to work at the upper part of the bridge. The inspector can access and examine the lower part of the bridge from the upper side using an "L"-shape ladder of the bridge inspection vehicle. This equipment is advantageous as it allows for inspection without constraints of the lower part of the bridge, but traffic should be controlled during the inspection and even if the equipment moves with the ladder opened, the ladder should be folded to avoid obstacles on the bridge handrails such as lights before being opened again to continue the inspection, which may take more time than scheduled.

Figure 3-30 | Approach Equipment for Bridge Inspection



High place operation car



Bridge inspection vehicle

Source: Structure Information System (2015), KEC.

Other inspection facilities are also built at the time of constructing the bridge for future bridge management activities. Pier inspection facilities to help see the bridge bearing and the abutment inspection stairs to see the abutment bearing are among the common facilities installed for bridge inspection in Korea. With these systems, it is possible to observe the bridge bearing as a key component and nearby bridge substructure deck either visually or via a telescope. As inspection facilities are indispensable to ensure the efficiency of inspection, installation of such inspection equipment is underway in Korea especially for older bridges, where inspection facilities are not available.

Figure 3-31 | Bridge Inspection Facilities



Pier inspection facilities



Abutment inspection stairs

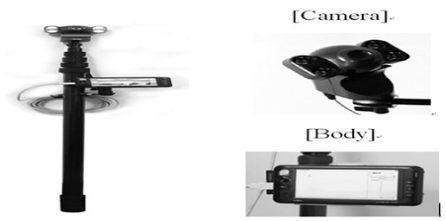
Source: Structure Information System (2015), KEC.

Besides, as inspection technology improves, hi-tech inspection systems are in use, as provided in Table 3-27.

Table 3-27 | Scientific Inspection Equipment

Ground Penetrating Radar(GPR)	Ground Penetrating Radar (GPR) is a device that processes and analyzes wave forms and evaluates thickness and deterioration of components by emitting electromagnetic waves through radar antenna to bridge deck or pavement and receiving waves from the non-uniform layer of the structure.	
Ubiquitous-Bridge Inspection Robot System (U-BIROS)	The Ubiquitous-Bridge Inspection Robot System (U-BIROS) is a system that inspects bridges by taking photos of bridge deck and lower girder using remote-controlled robots and digital image processing technique.	
Smart Bridge Load Carrying Capacity Evaluation System	The Smart Bridge Load Carrying Capacity Evaluation System is used to assess load carrying capacity by measuring vibration (acceleration) and dynamic strain caused by normal traffic and estimating analysis model through inverse dynamic analysis, comparing response of the model to design level.	
Bridge Video Management System(CCTV)	CCTVs are installed at bridges which fall short to the desired flood elevation or overhead clearance and are illegally occupies and need to be inspected periodically so that the situation room of each KEC Branch can conduct real-time monitoring and take quick disaster control actions.	
Side Scan Sonar	The Side Scan Sonar is a device that obtains using sound waves sent out from the transducer on both sides of Towfish, an object shaped like a torpedo. Towfish is equipped with Altimeter, Depth Sensor, and Motion Sensor, and detected data are saved and analyzed in a computer program along with photos and GPS data acquired from outside.	 

Table 3-27 | Scientific Inspection Equipment (continued)

Pole Camera	With a camera equipped with lights at adjustable pole corner, Pole Camera is a device that lets the user to examine an object located high of the structure. Angles of the camera are remote-controlled to check photos taken. It enables filming or taking photos and storing videos or photos.	
Narrow Space Inspection Camera	This small camera with a lighted flexible cable (probe) is used to inspect narrow space by pushing through a narrow gap into the corner of the structure. Angles of the camera are remote-controlled to check the surface. It enables recording videos or taking photos and saving such videos and photos.	

Source: A Sourcebook of Structure Maintenance Practices (2012), KEC.

3.3.3. Safety Rating Method for Bridge

In accordance with the findings of the in-depth inspection or precise safety diagnosis concerned, safety rating of a bridge falls into one of the following five classes. Either the resulting condition or safety rating, which is lower, becomes the safety rating of the structure. No managed expressway bridges are of Grades D and E in Korea now.

Table 3-28 | Standards of Safety Ratings

Safety Rating	Condition of Structure
A (Excellent)	Best condition with no problem
B (Good)	Having minor defects in auxiliary elements but having no problems in functionality. Requiring partial repair to enhance durability.
C (Fair)	Having minor defects in key elements or widespread defects in auxiliary members, causing no safety issues to the facility as a whole. Requiring repair or simple reinforcement of auxiliary members to prevent deterioration of durability and functionality of key members.
D (Poor)	Suffering defects in key elements requiring urgent repair and strengthening. Decision on restriction of use needs to be made.
E (Very Poor)	Serious defects in key elements pose a threat to the safety of the facility. Immediate ban on the use and reinforcement or reconstruction are needed.

Source: Detailed Guideline for Safety and In-depth Inspection (2010), Korea Infrastructure Safety & Technology Corporation

These assessments and evaluations to determine the safety raring of a bridge are examined in more detail below.

1) Condition assessment

Condition assessment is an activity to evaluate durability of a bridge taking into account defect levels (defect index of defect, distress, and deterioration) of individual elements (bridge deck, girders, secondary elements, abutments, piers, foundations, bridge bearing, expansion joints, bridge rails and curbs, drainage facilities, bridge deck pavement, carbonation, and chlorides) of the bridge found in materials testing and visual inspection and weighted values thereof. Depending on the range of defects, the bridge is rated one of the five grades: from Grade A to Grade E.

Table 3-29 | Criteria for Condition Ratings

Classification	Grade A	Grade B	Grade C	Grade D	Grade E
Defect Index	a (0.1)	b(0.2)	c(0.4)	d(0.7)	e(1.0)
Defect Range	0≤x<0.13	0.13≤x<0.26	0.26≤x<0.49	0.49≤x<0.79	0.79≤x

Source: Guide Book of Detailed Guideline for Safety and In-depth Inspection - Bridge (2010), Korea Infrastructure Safety & Technology Corporation

Take an example of condition assessment of a PSCI bridge, one of the major bridge types. The PSCI bridge has six spans and is composed of bridge deck, girders, secondary elements, bridge deck pavement, drainage facilities, bridge rails and curbs, expansion joints, bridge bearing, abutment and pier, and carbonation as shown in Table 3-30.

Table 3-30 | Example of PSCI Bridge Condition Assessment

Span No.	Bridge Deck	Girder	2nd Element	Bridge Deck Pavement	Drainage System	Handrail/ Curb	Point No.	Expansion Joint	Bearing	Abutment/ Pier	Foundation	Carbonation (Super)	Carbonation (Sub)	Chloride (Super)	Chloride (Sub)
003	b	a	a	b	a	b	A1	d	a	d	Q	a	X	X	X
001	b	a	b	a	a	a	P1	X	a	b	Q	a	X	X	X
005	b	a	b	a	b	a	P2	X	a	a	Q	a	X	X	X
002	b	a	b	a	a	a	P3	b	b	d	Q	a	X	X	X
004	b	b	a	a	a	a	P4	X	a	a	Q	a	X	X	X
006	b	a	a	a	b	b	P5	X	a	b	Q	a	X	X	X
							A2	b	b	c	Q	a	X	X	X

Source: Structure Inspection Alert System (2015). KEC.

Condition assessment is segmented into spans and spots by member, and defect indexes are evaluated on the basis of presented standards of condition ratings as in Table 3-32. Different condition rating standards exist for individual members, by which condition assessment is carried out. Upon completion of condition assessment, condition ratings are converted into numbers depending on defect index. As shown in Table 3-30, six members of bridge deck all have a defect index of b and therefore, the mean becomes 0.2×6/6=0.2, while five members of girder have a defect index of 'a', and one member has a defect index of 'b', so the mean becomes (0.1×5+0.2)/6=0.117. For the other elements, the same method applies to calculate the mean value.

Next, with consideration for their importance and bridge type, weighted values are given to individual members, with weighted values adding up to 100%. In the case of the PSCI bridge in this example, weighted values are 18% for bridge deck, 20% for girders, 5% for secondary elements, 7% for bridge deck pavement, 3% for drainage facilities, 2% for bridge rails and curbs, 9% for expansion joints, 9% for bridge bearing, 20% for abutments/piers, and 7% for carbonation, respectively.

Finally, condition ratings of individual members are determined by multiplying an average defect index calculated above and weighted value by member, all of which add up to decide the condition rating of the bridge. As provided in Table 3-32, defect index average 0.2 and weighted value 18% of bridge deck are multiplied together to result in 0.036, and 0.023 is resulted in for girders by multiplying 0.117 and 20%. Condition ratings of the other members are calculated in the same manner, and in the case of the bridge as shown in Table 3-31, values of condition ratings by member total 0.199 and its range of defects is $0.13 \leq x < 0.26$, which makes this bridge fall into Grade B.

Table 3-31 | Condition Rating by Defect Level and Weighted Value (example of condition rating B)

Category	Bridge Deck	Girder	2nd Element	Bridge Deck Pavement	Drainage System	Handrail/ Curb	Expansion Joint	Bearing	Abutment/ Pier	Foundation	Carbonation (Super)	Carbonation (Sub)	Chloride (Super)	Chloride (Sub)	-
Mean	0.2	0.117	0.15	0.117	0.133	0.133	0.367	0.129	0.343	0.0	0.1	0.0	0.0	0.0	
Weighted value	18.0	20.0	5.0	7.0	3.0	2.0	9.0	9.0	20.0	0.0	4.0	3.0	0.0	0.0	100
Condition rating	0.036	0.023	0.007	0.008	0.004	0.003	0.033	0.012	0.069	0.000	0.004	0.000	0.000	0.000	rating 0.199
															Condition rating: B

Source: Structure Inspection Alert System (2015). KEC.

2) Safety evaluation

Safety evaluation is a process to analyze results of load testing (measuring) and structural analysis or existing safety evaluation data as well as findings from member-specific condition assessment, materials testing, and a variety of measuring, instrumentation, survey and testing and thereby examine safety and load carrying capacity in a comprehensive way. Depending on the range of safety factor, the bridge inspected is classified into one of the five grades from Grade A to Grade E. Safety factor, SF, is calculated by dividing allowable stress by generated stress in allowable stress design method and design strength by required strength in strength design method, as presented in Table 3-27.

3.3.4. Major Defects and Repair and Reinforcement Methods

1) Major defects

Representative defects of bridge are 17 types as summarized in Table 3-33.

Table 3-32 | Major Defects

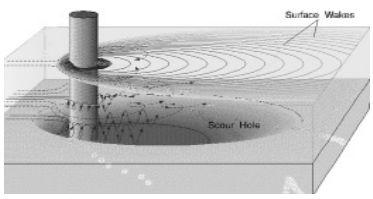
Defect	Defect is a state of instable initial deficiency deviant from the intended purpose caused by abnormal workmanship at stages of planning, design and construction that makes the system or the structure work incompletely.	
Damage	Damage is a condition of the structure working incompletely due to external or internal physical force.	
Deterioration	Deterioration is a process which makes a structure deformed and modified physically and chemically over time under natural and artificial influence.	
Scour	Scour is a phenomenon that water flow removes river bed materials around the structure. Local scour: rising flow and vortex Shrinkage scour: Higher flow velocity and smaller flow area.	

Table 3-32 | Major Defects (continued)

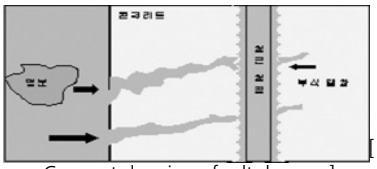
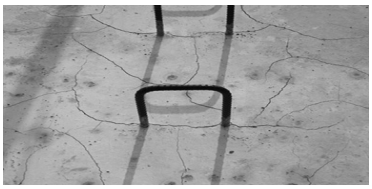
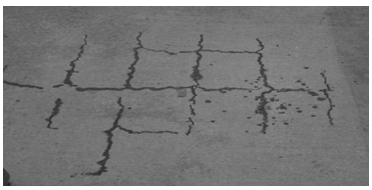
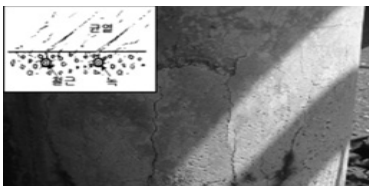
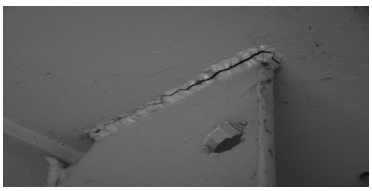
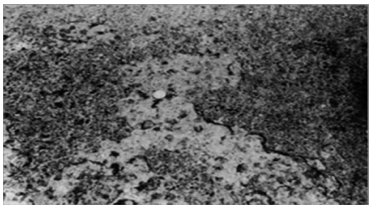
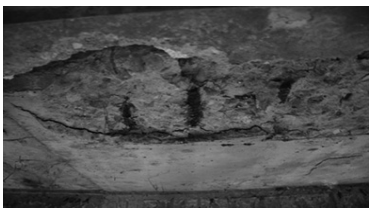
Alkali aggregate reaction	Alkali aggregate reaction is volume expansion due to chemical reaction between alkali contents (NaOH & KOH) in concrete and reactive aggregates and causes cracking and scaling.	
Salt damage	Salt mainly in sea water penetrates into capillary openings or voids of concrete, which make rebars in the concrete corroded and expanded in volume, causing cracks in concrete structures. Here, corrosion speeds up, causing scaling of surrounding concrete and reducing durability and life cycle.	 Concept drawing of salt damage]
Plastic Shrinkage Cracks	Plastic shrinkage cracks appear in the surface of fresh concrete. Soon after the concrete is placed and while it is still plastic, evaporation causes the concrete surface to dry out before it has set, causing tensile stress. These cracks are likely to occur when early age concrete has very low tensile resistance below restraint stress.	
Settlement Cracks	Soon after concrete is placed, settlement cracks appear due to settlement of the frame or poor compaction around rebars built in relatively deep section.	
Drying Shrinkage Cracks	Drying shrinkage cracks appear in irregular shape as moisture in the concrete evaporates in the course of curing.	
Rebar Corrosion Cracks	Rebar corrosion cracks are due to expansion in volume caused by corroded rebars in the concrete.	
Fatigue Cracks	If load within allowable level of stress applies to a steel structure, then this does not cause destruction. But repeated loads of this kind may cause fatigue cracks, possibly leading to sudden destruction.	

Table 3-32 | Major Defects (continued)

Scaling	Scaling is a process that concrete surface mortar gradually disappears (mainly by inappropriate finishing and curing of concrete.)	
Spalling	Spalling is a worsened delamination that concrete surface is broken off the main body due to cracks and explosive spalling.	
Leakage	Leakage is a condition that water comes out through concrete cracks or gaps.	
Delamination	Delamination is a process that as the Cl- ion comes in or concrete is carbonated, rebars begin to become rust, and thereby corrosion expansion pressure is imposed on the concrete around the rebars, separating the concrete and rebars.	
Efforescence	Efforescence is a solid white crystal in the concrete surface, which forms when hydrated lime and so on in the concrete melts in water and combines with CO2 in the air. It is evidence of concrete aging. In the worst cases, icicle-like free lime forms.	
Corrosion	Corrosion is a process that metals are damaged in a certain environment. - Types of corrosion: dry / wet corrosion - caused by environmental factors, current, leakage, excessive stress, wear, etc.	

Source: A Sourcebook of Structure Maintenance Practices (2012), KEC.

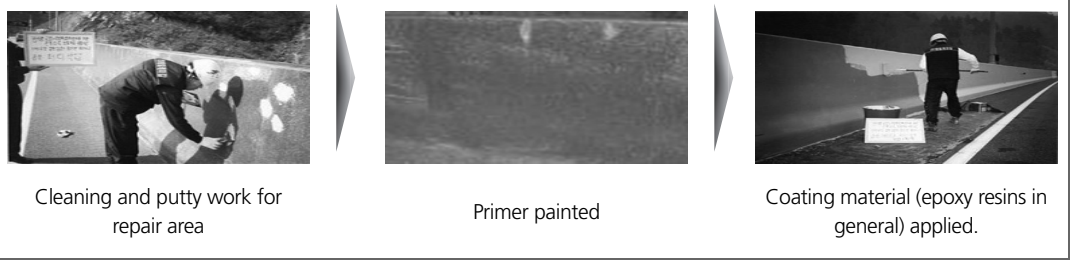
2) Introduction of major repair and reinforcement methods

Repair is to recover or enhance the durability of facilities, while reinforcement is a maintenance procedure seeking to recover or enhance mechanical properties of a member or structure such as load-carrying capacity and strength. It is necessary to consider carefully bridge

condition evaluation results for repair and bridge condition evaluation and safety rating results for reinforcement, and to determine how far a repair or reinforcement work needs to be made, given the type and degree of the defect, importance of the structure, environment, and economic aspect. In regards to the repair and reinforcement due to defects of the structure, applicability of the construction method, structural stability, and economic advantages should be taken into account in choosing construction materials and methods. In this case, what matters is a precise analysis on what caused the defect in the structure concerned, which in turn it is possible to select the appropriate repair method and material. Therefore, a precise analysis of causes for the defect should be conducted on the basis of structure related data of all kinds and results of diverse condition evaluation and safety rating carried out for diagnosis, before choosing the best suited method for the defective portion or member.

Above all, surface treatment is applied to micro-cracks (0.2 mm-deep or less) or non-structural cracks and to enhance the aesthetics of pavement. Epoxy-based materials, polyurethane, silicon, polymer cement, and cement mortar are used for surface treatment, which proceeds as illustrated in Figure 3-32.

Figure 3-32 | Surface Treatment Procedure



Cleaning and putty work for repair area

Primer painted

Coating material (epoxy resins in general) applied.

Source: Bridge Management Manual (2014), Korea Infrastructure Safety & Technology Corporation.

Sealing is used for 0.2 mm or larger cracks with epoxy resins.

Figure 3-33 | Sealing Procedure



Cracks sealed and bench in place

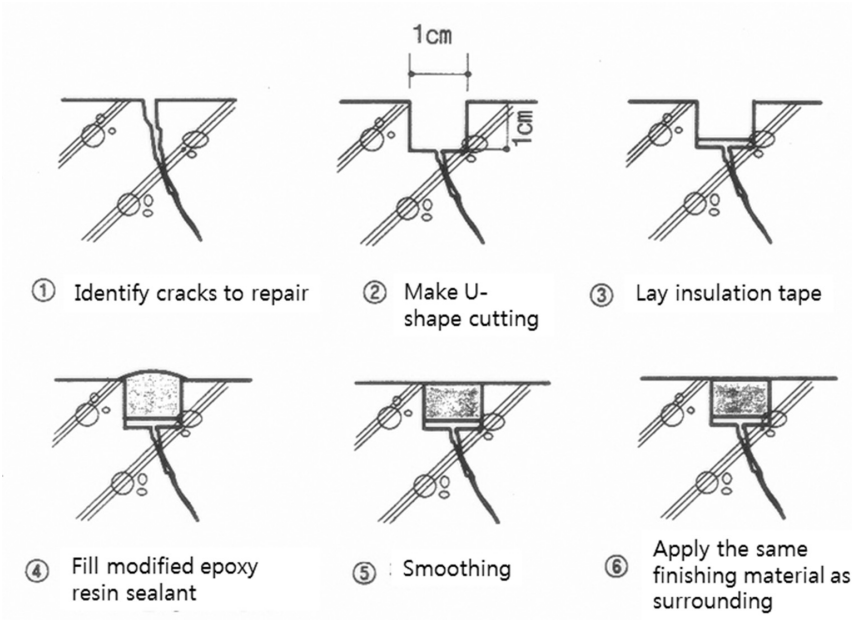
Epoxy sealing

Finishing

Source: Bridge Management Manual (2014), Korea Infrastructure Safety & Technology Corporation.

Filling is used to repair 0.5 mm or greater cracks with epoxy resins and epoxy-based lightweight mortar.

Figure 3-34 | Filling Procedure



Source: Bridge Management Manual (2014), Korea Infrastructure Safety & Technology Corporation.

Patching is in use for carbonated members or distressed components due to salt or freeze-thaw. Materials for this procedure are selected with consideration for construction conditions, existing concrete condition, and the surrounding environment.

Figure 3-35 | Patching Procedure



Cutting repair area | Breaking concrete | Mortar repair completed

Source: Bridge Management Manual (2014), Korea Infrastructure Safety & Technology Corporation.

To achieve an increased load-carrying capacity, steel plate reinforcement is performed with steel plates.

Figure 3-36 | Steel Plate Reinforcement Procedure



Plate fixing anchor in place | Fixing steel plates | Epoxy sealing and coat finishing

Source: Bridge Management Manual (2014), Korea Infrastructure Safety & Technology Corporation.

Fibre sheet reinforcement is carried out to increase load-carrying capacity with glass or carbon fibber.

Figure 3-37 | Fiber Sheet Reinforcement Procedure

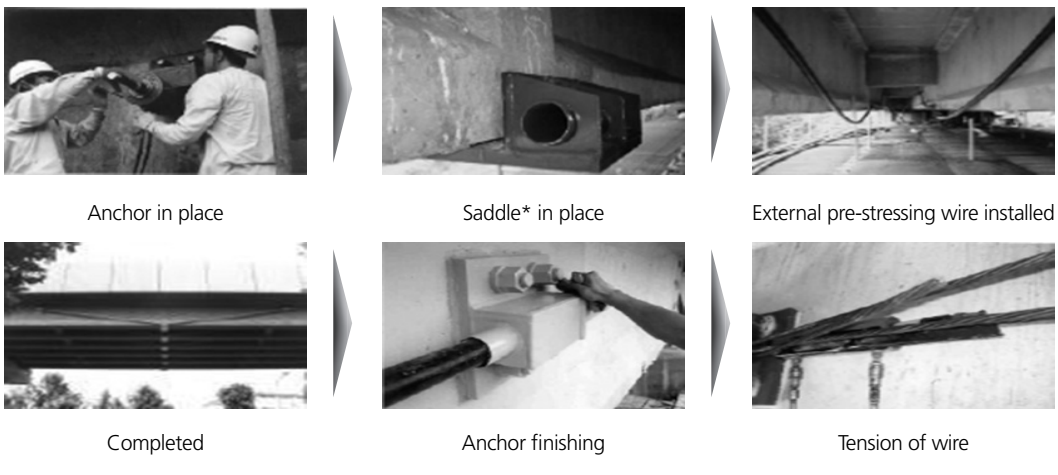


Concrete surface cleared & epoxy applied | Fiber sheet laid | Epoxy applied

Source: Bridge Management Manual (2014), Korea Infrastructure Safety & Technology Corporation.

Finally, fibre sheet reinforcement is a solution to enhance load-carrying capacity. Glass or carbon fibre is a common material used for this procedure.

Figure 3-38 | External Pre-stressing Wire Reinforcement Procedure



Anchor in place | Saddle* in place | External pre-stressing wire installed

Completed | Anchor finishing | Tension of wire

Note: Saddle is a spot where external pre-stressing wire is coiled to spread the stress.
Source: Bridge Management Manual (2014), Korea Infrastructure Safety & Technology Corporation

3.4. Introduction of BMS

3.4.1. Background and developments

The number of highway bridges subject to maintenance has risen 10 times over the past three decades or so from about 790 in 1982 to 8,500 in 2015, and that of 30-year or older bridges was approximately 490 in 2008, which is predicted to increase about five times to 2,360 by 2018 in 10 years from now. Consequently, it has become imperative to introduce a scientific system to manage older bridge structures more efficiently in limited budgets. The BMS enables bridge managers to record and monitor bridge management data with up-to-date database technology, store and analyse bridge condition evaluation data, prioritize repair and reinforcement works, and execute budgets effectively.

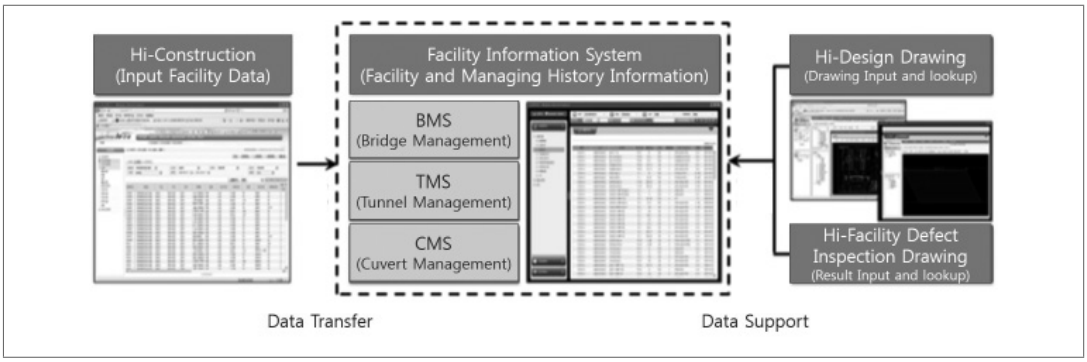
In Korea, the BMS was developed as a client/server-based system (where the user could use the system after installing a program at his or her PC) in November 1998 and enhanced into web based one (where the user can use the system simply using web browser, without the need of installing a separate program) in March 2004. The BMS has been improved annually to raise the efficiency of infrastructure management and solve various system issues since 2005. Repair and reinforcement prioritization system was developed in November 2011 with the aim of maximizing investment efficiency and assisting prompt and right decisions.

3.4.2. Key features

1) Overview

The Construction Department enters data on the structure into the Hi-Construction System prior to the completion of the construction, and the Maintenance Department examines the reliability of the data and receives the data. In addition, the Construction Department uploads design drawings onto the Hi-Design Drawings, and then the data are available in the Structure Information System used by the Maintenance Department. This Structure Information System manages the data and history records of bridges, tunnels, and culverts, of which BMS is a computerized system consisting of the Basic Module, the Inspection/Diagnosis Module, and the Repair/Reinforcement Module designed to manage structures in a scientific and efficient way by enabling the storage and display of bridge related information.

Figure 3-39 | Outline of Infrastructure Information System

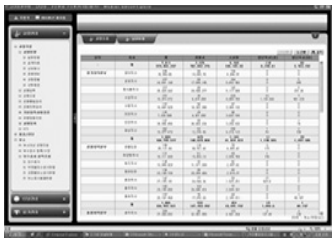


Source: Expressway Management Training Textbook (2013), KEC.

Specifically, the Basic Module of BMS is designed to manage basic bridge information and condition and provide a variety of statistics. It is comprised of the Bridge Data tap to view statistics, the Bridge Search tap to view detailed bridge-specific data, the Integrated Bridge

Search tap to find data of each bridge, the Bridge Drawing Search tap to view bridge-specific drawings, the Basic Entry Verification tap to verify data entry and errors, the Bridge Occupancy Search tap to view under-bridge occupancy data, and the Bridge Registration tap to register vehicles and change the management body.

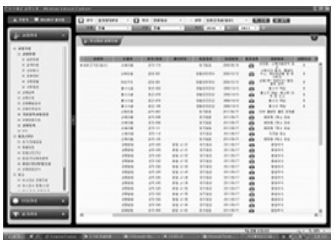
Table 3-33 | HBMS Basic Module

Classification		Feature
Basic Data	 <Bridge Data>	o **Bridge Data**: view statistics ※ (agency- and route-specific) general information, design loads, superstructure, service life, type, and condition ratings. o **Bridge Search**: view bridge-specific detail data ※ bridge register, location, drawings, investigation drawing, infrastructure management register, inspection and diagnosis information, repair registration/view, bridge structure type data, component-specific detail data, and initial inspection data. o **Integrated Bridge Search**: view bridge data by item. ※ Items: agency, route, distance, bridge specification, etc. o **Bridge Drawing Search**: view bridge drawings. o **Basic Entry Verification**: input data and error verification ※ Items: span/spot variability, basic data input rate, etc. o **Bridge Occupancy Search**: view under-bridge occupancy data o **Bridge Registration**: register bridges and change management authorities.
	 <Bridge Data>	

Source: Structure Information System (2015), KEC.

The Inspection/Diagnosis Module of BMS manages safety inspection and precise safety diagnosis data and evaluates structural defects and causes by type. This module provides regular/precise inspection, special inspection, and precise safety diagnosis features and has Inspection/Diagnosis Status tap to view data by item. The Repair/Reinforcement Module allows building up of bridge R&R data and history tracking and serves as a reference for the decision on R&R methods. It is made up of the Search Bridges Subject to Repair tap to view detailed information necessary for repair by bridge/component, the Repair Work Registration /Modification tap to register and modify repair results by bridge/component, and the Repair Work Performance Search tap to view repair work results by bridge/component.

Table 3-34 | HBMS Inspection / Diagnosis Module & Repair/Reinforcement Module

Classification		Feature
Inspection/ Diagnosis	 <Regular/Precise Inspection>	• **Regular/Precise Inspection**: register and view inspection plans/ results. • **Special Inspection**: register and view inspection plans/results. • **Precise Safety Diagnosis**: register and view diagnosis plans/results. • **Inspection/Diagnosis Data View**: view data by item. ※ Items: agency/rating/inspection type/bridge-specific data view, omitted item verification, and condition rating change verification.
Repair and Reinforcement	 < Search Bridges Subject to Repair >	• **Search Bridges Subject to Repair** : view detailed information necessary for repair by bridge/ component. • **Repair Work Registration/Modification** : register and modify repair results by bridge/component. • **Repair Work Performance Search** : register and modify repair results by bridge/component.

Source: Structure Information System (2015), KEC.

A Repair and Reinforcement Prioritization System prioritizes repair and reinforcement projects and supports the decision-making process using standardized evaluation algorithm in the course of plan development. Since the number of structures subject to management continues to rise and grow to be older and their maintenance costs soar despite budgetary constraints, this system was designed to maximize the investment efficiency within a limited budget and assist prompt and correct decisions. In order to help the personnel to evaluate repair and reinforcement projects objectively, not subjectively as before, the system selects prioritization standards given work type specific characteristics of 10 work types including bridge deck pavement and displays prioritization results automatically, upon user entering relevant figures in accordance with the standards. In this manner, this system makes it possible to select bridges to be repaired and reinforced first within a given budget. Introducing this system has made budget usage more efficient and detailed and

accurate safety inspection possible as data for prioritization standards are input through inspection findings.

As discussed so far, significant effects of the BMS used by the Korea Expressway Corporation are: making efficient management of structures possible through using a user-centred system; assisting in making decisions on the investment of construction costs; and enabling management by data, not by workforce, to name a few. The highway bridge management system, in particular, helps ensure the safety of users through bridge damage prediction and preventive maintenance based on scientific inspection and tracking and increase service life. It also raises economic advantages by managing the entire network and provides the optimal management environment that enables prompt and efficient management.

4. Comparative Analysis

4.1. Bridge Management Systems and Organizations

4.1.1. Bridge management laws and standards

Nicaragua has no bridge management related laws, and the Central American Bridge Risk Management Manual (Manual Centromericano de Gestión del Riesgo en Puentes, 2010) and the NICAPSAP Manual apply to bridge management practices. Despite having the Central American Bridge Risk Management Manual in place, the FOMAV outsources maintenance activities for roads covering pavements and bridges and has no bridge management organizations and personnel to carry out management duties as set out in the manual. The MTI uses the NICASAP Manual for bridge management and various bridge data and inspection findings are uploaded onto the management system.

This shows that bridge management practices in Nicaragua are greatly different than in Korea where the management is conducted in accordance with the Special Act on Safety Control for Public Structures and a series of detailed guidance. In Nicaragua, without detailed classification of bridges, inspection is conducted at least once a year in compliance with the Central American Bridge Risk Management Manual, while inspection cycles are determined in accordance with the condition scale (0: Best to 5: Worst) as set out in the NICASAP Manual. However, priority is given to the decision of the inspector, and visual inspection is performed at the level of regular inspection in Korea, with no classification system of inspection. Table 3-36 compares relevant laws and standards in Korea and Nicaragua.

As listed above, bridge management laws and standards are not properly in place, making consistent management practices hard in Nicaragua. Accordingly, bridge related laws, guidelines, and manuals are required to be formulated. For instance, inspection cycles and bridges subject to inspection must be specified in the relevant laws, and guidelines for inspection by bridge member would be necessary to make bridge management more efficient.

Upon the establishment of relevant laws and guidelines, moreover, bridges are required to be classified by inspection type, and inspection methods and cycles must be specified, as done in Korea. At present, bridges are not classified for management purposes in Nicaragua, and inspection remains at the level of regular inspection and is carried out via visual inspection and on a cycle decided at the discretion of the inspector. Consequently, these problems should be promptly resolved by the authorities in accordance with their internal policy prior to any legislation.

Table 3-35 | Comparison of Laws and Standards of Korea and Nicaragua

Classification	Korea	Nicaragua	
Relevant laws and standards	the Special Act on Safety Control for Public Structures of Korea	Central American Bridge Risk Management Manual	NICASAP Manual
Bridge type	Class 1&2 and other	N/A	N/A
Inspection type	Regular inspection, precise inspection, and precise safety diagnosis	Visual inspection to the level of regular inspection	Visual inspection to the level of regular inspection
Inspection frequency	Decided depending on condition grade. - once/semi-quarter-once/three years (safety inspection standard)	At least once/year	Decided depending on condition grade. (Priority is given to the views of the inspector.) - 0 - 2: once/6years - 4 - 5: once/year - Damaged bridges: within 1-6.
Condition Grade	5 grades A(Best)-E (Reconstruction needed)	N/A	6 grades 0(Best)-5(Worst)

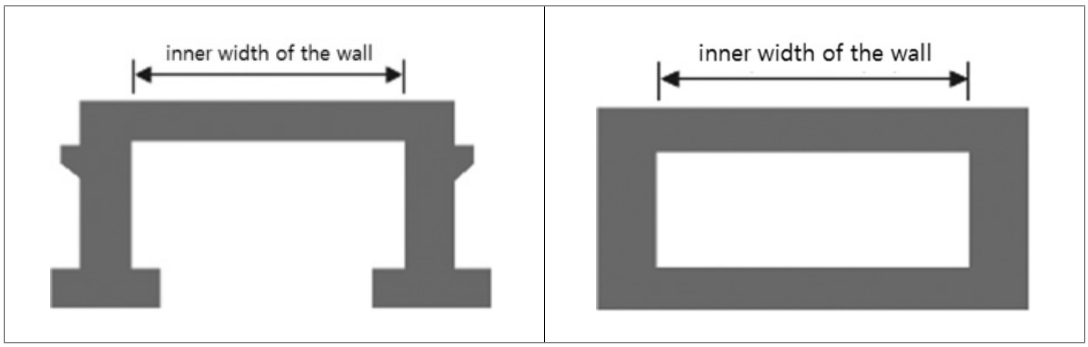
Source: Compiled by KSP Consultant (2015)

4.1.2. Definition of managed bridges

In Nicaragua, the number of bridges managed by the MTI is 2,888 and that of those by FOMAV is 2,485. MTI managed bridges and FOMAV managed bridges overlap. However, depending on the nature of the agency, the MTI is responsible for reconstruction of the managed bridges, and FOMAV for repair of the bridges. The field surveys on the FOMAV-managed bridges in Nicaragua revealed that many of the bridges belong to the category of culverts under the Korean classification system.

This is due to the different definition of bridges between the two countries. Nicaragua defines bridges as 'a structure having at least 6.0m of the central axle length included in the road', and 'all sorts of structures crossing over a river and supporting at least the weight of generally used cargo carrying vehicles' since 2001 (MTI, 2014). In Korea, bridges are defined as 'structures including piers crossing over obstacles such as waterways, roads, and railways which have tracks or passages for traffic and other cargo and enough space for traffic to pass'. In terms of length, they are defined as a structure where the distance between copings of abutments or clear span length exceeds 6m (KEC, 1990). Furthermore, rahmen bridges are discriminated from culverts by the width of inside wall, as depicted in Figure 3-40.

Figure 3-40 | Length Standards to Separate Rahmen Bridges and Culverts



Source: New Bridge and Culvert Classification Standards (2013), KEC.

As a result, definitions of the two countries are compared as in Table 3-37 below.

Table 3-36 | Comparison of Definitions of Bridges in Korea and Nicaragua

Classification	Korea	Nicaragua
Definition of bridge	Any and all sorts of structures crossing over a river and supporting at least the weight of generally used cargo carrying vehicles	Structures including piers crossing over obstacles such as waterways, roads, and railways which have tracks or passages for traffic and other cargo and enough space for traffic to pass.
Length management standard	Clear span length (width of inside wall for Rahmen bridges)	Total bridge length
Base length	A structure where the distance between copings of abutments or clear span length exceeds 6m.	6.0m or over of central axle length
Distinction between Rahmen bridges and culverts	Based on the width of inside wall.	N/A

Source: Compiled by KSP Consultant (2015).

As in Nicaragua, according to the definition of bridge, culverts are also managed as a bridge, and as a result, time for bridge inspection decreases. In this respect, a clarified standard to define bridges should be established to boost more thorough bridge inspection. Take a 2-cell box culvert (4.5×4.5m) for example. This culvert is defined as a culvert in Korea, because its width of inside wall is 4.5m, given the Korean definition of bridge based on the width of inside wall. In contrast, in Nicaragua, the definition is based on total length, and therefore the culvert is defined as a bridge, as it is as long as 9.0m including the width of the wall.

If Nicaraguan agencies follow Korean standards for bridge classifications, a significant number of drainage structures currently managed as a bridge will be labelled as a culvert, which would, we

believe, reduce the number of bridges considerably and make the management of major bridges more effective. Figure 3-41 shows drainage structures currently managed as a bridge in Nicaragua and structures managed as a culvert in Korea. Although they are similar in appearance, different management methods apply due to different standards of the two countries.

Figure 3-41 | Bridges in Nicaragua and culverts in Korea



Bridge in Nicaragua (San Benito)



Bridge in Nicaragua (Alcantarilla 4x60)



Culvert in Korea 1



Culvert in Korea 2

Source: Taken by KSP Consultant (2015).

Upon new standard for bridge definition established, inspection methods would change accordingly. As bridges are considered more important than culverts in Korea, there are diverse inspection cycles and methods available. Viewed as less important than bridges, culverts are inspected, when necessary. If Nicaragua re-defines the majority of the managed bridges as a culvert, this would reduce the number of bridges to be managed and increase time for bridge inspection, making intensified bridge inspection possible. However, a separate inspection standard would be necessary for structures which are changed from bridge to culvert, to make the management seamless.

4.1.3. Bridge management agencies

FOMAV has no bridge management organization, but MTI has a bridge management organization. On the other hand, the KEC as the Korean highway management agency is composed of Head Office, 7 Regional HQs, and 52 organizations. Bridge management organizations of both countries can be compared as documented in Table 3-38.

Table 3-37 | Comparison of Bridge Management Organizations of Korea and Nicaragua

Classification	KEC	MTI
Organization	- Head Office: 1 division, 2 teams (21 staffers) -Regional HQs (7) : 1 team, 3 departments (54 staffers) - Branch Offices (52) : 1 department (114 staffers)	- Road and Bridge Diagnosis and Evaluation Department of Planning Office (5 in total) - Road Maintenance Division of Road Office
No. of Staff	189 (inspectors: staff of HQs and Branch Offices)	5 (inspectors: 2)
Responsibility	General maintenance activities such as structure inspection, repair work, etc.	General maintenance activities such as structure inspection, repair work, etc.
Structures managed	Bridges, tunnels & culverts on highways (8,493 bridges, 760 tunnels & 9,254 culverts)	Bridges (2,888)
No of annually managed bridges per person	About 50 bridges /person/year	About 1,444 bridges/person/year

Source: Compiled by KSP Consultant (2015).

At MTI, five employees at HQ are engaged in bridge management, too small workforce, compared to the 189 structure management personnel of the KEC. As far as the number of bridges to be inspected by each staff member is concerned, one staffer inspects 50 bridges annually at the KEC, while two employees cover 2,888 bridges in Nicaragua, which means 1,444 bridges per person. Considering that the KEC personnel also manage 760 tunnels and 9,254 culverts in addition to bridges, the gap would be a lot wider in reality. In this respect, to achieve efficient bridge inspection and management, Nicaragua needs to launch or enlarge the bridge management team at FOMAV or at the MTI immediately and make sufficient bridge inspection workforce available to ensure thorough inspection.

4.2. Bridge Management System (BMS)

The comparison between NICASAP of Nicaragua and BMS of the KEC indicated that items of 'Bridge Basic Module' such as bridge name, location, length, type, and completion year and those of the 'Inspection Module' to upload and view inspection data are similar, but there were different items found as well. First of all, BMS of the KEC consists of the 'Repair and Reinforcement Module' and the 'Repair-Reinforcement Prioritization System Module' except for the two modules mentioned above, whereas NICASAP is made up of 'Routine Maintenance Module' and 'Prioritization Module' similar in name but different in usage. As far as the Prioritization Module is concerned, repair-

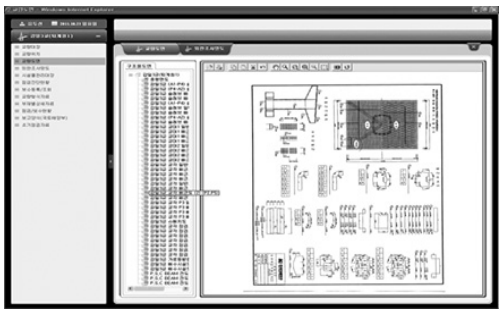
reinforcement priorities are given in line with an objective algorithm at BMS, while the module is used for reference purposes only in regards to repair and reinforcement works at NICASAP.

In addition, the two systems are found different in program operating system; BMS is a web-based system in which bridge managers anywhere in the country can access the relevant website and upload inspection and repair and reinforcement data of the bridge at his or her own computer, and, in turn, the data are stored in the relevant database In contrast, NICASAP is a C/S (Client-Sever) based system in which the program needs to be installed before data entry. It is managed by a single staffer of MTI, and the data is entered immediately after bridge inspection and repair. Moreover, interviews found that the database is managed by backing up data in a CD on a regular basis.

Figure 3-42 | Map and Drawing on KEC's BMS



Location of bridges on the map



Bridge drawing in the system

Source: BMS Information System (2015), KEC.

Similar features of the two systems, that is, 'Bridge Basic Module' has slight differences. In connection of bridge drawing DB management and indication of bridge location on the electronic map, BMS has DB's for most bridge drawings built up, while NICASAP has a function to upload and search bridge drawings. Moreover, it is possible to indicate and identify the location of the bridge on the map at BMS, but NICASAP has no similar function like this. Because bridge inspection standards are different by country, the 'Inspection Module' is designed differently among systems, but fit to the relevant inspection method.

Both systems have much in common basically, but many different features as well. These differences are mainly because despite being developed almost at the same time, BMS has undergone numerous improvements on a user basis over the past one decade, while NICASAP has never systemically improved since its inception in 2001. This may be because the number of bridges to be managed has risen amid the accelerating growth in bridge construction due to the growing attention to maintenance and safety in Korea, while priority is still given to road infrastructure development over bridge maintenance in Nicaragua. Since the Nicaraguan government pays more attention to bridge management than ever before, continued improvement of bridge management system from users' perspectives will make contributions to more efficient bridge management in the future.

Table 3-38 | Comparison of Bridge Management Systems

Classification		BMS of KEC	NICASAP of Nicaragua
System type		Web-based*	C/S (Client Server)-based**
Key features	Bridge Basic Module	Upload and view general specifications of bridges. (Bridge name, location, and type, etc.)	Upload and view general specifications of bridges. (Bridge name, location, and type, etc.)
	Inspection Module	Upload and view bridge inspection findings and print out reports	Upload and view bridge inspection findings and print out reports
	Repair-Reinforcement Module	Upload and view repair work data (Project name, construction method name, date of construction, etc.)	N/A
	Repair-Reinforcement Prioritization Module	Prioritize bridges to be repaired or reinforced.	N/A
	Prioritization Module	N/A	Upload bridge location, information on repair work method, and prices by repair work type. ※ For references only.
	Routine Maintenance Module	N/A	Upload and view data on cleaning, repair and reinforcement methods, bridge approach methods, etc.
	Administrator Module	N/A	Program's administrator function (e.g. creation, deletion, and modification of items)
Other	Design Drawing	Stored in the system	N/A
	Bridge location	Displayed on the e-Map	N/A
	Data upload	By each structure responsible person	One MTI staffer
Other	Data storage method	In a separate DB	Personal computer

Classification	BMS of KEC	NICASAP of Nicaragua
Personnel in charge of the system	170 (2 from HQ & other structure personnel from ROs and Branches)	1 (MTI HQ)

* : Without a separate program installed, the user can access the system via web browser.

** : A program needs to be installed and operated to access the system.
Source: Compiled by KSP Consultant (2015).

One of the biggest differences between NICASAP and BMS is who is responsible for data entry. In BMS, the person in charge of inspection directly enters and saves data in the browser, while, in NICASAP, the responsible person starts the program and enters inspection findings. This may take lots of time from inspection to data upload, decreasing the efficient, and if the computer of the person in charge does not work, data might be lost, resulting in huge damage. The KEC also developed the BMS in a C/S mode, but changed it to a web-based system for the user convenience and efficiency of bridge inspection. Therefore, it seems necessary to transform NICASAP into web-based system, too.

Moreover, it is also necessary to develop a database of bridge drawings at NICASAP. Bridge drawings are indispensable in the event of a defect and critical for bridge management. If they are not stored at NICASAP, it may take much time to find drawings if defects occur in a bridge. It is essential to make electronic files before entering bridge drawings, but the presence of paper versions should be verified first. For recently built bridges, however, drawings in CAD files may be uploaded onto the NICASAP.

Ⅳ SUGGESTIONS FOR EFFICIENT PAVEMENT MANAGEMENT IN NICARAGUA

In this chapter, we present recommendations to build the capacity of road assets management of Nicaragua on the basis of Korea's experience in this sector and results from the analysis on Nicaragua's current status in regards to road pavement and bridge management system. The recommendations are made in three aspects: common issues, pavement and bridge. In addition, estimated task-specific budget for the implementation of these recommendations have been proposed. A more in-depth review should be performed in the planning phase, since the budget was computed in consideration of Korea's experience and needs of Nicaragua with the aim of giving a general outline on the budget necessary by task.

1. General Comments

1.1 Stable Financial Sources

Although garnering funds for its operations from the oil tax at a rate of 16$/gal, FOMAV still needs additional financial sources to manage the entire national road network. Therefore, it is necessary to increase tax rates and explore diverse sources of taxation. In Korea, oil taxes are imposed at a rate of $1.8/gal (gasoline) and $1.3/gal (diesel), about 10 times the Nicaraguan tax rate. As a matter of fact, it is hard to directly compare the tax rates of the two countries to judge their appropriateness due to different economic scales and social environments such as income and public sentiment. Nevertheless, in an effort to secure financial sources for the sector, Nicaragua should seek to raise the tax rates to some degree by reaching a social consensus.

In addition to oil tax, in Korea, cars are taxed upon purchase at a rate of nearly 5% of their price as a road management financial source. Besides, diverse projects for profits such as toll imposition and service areas have been undertaken. The Nicaraguan authorities should find ways of stably securing budgets for the pavement and bridge management via public discussions and social consensus.

1.2 Expansion of FOMAV Organization

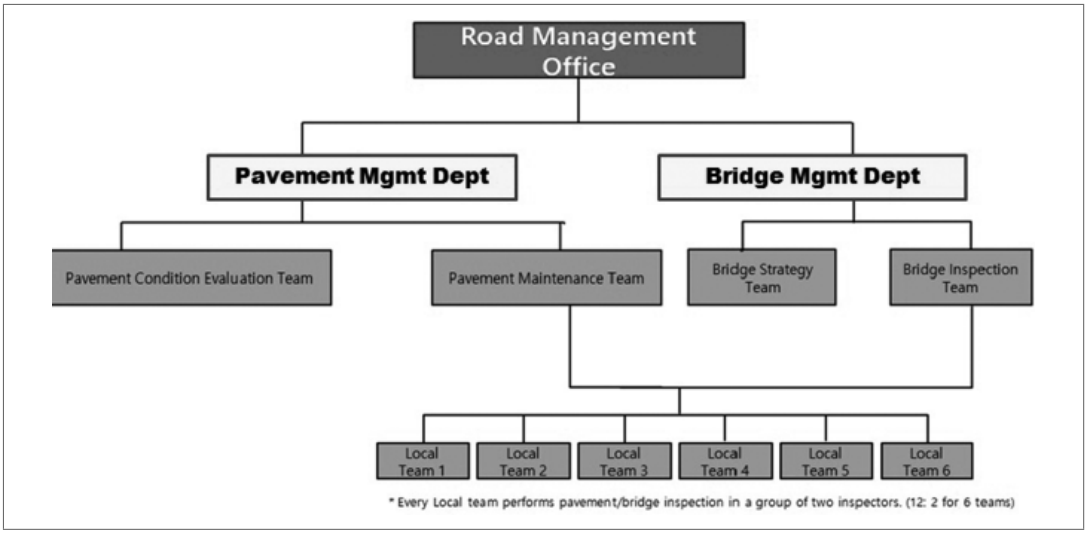
FOMAV should be expanded both in size and quality, as the organization is not big enough to effectively manage pavements and bridges of the national road network. To this end, the Planning

Office should be established, composed of the Pavement Management Department and the Bridge Management Department to help maintain the current organization and provide pavement management services seamlessly, as in Figure 4-1. Figure 4-1 and Table 4-1 show management organizations and their major responsibilities.

The Pavement Management Department should be further divided into two teams: the Pavement Condition Evaluation Team and the Pavement Maintenance Team. Specifically, the Pavement Condition Evaluation Team should examine pavement condition of the road network managed by FOMAV with survey vehicles and evaluate pavement condition by section, and the Pavement Maintenance Team manages pavement repair history and performs repair and maintenance prioritization and budget allocation. It also executes pavement improvement works and related incidental project works, sets up short- and long-term pavement repair and maintenance plan, and provides field support and supervision for the improvement of pavement quality.

Moreover, the Bridge Management Department should consist of the Bridge Strategy Team and Bridge Inspection Team. The former is responsible for bridge management planning and BMS operation, and the latter is in charge of bridge diagnosis and inspection and data entry into BMS, which are conducted by district personnel of six areas. For the Bridge Management Department, the proper number of the personnel has been calculated, with consideration for the KEC bridge management personnel. The KEC implements inspection of tunnels as well as bridges and culverts under the governing laws through each Regional Office; each inspector covers 6.3 km of bridge length on average. In contrast, there are no tunnels in Nicaragua, so the management takes place for short bridges and culverts only. One inspector examines 2.2 km in total. Given that bridge inspection staffs are sent from the capital city Managua in Nicaragua, the average length of bridges covered by one inspector should be set to nearly 2 times the KEC. We suggest that FOMAV put in place a bridge management unit so that one inspector can cover 166 bridges annually on average.

Figure 4-1 | Recommended Management Organization at FOMAV (Phase 1)



Source: Compiled by KSP Consultant (2015)

Table 4-1 | Responsibilities of FOMAV Pavement & Bridge Management Organization

Division		Responsibility
Pavement Management Dept.	Pavement Condition Evaluation Team	• Survey and analysis of managed section's pavement condition • Pavement survey with survey vehicles
	Pavement Maintenance Team	• Management of pavement R&R history • R&R prioritization and budget allocation • Implementation of pavement improvement work and related works • Short- and long-term pavement maintenance planning • On-site support and supervision for the improvement pavement quality
Bridge Management Dept.	Bridge Strategy Team	• Bridge maintenance planning and system establishment • R&R planning and execution management • Operation of BMS • Implementation of bridge engineer maintenance training
	Bridge Inspection Team	• Short-, mid-, and long-term bridge inspection planning and implementation • Execution of inspections covering regular, in-depth, and emergency inspection • Entry of inspection data into BMS • Implementation of precise safety diagnosis

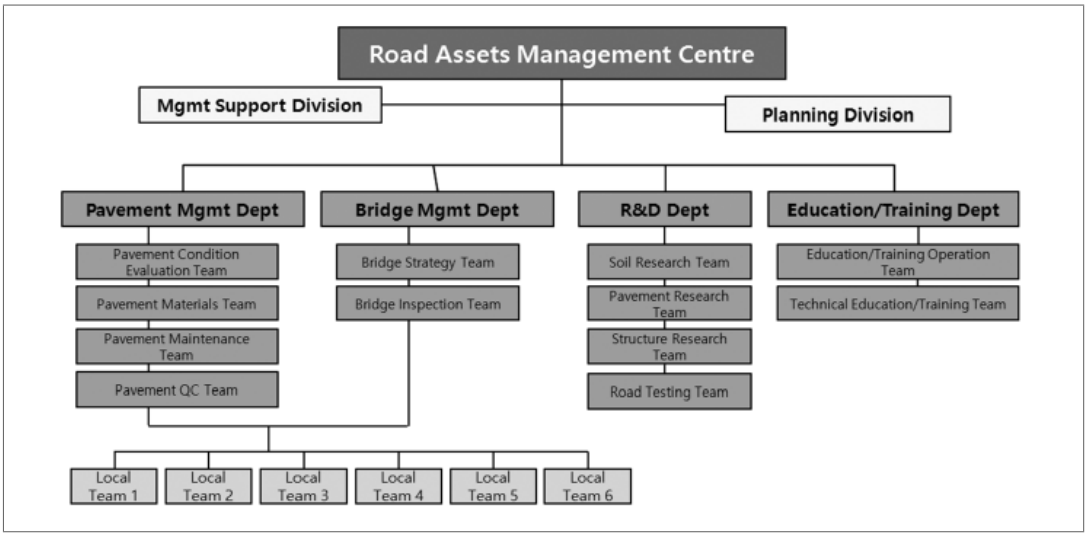
Source: Compiled by KSP Consultant (2015).

1.3. Formation of Road Assets Management Centre

As the number of bridges and pavements requiring maintenance is on the rise amid the ongoing increase in infrastructure assets, Nicaragua should form an organization in charge of road R&D efforts and education / training of professional workforce to ensure scientific management and efficient use of budget in the long term. In this respect, it is recommended to launch the Road Assets Management Centre (named so tentatively) dedicated to the efficient management of pavements and bridges and related research undertakings, as an expansion of the Road Office as we suggested. The Centre should be composed of the Pavement Management Department, the Bridge Management Department, the R&D Department and the Education /Training Department. Pavement and Bridge Management Departments are organized as in Table 4-1 and under the control of the Centre upon its establishment. The R&D Department is responsible for developing a road map of the road network in Nicaragua and research projects for this purpose, putting findings from research projects into practice for the enhanced performance of pavements and bridges across the country. The Education/Training Department provides education and training with respect to the operation of equipment, management of pavements and bridges, and operation and maintenance of road assets management systems. Manuals for the management of road assets should also be improved considering local factors, with testing items refined. Quality control measures and programs should be developed and put in place so that pavements and bridges perform properly for the period as designed.

Drawing on the construction cost of the KEC HRD Centre, the construction of the Road Assets Management Centre is estimated to cost a quarter of the KEC HRD Centre (1 story underground/ 5 stories above); approximately US$5,000,000 for education building and accommodation building (3 stories above ground) and US$2,000,000 for operation equipment and laboratory installations. Further, an estimated US$500,000 is required to develop related education/training programs and hire professional workforce. It is desirable to build the Centre when the bridge management system and practice stand on a firm ground. Required organization and costs are shown in Figure 4-2 and Table 4-2.

Figure 4-2 | Organization of the Road Assets Management Centre (Phase 2)



Source: Compiled by KSP Consultant (2015).

Table 4-2 | Costs of establishment of Road Assets Management Centre (USD)

Category	Amount
Basic Planning and Operation Strategy Development	100,000
Establishment of the Centre	5,000,000
Procurement of equipment	2,000,000
Development of training programs and human resources	600,000
Total	7,700,000

Source: Compiled by KSP Consultant (2015).

The Road Assets Management Centre will serve as a think-tank to drive the accelerating development of the country's road technology and policy and build up and utilize diverse data

related to road assets. The Centre is also expected to make contributions to the increase of national profits and pave the way for Nicaragua to take the lead in the road pavement and bridge management practice in the region by sharing research outcomes and providing technology transfer and services including quality testing.

2. PMS

Our suggestions regarding the PMS are presented as below.

2.1. Pavement Survey Vehicle Upgrade for Enhanced Efficiency

As part of effort to hire a pavement survey vehicle for its pavement management operations, FOMAV introduced the Hawkeye-1000 early in 2015. To ensure the efficient use of pavement survey vehicles efficiently, improvement of the survey vehicle, development of operation and analysis workforce, entry of survey findings into the PMS, and prescription of related regulations should be taken into consideration. Even though the Hawkeye-1000 is considered most suitable, given the situations of Nicaragua, equipment upgrade should be made for the efficient development of the PMS. The current equipment is designed to measure longitudinal profiles at two points, detect the location with a distance measuring instrument mounted on the wheels, and measure pavement conditions with a camera installed in the vehicle. To raise the accuracy of distance measurement, however, a GPS-based system should be in place and upgraded to measure pavement surface directly for an in-depth analysis of pavement conditions. We suggest that vehicles for this vehicle should be upgraded to Hawkeye-2000 or equivalent which can collect quantified data by means of pavement condition measuring and automatic crack recognition.

Table 4-3 | Costs of Improvement of Pavement Condition Survey Vehicle (USD)

Category	Amount
Equipment improvement	300,000
Total	300,000

Source: Compiled by KSP Consultant (2015).

2.2. Analysis and Improvement Design of Existing PMS

In order to upgrade SIGMAVIAL as the existing PMS to meet the needs of Nicaragua, its configuration, component modules and database should be examined to find issues to be improved, and to set directions for improvement. Findings from this KSP project show that SIGMAVIAL is based on HDM-4 logic in general and some of its features are reduced. For instance, performance model, LCCA model or combination of available maintenance method scenarios are not properly realized in SIGMAVIAL, requesting further examination, which proceeds by defining the improvement directions and roles of a new PMS to be developed in Nicaragua practically on the basis of the

existing system, defining realization methodology, analyzing modules to be added, and defining the GUI configuration method. The process also covers the definition of component modules and creating links. Required costs are shown in Table 4-4 below.

Table 4-4 | Costs for Analysis and Improvement Design of Existing PMS (USD)

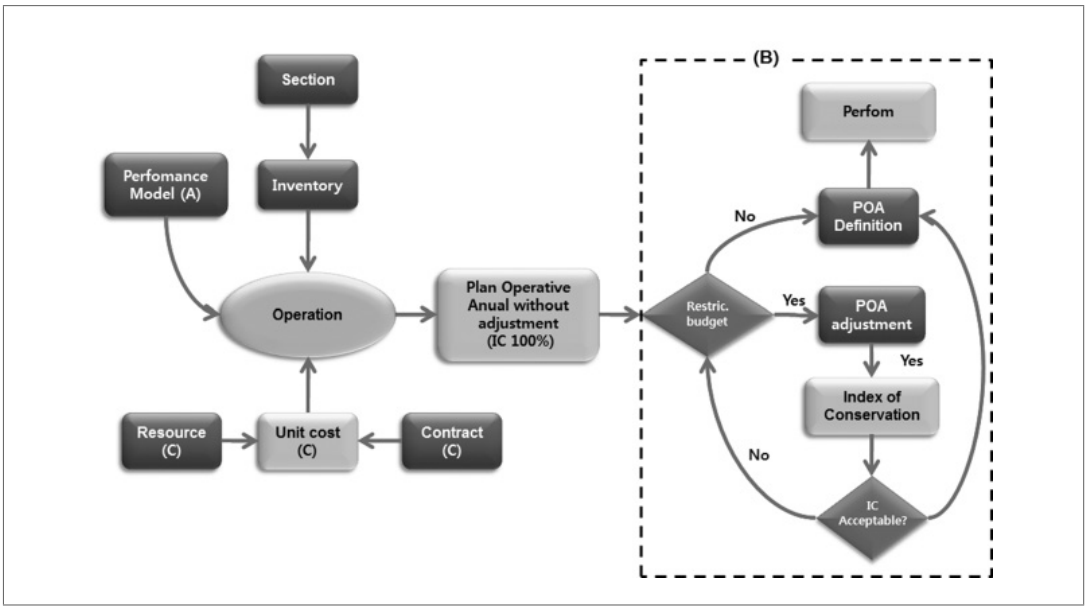
Category	Amount
Analysis and improvement design of existing PMS	200,000
Total	200,000

Source: Compiled by KSP Consultant (2015).

2.3. Pavement Management Server Development and System Improvement

The existing system of FOMAV seems to be more of a simple program than an integrated system and to be more suited to a small group as it is a closed-end Client/Server system. Therefore, the system should be modified into a web basis, followed by making up for weaknesses of the decision-making logic, in accordance with future strategies of FOMAV and its capabilities.

Figure 4-3 | SIGMAVIAL Logic Improvements



Source: Informe Final – Anexo 5 : Manaul de Usuario del SIGMAVIAL – Consultoría : "Desarrollo de un Sistema Integral de Gestión del FOMAV"(2013), FOMAV

As shown SIGMAVIAL logic, it seems that the performance model (A) provides no clear-cut standard to determine individual or overall damage condition for the application of maintenance methods. For according to Figure 4-3 above, any pavement condition index qualification method as in (B) is not specified, and prioritization of maintenance sections is not logical. In other words, there is a lack in logic of pavement condition index development, and the process to decide which roads should be maintained first from the index is not systematic. Consequently, criteria should be set forth with respect to what type of pavement damage or which pavement condition should be maintained, in order to improve the efficiency of relevant budget allocation. Furthermore, there is no model presented concerning annual change in pavement performance. HDM-4, in reality, provides a performance model of cracking and rutting constituting the comprehensive index IRI, making it possible to analyze how the pavement will change over time and to conduct an LCCA for a certain period of time. Although SIGMAVIAL determines feasible alternatives and priorities by comparing initial construction costs simply with consideration for input data, such prioritization lacks in validity since the program has no quantified index for pavement condition and performance model.

As a result, pavement lifecycle prediction and LCCA features should be added to the program to provide a basis for more reasonable decision. In selecting maintenance methods, SIGMAVIAL allows for a simple comparison of costs for alternatives entered by the analyst only, as illustrated in (B), and this may lead to the application of maintenance methods chosen by the field staff at their option. In contrast, HDM-4 suggests the optimal alternative by combining all the options selected by the input personnel. Therefore, SIGMAVIAL should be improved to have more sound and efficient logic behind maintenance method selection. Furthermore, a management server should be installed to save diverse field data on pavement condition and provide better access. With these matters in mind, the existing system should be enhanced to allow for more efficient road network management in Nicaragua. Costs for the system improvement and upgrade as suggested above are listed below.

Table 4-5 | Costs for PMS Improvement and Upgrade (USD)

Category	Amount
Improvement of existing system	500,000
Server development	500,000
System upgrade	400,000
Total	1,400,000

Source: Compiled by KSP Consultant (2015)

2.4. Road and Pavement Database Development

A broad range of road pavement data are available, including pavement types, classifications of layers and materials, gradients, geometric structures, traffic volumes, year of construction, and constructor, to name a few. For the efficient management and operation of road pavement, these diverse data should be built up into database to promote efficient extraction. Database development for pavement condition and performance including cracking, rutting, pothole, and IRR should continue. A pavement condition prediction model should be in use to execute the budget efficiently and establish an appropriate maintenance alternative. From the experience of Korea, database development is a tough on-going process requesting enormous time, workforce and money, but it is the key to successful operation of PMS. This is why the first priority needs to be given to the development of database, which can be the basis to find causes for phenomena and solve problems happening in pavement. Required costs for this purpose are as in Table 4-6.

Table 4-6 | Costs for Road and Pavement DB Development (USD)

Category	Amount
Digitalization of road and pavement history data	400,000
Development of pavement condition DB	500,000
Total	900,000

Source: Compiled by KSP Consultant (2015)

2.5. Development of Pavement Condition Quantification Index

The most important element of PMS development and operation is the pavement condition standard, which determines maintenance priorities. Currently, FOMAV uses IC as a pavement condition index, but it is a bit vague and complex index with too many non-pavement elements, making its specification and standardization difficult. The index is not seen as sufficient to reflect pavement conditions of the entire road network in Nicaragua, since it was developed heavily relying on data of other countries. Therefore, IC has limitations as a pavement maintenance standard and therefore, a new index tailored to Nicaragua like HPCI of KEC is needed.

In methodology, a specific pavement condition index suited to the situation of Nicaragua (climate, environment, traffic, and materials) may be developed or the HDM-4 performance model may be used. However, the latter requires an optimization process of appropriately adjusting coordination factors to meet different conditions of each country. Until now, no report has been made regarding a case that any county uses the HDM-4 performance model for PMS, and therefore, we recommend the development of new index. For pavement condition qualification, a series of processes to determine field survey method, distress calculation method, data processing and index computation method should be performed, and everything needs to be specified so that identical distress and condition index can be obtained even if survey vehicle and personnel change. We suggest panel

rating as the most widely used pavement condition index development method. In order to develop the index, it is necessary to set apart damage types which most adversely affect road pavement conditions in Nicaragua first, define the method which can quantify individual damage cases, and assign riding quality ratings based on actual driving test on the road. Next, an index is produced by connecting the ratings and known information. This index will be a more realistic barometer to indicate Nicaragua's road pavement condition.

Table 4-7 | Cost of Pavement Condition Quantification Index Development (USD)

Category	Amount
Collection of performance data from index development	400,000
Research and index development	200,000
Total	600,000

Source: Compiled by KSP Consultant (2015)

3. BMS

Our suggestions regarding BMS are presented as below.

3.1. Refinement of Definitions of Bridges to Be Managed

As documented above, definitions of bridges are different between the two countries and, as a result, many structures that would be regarded as a culvert in Korea become a bridge in Nicaragua. Consequently, a clearer standard for the definition of bridges is considered necessary. Inspection methods should change upon the establishment of new definitions of bridge by which the current bridges are split into bridges and culverts. This is because bridges are considered more important and their structural characteristics more complicated than culverts. If most of the bridges currently managed in Nicaragua are defined as a culvert, this may lead to the decrease in the number of bridges manage, which can significantly reduce time for bridge inspection and enable intensive inspection of bridges. Nevertheless, a separate standard for the inspection of structures whose classification changes from bridge to culvert should be developed for the seamless management. In this regard, referring to the Korean classification system, we suggest the bridge classification criteria as in Table 4-8. The suggested classification criteria are discussed in more detail in Appendix 2.

Table 4-8 | Suggested Bridge Classification Criteria for Nicaragua

Class	Criteria
Class 1	Special bridges (suspension, cable-stayed, arch, and truss bridges) Bridges with a total length of 50m or over.
Class 2	Bridges with a total length of 25m to 50m that do not fall into Class 1.
Other	Bridges with a total length of 6m to 25m that do not fall into Class 1 or Class 2.
Culvert	Structures with a total length of less than 6m

Source: Compiled by KSP Consultant (2015).

Under the criteria, bridges managed by FOMA are classified as in Table 4-9.

Table 4-9 | Proposed Bridge Classification for Nicaragua (FOMAV)

Class	Total	Class 1	Class 2	Other	Culvert
No	1,995	83	158	964	790
%	100	4.2	8.0	48.3	39.5

Source: Compiled by KSP Consultant (2015).

3.2. Establishment of Bridge Inspection System

At present, there are no clarified standards and legal basis for bridge inspection in place in Nicaragua, and standards are not available regarding inspection cycles and inspection agencies by bridge type. Therefore, considering the need of bridge inspection system and methods by class, we recommend bridge inspection for Nicaragua by drawing on the Korean standards.

Bridge inspection should be carried out in safety inspection and preside safety diagnosis: safety inspections are divided into regular and in-depth mode. Regular inspection is performed by experienced qualified personnel with resort to visual inspection or inspection equipment to find inherent risk factors of bridges. Furthermore, precise safety diagnosis is conducted with a view to detecting physical and functional faults by examining, measuring, and assessing structural safety and causes for faults and suggesting repair/reinforcement alternatives.

It is recommended that Nicaraguan authorities divide bridge inspection depending on the object of inspection, cycle, and agency for safety inspection and precise safety diagnosis. Regular inspection should be performed by the personnel at local teams every six months for bridges in Classes 1 and 2 as the KEC does in Korea, given their importance and every year for other bridges. For in-depth inspections, the Bridge Maintenance Team of the FOMAV HQ and six local teams under the supervision of the Technology Division should work together on the inspection of bridges that fall into Classes 1 and 2 only. It is considered desirable to perform in-depth inspection every one to three years depending on a comprehensive rating result (Grades A to E) as in Korea.

Table 4-10 | Recommendation for Regular Inspection

Category	Frequency	Method
Class 1 & 2 Bridge	Every 6 months	Implemented under the responsibility of local responsible person
Other Bridge	Every year	

Source: Compiled by KSP Consultant (2015).

Table 4-11 | Recommendation for In-depth Inspection

Category	Frequency	Method
Class 1 & 2 Bridge	Grade A (every 3 yrs.) Grade B & C (every 2 yrs.) Grade D & E (every yr.)	Bridge Maintenance Team and local team

Source: Compiled by KSP Consultant (2015).

Emergency inspection should take place upon damage found during a disaster or unexpected accident or in case where heavy rainfall, a typhoon or an earthquake is likely to cause defects of a bridge and be conducted more closely than regular inspections, with its importance in mind.15

Table 4-12 | Recommendation for Precise Safety Diagnosis

	Agency	Category	Frequency	Remarks
Precise safety diagnosis	Phase 1: FOMAV Phase 2: Professional safety diagnosis agency	Class 1	Every 4-6 yrs.	Grade A: 6 yrs. Grade B & C: 5 yrs. Grade D&E: 4 yrs.
		Class 2 & Other	If necessary	

Note: Initial precise safety diagnosis should be carried out 10 years after the completion of construction, and subsequent diagnoses are performed depending on the condition rating obtained in the initial diagnosis.

Source: Compiled by KSP Consultant (2015).

Table 4-13 provides a summary of suggestions for Nicaraguan bridge inspection practice.

Table 4-13 | Recommendation on Bridge Inspection Frequency for Nicaragua

Class	Inspection type	Agency	Category	Frequency	Remarks
Safety inspection	Regular inspection	Local team	Class 1 & 2 bridge	Every 6 months	
			Other bridge Corrugated steel plate culvert	Every year	
	In-depth inspection	Bridge Maintenance Team and local team	Class 1 & 2 bridge	Every 1-3 yrs	Grade A: 3yrs Grade B &C: 2yrs Grade D&E: 1 yr
	Emergency inspection	Bridge Maintenance Team and local team	Relevant bridge	If necessary	To the level of in-depth inspection
Precise safety diagnosis		Phase 1: FOMAV Phase 2: Professional safety diagnosis agency	Class 1 bridge	Every 4-6 yrs	Grade A: 6 yrs Grade B &C: 5 yrs Grade D&E: 4 yrs
			Class 2 and Other	If necessary	

Note: Culverts are inspected as necessary.

Source: Compiled by KSP Consultant (2015).

It is suggested that a precise safety diagnosis be conducted regularly for Class 1 bridges only 10 years after the completion of construction and every four to six years according to comprehensive rating results. For bridges of Class 2 and others, precise safety diagnosis should be performed depending on the condition of the relevant bridge. Trained for bridge inspection to some degree, the FOMAV personnel should be responsible for the precise safety diagnosis at Phase 1 and entrust the diagnosis to a professional safety diagnosis service provider at Phase 2 where the private sector is seen to have enough capacity to do it. Given its importance, precise safety diagnosis in Nicaragua should be carried out in the same cycles and standards as in Korea.

To allow a better understanding on bridge inspection activities, inspection areas and issues by bridge type are documented in Appendix 3, which is a brief summary of key inspection issues of major bridges in Nicaragua. For actual inspection activities, a bridge inspection manual tailored to the needs of Nicaragua should be adopted. A damage type-specific bridge maintenance manual should be prepared as well to help decide on the best maintenance measures against structure damage and ensure efficient and economic repair and reinforcement. Developing these manuals is projected to cost roughly USD 200,000 each.

Table 4-14 | Details of BMS Development in Nicaragua

Manual	Content	Amount (USD)
Bridge Inspection Manual	Major inspection methods by bridge type	200,000
Bridge Maintenance Manual	Maintenance and construction methods by damage type	200,000
Total		400,000

Source: Compiled by KSP Consultant (2015).

3.3. Introduction of BMS

As FOMAV performs no bridge management operations, it needs a BMS that helps efficient bridge management practices along with established bridge inspection team and standards. BMS used by the KEC in Korea has several modules: the Basic Module for the inquiry and registration of general status of bridges, the Inspection Module for the input and inquiry of inspection results, the Repair & Reinforcement Module for the inquiry of repair and reinforcement objects and results of repair and reinforcement works, and the Prioritization System for the efficient operation of limited budgets. It is advisable to configure priority components before necessary system upgrades that follow. Furthermore, as NICASAP operated now in MTI is C/S (Client Sever) based, requiring a program installation to start up the system, and is not available on the web, we suggest that FOMAV install its own BMS.

Three priority components should be configured first: the Basic Module that provides a quick overview of bridge status, the Inspection Module that allows the input of inspection results and printing out of report, and the Repair and Reinforcement Module that presents general information of repair and reinforcement works. A detailed description of configuration of the three modules is provided in Appendix 4. Moreover, in NICASAP of MT, inspection data are entered into the system by one system staff member, which may cause errors in data entry and take too much time to make inspection findings displayed in a short time. Therefore, FOMAV should have the inspector directly enter data into the system on a web-based system, in which data can be entered directly on site and be checked real time at HQ.

Considering possible expansion of infrastructure management in the future, it is recommended that the system be configured on a web basis, rather than C/S (Client Sever) basis.

Table 4-15 | Nicaraguan BMS Development Budgets

Classification		Amount (USD)	Remarks
System design		200,000	
System configuration cost	New development	1,500,000	
	Hardware	500,000	
	Commercial software	70,000	
	System maintenance	310,000	15% of system configuration cost
	Manual development	15,000	150 copies (200 pages)
	System training support	150,000	4 persons (6 trips)
	Sub-total	2,545,000	
Bridge DB development		800,000	Bridge log digitalization and drawing development
System upgrade and improvement		600,000	
Total		4,145,000	

Source: Compiled by KSP Consultant (2015).

3.4. Safety Inspection Equipment and Facilities Installation for Efficient Bridge Inspection

We suggest introducing diverse bridge inspection tools and facilities, which are needed to carry out regular and in-depth inspections. Among those are the movable inspection equipment such as a ladder for the inspector to access to the inspection site, high place operation car, and bridge inspection vehicle, cleaning tools like brush to clean the bridge surface and grinder, and inspection and measuring equipment such as inspection hammer, bore scope mirror, telescope, ruler, torch, and measuring instrument.

There are fixed and movable inspection facilities; fixed types include pier inspection equipment and abutment inspection stairs, which help reduce the risk of the inspection personnel while working at a high place and carrying out repair work and minimize losses in time and effort when it is necessary to set up or remove a work platform. These facilities also make safety inspection effective by providing easy access to the pier and abutment whenever necessary. Accordingly, we suggest installing fixed inspection facilities at expansion joints and abutments of major bridge type Class I bridges (83) first because expansion joints are highly likely to become deteriorated (corroded) in the bearing and pier concrete due to leakage at the bridge superstructure. Abutment inspection stairs should be installed first, as they are cheaper and easier to construct than pier inspection stairs.

Along with such fixed inspection facilities, movable inspection equipment should also be made available for the inspection of sections where no inspection facilities exist. Above all, the bridge deck should be inspected with a high place operation car from the substructure and a bridge inspection vehicle in the superstructure. Three sets of high place operation car need to be purchased to allocate to two local teams, and it is desirable to purchase a bridge inspection vehicle uninhibited by lower bridge conditions if there is no road under the bridge, with taking into account local situations. It is desirable to purchase one unit of bridge inspection vehicle first and afterwards purchase more if necessary. It is important, however, that while the bridge inspection vehicle is in use, traffic control should be taken in the superstructure to ensure the safety of the inspector.

Besides, it seems more suitable to use a pole camera for the inspection of shorter bridges, considering the local conditions in Nicaragua. Pole cameras may be useful for bridges as tall as 6m or shorter and serve as an effective alternative to fixed inspection facilities until they are set up. Nine sets of pole camera including three spare sets should be ideal, one for each local team.

Figure 4-4 | Inspection of Bridges with a Height of 6m or Less Using a Pole Camera



Inspection of bridge support (camera angle adjustable)



Photos displayed and saved (on smartphone)

Source: Structure Maintenance Training Materials (2013), KEC.

Costs for the purchase of such fixed inspection facilities and movable inspection equipment are presented in Table 4-16. Pier inspection facilities should be built at 23 Class 1 bridges as long as 100m or over and abutment inspection stairs at all Class 1 bridges standing at 83 in number. A total of three units of expansion joint systems should be mounted, one for the pier and two for the abutment. Two sets of abutment inspection stairs should be built on both sides of the abutment.

Table 4-16 | Inspection Facilities and Equipment Costs for Nicaragua

Classification		Qty	Unit Price (USD)	Amount (USD)	Remarks
Movable inspection equipment	Bridge inspection vehicle	1	1,000,000	1,000,000	Capable to inspect as wide as up to 20m and as deep as 8m and to carry 4 persons.
	High place operation car	3 (1 unit per 2 regions)	100,000	300,000	Capable to inspectup to 50m Capable to carry 2 persons.
	Pole camera	9 (6 regions+ 3 spare units)	2,000	18,000	Wifi and smartphone based.
	Sub-total			1,318,000	
Fixed inspection facilities	Pier inspection facilities	23x3=69	10,000	690,000	Based on 2-lane bridges with a 12.6m width
	Abutment Inspection stairs	83x2=166	1,000	166,000	12m long, 0.6m wide
	Sub-total			856,000	
Total				2,174,000	

Source: Compiled by KSP Consultant (2015).

3.5. Recommendations for In-serviceable Bridge Inspection Prioritization

Bridges on 12 NIC routes with higher availability in terms of traffic and freight volume, which account for 12% of the total, have been chosen for inspection, in consideration of diverse priority variables that affect the safety and maintenance of the bridges, such as length, width, length, height, and structure type, seismic rating, disaster protection rating, years of service, and traffic volume depending on the scale, use, location, and fatigue of the bridge. In Korea, prioritization of these variables is decided according to a seven tier priority system as in Table 4-17. In Nicaragua, maximum span length, superstructure, and total length are among the three key factors taken into account when determining the scope of bridges subject to inspection.

Table 4-17 | Priorities in The Importance of Bridges

Classification	Priority						
	1st	2nd	3rd	4th	5th	6th	7th
Variable	Max. span length	Super structure	Total length	Years of service	Bridge width	Load rating	Construction cost

Source: Standard for the Importance of Major National Infrastructure (2010), Korea Infrastructure Safety and Technology Corporation (KISTEC)

From FOMAV bridge data, it is considered desirable to select bridges subject to Class1precise safety diagnosis and Class 2 in-depth inspection, with superstructure type and total length in mind. Of priority factors, maximum span length was excluded due to the lack of data reliability. As a result, the following bridge inspection standard has been set up, as in Table 4-18.

Table 4-18 | Bridge Inspection Standard

Factor	Class 1	Class 2	Other
	Precise safety diagnosis	In-depth inspection	Regular inspection
Total length	50m≤L	25m≤L<50m	6m≤L<25m
Superstructure type	In respect of superstructure, suspension bridge, cable-stayed bridge, and truss bridge are subject to Class 1 precise safety diagnosis.		

Source: Compiled by KSP Consultant (2015).

Of 754 bridges on the 12 NIC routes managed by FOMAV, those requiring precise safety diagnosis are as many as 42 for Class 1, while the number of those requiring in-depth inspection amounts to 49. Appendix 5 provides analysis results of these bridges, which are classified in detain as in Appendix 6 by route name, management number, type, location, length, and width.

With respect to rough inspection costs by bridge type, precise safety inspection and in-depth inspection per concrete bridge cost 88,000 dollars and 22,000 dollars, respectively. In the case of steel bridge, per bridge cost of precise safety inspection and in-depth inspection are 99,000 dollars and 22,000 dollars, respectively, while special bridge (truss bridge) requires 110,000 dollars for precise safety diagnosis and 33,000 dollars for in-depth inspection.

Taken together, costs of precise safety diagnosis and in-depth inspection of 91 bridges nationwide in Nicaragua reach approximately 5,104,000 dollars, which would be required upon Nicaragua's bridge management system established and should be executed step by step, with priorities and budget taken into account. Table 4-19 shows estimated inspection costs for 91 bridges.

Table 4-19 | Estimated Costs of Precise Safety Diagnosis and In-depth Inspection of Bridges in Nicaragua (USD)

Bridge type	Precise safety diagnosis (Class 1, 50m≤L)			In-depth inspection (Class 2, 25≤L50m)		
	No	Unit cost	Inspection cost	No	Unit cost	Inspection cost
Concrete bridge	15	88,000	1,320,000	27	22,000	594,000
Steel bridge	24	99,000	2,376,000	22	22,000	484,000
Special bridge	3	110,000	330,000	-	33,000	-
Sub-total	42		4,026,000	49		1,078,000
Total	5,104,000					

Source: Compiled by KSP Consultant (2015).

4. Summary of Suggestions

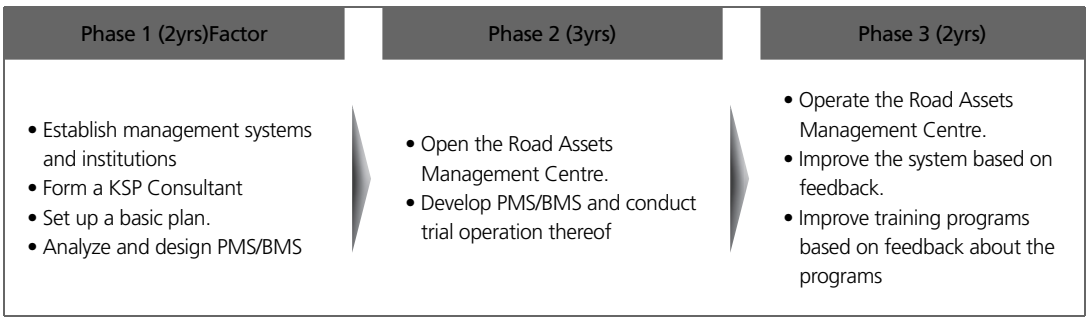
On the basis of a wide spectrum of data collected from field surveys and data analysis, we propose a 3-phase master plan over 7 years that aims to raise the efficiency of pavement and bridge management practices in Nicaragua.

In the initial stage of the plan for two years, system and organization for pavement and bridge management should be established to be tailored to the country's needs. Stable financial sources for maintenance should be secured and a dedicated organization should be formed. Moreover, a long-term plan should be set up to open the Road Assets Management Centre and implement pavement and bridge maintenance training program planning and development. In addition, basic design should be prepared to configure PMS/BMS, followed by a macroscopic review and analysis of component modules. Establishment of the system and organization should come before anything else as they are the basis to push forward subsequent tasks.

Phase 2 is a stage where the Road Assets Management Centre is established as planned at Phase 1 for a period of three years and testing equipment is introduced for R&D activities. PMS /BMS should be developed as designed and evaluated in the previous stage, Phase 1 and necessary DB should be built up.

Finally, at Phase 3, a plan should be established to operate the Road Assets Management Centre in an efficiency way and enhance the performance of the road network in Nicaragua. It is also essential to develop a plan for the quality enhancement of training, taking into account feedback on training provided at Phase 2. Besides, complementation and stabilization should be performed regarding problems to help the newly developed BMS and improved PMS work better.

Figure 4-5 | Phases of the Master Plan for Nicaraguan PMS/BMS



Source: Compiled by KSP Consultant (2015).

The suggestions made above should be put into practice in the long run under a detailed action plan by phase.

Table 4-20 | Road Management Action Plan by Phase

Phase		Common	Pavement	Bridge
Phase 1	Year 1	• Find ways of securing maintenance budget stably. • Set up a plan for KSP Consultant • Develop a basic design and operation plan for the Road Assets Management Centre (I). • Plan for the development of training programs.		• Prepare bridge inspection manuals • Design BMS.
	Year 2	• Enact a law on how to secure the budget. • Set up KSP Consultant • Develop a basic design and operation plan for the Road Assets Management Centre (II). • Develop training programs (I).	• Analyze issues to be improved for PMS survey vehicles and make improvements. • Assess and produce improved design of existing PMS	• Prepare R&R manuals • Purchase movable bridge inspection equipment (II) • Design BMS (II)
Phase 2	Year 1	• Operate the KSP Consultant (I) • Open the Road Assets Management Centre (I). • Develop training programs (II).	• Improve PMS (I). • Develop pavement/ bridge DB (I). • Develop pavement condition evaluation quantification index (I)	• Install fixed bridge inspection facilities (I). • Develop BMS (I). • Build bridge DB (I).
	Year 2	• Operate KSP Consultant (II) • Open the Road Assets Management Centre (II). • Plan for lab equipment procurement • Foster professional workforce (I).	• Improve PMS (II). • Develop pavement/ bridge DB (II). • Develop pavement condition evaluation quantification index (II)	• Install fixed bridge inspection facilities (II). • Develop BMS (II). • Build bridge DB (II).
	Year 3	• Operate KSP Consultant (III) • Open the Road Assets Management Centre (III). • Purchase lab equipment (I) • Foster professional workforce (II).	• Improve PMS (III). • Develop pavement/ bridge DB (III). • Develop pavement condition evaluation quantification index (III)	• Develop BMS (III). • Build bridge DB (III).
Phase 3	Year 1	• Put in place decision making system (I) • Operate KSP Consultant (IV). • Purchas test equipment (II) • Nurture professional workforce via training (III).	• Further improve PMS (I)	• Further improve BMS (I).
	Year 2	• Put in place decision making system (II) • Operate KSP Consultant (V). • Improve workforce training programs based on feedback	• Further improve PMS (II)	• Further improve BMS (II).

Source: Compiled by KSP Consultant (2015).

When it comes to the action plan for common issues, activities for Year 1 of Phase 1 include budget planning, KSP Consultant development planning, and training program development planning. In the second year, legislation of relevant laws to ensure stable funding should be pushed forward, and a dedicated pavement and structure organization should be formed at FOMAV. At the 2nd phase, the dedicated organization should be operated in an efficient manner to help establish the structure management system on a firm ground, and focus should be on the foundation of the Road Assets Management Centre. On top of that, test equipment for the Centre should be purchased concurrently with the construction of the buildings. Training programs should be upgraded to help foster professional workforce. At Phase 3, inspection and repair/reinforcement related decision making systems should be in place to improve and enlarge the management system stabilized in the previous phase, and efforts to cultivate professional workforce should continue. From feedback on previous training sessions, training programs should be improved continuously.

With respect to the action plan for pavement management, Hawkeye-1000 should be upgraded to collect more data, given that PMS is on the basis of road pavement condition survey as found in the first phase. In addition, data analysis should be automated to produce meaningful information within the shortest time possible. It is especially important to know what the essential modules for the PMS optimized for Nicaragua are and to set directions and strategies for the development of PMS. At Phase 2, the project should cover qualification of pavement condition evaluation, development of road and pavement condition database, and improvement of the PMS, in connection with pavement maintenance. Accordingly, it is necessary to prescribe pavement condition survey and analysis methodology and develop and verify a logical index for the purpose of Nicaraguan pavement condition qualification. That is to say, existing non-logical elements should be removed, and a realistic evaluation standard should be set up. At the third phase, the PMS developed at the 2nd phase should be updated to boost utilization of results. In consideration of the growing Internet communication network and road organization in Nicaragua, among others, feedback should be gathered via a web-based PMS accessible by all FOMAV officials. Manuals and training programs should be available for the operation and maintenance of the newly built PMS, and relevant laws or systems should be in place for reasonable and systematic allocation of road pavement maintenance budgets.

As to bridge management, the following action plan may be developed for the system. First of all, during the relevant system establishment at the first phase, clear bridge classification system should be generated for bridge inspection, along with a new standard for inspection methods and cycles considering Nicaragua's needs as mentioned above. In regards to movable inspection facilities, one set of bridge inspection equipment, three sets of aerial work platform, and three pole cameras should be available. At Phase 2, the system designed for three years at Phase 1 should be installed, into which bridge data should be entered. In particular, a close pilot operation should take place in an attempt to minimize system errors, and upon error occurring, it is critical to correct and improve the system through a thorough analysis of root cause. Furthermore, for the enhanced efficiency of inspection, fixed inspection facilities should be also mounted as suggested in this report; expansion joint for 100m or longer bridges and pier inspection stairs for the entire Class 1 bridges. At Phase 3,

further system improvements should be made. This needs to be continued for bridge management practice as it is indispensable to enhance the efficiency of bridge management. Responsible engineers should always reflect these enhancements into the relevant systems and mechanisms.

Thus far, we have described phased action plans for common issues, bridge and pavement management, respectively. These action plans should be implemented in sequence to attain goals of each phase, but some elements at Phases 1 and 2 may be put into action depending on the situations in Nicaragua. Reorganization of relevant practices may take place while capacity building workshop for pavement and bridge inspectors are underway. Also, movable inspection equipment may be purchased and used for the training. Costs for the Nicaraguan pavement ad bridge management road map and detailed action plans are estimated around at USD 18 million as shown in Figure 4-6. The costs are based on the budgets suggested above.

Figure 4-6 | Nicaraguan PMS/BMS Capacity Building Project Road Map

Category	Description		Phase 1			Phase 2				Phase 3			Total
			Year 1	Year 2	Sub-total	Year 1	Year 2	Year 3	Sub-total	Year 1	Year 2	Sub-total	
Common	System	Planning & legislation for stable sources of maintenance budget											
		Decision-making system in place											
	Organization	Planning & establishment of KSP Consultant											
		Operation of KSP Consultant											
	Road Assets Mgmt Centre	Basic plan & operation planning for the Centre	50,000	50,000	100,000								100,000
		Opening of the Centre				1,700,000	1,700,000	1,600,000	5,000,000				5,000,000
	Lab Equipment	Lab equipment procurement planning											
		Lab equipment procurement						1,000,000	1,000,000	1,000,000		1,000,000	2,000,000
	Training	Training program development planning	100,000		100,000								100,000
		Training program development		100,000	100,000	100,000			100,000				200,000
		HR development via training					100,000	100,000	200,000	100,000		100,000	300,000
		Training program improvement based on feedback											
	Sub-total		150,000	150,000	300,000	1,800,000	1,800,000	2,700,000	6,300,000	1,100,000	-	1,100,000	7,700,000

PMS	Survey Vehicle	PMS survey vehicle improvement		300,000	300,000								300,000
	PMS Development & Operation	Analysis and improvement design of existing PMS		200,000	200,000								200,000
		PMS server development & system improvement				200,000	700,000	100,000	1,000,000				1,000,000
		Road/pavement DB development				300,000	300,000	300,000	900,000				900,000
		Pavement condition evaluation quantification index development				100,000	300,000	200,000	600,000				600,000
		Further upgrade of PMS								200,000	200,000	400,000	400,000
	Sub-total		-	500,000	500,000	600,000	1,300,000	600,000	2,500,000	200,000	200,000	400,000	3,400,000
BMS	Manual	Development of inspection and R&R manual	200,000	200,000	400,000								400,000
	Inspection Equipment	Procurement of movable bridge inspection equipment		1,318,000	1,318,000								1,318,000
		Installation of fixed bridge inspection facilities				428,000	428,000		856,000				856,000
	BMS Development & Operation	BMS design	100,000	100,000	200,000								200,000
		Development of BMS				700,000	700,000	1,145,000	2,545,000				2,545,000
		Bridge DB development				300,000	300,000	200,000	800,000				800,000
		Further upgrade of BMS								300,000	300,000	600,000	600,000
	Sub-total		300,000	1,618,000	1,918,000	1,428,000	1,428,000	1,345,000	4,201,000	300,000	300,000	600,000	6,719,000
Total			450,000	2,268,000	2,718,000	3,828,000	4,528,000	4,645,000	13,001,000	1,600,000	500,000	2,100,000	17,819,000

Source: Compiled by KSP Consultant (2015).

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Knowledge Sharing Program

2015 KSP - IDB Joint Consulting :

Smart Grid Project for the Expansion of Electricity Distribution Infrastructure in the Dominican Republic

Part 4

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List of Abbreviation

Abbreviation	Full Description
3G	Third Generation Network
ADSL	Asymmetric Digital Subscriber Line
AHP	Analytic Hierarchy Process
AMI	Advanced Meter Infrastructure
AMM	Advanced Metering Management
AMR	Automatic Meter Reading
B/C	Cost-Benefit
BI	Business Intelligence
BMT	Benchmark Test
BPL	Broadband Power Line
BTL	Build Transfer Lease
BTO	Build-Transfer-Operate
BOO	Build-Own-Operate
BOT	Build Operate Transfer
CAD	Computer Aided Design
CB	Circuit Breaker
CBL	Customer Base Line
CDMA	Code Division Multiple Access
CDEEE	Corporación Dominicana de Empresas Eléctricas Estatales
CDE	Corporación Dominicana de Electricidad

Abbreviation	Full Description
CIM	Computer Integrated Manufacturing
CIS	Customer Information System
COS	Cut Out Switch
CT	Current Transformer
DAS	Distribution Automation System
DCC	Distribution Control Center
DCU	Data Concentrate (Collection) Unit
DG	Distribution Generation
DIS	Distribution Information System
DLMS	Device Language Message Specification
DMS	Distribution Management System
DNP	Distribution Network Protocol
DTRS	Digital Trunked Radio System
DTS	Dispatcher Training Simulation
EDEESTE	Empresa Distribuidora de Electricidad Este
EDENORTE	Empresa Distribuidora de Electricidad Norte
EDESUR	Empresa Distribuidora de Electricidad Sur
EMS	Energy Management System
EGE Haina	Empresa Generadora de Electricidad Haina
EGEHID	Empresa de Generación Hidroeléctrica Dominicana
EGE Itabo	Empresa Generadora de Electricidad Itabo
ESB	Enterprise Service Bus
ESS	Energy Storage System
E-Type	Economic Type Electronic Meter
ETED	Empresea de Transmisión Electrica Dominicana
EV	Electric Vehicle
Feeder	Distribution Line
FEP	Front End Processor

Abbreviation	Full Description
FLISR	Fault Location Isolation and Service Restoration
FMA	Fault Management Application
FPI	Fault Path Indicator
FRTU	Feeder Remote Terminal Unit
GIS	Geographic Information System
GPRS	General Packet Radio Service
GPS	Global Positioning System
G-Type	General Type Electronic Meter
HFC	Hybrid Fiber Coax
HMI	Human Machine Interface
ICCP	Inter Control Center Protocol
ICSID	International Center for Settlement of Investment Disputes
ICT	Information and Communications Technology
IDB	Inter-American Development Bank
IEC	International Electrotechnical Commission
IHD	In-Home Display
IMS	Information Management System
IoT	Internet Of Things
IPTV	Internet Protocol TV
ISND	Improving the System of Nationwide Distribution
IT	Information Technology
KEPCO	Korea Electricity Power Corporation
KODAS	Korean Distribution Automation System
KOTRA	Korea Trade-Investment Promotion Agency
KPI	Key Performance Indices
KSP	Knowledge Sharing Program
LBS	Load Break Switch
LTE	Long Term Evolution

Abbreviation	Full Description
LV	Low Voltage
MA	Maintenance Application
MCA	Magnetic Card Acquisition
MDB	Multilateral Development Bank
MDMS	Meter Data Management System
MPL	Monitoreo de Proceso de Lectura
MV	Medium Voltage
NCIS	New Customer Information System
NDIS	New Distribution Information System
NDSC	National Distribution Supervisory Center
NMS	Network Management System
NOA	Network Optimization Application
NOP	Normal Open Point
NPA	Network Planning Application
PCG	Partial Credit Guarantee
PRG	Partial Risk Guarantee
PRI	Political Risk Insurance
P.tr	Pole Transformer
PLC	Power Line Communication
PPA	Power Purchase Agreement
PT	Potential Transformer
QA/QC	Quality Assurance/Quality Control
RF	Radio Frequency
RTU	Remote Terminal Unit
RTP	Real Time Pricing
RMU	Ring Main Unit
SA	Substation Automation
SAIDI	The System Average Interruption Duration Index

Abbreviation	Full Description
SAIFI	The System Average Interruption Frequency Index
SCADA	Supervisory Control and Data Acquisition
SCLG	Single-Currency Loan Guarantee
SENI	Sistema Eléctrico Nacional Interconectado
SFDA	Single Feeder Diagram Application
SNF	Sub-National Finance
SFDA	Single Feeder Diagram Application
SOA	Service Oriented Architecture
SOAP	Simple Object Access Protocol
SOP	Standard Operation Procedure
ST	Smart Transportation
TOC	Total Operation Center
ToU	Time Of Use
TPL	Terminal Portable de Lecturareading
TRS	Trunked Radio System
TWACS	Two-Way Automatic Communication System
UI	User Interface
UPS	Uninterruptable Power Source
VFM	Value For Money
VPS	Visual Projection System

Summary

The main objective of this Project is to establish guidelines to improve the efficiency and operation stability of the infrastructure of distribution networks for the state owned Electricity Distribution Companies (EDEs) in the Dominican Republic. These guidelines are developed by a consultancy team with extensive experience and expertise of Smart Grid technology and know-how of smart grid project development in Korea. Data of this report was collaboratively gathered by the KSP consultancy team and Corporación Dominicana de Empresas Eléctricas Estatales (Dominican Corporation of State-owned Electrical Companies, or CDEEE). The information was collected during three (3) official visits by the consultancy team.

There is need for improvement in the current distribution system of the Dominican Republic. Many weaknesses are found in the system, such as deterioration of electrical networks and lack of appropriate equipment needed for optimal operations. Currently, the installed capacity appears to be sufficient to cope with the maximum demand of the SENI (Sistema Eléctrico Nacional Interconectado) . However, 52% of EDE's customers are affected by constant electricity outages due to restricted supply of electricity caused by technical and financial limitations. It is noted that 81% of all technical outages is caused by overload and poorly equipped feeders.

The ploblem is mainly derived from the type of current networks. The networks are of the radial type which reduces flexibility and safety to operations especially when load changes, outages and faults occur. Additionally, radial networks lead to critical operation problems when power demand exceeds the capacity of the facilities or when an expansion is required in urban areas with high population density and high population growth. In sum, the radial design restricts the operation and management of the networks and is an obstacle to enhanced network efficiency. With the increase in power demand due to urban growth, these networks have been converted to loop type networks in many other countries. Advantages of the loop network topology are it increases flexibility of operation mode and provides real time information about the status of the network to operators at every point, which minimizes power outages and ultimately improves the quality of electricity supply to customers.

In summary, a reliable electricity distribution and a fully automatic system are required for improved management of the networks. This can be achieved by installing automatic load breakers, switches and protection devices. With the implementation of new technologies and loop type net-

works, it is expected that CDEEE would be able to improve the reliability of electricity supply and in turn reduce frequency of power outages to a level comparable to international standards.

Besides, the Dominican Republic government and the EDEs have made progress in the reduction of non-technical losses to some extent by means of anti-tampering technologies and social capital investment in consciousness-raising education. However, as these efforts are limited to specific areas, reduction of non-technical losses is below the actual desired level of at least 20%. Specifically, non-technical losses reduction programs had not been large scaled due to limited economic resources of the EDEs. In this context, the construction of Meter Data Management System (MDMS) for telemetering control is recommended to improve the operations of telemetering systems properly and systematically.

Furthermore, the focus of management and investment for reduction of non-technical losses should not fully concentrate on low voltage usage customers given that this user sector does not represent the larger energy consumption. Thus, this focus shall be revised and distributed by comparing non-technical losses of large consumption customers. At present, there is no comparison between technical losses of low and large consumption customers; this lack of useful information makes it difficult to be informed of current trends and to discuss policies, resources and measures for effective reduction of non-technical losses.

Given the economic and social circumstances of the Dominican Republic, certain requirements should be considered to improve electricity supply service and ensure the competitiveness and financial security of the country. In this regard, KSP consultancy team recommends an in-depth feasibility studies to provide guidelines for the following projects: implementation of the automation of distribution networks; installation of MDMS to be used with the telemetering system; and expansion of electricity distribution networks and substations based on a loop structure using resources from the government and private sector.

I Overview

1. Project overview

This KSP-IDB Joint Consulting Project is entitled "Smart Grid Project for the Expansion of Distribution Infrastructure in the Dominican Republic". This project is aimed at improving the efficiency of electricity distribution infrastructure in the Dominican Republic, a nation that suffers high financial and social capital losses owing to inadequate and inefficient electricity distribution infrastructure, and thus unstable and unreliable power supply.

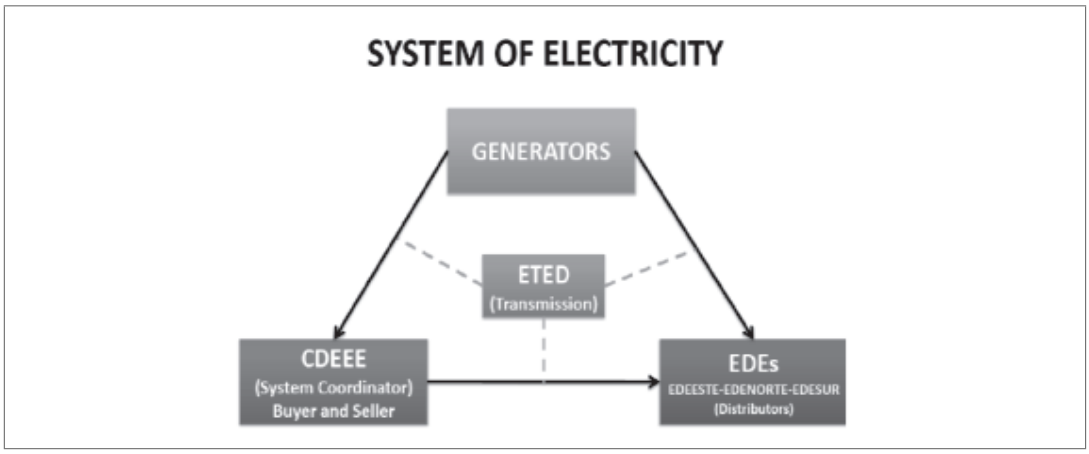
The final report presents technical contents and technical alternatives (presented as recommendations) based on an analysis of distribution data offered by CDEEE as well as data obtained during field surveys (1st: Aug. 26-Sept. 4, 2015; 2nd: Nov. 5-Nov. 21, 2015; and 3rd: Jan. 25- Feb. 1, 2016). This report includes a project baseline analysis as well as alternative technical recommendations - the automation of distribution networks and installation of a Meter Data Management (MDM) to be used with the telemetering system and conditions for the design, development and sustainable expansion of electricity distribution infrastructure for a smart grid network in the Dominican Republic.

2. Power industry status in the Dominican Republic

2.1. Structure of the electrical industry in the Dominican Republic

A national power connection system is an organized entity that manages the installation of facilities such as those for power generation, power transmission, power maintenance, power transformation, and power distribution. In the Dominican Republic, a national power connection system (National Interconnected Electric System or SENI) links power plants, three power distribution stations (EDEs) and one power transmission company (ETED). The following Figure 1 shows Power industry structure of the Dominican Republic.

Figure 1 | Power industry structure of the Dominican Republic



Source: The power market of major Latin American countries, 2014, KOTRA

2.1.1. Power Transmission Network

There are currently 20 power substations of 138/69 kV; the length of power transmission lines of 138 kV is 2,362 km, while that of 69 kV is 1,713.3 km.

2.1.2. Power Distribution Network

Three power distribution companies are found in the Dominican Republic. These three companies, namely EDEESTE, EDENORTE, and EDESUR, are in charge of power distribution and sales. The percentage of sales by power distribution company is as follows: 32% for EDEESTE, 32% for EDE NORTE, and 36% for EDESUR. Regarding power distribution voltage, the primary voltage uses 12.5 kV and 7.2 kV, while the secondary voltage uses 480 V for electric power and 240 V or 120 V for electric light.

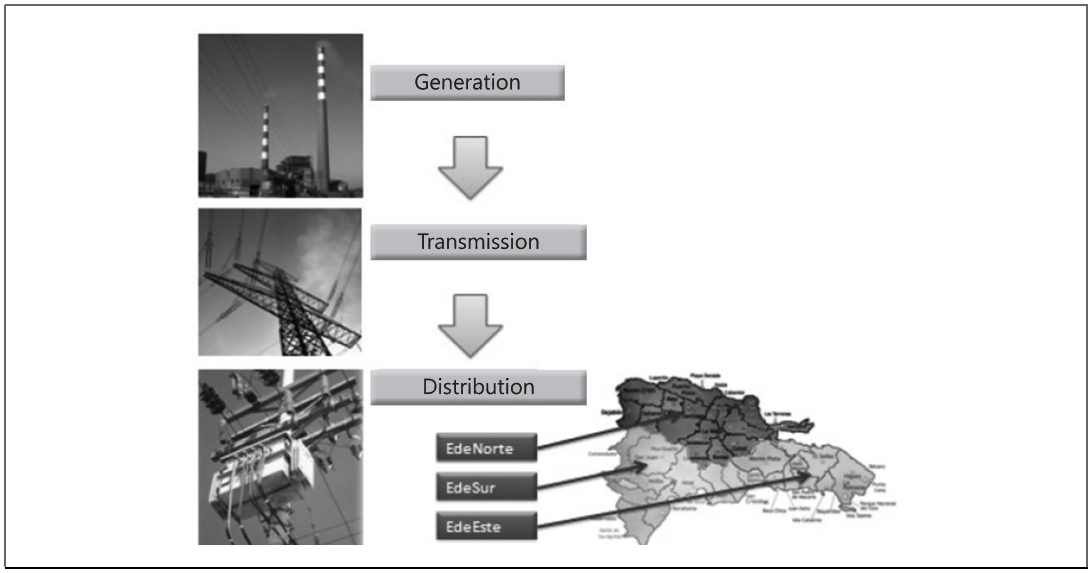
The power transmission system loss rate of the entire national power system is relatively stable, with a record of about 3-4%. However, there is a serious loss rate of the power distribution system with a record of approximately 30-40% (compared to 4% for Korea) due to reasons like ageing power distribution cables, power theft, and unpaid bills. As of 2008, the power loss rate by power distribution companies was 44.3% for Ede Este, 37.9% for Ede Sur, and 36.6% for Ede Norte.

2.1.3. Power Market and Trade

The power trade system in the Dominican Republic was introduced in 1998 based on the cost-based structure established in Chile. The power market can be classified as a bilateral contract market and a spot market based on Power Purchase Agreement (PPA). Basically, utilities provide contracted power with distribution companies under a PPA. If supply is insufficient, power is purchased from the spot market and is supplied to distribution companies. Bilateral contract can be signed between market segments, i.e., power generation companies, power transmission

companies, power distribution companies, independent power plants, and retail end users (i.e., customers consuming high capacity over 1MW). As of 2010, 80% of the power in the Dominican Republic was traded in the bilateral contract market while 20% was traded in the spot market.

Figure 2 | Power market of the Dominican Republic



Source: The power market of major Latin American countries, 2014, KOTRA.

There is only one power transmission company, the ETED which is a public corporation. EDE NORTE and EDESUR are 100% owned by the government, whereas EDEESTE is owned both by the government and a private company at the ratio of 50:50

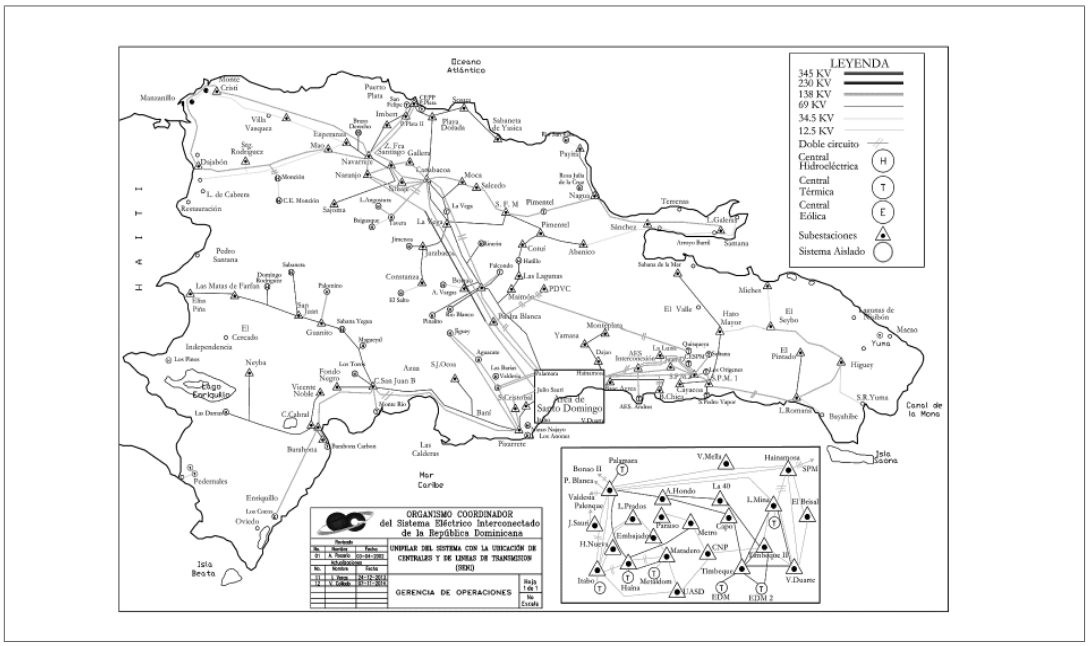
Table 1 | Utilities companies of the Dominican Republic

Function	Company	Ownership
Holding company	CDEEE	Public
Thermal power generation	EGE Haina	Private
	EGE Itabo	Private
Hydraulic power generation	EGEHID	Public
Power transmission	ETED	Public
Power distribution	EDENORTE	Public
	EDESUR	Public
	EDEESTE	Public (50%), Private (50%)

Source: The power market of major Latin American countries, 2014, KOTRA

The following figure demonstrates the entire power networks of the Dominican Republic, and it indicates all the power systems related to generation, transmission, distribution, and transformation. While the transmission systems are marked as 345kV, 230kV, 138kV, and 69kV, the distribution systems are marked as 34.5kV and 12.5kV. The greatest feature is that the entire system has branch type structure, which means it has a relatively higher probability of wide scale outage compared with a loop type.

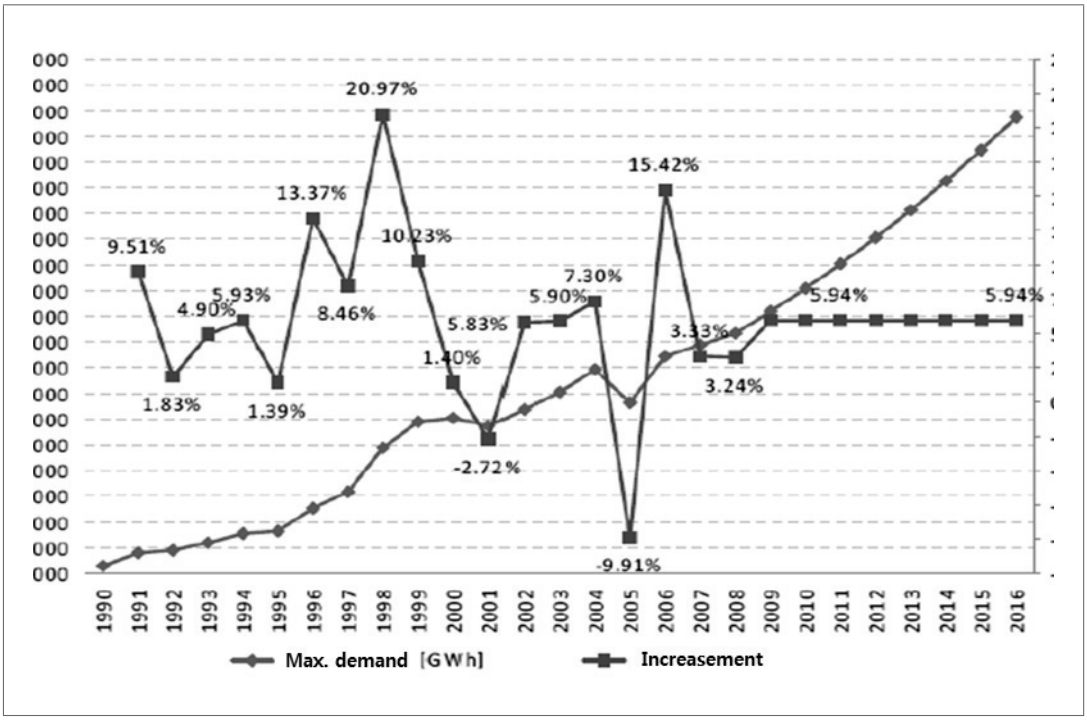
Figure 3 | SENI of the Dominican Republic



Source: CDEEE, http://www.oc.org.do/SENI/Seni/redNacional.aspx, 2015

In relation to the national power connection system in the Dominican Republic, Table 1 shows the organizational structures of the major institutions. All the more, the power demand of the Dominican Republic has shown a rapid increase since the 1990s. This is confirmed in Figure 4. Given the increase of maximum demand power, the introduction of distribution facilities is a very imperative national issue. This is because the insufficient facility capacity of the distribution system will lead to serious overload on existing facilities, which will raise the possibility of forcible rolling blackout and make power supply unstable. Accordingly, the power distribution needs to be stabilized through introduction expansion of distribution facilities.

Figure 4 | Power demand and increment rate by year


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Ⅱ Comparative analysis between the Dominican Republic and Korea

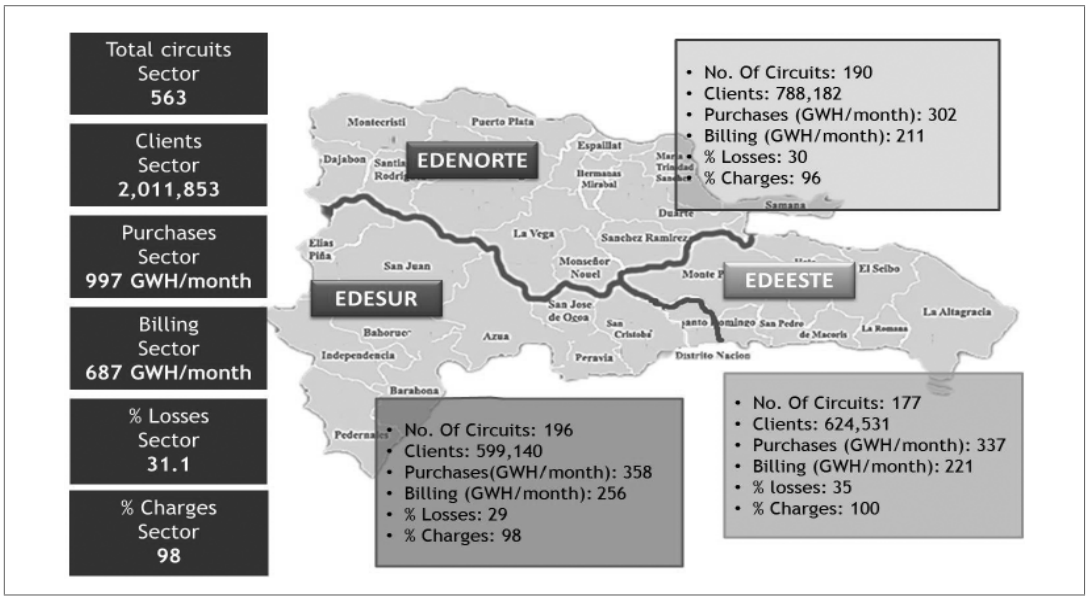
1. Power system status

1.1. Power system in the Dominican Republic

1.1.1. Current status of the electric distribution system

Currently, there are three distribution companies in the Dominican Republic: EDENORTE, EDEESTE, and EDESUR. EDENORTE has a total of 190 circuits of feeder and 788,182 clients. Meanwhile, EDEESTE has a total of 177 circuits of feeder and is in charge of 624,531 clients. Finally, EDESURE has 196 circuits of feeder and 599,140 clients in total.

Figure 5 | Current distribution of the Dominican Republic



Source: CDEEE

Data about the current power facilities of the Dominican Republic was obtained through a questionnaire survey distributed to the companies. Baseline information on the current power facilities of the Dominican Republic was obtained for this pilot study. Survey questions focused on substation facilities (substation capacity and form, voltage, circuit configuration, and automation), current distribution facilities (distribution voltage, frequency, circuit configuration, and electricity quality), and current power loss (electricity theft rate and current AMR installation).

Figure 6 | Preliminary survey questionnaires

❑ **General Information**

Item		Unit	Value	Remarks
Distribution Voltage	Mid-Voltage(MV)	kV		All existing voltages and wiring ex) 33kV-Y, 10kV-△
	Low-Voltage(LV)	V		All existing voltage and wiring Ex) 1P2W 230V, 3P4W 400V
Power Frequency		Hz		
Grounding System				Select among 'Ungrounded', 'solid-Grounding', 'Low Resistance Grounding', 'High Resistance Grounding', 'Ground fault neutralizer', 'Voltage transformer grounding', 'Zigzag Transformer'
No. of Primary Substations		EA		By regions/voltage level
No. of Distribution Substations		EA		By regions/voltage level
No. of Distribution Feeders		EA		By regions/voltage level
Installed Capacity		MVA		Sum of Distribution Transformers' capacity
Peak load		MW		
Maximum capacity of a feeder		MVA		
Distribution Circuit length	Overhead	c-km		
	Underground	c-km		
SAIDI				System Average Interruption Duration Index
SAIFI				System Average Interruption Frequency Index
Distribution Losses	Technical	%		
	Non-Technical	%		

Source: KSP Consultancy Team

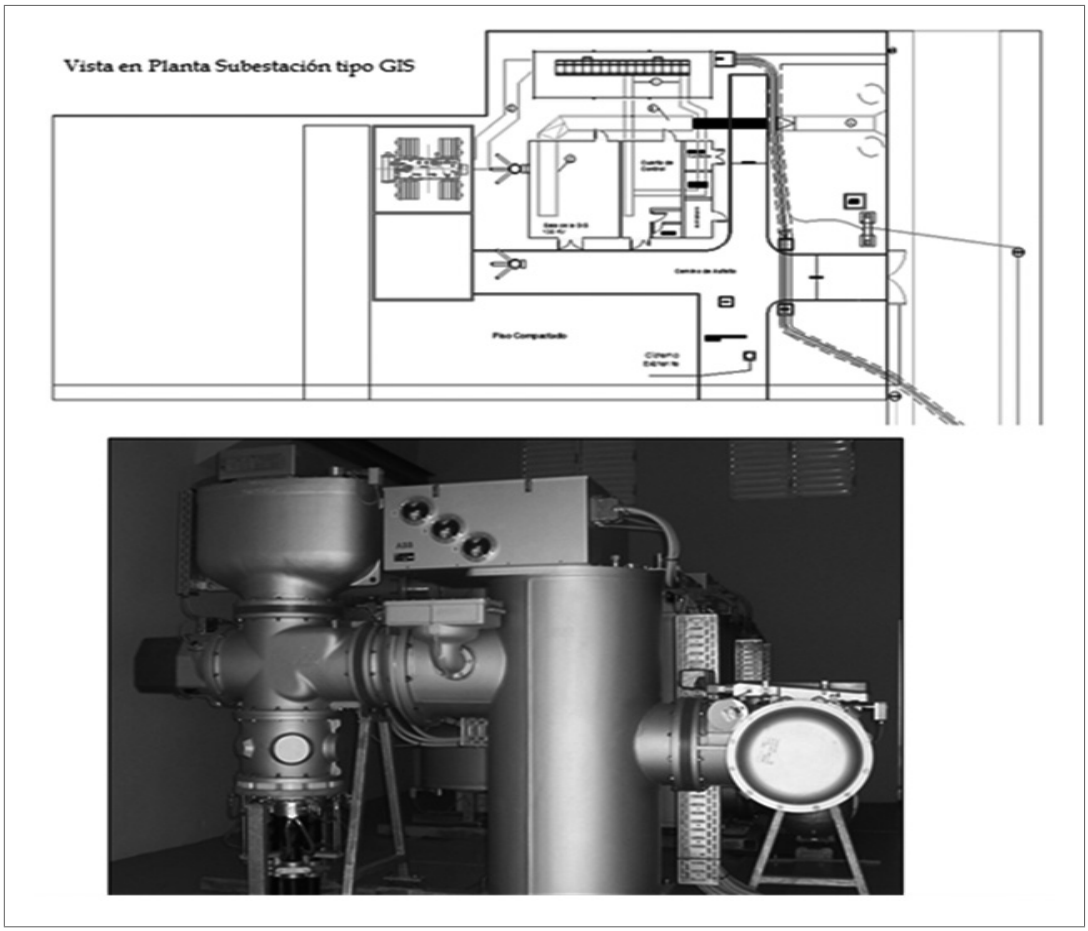
1)The transformation of electricity

As of 2015, there were 172 substations (79 with EDENORTE, 50 with EDESUR, and 43 with EDEESTE) with a total facility capacity of 3,578 MVA. Substations are divided into three standard types. They are GIS substations in the downtown areas (Figure 7), outdoor substations of over 20 MVA (Figure 8) and outdoor substations of less than 20 MVA in the suburban areas (Figure 9).

Besides, transformers have different capacities such as 7/10, 16/20, 20/28, 28/40, and 40/50 MVA, and indoor circuit breakers are used for protection and metering.

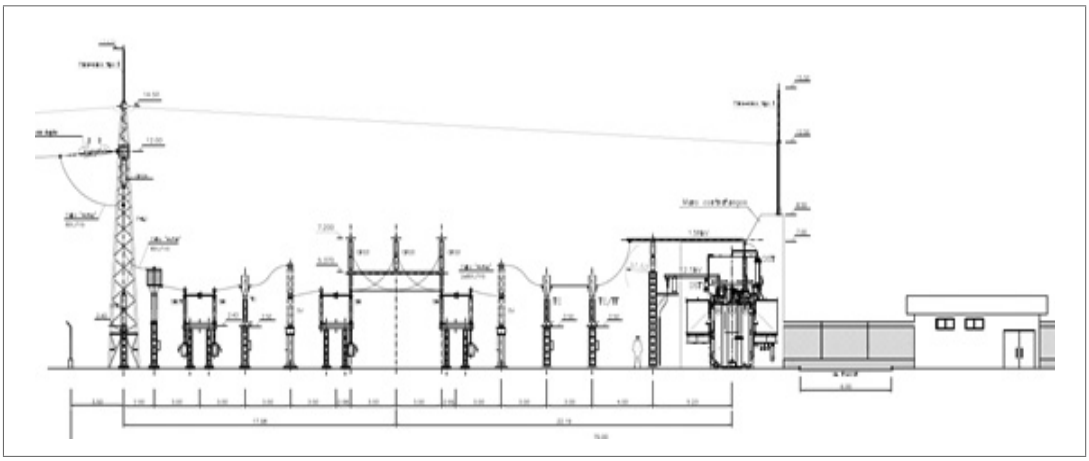
Survey findings showed that Substation Automation (SA) system has not been introduced. Instead, SCADA for automatic operation has used the system of SURVALENT, with DNP3.0 and EC60870-5-101/104 Protocol. However, this simple SCADA system has not utilized any additional applied application distribution management system, except for the automatic monitoring and operation of substation facilities.

Figure 7 | GIS substation



Source: CDEEE

Figure 8 | Outdoor substation



Source: CDEEE

Figure 9 | Outdoor substation in downtown area



Source: KSP Cousu Itaucy Team

2) Current Distribution Network

There are five distribution voltages, namely 34.5kV-△, 12.5kV-Y, 7.2kV-, 4.16 kV-Y and 242kV-. However, as 12.5 kV-Y accounts for 93.58% of the total distribution, the actual distribution voltage is almost unified as 12.5 kV-Y.

As of 2014, there were a total of 563 networks in the entire distribution network. This comprised 190 networks of EDENORTE, 196 networks of EDESUR, and 177 networks of EDEESTE. In the Dominican Republic, the low voltage system using 480 V, 240 V, 208 V, and 120 V makes the use of diverse

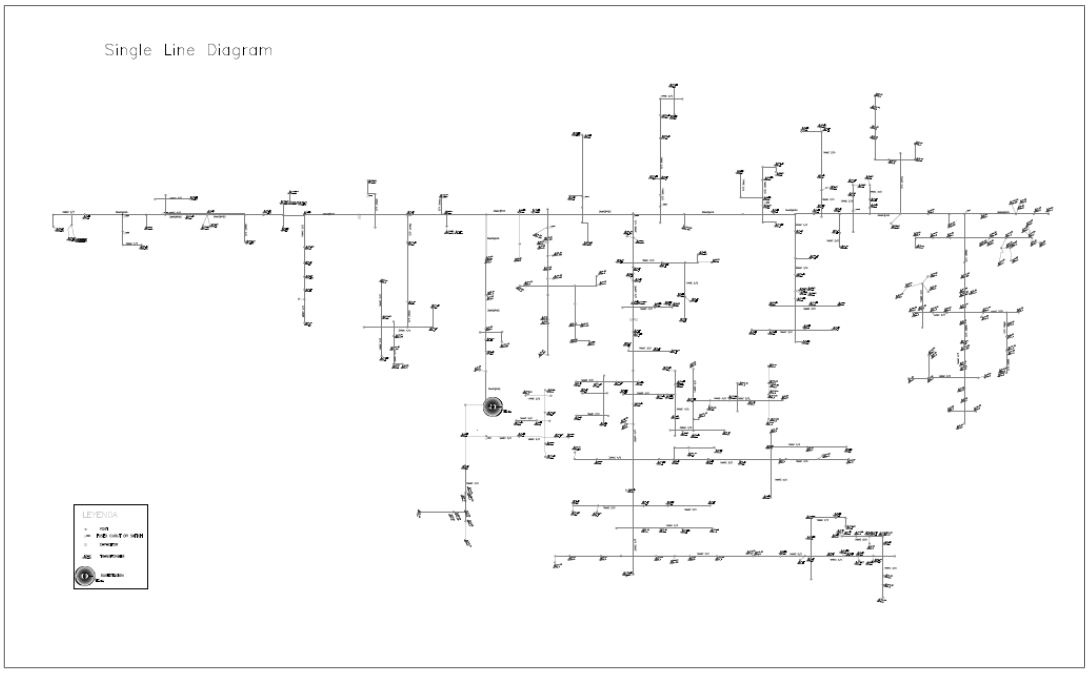
transformers and meters inevitable. The distribution frequency in the Dominican Republic is 60 Hz which is the same as that of Korea. Also, similar to Korea, it is 3-phase 4-wire solid grounded system of 12.5 kV-Y as well as there are many single-phase networks because of the use of 3-phase 4 wire.

As the types of distribution voltages have not been unified in the Dominican Republic, there would be limitations in connecting distribution systems. Also, repair and maintenance costs for distribution systems can be high as equipment for various voltages is necessary. Particularly, if exact voltages are not identified on site, it can lead to an accident; thus, distribution systems should be separated by voltage for operation. Furthermore, if different voltages are supplied to the same section, it becomes difficult for clients to purchase and use electrical appliances. This means that voltage unification is key to improving living environment. Therefore, distribution voltages should be unified within a shortest time possible, taking into account that the long-term operation and expansion of various distribution voltages will increase time and cost for unification.

3) Distribution System Configuration

Aerial line account for 98% of the entire distribution network. Out of the total network of 24,601c-kM, EDENORTE operates 11,020 c-kM, EDESURE 6,890 c-kM, and EDEESTE 6,691 c-kM. The distribution system is made up of an arborescent network without connection points with other networks. In this network, sections are opened and closed using COS or a switch in the middle of a feeder. This is seen in the Sample Feeder Diagram below where a switch and a fuse are installed in the middle of a feeder, together with a capacitor bank for compensating reactive power.

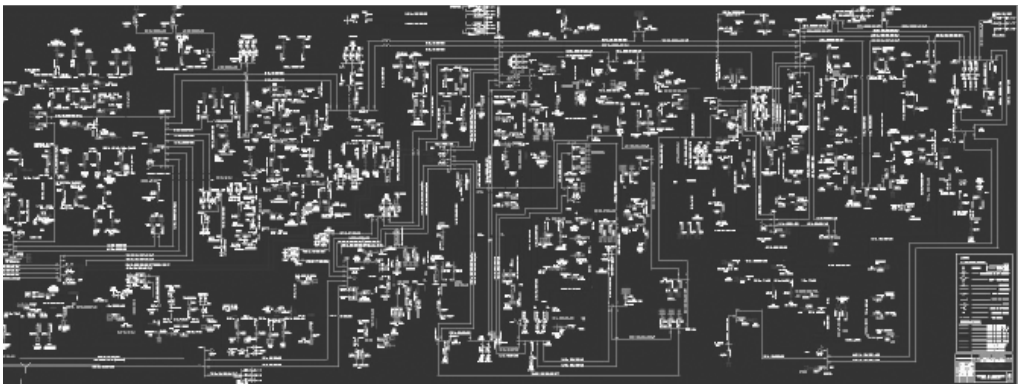
Figure 10 | Sample Feeder Diagram



Source: CDEEE

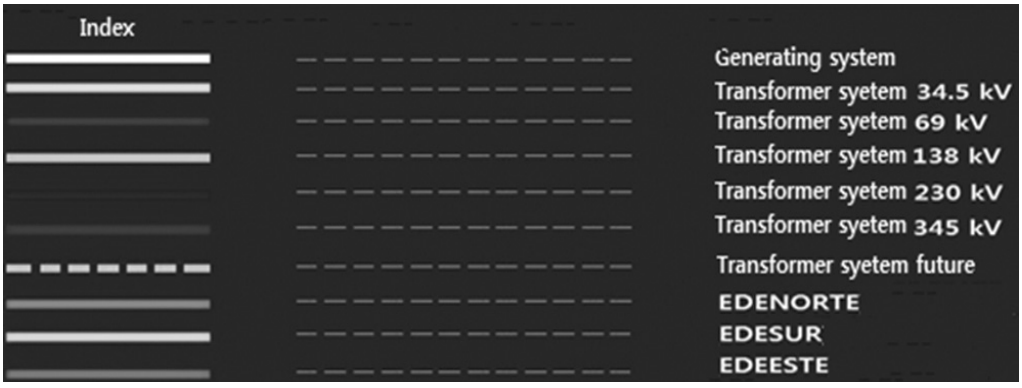
The transmission system is configured on 138 kV utilizing 69 kV feeders as branch feeders. The maximum voltage of the system comprising 345 kV and two feeders are constructed. The figure below shows part of the entire configuration and indicates all transmission system voltages. There are two substations with the maximum system voltage of 345 kV in El Naranjo and Julio Sauri, and these are connected with two feeders of 80.4 km and 130 km respectively. The figure shows the transmission system configuration of the Dominican Republic. The absence of additional switch or fuse at the junction of a low voltage feeder or any low voltage faults is more likely to directly lead to transformer breakdown or high voltage faults.

Figure 11 | Transmission system configuration of the Dominican Republic



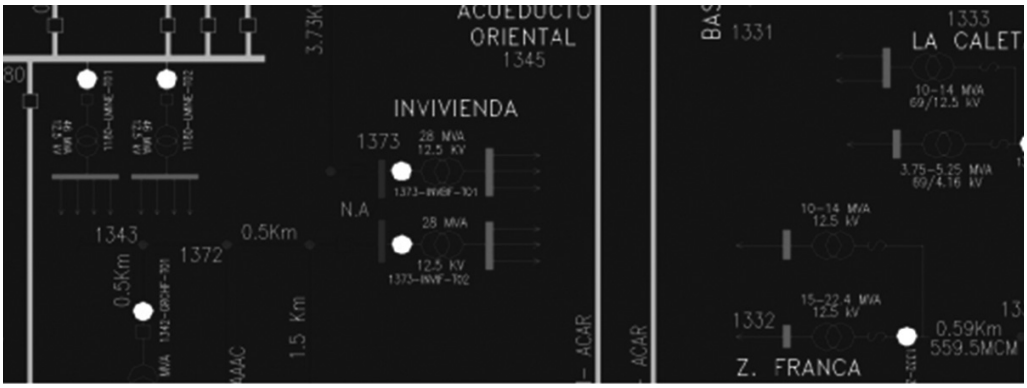
Source: CDEEE

Figure 12 | Index of Transmission system configuration of the Dominican Republic



Source: CDEEE

Figure 13 | Transmission system configuration of the Dominican Republic : Substation sample



Source: CDEEE

Substation capacities vary in terms of feeder output, ranging from single-feeder withdrawal to 8-feeder. Transformers also vary, ranging from 12.5 kV/46 M withdrawal with four feeders, 28 NW with three feeders, 14 MW with two feeders, and low capacity substations with one feeder. However, since the record of quantities of output feeders for substation capacity vary from region to region, there seems to be a lack of standardized regulations governing substation distribution and usage throughout the country.

This transmission system is constructed with annular networks of 138 kV, with appropriate voltage that suit its purpose. The system is considerably more efficient and stable, compared with the independently constructed distribution system.

1.1.2. Analysis of Distribution System Operation

1) Poor outage index

The System Average Interruption Duration Index (SAIDI) and System Average Interruption Frequency Index (SAIFI), commonly used to ensure steady power supply, are shown in the table below.

Table 2 | SAIDI/SAIFI

Category	EDENORTE	EDESUR	EDEESTE	KEPCO
SAIDI	130.5 Hr/month	118.44 Hr/month	152.2 Hr/month	16 min/year
SAIFI	35 times/month	34.6 times/month	47.2 times/month	0.45 times/year
Remarks	Outages mostly by power demand control , not by accidents.			

Source: CDEEE

The table above shows that the entire power supply quality of the Dominican Republic is extremely poor and is incomparable with the reliability of power supply in countries like Korea. Based on personal interviews with persons in charge at local utilities and other data collected in this study, several causes for poor power supply in the Dominican Republic have been identified.

a) Extensive time spent on FLISR

The results of the survey show that the average fault location isolation service and restoration (FLISR) time was about 1.8 hours. Although the SCADA system installed at the substation can identify a fault feeder immediately, there is a problem with the absence of a Circuit Breaker (CB) that can break the fault section in the middle of the feeder. This has resulted in electric fault being spread widely on the feeder inspection section. Instead, a fault section has been discovered by a fault path indicator (FPI) on a branch feeder. Accordingly, to isolate a fault section, remove the cause of fault, and suppy power, human resources are sent to the section to work on it. Therefore, this makes the average FLISR time longer.

b) Absence of a connection point with adjacent feeders

Most power systems are connected through at least one Normal Open Point (NDP) with an adjacent feeder. In case of a fault on any feeder, a normal section (outage section despite the absence of fault) receives transmission quickly from another feeder after the fault section is detached. This minimizes outage time for non-faulty section. However, this is not the case in the Dominican Republic, where distribution networks are operated independently without connection points, and so outage of the load side of the fault section would continue until fault recovery is completed.

c) Indices of different disruptions from those used in Korea

Regarding the definition of the SAIDI and the SAIFI, utilieis in most of the regions including North America include failures of more than 5 minutes of interruptions in the statistics of outages. However, the Dominican Republic has taken 3 minutes of interruptions as outages. Subsequently, the outage rates of the Dominican Republic may appear higher than those of Korea and other countries. However, as shown above in the Table 2, the difference is almost negligible in consideration of the relatively long duration of outages overall.

2) Outage by insufficient power supply and demand

Despite problems with the distribution system, the average outage of over 130 hours a month cannot be caused only by system failures per se. Thus, a survey was conducted to examine the causes of outage. According to the results, 81% of the entire outage was due to demand management. In other words, about 81% of outages occurred mainly because of an imbalance of power supply and demand, whilst the remaining 19% of outages was due to system failure. The table below shows statistics on causes of outages for the first half of 2015, based on survey findings.

Table 3 | Statistics by cause of outage

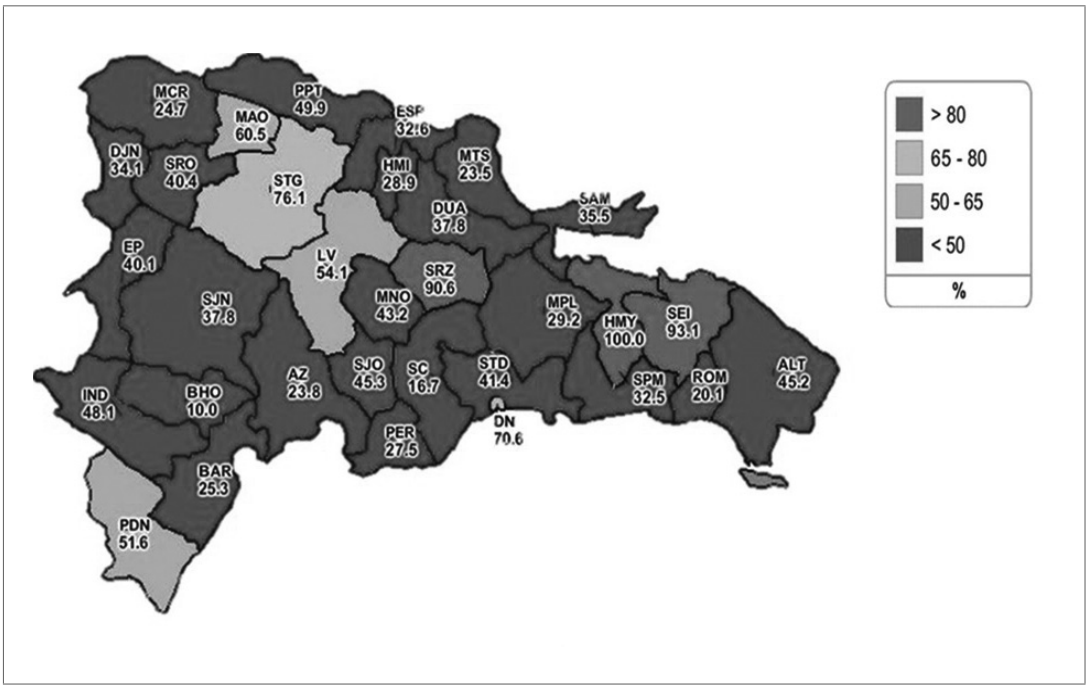
Cause of outage	No. of outage	Share (%)
Demand management	90.455	81.12
Section outage for fault removal	3.545	3.18
Load switching	2.651	2.38
Network fault	1.561	1.40
Load transfer to another feeder	1.540	1.38
Jumper cable cut	1.218	1.09
Job outage	1.218	1.09
34.5 kV outage	71	0.06
Others	10.464	9.39
Total	111.505	100.0

Source: CDEEE

a) Limited transmission

For the Dominican Republic, only 48% clients received electricity for 24 hours owing to an imbalance in power supply and demand. The remaining customers (52%) received electricity for limited periods of 21 hours, 18 hours, or 16 hours a day. This diagram (Figure 14) shows the statistics for clients who received limited transmission.

Figure 14 | Current limited transmission



Source: CDEEE

b) Imbalance in power supply and demand by specific concentration of substation facilities

The distribution facilities of the Dominican Republic are affected by sever imbalance in power supply and demand, resulting in limited transmission. The consultancy team's research (literature review and field survey) shows that the installed capacity is 3,578 MVA and the leak load reaches 2,270 MW, with a demand factor at the substation terminal of 63.4%. That is to say, the entire substation facilities are sufficient to ensure the capacity to respond to the current demand.

However, two possible setbacks are identified, i.e., the substation facilities are concentrated on specific areas, and imbalance in technical power supply-demand occurs as a result of location. The tables below show the power supply and demand of each local distribution company, and its current main transformers.

Table 4 | Power supply and demand of EDENORTE

Sub-station	Tr.	Capacity (MVA)			Annual usage (MVA)								
		PI	80 (%)	90 (%)	2012	2013	2014	2015	2016	2017	2018	2019	2020
ELCHIVO	TR1	40	32.0	36.0	-	40.14	42.15	44.25	46.47	48.79	51.23	53.79	56.48
RINCON	TR1	14	11.2	12.6	-	13.51	14.19	14.89	15.64	16.42	17.24	18.10	19.01
COTUI	TR1	37.5	30.0	33.8	-	26.54	27.87	29.26	30.72	32.26	33.87	35.57	37.34
NIBAJE	TR1	37	29.6	33.3	-	34.00	35.70	37.49	39.36	41.33	43.39	45.56	47.84
NIBAJE	TR2	37	29.6	33.3	-	37.00	38.85	40.79	42.83	44.97	47.22	49.58	52.06
IMBERT	TR1	20	16.0	18.0	-	17.11	17.97	18.86	19.81	20.80	21.84	22.93	24.08
ELCHIVO	TR1	40	32.0	36.0	-	40.14	42.15	44.25	46.47	48.79	51.23	53.79	56.48
NIBAJE	TR1	37	29.6	33.3	-	34.00	35.70	37.49	39.36	41.33	43.39	45.56	47.84
QUINIGUA	TR1	14	11.2	12.6	-	14.0	14.73	15.47	16.24	17.05	17.91	18.80	19.74

Alert status Immediate action needed

Source: CDEEE

Table 5 | Power supply and demand of EDESUR

Sub-station	Tr.	Capacity (MVA)			Annual usage (MVA)								
		PI	80 (%)	90 (%)	2012	2013	2014	2015	2016	2017	2018	2019	2020
BNV	TR1	14	11.2	12.6	13.70	14.48	15.30	16.17	17.09	18.06	19.08	20.17	21.31
SPER	TR1	28	22.4	25.2	30.69	32.43	34.28	36.22	38.28	40.45	42.75	45.18	47.75
DAJA	TR1	30	24.0	27.0	20.69	21.87	23.11	24.42	25.81	27.27	28.82	30.46	31.19
DAJA	TR2	14	11.2	12.6	13.29	14.04	14.84	18.69	16.58	17.52	18.51	19.56	20.68
VIME	TR1	40	32.0	36.0	42.28	44.68	47.22	49.90	52.74	55.73	58.90	62.24	65.78
VIME	TR2	50	40.0	45.0	-	-	20.67	21.84	2308	24.40	25.78	27.25	28.79
HAMO	TR1	28	22.4	25.2	22.18	22.86	23.56	24.29	25.03	25.80	26.59	27.41	28.25
HAMO	TR2	40	32.0	36.0	26.11	26.91	27.74	28.59	29.47	30.37	31.30	32.27	33.26
INVI	TR1	28	22.4	25.2	21.57	22.23	22.91	23.62	24.34	25.09	25.86	26.65	27.47
INVI	TR2	28	22.4	25.2	23.03	23.74	24.47	25.22	25.96	26.79	27.61	25.46	29.33
LM138	TR1	50	40.0	45.0	38.00	39.17	40.37	41.61	42.89	44.20	45.56	46.96	48.40
LM138	TR2	50	40.0	45.0	38.27	39.44	40.66	41.90	43.19	44.52	45.88	7.29	48.74
LM69	TR1	22	17.6	19.8	18.03	18.58	19.15	19.74	20.35	20.97	21.62	22.28	22.96
VDU8	TR1	40	32.0	36.0	20.74	21.38	22.03	22.71	23.41	24.13	24.87	25.63	26.42
EBRI	TR1	50	40.0	45.0	37.00	38.14	39.31	40.51	41.76	41.04	44.36	45.72	47.13

Alert status Immediate action needed

Source: CDEEE

Table 6 | Power supply and demand of EDEESTE

Sub-station	Tr.	Capacity (MVA)			Annual usage (MVA)								
		PI	80 (%)	90 (%)	2012	2013	2014	2015	2016	2017	2018	2019	2020
EMBA	TR1	50	40.0	45.0	35.50	37.28	39.14	41.10	43.15	45.31	47.57	49.95	52.45
EMBA	TR2	50	40.0	45.0	33.80	35.49	37.26	39.13	41.08	43.14	45.30	47.56	49.94
COHE	TR1	40	32.0	36.0	33.90	35.60	37.37	39.24	41.21	43.27	45.43	47.70	50.09
ZFAL	TR1	33.6	26.9	30.2	21.60	22.68	23.81	25.00	26.25	27.57	28.95	30.39	31.91
KDIE	TR1	40	32.0	36.0	39.80	41.79	43.88	46.07	48.38	50.80	53.34	56.00	58.80
KDIE	TR2	40	32.0	36.0	37.10	38.96	43.90	42.95	45.10	47.35	49.72	52.20	54.81
KDIE	TR3	20	16.0	18.0	12.70	13.34	14.00	14.70	15.44	16.21	17.02	17.87	18.76
CSAT	TR1	14	14	12.6	11.60	12.18	12.79	13.43	14.10	14.80	15.55	16.32	17.14
PALA	TR1	22.4	22.4	20.2	20.90	21.95	23.04	24.19	25.40	26.67	28.01	29.41	30.88
AZUA	TR1	18.5	18.5	16.7	16.30	17.12	17.97	18.87	19.81	20.80	21.84	22.94	24.08
BAYO	TR1	14	11.2	12.6	12.30	12.71	13.34	14.01	14.71	15.44	16.22	17.03	17.88
HNUV	TR4	50	40.0	45.0	31.60	33.18	34.84	36.58	38.41	40.33	42.35	44.46	46.69
HERR	TR2	30	24.0	27.0	20.90	21.95	23.04	24.19	25.40	26.67	28.01	29.41	30.88
KDIE	TR1	40	32.0	36.0	39.80	41.79	43.88	46.07	48.38	50.80	53.34	56.00	58.80
KDIE	TR2	40	32.0	36.0	37.10	38.96	40.90	42.95	45.10	47.35	49.72	52.20	54.81
KDIE	TR3	20	18.0	18.0	12.70	13.34	14.00	14.70	15.44	16.21	17.02	17.87	18.76
MVIE	TR1	40	36.0	36.0	36.5	38.33	40.24	42.25	44.37	46.58	48.91	51.36	53.93
MVIE	TR2	30	27.0	27.0	26.6	27.93	29.33	30.79	32.33	33.95	35.65	37.43	39.30

Alert status Immediate action needed

Source: CDEEE

As shown in the tables above, in the case of EDENORTE, overloading occurs in the main transformers of 9 substations among its 79 substations. For EDESUR, overloading occur or may occur in the main transformers of 11 substations among its 50 substations, while for EDEESTE overloading occurs or is likely to occur in the main transformers of 10 substations among its 43 substations.

On the whole, problems of supply-demand imbalance, i.e., overloading in substations and inefficient demand management, occur largely because of the inappropriate location of the substations. Consequently, active load transfer cannot be conducted between the regions despite sufficient connections of distribution lines from the substations.

1.2. Power system in Korea

1.2.1. Current status of electric power system

The majority of power systems in Korea are owned and operated by Korea Electricity Power Corporation (KEPCO). As shown in the Table 7, the maximum voltage of transmission systems is

765kV, and the entire system is installed with branch feeders of 154kV based on annular networks of 345kV. Direct current feeders of 180kV are installed to connect the mainland and an island (Jeju Island) and feeders of 66kV are installed in some other regions. Besides, distribution systems are 100% owned and operated by KEPCO. Unlike those in the Dominican Republic, distribution voltages are unified as 22.9kV-Y; thus, there is no additional substation. In addition, distribution systems are composed of aerial line networks and underground line networks based on 22.8kV. Transformation and distribution facilities which are the main focus of this project will be described in detail as follows.

Table 7 | Current power systems of KEPCO

Transmission network					
Transmission voltage	765kV	345kV	154kV	66kV	DC180kV
Line length (c-km)	1.014	9.369	22.440	144	231
Distribution network					
Line length (c-km)	Support (EA)		No. of Transformers (EA)	Underground networks (22.9 kV)	
460,779	8,892,000		2,100,000	43,567 c-km (Underground network rate 9%)	

Source: KEPCO, 2015

1) Substation facilities

The substation facilities in Korea are also 100% owned and operated by KEPCO, and managed entirely by the transmission and transformation system, whilst facilities installed after the substation output are defined as distribution system.

Table 8 | Substation facilities of KEPCO

Substation facilities	765kV	345kV	154kV	66kV	No. of substations
Capacity (MVA)	37.116	123.379	134.591	331	812

Source: KEPCO, 2015

2) Current status of the distribution lines

a) Single voltage system

The greatest feature of the distribution system of Korea is a “single distribution voltage system”. Through efforts of over 40 years to unify distribution voltage, high voltage was unified as 22.9 KV-Y in 2012 while low voltage was unified as 380/220 V. This is very good condition for facility operation. As the entire distribution system is operated using the same voltage, there is no problem in connecting loads. Similarly, since all the distribution facilities have the same voltage, it is easy to work on insulation coordination and to manage spare parts.

b) Installation of distribution automation system nationwide

KEPCO completed the installation of the distribution automation system nationwide in 2003, and has since automated the entire distribution networks through the distribution automation system. Following this, optimal operation of the distribution system was enabled using diverse applications.

The distribution automation project that started in the 1980s laid the foundation for distribution companies to develop their optimal independent distribution automation systems in the 1990s. By the turn of the 21st century, the expansion project of the distribution automation system was carried out nationwide, and since then the use of distribution automation switches has increased steadily over the years. The distribution automation system in Korea was upgraded into a comprehensive system that enables the operation of a smart grid. The efficient distribution automation system was made possible with enforcing necessary regulations for the introduction and operation of distribution automation equipment.

3) Distribution System Configuration

KEPCO established the installation standards of distribution switches as shown in Table 9, as a basis for configuration of the nation's electricity distribution system. With the introduction of distribution automation, basic distribution feeders were defined as 6 divisions and 3 connections (5 distribution section automation swtiches on one distribution circuit and 3 switches in connection with other feeders), and the number of switches has been gradually increased.

The establishment of the division-connection standards using distribution automation switch is significantly meaningful in minimizing failure at the regional office level. While defining KPI as the most important factor for reducing any distribution failure, KEPCO initiated healthy competition among regional offices to increase the usage of distribution automation switches. Against this backdrop, regional offices that have improved the SAIDI/SAIFI indices managed to increase the number of switches and scored well in assessment of failure reduction. Such competition has led to a remarkable increase in the quantity of distribution automation switches. For this reason, high performance in failure reduction assessment was achieved within a short period of time even without a planned distribution automation project.

Table 9 | Distribution switch installation standards

Area	Manual switch	Automatic switch	Branch feeder
Metropolitan areas	0.5 km	1 km or over 1,600 kW	Over 5 spans
Small and medium cities	1.0 km	2 km or over 2,000 kW	Over 10 spans
Suburban areas	2.0 km	4 km or over 4,000 kW	Over 30 spans

Source: KEPCO, Design criteria (distribution field), 2008

In general, three divisions and three connections are recommended for improved economical distribution line division/connection through distribution automation. The three divisions and three

connections form a system configuration that is able to cope efficiently with any distribution line failure. This is done by connecting to other lines through the installation of a switch that connects to each section of the three distribution lines, or by installing switches for two sections on one distribution line.

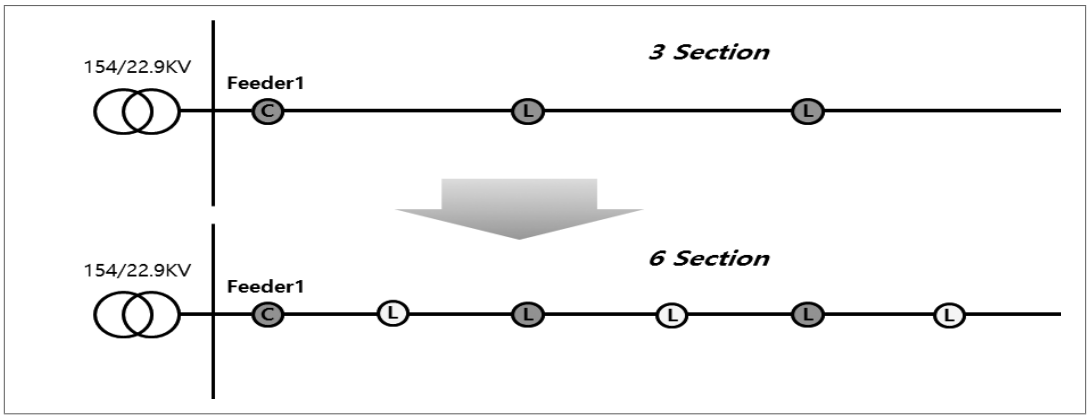
Meanwhile, KEPCO has increased the number of distribution automation switches to enable six divisions and three connections. Thus, in case of any failure, KEPCO can resupply power to the load, i.e., 5/6 of the line within several minutes (average FLISR time = 3.3 minutes) and maximize the system stabilization by lowering the SAIDI and SAIFI to be less than 10 minutes and 0.43 times, respectively.

Futhermore, KEPCO is currently pursuing a project to change the entire distribution switches to 100% automation switches. Therefore, in case of failure on a distribution line where the 6 divisions and 3 connections have been completed with distribution automation switches, a normal section (outage section owing to power loss without failure in that section) can be stably supplied with power within a short time through adjacent 3 connection lines that have an appropriate reserve rate. Since the 6 sections exist in one distribution line using five automation switches, the outage section can be reduced to 1/6 of the entire line within several minutes.

a) Establishment of section standard through distribution automation

At the early stage of installing distribution automation switches, KEPCO divided each distribution feeder into three equal load sections. Likewise, in completing the distribution system configuration with an equal three section feeders, additional sections can only be made by dividing each section into half, while maintaining equal load. Thus, the expansion plan should be determined as six sections. In fact, only one section among three can be divided into two, which makes four sections in total. However, this was not very meaningful as it becomes an exception in flexible load restructuring through distribution automation.

Figure 15 | Section standards for distribution automation



Source: KSP Consultancy Team

After completing the three sections-three ties standards established at the initial stage, KEPCO expanded and carried out a subsequent growth model to provide for six sections-three ties restructuring. Initially, KEPCO had to decide whether to use sections of even or odd numbers as section standards for distribution automation switches. Detailed consideration and discussion on this issue was presented in the "Contents – Policy Proposal".

Apart from the consideration of the current situation, it is required to review preliminary procedures of newly introduced section/tie standards and additional plans for development after the restructuring of the power system. This review and monitoring process is necessary for the establishment of section/tie standards of the distribution system.

b) Use of Circuit Breaker (CB)

KEPCO, as well as most utilities organizations, uses protection devices including reclosers and sectionalizers on overhead lines.

Unlike distribution automation, these protective devices can separate any failure on the load of a relevant location immediately (within several cycles). This can be done through self-operation during the occurrence of failure, and they are therefore indispensable for the stable power supply of distribution lines.

Basically, a recloser, functioning as a circuit breaker (CB), can break the fault current by itself. But this is not the case of sectionalizer since this device cannot break the fault current independently. In other words, a sectionalizer should be installed on the load side of a CB. In case of occurrence of fault on its load side, when a CB on the power side recloses (when voltage/current become "0"), it separates a fault by opening itself. Then, a CB on the power side stops reclosing and performs normal operations because the fault on the load side of a sectionalizer has been removed.

Before executing distribution automation, KEPCO operated a combination of reclosers and sectionalizers as a basic solution for faults. However, since the installation of the distribution automation system, no more additional sectionalizers were installed. It is because, to minimize the fault section when automation operation is unavailable, a sectionalizer is more useful than a breaker. Meanwhile, when automatic operation and automatic monitoring are available, fault can be managed immediately only by a load switch which is relatively cheaper than sectionalizer, and sectionalizing can be realized through terminal equipment. KEPCO has introduced and operated various protection devices for such distribution networks, but after the construction of distribution automation, feeder protecting switches and protection devices were simplified for operation based on the high usage of distribution automation switches.

① **Recloser operation**

The most important aspect for reclosers to operate efficiently is the cooperation within the protection setting group, or cooperation on protection among CBs that are installed in series. For instance, when a recloser is installed after a substation CB and a fault occurs on the load side of the recloser, such cooperation allows reclosers to be locked out just in time before the lockout of the substation CB. However, without cooperation on protection, when a fault appears on the load side

of a recloser, either a substation CB is locked out first, or both CBs are locked out. This would hinder the functioning or initial purpose of a CB installation.

Since CBs operate within a few cycles, it is vital to obtain accurate calculation and relevant verification. In particular, it is important to consider that each of the switches has its own operation characteristics during the review of cooperation on protection. This is because there may be a difference in cooperation on protection according to electric characteristics caused by harmonic waves or surrounding environments even during the short operation time. Consequently, utilities have purchased switches by establishing clear specifications on switch operation characteristics.

However, utilities companies that lack adequate know-how or engineering knowledge concerning cooperation on protection among protection device functions tends not to benefit much from use of these devices. Accordingly, for the effective operation of power systems, it is critical to enhance the ability to review cooperation on protection.

Generally, reclosers have four reclosing functions, and the surest method of cooperation on protection is to limit the number of reclosing. For example, when two reclosers are installed in series, the recloser on the power side is set to operate 4 times of reclosing, and the one on the load side is set to operate 3 reclosing movements. Then, in case of occurrence of a fault on the load side, the recloser on the load side[1] will be locked out first with three reclosing movements, so that the recloser on the power side can operate with the remaining one reclosing. For this reason, KEPCO has operated with a limit of three reclosers, ensuring highly reliable cooperation on protection via smooth section cooperation function[2] per recloser.

② **Installation location of a recloser**

The selection of recloser location must be reviewed to prevent the spread of a fault and to protect major load. Also, even with superior CBs, if two CBs are installed in an extremely adjacent distance, the reliability of cooperation on protection decreases significantly. For highly reliable cooperation on protection, an appropriate distance between protection devices is desirable.

The location that needs recloser installation most is a branch section with frequent fault. If any section with frequent faults can be separated automatically through a recloser, the fault on the section will not spread to the entire networks, resulting in high reliability in power supply.

On the contrary, a recloser can be installed to protect important load. For example, if there is important load on the branch line of a distribution feeder, even if the fault section becomes wider, a recloser can be installed on the load side adjacent to the load to protect the load safety. The installation of a recloser is also necessary to separate any fault in the middle of a feeder that is difficult for maintenance and inspection.

1) T-C curve: As a Time-Current characteristics curve, it is a graph showing the operation characteristics (operation time) of a CB according to fault current. It should be compared to undertake a review of cooperation on protection among CBs
2) Section cooperation function: To prevent simultaneous operations of a Recloser, if another switch operates first, the number of reclosing can be counted without reclosing operation.

③ Configuring coordination between reclosers

Since grounded system protection devices are triggered by electric current, clear separation between load current and fault current is required for highly reliable operation of protection devices. This means protection devices should respond sensitively under fault current while they should not work under general load current. Therefore, utilities need to establish basic correction directives according to the characteristics of distribution systems. In this context, KEPCO established general recloser correction directives through the calculation of the minimum fault current (one-wire ground fault) and the maximum fault current (three-phase short circuit current) of a general distribution feeder. Subsequently, protection devices can be corrected easily on site without specific calculation.

Table 10 | Correction standards for cooperation on protection of a recloser

Classification		Directives for correction
Minimum operating current	Phase	① More than 2.8 times and less than 4.0 times of the maximum load current ② Less than the corrected value of the minimum operational current of back protection device
	Grounding	① Maximum load current × more than 0.3 ② More than the maximum load current of the maximum single phase branch on the recloser load side ③ Minimum 1 line grounding current of the protection section × less than 0.5 ④ Less than the corrected value of the minimum operational current of the grounding of back protection device
Total no. of operations		When there is a recloser on the back, total no. of operations of recloser on the back – less than 1
No. of instantaneous operations		① Less than the total no. of operations ② Correspondence of the no. of instantaneous operations of phase and grounding
Reclosing time		① When the substation relay is analog, more than the reset time of the original plate of relay ② More than the time that a recloser body can be ready to be applied *** ③ Correspondence of reclosing time of phase and grounding
Reset time		30 seconds
X times	Phase	(Maximum load current of the installation point × 10) / more than the minimum operational current of phase
	Grounding	(Maximum load current of the installation point × 10) / more than the minimum operational current of grounding

Source: KEPCO, Design criteria (distribution field), 2008

④ **Protection of single phase networks**

KEPCO has single-phase networks depending on its system characteristics. Single-phase networks use an inexpensive COS (Cut Out Switch) to prevent the expansion of any fault on a single feeder. However, unlike a recloser, a COS has no reclosing function. A COS is not significant to be operated automatically by distribution automation. Accordingly, in case of the occurrence of a fault (during fuse short circuit), the fault can be managed only by a field visit after recognizing the situation of the fault from a report by a client.

1.2.2. Anslysis of power system operation

1) Effort to reduce outage

① **Fault outage reduction**

For KEPCO, an important factor of performance evaluation is obviously an effort to reduce faults. Unlike any other assessment indicators, it is an indicator for relative assessment; thus, the ranking among regional offices is determined by fault frequency and time, and this affects tremendously the total ranking among regional offices. Also, because such ranking is related directly to incentives of employees in the offices, there has been active competition.

This active competition requires objective and clear assessment standards for accurate ranking assessment. For instance, to prevent any random omission of the number of faults in the offices, the number of faults has been determined thoroughly by obtaining the outage information of an AMR meter installed on site. In addition, as a penalty point is given to the omission of a fault, an intentional omission of a fault owing to heated competition is nearly impossible.

② **Execution of hot line work**

Outage index is classified into fault outage and work outage. Fault outage is caused by a fault on power facilities, while work outage is unavoidably generated by general work including the reinforcement and new construction of the power system. Work outage is also called planned outage.

Although work outage can be minimized by the effort of utilities, the costs are relatively higher. For example, as KEPCO has undertaken most of maintenance as hot line work, it rarely has work outage. As SAIDI itself is 16 min/no./year, the comparison of the share is not meaningful. However, due to increased outage cost[3] from economic growth, KEPCO, as a public company, has applied hot line work in most cases.

Most utility works rely on the cutting and compression of jumper wire for construction. The cutting and compression of jumper wire is frequent for the change of faulty facilities or connection with a new facility. However, utilities without hot wirework have to perform this work in a circuit lockout after the opening of a nearby switch. Utilities that are even without a switch have to lock

3) Outage cost: It means social and economic cost caused by of interrupted power supply. In particular, in case of an outage at large plants or service facilities, economic activities are interrupted during the outage; thus, advanced countries tend to have higher outage costs.

out substation CBs for such frequent work, which causes frequent outages in the entire network. Such work also requires much time (approximately 1 hour), and for utilities that do not apply hot wirework, this has a great effect on the outage index.

KEPCO started hot line work from the 1980s, and it has utilized the latest, various power facility hot line methods including the portable transformer method, uninterruptable cable method, and uninterruptable switch method. For this, KEPCO has evaluated the job performance of hot line workers (general people and employees) and given an official certificate, and it has gained a basis for safe hot line work.

Meanwhile, because the Dominican Republic has not introduced hot line work, outage work for the construction of power facilities may account for most of the total outage index. Also, if this job outage is not managed accurately, the announced outage index will have reduced reliability and the actual outage index will be higher.

Hot line work minimizes work outage, but it requires technical workmanship, and may cause casualties. Implementation of hot line work can only be carried out when utilities have outlined independently secure regulations for safety in hot line work. In particular, because hot line work is to be conducted mostly by external human resource personnel instead of employees of the utility company, it is difficult to introduce improvement of the technical ability of utilities without .

The operation of hot line work needs high level of organization, planning and preparations, and it can be easily applied to develop and advance adequate methods related to the situation of each utility company. However, because it is the surest way to improve the outage index, the localization of an advanced hot line method in the Dominican Republic should be reviewed through collaborative projects with Korea.

③ Calculation of outage index

Unlike the Dominican Republic, KEPCO has included only outage lasting over 5 minutes in the calculation of the fault index. Most utilities in other countries have also included outage lasting over 5 minutes for this statistic just like KEPCO. However, utilities in the Dominican Republic have defined outage to be over 3 minutes, which is a severer outage index for operations. Although this could cause a great difference in the statistics when the average FLISR time is about 3 minutes as is the case with KEPCO, there will be not much difference when the average FLISR time exceeds 1 hour as is the case with the Dominican Republic.

2) Stabilization of power supply and demand

Korea has not experienced limited transmission because of an imbalance in power supply and demand. Since 2010, despite delays in the construction of additional power facilities because of NIMBY and stoppages at old nuclear power plants, a temporary outage from instant overload occurred only once, during the summer of 2012. In Korea, the forecast of power supply and demand and timely expansion of the power system owing to load increase stemming from rapid economic growth has been more important than in any other country. Therefore, various measures have been prepared and operated.

① Application of midnight electricity

Because of its distinctive four seasons, Korea has seen a rapid increase both in heating load in winter and cooling load in summer. Particularly, as the soaring price of oil has led to increased cooling/heating load that utilizes cheaper electricity since the late 2000s, KEPCO has gone through much difficulty in power supply and demand in winter and summer. To improve this, KEPCO imposed cheaper electricity charges to clients who installed facilities for cold storage/heat storage at midnight when there is lower power demand, and this was able to realize peak saving by moving the load from the afternoon, which is the peak time, to midnight.

② Installation of direct load control equipment

Along with this, KEPCO has given incentives to clients who install facilities that control load directly and automatically, and this has increased direct load control facilities. In terms of load control, the expansion of direct load control facilities is the surest solution for utilities; yet, such incentives are not enough for clients to compensate for resolving discomfort from limitations imposed by utilities for the use of specific load. Accordingly, the capacity secured was not sufficient to be meaningful .

For the expansion of direct load control facilities, an active support system of the government is required. Meanwhile, the effort to settle relevant systems has been continuing because of complicated differences in interest among clients-government-utilities.

1.2.3. Introduction to DAS in Korea

A) Distribution Automation System (DAS)

DAS allows to discover automatically a fault section through utilization of computer and communication technology. DAS is classified into the SCADA system functions and Distribution Management System (DMS) functions. SCADA has widly used function at plants and utilities to acquire and control data automatically from a device on site. Meanwhile, DMS helps to operate distribution systems efficiently by processing and analyzing data through SCADA.

DAS is constructed based on knowledge from diverse fields including power, communication, data processing, and computer applied technology. The pre-requisite for DAS to function is the construction of basic infrastructure such as the power system, communication networks, and database. Ultimately, the introduction and implementation of DAS should progress step-by-step under a long-term plan.

(1) Process of the development of distribution automation in Korea

Korea started a distribution automation project as a government project in the 1970s, era when there was an absence of a technology base for distribution automation. Hence, the actual DAS could only be constructed in the late 1990s, through the experience gained from various model projects. According to the research on DAS carried out by KEPCO, the major foundations of its development are as follows.

a) Establishment of the distribution automation pursuit plan of Korea (Nov 1979)

The first distribution automation establishment plan of Korea began as a government project in 1979. As a short-term plan, a loop switch was installed; while, as a long-term plan, the introduction and operation of the distribution network automatic control system was included.

b) First distribution automation pilot project (Nov 1983-1984)

The first distribution automation pilot project of Korea was begun for distribution networks, and the communication method was started as a PLC type. At that time, because of the extremely poor technical state of PLC, the reliability of PLC could not be secured and it ended in failure with low transmission speed and frequent power system change.

Following the failure in the aerial network distribution automation project, a distribution automation pilot project for an underground system was undertaken. The project was performed for 58 underground switches utilizing the PLC type, and the operation system utilized the established substation SCADA system. However, this also turned out to be a failure because of insufficient reliability of communication networks.

c) Korean style DAS (KODAS) development research (after 1990)

Based on the failure of pilot projects, the KEPRI of KEPCO and the KERI (Korea Electrotechnology Research Institute), which are special research institutes in the Korean power industry, started a Korean style DAS development project (Dec. 1990). This Korean style distribution automation development project was begun mainly for the independent development of communication protocol for distribution automation while there are no communication protocols at all. As a result, independent KODAS protocol could be developed. Furthermore, to overcome the limitations of PLC communications, a pair cable communication method for distribution automation was adopted; thus, more successful results could be obtained. However, there was still a limitation in constructing a stable system for actual operation.

d) Successful development of the KODAS (Sept. 1997)

Through the pilot project with a pair cable communication method, KODAS achieved some technical advancement. In 1997, Korea had various communication methods including optical cable, TRS (Trunked Radio System), wireless data communication, and ADSL (Asymmetrical Digital Subscriber Line).

Based on such technical advancements, KEPCO developed 'small distribution automation systems' equipped with SCADA and fault management functions. Also, KEPCO completed distribution automation systems first in Korea.

e) Expanded distribution of small scale DAS (after 1998)

Highly completed small DASs were distributed nationwide. The preferential distribution of simple function software was committed greatly to the early settlement of DAS because users who first experienced distribution automation could use it conveniently. Also, with the use of inexpensive workstation level hardware, the project could be expanded nationwide economically.

f) Development and expanded distribution of comprehensive DAS (after 2003)

With the nationwide utilization of DAS, users required more functions in DAS. Based on the research results, KEPCO developed a comprehensive DAS, the current DAS. Based on middleware, the comprehensive DAS was able to have various DMS applications besides the SCADA system functions. Unlike small distribution automation systems in the past, comprehensive distribution automation systems were developed to connect various programs and hardware, and theoretically there were no limitations to expans system capacity.

g) Broad operation of DAS (2007)

The development of DAS enabled the wider operation of the power system with a single system. Eventually, KEPCO unified 190 DASs nationwide into 41 broad systems nationwide, and it reduced personnel in the control center. Besides DAS, KEPCO could improve the operation ability of the power system by constructing diverse power IT systems.

(2) Current status of distribution automation in Korea

Currently, KEPCO as a Korean public company, has been primarily in charge of Korean distribution networks, and DAS has been introduced and utilized stably in all the networks. The current DAS has been operated in connection with a new distribution information system (NDIS) based on the geographical information of KEPCO.

a) Scale of system

The current DAS size is as follows. As in the below Figure 29, KEPCO has operated 75,000 distribution automation switches in 41 distribution centers.

b) Distribution automation communication method

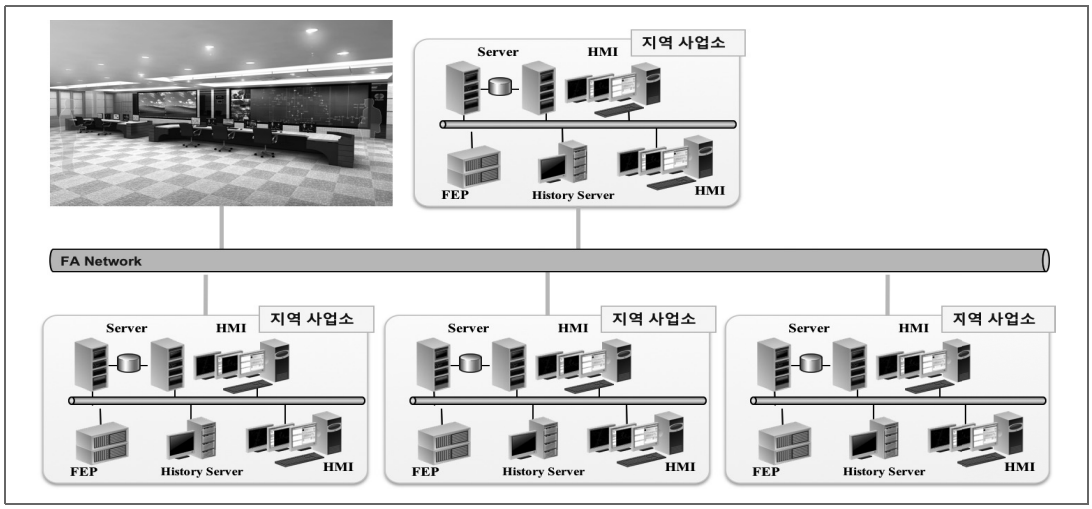
The current communication methods for distribution automation are as follows. Since KEPCO opted for the distribution automation communications as an optical communications, the reliability of the optical communication method has to be maintained at over 99.06%. However, since KEPCO is not allowed to establish own communication networks under government control, it has leased optical communication networks from a communication service provider; thus, it has paid tremendous fees for communication service.

c) System configurations

DAS can be expanded infinitely in theory as it has a distributed structure using middleware. The distributed structure refers to the division of roles of hardware, i.e., communication, control, data management, and system operation, in order to increase the stability and expandability of the system.

The part indicated as Local Office in Figure 16 below is a system operation unit organization of an administrative section or utility. "Dist. IT center" means a distribution control center in charge of one system operation by connecting the systems of Regional Office. This structure enables the reduction of operation cost of a control center by minimizing the manpower of controlling personnel in charge of the system operation. In addition, this structure helps to ensure system safety during any emergency by allocating various individually operable systems to different regions.

Figure 16 | Diagram of the system structure of distribution automation in Korea

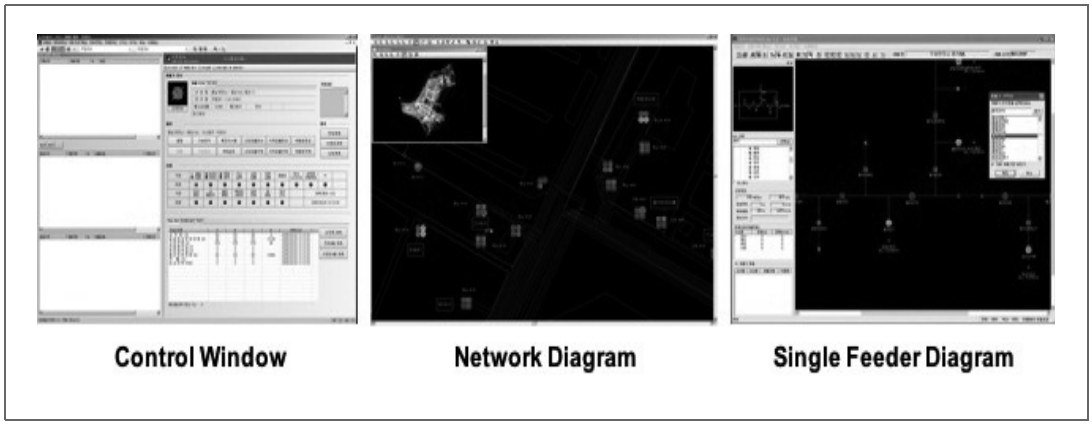


Source: KSP Consultancy Team

d) User interface environment

User interface environment comprises 3 monitors as shown in Figure 17, and the schematic diagram can use GIS or all of the single line diagram forms. The first monitor offers all the necessary information for system operation, and it indicates the screen for performing automatic operation all the time. The second monitor indicates the entire distribution system managed by the system. This is to enable an operator to confirm the whole of the system or a specific part if necessary. The third monitor allows applications to be seen for the efficient execution of the automatic operation of the distribution system, and it is set to confirm the single line diagram and system optimization functions by feeder for fault management.

Figure 17 | Structure of the man-machine system distribution automation interface



Source: KSP Consultancy Team

e) DMS application program

The application for DMS's performance improvement has been continuing through consistent research into individual application programs. The components of network optimization functions are such as "load balancing" (to propose a solution for maintaining the regular load by feeder and substation), "loss minimizing" (to propose a solution for operation by minimizing technical losses by feeder and substation), "overload release" (to propose a solution for releasing overload through load sharing during overload by feeder and substation), and "load forecasting" (for forecasting future load). The data effort detection function makes it possible to key in highly accurate data entry by detecting automatically errors during manual system data entering in the system configuration. Meanwhile, a training program is a function for the simulation of distribution system operation and training for simulated faults.

B) Distribution Information System (DIS)

The DIS of KEPCO utilized GE's Smallworld and GIS, and this was constructed through a nationwide field survey, matching the distribution facility data constructed with existing DIS and blueprint drawing with the field drawing. The NDIS of Korea added the entire distribution facility layer on the national topographic map owned by the Korean government, and it includes all the facility information and actual field pictures of the facilities. NDIS has comprehensive distribution management functions such as asset management, distribution system design, planning, repair and maintenance management, and construction management, KEPCO has undertaken through NDIS all the distribution jobs including billing/collecting/client management.

(1) Background of the NDIS project of Korea

In Korea, KEPCO began the construction of a DIS from 1997 with a two-step preparation for the system followed by another two-steps for extending the system nationwide. During the first step of system design (November 1997 to September 1998), the basic functions of NDIS were classified largely into distribution design, construction management, facility management, system analysis, and electrical installation of a building. Also, a systematic computerization was undertaken through analysis of the manual procedures of each work. Then, in the second step of detailed system design (February 1999 to December 1999) a user screen, database, and a program model were designed.

(2) Current NDIS construction of Korea

a) System configuration

Each system is managed by 15 servers at the headquarters. In particular, as all the systems are connected to the intranet of KEPCO, data can be mutually connected and also integrated. In addition, the center can verify the reliability of all data. The work area and main functions of NDIS are as shown in Table 11 below.

Table 11 | NDIS field of Korea

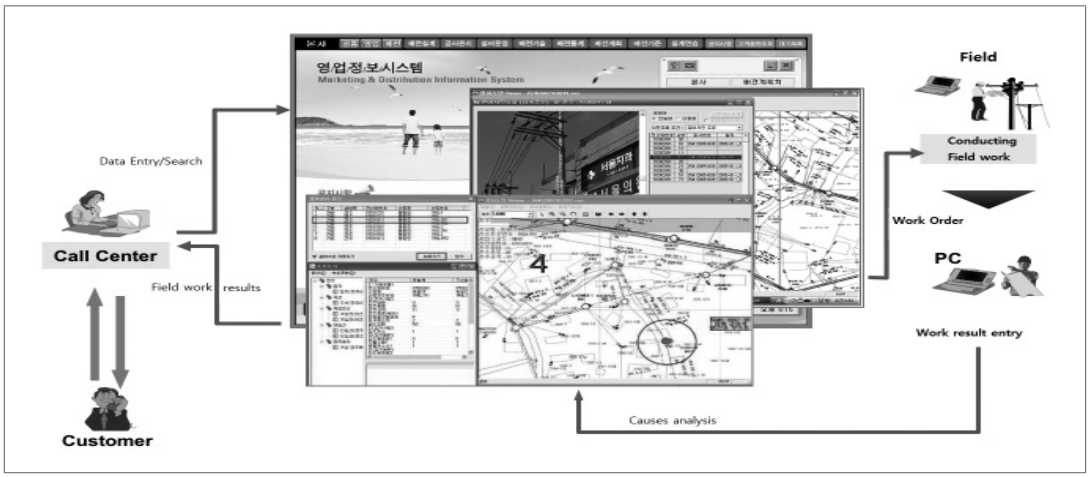
Jobs	Main Funcitions
Distribution facility database construction	• Importing of a national base map • Entering and printing out of virtual/underground facility drawing and field survey data • Entered data verification QA/QC system • High voltage system circuit diagram, high voltage system progress map, underground traverse/ longitudinal map automatic creation system • Shifting of IMS facility data such as P.tr load management, protection device, and underground facility history
Distribution design	• Acceptance and current condition management of design target • High/low voltage supply plan review • Virtual/underground design drawing/specifications preparation • Financial source management including financial source of material/price/wages
Construction management	• contract management, construction progress management • Billing for material/release management • Circulating of the specifications, design drawing, instructions, and notices to a contractor • Entering of facility management data and construction drawing point terminal • Storing of construction settlement of construction with estimated price
Facility operation and system analysis	• Acceptance of fault report – connected with a customer center • ault section, fault point forecast, and support of recovery • High voltage system load management (voltage drop, current) • Transformer low voltage load management / • review of cooperation on protection • Loss calculation and management by facility • Network inspection/checkup/measurement management • Facility statistics, outage statistics, system operation statistics
Internal line meter	• Construction management and cost payment for meter construction, removal, and change • Meter planning construction management / • high voltage client equipment management • Service wire GIS registration and construction cost payment management • Warehousing and delivery of meters and inventory management

Source: Power IT introduction book, 2009. KDN.

b) Response of response to clients utilizing NDIS

As all the work procedures could be managed on the computer using a time tag, customer response utilizing NDIS has changed drastically. For instance, in the past, a customer location had to be obtained by explanation to visit the customer's site and repair the fault in order to respond to customers on the call reporting any fault and requiring a manual work. However, after the introduction of NDIS, a customer's location can be confirmed immediately only by customer's name, telephone number or customer number. Also, it is possible to check any information and pictures of relevant facilities in the office without visiting a customer's site, more prompt and accurate customer response became available. Besides, as customer's bills and usage can be checked immediately, additional customer service became also available. The below figure shows computerized customer response screens through NDIS.

Figure 18 | Response to customers utilizing a sales information system



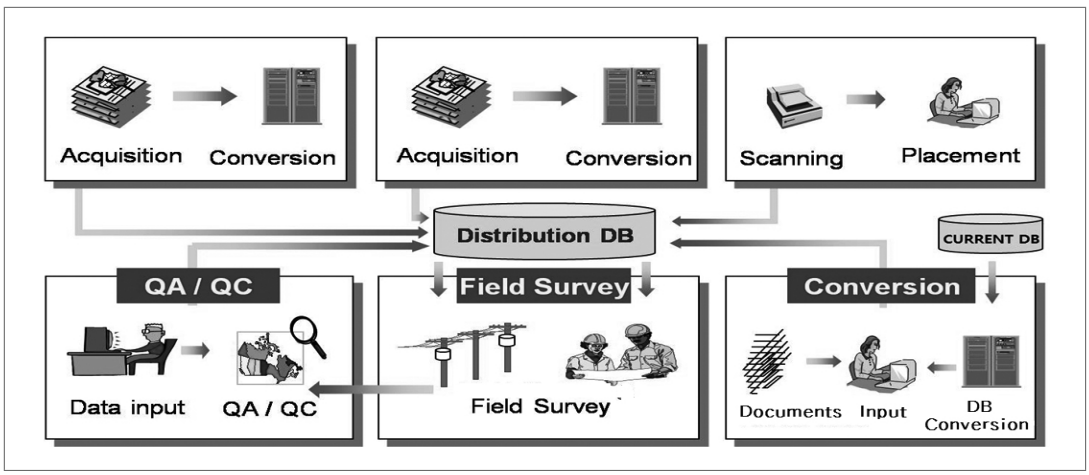
Source: KSP Consultancy Team

c) Power system and facility data management

Figure 19 shows the changes of power system and facility data management based on a field survey of existing blueprint drawings, DIS-based computer data, and other facilities. In early 21st century, the distribution system management of KEPCO was conducted manually by drawing the power system on the blueprint drawings. By drawing the power system on the blueprint drawings, information captured including type of equipment and the DOS console.

However, after the introduction of NDIS, distribution system management has been made easy via computerized drawing so that employees can utilize that on their PC. Field pictures and detailed facility information were included in the distribution system drawings.

Figure 19 | Manual job vs DIS – system data



Source: KSP Consultancy Team

1.3. Implications

Currently, the distribution lines in the Dominican Republic are composed of dendritic systems, and they are not connected with other distribution lines through normal open points (NOPs). In Korea, as each of the distribution lines has interties with adjacent distribution lines at least in 3 places, in case of any overload on one line, the distribution automation system immediately calculates the loads of connected distribution lines, and proposes an appropriate load transfer plan. However, as the distribution lines in the Dominican Republic are mutually independent, in case of any overload, almost the only available way for some sections is load shedding. In addition, even if a distribution automation system is introduced, as the distribution automation system also cannot offer any specific solution in this situation, it cannot be very effective except for prompt load shedding by remote operation.

According to "Improving the nationwide distribution system report", there are plans for the new construction of a total of 34 substations, which is approximately 20% of the number of current substations, and the expansion of a total of 27 substations, which is up to 16% of the total of substations planned by 2020. Also, the new construction or reinforcement of 1,194 C-Km of distribution lines, which is about 5% of the length of those of the current substations, is planned. Although these distribution facility expansion plans are obviously indispensable for consistently increasing power demand, in order to solve the radical issues of the distribution systems in the Dominican Republic, strategic system design plans are required rather than simple facility expansion.

The current plans applicable to the Dominican Republic among the current distribution configuration plans in Korea may be as follows. KEPCO has the standard for one distribution line of 6 divisions and 3 connections using distribution automation devices. In other words, 5 automation switches are installed on average for the division of 5 sections on one distribution line. Accordingly, as 3 places create interties with adjacent distribution lines, in case of any failure on the distribution line, the outage section is reduced immediately to only 1/6 of the entire section. The remaining normal sections can be supplied with power from adjacent lines. Also, diverse system restructuring plans can be found and applied in the field, including overload removal, load leveling, and minimization of technical losses by reviewing the transfer plans of multiple interties through the system optimization algorithm of the distribution automation system.

Taking into account this Korean case and considering that 81% of the causes of outage in the Dominican Republic are concerned with demand management, the most efficient way applicable to the Dominican Republic is the new installation of distribution networks lines and the construction of a distribution system that can respond actively to any increase of power demand by expanding interties between distribution networks. However, the Dominican Republic has not introduced DAS and has not been prepared with efficient distribution system configuration which is the basic requisite for DAS introduction. As stable power supply is a major component in national economic growth and improvement of lifestyle, countries striving to realizing economic growth including the Dominican Republic need to stabilize the power system. Distribution automation can be important in this. In case of monitoring and analyzing functions of the entire power system,

distribution automation is also useful not only for the stable operation of the system but also for the establishment of the growth plan of the power system. For this reason, the introduction of a distribution automation system to the Dominican Republic should be made before investment in basic infrastructure of the electricity field.

Also, in terms of the operation of distribution networks, work outage by powr facility construction is mostly accountable for the total outage indicator owing to the absence of hot line work. If this work outage is not managed accurately, official outage indicator will not be very reliable and the Dominican Republic is supposed to have a higher outage indicator. Hot line work is a good way to minimize work outage; however, since it can lead to casualties, it requires a technical proficiency of a person in charge. In particular, when utilities are not prepared with indepent regulations, it is difficult to introduce hot line work. In addition, as most of hot line work is undertaken by external parties, it cannot be introduced only by improvement of technical competence of utilities. That is, hot line work cannot be applied immediately as it requires organized and planned preparations, as well as appropriate methods for each utility. However, since this is the critical way of improving the outage indicator, the localization of advanced hot line work techniques in cooperation with Korea will be important.

2. Distribution loss status

2.1. Distribution losses in the Dominican Republic

The high distribution loss rate of the Dominican Republic is a serious problem, as indicated in the distribution quality index. The table below shows the loss rate of four local distribution companies (3 in Dominican Republic, 1 in Korea) for 2014. Non-technical losses are almost double the technical losses. It can be inferred from above situations that overload by insufficient supply and voltage drop of old facilities are the cause of higher technical losses. Also, non-technical losses caused by various social factors are quite high. However, even after excluding such non-technical losses, technical losses up to 12% are pretty higher than 3.7% of Korea. Moreover, the rate is far above the appropriate loss rate of 5% proposed by the World Bank.

Table 12 | Distribution loss rate by region

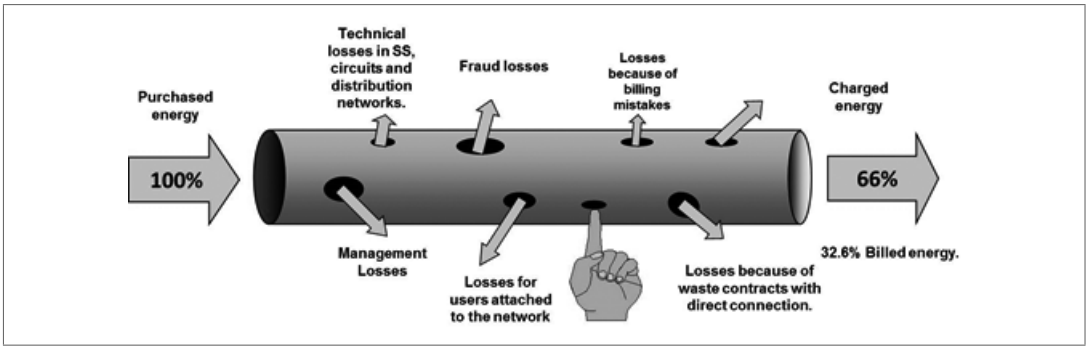
Classification	EDENORTE	EDESUR	EDEESTE	KEPCO
Technical losses	12.59%	12%	12.1%	3.7%
Non-technical losses	20.6%	20.6%	23.6%	-

Source: CDEEE

According to the Figure 20, the causes of tremendous losses assumed by CDEEE include poor power systems, high electricity purchase cost, absence of customer service, small investment in power

facilities, absence of thorough plans and unified efforts toward power loss reduction, insufficient technical/economic management, and misunderstanding of reasonable electricity use.

Figure 20 | Power loss type



Source: CDEEE

Among the above causes, high electricity purchase costs makes it difficult to purchase electricity from some power plants. Therefore, power is supplied only to some networks among various networks connected to those power plants. This aggravates the load concentration per circuit of feeder; thus, demand management outages to solve overload become unavoidable. This leads to reduction in power purchase and eventully to distribution losses.

Also, the major cause of power loss stems from the absence of customer service. That is, although distribution companies need to supply sufficient power to reliable customers who have paid their electricity bills normally, they make frequent outages due to overload. This may cause nonpayment and electricity theft. Furthermore, the Dominican Republic currently forces distribution companies to supply power for 24 hours to the areas with a higher collection rate of electricity bills. To do so, it requires large investments in facilities; however, at the same time, the Dominican Republic has forced distribution companies to cut budgets for facility investment. As a result, there has been no facility investment, which is the cause of non-technical power loss. Finally, there are limitations in controlling losses actively because relevant regulations are not prepared yet.

2.1.1. Non-technical loss

The major causes of non-technical losses consist of the following factors, i.e. electricity theft by clients, poor operation of distribution companies, increase of management cost, and social antipathy of clients. The types of losses from client electricity theft include mechanical manipulation of metering value using strong magnet, power usage by unauthorized access with electric cable to the distribution networks, manipulation of the CT/PT ratio, change of metering value by software manipulation, and overuse by clients who have signed to pay charges for the distribution networks.

In addition, the major causes of losses resulting from the poor operation and misunderstanding of distribution companies were among others, mistake during the issuance of electricity bills, passive response of distribution companies to civil complaints about charges, negligence in relation

to households without the installation of meters owing to insufficient funds, human error when collecting metering value from diverse non-standard models, loss by the change of meters of households with sincere payment of electric charges and households with insincere payment of electric charges, late response to new type of intelligent electricity theft, vulnerable distribution networks, delayed change of incorrect meters, poor management of street lights, and errors from immature billing control for various different meters. In particular, because of social antipathy as a result of unstable power supply, non-technical losses were more significant in regions with limited distribution.

In particular, some areas with frequent limited distribution due to unstable power supply have more non-technical losses. This is because 77% of the contracts with power generation companies to satisfy over 94% of customer demand are long-term contracts of over 10 years while only 17% of the contracts are short-term contracts of less than 36 months. The power supplied by the short-term contract is very expensive compared with that of long-term contracts. This is due to the nature of short contract term and the recently soared oil prices. For this reason, each distribution company executes limited distribution with the real-time monitoring of power demand so that power demand may not exceed 77%.

Likewise, distribution companies that haved suffered non-technical losses classified some areas where there are many households that cause losses as in the Table 13, and have limited power supply to them. This prevents any burden from a power supply cost increase by power generation source because it has a maximum demand power limit effect. That is, if the power demand reaches the maximum demand power which requires the operation of power plants with high generation costs, the maximum demand power has been suppressed by stopping power supply to householes that are usually behind with the payment or refuse to pay the bills before operating power plants with high generation costs. Therefore, distribution companies have differenciated these problematic regions from normal regions that pay the bills timely (regions supplied with power for 24 hours) and have undertaken punitive power demand management. However, from the viewpoint of clients in the regions where power supply is not consistent for 24 hours owing to old distribution networks and technical limitations, dissatisfaction has been intensified because of limited power supply, unstable power quality, and frequent unexpected outages. This has caused their refusal to pay the bills or moral hazard such as electricity theft.

Table 13 | Limited transmission by group

Group	Power supply (hour)	Electricity usage (%)	No. of clients	Loss rate (%)
A	24	66	413.000	16
B	21	2	21.000	41
C	18	10	126.000	52
D	16	22	206.000	65

Source: CDEEE

Currently, the Dominican Republic actively pursues an AMR/Telemetering project to reduce the large non-technical losses. Positive results were gradually achieved via various physical preventive measures such as reinforcement of the low voltage system for electricity theft prevention, installation of gathering instrument case, metering at the upper part of electric pole, distribution of prepaid meters, as well as administrative preventive measures including education on the penalty system.

In addition, the Dominican Republic has improved the distribution field in cooperation with the IDB since 2009 on the modernization of the distribution industry. However, non-technical losses appear to be reduced less than technical losses. This is because non-technical loss reduction projects could not have been extended for financial reasons. Also, owing to poor follow-up management during operation, the initial loss reduction effect is likely to go back to the level which was shown before the installation of electricity theft prevention facilities. Accordingly, it is imperative to build a center that can carry out integrated management of consistent operations after the installation of electricity theft prevention facilities. As one of these improvement projects, the Dominican Republic has plans to install meters for 500,000 households as well as 43,000 macro meters for electricity theft monitoring and power demand monitoring. The Dominican Republic also plans to attract 700,000 clients who make payment through distribution network improvement, to offer electricity theft prevention education and to install meters after transformer sealing for the prevention of unauthorized electricity usage.

2.1.2. Technical loss

In general, the improvement of technical losses is much easier compared with the improvement of non-technical losses. Especially, for countries still struggling with both technical and non-technical losses such as the Dominican Republic, it is relatively easier to prevent technical losses than to reduce non-technical losses.

In accordance with the report of improving the System of Nationwide Distribution (ISND) announced in 2013, CDEEE calculated the technical losses based on a uniform distribution load formula. However, considering the power system structure of the Dominican Republic, a more detailed loss calculation method needs to be adopted. For instance, in calculating technical losses using uniform distribution load in the Dominican Republic, the coefficient of distribution loss is 1/3. However, in extreme cases, if the actual load distribution is in the form of end concentrated load, the technical losses are calculated as only 1/3 of actual technical losses.

Since losses are directly related to income, utilities should carefully identify and review the various causes of the losses they encountered. In particular, non-technical losses is calculated by excluding the technical losses from the total losses. Thus, exact calculation of technical losses is as important as accurate measurement of demand/supply.

2.1.3. Voltage maintenance rate

Although accurate data for the voltage maintenance rate could not be obtained, the voltage maintenance rate is specified to be ±7%. According to the ISND report, about 20% of the networks do not maintain the standard voltage. In the Dominican Republic, there are not much management and supervision on the voltage maintenance rate; thus, there must be great problems in the voltage maintenance rate which is an important factor for ensuring power quality and maintaining the entire power system in a stable condition.

2.2. Distribution losses in Korea

2.2.1. Non-technical losses

Currently the amount of Korea's non-technical losses is insignificant. This is the result of continuous efforts to reduce non-technical losses since the 1970s. The most effective method is to track down electricity electricity theft. As a penalty against electricity theft, KEPCO imposes a charge of 3 times of the electricity fees considering maximum use of the capacity and provides certain percentage of the electricity theft penalty to the person exposing the electricity theft (it can be a KEPCO employee or member of the public). Collection rate is also one of the major KPI in KEPCO. For this KPI, the major problem is default by customers and cutting off the power of defaulted customers. Cutting off power is dangerous for employees because of the aggressive attitude of customers. Therefore, KEPCO can officially request for police protection in the event where power needs to be cut off.

In order to prevent meter reading error, AMI is being expanded in Korea. For manual metering, KEPCO meter readers use a portable metering device, i.e. Hand Terminal. It is a portable electronic device that enables meter data to be saved as computerised data. Moreover, Hand Terminal can connect directly to the billing system and transmit the metering data to prevent any possibility of human error.

2.2.2. Technical losses

The best method to reduce technical losses of utilities is to change the old facilities. Since the late 1980s, KEPCO has improved remarkably on reducing technical losses via active modernization of distribution facilities. Given the characteristics of a public company operated for public convenience, KEPCO was able to improve power facilities without restrictions. To define and observe the exchange cycle of old distribution facilities, focusing on public convenience instead of economic efficiency, was most effective in improving technical losses.

KEPCO is responsible for developing distribution facility design standards and construction standards to accommodate all situations. KEPCO also operates the distribution system, and minimizes technical losses all the time. This is done by obtaining real-time operation information of the system utilizing the distribution automation system installed nationwide. Furthermore, KEPCO manages technical losses by realizing a complicated and detailed algorithm for the distribution system con-

figuration, calculating and establishing the algorithm with the distribution automation system, and applying the algorithm easily to the distribution system through automatic operation.

2.2.3. Maintenance of standard voltage[4)]

In Korea, the utilities have a mandatory obligation to inspect the maintenance of standard voltage twice a year and the results are submitted to the government. This is performed to measure voltages randomly for 24 hours and notify the government of the results according to the voltage maintenance rate inspection standard legislated by the government. As this method is one of the assessment criteria for regional offices, KEPCO has executed low voltage facility improvement for each office, and has put great efforts to maintain actively standard voltages. Through these efforts, the standard voltage maintenance rate of Korea is at the high level of 99.99%.

KEPCO does not use a condenser for voltage compensation in the middle of a feeder due to inconvenience in repair and maintenance and the increased probability of fault. However, in the case of anticipating long distance distribution networks interruption or a voltage drop, KEPCO installs and operates voltage regulator in the middle of a feeder.

2.3. Implications

The non-technical loss in the Dominican Republic is considered to be directly related to the imbalance between supply and demand because more non-technical loss occurs in the area in which the power supply is limited, and that all kinds of physical preventions have not noticeably improved this problem. In order to reduce non-technical loss, enhancing the electricity customers' satisfaction by providing a stable power supply would be fundamental, rather than focuing on the problem itself.

In the case of Korea, the most efficient effort to reduce the non-technical loss was to thoroughly detect electricity theft. KEPCO implemented and still maintains the program that gives incentives of a certain part of the detected loss to the reporter. KEPCO is also encouraging competition between distributors by adopting the collection rate as a main evaluation index of local distributors. Furthermore, in case that the power supply to the long term default customer needs to be stopped, support by the police is systemically requested to protect the service workers.

The Dominican Republic has a high technical loss index in addition to non-technical loss. This is also considered to be closely related to the demand management. High technical loss in some lines due to the overload causes deterioration and break down of the facility, worsening the technical loss. From this point of view, an effective supply-demand control, balanced load distribution, and stable power supply are critical to improve the loss in power distribtion problem in the Dominican Republic. Deterioration of electricity facilities is also a significant cause of technical loss. Since the Dominican Republic nationalized the former private distribution companies, old facilities from the past have not been improved yet. Accordingly, modernization of the old facility is a very urgent problem.

4) The standard voltage maintenance range of Korea is defied as 220V(low voltage single phase) plus or minus 13V.

Lastly, as the voltage maintenance was found to be lower than 80%, the power loss due to voltage drop is considered to increase. The results of field survey show that the power factor of the substations is at about 90%, so improvement of power factor is considered to be an important factor to reduce the loss.

Therefore, the Dominican Republic needs to establish more comprehensive and strategic plan to reduce technical and non-technical loss. That is, in order to reduce the technical loss, distribution lines should be modernized to make a stable power supply for 24 hours in regular households. This can alleviate the resistance against the electricity bill collection and this can reduce non-technical power loss. Furthermore, it would be better to development more programs such as remote metering project to reduce the non-technical loss.

3. Power metering analysis

3.1. Power metering in the Dominican Republic

Through the nationalization process of EDESUR and EDENORTE in 2003 and EDEESTE in 2009, followed by privatization of the three distribution companies in 1999, the Dominican Republic has operated diverse types of meters and metering systems. According to payment mode and measurements, clients are further classified and managed as follows: clients using deferred payment type electronic watt-hour meters (post-payment based on bills used by metered amount after electricity usage), clients using pre-paid electronic watt-hour meters (purchase electricity using the prepayment system), clients using deferred payment type mechanic watt-hour meters, clients using flat rates, and households with unauthorized electricity usage by electricity theft. Each distribution company operates by power metering and billing attuned to local characteristics. Different meters are distributed by region; however, billing solutions are the same for the issuance of the final bills. The number of clients has grown with consistent economic growth, and active efforts have been rendered to change clients with unauthorized electricity usage by electricity theft to normal clients. There was an increase of approximately 237,000 households in 2011 and about 133,628 households in 2013.

Table 14 | No. of clients to issue bills by distribution company

(unit: person)

Category	2011	2012	2013
EDEESTE	634.411	562.656	597.682
EDENORTE	741.556	631.328	703.615
EDESUR	529.243	526.573	552.889
Total	1.905.210	1.720.557	1.854.186

Source: CDEEE

3.1.1. Current situation of EDEESTE

There are 646,553 residential customers and 4,785 industrial customers. With regard to customers with watt-hour meters installed, 428,274 residential customers use general manual reading meter whereas 56,709 residential customers use general automatic reading meter, 2,870 industrial customers use manual reading meter, and 1,915 industrial customers use automatic reading meter. There is no household with unidentified billing with the installation of a watt-hour meter. Among residential customers, a total of 162,571 households did not have watt-hour meters installed. The reasons for non-installation include resistance against the installation of meters (owing to their experience of free power supply from the government in the past), the possibility of breakage after installation, and delayed installation due to insufficient budget.

1) Communication type

For communication, General Packet Radio Service (GPRS), Power Line Network Communication (PLC), and Radio Frequency (RF) are used. GPRS has adopted the TCF/IF protocol and an Internet transfer method using the 850-1900 MHz bands. As for PLC, the standard method using a Two-Way Automatic Communication System (TWACS) is used. Meanwhile, RF communication using 2.4 GHz or 5.8 GHz frequencies is used mainly for communication between substations.

2) Meter types

The current meters of EDEESTE are as follows. The communication types are mainly GPRS, PLC, MCA, and RF. Table 17 shows details of manufacturers, brand names and communication type.

Table 15 | Current status of EDEESTE telemeteing meter type

Brand Name	Communication Type	Manufacturer
Itron Schlumberger Sentinel	GPRS	ITRON INC
Landys and Gyr RXRS4	GPRS/DIAL UP	LANDYS AND GYR
ELSTER-ABB Alpha A3	GPRS/DIAL UP	ABB
HEXING	MCA	HEXING
SPECTRUM SIM 120V TIPO BOTTOM	MCA	SPECTRUM
Itron-Centron	PLC	ITRON INC
Landys and Gyr- Focus	PLC	LANDYS AND GYR
General Electric	PLC	General Electric
ELSTER A3RALN	PLC	ELSTER
LINGYANG	PLC	LINGYANG
ELSTER	RF	ELSTER

Source: EDEESTE

3) Current situation of the communication software for metering

Table 16 shows communication software used for metering and maintenance of meters.

Table 16 | Current status of the communication software EDEESTE

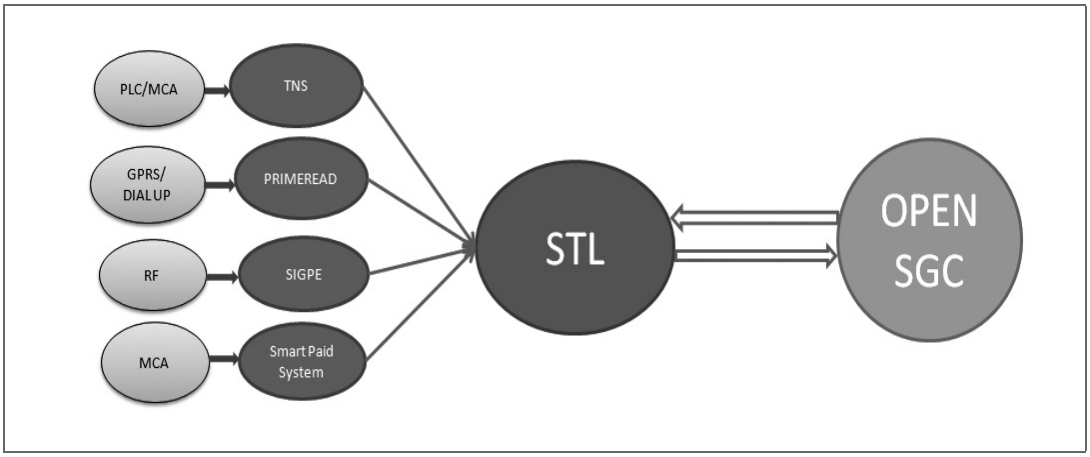
Software	Type
PRIMEREAD	GPRS/DIAL UP
TNS(TWACS NET SERVER)	PLC
TNS(TWACS NET SERVER)	MCA
SMART PAID SYSTEM	MCA
SIGPE (Sistema Integrado de Gestión de Pérdidas)	RF

Source: EDEESTE

4) Meter reading structure

Billing is made through automatic interfacing with a billing server, after obtaining the metered values using a portable manual meter.In reviewing the metering configuration of EDEESTE, as shown in Figure 21, the PLC/MCA communication type meter uses the TNS (TWACS NET SERVER) type, the GPRS DIAL UP communication type meter uses the PRIMEREAD and RF uses the SIGPE type and MCA uses the SMART PAID SYSTEM type to read the primary metering information. The metered values are composed of a system that converts information in different forms into the STL (Sistema de Telemedición) system and transfers it to billing software, OPEN SGC.

Figure 21 | Metering configuration of EDEESTE



Source: EDEESTE

5) Billing server

The billing software OPEN SGC by Indra, manufactured in Spain, provides services such as metering, billing, collecting, technical service and its independent billing validation test function.

6) Integration of different types of meters and classification method of electricity theft clients

In order to integrate different communication methods and protocols, a platform called STL (i.e. Sistema de Tele-medición) integrating different types of meters is used. The STL system has a monitoring function of clients' electricity usage patterns. It analyzes and classifies the patterns of the maximum peak usage and pattern of no consumption. Electricity theft clients have been identified with this function. If small amounts of power use are monitored using this function, electricity theft clients may be distinguished by comparing the pattern of the previous peak use and small use during normal times.

3.1.2. Current situation of EDENORTE

There are 826,467 residential customers and 2,014 industrial customers. With regard to customers with watt-hour meters installed, 619,373 residential customers use general manual reading meter whereas 2,014 industrial customers use automatic reading meter. There were 18,498 residential customers with unidentified billing despite the installation of watt-hour meters. Among residential customers , a total of 188,605 households did not install watt-hour meters.

1) Communication type

Communication types are the same in all three distribution companies. (See "Communiction type of EDEESTE".)

2) Meter type

The current meters of ESTENORTE are as follows. The communication types are mainly GPRS, PLC, and RF, and each of the manufacturers is shown below Table 17.

Table 17 | Current status of EDENORTE telemetering meter type

Brand Name	Communication Type	Manufacturer
ACTARIS SL7000	GPRS	ITRON INC
SENTINEL	GPRS	LANDYS AND GYR
ISKRAEMECO	GPRS	ISKRAEMECO
Hexing	GPRS	HEXING
CENTRON	PLC	ITRON INC AND ACLARA
ELSTER	RF	ELSTER
GE Onramap	RF	GENERAL ELECTRIC

Source: EDENORTE

3) Current situation of the communication software for metering

Table 18 shows the use of software for the reading and maintenance of a meter.

Table 18 | Current status of the communication software EDENORTE

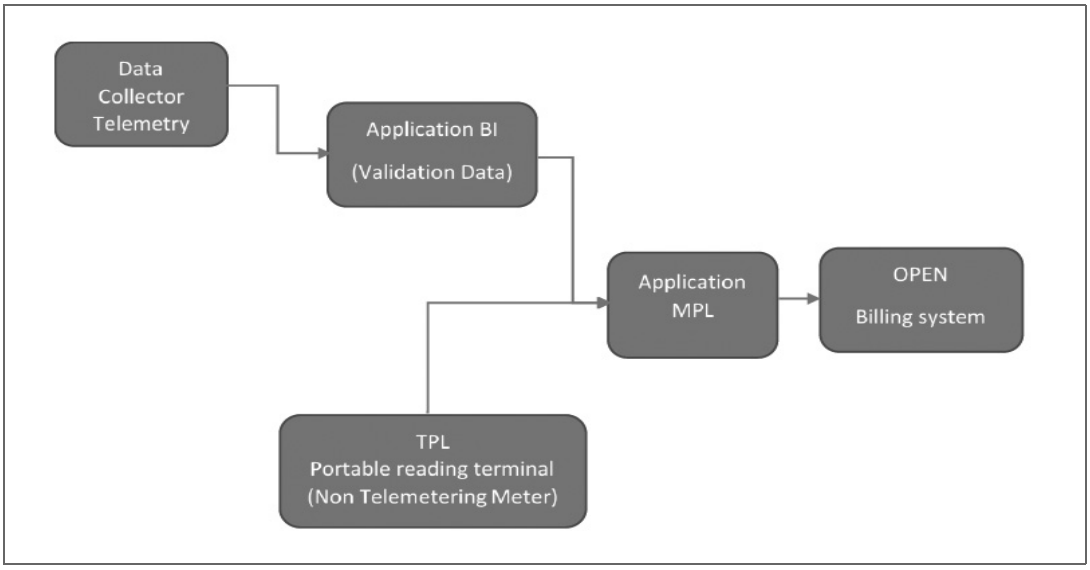
Software	Type
MV90xi (3 tipos)	GPRS
Energy Axis Management System	GPRS
TNS(TWACS NET SERVER)	PLC
OTV(Onramp Rotal View)	RF 2,4GHz
AMI Sistem	GPRS

Source: EDENORTE

4) Meter reading structure

In the metering configuration of EDENORTE, a billing system is used that reviews the efficacy of data read from a meter using an application billing module (Application BI: Business Intelligence), and it is interfaced automatically with a billing server through the management module (Application MPL: Monitoreo de Pocesos de Lectura). Also, manual metering with the use of a portable terminal (TPL: Terminal Portable de Lecturareading Terminal) is applied in the same manner.

Figure 22 | Metering configuration of EDENORTE



Source: EDENORTE

5) Billing Server

The billing server is the same in all three distribution companies (see "Billing server of EDEESTE").

6) Integration of different types of meters and classification method of electricity theft clients

EDENORTE is using 3 types of MV90xi software for industrial customers and also using separate softwares per meter manufacturer. Same as EDEESTE, EDENORTE detects power theft customers by using STL system. The STL system has a monitoring function of clients' electricity usage patterns. It analyzes and classifies the patterns of the maximum peak usage and pattern of no consumption. Electricity theft clients have been identified with this function.

3.1.3. Current situration of EDESUR

There are 610,214 residential customers and 3,348 industrial customers. Among customers with watt-hour meters installed, 423,674 customers use general manual meter reading. Meanwhile, 85,540 customers use general automatic meter reading and 3,348 industrial customers use automatic reading meter. None of the households had unidentified billing despite the installation of watt-hour meters. With regard to customers for residential, a total of 86,023 households did not have watt-hour meters installed.

1) Communication type

Communication types are the same in all three distribution companies. (See "Communiction type of EDEESTE".)

2) Meter type

The current meters of ESTESUR are as follows. The communication types are mainly GPRS, PLC, and RF, and each of the manufacturers is shown below Table 19.

Table 19 | Current status of EDESUR telemetering meter type

Brand Name	Communication Type	Manufacturer
Elster Serial 8	RF	Elster
Hexing Electrical 7	RF	HEXING
ION Serial 7,8	GPRS	Schneider
MNeta-Sentinel GPRS 8	GPRS	Itron
Nansen TDCU 8 SPECTRUM	PLC	Nansen
Q1000-SCHLUMBERGER	GPRS	Schlumberger
Sentinel GPRS 8	GPRS	Itron
Sentinel TWACS	PLC	Itron

Brand Name	Communication Type	Manufacturer
T7 SCHLUMBERGER 7	PLC	Itron
T8 General Electric Serial 8	PLC	GE
T8 Landis & Gye Serial 8	PLC	Landis & GYR
T8 Centron S8	PLC	Itron
T8 SCHLUMBERGER 8	PLC	Schlumberger
T WASION Serial 8	PLC	Wasion

Source: EDESUR

3) Current status of the communication software for metering

The communication software for metering and maintenance of meters uses the programs listed below.

Table 20 | Current status of the communication software EDESUR

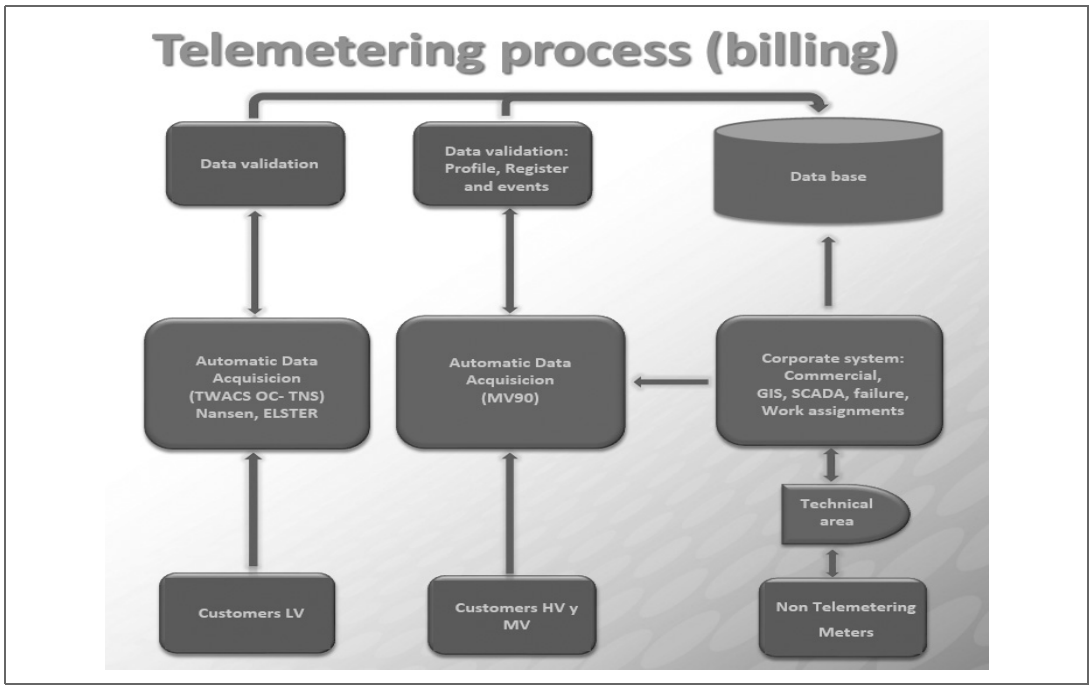
Software	Type
ALPHAPLUS	Local
Meter CAT	RF 2.4GHz
Sistema Prepago Hexing	RF 2.4GHz
ION SETTUP	GPRS
PC-PRO	GPRS
Meter Shop	Local
Meter buddy	PLC

Source: EDESUR

4) Meter reading structure

The metered values from a meter are scheduled at 0:00 every day for reading. LV clients use TWACS–OC while MV clients use MV-90 for metering. Subsequently, this information is transferred to the database of the billing server to issue billing.

Figure 23 Metering configuration of EDESUR



Source: EDESUR

5) Billing Server

Billing server is same in 3 distributors (see the billing server of EDEESTE)

6) Integration of different types of meters and classification method of electricity theft clients

Three types of MV90xi software are used for industrial customers, whilst each manufacturer engaging additional operating software respectively. Each metering system detects electricity theft by checking daily power consumption using excel macro system check method. The system reviews deviation in demand power, no load period, interval of meter interruption, maintenance interval of deviation, time deviation, abnormal critical change, and abnormally repeated information. Macro reviews consumption patterns, phase check (check of alternating current power), interruption validation for irregular interference error, connectivity validation, determination of validation through comparison with existing profiling versus measured values, and validation test for a specific condition.

3.1.4. Current situation of loss rate readings

The main causes of the high meter loss rate are clients' electricity theft and immature operation and misunderstanding of distribution companies. There have been attempts of electricity theft by all types of clients. Despite active detection by each of the three distribution companies, there is

disparity in figure between the actual electric energy purchased by distribution companies and record of the generation company. However, losses have been reduced annually since the consistent installation of meters for electricity theft prevention, community education on electricity usage, and improvement of the distribution networks.

Table 21 | Integrated energy loss of distribution companies

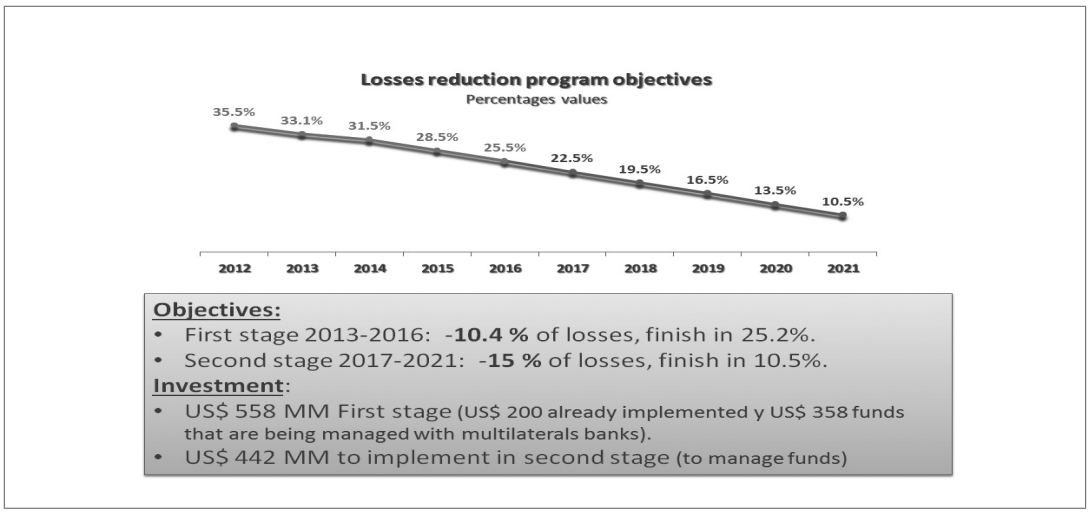
(Unit: GWh)

Classification	2012	2013
Purchase	11,548	11,950
Billing	7,041	7,663
Collection	7,444	7,989
Loss	4,104	3,961

Source: EDESUR

As in the below Figure 24, the first goal of CDEEE is to reduce the loss rate of 10.4% by 2016, and it managed to lower the loss rate to 10.5% in the second stage. The CDEEE of the Dominican Republic intend to attract more investment to enable smooth execution of the project by the end of 2015. The main goal is to install about 500,000 automatic meters and shift approximately 700,000 household clients to be regular clients for payment by constructing roughly 43,000 macro meter systems. To ensure smooth execution of the project, CDEEE set up social welfare policy in handling application of electric charges and education about electricity theft prevention.

Figure 24 | Loss rate reduction plan



Source: EDESUR

3.1.5 Current efforts to reduce the rate of reading loss

Electricity theft is defined as a crime; thus, clients who committed electricity theft will be referred to arbitration. Distribution companies need to improve on their preventive measures to eliminate cases of electricity theft recurrence. For instance, as high as 14% clients repeat electricity theft act after going through arbitration for electricity theft. This problem discloses that certain social classes still resist billing and paying for their consumption, despite knowing that electricity theft is a crime.

In order to prevent electricity theft, distribution companies are charging a high price for reinstallation of meter cases damaged by clients with intention to commit electricity theft (Figure 25). This helps to prevent the recurrence of electricity theft.

There are clients who attempt electricity theft using sophisticated methods such as Modulation of the LCD indication value of a meter, or initialization of a meter using a super magnet. Specialists hired by each distribution company can detect such attempt using data analysis software offered by meter.

Figure 25 | Installations atop meters affected by electricity theft



Source: KSP Consultancy Team

Effective electricity theft detection and countermeasures operate efficiently using macro meters and collective style gathering instrument cases. Macro meters detect the history of electricity theft in a relevant area by monitoring the entire electricity usage of a specific region in real-time. This is done by comparing it with the electricity usage of multiple collective style meters in the area. Be-

sides, macro meters are effective in reducing loss rate, e.g. by locking out an electronic contactor within a collective style instrument case and shutting off power against households attempting electricity theft. This collective style meter is made up of one CT part meter inside an enclosure, 15 single meters, and one data collection unit DCU. When a failure to pay or electricity theft warning is detected, it shuts off power by turning off an electronic contactor. DCU transfers metered values with a GPRS modem on it. In addition, in case of the random opening of a collective style instrument case, this is perceived as a electricity theft attempt, and power to all the households is shut off.

Pre-paid meters are accountable for 10% of the entire meters in operation, and they have a pre-payment system. Pre-paid meters have a built-in power shutdown relay; thus, they shut off power when the pre-payment is consumed. Collective style meters are all pre-paid meters.

Distribution companies would identify a leader or manager in the community to initiate active communications with residents. This allows the company personnel to inspect the installed meters after designating a manager of the community. As a consequence, residents recognized power loss by electricity theft as a community issue, and self-monitoring is their shared responsibility.

Figure 26 | Installing sets of collective meter on top of electric poles



Source: KSP Consultancy Team

Figure 27 | Oversight activities of local communities EDESUR





Source: KSP Consultancy Team

Recently, each distributor has been putting efforts to reduce the loss rate with the support of multilateral development banks such as IDB. Representative among them are projects for modernization of old distribution lines, substations construction and remote reading to prevent power theft. In particular, after the implementation of remote reading project, the loss rate was reduced from 46% to 20% in EDENORTE, from 80% to 45% in EDESUR, and from 53% to 20% in EDEESTE. The effect of loss rate reduction can be found in the table below.

Table 22 | Result of Multilateral Development Bank (MDB) on the rate of non-technical losses

Classification	EDENORTE		EDESUR		EDEESTE	
Client of feeder (EA)	13		15		7	
Clients (person)	66,271		61.309		55,205	
Investment (MM USD)	48.45		29.72		24.53	
Class	start	end	start	end	start	end
SupplyEnergy (GWh)	19.04	20.46	25.14	14.76	175.40	189.00
Billing Energy (GWh)	10.32	16.42	5.06	8.14	83.10	150.96
Losses (GWh)	8.72	4.05	20.08	92.30	92.30	38.04
Loss rate (%)	46	20	80	53	53	20
Billing rate (%)	88	99	75	91	91	89

Source: CDEEE

3.1.6. Current situation of broadband networks

For the broadband communication networks of the Dominican Republic, consistent investment was prompted by wireless business and broadband distribution projects. This is in line with the government's goal of creating "the best IT country in the Caribbean". INDOTEL established in 1999 has been instrumental in law execution, systemization and advancement of the information communication market in the country.

In mid-2012, a communication company Orange began to provide LTE networks, and the internet speed reached 100 Mb/s. In the meantime, INDOTEL also pursued a plan to install broadband services to local provinces. By March 2013, domestic networks for the use of internet service at inexpensive prices were installed. This has led to a rapid increase in internet users. As of 2014, there were close to 4 million internet users out of a total population of 11 million. In addition, investment in the communication field has been ongoing despite the global economic downturn. ICT service providers in the Dominican Republic are either foreign investors or joint investment companies. The key players are three big foreign companies: CLARO (Mexico), Orange (France), and VIVA (USA), whilst the local company is WindTelecom.

With a modest starting point of a 700 MHz mobile service advancement project in 2012, faster mobile communication and broadband services at 270 MHz and 818 MHz were made possible. Recently, INDOTEL announced a construction plan for telephone networks of 1700-2100 MHz and 941-960 MHz. It aims to raise the internet distribution rate of the Dominican Republic to above 60% before 2020, and it also plans to install 3,224 km long cables in 5 years. The growth of communication network users each year since 2012 is shown in the table below.

Table 23 | Annual number of users of communication networks

(Unit: persons)

Category	2012	2013	2014	2015(August)
Wire phone users	1.083.619	1.095.420	1.116.076	1.143.546
Wireless phone users	8.934.196	9.059.820	8.303.536	8.721.458
No. of internet connection lines	2.054.905	3.773.134	3.773.134	4.626.497

Source: INDOTEL

The communication networks used by each distribution company of the Dominican Republic are combined with radio frequency 2.4 GHz and 5.8 GHz networks and GPRS networks. The RF type was used for operating the transmission and transformation SCADA system. Besides, PLC communication is engaged for their power networks.

With regard to GPRS type automatic metering, EDEESTE used CLARO for all networks, EDENORTE used CLARO (60%) and ORANGE (40%), and EDESUR engaged the same companies as EDENORTE. The current automatic metering meters and communication methods of each distribution company are summarized in the following table.

Table 24 | Current operation of automatic reading meters by communication method of each distribution company

(Unit : site)

Company	RF type	GPRS type	PLC type
EDEESTE	18,000	3,000	38,000
EDENORTE	25,300	5,940	82,871
EDESUR	38,039	3,406	144,788
Total	106,639	12,346	265,659

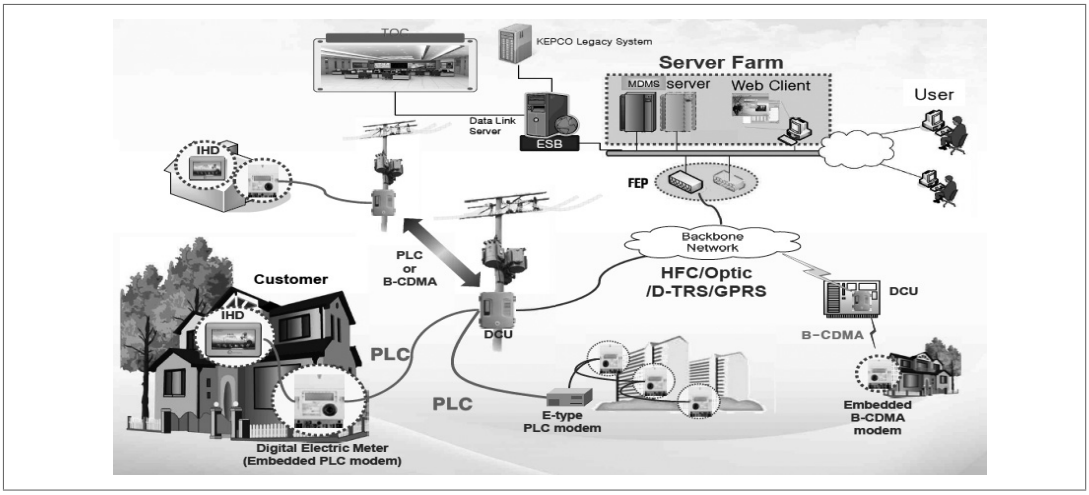
Source: CDEEE

3.2. Power metering in Korea

3.2.1. Configuration of KEPCO's AMI system

As shown in Figure 28 below, the AMI network of KEPCO uses a method of collecting metering information by reading data repeater equipment (DCU) and transferring the data to an FEP (Front End PC) at the end of the reading server through the KEPCO backbone network. Also, reading data repeater equipment (DCU) that uses an imbedded B-type CDMA modem has been used. The metering information collected in the FEP is saved in the reading data management system (MDMS), and the use information is delivered to customers through an additional web client server.

Figure 28 | AMI Network configuration of KEPCO



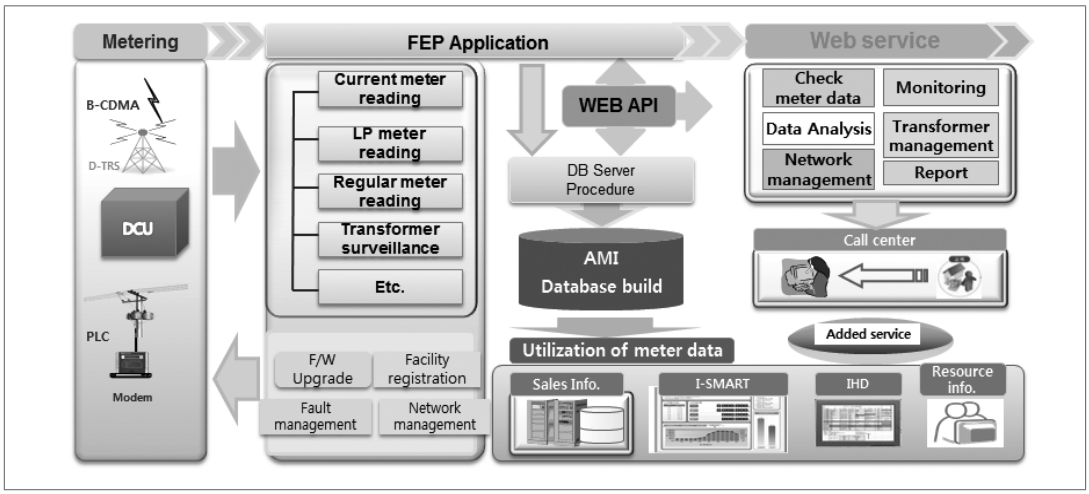
Source: Export-Import Bank of Korea, Support of smart grid technology introduction to Equador, 2013

3.2.2. AMI Network configuration of KEPCO

The advanced AMI system of Korea is connected with the Enterprise Service Bus (ESB)-based integration platform of CIS, which is a legacy system of KEPCO, and Total Operation Center (TOC) for data connection. The top tier system of advanced AMI consists of a Meter Data Management System (MDMS) and an ESB-based system for data connection. This system is able to receive or send customer information and meter information directly from a customer information system (CIS). Furthermore, it can send and receive information such as an ESB-based common information model through data connection with the TOC.

In addition, TOC provides timely information or Real Time Price (RTP) and Customer Base Line (CBL) information. Transmitting and receiving cycle and information factors regarding such information are defined in a common information model profile, and the TOC has always abided by this principle. The MDMS of advanced AMI can transmit and receive information on outages of customers on low voltage lines, power quality information, and information about small decentralized power generation (solar power generation, vehicle to grid) as well as metering information.

Figure 29 | AMI system configuration

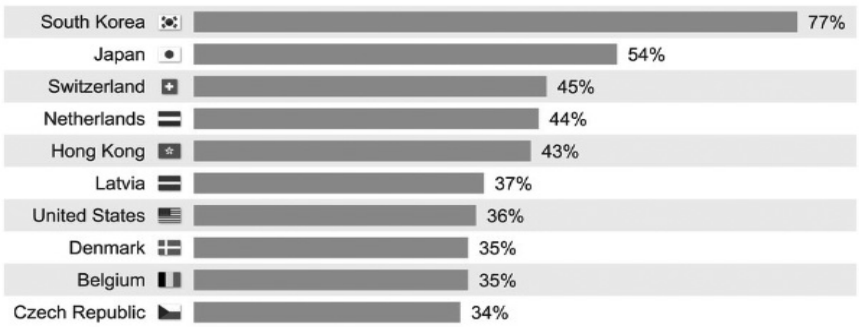


Source: Export-Import Bank of Korea, Support of smart grid technology introduction to Equador, 2013

3.2.3 Current situation of broadband networks

The broadband networks of Korea have shown a world class, super speed internet (10 Mbps) adoption rate, which proves that Korea is strong and advanced in IT[5]. As of November 2014, super speed internet service subscribers totalled 19,210,000. As of 2015, the super speed internet market appears to have no more demand. Despite this situation, along with the increase of single households, new subscribers are increasing consistently. Based on this infrastructure, the Korean government succeeded in the distribution of e-government. Also services using broadband communication networks, such as internet and IPTV broadcasting have been utilized in a stable manner.

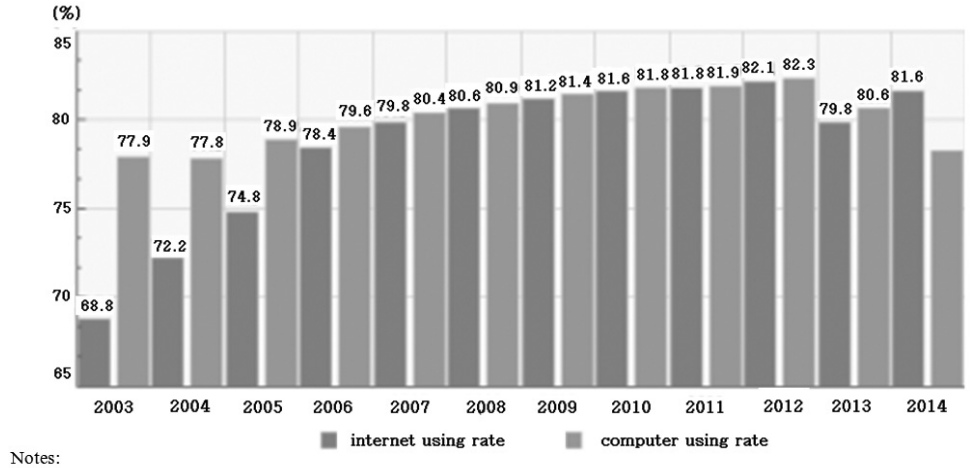
Figure 30 | 10 countries with the highest rate of use of high-speed Internet



Source: Akamai, http://www.akamai.co.kr, 2015

5) In January 2015, the average inernet connection speed reached 25.3Mbps to take the fastest in the world in 3 consecutive quarter.

Figure 31 | Rate of households with internet access and househols with computers



Notes:

1) "Internet distribution rate" refers to the ratio (%) of households with access to the internet among the total number of households, and wireless internet (mobile phone and wireless internet) connection through mobile communication networks are excluded.

2) "Rate of households with computer" is the rate of households that have computers such as desktop and laptop out of whole households.

Source: The Ministry of Science, ICT and Future Planning and the Korea Internet & Security Agency

KEPCO utilized CDMA communication networks in introducing automatic metering and the AMI system, and it also attempted the active introduction of IoT technology in smart grid system promotion. Such IoT technology can be used in smart sensor groups involving the following - smart sensor nodes customized for power facilities, wearable smart safety helmets, and module products such as self-diagnostic IoT transformers and switches.

3.3. Implications

CDEEE and each distributor have made great efforts to reduce the loss by implementing pilot programs of the latest technology and optimized loss reduction solution. Through these efforts, it is considered that the distributors have already acquired a certain level of know-how. However, reading loss has been continued by customers' power theft, distributor's operational mistake, and insufficient response toward complaints. In particular, power thefts are becoming smarter in every category of customers.

For now, accurate measurement of the ratio of power loss between low and high voltage customers is not availabe. Therefore, it is hard to objectively determine customers which is more efficient and urgent: the large scale expansion of remote reading system simply based on low voltage system or the power loss by measuring an accurate reading of high voltage system in which remote reading is already available. It is also difficult to determine how to prioritize policies between low voltage and high voltage systems. The only alternative to solve this problem is TOC (total operation center) for remote reading. If the reading of LV system and HV system is measured in real

time or regularly compared to each facility capacity, it can be more clear which area or substation should be intensively managed.

When a comprehensive management of various power meter systems becomes enabled, operation cost can be saved and pattern analysis of power usage is available. It also makes easier the installation of different meters and thus, monopoly of a few manufacturers can be avoided. In terms of service, extra manpower can be assigned to field surveillance and service response to provide high quality electricity service to the citizens. Then the resistance to electricity billing can be alleviated and the cost of electricity loss caused by power theft and unpaid bills are considerd to be reduced. Therefore, a total operation center (TOC) is necessary to check all meterages at one place.

III Policy recommendations

1. Distribution technology sector

1.1. Stabilization of power supply

The most urgent key issue of the electricity distribution system in the Dominican Republic is the imbalance in supply and demand as a consequence of inadequacy in its distribution infrastructure. In terms of usage, 33% of utility customers in the Dominican Republic consume electricity for an average of 16 hours per day. Field survey results showed that only 48% of these customers are able to have electricity supply without deliberate or forced interruptions, while the majority of the customers encountered problems in unstable supply due to insufficient power supply.

In view of the extent of this problem, modernization and improvement plans for electricity distribution infrastructure in the Dominican Republic should progress toward solving the supply-demand imbalance problem as well as toward improved distribution demand management.

As shown in reliability indices (SAIDI and SAIFI) applied to the Dominican Republic, the stability of power supply in this country is extremely poor. Continued inefficiency in performance is the main barrier for overall economic growth and a cause of utility customers' dissatisfaction with electricity use in the Dominican Republic. Primarily, since 81% of power outages in the Dominican Republic is a result of demand management, it is difficult to find an immediate solution. Nevertheless, the Dominican Republic will have to find an effective and progressive solution to the problem of stabilization of power supply.

The current state of unstable power supply causes enormous hindrance in the operation of various industrial facilities, and also has adverse effects on development of the tourism service industry. In particular, as stable power supply for the manufacturing industry is related directly to the quality of its industrial products, it is challenging and near impossible to ensure industrial growth without stable power supply. Stabilization of power supply is therefore viewed as a main obstacle when introducing cutting-edge power transmission technologies for industry developments in the Dominican Republic.

1.1.1. Installation of protection devices

To ensure consistent and reliable electricity power distribution, protection devices are used to detect and interrupt momentary faults. For example, recloser/sectionalizer devices can detect any fault in the distribution feed, can break automatically a fault without remote control to isolate faulty section(s), and keep normal section(s) stable without interruption. Theoretically, by installing a recloser in the middle of the line, SAIDI/SAIFI can be improved by 50%, compared with non-installation. If a recloser is installed with low pickup current setting (lower than normal fault current pickup value but higher than normal load current), the overload on the entire line can be prevented by breaking the load in a specific section automatically.

Installation of protection devices can contribute to improve distribution demand management. Since a recloser can be operated by the pick-up current setup, if this pick-up current is set below an allowable load current that is smaller than the fault current, the recloser breaks its load side when its load side current exceeds its pickup value. In this manner, any outage due to overload on the entire lines can be avoided. For instance, to ensure smooth distribution demand management, if the maximum allowable load after a recloser is 150A, any outage on the entire feeders which may occur owing to overload can be limited to the load side of the recloser only by setting the pick-up current of a recloser as 150A.

1.1.2. Installation of section switch

The consultancy team recommends that the use of section switches in distribution feeders needs to be increased. A section switch is relatively economical compared with a recloser. The design of an adequate combination of a recloser and a section switch is a considerable cost-effective solution.

In principle, the more section switches that are installed, the higher the possibility that fault section can be minimized. However, this requires a relatively large budget, and the installation of appropriate numbers of switches always has to take into account cost effectiveness concerns. On average, the number of section switches per feeder is 5-10, including reclosers. These quantities are determined by section load and the length of a line. For Korea Electric Power Corporation (KEPCO) systems, section switches are installed according to regulations presented in the table below. The load separation is based on six divisions and three connections, and this capacity is considered adequate for load transfer.

To enable extensive distribution system reinforcement in the Dominican Republic, the installation of section switches during the execution of such a project is necessary to ensure stable power supply as well as enhance utilizability of the power distribution system.

1.1.3. Configuration of multiple connection lines

Mesh distribution feeders, which are able to respond actively to power demand and fault management, should be constructed together with distribution systems. In this regard, it is to define the system design to enable load transfer during load circulation and to reduce the outbreak of fault between distribution feeders. This should be executed when designing new distribution feeders and during distribution feeder reinforcement construction.

To cope actively with power demand and failure management in connection with the distribution system, a mesh circuit for distribution should be constructed. For this, it is effective to define the system to enable load borrowing between the circuit of distribution and load transfer during any failure stemming from any new circuit of distribution design and circuit of distribution reinforcement design. In particular, if there is no connection with any other network as in the Dominican Republic, the distribution system has any overload, and, further if it experiences any additional new load, theoretically, a new network construction is required. However, for multiple connection lines, the probability of supplying a new load directly without any overload through an appropriate switch operation (circuit of distribution restructuring) becomes much higher. Accordingly, it is necessary to respond flexibly to the load increase compared with an independent system or a single connection system by composing multiple connection lines.

Currently, the circuit of distribution in the Dominican Republic is unable to consider the acceptance rate because of serious overload. That is, since the acceptance rate is over 100%, power outage by demand management has occurred frequently. However, as explained above, such overload is concentrated on specific regions and the acceptance rate of the overall distribution facilities is merely 63.4%. Therefore, much of the overload problem can be solved only with an efficient distribution system configuration. Furthermore, the cause of this problem is unplanned power supply as well as facility expansion. Also, hasty system change to respond immediately to overload may be another cause, which requires urgently a computerized system management system in the Dominican Republic. Subsequently, to solve the overload problem caused by demand concentration and an inappropriate system configuration, first it is necessary to secure a highly reliable system configuration and demand distribution data.

For this, it is necessary to ensure data for Distribution Information System[6] and introduce a DAS. Specifically, in case of the construction of a GIS in the distribution field, all the field data should be researched as much as possible and a huge amount of data should be entered in the system, which takes a considerable amount of time. Meanwhile, in case of the Dominican Republic, where a great number of facilities should be provided and the distribution system configuration should be changed extensively, the field survey becomes accordingly very unreliable. However, with the introduction of the DAS, the system data is constructed focusing on the high voltage circuit of distribution; thus, the reliability can be relatively easily enhanced through the current system drawings and some field survey. Also, even without data about the entire distribution facilities, field data can be obtained in real time through distribution automation equipment, which ensures accurate data about the current conditions within a short time. Consequently, more highly reliable facility investment and reinforcement plans may be established. Furthermore, DAS will be dedicated greatly to monitoring distribution system information concerning multiple connection lines and preparing optimized plans for the complicated distribution system.

6) Distribution Information System : the basis of distribution facility statistics and operation by entering the overall data of the distribution field into a numerical map, was included in previous blueprint drawings and constructed on the basis of a GIS (Geographical Information System) and has been used by most of the distribution companies

1.2. Loss reduction

To reduce current non-technical losses among the total power loss by over 20%, CDEEE of the Dominican Republic has introduced the AMR system. This has not only detected electricity theft utilizing the computerized system, but also it has minimized any possibility of electricity theft through the set up of collective instrument cases and virtual instrument cases. These efforts of the Dominican Republic to reduce non-technical losses appear very meaningful. However, there is a need to reinforce the cooperative system with the government and the reward system for a reporter regarding electricity theft prevention. If electricity theft is not regarded as a serious illegal act in accordance with social norms or there is no official penalty for it, it is difficult to prevent electricity theft.

With a view to solving these problems, active promotion toward customers may be needed. However, as it is difficult to expect a direct effect prior to the introduction of legal regulations, relevant regulations should be established and proclaimed through cooperation with the government. Also, for utilities, active pilerage detection and prevention by employees may be the most effective method; however, as it is a relatively sensitive issue, it may incur serious disputes with customers without any incentives. KEPCO has also detected pilerage mainly through reports by employees. KEPCO employees have been active in the detection of electricity theft because they are given as incentives for their reports a certain portion of the equivalent amount of the pilerage. Consequently, such efforts have reduced gradually non-technical losses while being recognized in Korean society.

In the meantime, technical losses can be improved significantly by the effort of utilities without any interaction with outsiders. As this leads directly to improved profitability, the Dominican Republic should place a primary focus on this issue rather than other issues. Considering that the current technical losses are over 12%, an increase in profits on electricity sales of 1% can realize a tremendous return. Accordingly, technical loss reduction can be the basis for solving the difficulties of utilities in the Dominican Republic. Solutions to reduce technical losses are provided in detail as follows.

1.2.1 Enhancement of accuracy in loss calculation

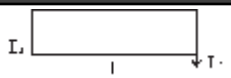
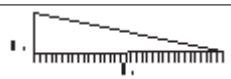
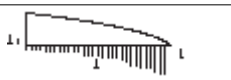
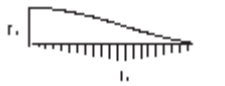
According to the CDEEE's 2013 "Improving the system of nationwide distribution" report, the loss calculation of the Dominican Republic assumed that all the loads were uniformly distributed to the distribution system based on the formula below.

$$\textbf{Technical loss kW} = 3 \times R \times L \times I^2$$

Basically, the above formula is most commonly used during the technical loss calculation of 3-phase distribution feeders. However, this formula assumes the uniform distribution of all the loads on the distribution feeders; thus, technical losses should be calculated with a more detailed method considering the load distribution form of each utility. For instance, the distribution system loss in the form of terminal concentrated load is three times that of uniformly distributed load. To consider differences between these load distributions and to compare the losses of various load forms in

terms of terminal concentrated load producing the greatest loss, the concept of "distribution loss coefficient" is commonly used. The distribution loss coefficient is based on the load distribution form; thus, basically, the load distribution pattern should be defined by taking into account characteristics by each line, and the loss should be calculated by applying the relevant distribution loss factor. The distribution loss coefficient used by KEPCO is presented in Table 25.

Table 25 | Load loss coefficient by load distribution: Based on KEPCO design

Load condition		Load distribution and current distribution	Distribution loss coefficient: h
A	Terminal concentrated load		1
B	Equally distributed load		1/3
C	Distributed load with growing terminal		8/15
D	Distributed load with growing center		23/60
E	Distributed load with diminishing terminal		1/5

Source: KEPCO

When assuming the terminal concentrated load producing the greatest loss as 1, the loss of equally distributed load is 1/3 of the same capacity, but calculations show a greater distribution at the terminal yields a distribution loss coefficient of 8/15 for the same capacity. Since loss is closely related to load distribution and exhibits a considerably great difference in the loss rate according to load distribution for the same load, this status requires a more detailed review when discussing measures for loss reduction.

In the Dominican Republic, new lines built within a short time to resolve overload are likely to have terminal concentrated load. Also, if substations are highly concentrated in specific regions, distribution feeders for power supply become relatively farther from substations to the central point of load in other regions. Consequently, this will produce a substantial error in calculation of losses from uniformly distributed load. In particular, since the Dominican Republic has both of these possibilities, a more detailed review of loss calculation is required.

If the current technical losses calculated in the Dominican Republic assume uniformly distributed load for the whole system, as explained above, in calculations made by considering distribution loss coefficient by line, the technical losses actually incurred are very likely to be much higher than the currently calculated losses.

As no analytical study has been done that focuses on clear calculation processes for the technical losses under discussion here, it may be difficult to confirm the above likelihood. Nevertheless, there is evidence according to the CDEEE's "Improving the system of nationwide distribution" report that indicates it is very probable technical losses determined are much smaller than actual losses incurred under the load conditions mentioned.

1.2.2. Loss reduction plans

Once the cause of losses and calculated loss amount are clarified, these should be used as the basis for discussing economic impact and effective loss reduction plans.

A review of Dominican Republic regions affected by technical losses has the following findings. Currently, the regions with smaller losses are related significantly to distribution in the previously indicated regions where utility customers receive electricity for 24 hours. The losses in the regions with more customers provided with electricity for 24 hours were relatively smaller than the losses of the other regions. That is to say, because regions with many customers receiving electricity for 24 hours have relatively fewer utility-related complaints, technical losses were relatively lower. In conclusion, the regions with many more customers receiving electricity for 24 hours experienced active investment in facilities. By comparison, technical losses in this region were proportionately smaller than other regions. Also, as most of the regions were downtown areas and had high load density, the length of distribution feeders may be shorter than that of other regions, which was also a reason for lower rate of technical losses.

As such, to enhance efficiency and reduce technical loss rate, the surest and most direct method is the expansion of distribution facilities and the increase of facility investment. Guidelines for planning and executing facility investment leading to this enhancement are as follows.

First, the losses by region as well as the cause of losses by region should be clarified. Inaccurate loss estimation leads to an inaccurate investment result assessment, which creates a negative image about the investment itself. If unresolved, this will lead to weaker customer support and lower interest in stakeholders' active engagement and participation. To ensure precise identification of losses, accurate metering data by billing and region is required. Property limit points among regions and highly reliable watt-hour meters should be installed at the output terminal of distribution feeders between transmission networks and substations; on that basis, accurate losses among facilities and regions should be calculated.

Second, economic-related measures to address the cause of losses by region should be pursued. Any unreasonable power system structure should be improved, along with appropriate plans for establishment or expansion of substations, and replacement of outdated substation facilities. The selection of loss improvement plans by region has a direct impact on the budget operation and profit increase of utilities. For this reason, the Dominican Republic government should consider using foreign expertise and hiring consultants with actual field experience to execute loss improvement plans to determine the most effective means to bring about desired outcomes. Also, as plans are directly related to fault management and demand management, utilities companies need to agree to sub-

stantial facility investment involving development measures for loss reduction, fault management, and demand management.

Third, there is a need to classify relevant execution plans as either short-term projects or long-term projects, and to execute these with specific measures. For example, multiple connections for system optimization can be a short-term plan compared with the establishment of lines or substations. However, to prevent any change or nullification of any completed or ongoing items as short-term projects because of the establishment of lines or substations, these items should be extended and included as agenda for mid-term projects. In general, short-, mid- and long-term project goals should not overlap as far as possible with regard to planned agenda for establishment, expansion, maintenance, and management design.

Fourth, efficiency of ongoing investment plans should be assessed and verified on a regular basis so that future investment plans can be better designed based on this cost-bebefit analysis.

Several measures for loss reduction soutions to be required in the Dominican Rpublic are discussed here.

1) Establishment of facility investment plans tailored to regional characteristics

According to statistics, there is a great difference in losses by region, ranging from 13.7% to 55.1%. In general, losses differ according to facility capacity, and for a small region, even at 55.1%, the impact may be relatively small. Therefore, it is more vital and urgent to establish and operate plans to pursue intensive loss reduction concerning the relevant type by classifying largely similar regions. For instance, a plan that ensures intensive loss reduction through regional characteristics can encompass downtown areas, farming areas, or mountainous areas. Verification and extended efficiency of these plans in model projects according to type will help in more efficient budget planning and operation. This kind of planning is more effective in loss reduction result projection and capability assessment.

In addition, if the investment projects become prioritized by region through the application of weighted value to the facility capacity and the loss rate by region and their assessments, more cost-effective plans for pursuing the projects may be proposed and approved for implementation.

2) Reduction of distribution feeder length through extension of power transmission network

Most suburban areas are supplied with power through long distance distribution feeders. On the whole, loss per distribution feeder in these suburban areas is higher than that of short distance distribution feeders in downtown areas. Furthermore, loss is expected to be even higher in cases of supplying power to high density sites in suburban areas that have only a minimum number of distribution feeders because of the lack of substations.

To resolve this problem, plans for the extension of power transmission networks should be pursued actively in cooperation with transmission companies. In designing the nationwide distribution system, it is quite difficult to construct efficient distribution networks without the help of transmission companies. Thus, it is recommended that distribution companies need to place emphasis on site

to allow substations to be located as far as possible on the load central point through connection with transmission companies.

3) Low voltage improvement on low voltage lines

Apart from loss reduction, plans for construction for low voltage improvement are required to enhance customer satisfaction. While observing the standard voltage maintenance rate for low voltage lines and not only for high voltage lines, any loss on the low voltage side should be minimized.

The consultancy team's field survey results did not specify the ratio of low voltage lines versus the entire lines, and so possible loss on the low voltage side could not be analyzed. However, as most low-quality distribution feeders have relatively more low voltage lines and use long lines, it is reasonable to recommend that facility reinforcement for the low voltage part or extension of high voltage lines is a solution for loss reduction.

4) Regularization of use of low loss equipment

The purchase price of low loss type equipment can be reduced by defining the use of low loss type for equipment use. Generally, low loss type equipment is more expensive than general equipment; however, in the long term, more use of low loss type equipment is likely to lower the price of low loss type equipment. Accordingly, it will be efficient to define the use of low loss type equipment as well as regulate the use of low loss type equipment either in small new construction or in repair situations.

5) Selection of appropriate conductors

If the construction of long distribution feeders is unavoidable, conductors that can minimize any loss/voltage drop should be chosen. To minimize the connection point in the trunk line section, and to avoid connection of a different conductor or to different sizes of conductors in the middle of a trunk line, possible loss should be prevented. These are possible solutions for consideration.

6) Voltage increase

The market share of current voltages for 7.2 kV, 4.16 kV, and 2.4 kV is no more than 5% of the total utility usage. Nevertheless, many outdated facilities still use these voltages, incurring high costs in facility maintenance. It is recommended to implement immediate voltage increase.

7) Introduction of distribution IT-based system

Densely loaded downtown areas may have great differences in losses according to the system configuration. Since a manual detailed loss calculation is impossible because of the complicated system configuration and this makes it difficult for the establishment of system reinforcement plans, it is recommended that system be based on accurate computer calculations and optional configuration through introduction of GIS, DAS, and AMR.

1.3. Introduction of Distribution Automation System (DAS)

Key efforts of distribution companies in the Dominican Republic have focused on currently used automatic meter reading (AMR) and distribution facility expansion. These are important aspects that bring meaningful improvements. However, to ensure efficient budget execution and optimal expected effects, there is a need to provide a reliable and statistically valid means for accurate assessment of the distribution system design and operation as well as of distribution facility expansion. Futhermore, as the Dominican Republic experiences a long-term and serious imbalance in supply and demand owing to insufficient distribution facilities, it is imperative to put into place an efficient distribution automation system (DAS) in order to design and operate an effective power system.

Currently, distribution automation systems are used at various levels, ranging from a simple SCADA function to complicated DMS (Distribution Management System) functions. With a distribution automation system that has a relatively economical and simple SCADA function, very significant effects can be expected with a detailed design and specific implementation plans. This advice is based on the experience of Korea when introducing distribution automation system. If the distribution automation system is constructed by taking into account the specific utility contexts and constraints, the Dominican Republic should be able to gain maximum effect benefits from this project, at minimum cost. Moreover, the Dominican Republic currently has a high technical loss rate and outage index, and under these conditions, it is expected that after introducing distribution automation, the benefits of using DAS will be realized in a relatively short time (likely within several months).

1.3.1. Execution procedures of Distribution Automation System (DAS) project

The distribution automation project implementation stages are based on the following procedures. The procedures involve several stages of infrastructure expansion: analysis and design, execution, verification of operability followed by adaption, and sustained management.

Table 26 | Execution procedures of Distribution Automation System (DAS) project

Stage	Details
1st stage	Analyze the current infrastructure and systems • Expand insufficient infrastructure for construction of distribution automation system
2nd stage	• Set up objectives of system • Design system matching objectives of system
3rd stage	• Execute small model project by region • Verify operability of designed system • Complement detected inadequacy and change design accordingly
4th stage	• Conduct an expansion project through complemented system • Define and document procedures on repair and maintenance, and on performance improvement • Stabilize operating system

Source: KSP Consultancy Team

In some instances, the distribution automation system can be operated as a stand-alone system. However, in order to benefit from advanced functions and sharing of system operation information in real-time using the distribution automation system, connections with other systems are deemed necessary.

1.3.2. Major considerations for implementation

1) Selection of distribution automation communication type

The Dominican Republic has already introduced and utilized diverse communication types such as TWACS (Two-Way Automatic Communication System Power Line Communication), GPRS, and radio into the AMR system. Therefore, it would not be difficult to accommodate different communication types for data communication in the distribution automation system project.

Although the GPRS/3G is the commonly used network because of different regulations on the communication network operation, there should be an agreement with the relevant communications companies for efficient data communication through the network for distribution automation. However, as companies like Claro and Orange have already offered a communication solution for AMR, GPRS for distribution automation can be used without any problem. Also, the Dominican Republic uses 24 GH and 5.8 GH, which are free frequencies in AMR and SCADA/DMS, this is also positive for introducing distribution automation.

Regarding the communication protocol, the most common protocols for distribution automation are DNP3.0 and IEC60870-5-101 and 104. These two protocols have almost the same structure; however, the DNP protocol is primarily used in North America or the southern hemisphere, whereas the IEC60870 protocol is commonly used in Europe and the Middle East. However, as the Dominican Republic uses both protocols in the SCADA system, communication protocol will not be a problem in starting distribution automation in the Dominican Republic.

2) Scope of system operation

Basically, DAS has SCADA system functions and is able to utilize various applications effectively; thus, its scope of operation should be determined. The current advanced DAS can include substation monitoring as well as the automatic operation of the distribution system. Also, it can be used for the automation of low voltage facilities and smart grid facility operation, which shows the large scope of its utilization. Accordingly, utilities that introduce distribution automation should define the scope of system operation and design a suitable system size. Also, even if all the above functions are implemented, it should be determined whether these functions will be mutually interfaced as separate applications or whether one application will include all the functions.

Currently, as most of the utilities are introducing distribution automation upon the completion of substation SCADA, in most cases the SCADA system and DAS are constructed as different systems. Even in that case, because of the need for mutual data exchange for smooth operation of the power system, definitions of interface between different systems are standardized internationally. For instance, since regulations for data exchange between systems such as ICCP (Inter Control Cen-

ter Protocol : IEC60870-6) and IEC61850 were legislated, interface has become possible between different systems such as ones between SCADA and distribution automation systems, between SCADA systems, or between distribution automation systems.

Also, if the Dominican Republic is planning to introduce automation and smart grid systems (including DG, ESS, and ST regarding low voltage within a short time, this aspect should be also reviewed during DAS design. For example, in case of introducing DG, facilities for DC connection should be defined as a target to monitor DAS. Also, unlike the fault management algorithm that is applied to existing distribution automation, the irregularity of load flow direction and load movement should be redefined. Therefore, customer tailored support for some functions is required.

Accordingly, during the early stage of executing distribution automation, it is effective to introduce and apply first DAS with simple functions of automatic operation of the distribution system and automatic monitoring. The inclusion of substation facilities may be a simple decision because there is no technical difficulty; however, since it is related to the organizational system inside utilities, it should be reviewed from an administrative aspect rather than from a technical aspect. For the Dominican Republic, as the SCADA system has been installed in high voltage substations and it has been operated by distribution companies, separation of DAS from the SCADA system has to be considered.

Although the substation SCADA system is simpler than distribution automation, because of its relative importance, it is beneficial for it to be separated for stable operation. In other words, it is not desirable to lower the reliability of the system in connection with different systems (including GIS and AMI). Also, as the protocols used for the SCADA system and for distribution automation are the same in the Dominican Republic, despite the independent operation of the SCADA system and DAS, there will be no problem in interface between field devices.

In addition, technically, DAS is classified into SCADA functions and DMS functions. As SCADA functions are for automatic operation and monitoring, physical facility construction should be focused on through communication networks. Meanwhile, DMS functions help efficient operation of the power system utilizing data and computer applied technology; thus, they can be introduced additionally by system upgrades after a sufficient time from the SCADA function setup.

In this regard, the Dominican Republic should design DAS by classifying it into SCADA software and DMS software, and it should evaluate the functions concerning the communication network and power system operation by introducing SCADA functions first. Furthermore, it is desirable to set up an efficient and highly utilizable optimization system by installing additionally SCADA functions after DMS function setup.

Furthermore, the Dominican Republic should seek solutions to localize algorithms by introducing DAS that was included through a pilot project and by selecting necessary functions to enable the application of DAS to the local distribution system. In order to construct these functions, basically various and accurate distribution system data should be obtained. Moreover, since some functions may not be actually used according to the operation standards in the distribution field of the

Dominican Republic, exchange of technical opion between DAS specialists and employees of utilities is required. For this reason, the initial DAS design should be pursued as an another engineering project.

3) System size selection

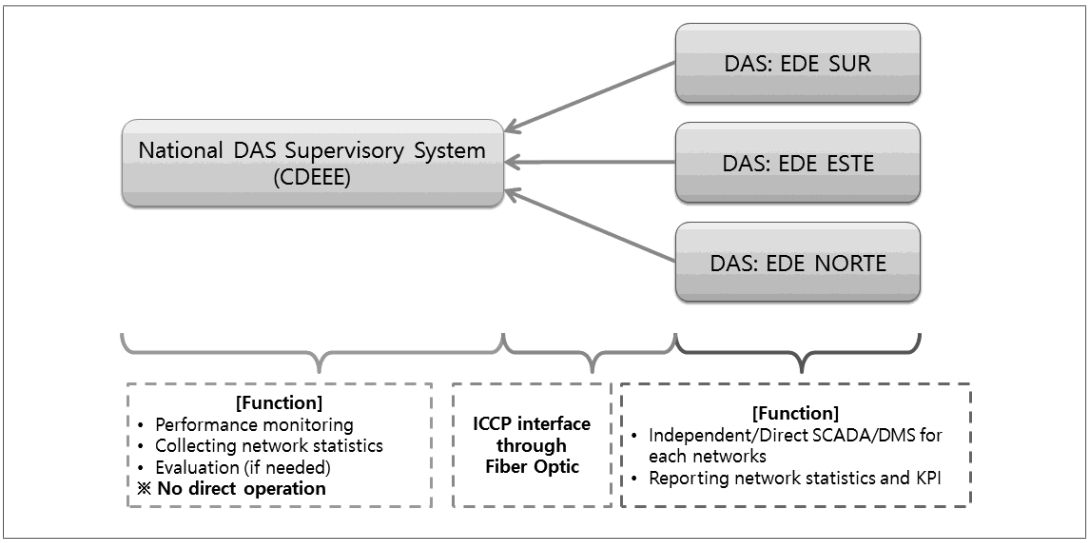
According to power system size or required functions, DAS can be constructed simply as one workstation or a multiple server system. Accordingly, it is important to select a system size during the early period of the execution of distribution automation.

Most of the currently operated DASs worldwide have been constructed in a multiple server structure. This is because the system is designed to enable hardware to work on data cooperation for reducing load burden on DAS hardware along with consistent development of DMS functions. That is, DAS for simple SCADA functions can be operated stably only in a single server structure or below. However, to propose the system analysis and optimal operation plans utilizing the data of the entire power system facilities, it is desirable to configure hardware in a multiple server structure.

Furthermore, the Dominican Republic is very likely to experience a broad spectrum of outages owing to serious imbalances between supply and demand, and 3 distribution companies have been operated independently by region. Therefore, during the occurrence of extensive outages, monitoring of the entire condition and a single restoration instruction system for emergencies will be required regardless of any region of outage. For this reason, the introduction of a national distribution system control system should be also realized to manage and monitor the current distribution system operation of the 3 distribution companies.

In conclusion, it is desirable for distribution companies in each region to install and operate one DAS and determine the quantities of DAS after undertaking a sufficient review of the basic operation plans. That is, after installing DAS with all functions in one distribution company first and verifying this on the site, it will be better to establish overall distribution automation expansion plans. Also, even if it was begun only with one DAS, an additional system may be needed. Therefore, it is desirable to ensure a sufficient size of system for sustainable operation from the beginning so that the initial system may play a management supervision system role for the rest of the follow-up systems without additional complementation. In addition, the scope of operation of DAS is determined by the operation subject and the ability of an operator and the system size according to the scope of operation changes. Accordingly, not only a technical review but also an administrative review must be accompanied. The overall system construction plans are as in the below Figure 32.

Figure 32 | DAS system implementation plan

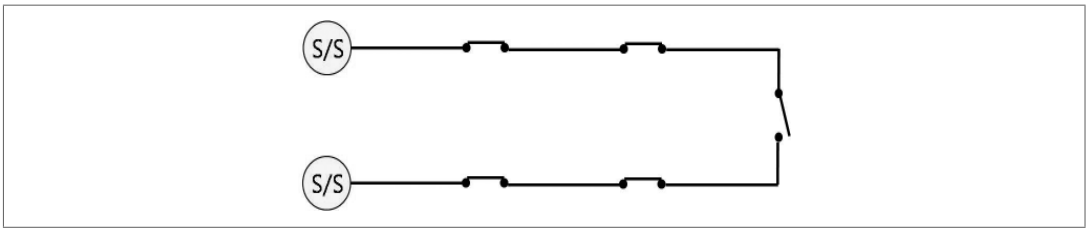


Source: KSP Consultancy Team

4) Power system configuration

The figure below shows the distribution system in a 2-line open-loop form. Such a distribution system clearly distinguishes distribution feeders, and the stability is calculated from various viewpoints at the system design stage. In this way, it can ensure considerable reliability with only manual operation under the direction of a commander. However, in the case of an emergency, since it has to withstand the load on the remaining neighboring feeders, the usage rate per feeder cannot exceed 50%. If both of the two lines are faulty, the fault section then becomes wider, and active response to new load becomes problematic. If there is a fo recast of over 50% overload, a new line should then be installed.

Figure 33 | Two line open loop type

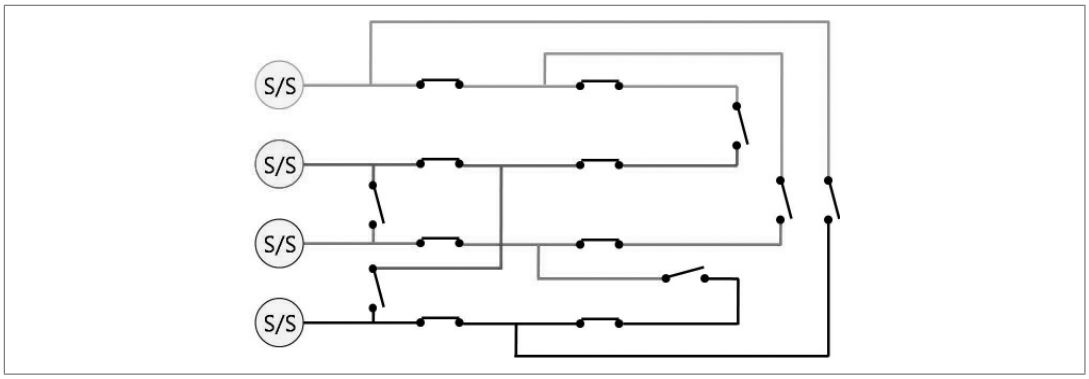


Source: KSP Consultancy Team.

The figure below shows the distribution system using the multiple open-loop form, by comparison. As this multiple open loop form is complicated, and it is difficult for a commander to make an intuitive decision with the system, and thus load circulation relationships with various lines should

be identified during the system design. For this reason, designing this system becomes difficult unless real-time data by section is made available. However, in the case of operating several lines in multiple loops, a relatively higher feeder usage rate can be secured compared with the operation of a 2-line loop, and this can respond flexibly to a new load.

Figure 34 | Multiple open loop type



Source: KSP Consultancy Team.

Apart from this technical variation, as the current distribution feeder becomes more complicated with the increasing number of distribution facilities based on economic growth, the existing 2-line or 3-line loop type cannot possibly cope with further load increase. Consequently, multiple loop type distribution feeders have increased in use, especially with the introduction of distribution automation to cope with current utilities-related demands. Therefore, to enable the introduction of the automation system for such a complicated distribution system, there should be consistent review of system configuration standards based on international power distribution standards framework.

5) Line division and connection standards

In reviewing the need for the distribution system to convert to the multiple loop system and enabling a stable design, it is necessary to calculate maximum load per line. The maximum load per line data is determined by considering the allowable capacity of a single equipment including power cables and stability by region/situation. The maximum load by line is classified into the maximum load that can be supplied all the time (In), and the load that can be provided within a determined scope of time during an emergency (Ie). In summary, the utilities companies can assess the appropriate quantities of connection lines and most economic automation switches for configuring the multiple loop system through In and Ie calculations. The calculation formula for the appropriate quantities of connection lines (N(t): the number of connection feeders per line) based on predetermined In and Ie is as follows.

$$N(t) \geqq In / (Ie - In)$$

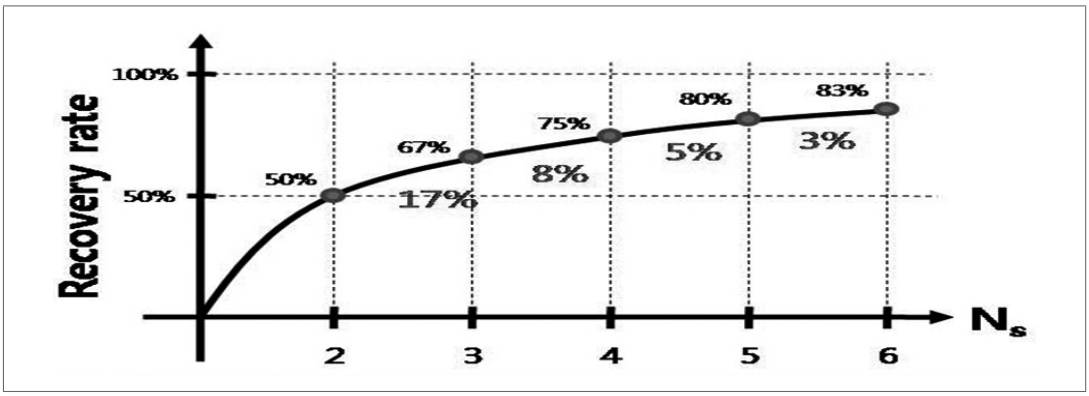
This formula shows how many lines can divide and supply the maximum load during an emergency occurring on one line, and based on this data, the minimum quantity of connection feeders can

be calculated. Additionally, the number of connection points greater than that quantity can be determined considering economics.

Division standards refer to the decision of how many distribution automation switches will be installed for one line. The principle is, the higher the number of distribution automation switches, the shorter the fault section, and the more beneficial for load management. However, it should be determined based on cost-benefit analysis. Also, an analysis of the fault recovery rate during the fault occurrence is needed to calculate the optimal quantity of distribution automation switches for effective operation. The graph below shows the fault recovery rate according to the quantities of distribution automation switches per line.

As shown in the graph above, the higher the quantity of the section, the greater the fault recovery rate. However, that increase becomes smaller along with an increasing quantity of the section. That is to say, while the difference in the fault recovery rate reaches 18%, if the quantity of the sections is 2 and 3, the difference recorded becomes much lower at 8% if the quantity changes from 3 to 4. From this point, the most economic quantity for the sections is determined as "3".

Figure 35 | Fault recovery rate by the quantity of distribution feeder sections



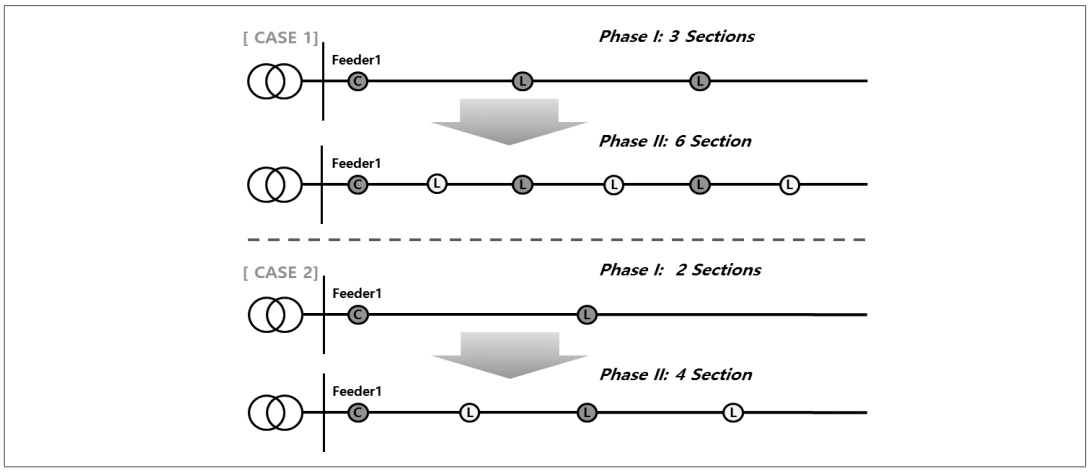
Source: KEPCO

In determining the quantity of the initial section, an additional review is required for the suitability of the follow-up complementary plan. For example, in the case of dividing each distribution feeder into three sections, the load of each section will be divided uniformly to realize efficient DMS functions. Thus, the feeder that has been designed and operated initially as three divisions should be redesigned as six divisions to cope with additional load. In fact, despite the difference of the load of each section, there is no complication as regard the the system switchover itself with the upgrade to distribution automation. However, in terms of improvement of the demand factor, the detailed division with different capacities has reduced efficiency and this will impair intuitive load division to a certain extent.

For this reason, in determining the initial section, it should first be determined whether the number will start with odd number or even number. In the case of KEPCO, it started with an odd number

of sections (three sections), with additional complementation of six divisions after completion of the targeted three divisions. That is, since three more section switches should be added, excessive investment has to be made. However, in the case of having "2" initial sections, although initial efficiency may be lower than that of three divisions, additional complementation can be four divisions, which is more economic compared with complementing with six divisions.

Figure 36 | Cases of distribution automation switch section



Source: KEPCO

As construction of system and communication network are accompanied when introducing distribution automation, increasing the quantity of automation switches is a burden for utility companies. However, once the distribution automation system is established, the quantity of automation switches is ultimately continued to increase due to its usefulness. As all lines need to be closely connected to each other, it is efficient to construct the line in a certain pattern. Therefore, the same critria of sectioning and connection are applied to all lines.

Furthermore, in introducing the distribution automation system, increase of the quantity of distribution automation switches very often requires the greatest investment. This situation should be carefully reviewed. Especially, the Dominican Republic should review limitations in overall investment and prepare an appropriate quantity of section division standards before the execution of distribution automation. Based on more detailed technology consulting and a feasibility study project, utilities companies will be able to operate budgets efficiently and prevent over-investment.

6) Selection of power equipment

Selection of power equipment is discussed based on understanding general requirements of distribution automation switches, and identifying distribution automation equipment types. First, it is important to note that distribution automation switches installed on distribution feeders to maximize the strengths of distribution automation require additional functions. These external functions include current metering by phase, voltage metering by phase and direction, a driving device for

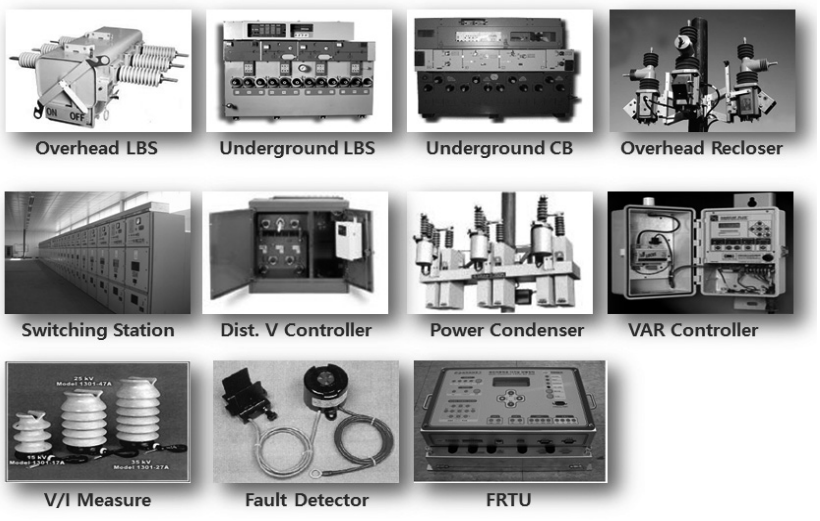
remote operation and necessary external power, operation panel for operating the field switch, and a control box for installing communication devices. For the acquisition of real-time system data, which is a major feature and advantage of distribution automation, voltage/current values should be obtained. When installing a meter apart from a switch, additional communication devices should be installed, though in most cases, a meter is installed on the distribution automation switch.

In addition, voltage metering by phase and direction on the distribution automation switch can be useful not only for voltage monitoring but also for the determination of the coincidence of phase rotation on both ends of normal open points. In particular, motorized switch must have external power, and it requires a backup power source if it has to operate without external power.

In discussing distribution automation equipment types, it is interesting to note that there are many equipment types utilized for distribution automation, as shown in Figure 37. Among others, a switch (Load Break Switch, or LBS) is the most basically utilized

type. The distribution automation switch is relatively cheaper than a recloser or sectionerizer. For automatic operation by terminal unit (Feeder Remote Terminal Unit, or FRTU) loading, it is sufficiently effective in system operation, which makes the switch most widely used. A recloser is the most widely used equipment in manual operation of the distribution system, and even higher efficiency is expected from its conversion to distribution automation function. In addition to this, a voltage controller, a power condenser for reactive power, and various metering devices can be operated automatically or monitored by the distribution automation system. Particularly, as the Dominican Republic experiences high power loss and serious voltage drop, it is advisable to install, monitor, and control a voltage controller and a power condenser in the middle of a feeder.

Figure 37 | Distribution automation equipment types



Source: KEPCO

The Dominican Republic experiences serious voltage drop because of long distance feeders and overload, and its power factor does not match that of general utilities. Therefore, it will be effective to install an automatic voltage controller and a condenser for power factor improvement in the middle of a feeder for real-time monitoring and compensation. With the added effort to localize existing equipment to be suitable for the Dominican Republic through a pilot project, better performances are to be expected.

7) Construction of the distribution control center (DCC)

As proposed earlier, when constructing a distribution automation system for each local distribution company, the system should be of adequate size that can accommodate possible increase or expansion of the distribution system. A DCC should be sufficiently large, considering the number of employees.

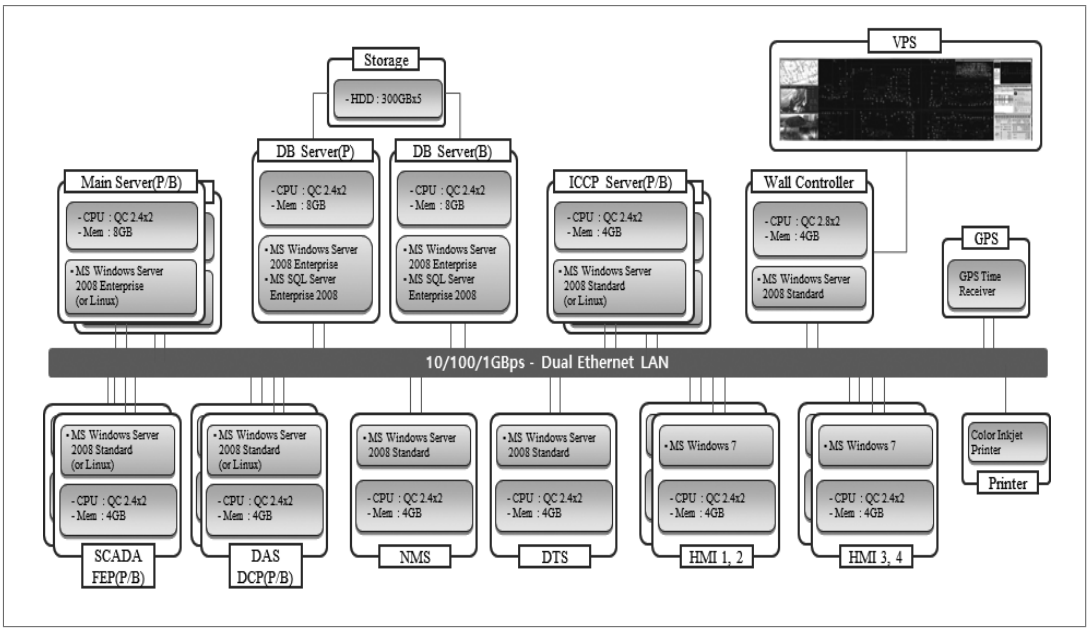
The system area under the total distribution control center area does not need to be too large. For a general server room, the total system installed should accommodate three 19-inch racks. In addition, a UPS, battery, and thermohygrostat will be installed. VPS (Visual Projection System) is determined by the requirements of utilities and generally a VPS installed would consist of 21 50-inch LED monitors, taking up seven columns and three rows. A wall of 15m wide and 4m high is sufficient for this installation. The area for work related to HMI (Human-Machine Interface) is a workstation computer with three or four monitors, which takes up the largest space as it is operated by a distribution commander. The space for an individual HMI is not that large; but if there are many commanders needed, a substantial number of console desks and HMIs are required. Accordingly, it is important to calculate the number of commanders needed when designing the control center.

Concerning EDESUR, which owns the greatest number of distribution facilities at present, the entire number of lines is 190. According to the installation standard of 3.5 distribution automation switches (based on three divisions, three connections) per line, 665 distribution automation switches can be installed. Since this quantity is managed by one person for one system, in theory two HMIs including a standby are considered sufficient. For instance, in the case of KEPCO, there is a two-person team which includes personnel to operate roughly 2,000 distribution automation switches for 24 hours, working in four shifts. However, as this will be the first time for the Dominican Republic to introduce distribution autotmation, commanders' managing skill will be insufficient and they will need to cope with relatively high volume of repair and power outage. Thus, operation by about 1,000 distribution automation switches, which is half a quantity of Korea, and 2 HMIs including standby would be adequate. Based on task division and job delegations by organization's composition and regional classification of each distribution company, the number of personnel (including commanders) may need to increase.

In addition to the above facilities, a special system engineer room should be designed. This is because the distribution automation system includes various IT devices, and system engineers for professional system repair and maintenance should be ready to assist in the distribution control center.

The distribution control center is operated for 24 hours. In cases of emergency, personnel like commanders may need to stay for even longer durations. Thus, the center needs to be equipped with convenience facilities and a situation room for commanders. Recommended facilities for convenience include additional restroom, bathroom, rest area, office pantry, as well as a conference room for emergencies. The Figure 38 is an example of a distribution automation system configuration.

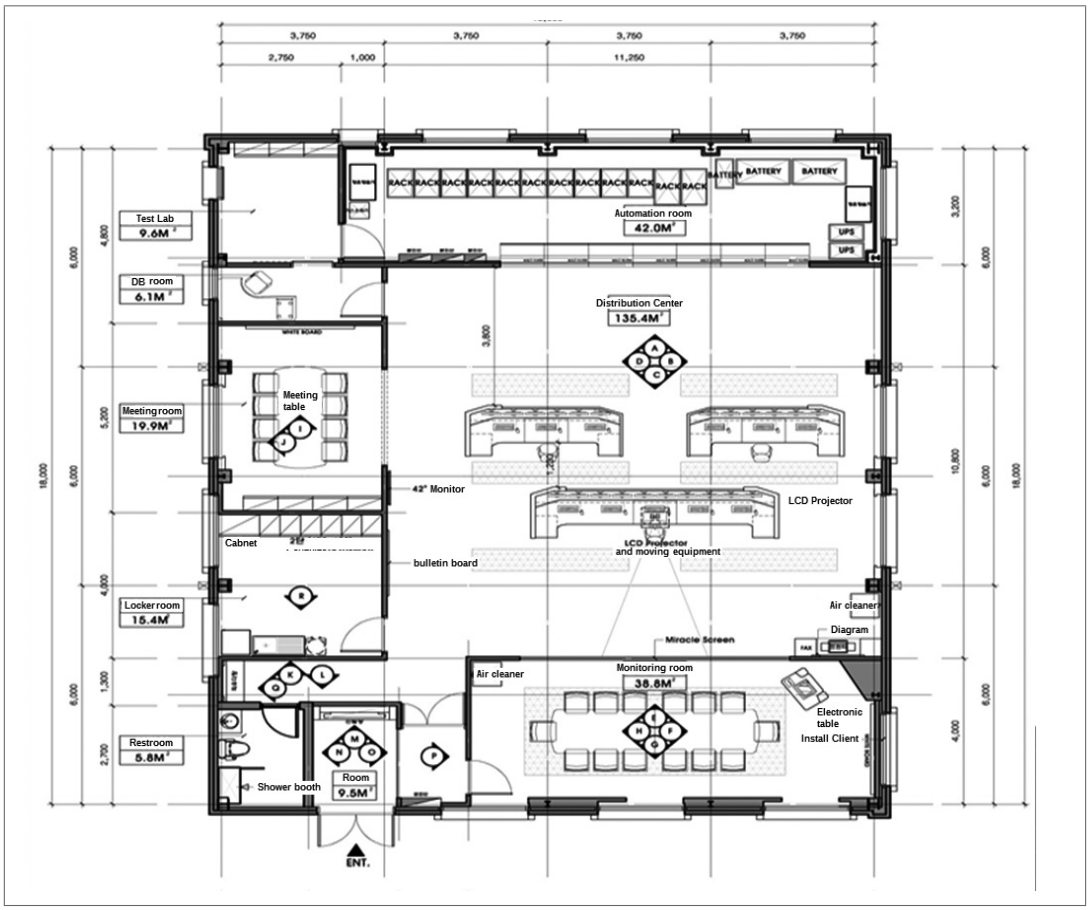
Figure 38 | Distribution automation device specification



Source: KEPCO

The main server performs the management and supervision of the entire system, and it plays the key role of distribution automation. The DB server is in chage of input and output and change of real time data and system data. The ICCP server has a connecting role with other systems; and, in particular, it is designed for connection with the substation SCADA system. For the Dominican Republic, it can be used for connection with the national DAS supervisory system. A wall controller manages VPS and offers a monitoring environment in various combinations. In case the SCADA FEP server includes substation SCADA system functions, it manages communications between substation equipment and the system, while DAS DCP manages communications between distribution automation equipment and the system. The NMS (Network Monitoring System) server monitors the communication condition between the H/W and S/W of each system. Meanwhile, the DTS (Dispatcher Training Simulation) server provides a simulation to be utilized for distribution automation education. HMI plays the role of a console to operate DAS by a controller.

Figure 39 | Floor diagram of distribution automation device types



Source: KEPCO

1.4. Plan to introduce the integrated system of electric power reading data

Electricity distribution companies in the Dominican Republic do not use nationally standardized meter protocol and standardized hand-held terminal and metering software. Instead, the companies analyze billing data and customer electricity theft using hand-held terminal for meter maintenance and operation software offered by meter providers. This poses a structural difficulty as the manual task requires the expertise of professionals experienced in a specified software and operation system for a specific meter; also, management staff needs additional support staff to cope with the increasing distribution of automatic meter reading meters.

This is a problem initially faced in Korea as well. For KEPCO, industrial meters presented many issues, for example, software compatibility issue, management staff education, as well as maintenance issue. Therefore, KEPCO adopted an international standard meter protocol (DLMS) and continues to operate this after its successful standardization. KEPCO also allows eligible bidding for products that have passed a communication suitability test by a test agency recognized by KEPCO.

Although this may be an adequate method for a situation with companies such as KEPCO that possess high operation ability to control meter providers or other bidders, the same solution may not be applicable to the Dominican Republic's situation where operation efficiency and management capacity are lacking. In addition, the Dominican Republic companies face stiff competition among major worldwide meter providers. It is thus recommended that the standardization and power metering data integration system should be reviewed in cooperation with major automatic meter reading meter providers under the determination of CDEEE. In addition, a consulting service to review and construct meter maintenance and adopt a standard hand-held terminal and remote data integration system is strongly advised. This needs the disclosure of exclusive information of existing meter providers, and thus requires the strong willingness support of CDEEE.

2. Phased plans for distribution facility modernization

2.1. Feasibility study of substation and distribution feeder modernization project

The utilities of the Dominican Republic experience limited power transmission owing to chronic overload by increasing electricity use and ineffective power system configuration. This has led to subsequent power loss for the power industry. To solve the situation, utilities in the Dominican Republic have plans to expand facility investment and pursue a power system modernization project. Therefore, based on the comprehensive analysis on the current status and a solid technical review, a way to enhance the efficiency of the project needs to be found. Finally, a realistic investment model for future growth plans should be established with clear development agenda and details to avoid unnecessary delays or investment overlap or conflict.

The phased development agenda include a feasibility study of a substation and facility modernization project, a system optimization project on distribution automation, and construction of a private investment model to fund the modernization proposals. For this, it is critical to select a specific areas, carry out the specified feasibility study, and establish a future investment plan model. The scope of the relevant basic duties is as follows..

- Study and analysis of the current power distribution rate, power demand, and power infrastructure
- Calculation of substation facility capacities through power demand forecast, selection of cable routes, and extraction of existing substation reinforcement plans
- Developing construction process plans and yearly investment plans through the estimation of project cost
- Focus on education and training, human resources operation, as well as repair and management plans
- Analysis of economic efficiency of the project.

Through the feasibility study project proposed above, the Dominican Republic is expected to establish an exemplary improvement model to overcome problems caused by imbalance in power supply and demand, such as overload and technical losses. At the same time, it can have a positive impact on growth in society such as enhanced productivity and living environment thanks to improvements in power supply capability and enhanced power supply reliability. Furthermore, through the overall structural change (multiple loop structure) of the distribution system emphasized in this report, the Dominican Republic can improve power supply reliability.

2.2. Project for distribution automation and reliability enhancement

A distribution automation system (DAS) is indispensable and critical for the stable management of an increasing number of power facilities. Thus, it is necessary for the Dominican Republic to optimize the distribution system in specific areas. The authorities should first introduce an exemplary distribution automation system and then decide on the optimal design plan for overall expansion projects.

To this end, general distribution systems should be selected, and their feasibility should be reviewed via an intensive distribution optimization design. Distribution automation equipment, voltage compensation device, and factor compensation device should be installed to assess actual effects. In addition, through an analysis of the currently operated distribution system's maintenance standards and design standards, reinforcement/modification plans for relevant technologies after future introduction of distribution automation should be established. Technology standards about equipment required for distribution automation should be prepared as well. These should be verified as a pilot project to complete the procurement standards for future expansion projects.

Finally, there should be workshops with professional consultants to work on relevant technology transfer and to work out effective field application plans of relevant technologies. A well designed utilizable distribution automation system should be established and verified, and there should be sufficient preparation for subsequent operation, maintenance, and expansion projects. The overall H/W and configuration of the required distribution automation system are presented here.

Table 27 | Main control system equipment configuration of distribution control center

No. of order	Equipment name
1. Main Control System	
1.1	Main Server (including OS license and CD)
1.2	DB Server (Including OS, SQL license, and CD)
1.3	SCADA FEP Server (including OS license and CD)
1.4	DAS FEP Server (including OS license and CD)
1.5	ICCP Server (including OS license and CD)

No. of order	Equipment name
1.6	NMS Server (including OS license and CD)
1.7	DTS Server (including OS license and CD)
1.8	HMI Workstation (including OS license and CD) + 3 Monitors
1.9	Engineering Workstation (including OS license and CD) + 3 Monitors
1.10	Laptop Computer for backup (including OS license and CD)
1.11	Storage
1.12	Rack
1.13	GPS Time Synchronizer
1.14	Color Laser Printer
1.15	Cyber Security S/W (Full system/site license)

Source: KSP Consultancy Team

Proposals for workstations include a focus on HMI (Human Machine Interface) that enables efficient and prompt distribution system operation by a commander. There should also be an engineering workstation for database entry work and the design should make sure special DMS applied functions are reflected in the design. Other proposed facilities include a GPS Time Synchronizer for time synchronization between a laptop, an emergency system during HMI or computer device breakdowns, as well as Cyber Security S/W for data communication security.

Server configuration within distributed system architecture should consider future extendibility or expansion plans. The main server configuration has the following complementary parts: DB server for DB management, SCADA FEP server for communication management with substation RTU, DAS FEP server for communication management with distribution automation equipment, ICCP server (Inter Control Center Protocol: utilized for connection through ICCP) for stable interface with the SCADA system or a different system, NMS (Network Management System) server for communication monitoring between internal system devices, and DTS (Dispatcher Training System) server for simulation and education.

Additionally, it is proposed that the VPS (Visual Projection System) uses 50-inch DLP Cubes. Based on the area of a control center and budget, this quantity can be controlled. Also, the design should include acquisition of all relevant equipment needed to operate multi screens utilizing DLP Cube.

Table 28 | VPS equipment configuration of distribution control center

No. of order	Equipment name
2. VPS	
2.1	DLP Cube (50" LED)
2.2	Cube stand + Frame
2.3	Wall controller
2.4	RGB Matrix switcher
2.5	A/V Matrix switcher
2.6	PC interface
2.7	Power distributor
2.8	Audio mixer
2.9	Speaker
2.10	Power amplifier
2.12	Main control unit
2.13	VPS control PC (including Control Program)
2.14	Volume box
2.17	VPS Rack
2.18	Thermo-hygrometer(Digital)
2.19	GPS Time display
2.20	Switching HUB (24 Ports)
2.21	Router (24 Ports)
2.22	Firewall

Source: KSP Consultancy Team

For other equipment, UPS (uninterruptible power supply) for stable power supply to the system, battery and other low voltage power distribution panel were included. Entrance security system and CCTV that are required specifically in control room are also suggested as follows. These are the items required in general large scale automated distribution system, and the types and quantity of hardware can be adjusted following the situation in the Dominican Republic. Required functions of the automated distribution system are shown in Table 30.

Table 29 | Other facilities and software of distribution control center

No. of order	Equipment name
3. Other Facilities	
3.1	UPS (3P 20KVA)
3.2	Battery (20KW * 3 HR)
3.3	LV Power Distribution Panel
3.4	Fire fighting system
3.5	Security System (videophone, security access)
3.6	Multi Access floor (10m2*2)
3.7	Call Recording System
3.8	Telephone
3.9	Temperature-Humidity Controller
3.10	Console desktop computer
3.11	Air-conditioner
3.12	Console table + chair
3.13	Desk + chair
3.14	Multi-purpose cabinet
3.15	CCTV System (7 CCTV + Console system)
4. Software	
4.1	SCADA/DMS S/W (Full package/site-license)

Source: KSP Consultancy Team

Table 30 | Necessary distribution automation system functions

Items	Functions
SCADA	Field equipment automatic monitoring, measuring, setup, real time data saving, and past information replay
DMS	Single line creation per automatic circuit, fault management and cooperation on protection, fault data
Grid optimization function	Load standardization, loss minimization, overload removal, short-term load forecast, load flow calculation
Statistics function	Possible during entering of customer data
System plan	Automation switch location selection and system simulation
Repair and maintenance function	Various reports preparation and management, simulation for field history management education

Source: KSP Consultancy Team

For the pilot project, first, the SCADA functions should be verified. Then, DMS functions that can operate actually after an analysis of distribution system data owned by the Dominican Republic should be added. Moreover, database construction can rely on already estsablished GIS (supplier: Indra-Sapin) or can be constructed directly through DAS. However, unless there are no problems with reliability of the current GIS data, a database should be constructed through a data interface with the currently used GIS. Meanwhile, since the currently used GIS is not a universally used system, the availability of an interface through CIM, the international standards of data interface for power facilities, should be discussed with the manufacturers. If this is not available, a technically available interface should be prepared through discussion with the manufacturers. The field equipment and additional facilities for distribution automation are as shown in Table 31.

Table 31 | Field equipment and additional facilities for distribution automation

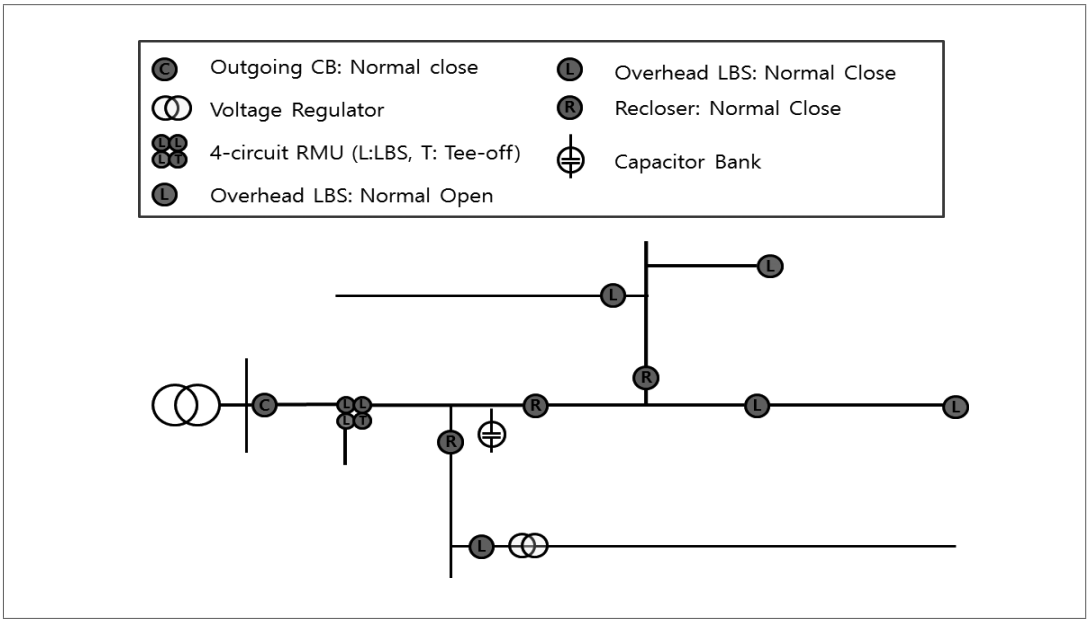
No. of order	Item
1	Overhead LBS (SF6 insulated, Sectionalizer)
2	FRTU_OH
3	Recloser (SF6 insulated)
4	Ring Main Unit (SF6 insulated 3L1T)
5	FRTU_RMU
6	Wireless Modem (GPRS/3G)
7	Lightning Arrester (Polymer type 1P 10kA)
8	Grounding Lug (Cupper 1.2M *2)
9	Capacitor Bank
10	Pole-mount Voltage regulator (12.5kV 1P 200A)
11	CPT
12	Smart Meter + Enclosure + TTB
13	Substation IED
14	Data concentrator (Gateway) + Rack
15	Wireless Modem (Radio/PLC)
16	Pole Mounted Transformer (MV-LV 10 KVA)

Source: KSP Consultancy Team

The above facility quantities are proposed to allow for distribution system optimization and distribution automation with four lines, and these will be installed, as depicted in Figure 40. There should be grounding and arrester installation included to protect each critical facility. As shown in

the figure, the trunk line section (thick line) should be divided into four sections, including multiple circuit switches for underground lines. A branch line section (thin line) is attached with a recloser to prevent the spread of a fault in the branch line section. Based on a review of the current needs, the connection points with other feeders can be in three places. In some cases, new construction or expansion plans of the system can include the configuration of more connection feeders. In view of the voltage drop in the long distance branch line section, an automatic voltage controller is proposed. A power condenser will be positioned in the middle of the distribution feeder for factor management.

Figure 40 | Distribution automation section division type



Source: KEPCO

This system configuration is applied to the distribution system of the Dominican Republic in a general sense. Based on field situation, active design change may be required. In particular, for the substation, utilities need to determine whether to include the constructed SCADA system in the pilot project and improve its performance by reviewing its usability.

There is a need to determine future investment plans through a review of integration plans for the substation SCADA system and the distribution automation system. In addition, since distribution companies should be connected with the SCADA system of transmission companies, there should be immediate review and determination of the connection plans with the SCADA system of transmission companies. In most cases, the interface concept between different systems uses ICCP (IEC60780-6). This is not a concern either in terms of reliability or technical maturity; however, detailed discussion on the scope of the mutual data interface and operation and repair and maintenance is highly recommended.

It is projected that the proposed pilot project and feasibility project will take about 1.5 years, and the addition of an adequate field test period will boost efficiency. After the system setup, a main goal for this pilot project will be to review and estabilish detailed plans for relevant assessment, improvement, localization, maintenance, education, and expansion.

3. Construction of private investment models for distribution facility modernization

In pursuing the distribution modernization project of the Dominican Republic, it is a challenging task to have facility construction funded by foreign investments as it may increase national debt and the government's financial soundness will be threatened. Accordingly, to achieve the target value for power loss reduction for 2016, a primary consideration is private investment, which will be suitable for modernization of multiple distribution feeders for the near term.

Private investment in public sector can be divided into 4 types of BTO7), BTL8), BOT9), and BOO10). The main difference between BTL and BTO is who has the right to collect the electricity bill. This is related to who bears the business risk. In BTO, the private investor directly collect the bill, so the investor bears the risk to fail to collect the bill, while the Dominican government and distributors are free from the risk of bill collection. However, this may hinder private investment. The opposite is BTL. In BTL, the Dominican government and distributors take the risk of bill collection whereas the private investors can focus on the construction and operation of the distribution facility.

In general, the utilization of risk mitigation products for the risk of infrastructure financing support has increased in developing countries, donor countries, and in the private sector. Representative risk mitigation tools are insurance or guarantee services offered by an MDB (Multiateral Development Bank). An MDB renders project financing support through loan offer or grant and at the same time mitigates risk by country through the provision of risk mitigation programs. In particular, most of the countries in need of the project have high political risk such as institutional instability; thus, it is difficult to secure a stable cash flow for construction infrastructure throughout the development, construction, and operation stages. Also, it is difficult to complete the project upon agreement with the interested parties. However, such political risk may be reduced by utilizing risk mitigation financial products offered by an MDB.

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7) BTO (Build-Transfer-Operate): Upon completion of distribution facilities, the ownership of such facilities belongs to the government or a relevant local government, and the rights to manage and operate the distribution facilities are given to a project operator during a certain period.

8) BTL (Build-Transfer-Lease): Upon completion of distribution facilities, the ownership of such facilities belongs to a country or a relevant local government, and the rights to manage and operate the distribution facilities are given to a project operator during a certain period. However, the facilities are leased to the project operator for use and profit generation during a fixed period under an agreement with the government or a relevant local government.

9) BOT (Build-Operate-Transfer): After completion of distribution facilities, the ownership of such facilities is given to a project operator during a certain period, and after the termination of the period, the ownership of the facilities belongs to the government or a relevant local government.

10) BOO (Build-Own-Operate): Upon completion of distribution facilities, the ownership of such facilities is given to a project operator.

The feature of these products is to obtain a definite guarantee from the local government regarding the execution of the contract. Representative cases include political risk guarantee or partial risk guarantee and partial credit guarantee offered by the IBRD and IDA within the World Bank group. If the local government concerned fails to execute the guarantee, relevant compensation may be given through the international status of the World Bank with the utilization of such risk mitigation financial products. Consequently, the introduction of risk mitigation financial products by an MDB reduces uncertainty about future cash profits and it can promote private capital investment by reducing the risk by country for a project operator or an investor. Furthermore, it is good for the government (customer) concerned with the project in reducing the burden of direct financing as private investors can be attracted public capital.

Table 32 | Advantages of risk alleviated financial instruments

Viewpoint	Advantages
From the view of project owner and investors	- To facilitate the project participation by foreign investors - Risk alleviation by ordering country
From the view of the government of the project location	- To use limited public capiptal, attract private investors, and reduce the burden of direct financing - Through the project execution experience, credit upgrade and financing expense reduction are expected
From the view of MDB	- Leverage effect of project funding using non financial status - Possible to maximize economic support to low income countries and developing countries

Source: Energy Economics Research Center, Study to Alleviate Risk in Resource Development Investment through Multilateral Development Bank (MDB), 2012

Ⅳ Conclusion

All the problems of the Dominican Republic stem from poor distribution facilities. As reviewed above, in case of comparing facility capacity and the maximum demand power, facility capacity itself appear sufficient. However, the fact that 52% of the customers should receive limited power and 81% of the cause of power outages was limimted power transmission by overload shows inefficient configuration of distribution facilities. Moreover, this has led to high non-technical losses such as electricity theft owing to growing dissatisfaction of customers, as well as to high technical losses because of overload and voltage drop.

To solve these problems, the Dominican Republic has received a variety of consulting services and has executed exemplary projects. In addition, the Dominican Republic has pursued the expansion of distribution facilities through integrated plans for the distribution facility improvement. In particular, CDEEE has undertaken a detailed analysis of current conditions by each region and has proposed detailed goals regarding power loss reduction; therefore, the Dominican Republic is supposed to archive significant improvement by 2020.

However, for enhancement of the realizability of the goals and more efficient investment, it is necessary to expand the distribution system to meet the power demand consistently, improve old facilities, and introduce various power IT systems and advanced distribution system operation technologies. The followings may be required: first, detailed calculation of technical losses; second, construction of the distribution system for load increase in connection with distribution networks; and third, stable power supply (outage reduction). The non-technical loss reduction which is a current focus of distribution companies in the Dominican Republic is very important. However, because of complicated interests with external parties of utilities, such as clients and the government, more time and effort are required in comparison with technical loss reduction. Nevertheless, technical loss can be reduced by distribution companies. Particularly, since the Dominican Republic has a high technical loss rate, the loss reduction is related directly to profit generation. Accordingly, technical losses should be reduced more actively. If technical losses are calculated more accurately and ongoing distribution facility expansion plans can contribute to generating profits through technical loss reduction, it will boost the economic efficiency of the plans.

Finally, the outages should be reduced by installing section switches and protective devices on distribution networks and introducing a distribution automation system. In consideration of the current condition of the Dominican Republic, the introduction of the smart grid system may be meaningful to raise reliability of distribution networks and ensure stable power supply. In particular, stable power supply will be a great contributor to the development of overall industries in the Dominican Republic.

The following is the suggestion of KSP consultancy team to improve distribution infrastructure of the Dominican Republic.

1. Feasibility study on restructuring of the distribution system and modernization of distribution control center

Distribution facilities that directly connect utilities with customers have a highly complicated. Accordingly, it is difficult to maintain and repair them, as well as construct their remote/automatic operation system. Owing to serious imbalance between supply and demand, the Dominican Republic is very likely to experience extensive outages. Also, as three distribution companies are operated independently by region, it is necessary to prepare a system to monitor the entire current situation regardless of the regions and to recover a single system in case of emergency. For this reason, a national distribution controlling system should be introduced to supervise and monitor the current distribution system operation of three distribution companies along with a distribution automation system.

Therefore, distribution companies need to computerize distribution facility data and conduct a feasibility study for the introduction of an automatic monitoring and control system; for example, a feasibility study on the distribution automation system (DAS) and distribution information system (DIS).

More in detail, to maximize the efficiency of a distribution automation system, a standardized distribution system for distribution network connection should be developed, and a basic design should be prepared to review its viability. Also, major tasks include a distribution system maintenance standard analysis, design criteria analysis, and technical specification analysis as well as the preparation of workshops for distribution system modernization.

Furthermore, we suggest the selection of functions and size of an appropriate distribution automation system for the Dominican Republic and a feasibility study on the applicable communication methods, distribution control centers of three distribution companies, and construction of a national distribution supervisory system.

2. Feasibility study on the installation of AMI and integrated management system for metering

Accurate metering and measuring are important for the power usage measurement and billing. Therefore, it is necessary to undertake a project that will analyze the power usage of customers through AMI. Also, despite the automatic meter reading installation to reduce non-technical losses in three distribution companies, the intial effect has decreased over time because of system operation inefficiencies and problems. In order to identify such operation problem and establish more effective policies, an integrated management system is required. Furthermore, each of the distribution companies has operated various power meters, and has experienced an increase of human resources for operation along with increase of diverse solutions after the installation. Thus, it is likely to increase the operation cost, which highlights the needs of integrated management system construction.

Accordingly, several analyses and activities are required as follows: a current condition analysis of the AMI implemented regions, local communication environment analysis, field trip to pilot region, cost estimation and economic analysis, AMI system design and operation method determination, system analysis (billing system, OS, DB, web server, communication method, development language, software and system information, hardware, and current operation) and technical design development (integrated management system design).

3. Feasibility study on the modernization of substation and distribution networks

In solving the substation overload and power loss increase, the minization of the high voltage distribution networks length may be one alternative. As the Dominican Republic is planning to install 34 substations and expand distribution networks, it is necessary to carry out a relevant feasibility study. More in detail, the study involves the power distribution rate of the project regions, power demand, current power infrastructure (location, capacity, operation human resources, and management), appropriate substation facility capacity based on power demand forecast, optimal distribution networks design plan, management and budget plan, facility operation plan (education and training, human resources operation and maintenance plan), project cost (Korean product, local product, and third country product) and economic feasibility.

The project regions are metropolitan areas with great power demand. Therefore, this project will contribute to solving a power shortage of the regions, promoting the local economy, increasing productivity and enhancing quality of life through expansion of power distribution, and improving national welfare. From a mid to long term perspective, the project will form a foundation to connect the power networks of the Dominican Republic as a loop and reduce power losses and outages.

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Knowledge Sharing Program

2015 KSP - IDB Joint Consulting :

Support for Customer Protection in Digital Financial Services in Latin America and the Caribbean (LAC)

Part 5

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List of Abbreviation

Abbreviation	Full Description
ACH	Automated Clearing House
BCP	Banco Central del Paraguay(Central Bank of Paraguay)
BdO	Banca de las Oportunidades Program
CAES	Electronic savings accounts(Cuentas de Ahorro Electrónicas)
CATS	Simplified savings accounts(Cuentas de Ahorro con Trámite Simplificado)
CCCT	Colombian Department of informatics and telecommunications
CERT	Computer Emergency Response Team
CONATEL	Comision Nacional de Telecomunicaciones(National Telecommunications Commission)
CP	Consumer Protection
DDOS	Distributed Denial of Service
E-Commerce	Electronic Commerce
EDCF	Economic Development Cooperation Fund
EIF	Encuesta de Inclusion Financiera(National Financial Inclusion Survey)
E-Money	Electronic Money
EMPE	Entidad de Medio de Pago Electronico(Entity of Electronic Method for Payment)
E-Payment	Electronic Payment
E-Procurement	Electronic Procurement
E-Signature	Electronic Signature
EU	European Union
EV SSL	Extended Validation SSL(Secure Socket Layer)

Abbreviation	Full Description
FCP	Financial Consumer Protection
FI	Financial Institution
FSS	Financial Supervisory Service
HSDPA	High Speed Downlink Packet Access
GSES	Offsite Monitoring Management Office
GSIS	Onsite Monitoring Management Office
HSDPA	High Speed Downlink Packet Access
IC	integrated circuit
IDB	InterAmerican Development Bank
IMF	International Monetary Fund
INCOOP	Instituto Nacional de Cooperativismo(National Institute of Cooperatives)
ISO/IEC	International Organization for Standardization/International Electrotechnical Commission
KCA	Korea Consumer Agency
KISA	Korea Internet & Society Agency
KRW	Korea currency(Won)
KRX-DRC	Korea Exchange Dispute Resolution Center
KSP	Knowledge Sharing Program
LAC	Latin America and the Caribbean
MDB	Multilateral Development Bank
MH	Ministerio de Hacienda(Ministry of Finance)
MIC	Ministry of Industry and Commerce
MinCIT	Ministry of Commerce, Industry and Tourism
MinHacienda	Ministry of Finance and Public Credit
MFS	Mobile financial service
MFSP	Mobile financial service Provision
MNO	Mobile network operator
ODA	Official Development Assistance
OECD	Organization for Economic Co-operation and Development

Abbreviation	Full Description
P2P	Person-to-Person
PKI	Public Key Infrastructure
POS	Points of Sale
Programa Mas Familias en Accion	More Families in Action Program
QR code	Quick Response code
SEDECO	Secretaria de la Defensa del Consumidor(Secretariat of Consumer Protection)
SEDPES	Specialized Electronic Deposit and Payment Institutions
SES	Superintendencia de Economia Solidaria(Cooperatives supervised by the Superintendence of Cooperative Economy)
SFC	Superintendencia Financiera de Colombia(Financial Superintendence of Colombia)
SIB	Superintendencia de Bancos(Banking Superintendence)
SIC	Superintendencia de Industria y Comercio(Superintendence of Industry and Commerce)
SSL	Secure Socket Layer
TTAK	Telecommunication Technology Association Korea
USD	United States Dollar
USIM	universal subscriber identity module
VM	virtual machine
WAP	wireless application protocol

Summary

Poverty refers to more than simply a lack of money; it also refers to a lack of access to the instruments and means through which someone could improve their way of life or economic situation. Exclusion from access to formal financial systems has increasingly been identified as one of the barriers to a world without poverty.

Digital financial inclusion is defined as digital access to and use of formal financial services for excluded and underserved populations (CGAP Brief, 2014). Finding innovative models to extend financial services to the poor is a critical challenge faced by many developing regions; for example, Latin American and Caribbean (LAC) countries have substantial portions of their population excluded from present banking systems. However, progress is steadily evident in improving financial inclusion in these countries over the last three years, according to the World Bank Global Financial Index (Findex) 2014 statistics. Specifically, low-cost and easily-accessible digital channels for financial transactions have great potential for facilitating financial inclusion and the LAC region has seen a vast increase in the number of adults with bank accounts, rising from 39% in 2011 to 51% in 2014. For LAC countries, ecosystem transactions with third parties, such as bill payments, bulk payments, and merchant payments, are on the rise. This in turn gives rise to boosting the full potential of mobile financial services, although these in the past have faced severe challenges in the arena of mobile money market. It is important to note that digital financial inclusion of formerly excluded customers brings not only benefits but also potential risks, partly due to not understanding the profile of a typical inexperienced and underserved customer who remain uninformed about financial services risks such as consumer protection issues.

On the whole, digital financial inclusion poses various risks, which include operational risks, consumer-related risks, and risks related to financial crime. The types of risks involved are linked to three key components found in digital financial inclusion models (CGAP Brief, 2014), namely (i) provisions and arrangements for the management of account data and customer funds; (ii) the digital technology involved; and (iii) the use of agents in the form of principal customer interface.

It is undeniable that in current times, digital finance fraud and cyber-crimes have become increasingly sophisticated where the nature of cyber-fraud evolves with regional circumstances and the scale of damage is implausible. Latin America and the Caribbean have the fastest growing Internet user population in the world. While today this region accounts for only a small percentage

of global cybercrime, the rise in global Internet use and corresponding cyber-attacks brings to the forefront the need for the development of effective cyber policies and defences.

In order for digital financial services to gain favour and acceptance among an underserved financial segment, a set of adequate measures such as easily comprehensible regulatory systems and financial education should be given the same emphasis as expansion plans for digital finance inclusion. Korea's safe and secured digital financial environment is exemplary and its financial sector has made remarkable achievements in certain aspects of financial inclusion and in ensuring support for consumer protection. Hence, it is hoped that the digital financial experience of Korea's financial systems can serve as a case in point to provide useful insights and direction for LAC countries in achieving their own financial inclusion objectives.

Apart from analyzing the financial infrastructure state of a nation or region, it is important to comprehend its legal infrastructure. In order to better understand digital financial services and consumer protection support systems of Korea and the LAC region, this paper reviews and compares several aspects of these countries' financial organizational systems, including laws and regulations as well as supervisory agencies and their roles in supporting consumer protection.

Among the LAC countries, Colombia, which has a voucher, and Paraguay, which has an integrated legal framework for consumer protection, was selected. These three countries, namely Korea, Colombia, and Paraguay, have enacted laws and regulations for digital financial services as well as for supporting consumer rights in financial markets, such as personal data protection, account safeguard, customer due diligence, and other mechanisms for digital financial services supervision and control of financial crime. However, there remains a lack of regulation regarding procedures for overcoming financial crimes and for overseeing the prevention of such crimes.

In general, regulations governing the authorities in financial services also apply to authorities in digital financial services. In Korea, Colombia and Paraguay, there are single agencies in each country tasked with the supervision and management of financial consumer protection, including that of digital financial services. Paraguay has a separate agency as well that deals with management and issuance of specific digital financial services such as e-Money licenses.

I Project Overview

1.1. Background and Objectives

The project is designed to provide LAC with an informed model of financial consumer protection by sharing Korea's experience and knowledge on the support of consumer protection in the digital financial services sector. It is specifically aimed at supporting LAC in reinforcing customer rights and the protection of such rights in the financial sector, such as strengthening the capacities of involved parties, and transferring knowledge on adopting laws and policies appropriate to the economic profile and financial circumstances of customers in LAC.

In the context of this report, the term "digital financial services" refers to the provision of some mix of financial and payment services that are delivered and managed using mobile or web technologies and a network of agents. Generally, the data for these services are in a digitalized form. At the low end of digitalized financial transactions, customers may conduct cash-in or cash-out physical cash transactions for electronic currency, via means linked to a client's mobile phone number, bank account, or voucher ID. Customers would then use a network of agents or mobile phone or computers to make purchases, take out loans, buy insurance, pay bills, and so on.

a) Growing need for digital financial services

According to a 2013 report on financial education in developing regions, 38.2% of LAC's urban population did not have accounts at formal financial institutions and did not know the requirements for opening such accounts (García, et al, 2013). More recent surveys on global financial inclusion show that in 2014, only 51% of adults in LAC hold an account in a formal financial institution, a proportion that accounts for only 41% of adults within the lower 40% of income distribution (Demirguc-Kunt, et al, 2015). As such, it is highly likely for low-cost, easily-accessible digital channels to be used in financial transactions in the promotion of digital financial services in this region.

On the whole, financial inclusion, particularly through digital channels, is an issue of immediate concern and focus for many LAC countries and the IDB. Many LAC countries, particularly Colombia and Paraguay, have declared financial inclusion as one of their countries' top commercial infrastructure goals and have already enacted laws and regulations designed to manage, monitor, and support digital financial services.

b) Increased demand for consumer protection

Adoption of digital financial services presents a variety of challenges. While new technologies and use of digital delivery channels enhance financial inclusion, these can in turn POSe threats to customers by increasing their exposure and risks to inadequate fund safeguarding, agent fraud, and improper management of private data. Financial crimes resulting from the exploitation of electronic communication media, such as mobile phones and the Internet, have evolved and increased exponentially over the years. In particular, security incidents involving leakage of personal data can create loss of trust and confidence in the financial sector, and may lead to social disorder within consumer communities. In LAC consumer communities, risks faced by customers new to the use of digital financial services and ensuing policies and systems established to help them manage such risks should be studied. At the same time, threats and risks linked to the use of emerging technologies must be recognized in order to curtail or minimize financial costs and losses.

Given the growing interest and efforts to expand digital financial services in LAC, there is a priority to set up regulative legislation and policies for "consumer information protection" in digital financial services. A major part of consumer protection in digital financial services pertains to the efforts to maintain credibility for digitalized data in its creation, communication, and custody process, and to minimize related risks. Each country presents a different environment for digital finance services, and rules and systems should be applied in consideration of the nature and principles of financial applications and practices.

c) Emerging necessities in consumer protection infrastructure

It is important to improve the existing legal framework and ICT infrastructure for digital financial services with the purpose of developing trusted and secured means for performing electronic transactions and for protecting the rights of financial consumers. In order for new financial schemes to have a positive effect on uninformed and underserved segments, a set of adequate measures including the provision of relevant services, regulatory systems, and financial education should run in parallel with the expansion of digital finance services.

1.2. Project Purpose

The project's purposes are three-fold and listed below.

a) Improve LAC's digital financial services through knowledge and experience sharing

A main purpose of this project is to expand the capacities of digital financial services and envisage digital financial service infrastructure in LAC. This is to be accomplished by transferring Korea's experience and knowledge of developing consumer protection systems and its best practices in digital financial services.

b) Improve consumer protection in LAC by reviewing advances and accomplishments of Korea in aspects of legislation, regulatory measures, policies, operations and technologies

The project reviews and explains the development and establishment of laws, regulations, and government policies related to consumer protection in using digital financial services in Korea. Using this information as a framework, it is envisioned that LAC government officials now have a strong reference point, direction and guidance to help build relevant consulting services as well as review their policies to effectively establish a strong consumer protection support infrastructure.

c) Recommend direction and advances for improving consumer protection infrastructure in LAC countries

This project combines a review of consumer protection in digital financial services in LAC and best practices of this development in Korea in order to provide government officers with future direction and a step-by-step roadmap containing related policies and recommendations for improved consumer protection in LAC.

Following this consultation work and final report, a LAC country requiring support and guidance for financial inclusion policy making may refer to members of the consulting group to facilitate connections to ODA/EDCF/MDB funding or to seek advice on technical assistance programs. The consulting group will endeavour to help countries represented in this report accomplish desired goals of financial inclusion and to realize outcomes mentioned in this report.

1.3. Project Scope

The consulting group commenced their study of this topic with an as-is status analysis of digital financial services found in two countries in LAC, namely Colombia and Paraguay. The scope of this project involves data collection, research and analysis based on the five action plans mentioned below:

a) Analyze consumer protection and ecosystem of digital financial services in LAC

- Conduct a Fundamental PEST analysis using existing materials and documents
- Conduct an as-is analysis on consumer protection in digital financial services, with reference to related laws and regulations as well as information security systems and infrastructure
- Review emerging issues in consumer protection in digital financial services

b) Conduct research into digital financial consumer protection in Korea

- Provide a development history of Korea's digital financing sector
- Present relevant laws, regulations, and government policies
- Outline organizational and systematic arrangements
- Share Korea's best practices and lessons learned

c) Make recommendations for consumer protection policy and ICT infrastructure based on a two-country comparative analysis

- Describe existing systems, regulations, and policies for consumer protection
- Describe government agencies and related institutions in charge of consumer protection
- Clarify commitment and willingness of governments in developing consumer protection mechanisms
- Describe prospects and potential of digital finance
- Explain the process of victim relief and conflict resolution in digital finance services
- Expand on ICT and relevant technical infrastructure
- Explain ISMS (information system management system), IT governance, and supervision measures

d) Benchmark advanced cases and best practices via capacity building workshops

- Outline the development of a consumer protection system
- State laws and regulations relevant to the system
- Explain implementation of the system
- Expand on institutional and organizational coordination and arrangement
- Clarify benefits from the implementation of the system
- Present challenges and lessons learned during the process of development

e) Disseminate final report's main findings through seminars and experience sharing

- Produce a final report that covers results, outputs and outcomes of consulting activities
- Conduct sessions to share knowledge on the project's deliverables and future direction for projects focused on consumer protection in digital financial services

1.4. Main Project Activities

1.4.1 Planning project directions

1) Understand project characteristics

- Involve an understanding of circumstances in digital financial services and the ICT infrastructure for LAC region
- Build on consulting capabilities to analyze related regulations and government policies on digital financial services
- Expand on knowledge and practices that concern consumer protection in digital financial services
- Establish communication with relevant stakeholders such as IDB delegates and government officers in target countries

2) Determine critical success factors (CSF)

- Involve expert specialists with knowledge and experience in consumer protection in digital financial services and know-how for global consulting projects
- Present available to-be models and relevant regulations and government policies in LAC to arrive at a regulations framework on consumer protection in digital financial services
- Suggest available ICT infrastructure to meet needs of the regulations framework derived as an outcome of this study
- Prepare for the development of a major project with ODA/EDCF/MDB funding or technical assistance programs through an acquired network of related stakeholders and government authorities in LAC

3) Identify strategies for project activities

Strategy 1: Effective implementation by deploying expert specialists

- Action Plan I: Involve professional consultants with global consulting experience and with expertise in digital financial services
- Action Plan II: Carry out in-depth research on Korea's best practice model for digital financial services and deliver the de-factor model to LAC
- Action Plan III: Conduct effective and successful workshops in Korea to improve capacities for consumer protection in digital financial services for related stakeholders and government officers in LAC

Strategy 2: Provide advice on existing regulatory policies on consumer protection in digital financial services for the entire LAC region

- Action Plan I: Understand the network of relevant stakeholders and governments in LAC and research the correlated mechanisms between existing financial regulations framework and its consumer protection system
- Action Plan II: Research the role of financial supervisory authorities and private consumer protection organizations in target countries

Strategy 3: Prepare detailed Activity Plan for each implementation stage

- Action Plan I: Conduct a PEST (Politics/Economics/Social-Cultural/Technology) analysis to obtain relevant data prior to pre-investigation event in Washington D.C.
- Action Plan II: Survey the as-is status of targeted countries with a checklist of digital financial services and analyze Korea's best practice models
- Action Plan III: Apply selected to-be model based on gathered materials and deliver the de-factor model to establish a step-by-step roadmap aimed at constructing the legal framework and ICT infrastructure for digital financial services

1.4.2 Description of project outputs

The outputs of the project are: (i) a case study on best practices and lessons from Korea's experiences; (ii) policy recommendations for financial protection and inclusion for LAC countries; (iii) capacity building workshops; and (iv) a final dissemination workshops and propagation seminars.

To realize the goals of the study, the following activities are planned:

Division	Detailed Action Description
Analyze consumer protection and ecosystem of digital financial services in LAC	• Survey usage status of digital financial services and related regulations • Analyze current status of consumer protection in digital financial services - Social recognition and issues that arise regarding consumer protection in digital financial services, based on available data - Related regulations and legal framework of digital financial services - ICT Infrastructure status of digital financial services • Delineate roles of government authorities involved in digital financial services and consumer protection agencies according to the digital financial services model of each target country - Identify problems in operating digital financial services - Understand needed improvements in current operation of digital financial services to protect consumers' rights

Division	Detailed Action Description
Conduct research into digital financial consumer protection in Korea	• Examine history and background of development for consumer protection in digital financial services (including mobile services) • Analyze legal framework and regulations to protect consumer rights in digital financial services • Analyze operating system mechanisms of related government authorities in Korea to protect consumer rights in digital financial services • Analyze outcome and success factors derived from the consumer protection system in digital financial services
Recommend consumer protection policies and ICT infrastructure in digital financial services based on a two-country comparative analysis	• Suggest action plan to protect consumer rights in digital financial services based on a two-country comparative analysis following results of the study (Regulations, Government Policy, Preparing a Budget, Organizational Setup, etc.) • Analyze entry barriers and obstacles in pursuit of a consumer protection scheme for digital financial services
Benchmark advanced cases, best practices and capacity-building workshop programs	• Set workshop agenda through discussions with IDB • Invite five key individuals working for related government agencies in Colombia and Paraguay • Provide lectures on consumer protection in digital financial services • Provide benchmarking and field study programs to gain better understanding of related government authorities and offices
Disseminate Final Report's findings and outcomes through seminars and experience sharing workshops	• Assemble the final report as a result of consulting activities • Share knowledge of project output and future direction for project planning to • enhance consumer protection in digital financial services

1) Implementation stages

This consulting project will be jointly implemented with IDB and stakeholders from Colombia and Paraguay. The overall purpose is to design an advanced model applicable to the financial environment of LAC based on Korea's experiences. The project team also aims to conduct an informal analysis of the feasibility of this model.

Stage	Tasks	Jul.		Aug.		Sep.		Oct.		Nov.	
Inception	Contract signing										
	IDB cooperative arrangement										
	Kick-off preparation										

Stage	Tasks	Jul.		Aug.		Sep.		Oct.		Nov.	
Exemplary case study	Pre-investigation on consumer protection model in Korea										
	Advanced case study and literature research work										
	Applicable candidate model development										
Pre-investigation & as-is analysis	Kick-off meeting										
	On-site survey & information- gathering										
	Workshop with stakeholders										
	as-is analysis										
	Interim report development										
to-be model establishment	Gap analysis										
	Vision/strategy for consumer protection										
	to-be model establishment										
	Workshop preparation										
to-be model establishment	Capacity building workshop										
Workshop/ Dissemination seminar	Defining unit tasks										
	Project priority selection										
	Milestone setting										
	Resource planning										
	Development plan										
Completion	Final Report completion										
	Submission of Project deliverables										

II General Status Analysis of Colombia and Paraguay

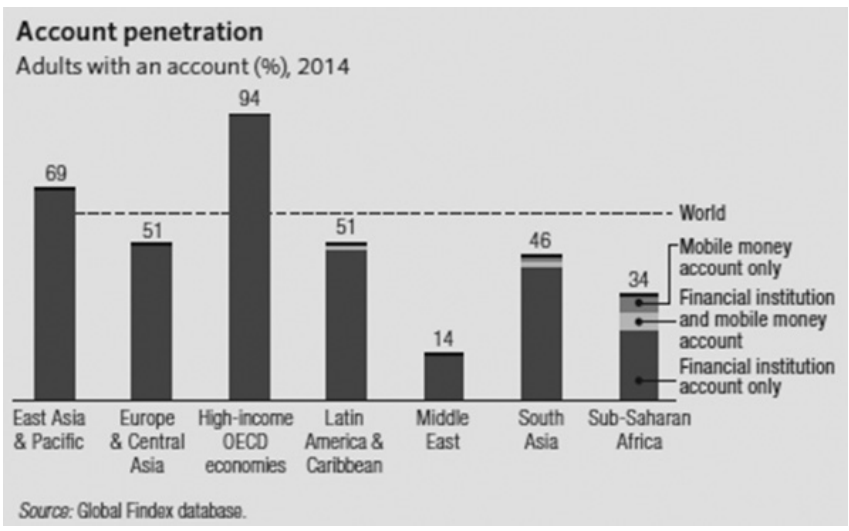
2.1. General Status of Financial Services

2.1.1 Financial services in LAC

Notable progress has been made in improving financial inclusion in Latin America and the Caribbean (LAC) over the last three years, according to recent World Bank Global Findex statistics. The region has seen a major increase in the number of adults with bank accounts, from 39% in 2011 to 51% in 2014.

Financial inclusion has been broadly recognized as critical in reducing poverty and achieving inclusive economic growth. When people can participate in financial systems, they are better able to start and expand businesses, invest in their children's education, and absorb financial shocks (World Bank, 2015).

Figure 2- 1 | Account penetration by region (global)



Source: World Bank, 2015c, the global findex database 2014 - measuring financial inclusion around the world, World Bank

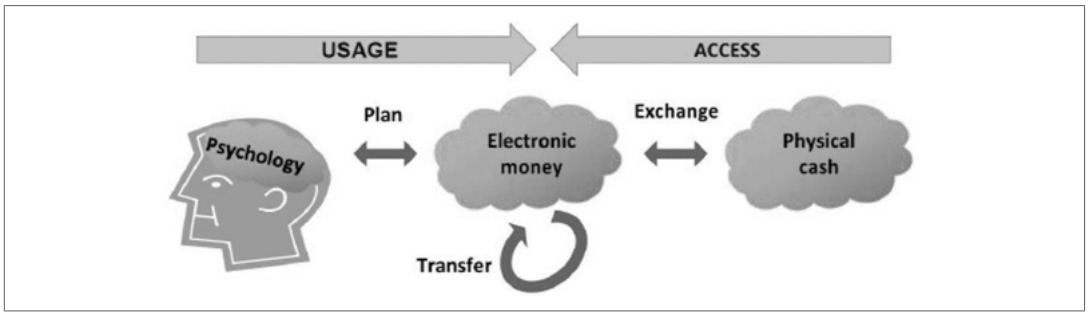
According to the 2015 Brookings Financial and Digital Inclusion Project (FDIP) scorecard, four countries from LAC are ranked in the top 10, that is: Brazil(3), Colombia(6), Chile(6), Mexico(9). Still, approximately half of all adults in LAC remain unbanked, ranging from as high as 80% of adults in Haiti and Nicaragua, to under 35% in Brazil, Jamaica, and Costa Rica (John D. Villasenor, et al, 2015).

Typically, it is considered that an increase of 10% in the access to financial services has the effect of a reduction of 0.6 points in the Gini inequality coefficient (Honohan, 2007), and an increase of 10% in private credit reduces poverty by close to 3% (Clarke, Xu and Zou, 2003; Honohan, 2007).

Mas (2012) states Financial inclusion is the process of bridging three clouds: 1) a physical cash cloud which is the legacy financial system where most poor people operate today; 2) a digital cloud where money is stored in a virtual account; and 3) a psychological cloud (i.e. the brain) through which people interpret and plan their financial lives. Connecting the physical and digital clouds unlocks "access" while connecting the digital and psychological clouds unlocks "usage" (Dan Radcliffe, et al, 2012). Financial Inclusion is accessed by the degree of access indicator and use indicator. Access indicator contains cash-in and cash-out channels, whereas use indicator contains e-money distribution channels and its transactions (Ignacio Mas, 2012).

1) Account penetration

Figure 2- 2 | Financial inclusion as the process of bridging physical, digital, and psychological clouds



Source: Ignacio Mas, 2012, Payments in developing countries: Breaking physical and psychological barriers, Transaction World Magazine.

Financial inclusion, at its most basic level, starts with having a bank account and with regular use, it is expected that people will fully benefit from having an account. The 2014 Global Findex database reveals that 62 percent of adults worldwide have an account at a financial institution or through a mobile money provider, up from 51 percent in 2011. But large gaps remain. Many people around the world, particularly women and low-level income adults, still do not have an account. In relation to this, the gender gap in account ownership still exists. In 2011, 47 percent of women had an account, while 54 percent of men did. In 2014, 58 percent of women have an account, and 65 percent of men do. This reflects a persistent gender gap of 7 percentage points globally.

Table 2- 1 | Statistics of account penetration rate and banked

Global	2011	2014	Remarks
Penetration (%)	51%	62%	+11%
Population (person, %)	5B	5.2B	+1.3B
banked	2.5B	3.2B	+7M
unbanked	2.5B	2B	-5M
Men(banked)	47%	65%	Gender Gap 7%->7%
Women(banked)	54%	58%	

Source: World Bank, 2015c, the global findex database 2014 - measuring financial inclusion around the world, World Bank, compiled by KSP Consultants

In LAC, there are opportunities to expand financial inclusion among women. Existing statistics are not encouraging, however. In 2011, 44 % of men and 35 % of women held accounts; in 2014, this figure increased to 54 % and 49% respectively. The gap improved only by 7 % for women. Overall, the gender gap in developing economies unchanged from 2011, at 9 percentage points. In 2011, 54 % of men and 47 % of women had an account in 2014 65 % and 58% respectively.

Table 2- 2 | Account penetration comparison between LAC and developing countries population

Region	Population	2011	2014	Remarks
LAC	Penetration (Adult)	39%	51%	+12%
	Men	44%	54%	Gender Gap 9%->7%
	Women	35%	47%	
Developing Countries	Penetration (Adult)	41%	54%	+13%
	Men	54%	59%	Gender Gap 9%->9%
	Women	45%	50%	

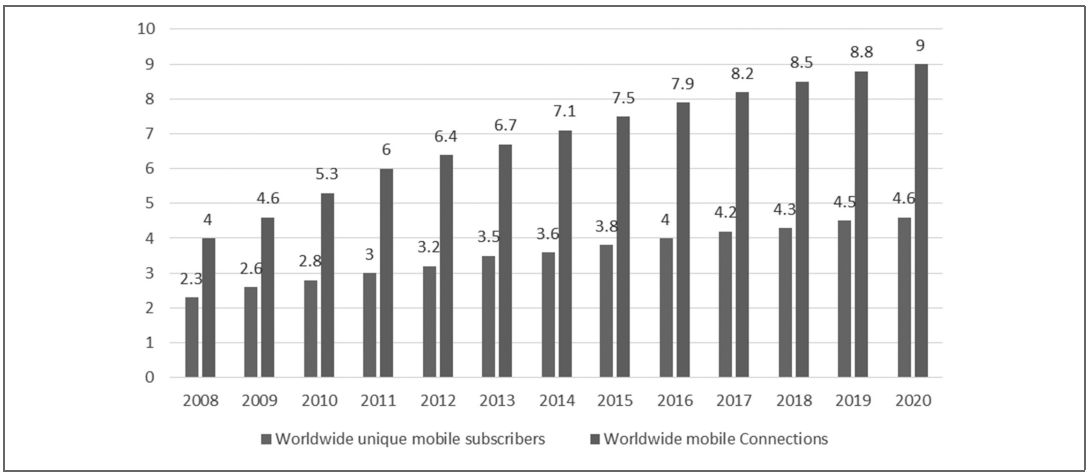
Source: World Bank, 2015c, the global findex database 2014 - measuring financial inclusion around the world, World Bank, compiled by KSP Consultants

2) Mobile penetration

According to a 2015 GSMA report, the number of unique mobile subscribers has risen dramatically since 2008 and is expected to grow even further in the next few years. Mobile device subscribers increased from 2.3 billion in 2008 to 3.8 billion in 2015 and this figure is predicted to reach nearly 4.6 billion by 2020. With respect to the number of mobile devices, the rise is even more dramatic. Many people worldwide now have more than one mobile device, whether it is a phone, smartphone, or tablet. The total number of cellular connections was 7.5 billion in 2015 and this figure is expected to increase to over 9 billion by 2020 (GSMA, 2015).

Figure 2- 3 | Worldwide mobile subscribers and connections

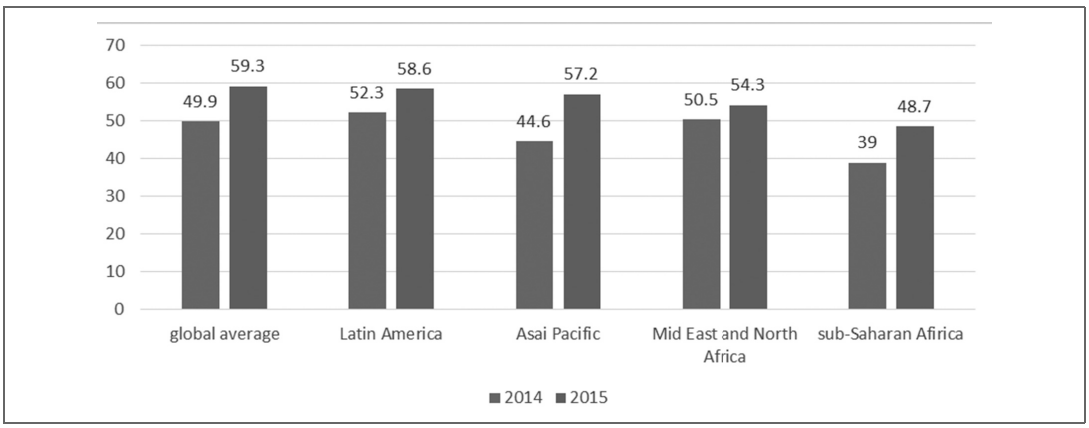
(Unit: billion persons, %)



Source: GMSA, 2015, the mobile economy 2015, GSMA publishing; data compiled by KSP Consultants

By comparison, less than half of the population in developing countries and money markets currently has a mobile subscription, with the penetration rate under 44.6% at the end of 2014. This leaves significant room for growth, with the penetration rate expected to rise by about 11 percentage points to 56% by 2020 (GMSA, 2015).

Figure 2- 4 | Unique subscriber penetration by region



Source: GMSA, 2015, the mobile economy 2015, GSMA publishing; data compiled by KSP Consultants

3) Mobile money account

In 2014, 75 million additional mobile money accounts were opened globally, bringing the total to 299 million by year end. Although growth in registered mobile money accounts was significant in the past couple of years, i.e., almost doubling since 2012 when it was only 155 million, this

represents a penetration of a mere 8% of mobile connections in markets where mobile money is available. This sluggish increment highlights a huge potential for further growth.

In the same year of 2014, the number of 90-day active mobile money accounts increased faster than the number of registered accounts, at a rate of 41.7%, to reach 103 million by year end. This trend suggests that the industry has become more perceptive on what it takes to prompt usage of the service. The highest growth was seen in Latin America & the Caribbean, where the number of accounts grew by 50% between December 2013 and December 2014 to reach 14.9 million.

Table 2- 3 | Registered account and active account by region

(Unit: million accounts)

Region	Registered account	Active account
Latin America & the Caribbean	14.9	6.2
East Asia & Pacific:	21.8	4.7
South Asia	76.9	22.1
Sub-Saharan Africa	146	61.9
Middle East & North Africa:	37.9	8.5
(Total)	229	103

Source: GSMA, 2014b, 2014 state of the industry - mobile financial services for the unbanked, GSMA publishing, compiled by KSP Consultants

The table shows that at the end of 2013, there were already more registered mobile money accounts than bank accounts, with the highest figures located in Africa. Paraguay passed this threshold in 2014 (GSMA, 2014b).

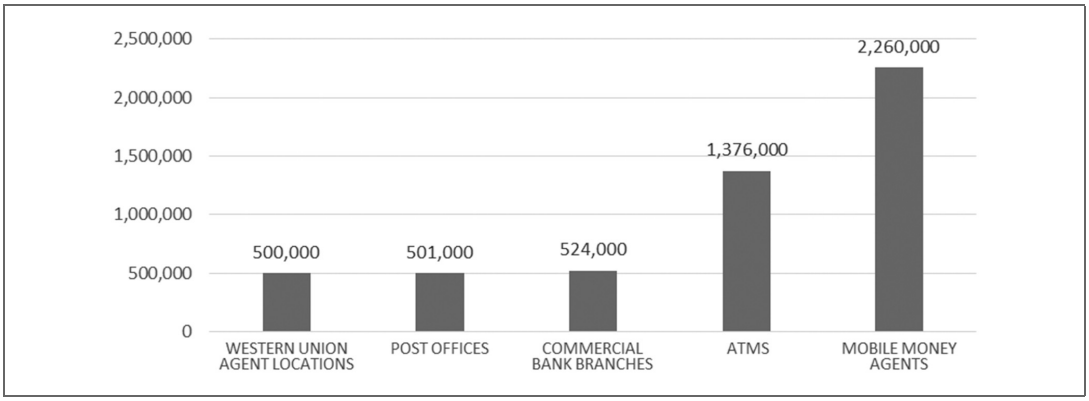
The data presented in this section show mobile money is bringing financial services to millions of previously unbanked and under-banked people around the world, making this industry a key enabler of financial inclusion.

4) Mobile money accessibility

The number of mobile money agent outlets grew by 45.8% in 2014, reaching a total of 2.3 million globally by year end of 2014. However, little is known about the actual reach of this network and just how far financial services access extends to hard-to-reach, often underserved, locations. In harder-to-reach areas, an increasing number of mobile money providers now partner with petrol stations, bus companies, and pharmacies to extend their reach to areas which are not served by traditional financial institutions. This is considered a cost-effective and facilitative way of enabling access.

Figure 2- 5 | Number of financial access points across developing countries

(Unit: each)



Source: GMSA, 2015, the mobile economy 2015, GSMA publishing; data compiled by KSP Consultants
Note: figures for Western Union agent outlets are global figures; others are for developing countries

The table shows the total number of active mobile money agent outlets that facilitated at least one transaction during the month grew by 44.2%, rising from 946,000 in December 2013 to 1.4 million in December 2014. In LAC the figures are 16,000, 29,000 and 88.1 respectively for the years concerned.

Table 2- 4 | Comparison of actual agents and agent activity rates

(Unit: million accounts)

Agent	2013	2014	Remarks
Actual Agents			
Global	946,000	1.400,000	+44.2%,
LAC	16,000	29,000	+88.1%
(LAC registered)	27,000	63,000	+130%
Agent activity rates			
West Africa	32%	43%	+11%
LAC	59%	46%	-13%

Source: GMSA, 2015, the mobile economy 2015, GSMA publishing; data compiled by KSP Consultants

To successfully serve customers, mobile money providers need to do more than register as agents. Agent activity rates of business reveal some interesting trends. In West Africa, there was impressive increase of 11% in activity rates due to these factors: providers focused efforts on activation rather than registration of agents, and in some cases some even terminated inactive agents. In LAC, the number of active agents (30-day) grew by 88.1% but activity rates fell by 9% in 2014. The trend is large retail chain partnerships for mobile money distribution drove up agent registration rates significantly without a corresponding increase in activity rates.

5) Mobile money use

The majority of mobile money transaction types can be grouped into six product areas: domestic P2P transfer, international transfer, airtime top-up, bill payment, bulk disbursement, and merchant payment.

In 2014, while domestic P2P transfers and airtime top-ups continued to dominate the global product mix in terms of volume and value, growth was also seen in bulk disbursements, bill and merchant payments. This trend reflects an expanding ecosystem of institutional and business users of mobile money.

Table 2- 5 | Global product mix (December 2014)

(Unit: %)

Product	Global	Latin America & Caribbean	East Africa
Airtime Top-up	62.3%	50%	66%
P2P Transfer	25.1%	23%	28%
Bill Payment	8.9%	11%	3%
Bulk Disbursement	2.3%	14%	1%
Merchant Payment	1.3%	2%	2%
International Remittance	0.1%	0%	0%

Source: a) GSMA, 2014b, 2014 state of the industry - mobile financial services for the unbanked, GSMA publishing, compiled by KSP Consultants (Global)

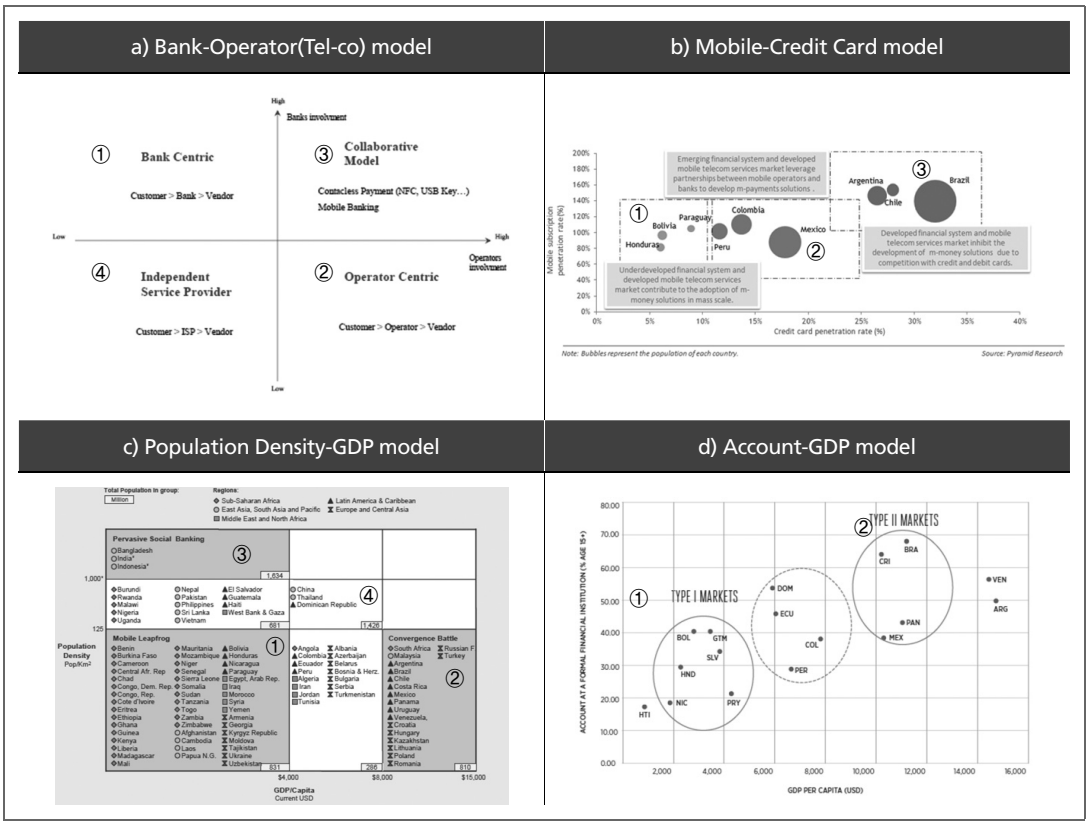
b) GSMA (Mireya ALMAZÁN and Jennifer Frydrych), 2015, mobile financial services in Latin America & the Caribbean, GSMA publishing, compiled by KSP Consultants (LAC & East Africa)

For the year 2014, P2P transfers and airtime top-ups in LAC represented 73% of transaction volumes, compared to 94% of transaction volumes in East Africa. Over a quarter of all transaction volumes in LAC were from ecosystem transactions with third parties-such as bill payments, bulk payments, and merchant payments. These figures were up from just 14% in September 2012. By comparison, in East Africa only 6% of all transaction volumes were considered ecosystem transactions. Ecosystem transactions are critical to realising the full potential of mobile financial services; however, they are often regarded as the most difficult products to gain popularity among users in a mobile money market.

6) Mobile financial service model

There are many mobile financial service models; each is unique and will deliver desirable results when all components work well together. But there is no one-size-fits-all model, and for the LAC market, there is a need to consider the merits and drawbacks of several mobile financial service models.

Figure 2- 6 | Mobile financial service model



Source: a) Laetitia Chaix and Dominique Torre, 2011, four models for mobile payments, University Nice Sophia-Antipolis
b) Marcelo Kawanami, 2015, banking the unbanked, Pyramid Research
c) CGAP (Faz, Xavier, and Ted Moser), 2013, advancing financial inclusion through use of market archetypes, focus note 86. Washington, D.C., CGAP
d) GSMA(Mireya ALMAZÁN and Jennifer Frydrych), 2015, mobile financial services in Latin America & the Caribbean, GSMA publishing

a) Bank-Operator (Tel-co) model

Generally, mobile financial services models are discussed according the level of involving of its main partners, namely the operator(s) and the bank(s). Chaix and Torre (2011) present four models for mobile payments and highlight the roles of their main partners, as follows:

i) The Bank-centric model: a bank as the central node of the model manages the transactions and distributes the property rights

ii) The Operator-centric model: the same scenario, but with the operator in the strategic role

iii) The Collaborative model: financial intermediaries and telephonic operators collaborate in managing tasks and share cooperatively the proprietary rights

iv) The Independent service-provider (ISP) model: a third party of confidence operates as an

independent and "neutral" intermediary between financial agents and operators. Google or PayPal are ISPs most frequently associated with this model

b) Mobile-Credit Card model

Nowadays, most countries in Latin America have high mobile subscription rates, which is a trend aided by decreasing mobile handset prices, improved mobile coverage and poor fixed line infrastructure. However, access to credit cards varies widely across countries. The Latin America market can be divided into three groups: (i) countries with a developed financial system and mobile telecom services market; (ii) countries with an emerging financial system and a developed mobile telecom services market; and (iii) countries with an underdeveloped financial system and developed mobile telecom services market. Detailed descriptions of the systems found in various LAC countries are given here:

i) Bolivia, Honduras, and Paraguay: These countries have underdeveloped financial systems and developed mobile telecom services markets, and this contributes to the adoption of m-money solutions in mass scale. Consequently, m-money solutions serve as a key platform for financial inclusion.

ii) Colombia, Mexico, and Peru: These countries have emerging financial systems and have developed mobile telecom services market leverage partnerships between mobile operators and banks to develop m-payments solutions. For banks, m-payment solutions are a way to reach a mass market with financial services; for mobile operators, this is seen as an opportunity to develop value-added services and differentiate from competitors.

iii) Argentina, Brazil, and Chile: These countries are equipped with developed financial systems, but mobile operators here face difficulties fostering usage of m-money or m-payment solutions, mainly due to the competition with alternative forms of payment that are already largely adopted such as debit and credit cards. Within those countries, m-payment is increasing its presence in the form of online purchases using the mobile device's browser or mobile application (m-commerce), which opens the opportunity for new market entrants such as device makers (Apple Pay) and online companies (Google Wallet).

c) Population Density-GDP model

An analysis of 148 countries covering 5.6 billion people suggests that population density and per capita income influence financial inclusion (Demirguc-Kunt & Klapper, 2012). Combined income and density is associated with still-higher financial inclusion. Researchers in CGAP (2014) argue that countries can be broadly grouped into three market archetypes (CGAP (Faz, Xavier, and Ted Moser), 2013).

ⅰ) Mobile Leapfrog markets (low income, low density)

- Mobile network operators (MNOs) fill a banking infrastructure gap to increase the percentage of the population that has access to services;

- In these markets, individuals live too far apart and account balances are too small for widespread bank branch economics to work well. As a result, consumer retail banking systems are generally underdeveloped; with little banking infrastructure and few branch-based access points;
- MNOs often take the lead in launching mobile banking initiatives, particularly money transfers. Some also create partnerships with microfinance banks or small commercial banks to offer more holistic branchless banking solutions.

ii) Convergence Battle markets (higher income, low density)

- Branchless banks and retailers (and perhaps MNOs in the future) fiercely compete for the same customer in urban areas, while the countryside remains underserved;
- All major types of branchless banking providers (banks, retailers, and MNOs) have a strong enough market presence that they converge on and fight for each other's customers. Higher income per capita and higher urbanization enable major commercial banks to have a relatively strong financial inclusion footprint;
- Rural areas represent the main challenge for financial inclusion in these markets. Commercial banking penetration in these areas remains low because traditional financial institutions lack the required business case for branch-based operations to be profitable, and while agent banking is beginning to develop, it often mostly focuses on urban branch decongestion.

iii) Pervasive Social Banking markets (low income, high density)

- Countries where average income per capita is very low, but population density is significantly high, have distinctively developed large, successful social banking systems;
- Historical financial inclusion success achieved through social banking leads to regulations that heavily favour future social banking, leaving less room for innovation;
- The key characteristic of this market archetype is the pervasiveness of social banking, implemented through non-commercial banks and through government mandates for commercial banks to partially address social equality.

iv) Middle cell environments

- These markets are more likely to be hybrids of these three archetypes than distinctively different environments.

d) Account-GDP model

LAC markets are mapped according to GDP per capita and corresponding penetration rates of accounts at financial institutions. While these two variables are not independent, they provide a spectrum by which to view how specific markets are developing in the region.

Table 2- 6 | Market comparison between Type I market and Type II market

Type	Countries	Feature
Type I MARKETS Low-income, low banking rates	Bolivia, El Salvador, Guatemala, Honduras, Nicaragua, and Paraguay	The highest rates of financial exclusion on average - GDP per capita of USD 3,130 - 33% of adults have an account at a financial institution - 58% mobile subscriber penetration rate (of total population) - 9 mobile money services
Type II MARKETS High-income, high banking rates	Brazil, Costa Rica, Mexico, and Panama	Higher rates of financial inclusion. - GDP per capita of USD 10,860 - 57% of adults have an account at a financial institution - 50% mobile subscriber penetration rate (of total population) - 10 mobile money services
Hybrids market	Colombia, Ecuador, Peru, Dominican Republic	- GDP between USD 4,000 and USD 8,000

Source: GSMA (Mireya ALMAZÁN and Jennifer Frydrych), 2015, mobile financial services in Latin America & the Caribbean, GSMA publishing

These market groupings closely correlate with CGAP's market archetypes for financial inclusion. CGAP classifies the majority of Type I markets as "Mobile Leapfrog" markets, in which "MNOs fill a banking infrastructure gap to increase the percentage of the population that has access to services". Type II markets are classified as "Convergence Battle" markets, in which branchless banks, retailers and, to some extent, MNOs, compete fiercely for the same customer in urban areas.

i) Type I Markets

- It is difficult for financial services providers to reach underserved populations through traditional banking models;
- These characteristics make Type I markets ideal candidates for mobile money services offered by mobile operators. These markets could adopt commercial models with simple value chains, similar to the ones that have been so successful in East Africa;
- The operator-driven commercial mobile money models flourishing in Type I markets would be greatly enhanced by greater ecosystem development. In particular, more collaboration between operators and traditional financial services providers could be an attractive option;
- Partnerships between mobile operators and financial institutions to offer products such as mobile credit, savings, and insurance can be a win-win scenario. This type of partnership is yielding results in Paraguay, for example, TIGO's partnership with Banco Familiar on a mobile credit product has attracted 50,000 new loan clients, most of whom were previously unbanked.

ii) Type II Markets

- Banks are deeply rooted in the economy and are strong contenders to become mobile financial services leaders in their respective countries;
- Mobile operators and retailers have achieved high penetration levels and built strong customer relationships in their core business;
- These markets tend to be more integrated with current financial and retail infrastructure. Existing distribution networks are leveraged for cash-in/cash-out, companion cards are introduced to tap into point-of-sale infrastructure, and back-end interconnections can be made with national clearing and settlement systems. In this way, many mobile money deployments in Type II markets are born interoperable with the banking sector and begin to develop an ecosystem from the start.

iii) Hybrid Markets using unique approaches

- Two LAC markets, Peru and Ecuador, use unique approaches to introduce mobile financial services;
- In Peru, based on an initiative of the Association of Banks (ASBANC), more than 30 e-money issuers are preparing to launch an open and interoperable e-money platform;
- In Ecuador, the central government is the only issuer of e-money, which was established by a legal framework in 2014.
- While both adoptions are in early stages, these markets have attracted international attention.

7) Cybercrime characteristics and trends

Today's connected world relies on technology for many daily transactions and needs, from mobile banking to security enhancement. Unfortunately, risks and threats to well-being of users increase with use of technology to meet users' needs. In effect, every computer in the world is a potential entry point, making investigation and prosecution of cybercrime a formidable challenge. Latin America and the Caribbean (LAC) have one of the fastest-growing Internet populations in the world, thus giving rise to significant cyber security challenges faced both today and in the future (OAS and Symantec, 2014).

The most commonly reported incidents affecting individual users involved phishing, followed by misappropriation of a person's identity for financial fraud. Growth in digital finance services has brought about a parallel increase in efforts to defraud both banks and their clients, and has caused tremendous although greatly under-reported financial losses. Unauthorized access to systems and the information they contain is another significant threat. Cybercrime authorities noted a rise in the number of incidents, particularly involving private companies and small and medium sized enterprises (SMEs). In such situations, it is becoming increasingly common for ransomware such as Cryptolocker to demand payment for aid to recover or to restore files (OAS and Symantec, 2014).

Cryptolocker is a file-encrypting ransomware, which will encrypt the documents found on victim's computer using RSA-2048 key (AES CBC 256-bit encryption algorithm). Cryptolocker then displays a message which offers to decrypt the data if a payment of requested money is made within requested hours, otherwise the data will be destroyed. The Cryptolocker virus is distributed through several means such as email containing infected attachments or links to malicious websites.

When combined as a single region, Latin America and the Caribbean have the fastest growing Internet population in the world, with 147 million unique users in 2013, with this figure growing each year. Mobile devices are proliferating as the preferred method for accessing the Internet, especially in the use of social media. Nearly 95% of Internet users in the region actively use social networking sites, and Latin American and Caribbean nations occupy five of the top ten spots for most time spent on social networks. While today the region of Latin America and the Caribbean accounts for only a small percentage of global cybercrime, the rise in Internet use and corresponding cyber-attacks emphasize the need for the development of effective cyber policies and defences.

The current threat landscape in Latin America and the Caribbean shows cybercrime threats that are region-specific as well as global. These are some major trends that leave an impact on the LAC region.

① **Data breaches**
The year 2013 is also known as "Year of the Mega Breach" with over 552 million identities exposed by data breaches, putting at risk consumer credit card, financial, medical and other types of personal information. The source for this trend was cybercrime-driven breaches and hacking acts, with hackers accounting for 32 percent of all breaches.

② **Targeted attacks**
Attacks against specific individuals or organizations are evolving, with cybercriminals adapting spear-phishing campaigns to be stealthier and adding watering-hole attacks to sophisticated cybercrime toolkits.

③ **Social media scams**
In 2013, cybercriminals sought to exploit data shared online through social media. Social media channels have become increasingly interconnected with the security of personal data, and the sharing of personal information online is now made more accessible and also more open to cybercrime.

④ **Banking Trojans and heists**
Across Latin America and the Caribbean, the number of incidents involving banking Trojans has increased significantly. Initially discovered in Mexico, malware targeting ATMs has spread to other countries throughout the Americas, especially in Spanish speaking countries.

⑤ **Global events as gateway**
Global events inviting online ticket bookings and gambling such as sports tournaments (e.g., World Cup in Brazil) have become a major vector for cybercriminals to engage in countless malware operations, phishing schemes, and email scams related to the events.

a) Vulnerability in mobile money transactions

The low security functionality of basic mobile phones do not assure end-to-end encryption, which means traffic can be intercepted between the mobile transaction and the point of service, potentially resulting in identity theft and fraudulent transactions. In addition, a customer's lack of technological literacy may produce erroneous transactions. These errors include sending money to the wrong account or paying the wrong bill, failure to complete a transaction, weak PIN choices, and carelessness in safeguarding personal information. Another practice inviting invulnerability is for low-income households to share mobile phone use, which potentially invites risks when the mobile device is used for financial transactions.

These risks leave users, especially those from low-income households, vulnerable to losing funds either directly or through increased probability of identity theft or theft of authentication parameters. The source of risk may come from the client (demand) side or the operator (supply) side. In both cases, exposure to these risks has a negative impact on consumer trust in the system, making it difficult for the MFSP to reach the scale it needs to become viable (Alliance for financial inclusion (Mobile financial services working group (MFSWG), 2014).

Table 2- 7 | Vulnerabilities and risks facing MFS consumers at transaction stage

Vulnerability	Threats	Risks
• Client's equipment with low security functionality and lack of end-to-end encryption • Client's lack of skill in following procedures and security measures	• Interception of traffic between mobile phone and point of service • Inaccurate transactions	• Identity theft and wrongful access • used to conduct transactions • Erroneous transactions Loss of client funds
• Communication network	• Failures in the system and inability to complete transactions	• Reputational risk • Incomplete or delayed • transactions • possible loss of funds
• Agent network	• Fake agents • Agent misconduct and poor service • Lack of agent liquidity	• Potential for fraud • Perception that service is unreliable

Source: Alliance for financial inclusion (Mobile financial services working group (MFSWG)), 2014, consumer protection in mobile financial services (guideline note no.13), Alliance for financial inclusion

Note: Transaction stage refer to that Customer performs cash-in/out transactions, payments and transfers

b) Fraud risk in mobile money deployment

Fraud not only results in financial losses for customers or mobile money providers, but also damages the reputation of the services provided to customers. More critically, it carries also the risk of ruining the reputation of the industry as a whole. In practice, MNOs, banks, and third parties recognize risk management as an essential pillar to the sustainable commercial success of mobile money deployment.

Table 2- 8 | Potential types of fraud in mobile money deployment

Location	Type of fraud	Content
Transaction	Vishing/Smishing	Use of phone calls or SMS to gather personal details such as account numbers, PINs, or personal identification details
	Advance fee scam	Customers duped into sending funds under fake circumstances or promises
	Payroll fraud	Non-existent or "ghost" employees receiving funds
	Reversal Request	Customers' request to reverse transactions that were in fact successful
	False transaction	Sending a fake SMS to make customers believe a transaction was successful. Often accompanied by a reversal request
Channel	Split transaction	Agents split cash-in transactions in order to earn multiple commissions (only applies to tiered commission structures)
	False transaction	Agents transferring customer funds to personal accounts
	Registration Fraud	Creation of accounts for false, invalid, or duplicated customers for the purpose of obtaining extra registration commissions
Internal	Internal fraud	Employees colluding for unfair personal financial gain
	Identity theft	Employees accessing and exploiting customer information without authorization

Source: GSMA (Lara Gilman and Michael Joyce), 2012, managing the risk of fraud in mobile money, GSMA-mobile money for the unbanked

c) Types of fraud control

In order to build an effective risk management strategy, operators need to identify the vulnerabilities of the operation in its deployment. With key risks identified, the next step for a mobile money operator is to establish effective controls. Preventive controls are generally regarded to be stronger than detective controls, especially if such controls can be implemented as technical features of the mobile money system.

Table 2- 9 | Managing the risk of fraud in mobile money

Preventive Controls	Detective Controls
• Control access rights to protect customer information • Segregation of duties to reduce error or fraud in high risk procedures (e.g., e-money reconciliation) • Threshold limits to reduce risks associated with AML/CFT • Customer awareness campaigns to increase customer education and protection • Agent training on acceptable practices and terms and conditions • Employee training on roles and responsibilities	• Monitor and analyze suspicious activity • Monitor activity on system access • Create robust customer recourse and escalation procedures • Monitor agent transaction activity • SMS alerts to customers • Management review of high-value transactions

Source: GSMA (Lara Gilman and Michael Joyce), 2012, managing the risk of fraud in mobile money, GSMA-mobile money for the unbanked

2.2. General Status of Colombia

2.2.1 General Information

The Republic of Columbia is the fifth largest country in Latin America. More details on the general status of Colombia is summarized in the table below.

Table 2- 10 | General status of Colombia

Division	Content
Official country name	Republic of Colombia
Capital city	Bogota
Area	1,141,748 sq. km
Population	Approximately 47.79 million (in 2014)
Language(s)	Spanish, and more than 200 aboriginal Indian languages
GDP	US$ 4,001 billion(in 2014)
GDP per capita	US$ 8,393(in 2014)

Source: World Bank, 2015; data compiled by KSP Consultants

On July, 2014, the Colombian Ministry of Information and Communications Technology (ICT) launched Colombia's Vive Digital (Digital Living) II Plan – a $10 billion nationwide effort that has set two main objectives: become a world leader in the development of applications for lower income citizens in order to lift them out of poverty and improve their quality of life, and to become the most transparent and efficient government with the use of information and communication technologies (www.colombiaemb.org, Colombia Today, 2014.8.4).

Vive Digital has already achieved: from 2.2 million Internet connections in 2010 to 8.8 million Internet connections in 2014, from 200 municipalities which connected with optical fiber in 2010 to total of 1,078 municipalities in 2014(Diego Molano, 2014).

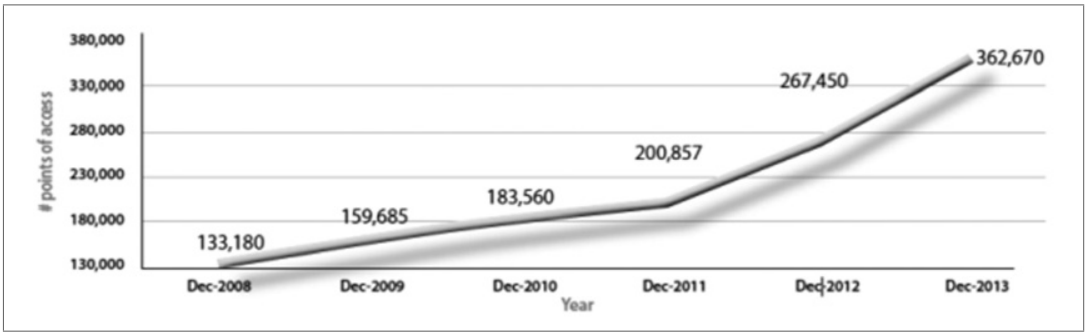
Phase II of the Vive Digital Plan will build upon the successes of Phase I, and aims to:

- Triple Internet connections from 8.8 million in 2014 to 27 million in 2018
- Boost Internet penetration in households and small businesses from 45 percent to 63 percent and 60 percent to 70 percent, respectively
- Double the number of companies in the IT sector to 3,600
- Triple IT sector revenues to $10.4 billion and the number of IT employees to 117,000 by 2018
- Continue subsidizing low-income families' purchase of PCs or tablets, and maintain the lowest price for PCs throughout the region

2.2.2 Financial inclusion

In Colombia, people have the possibility of accessing financial products and services through the following points of access (POA): branches, agents, automatic teller machines (ATMs), and points of sale (POS). Between December 2008 and December 2013, the number of POA increased by 172.3% from 133,180 to 362,670. If this figure is compared to the 159,685 available POA as of December 2009, it can be seen that the possibilities offered to citizens accessing financial services doubled in Colombia over the years.

Figure 2- 7 | Growth of POA (points of access)



Source: Gerardo Hernandez Correa and Juliana Alvarez Gallego (Reporte de Inclusión Financiera (Financial inclusion report)), 2014, SFC (Forms 398, 322, and 444) and BdO, SFC and BdO

As of December 2013, 298,751 Points of Sale (POS), 42,638 agents, 13,679 automatic teller machines (ATMs), and 7,602 branches had been recorded. Banks have 356,041 POA and the greatest market share (98%) followed by financing companies with 4,975 (1.37%) and lastly the cooperatives with 1,054 and NGOs with 600 (0.29% and 0.17% respectively).

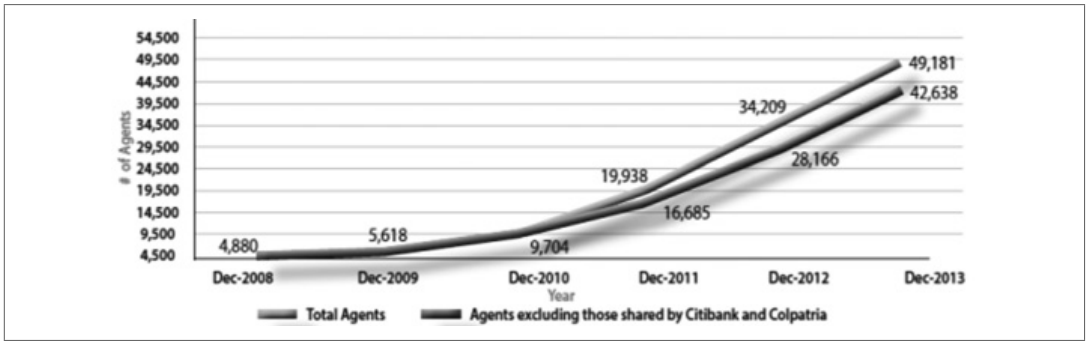
Financial inclusion in Colombia is accessed by degree of access indicator and use indicator.

1) Access Indicator, which includes Agent and Branch.

a) Agents

The agents stand out as the driver of POA growth. These agents were authorized in 2006 as a new channel to offer financial services, with low implementation costs in terms of infrastructure and operating costs, allowing financial institutions to expand their coverage in areas of the country that in the past they did not consider venturing into.

Figure 2- 8 | Evolution in the number of agents

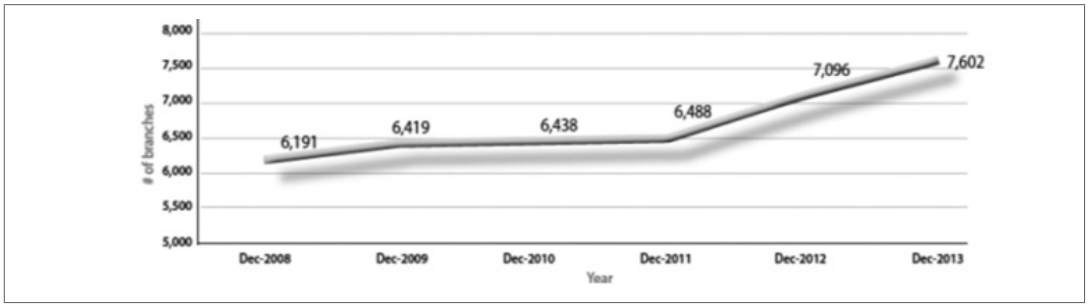


Source: Gerardo Hernandez Correa and Juliana Alvarez Gallego (Reporte de Inclusión Financiera (Financial inclusion report)), 2014, SFC (Forms 398, 322, and 444) and BdO, SFC and BdO

As of December 2013, 49,181 agents were recorded, covering 1,069 municipalities in Colombia, equivalent to 97% of the national territory. By 2013, this type of POA (agent) had been implemented by 23 financial institutions and distributed as follows: 45,000 operated by 15 banks (91.5%); 4,145 by 5 financing companies (8.4%); and cooperatives supervised by the SES and SFC-operated agents (0.1%).

b) Branches

Figure 2- 9 | Total number of branches according to type of financial institution



Source: Gerardo Hernandez Correa and Juliana Alvarez Gallego (Reporte de Inclusión Financiera (Financial inclusion report)), 2014, SFC (Forms 398, 322, and 444) and BdO, SFC and BdO

As of December 2013, the number of branches had reached 7,602, located in 873 municipalities and covering 79% of the national territory. Most of them (5,398) were bank branches; equivalent to 71% of the total. The 164 SES cooperatives had 735 branches (10% of the total), while the 6 SFC cooperatives had 212 branches (2%). The cooperatives sector accounted for 12% of the total number of branches.

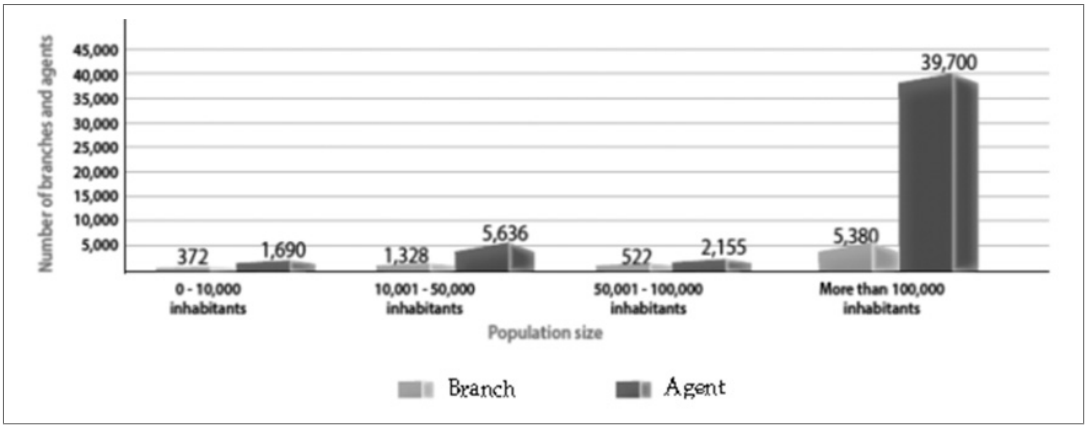
An analysis of the evolution of branch and agent coverage reveals the following developments based on the type of municipality:

① Significant progress was achieved in terms of national coverage, given that between 2008 and 2013 the number of municipalities without any type of financial institution dropped from 70 to 3; and two of the non-covered municipalities had very low population densities (less than 10,000 inhabitants);

② A substantial number of municipalities (265) were served exclusively by agents; of these, close to 70% (182) had less than 10,000 inhabitants. This aspect reveals the power accorded to agents to offer financial services in the smallest towns and, at the same time, highlights the need to optimize agents' potential through the development of products adjusted to small towns' needs and also by diversifying services provided;

③ Another interesting indicator arises when considering municipalities situated in the two lower ranks for population density, i.e., between 0 and 10,000 inhabitants and between 10,001 and 50,000 inhabitants. Both municipalities have simultaneous access to branches as well as agents. In 2008, there were only 67 and 293 such cases, but by the end of 2013 these numbers had increased to 229 and 445.

Figure 2- 10 | Total number of branches according to type of financial institution



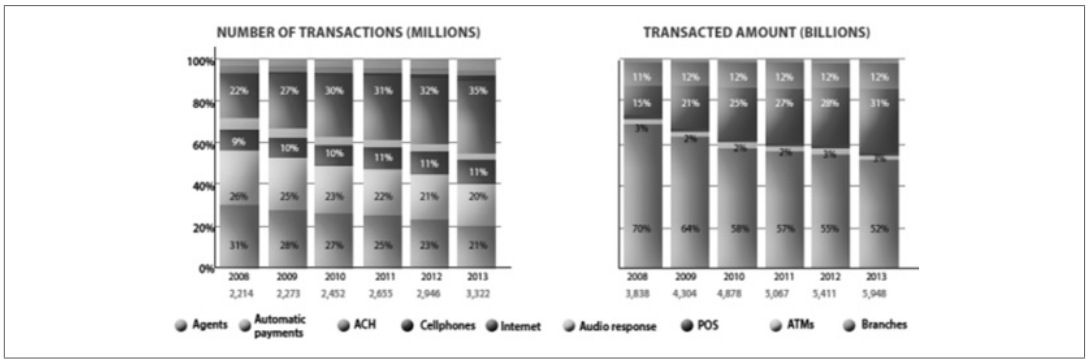
Source: Gerardo Hernandez Correa and Juliana Alvarez Gallego (Reporte de Inclusión Financiera (Financial inclusion report)), 2014, SFC (Forms 398, 322, and 444) and BdO, SFC and BdO

2) Use Indicator, which is to transactions through channels and points of sale

a) Transactions

Branches continue to act as the channel that transacts the greatest volume in terms of amounts and the second greatest number of transactions and, in comparison to other channels, they make up 52% of the total amount transacted and 21% of the number of transactions. Nevertheless, recent trends indicated a reduction in these numbers between 2012 and 2013; it was recorded that 55% of the amount transacted and only 23% of all transactions in the financial system in 2012 were performed through branches. Automatic teller machines show the same downward performance, while the use of points of sale (POS) remains constant.

Figure 2- 11 | Share of transactional channels in all transactions



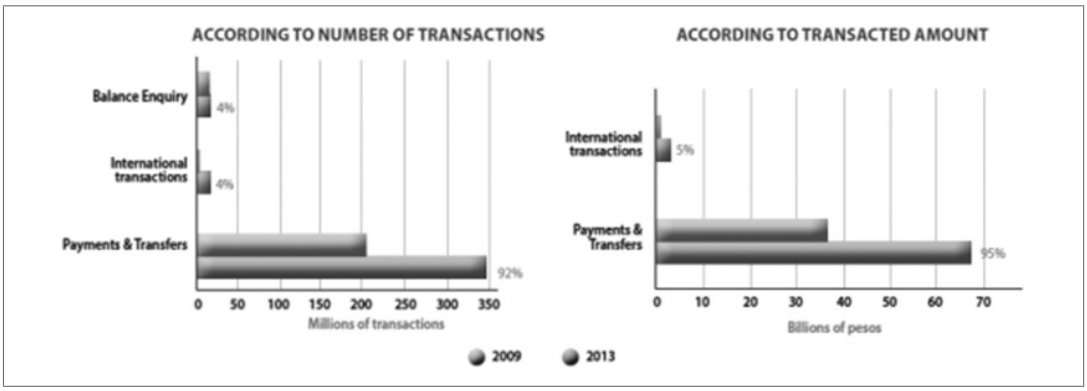
Source: Gerardo Hernandez Correa and Juliana Alvarez Gallego (Reporte de Inclusión Financiera (Financial inclusion report)), 2014, SFC and BdO (Forms 444and 368), SFC and BdO

b) Points of Sale (POS)

This channel recorded growth of 116% in number of points and 70% in number of transactions between 2009 and 2013, due to the generalized use of debit and credit cards as a substitute for cash payments.

In 2013, this channel was mostly used for payments and transfers (92%). The total amount transacted through this channel corresponded to the amount reported for payments, transfers, and international transactions, which totalled COP 37 billion in 2009 and COP 70.4 billion in 2013.

Figure 2- 12 | Type of transactions performed though points of sale



Source: Gerardo Hernandez Correa and Juliana Alvarez Gallego (Reporte de Inclusión Financiera (Financial inclusion report)), 2014, SFC and BdO (Forms 444), SFC and BdO

2.2.3 ICT infrastructure

The Colombian Ministry of Information, Technologies and Communications is in charge of state-dominated information and communication technology (ICT) projects. Since 2010, notable improvements have been made in the sectors of government performance, civil affair services, provision of public information, and national participation through Vive Digital Colombia ICT. As a whole, transparency of public administration mechanism and procedures is enhanced through use of ICT by the Columbian government.

The Government has also established the following four strategies and is implementing them to forge a better electronic government system through enhancement of its ICT infrastructure.

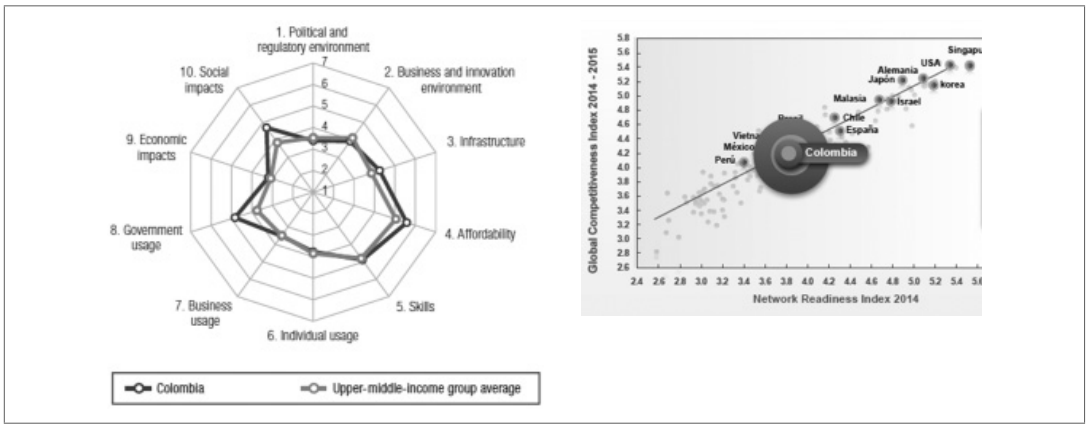
Table 2- 11 | National strategy of Colombia

Strategy	Content
ICT for the civilized government	Reinforcing transparency, the degree of participation, cooperation based on decision-making through ICT technology
ICT service	Providing the best online service to satisfy the requirements of the people through ICT technology
ICT management	Extending ICT technology to simplify the tasks of governmental administration
Security and data protection	Reinforcing security services for people's data and information

Source: assessment of the consultants

According to the Global Information Technology Report 2015(the World Economic Forum and INSEAD) the Networked Readiness Index (NRI) 2015 of Colombia is 64 from out of 143 countries, average point is 4.05[Figure 2-13]. In this report, ICTs act as a vector of social development and transformation by improving access to basic services, enhancing connectivity, and creating employment opportunities.

Figure 2- 13 | Networked Readiness Index (Colombia)



Source: 1) WEF, 2015; the Global Information Technology Report, 2015, WEF
2) Network readiness index, 2014, http://www3.weforum.org 2014, recited from Colombia Vive Digital 2014-2018
Note: Global Competiveness Index 20142015 is 4.2, Networked Readiness Index 2014 is 4.05

2.2.4 Developments in financial inclusion

Colombia is a prominent example of a country that has listed financial inclusion as a priority in its national agenda from a very early stage. In 2006, the Colombian government established a national agency named Banca de las Oportunidade (BdO) to work with the financial sector to deal exclusively with financial inclusion and financial education.

Over the years, Colombia approved many relevant policy and regulatory reforms focused on promoting greater financial inclusion. For example, it uses correspondent agents (municipal agents) and mobile banking to deposit conditional cash transfers to social program beneficiaries of "Familias en Acción." More recently, on October 21, 2014, the Colombian Congress passed Law No. 1735 and created a new type of financial institution called Sociedades Especializadas en Depósitos y Pagos Electrónicos (SEDPED, Specialized Electronic Deposit and Payment Institutions). SEDPES are a deposit-taking licensed entity that can be incorporated by a natural person, postal service offices, and/or mobile network operators or other non-bank companies.

In Columbia, new non-bank electronic deposit funds are now covered by deposit insurance and can earn interest (regulated by the financial authorities). The law also allows for the remote opening of electronic deposit accounts, only requiring the client to use his/her national ID. The law envisions that electronic deposit services will primarily be provided via correspondent agents. Thus, it also provides incentives for clients to use the service by exempting electronic deposits (within limits) from banking transaction taxes (Alliance for Financial Inclusion (María del Rosario Moreno Sánchez, 2015).

2.2.5 Cyber crime

In figures released by Colombia Norton report 2013 still rates higher than the global average for people affected by cybercrime in 2013 with 45 % having fallen victim to online crimes, compared to a global average of 41%. These crimes in 2013 affected roughly 6 million people and cost $46 million [Figure 2-14].

A November 2014 report released by the Colombian Department of Informatics and Telecommunications CCCT shows that cybercriminals are diversifying and a new problem on the rise relates to electronic cloning of credit cards; this particular cybercrime reportedly rose by 25% in 2013 compared to earlier years.

Figure 2- 14 | 2013 Norton Report on Cybercrime Rate in Colombia

2013 NORTON REPORT	COLOMBIA	GLOBALLY (24 countries)
CYBERCRIME EXPERIENCES		
• Adults who have experienced cybercrime in their lifetime	64%	61%
• Adults who experienced cybercrime in the past 12 months	45%	41%
• Adults who have been victim of cybercrime and risky behaviors	57%	50%
• Number of victims in the past 12 months	6 m	378 m
• Percentage of males who have been victim of cybercrime in their lifetime	74%	64%
• Percentage millennials who have been victim of cybercrime in their lifetime	70%	66%
CYBERCRIME COSTS		
• Total cost of cybercrime in the past 12 months	US$464 m	US$113 bn
• Average direct cost per cybercrime victim in the past 12 months	US$74	US$298
CYBERCRIME GOES MOBILE BUT SECURITY IS LEFT BEHIND		
• Smartphone users who have experienced mobile cybercrime in the past 12 months	42%	38%
• Smartphone users who have a basic free security software	45%	33%
• Tablet users who have a basic free security software	51%	42%

Source: Norton Report, 2013, https://www.symantec.com/content/en/us/about/presskits/b-norton-report-2013-colombia.pdf, Symantec

2.3. General Status of Paraguay

2.3.1 General Information

The Republic of Paraguay, situated in Latin America, ranks ninth in area among the twenty Latin American Republics, is among the least economically developed countries on the continent. General data on Paraguay is summarized in the table below.

Table 2- 12 | General status of Paraguay

Division	Content
Official country name	Republic of Paraguay
Capital city	Asuncion
Area	397,300sq. km
Population	Approximately 6.6 million (in 2014)
Language(s)	Spanish and Guarani are the official languages, and most people use Spanish in combination with the native language (Guarani language)
GDP	US$30.88 billion (in 2014)
GDP per capita	US$4,713 (in 2014)

Source: assessment of the consultants

Paraguayan government has been promoted to improve communication infrastructure in many areas through the National Telecommunications Development Plan 2011-2015, it showed significant progress in mobile communication penetration and Internet penetration. The future introduction of 4G frequencies through government support will improve communications sector.

2.3.2 Financial Inclusion

1) Definition of financial inclusion in Paraguay

The definition by consensus of the BCP, MH, STP, and INCOOP for financial inclusion is as follows: "access to and usage of a range of quality, timely, convenient, and informed financial services at affordable prices. These services are under appropriate regulations that guarantee consumer protection and promote financial education to improve financial capabilities and rational decision-making for all segments of the population." (Banko Mundial, 2014).

With this as the agreed upon definition, the vision of financial inclusion for Paraguay is: Quality and affordable financial services available to all Paraguayans through a diverse and competitive marketplace.

2) Principle of financial inclusion in Paraguay

As part of Paraguay's National Development Plan, there is a clear understanding that financial inclusion is one of the three necessary components in achieving an inclusive society in Paraguay, with the other two components being social and economic inclusion.

In this context, all three inclusions hold similar principles. While social inclusion is seen as the ability for Paraguayan society to meet the basic human needs of its citizens and communities, economic inclusion requires inclusive growth to create economic opportunities, promotes employment and equal access, and also to sustain macroeconomic stability while ensuring competition, freedom of entrepreneurship, and the rational use of resources.

3) Structure of financial inclusion in Paraguay

a) Financial inclusion environment

The National Financial Inclusion Survey (or Encuesta de Inclusion Financiera, i.e., EIF in Spanish) reports that 58% of adults in Paraguay use some sort of formal or commercial financial product to manage their day-to-day finances. This number is largely driven by the strong presence of cooperatives and mobile money providers in Paraguay, which reach a combined 40% of the population. Yet 42% of adults remain almost totally excluded from using the financial system. These adults do not have an account with a formal financial institution, do not have an ATM or credit card, do not use mobile money, do not have insurance, and they receive wages and remittances in cash only. Adults in this category, i.e., the 'totally excluded' are disproportionately poor, have a primary education or less, and are unemployed or outside of the workforce.

In particular, rural areas of the country have limited access to formal financial services. There are no bank or cooperative branches available in parts of the country inhabited by 17% of the population. In addition, 30% (or 69) of the country's 224 districts with more than 2,000 inhabitants do not have any bank presence, whether through branches, bank agents, or ATMs. In terms of administration, the BCP is in charge of licensing and prudential oversight of banks, finance, and insurance companies, as well as e-money issuers, to a limited extent. INCOOP is the regulatory body for all cooperatives. The Secretary for Consumer Protection (SEDECO) is an umbrella consumer protection regulator whose remit covers all sectors, including the financial sector. Neither BCP nor INCOOP has the explicit mandate to also include supervision and enforcement of the Consumer Protection Law for their supervised entities.

In the current environment, it is envisaged bank presence in rural, low-access areas in Paraguay has the opportunity to increase rapidly through the use of bank agents, electronic money, and mobile financial services.

b) Payment

With a population of 6.6 million, there are 7 million mobile lines in Paraguay. It has been reported that 28% of adults in Paraguay used mobile money within a span of 12 months. Mobile money is the most popular way to send or receive money from family and friends living elsewhere in Paraguay. Over the past decade, the government and national pension system have begun making electronic salary and pension payments.

Banks could potentially benefit from the robust networks of agents already developed by other types of financial service providers, such as payment processing companies and mobile network

operators. For example, about 1% (310 agents) of TIGO's network of 33,000 agents is approved to perform banking operations; personal agents will extend financial services to 58 districts (26% of all districts in the country) and areas in which banks do not serve (where there are no branches or agents).

c) Financial education

There is significant scope for expanding the availability of financial education programs in Paraguay. One in ten adults reported that someone in their household had in the past received personal finance or money management lessons. Since the need for digital finance transactions exists, well-designed financial education programs can readily equip people with the knowledge and skills to take advantage of appropriate financial services in order to save, borrow, make payments, and manage risks in mobile money transactions.

d) Consumer protection

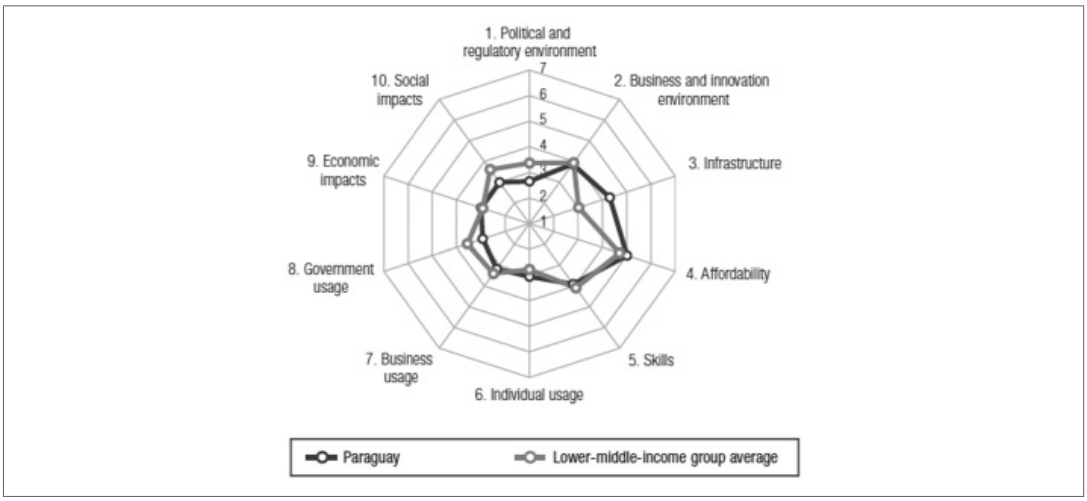
The Consumer Protection Law and Civil Code set the legal basis for consumer protection in Paraguay, although most of the provisions are broad in nature and may need further regulations to be realistically enforceable. The BCP introduced a number of regulations over the last few years for banks and finance companies to follow. These new regulations aim to enhance the comparability of prices and commissions, and also to improve rules for the general disclosure of information. However, the supervisor of cooperatives, INCOOP, lacks a dedicated unit responsible for financial consumer protection and financial education.

2.3.3 ICT infrastructure

According to the Global Information Technology Report 2015, the World Economic Forum and INSEAD, the Networked Readiness Index (NRI) 2015 of Paraguay is 105 from out of 143 countries, average point is 3.4, which implies future development opportunities of ICT and a greater potential of development in many industries through this ICT.

Application of ICT is not merely restricted to domestic areas, but allows brisk exchanges and financial transactions with overseas countries to be conducted freely. Therefore, ICT is also expected to contribute significantly to export/import activities in Paraguay.

Figure 2- 15 | Networked Readiness Index (Paraguay)



Source: WEF, 2015; the Global Information Technology Report, 2015, WEF

2.3.4 Developments in financial inclusion

There are five main factors to evaluate financial inclusion. These are savings, payment, financial education, consumer protection, and vulnerable populations.

1) Key performance indicators in financial inclusion

a) Savings

The goal is to increase savings account ownership from 29% to 50% for the adult population and increase actual usage from 14% to 30%. The EIF indicates that many more people (25%) are beginning to manage their money via informal means rather than formal (14%) means. For people here, informal savings accounts generally present greater risks of loss and keep credit markets unnecessarily shallow.

b) Payment

The goal is to decrease usage of cash/checks for salary and wage payments from 76% to 20%. In terms of mobile money usage, Paraguay is a regional and global leader. However, many transactions are currently conducted over-the-counter (OTC) as opposed to e-wallet transactions.

c) Financial education

Gradually, the goal is to increase the percentage of adults (aged 15+) wishing to receive some training, advice, or support for managing personal finances and the administration of money, from 10% to 20%.

d) Consumer protection

All institutions that provide regulated and non-regulated financial services have publicized arrangements for customer complaints and queries that take into account the realities of all income groups, including the financially vulnerable.

e) Vulnerable populations

The goal is to extend financial services via cost effective channels to all 69 financially excluded districts, along with the more heavily populated districts in the country, with focus given to the 17 vulnerable priority districts. This forms part of the Paraguay government's plan to end extreme poverty.

2) Challenges

In 2011, it was found that only 22% of the population held a formal financial account. While Paraguay is below the average for account penetration in Latin America (39%, according to the 2011 Global Findex), the country remains a regional leader in the development of mobile financial services.

In Paraguay, the importance of cooperatives is demonstrated by the fact that 21% of adults have either an account or loan with a cooperative, compared to 15% with either an account or loan with a commercial bank. The cooperative sector is an important player in improving financial inclusion, and the country has a fast-growing mobile financial-services industry, led by mobile network operators (MNOs).

Non-banks seem to be at the forefront of developing services for the poor, while commercial banks are at the same time making it easier for people to open basic savings accounts. Although credit is slowly becoming available, other products, such as micro-insurance, are not yet offered. In addition, consumer-protection rules do not consider mandatory internal-redress mechanisms. In addition, aggressive collection practices are not forbidden. A recent survey on financial inclusion provides the government with valuable demand-side data to develop a national financial-inclusion strategy.

2.3.5 Cyber crime

There is no specific statistics of Cybercrime in Paraguay yet. But as the account opening is enlarged and electronic financial transactions is increased, that the expansion of cyber-crime is expected. So, it is the time to prepare infrastructure for the consumer protection of digital finance urgently.

For future measures and plans, a thorough review of regulatory and financial consumer-protection structures is on the agenda. All of these should provide a strong basis for considerable progress in the provision of financial services to the poor and the underserved in Paraguay.

2.4. Analysis of the In cture Status

2.4.1 Infrastructure Status of Colombia

Details of the status of digital finance infrastructure in Colombia are presented below.

Table 2- 13 | Infrastructure of digital financial system in Colombia

Sector	Content
Colombia's financial system	• Complex and large financial corporations own large-scale financial systems; many brokers dominate the financial industry. • Credit institutions are in sound state; enterprises and households maintain healthy balance and possess high credit ability; banks create profit, and non-bank financial brokerage companies are operated favorably.
Main risk factors in financial field	• Continuous global recess may slow down domestic economic growth and degrade the quality of loan portfolio; effect of de-leveraging from Europe is not expected to have any significant impact on financial system of Colombia. • Speedy expansion of bank credit loan may pose a potential weakness as excessive commercial loans can incur grave risks. Banks of Colombia seem to have enough resilience to weather various shocks.
Financial supervisory system	• All financial institutions are effectively supervised by the Financial Supervisory Service of Colombia (SFC, or Superintendencia Financiera de Colombia). • SFC has capability and power to develop a common supervisory system for the financial sector, secure information of financial groups, prohibit regulatory arbitrage, and/or provide main privileges. • The above wide-ranging regulatory power may give rise to crucial supervisory problems for financial institutions. Issues that may arise include legal independence of SFC, adopting laws for extending supervision, regulation and power of SFC to holding companies of financial institutions, and strengthening supervision of brokers, dealers, and collective investment companies.
Financial safety net	• Proper safety is provided. The liquidity of Colombia's financial system is quite good; deposit insurance is effective, and the regulator follows proper procedures in liquidating the bank. • The authority has taken steps to cultivate a high-level inter-bank money market by reinforcing supervision of brokers and dealers, non-bank financial institutions, and strengthening the bank liquidation system.

Sector	Content
Financial consumer protection	• The establishment of a comprehensive consumer protection system stipulated in Law 1328 of 2009 is a significant starting point for reinforcing consumer protection. • Surveillance of insurance companies' activities needs further improvement - Need to set up public registration system of insurance agencies: assign items for checking suitability, minimum education criteria, performance and training code - Public database (DB) of the insurance company required, which includes official training for undertaking insurance business, or incongruity of registration - Establish transparency in methods/procedures for customers to check qualifications and duties of insurance agents - Support insurance companies that face difficulties in checking background and suitability of potential agents (i.e., there is a need to set up a public DB of all registered insurance companies) - Establish a self-regulatory agency of each industry under supervision of SFC to serve as a model that benefits both industry and consumers.
Financial consumer protection department of SFC	• This department serves to provide information and advice regarding issues of market behavior and financial education in financial service; it reports directly to SFC, and consists of 15 members. • JPD (a government department with judicial power) was established to take charge of trials of financial consumption affairs, and serves as an alternative to judicial system or commercial arbitration.

Source: assessment of the consultants

1) Internet use in Colombia

a) Status of Internet usage

With the advent of broadband being widely available through many Internet providers, Internet usage has greatly increased during the last few years, with over 30 million Colombians connected to each other and to services via the Internet.

Table 2- 14 | Internet usage in Colombia

	2013	2014	2015	2016	2017	2018
Internet users(millions)						
Brazil	99.2	107.7	113.7	119.8	123.3	125.9
Mexico	53.1	59.4	65.1	70.7	75.7	80.4
Argentina	25.0	27.1	29.0	29.8	30.5	31.1
Colombia	24.2	26.5	28.6	29.4	30.5	31.3
Peru	13.0	14.5	16.0	17.6	19.0	20.1
Chile	10.7	11.6	12.3	12.7	12.9	13.2
Other	56.7	62.7	67.0	70.7	73.7	76.2
Latin America	282.0	309.5	331.7	350.6	365.5	378.3

	2013	2014	2015	2016	2017	2018
Internet user penetration(% of population in each group)						
Chile	62.4	66.7	70.5	71.7	72.7	73.5
Argentina	58.7	63.0	66.8	68.0	69.0	69.8
Colombia	53.0	57.3	61.1	62.3	64.0	65.0
Brazil	49.3	53.1	55.7	58.2	59.5	60.3
Mexico	44.9	49.7	53.8	57.8	61.2	64.5
Peru	43.5	48.1	52.6	57.1	61.1	64.3
Other	38.9	42.4	44.8	46.7	48.1	49.2
Latin America	46.9	51.0	54.1	56.7	58.5	60.0

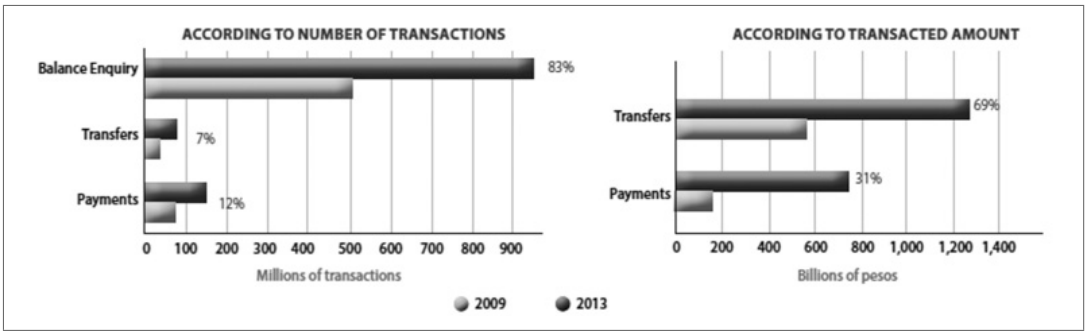
Source: eMarketer, Nov 2014, http://www.emarketer.com/Article/Colombia-Set-Reach-286-Million-Internet-Users-2015/1011864, compiled by KSP Consultants

Note :individuals of any age who use the Internet from any location via any device at least once per month

eMarketer estimates that Colombia will boast 28.6 million web users in 2015, up from 26.5 million 2014, and there will be 31.3 million web users in 2018.

A different measure comes from CISCO. The number of wired Internet members amounted to 5.5 million as of June 2013, which is 10% more than that of 2013's 1st quarter, and 23.6% greater than that of the same quarter in 2012. In addition, the 2013 Internet penetration rate per home was 43% but was expected to amount to 50% in 2014. It is predicted that by the year 2017, the number of wired Internet and mobile Internet members in Colombia will be greater than 10.3 million, and over the next five years, the number of mobile Internet users in Colombia will increase by 15.3% and wideband 2.0 wired Internet users will account for 68.3% of all wired Internet users (KOTRA globalwindow, 2014).

Figure 2- 16 | Types of transactions performed through Internet



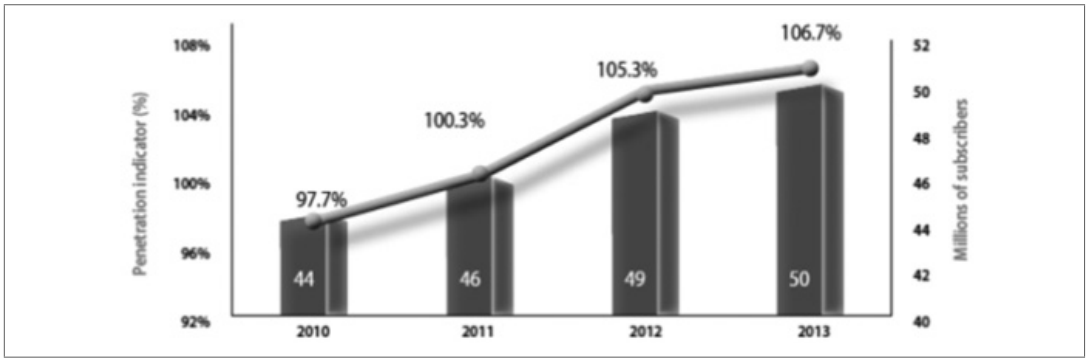
Source: Gerardo Hernandez Correa and Juliana Alvarez Gallego (Reporte de Inclusión Financiera (Financial inclusion report)), 2014, SFC and BdO (Forms 444), SFC and BdO

In terms of Internet usage, the most commonly performed transactions are balance inquiries, with a growth rate of 96% between 2009 and 2013 and a total of 83% share in terms of total transactions. Other popular transactions are payments (12%) and transfer (7%). In terms of growth from 2012 to 2013, payments increased by 156% and transfers by 85%. Since 2009, the amount transacted for payments increased 276% and 69% for transfers. In 2013, although the number of payment transactions was higher than that of transfer transactions, the total amount transacted for both was equivalent to 69% of the total amount, with the amount for payments being the remaining 31%. This trend of usage suggested that consumers preferred these channels because they were perceived to be more secure and trustworthy means of payment [Figure 2-16].

b) Status of mobile phone usage

Figure 2- 17 | Number of subscribers for mobile phone services and service penetration

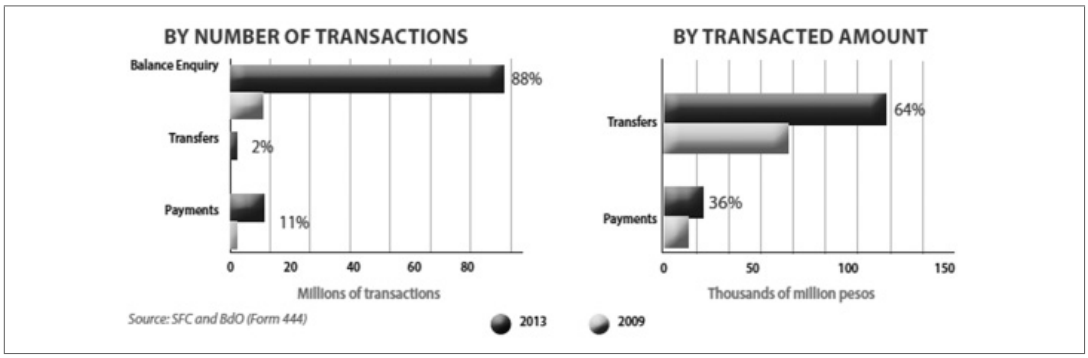
(Unit: Million persons, %)



Source: Gerardo Hernandez Correa and Juliana Alvarez Gallego (Reporte de Inclusión Financiera (Financial inclusion report)), 2014, SFC and BdO (Forms 444), Ministerio de Tecnologías de la Información y las Comunicaciones

Mobile phones remain the fastest growing medium of communication since 2012. As of end 2013, this channel has had a total of 50,295,114 subscribers, with 13% growth between December 2010 and December 2013, and a penetration rate of 106.7% of the country's total population. The number of subscribers versus the adult population in 2013 indicates a subscription rate of 1.1 registered numbers per adult Colombian (refer to Figure 2-17).

Figure 2- 18 | Types of transactions performed through mobile banking



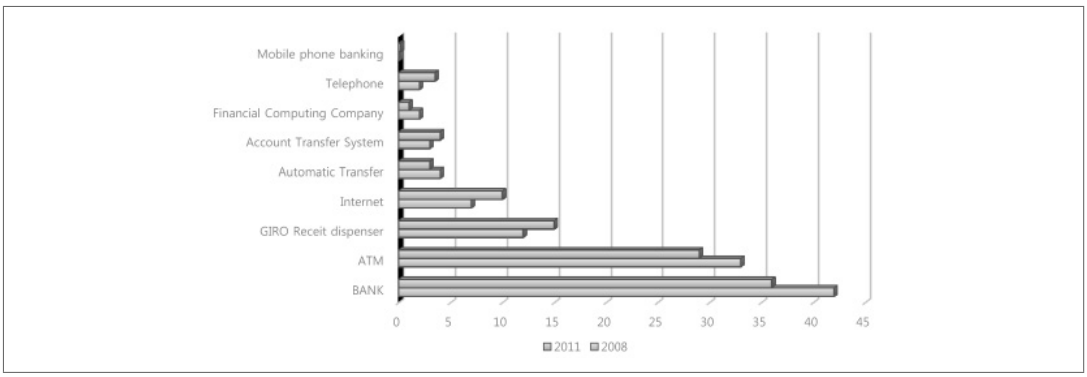
Source: Gerardo Hernandez Correa and Juliana Alvarez Gallego (Reporte de Inclusión Financiera (Financial inclusion report)), 2014, SFC and BdO (Forms 444), SFC and BdO

Mobile devices are at the core of "Vive Digital Colombia" a program overseen by Ministerio de Tecnologías de la Información y las Comunicaciones (MinTIC) that leverages mobile connectivity to achieve its four-year goal of "widespread adoption of Internet and the development of a nationwide digital ecosystem".

In 2013, the most frequent financial transactions performed through mobile banking, specifically mobile phones, were balance inquiries, representing about 88% of total transactions, followed by bill payments (11%) and lastly, transfers of funds (2%). The number of these transactions increased 742%, 1,893%, and 475%, respectively, when compared to 2009's figures, partly due to the supply of new mobile banking services by some credit institutions (refer to Figure 2-18).

In contrast to the situation of Internet and mobile phone penetration rates that have increased rapidly in Colombia, the growth of Internet banking services remains stagnant. According to the 2011 report by Columbia Financial Association, 35.7% of all banking transactions were carried out through direct visits to bank branches, followed by ATM use and Internet banking, accounting for 29.4% and 9.9%, respectively. Notably, the portion of mobile banking was lowest of all, at 0.2%. With the generalized belief among the bank user population that Internet banking can very often be slow and sluggish, the growth of online business transactions appears to be delayed to an extent with a growth rate of only 3.3% over the past four years.

Figure 2- 19 | Portion of Colombian financial transactions



Source: KOTRA OIS, 2013, Portion of Colombian financial transactions, http://www.ois.go.kr (overseas investment information system)

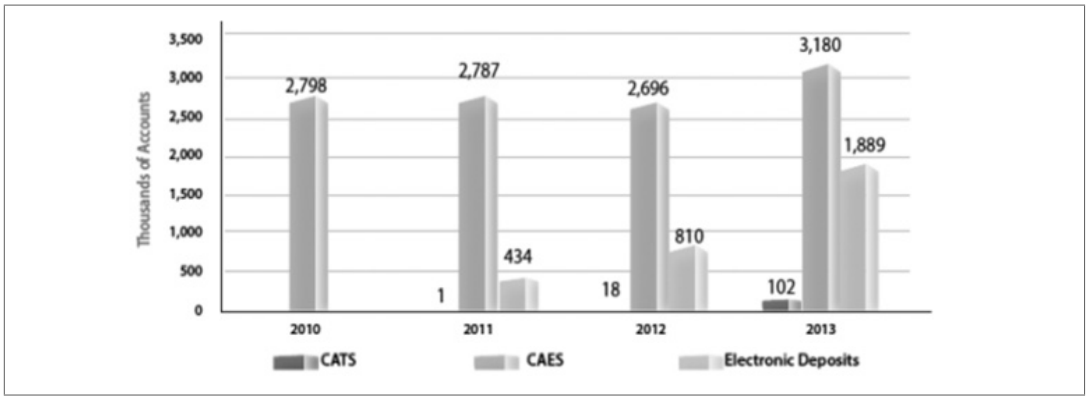
c) Account opening and usage

In the past, it was customary in Colombia that banks opened accounts selectively for people with a certain level of income and credit and, as a result, personal financing was regarded as an exclusive service for the middle and upper classes. Recently, however, as the criteria for opening a bank account has been relaxed, the issuance of credit cards and bank accounts has rapidly increased. Going beyond the general online services of balance checking, account management, remittance banks are now launching additional services, such as the development of derivative products linked to shopping, overseas remittance services, credit card management.

While in 2013 the total number of savings accounts increased to 3.5 million, the number of inactive accounts increased to 3.4 million. In the last two years, the growth of inactive accounts has surpassed the growth of the active ones, which reveals the need for the financial institutions to design innovating savings products or to generate adequate incentives for the financial consumer to

optimize the use of savings accounts.

Figure 2- 20 | Simplified procedure savings accounts (CATS), electronic savings accounts (CAES), and electronic deposits



Source: Gerardo Hernandez Correa and Juliana Alvarez Gallego (Reporte de Inclusión Financiera (Financial inclusion report)), 2014, SFC and BdO (Forms 444), SFC and BdO

The number of CATS (simplified procedure savings accounts) reported by the two banks offering the product increased to 102,000, with growth of 453% compared to 2012, and for CAE (electronic deposits account), the increase was 133%, reaching 1.9 million accounts. An important part of this growth is explained by the assistance provided through the government program "Mas Familias en Accion", managed by the Department for Social Prosperity (Departamento de Prosperidad Social in Spanish).

This program also has influence on the performance of electronic savings accounts (CAE, in Spanish), which increased to 2.8 million, equivalent to an annual growth of 16%. CAEs follow the performance trend of all the savings accounts because 42% of them have been inactive since December 2012. The above result has been influenced by the fact that new persons joined the "Mas Familias en Accion" program, and some of the people who had already joined left it because they had not fulfilled the established conditions. In the latter case, when the people left the "Mas Familias en Accion" program, they stopped using the accounts.

d) Status of Internet users in Colombia

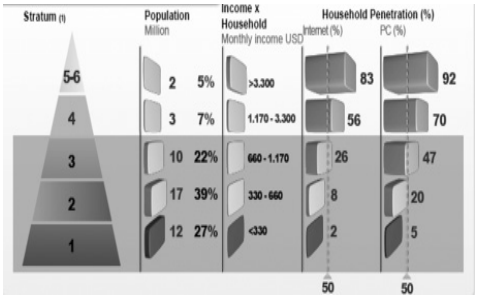
Internet is a channel which grows significantly recently. It shows the importance of banking services using the ICT. This is because Internet banking and mobile banking can increase the use of financial products and financial services. But Internet use in Colombia has shown an imbalance between user groups.

In the point of individual use, the current population of the low-income bracket (falling under groups 1 and 2 of Estrato) amounts to 29 million, this is more than half of Columbia's total population. Penetration rates for Internet use and PC use for these groups are 10% and 25%, respectively. Meanwhile, the proportion of the population falling under the highest-income bracket (groups 5 and 6) makes up only 5% of the total population, but their penetration rates for Internet

use and PC use are 83% and 92%, respectively, thereby revealing a sharp differential in access to data via the Internet.

Table 2- 15 | Status of Internet usage by Estrato

Estrato	Population		Household Penetration rate (%)	
	Million	(%)	Internet	PC
5-6	2	5	83	92
4	3	7	56	70
3	10	22	26	47
2	17	39	8	20
1	12	27	2	5

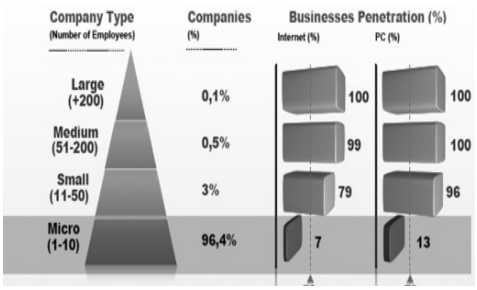


Diego Molano, 2014, Vive Digital 2014 -2018_engish version, MINTIC, compiled by KSP Consultants

In the case of enterprises, the portion of small enterprises (employing 1~10 workers) amounts to 96.4% of all enterprises in Colombia, but their Internet penetration rate is at the 7% level, which is analyzed to negatively affect the reinforcement of the national growth potential. The most common answers to the question of why these micro enterprises do not use Internet services was 'Because it is not needed in the business,' representing 60.6% of responses, followed by 'Because we have no computers,' and 'Economical reasons', accounting for 17.6% and 12.9% of responses, respectively. Therefore, the Colombian Government plans to extend investment to increase the dissemination of IT to small and micro enterprises, which can be a major factor in reinforcing future growth potential in Colombia, and promoting the IT environment available to these small and micro enterprises (Market Research of 1500 micro and small enterprises in 43 municipalities 2010, Colombia Vive Digital 2014-2018).

Table 2- 16 | Status of Internet penetration rates for business groups

Business group	Portion	Internet penetration rate	PC penetration rate
Large enterprise	0.1	100	100
Medium enterprise	0.5	99	100
Small enterprise	3	79	96
Micro enterprise	96.4	7	13



Diego Molano, 2014, Vive Digital 2014 -2018_engish version, MINTIC, compiled by KSP Consultants

As of June 2013, the average Internet speed in Colombia was 2.505 Mpbs, an increase of only 217 Kpbs over the speed for the 4th quarter of 2012. Though the number of Internet users increased, the improvement of speed was inferior to the increase in number. Thus, it is feared that, henceforth, the communication infrastructure will be saturated and customer complaints will be compounded.

2) Cybercrime in Colombia

The biggest flaw to Internet banking is the issue of security and, at present, Colombian financial institutions are grappling with the arrangement of a system for customer safety in the usage of Internet financial transactions. Colombia uses various techniques (similar to Mexico and Brazil) in preventing Internet financial fraud, and its government has also provided an institutional strategy for financial security. However, the prevention systems in place for each bank, if anything, are noted as factors hampering the increase of demand for Internet banking, thereby requiring improvements for such problems. Actually, certificates, security cards as methods used in Korea, are being applied to some banks in Colombia, and most of the financial transactions are carried out through security questions on ID, passwords, and 5~10 personal items. In addition, in the case where answers do not coincide with the question's initial input value, the connection is interrupted and the customer must take steps to release funds by phone or by visiting the branch. Thus, the customers have no alternative but to prefer handling their services at the ATM or by visiting the bank in person.

a) Cybercrime damage or losses

It was estimated that in Columbia, victims of cybercrime number about 6 million, and investigations showed that about 64% of Colombian adults suffer from damages or losses from cybercrime during their lifetime. In 2013 alone, total damages amounted to about 900 billion pesos (equivalent to KRW 873.466 billion), with the average amount per item at 150,000 pesos. The main targets were mostly male, and about 74% of adults were deemed potential victims of crime (Norton Report, 2014).

According to 2012 statistics released by the Organization of American States (OAS), among its member nations, cybercrime decreased only in Chile and Colombia. While other countries showed increased rates of cybercrime from 8% to 40%, the rate in Chile decreased by 33% vis-à-vis the previous year, while Colombia did not reveal specific numerical values. In the 2012 analysis of cybercrime, the report claimed that cybercrime were committed for initially economic reasons but increasingly, these crimes are also committed to serve political motives (OAS, Symantec, 2014).

b) Smartphone related crime

At present, Colombia's smartphone adoption index is over 100% and the country is experiencing a 'smartphone boom,' thus increasing the threat of crimes related to the use of these devices. Over the past 12 months, 40% of smartphone users were the target of cybercrime related to their phones, which is acknowledged now as the most vulnerable area in cyber security.

At present, as many Colombians use smartphones for personal use and simultaneously for business purposes to gather and save vital company data, the occurrence of smartphone-related crime not

only results in the loss of personal property but also causes severe economic or monetary damage. If smartphone usage for business purposes increases before proper attention is accorded to issues of security, the smartphone environment will become increasingly vulnerable to cybercrime and users will face challenges posed by high levels of risk.

c) Phishing damage

A recent type of phishing in Colombia has emerged where the culprit, pretending to be a police officer, sends an e-mail related to a penalty or fine and, once the victim has opened the mail, steals personal information and data. Across the globe, using this scheme, such information has been stolen from more than 21,000 companies in 80 countries. Though the criminal organization circulating the fraud was arrested, the scheme has resurged in Latin America and each country's police forces have to take special measures to combat this cybercrime known as phishing.

Colombia and Panama are the only countries in Latin America that cope with cybercrime through an established strategy at the state level, but these measures are still not adequate. At present, only 45% of smartphone users in Colombia use basic security programs, and only 51% of tablet PC users use security programs. Therefore, the majority of users are very vulnerable to security. When necessary, after downloading the module through a website, users can configure it to set their smartphones to refuse all commercial messages, and also can submit civil complaints by sending messages to '85432' to prevent cybercrime via their smartphones.

2.4.2 Infrastructure Status of Paraguay

The status of the digital finance infrastructure in Paraguay is as follows.

Table 2- 17 | Infrastructure of digital financial system in Paraguay

Sector	Content
Useful financial education program	• In most households, at least one family member takes classes in personal banking or fund management. • Well-designed financial education programs provide knowledge and techniques for using suitable financial services such as deposit, loan, consumption and risk management.
Legal grounds for consumer protection	• Consumer Protection Act and safeguard of rights through Civil Law are considered far-fetched by many consumers. • BCP draws up regulation for banks and financial companies to enhance comparability of price and fee and to make information public. There is, however, no legal instrument that exists to protect consumers in the current insurance industry. • Operation of Agency (BCP, Resolution 1, Act 70, 2011), Publisher of E-money (Resolution 6, Act 18, 2014) exist but are not well implemented. These include: - Regulations on issues related to consumer protection, such as business practice, transparency, supplier's responsibility, complaints procedure et al. - Regulations for protecting consumers from vague bundling products and vicious credit collection practices.

Sector	Content
Monitoring of supervisory agent	• NCOOP, the supervisory agency of associations, do not have exclusive departments in charge of providing financial consumer protection and financial education. • Laws and regulations do not require banks, financial companies and associations to have proper internal complaints procedures. • Public institutions do not have clear and legal budgets exclusively for providing financial education and for conciliating disputes related to consumer rights. • By December 2016, new measures for financial consumer protection and information sharing shall be established. • Collaborative departmental efforts focused on financial consumer protection will be established among SEDECO, BCP and INCOOP.

Source: assessment of the consultants

1) ICT market status and policies of Paraguay

Along with economic growth, Paraguay's information and communication technology field is continuously growing, but still lags behind other countries in Latin America in terms of its overall infrastructure for communication systems.

The National Commission of Telecommunications of Paraguay (CONATEL) handles all matters related to ICT market supervision and control, and is an independent regulatory agency that was established under the Ministry of Construction and Transport (MOPC) in 1995. CONATEL performs management and control of the overall information and communication business, such as enactment, regulation, and enforcement of national policies related to ICT, issuance of business licenses, control, and supervision of business operators.

2) Communication environment in Paraguay

In Paraguay, COPACO, the national communications company, is the exclusive provider for wire telephone, public telephone, and VoIP services. Due to the country's comparatively inferior wire communications environment, the mobile communications market has developed rapidly and thus, the field of mobile communications is leading the country's overall communications market.

More than 30 companies supply Internet service, the most significant of which are COPACO and TIGO. Mobile communications service is provided by four mobile-service companies, which are TIGO Paraguay (a subsidiary of Millicom International Cellular), PERSONAL (a subsidiary of Telecom Argentina), CLARO Paraguay (a subsidiary of America Movil), and VOX (under the control of COPACO, the national mobile-service company of Paraguay). At present, TIGO takes up 55% of the mobile communications market and its volume is the biggest among mobile-service companies in Paraguay. PERSONAL occupies 30% of the market share, and the remaining two companies, CLARO and VOX, take up 10% and 5%, respectively.

Internet speed in Paraguay is 3.33 Mbps on average, which is very slow in contrast to that of other countries in Latin America.

The status of wire and mobile telephone services in Paraguay is as follows.

Table 2- 18 | Trends of telephone subscribers and penetration rates in Paraguay

(Unit: 1,000 persons, %)

Item	2009	2010	2011	2012	2013	2014
Number of wire telephone subscribers	387	362	368	410	437	371
Penetration rate for wire telephones	6.10	5.62	5.61	6.15	6.43	5.38
Number of mobile telephone subscribers	5,618	5,920	6,529	6,793	7,053	7,305
Penetration rate for mobile telephones	88.52	91.66	99.33	101.59	103.69	105.60

Source: ITU, 2014, World Telecommunication/ ICT Indicators database 2014, ITU

a) Trends in wire communication market

As of 2014, the number of wire telephone subscribers in Paraguay was 371,000 and the penetration rate was at a low level of 5.38%. In 2015, the number of subscribers is expected to be only 345,000 though the penetration rate will decrease to 4.9%, showing a downturn of about 6.7%.

As CONATEL, Paraguay's communications regulatory agency, provides VoIP supply licensing only to COPACO, the national communications business operator, the wire communications market is maintained as a monopoly. As the penetration rate for wire communications is low, growth potential can be assumed to be high. However, because investment in wire communications infrastructure is not implemented smoothly under the monopoly by the national communications company, this can act as the biggest barrier hindering market growth.

b) Trends in mobile communication market

As of 2014, the number of mobile communications subscribers in Paraguay was 7.305 million and the penetration rate was 105.6%, showing a very high level. In 2015, it is expected that the number of subscribers will approach 7.515 million and the penetration rate will exceed 106%.

The number of subscribers for local communications companies has been fluctuating over the years, though market leaders TIGO and PERSONAL have seen a steady increase since the second half of 2014. The use of diverse marketing strategies offering discount events and introducing various other events, such as mobile number portability (MNP), mobile financial services has helped to considerably increase the number of subscribers, and this trend is expected to continue into 2015.

3) Status of Internet service in Paraguay

As of 2014, the Internet penetration rate was recorded at about 43.1% and is expected to reach 50% by the end of 2015. As the national income per capita in Paraguay is low, the PC penetration rate is also low. However, following the continuous growth of smartphone penetration rates, the number of subscribers and the penetration rate for mobile Internet use are increasing rapidly.

Being a landlocked country, Paraguay uses the method of connecting to Internet networks through neighbouring countries, including Argentina. Therefore, as Paraguay's communications companies have to purchase Internet network services at a higher price (by 50-60%) compared to neighbouring countries, local Internet charges are exorbitantly expensive, considering the backwards infrastructure and slow speed.

Table 2- 19 | Trends of high-speed Internet subscription and penetration rates in Paraguay

(Unit: 1,000 persons, %)

Item		2009	2010	2011	2012	2013	2014
Mobile broadband	subscribers	57	217	287	343	332	252
	penetration rate	0.87	3.33	4.41	5.27	5.10	3.87
3G, 3.5G, GPRS	subscribers	-	-	-	-	-	2,368
	penetration rate	-	-	-	-	-	36.43
Wired Internet	subscribers	74	105	118	137	166	185
	penetration rate	1.13	1.61	1.81	2.10	2.55	2.84

Source: ITU, 2014, World Telecommunication/ ICT Indicators database 2014, ITU

4) Status of mobile financial services (e-money) in Paraguay

For the past three years, the utilization rate of e-money has shown a growth rate of 50% per annum. The use rate of mobile phones in Paraguay is very high, with 104 mobile phone contracts signed for every 100 persons (Statistics of the World Bank, 2015). The volume of e-money use in Paraguay was USD 1.2 billion in 2014, and is increasing every year.

In Paraguay, where accessibility to financial services is inferior, the growth of substitute financial services like e-money can be a strong measure to improve ease of access to the financial market. A few contributing factors for this are as follows: (i) only 29% of adults currently use official financial services; (ii) according to the Central Bank of Paraguay (BCP), in the past year about 1.7 million people (roughly 28% of the population) already used mobile financial services, such as electronic wallet and remittance; and (iii) as mobile financial services are highly accessible compared to other financial services requiring direct visits, people will more readily turn to e-money transactions.

In step with the growth of e-money services, the Government of Paraguay plans to promote the growth of the e-money market and set up many more finance education courses and promotions through the establishment of relevant regulations.

At present, Paraguay owns two mobile financial services (TIGO Money and Billetera PERSONAL), and these services are provided by TIGO and PERSONAL, the two biggest communication companies in Paraguay. Depending on the type of business transaction and Communications Company, commission rates of 3%~5% are charged.

Most mobile financial services are conducted using these methods. The first is using the mobile phone electronic wallet for business transactions through a mobile phone. The second method involves the direct over-the-counter method of visiting an agent from the communications company (regarded as a substitute financial service), for example, conducting a mobile money transaction likes an electronic remittance, simply by presenting an ID card.

Table 2- 20 | Comparison of mobile financial services providers: TIGO Money and Billetera PERSONAL

TIGO Money	Billetera PERSONAL
Began service in 2008 under the name of TIGO Cash	Began service in 2010
Market share: 55%	Market share: 30%
Substitutes as remittance service	Substitutes as remittance service
Cash withdrawal using ATM device	Cash withdrawal using ATM device
Used for settling public utility charges	Used for settling public utility charges
Electronic wallet service	Electronic wallet service
Reimburses mobile phone charges	-nil-
Commission of 3%~5%	Commission of 3%
	Online commission
	Electronic wallet is linked to actual bank account

Source: assessment of the consultants

In terms of legal concerns for e-money services providers, the Central Bank of Paraguay enacted related relevant laws and regulations in June 2014 as users of e-money services increased. Some of these regulations are listed here:

- A mobile phone communications company can expand its business range as a digital finance company (i.e., permitted e-money service supplier) and has the obligation to protect users' proceeds.
- Business transactions should be implemented online in real time; upper limits for the balance amount of the mobile financial account need to be set up.
- Users of electronic accounts can have only one account at each digital finance company, and the amount for each account cannot exceed 2,806,238 Guarani, the equivalent of Paraguay's

minimum wage for 40 days. For cases exceeding the above amount, transactions must be done through a basic checking account at a financial institution, and not through electronic accounts.

- The area for business transactions is restricted to the territory of Paraguay. In cases where remitted amounts are not withdrawn within four days, the amount is to be re-remitted to the remitter through the digital finance company.

The above regulations are instituted to safeguard the interest of online users and serve as a positive move of the government toward supporting financial consumer protection.

2.5. Analysis of Laws and Regulations

2.5.1 Current Status of Laws and Regulations

An analysis of laws and regulations will lead to a better understanding of laws and regulations on consumer protection in digital financial services in LAC countries. The first step of this analysis was to identify the focus of analysis, which included consumer protection, regulatory and organizational systems, scope and details of consumer protection (as defined in relevant laws and regulations), and organizations in charge of consumer protection.

In 2014, the World Bank conducted a Global Survey on Consumer Protection and Financial Literacy. From this survey, the World Bank drew up a legal and regulatory framework focused on financial consumer protection. The summary of results for countries in LAC is shown below.

Table 2- 21 | Law and regulatory framework for financial consumer protection in LAC

Country	General CP law without explicit reference to financial services	CP law with explicit reference to financial services	Separate FCP law	CP regulations within the framework of financial sector legislation	Other FCP law of regulation
Argentina	○	○		○	○
Bolivia				○	○
Brazil		○		○	
Chile	○	○	○	○	
Colombia		○	○	○	○
Costa Rica		○			
Dominica Republic	○			○	○
Ecuador	○		○	○	
El Salvador		○		○	

Country	General CP law without explicit reference to financial services	CP law with explicit reference to financial services	Separate FCP law	CP regulations within the framework of financial sector legislation	Other FCP law of regulation
Guatemala	○				
Honduras		○		○	
Jamaica	○			○	○
Mexico	○	○	○	○	○
Nicaragua	○			○	
Panama	○			○	○
Paraguay	○				
Peru	○	○	○	○	○
Uruguay	○		○	○	
Venezuela, RB	○			○	

Source: World Bank, 2014, Global Survey on Consumer Protection and Financial Literacy, World Bank

As shown in the above table, the majority of LAC countries have legislated consumer protection laws or Articles for consumer protection as part of the laws and regulations in the financial sector.

In comparison with other LAC countries, Colombia has laws and regulations for consumer protection in the financial sector. Paraguay, on the other hand, has only laws and regulations for general consumer protection, and the financial sector may utilize these as well for their own dealings. Hence, it is interesting to compare Columbia and Paraguay based on differences in emphasis on and provision of financial consumer protection laws and regulations.

2.5.2 Development of laws and regulations on financial consumer protection in Columbia

As of 1999, it can be seen that Colombia enacted many laws for data transmission, e-commerce, e-signatures, certifications, security. These include Access and Use of Data Messages, Electronic Commerce and Digital Signatures and Certification (Law 527, 1999) to support the infrastructure for digital financial services. Columbia was a pioneer in these enactments compared to other LAC countries. In 1999, the European Union (EU) applied a two-tiered approach in its technology and came up with guidelines on using a common framework for digital signatures. Colombia also applied and enacted this law in 1999 (Law 527). By 2001, most LAC countries, such as Argentina, Venezuela, Chile, Ecuador, Puerto Rico, Guatemala, Uruguay, and Paraguay have since enacted laws and regulations regarding digital signatures which apply the same technology.

In terms of financial consumer protection, Colombia enacted numerous laws and regulations such as Law 1328 of 2009 (regulated by National Decree 2241 in 2010), Rules on the Financial, Insurance and Stock Market Sectors (Decree 2555, 2010), and Consumer Statute (Law 1480, 2011). Acceptance and use of financial transactions have increased leaps and bounds, from off-line to online, with the emergence and ease of use involving e-money, Internet banking, mobile banking and other digital financial services.

In 2014, the Government of Colombia enacted Specialized Electronic Deposit and Payment Institutions (Law 1735, 2014) to establish specialized public organizations or private companies to be in charge of digital finance transactions and to provide easy access to the financial market's services. As a result of this law, non-financial organizations and companies such as telecommunications companies can also participate in digital financial markets. The government also enacted and amended the Basic Legal Circular (External Circular 007 of 1996, reissued in 029, 2014) and Obligation to Provide Transparent Information to Consumers of Financial Services (Law 1748, 2014) to regulate authorities concerned in their access to information and to improve the transparency of information provided to users of digital finance transactions.

1) Types of laws and regulations

Laws and regulations on financial consumer protection in Colombia include the following: Organic Statute of the Financial System (Decree 663, 1993), Basic Legal Circular (External Circular 007, 1996, reissued in 029, 2014), Access and Use of Data Messages, Electronic Commerce and Digital Signatures, and Certification (Law 527, 1999), Financial Consumer Protection (Law 1328, 2009, Regulated by National Decree 2241, 2010), Rules on the Financial, Insurance and Stock Market Sectors (Decree 2555, 2010), Consumer Statute (Law 1480, 2011), Specialized Electronic Deposit and Payment Institutions (Law 1735, 2014), Obligation to Provide Transparent Information to consumers of Financial Services (Law 1748, 2014).

The main contents regarding financial consumer protection in the above laws and regulations are shown on the next page.

Table 2- 22 | Laws and regulations on financial as well as digital financial consumer protection in Colombia

Classification	Laws and Regulations	Summary
Financial Consumer Protection	Consumer Statute (Law 1480, 2011)	• Definition of authority and tasks regarding consumer protection of the Financial Superintendence of Colombia (Superintendencia Financiera de Colombia, SFC), which is responsible for management and supervision of consumer protection • Definition of security methods to protect consumer information and transaction in e-commerce
	Financial Consumer Protection (Law 1328, 2009, Regulated by National Decree 2241, 2010)	• Definition of scope and principle of financial consumer protection • Definition of roles and responsibilities for consumers, SFC, financial institutions • Definition of financial consumer protection systems, scope of financial consumer information, procedure for complaint resolution, punishments • Before this law was enacted, regulations regarding consumer protection defined in the Organic Statute of the Financial System (Decree 663, 1993) had been applied for financial consumer protection
	Financial Data Privacy (Law 1266, 2008)	• This law controls the collection, use, and transmission of personal information regarding financial debt in order to use financial transactions, credit transactions, and bank services. • Appointment of data protection agencies—the SFC and SIC (Superintendence of Industry and Commerce) • The above agencies have to appoint security systems and the person in charge of security for the stability, accuracy, and protection of the data
	Rules on the Financial, Insurance, and Stock Market Sectors (Decree 2555, 2010)	• Definition of scope, authority, roles, and responsibilities, procedures for registration, resolution, and method of result disclosure regarding the ombudsman system • Definition of roles and responsibilities of the Directorate of Financial Consumer Protection regarding financial consumer protection
	Obligation to Provide Transparent Information to Consumers of Financial Services (Law 1748, 2014)	• Statement of regulations that should protect not only general financial information and personal information, but also pension information regarding financial consumer protection • Statement of regulations that all information has to be provided to the consumers transparently
	Organic Statute of the Financial System (Decree 663,1993)	• Definition of the roles and responsibilities of financial service providers, scope of public information, service information provided to financial service users, competition rules, provision of correct information regarding consumer protection and advertisement rules as the basic law for the finance system in Colombia
	Basic Legal Circular (External Circular 007, 1996, Reissued in 029, 2014)	• Definition of regulations to access and utilize financial consumer information

Classification	Laws and Regulations	Summary
Digital Financial Consumer Protection	Access and Use of Data Messages, Electronic Commerce and Digital Signatures, and Certification (Law 527, 1999)	• Definition of application scope, technology, and legal bindings regarding data exchange, e-commerce, digital signatures, certification, and security as the law introducing the infrastructure for digital financial services • Definition of the procedure of management and supervision, function, and restrictions regarding digital financial services
	Specialized Electronic Deposit and Payment Institutions (Law 1735, 2014)	• Statement of regulations allowing non-financial institutions, such as telecommunication companies to provide digital financial services as the specialized law for the establishment of organizations and companies providing digital financial services such as electronic deposits, and electronic payments • Statement of regulations for digital financial information to be protected by the Financial Consumer Protection Law when digital financial services are provided
	Financial Superintendence of Colombia External Circular (SFC External Circular 042, 2012)	• Statement of the qualifications of the person in charge of security and the security system for the management of consumer information by the financial institutions' service channels • Statement of regulations for all agencies (except some specialized agencies) to be supervised by the SFC in Colombia when they utilize personal information • Statement of regulations for the security and eligibility of digital financial services
Other Relevant Laws and Regulations	Personal Data Protection (Law 1581, 2012)	• Definition of the scope of personal data (information), procedures for the collection and use of personal data and management method as the law for personal data protection • According to the law, personal data is clearly related to the person or is able to identify one's identity • Statement of regulations that must be followed when personal data is collected, utilized, or transmitted • Statement of regulations for the national database registration agency, which is managed by the SIC, to establish for the management and operation of all public databases which are used for public services

Source: Government Website of Colombia, Reports published by MDBs; data compiled by KSP Consultants

In addition to the above laws and regulations, applicable details to the regulatory framework regarding financial consumer protection in Colombia among the regulatory framework classifications on the report 'Global Survey on Consumer Protection and Financial Literacy' which is announced by World Bank are shown as below.

Table 2- 23 | Regulatory framework for financial consumer protection in Colombia

Classification		Application
Institutional Structure for Consumer Protection (CP) Supervision	CP supervision falls under a single supervisory agency	○
	CP supervision falls under multiple agencies	
	CP supervisory responsibilities fall under a single agency dedicated to broader financial services market sector that conducts supervision	
	CP supervisory responsibilities fall under a single specialized FCP agency that does not have broader financial services market sector that conducts supervisory responsibilities	
	CP responsibilities fall under an agency or agencies responsible for broader CP supervision	
Supervisory Resources	Agency is responsible for implementing any aspect of FCP laws	○
	Agency has a designated unit to work on FCP as part of prudential supervision	○
	Agency has a designated unit to work on FCP separate from prudential supervision	○
	Agency is responsible for FCP, but no separate unit exists	
Compliance Monitoring Tools	Financial institutions (FIs) are required to report statistics on the number of complaints to the agency	○
	FIs are required to report rates and fees for financial services, which are then posted on the agency website	○
	To ensure compliance, agency operates a hotline/call center to receive complaints	
	Responsible agency ensures compliance by monitoring the market, including advertisements and websites	○
	Mystery/incognito shopping	
	Interviews, focus groups, and research with consumers carried out to ensure compliance	
	On-site inspection and investigations of FIs to ensure compliance	○
	Off-site inspection and investigations of FIs to ensure compliance	○
Agency Action in Relation to Complaints	Register/record complaints	○
	Respond to complaints	○
	Analyze/publish complaint statistics	○
	Assist directly in resolution of complaints	○
	Assist indirectly in resolution of complaints	○
	Make binding decisions for any parties involved	○

Classification		Application
Enforcement Actions	Issue warnings to FIs	○
	Require providers to refund excess charges	○
	Requiring providers to withdraw misleading advertisements	○
	Impose fines and penalties	○
	Issue public notices of violations	
	Withdraw offending provider's license to operate	○

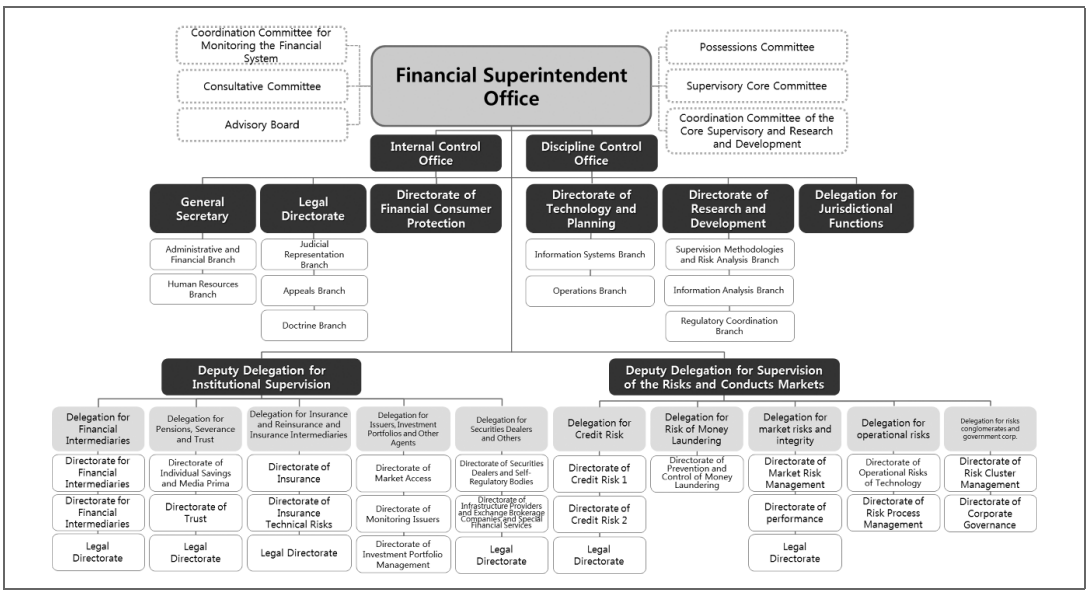
Source: World Bank, 2014, Global Survey on Consumer Protection and Financial Literacy, World Bank

2) Agency for consumer protection supervision

The Financial Superintendence of Colombia (Superintendencia Financiera de Colombia, SFC), under the Ministry of Finance and Public Credit (Ministerio de Hacienda y Crédito Público, MinHacienda), is in charge of the management and supervision of financial consumer protection as the single supervisory agency in Colombia.

The SFC was established in 2005 by consolidating the Bank Supervisory Agency and Stock Supervisory Agency to secure the stability, security, and reliability of the financial system, to protect the investors, depositors, and assurers of the financial market, and to improve the protection system in financial services in Colombia.

Figure 2- 21 | Organizational structure of Financial Superintendence of Colombia



Source: Financial Superintendence of Colombia Homepage (https://www.superfinanciera.gov.co)

The SFC comprises 10 core directorates such as Internal Control Office, Discipline Control Office, General Secretary, Legal Directorate, Directorate of Financial Consumer Protection, Directorate of Technology and Planning, Directorate of Research and Development, Delegation for Jurisdictional Functions, Deputy Delegation for Institutional Supervision, Deputy Delegation for Supervision of the Risks and Conducts Markets. These parties are responsible for supervising financial activities, preventing illegal financial activities, and protecting financial consumers. They are also responsible for the monitoring, review, and control of the people in charge of management, utilization, and investment in financial activities, the stock exchange, insurance, and financial resources.

The organizational structure and responsibilities of each directorate are shown below.

Table 2- 24 | Responsibilities of each directorate of financial superintendence of Colombia

Directorate	Responsibility
Internal Control Office	• Internal audit of SFC • Recommendation of improvement opportunities and continuous management and monitoring after the analysis of internal risks
Discipline Control Office	• Management of regulations regarding business process • Education and training staffs, evaluation of performance of education and training • Disciplinary action when the internal issues are occurred
General Secretary	• Administrative services and management regarding financial services, management of human resources, and management of contracts • Collecting the annual budget of each financial institution
Legal Directorate	• Establishment of standardization plan of the laws and regulations regarding the supervision of financial activities • Publication and public relations of the laws and regulations regarding the supervision of financial activities • Resolution of financial consumers' complaints regarding the relevant laws and regulations
Directorate of Financial Consumer Protection	• Resolution of financial consumers' complaints regarding financial consumer protection from the financial supervisor • Recommendation and adjustment for the application of the financial consumer protection system and the relevant policies • Suggestion and monitoring the guideline for the financial supervision to the financial institutions
Directorate of Technology and Planning	• Plan, conduction, and adjustment of ICT projects of the financial institutions • Securing the continuity of maintenance, and confirmation of the application of standardization of the information systems regarding financial services • Suggestion and management of the platform to supervise the information systems
Directorate of Research and Development	• Approval of analysis reports and risk factors regarding financial institutions • Research the regulatory framework for the supervision of financial activities • Approval of monitoring methodology and process of financial activities

Directorate	Responsibility
Delegation for Jurisdictional Functions	• Management and control of the jurisdictional authorities of SFC • Publication of execution of financial supervision, and establishment of the relevant policies • Establishment of the competition scope of financial institutions and its application • Establishment of the applicable regulations for the prevention and protection of issues which are able to occurred in financial markets
Deputy Delegation for Institutional Supervision	• Management of pension, retirement allowance, credit rating, insurance company, investment portfolio, other agencies
Deputy Delegation for Supervision of the Risks and Conducts Markets	• Supervision of credit risk of financial consumers, risk of financial markets, and management risk of financial institutions • Prevention of money laundry of private companies and supervision of management risk of private companies

Source: Recomposed by the KSP consultants based on the contents on Financial Superintendence of Colombia Homepage

Specifically, the SFC has a directorate to exercise its jurisdictional functions. It can resolve financial consumers' complaints which are considered unresolvable by the financial institutes by utilizing its authority. This regulation has been executed since 2012 and its efficiency has been proven by its successful operations as of today. If this regulation is applied for the resolution of financial complaints, the complaints will usually be resolved within 3 months. On the other hand, it will take at least 2 years to resolve the complaints if it goes to trial according to the law.

Moreover, the SFC has 6 committees which include Coordination Committee for Monitoring the Financial System, Consultative Committee, Advisory Board, Possessions Committee, Supervisory Core Committee, and Coordination Committee of the Core Supervisory and Research and Development. These committees function under the chief of the SFC and have roles in monitoring the financial system in Colombia, consultation for the supervision of financial system, tax assessment, sustainable research and development of financial system in Colombia.

Although consumer protection in financial services is overseen by the SFC, consumer protection for industries and commerce is controlled by the Superintendence of Industry and Commerce (Superintendencia de Industria y Comercio, or SIC), which is under the Ministry of Commerce, Industry and Tourism (MinCIT). The SIC is an autonomous financial and administrational agency. It is the only data protection agency responsible for the supervision of regulations on principles, authorities, and procedures, as stated in the Personal Data Protection Law for industrial and commercial transactions. The main responsibilities of the SIC involve consumer protection in the commercial sector, competition protection, industrial property, personal data protection, checks and management of technical regulations, as well as legal weight, legal problems.

2.5.3 Development of laws and regulations in Paraguay

Paraguay enacted and applied the Civil Code (Law 1183, 1985) for its laws and regulations for consumer protection, and General Banking, Financial and Other Credit Institutions (Law 861, 1996) and Consumer Protection (Law 1334, 1998) for financial consumer protection.

After the enactment and application of the above laws and regulations, Paraguay introduced and applied these laws to its digital financial services, consequently enacting the law on Electronic Signature and Contracts (Law 4017, 2010, as amended by Law 4610, 2012). In addition, the law on Electronic Commerce (Law 4868, 2013) was enacted for electronic commerce to provide definitions and regulations regarding consumer protection, including consumer information on goods and service transactions as the obligation of the providers via trade and e-procurement.

Recently, the Central Bank of Paraguay (Banco Central del Paraguay, BCP) selected and adopted Non-Bank Agents Resolution (Resolution 1, Act 70, 2011), Payment Systems Resolution (Resolution 1, Act 67, 2012), and E-Money Resolution (Resolution 6, Act 18, 2014) as regulations used by bank agents for simple tasks, payment systems, and digital financial services (including e-money). According to these resolutions, all agencies that issue e-money in Paraguay have to be approved as e-money issuance agencies, and to have been issued a license for the issuance of e-money (Entidad de Medio de Pago Electrónico, EMPE) by the BCP since September 2015. EMPEs are managed and supervised by the BCP.

1) Types of laws and regulations

In Paraguay, the basic law used to safeguard consumer protection in financial as well as digital financial services is the Civil Code (Law 1183, 1985). In addition to the Civil Code, there are laws in the Constitution (Political Constitution, 1992), General Banking, Financial and Other Credit Institutions (Law 861, 1996), Consumer Protection (Law 1334, 1998), Electronic Signatures and Contracts (Law 4017, 2010, amended by Law 4610, 2012), Electronic Commerce (Law 4868, 2013), Non-Bank Agents Resolution (Resolution 1, Act 70, 2011), Payment Systems Resolution (Resolution 1, Act 67, 2012), and E-Money Resolution (Resolution 6, Act 18, 2014), as laws and regulations on consumer protection in financial services.

The main contents regarding financial consumer protection in the above laws and regulations are shown on the next page.

Table 2- 25 | Laws and regulations on financial and digital financial consumer protection in Paraguay

Classification	Laws and Regulations	Summary
Financial Consumer Protection	Civil Code (Law 1183, 1985)	• Definition of obligations for financial institutions to provide a certificate of payment or receipt for consumer protection in financial transactions, as per the Civil Code • Definition of the forbidden clauses and criteria for contract termination regarding contracts other than financial transactions
Financial Consumer Protection	Consumer Protection (Law 1334, 1998)	• Definition of the standard of rights to protect consumers' economic benefits • Statement of forbidden clauses and contract termination clauses, obligations regarding the commercial transaction of goods and services between providers and consumers
	General Banking, Financial and Other Credit Institutions (Law 861, 1996)	• Definition of authority, obligation and guarantee, requirement of the financial system • Statement of the obligations for financial institutions to provide the financial information to the Banking Superintendence under the Central Bank of Paraguay (BCP-SIB) in order to conduct tracking and supervision of the financial system, periodically • Definition of the obligations, roles, and responsibilities regarding financial consumer protection of BCP-SIB
Digital Financial Consumer Protection	Electronic Commerce (Law 4868, 2013)	• Definition of e-Commerce, what consumers are using, and its applicable scope • Statement of the clauses for the protection of transaction records and personal information for digital financial consumer protection
	Electronic Signatures and Contracts (Law 4017, 2010, amended by Law 4610, 2012)	• Definition of the legal effects of electronic signatures and electronic contract forms that are used in digital financial services • Statement that does not need consent from the parties for the use of electronic means when they contract electronically
	Payment Systems Resolution (Resolution 1, Act 67, 2012)	• Statement of clauses regarding the disclosure of information, transparency of the system processing the account information and payment transaction information as the resolution that regulates the technical sector of the payment system in Paraguay • Statement of the legal liability of the digital financial service provider when a cybercrime occurs, such as personal information infringement while the consumers are using digital financial services
	Non-Bank Agents Resolution (Resolution 1, Act 70, 2011)	• Definition of the obligations and legal liability of non-bank agents • Definition of the clauses required to conduct tasks such as the opening of accounts, financial transactions and loans of non-bank agents • Statement of the clauses regarding the transparency of information disclosure, the resolution process for consumer complaints, the protection of the consumers' information, and the regulations on fees of non-bank agents

Classification	Laws and Regulations	Summary
Digital Financial Consumer Protection	E-Money Resolution (Resolution 6, Act 18, 2014)	• Definition of the qualifications of agencies holding an e-money issuance license (EMPE) and their obligations and legal liabilities as the resolution regarding the use of e-money in digital finance • Definition of the protection of deposits and technology for protection regarding e-money • Statement of the essential clauses of the contract to use e-money • Statement of the clauses regarding money transfers from e-money accounts to bank accounts
Other Relevant Laws and Regulations	Constitution (Political Constitution, 1992)	• Statement of the authority of the citizen to access to their personal information

Source: Government Website of Paraguay, Reports published by MDBs; Data compiled by KSP Consultants

In addition to the above laws and regulations, details of a regulatory framework for financial consumer protection in Paraguay, as reported in the World Bank's 2014 report on 'Global Survey on Consumer Protection and Financial Literacy', are shown below.

Table 2- 26 | Regulatory framework of financial consumer protection in Paraguay

Classification		Application
Institutional Structure for CP Supervision	CP supervision falls under a single supervisory agency	
	CP supervision falls under multiple agencies	○
	CP supervision responsibilities fall under a single agency dedicated to broad financial market conduct supervision	
	CP supervision responsibilities fall under a single specialized FCP agency that does not have broader financial sector market conduct supervisory responsibilities	
	CP responsibilities fall under an agency or agencies responsible for broader CP supervision	○
Supervisory Resources	Agency is responsible for implementing any aspect of FCP laws	○
	Agency has a designated unit to work on FCP as part of prudential supervision	
	Agency has a designated unit to work on FCP separate from prudential supervision	
	Agency is responsible for FCP, but no separate unit exists	○
Compliance Monitoring Tools	FIs are required to report statistics on the number of complaints to the agency	
	FIs are required to report rates and fees for financial services, which are posted on the agency website	○

Classification		Application
Compliance Monitoring Tools	To ensure compliance, agency operates a hotline/call center to receive complaints	
	Responsible agency ensures compliance by monitoring the market, including advertisements and websites	
	Mystery/incognito shopping	
	Interviews, focus groups, and research with consumers are carried out to ensure compliance	
	On-site inspection and investigations of FIs to ensure compliance	
	Off-site inspection and investigations of FIs to ensure compliance	
Agency Actions in Relation to Complaints	Register/record complaints	
	Respond to complaints	○
	Analyze/publish complaint statistics	
	Assist directly in resolution of complaints	
	Assist indirectly in resolution of complaints	
	Make binding decisions for any of the parties involved	
Enforcement Actions	Issue warnings to FIs	
	Require providers to refund excess charges	
	Require providers to withdraw misleading advertisements	
	Impose fines and penalties	
	Issue public notices of violations	
	Withdraw offending provider's license to operate	

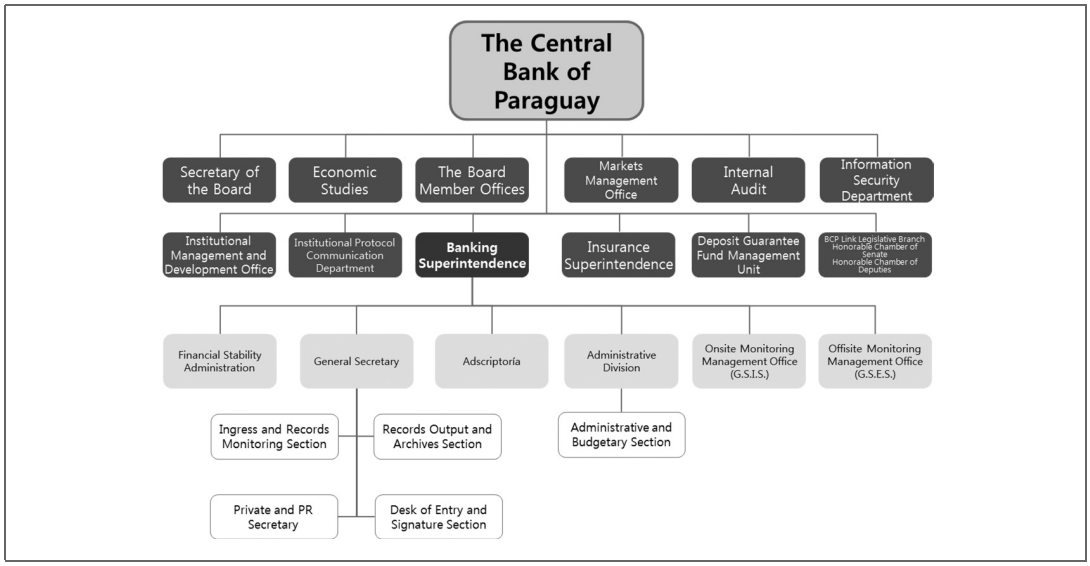
Source: World Bank, 2014, Global Survey on Consumer Protection and Financial Literacy, World Bank

2) Agency for financial consumer protection supervision

The Banking Superintendence (Superintendencia de Bancos, BCP-SIB), under the Central Bank of Paraguay, is in charge of management and supervision of consumer protection in digital financial services as the single supervisory agency in Paraguay.

The BCP-SIB was established as a directorate of the Central Bank of Paraguay in 1952, and was upgraded as the Banking Superintendence of Paraguay in 1995. It is responsible for the supervision of the administrative activities of banks, financial institutes, and other credit institutes as a supervisory agency under the Central Bank of Paraguay. It is also responsible for the supervision on the conformity of laws and regulations regarding taxes for financial institutions, control of the financial system, and decisions on penalties for financial institutions.

Figure 2- 22 | Organizational structure of Central Bank of Paraguay and Banking Superintendence of Paraguay



Source: Banking Superintendence of Paraguay Homepage (http://www.bcp.gov.py)

The BCP-SIB consists of six core directorates, which include Financial Stability Administration, General Secretary, Adscriptoria, Administrative Division, Onsite Monitoring Management Office (GSIS), and Offsite Monitoring Management Office (GSES). The directorates conduct the supervision of financial administrative functions, improvement of financial regulatory framework, and control of credit and transparency. The organizational structure and responsibilities of each directorate are shown below.

Table 2- 27 | Responsibilities of each directorate of banking superintendence of Paraguay

Directorate	Responsibility
Financial Stability Administration	• Monitoring the financial institutions, and guidance for the stabilization of financial systems • Research for the improvement of financial systems • Suggestion for the improvement of laws and regulations regarding the financial systems, institutions, and markets
General Secretary	• Composed of Ingress and Records Monitoring Section, Records Output and Archives Section, Private and PR Secretary, and Desk of Entry and Signature Section • Management of the movement of records and data of BCP-SIB • Management of entrance authority and monitoring the entrance records of the limited areas
Adscriptoria	• Management of relationship with other public organizations, financial institutions, and other relevant organizations • Communication with financial institutions

Directorate	Responsibility
Administrative Division	• Administrative tasks and budgeting of BCP-SIB • Management of internal process and budget of BCP-SIB
Onsite Monitoring Management Office (GSIS)	• Management and supervision of issues of financial institutions by visiting • Decision making and execution of punishment to financial institutions in accordance with the conformity of laws and regulations regarding financial services and taxes
Offsite Monitoring Management Office (GSES)	• Monitoring and supervision of issues of financial institutions by linkage of systems • Supervision of administrative activities of financial institutions and control of transparency of financial institutions

Source: Recomposed by the KSP consultants based on the contents on Banking Superintendence of Paraguay homepage

In addition, there are agencies like CONATEL (Comisión Nacional de Telecomunicaciones), which performs only technical tasks regarding the issuance and confirmation of e-money on telecommunication companies. CONATEL was established by the Electrical Communication Law (Law 642, 1995). Its duties include planning technical and administrative regulations in communication, the management of radio frequencies, development of infrastructure, promotion of new communications technologies, and communications services, and securing fair competition within the communications industry. It also manages telecommunications companies with EMPE and issues the certification of e-money service plans in accordance with the Electrical Communication Law, Article 2.

In addition to the above agencies, there are Secretariat of Consumer Protection (Secretaría de la Defensa del Consumidor, SEDECO) and National Institute of Cooperatives (Instituto Nacional de Cooperativismo, INCOOP) which perform tasks related to supporting consumer protection. SEDECO was established by Law 497 in 2013 and replaced the General Office of Consumer and User Protection, which had been in charge of consumer protection under the Ministry of Industry and Commerce with SEDECO. SEDECO is an independent, autonomous, and decentralized agency, possessing the authority to enforce laws for consumer protection and manage the budget for consumer protection. In addition, it carries out many roles in consumer protection such as the acceptance and resolution of consumer complaints, analysis of consumer infringements regarding goods and services, research on cases of violations to prevent their recurrence, management of consumer organizations, and financial services education for consumers.

INCOOP was established by Law 2157 in 2013. Its duties include securing the stability of cooperatives, continuous research on human resources expansion in the financial sector, and promotion of policies in the public sector. It also establishes and supervises regulations regarding cooperatives, including consumer cooperatives.

2.5.4 Comparison of laws and regulations on digital consumer protection in Colombia and Paraguay

A comparison of laws and regulations on consumer protection in digital financial services between Colombia and Paraguay is conducted to identify differences in legal frameworks of the two countries. The contents for this comparison are classified as personal data protection, consumer protection, and digital financial services. Details of the comparison are shown below.

Table 2- 28 | Comparison of laws and regulations on digital financial consumer protection in Colombia and Paraguay

Classification	Requisite	Colombia	Paraguay
Personal Data Protection	Scope of personal data, authority of access to data, and management agency	Specifically defined	Defined by the Constitution
	Obligation of personal data protection and punishment for violations	Specifically defined	No specific definition
Consumer Protection	Obligation and principle of consumer protection	Specifically defined	Specifically defined
	Rights and obligations of consumer	Specifically defined	Defined by the Civil Code
	Rights and obligations of financial institutions	Specifically defined	Comprehensively defined
	Scope of consumer information	Specifically defined	Defined by the Civil Code
	Method and procedure for complaints resolution	Specifically defined	No specific definition
	Roles and authority of consumer protection supervisory agency	Specifically defined	Specifically defined
Digital Financial Services	Regulations for financial institutions providing digital financial services	Specifically defined	Specifically defined
	Regulations for security in use of digital financial services	Specifically defined	Specifically defined
	Regulations for technology in digital financial services	Specifically defined	Specifically defined

Source: assessment of the consultants

From the table, it can be seen that Colombia has more defined laws and regulations regarding personal data protection, financial consumer protection, and digital financial services, specifically, when compared to Paraguay. In Paraguay, laws and regulations regarding digital financial services has comparatively specifically defined than personal data protection and financial consumer protection. In Paraguay, some aspects of personal data protection and financial consumer protection are defined by the constitution or civil code; other aspects are defined only comprehensively but not

specifically. Especially, personal data protection has defined by the constitution but has no specific definition. Legislation and regulatory action on personal data and financial consumer protection are more strongly reinforced in Columbia than in Paraguay.

1) Agency for consumer protection supervision

The SFC is the single supervising agency for management and supervision regarding financial consumer protection in Colombia. It conducts tasks for financial consumer protection such as reviews, monitoring, and complaint resolution in financial activities through its monitoring of the financial system.

The BCP-SIB is a single supervisory agency for the management and supervision regarding financial consumer protection in Paraguay. BCP-SIB is in charge of monitoring the conformity of laws and regulations in financial institutions, and also supervision of financial administration. In addition to the BCP-SIB, there are three relevant agencies tasked with supporting consumer protection, financial services and digital finance services in Paraguay. CONATEL is in charge of qualifications management for e-money service providers and supervision of e-money. SEDECO is in charge of the protection of consumers' rights, the acceptance and resolution of consumer complaints, and education for financial consumers. Lastly, INCOOP is in charge of the establishment of internal regulations for cooperatives and the supervision of such cooperatives.

III Case Study on Korea's Experience

3.1. Analysis of the Financial Infrastructure

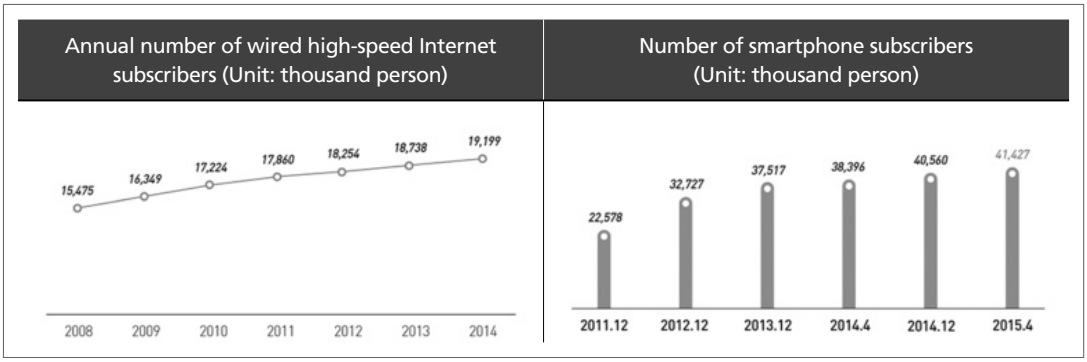
3.1.1 Status of Korea's ICT Development

1) Internet advancement in Korea

Korea's Internet service was first introduced with the implementation of the world's second-connected Internet of SDN (System Development Network) in 1982 and witnessed dramatic growth with the launch of a commercial Internet service from 1994, recording 10 million high-speed Internet connections in 2002. With Korea heading world's standards by providing systems for high data rate mobile services via Wibro and HSDPA services in 2006, this country has stepped up into being globally acknowledged as an Internet powerhouse.

With the current explosive expansion in mobile devices, the paradigm of the Internet industry has indeed transformed around smartphones. This has transformed the era of the mobile Internet, where a large number of mobile Internet services and social network services have emerged.

Figure 3- 1 | Trends in wired high-speed Internet and smartphone subscribers



Source: KISA, 2015, 2015 Korea Internet White Paper, KISA (Korea Internet & Security Agency)

Over the last 30 years, the Internet has brought fundamental changes to overall lifestyle in terms of politics, economy, society, and culture based on the core philosophy of openness and sharing. In

the information age, people can now acquire information and communicate with others anytime, anywhere through the Internet. The Internet, whilst playing such a positive role, presents adverse effects as well. Drawbacks of Internet abuse include dissemination of false information, online financial fraud, data theft, and other risks.

As of December 2014, Korea ranks 4th in terms of wireless high-speed Internet subscription with 53.75 million subscribers and a penetration rate of 106.5% (OECD, 2015), following the USA, Japan, and the U.K. As for wired high-speed Internet subscription, Korea stands at the world's 6th position with a penetration rate of 28.2% with 19.19 million subscribers as of December 2014; this figure is up by 460,000 compared to the same period last year. Compared to other countries, Korea has also a growing penetration of fibre/LAN, leading to the highest quality of high-speed Internet service. As of April 2015, Korea's smartphone subscribers stand at 40,560,311 according to statistical records of the Ministry of Science, ICT, and Future Planning.

International Information Indices currently ranks Korea number 2 in the ICT Development Index, number 1 in the UN e-Government Development Index, number 1 in the e-Participation Index, and number 10 in terms of Network Readiness Index.

Table 3- 1 | Korea's ranking in international information indices

(Unit: ranking/number of countries)

[Organization] Index name	PurPOSe of index	Ranking of Korea/ (Total number of countries)				
		2010	2011	2012	2013	2014
[ITU] ICT Development Index	Comprehensive evaluation of each country's ICT accessibility, usage, and utilization capability	1 (159)	1 (152)	1 (155)	1 (157)	2 (166)
[UN] e-Government Development Index	Competency and will to leverage e-government for ICT-led development	1 (192)	-	1 (193)	-	1 (193)
[UN] e-Participation Index	Each country's level of public participation in the public policy-making process through online	1 (192)	-	1 (193)	-	1 (193)
[WEF] Network Readiness Index	Each country's level of leveraging ICT for economic development and competitiveness	15 (133)	10 (138)	12 (142)	11 (144)	10 (148)

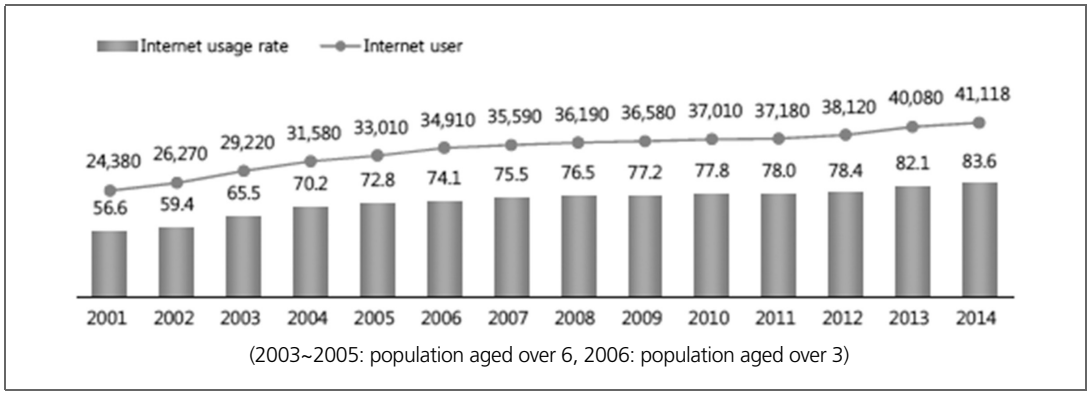
Source: a) ICT Development Index: ITU, 2015, measuring the information society report 2015, ITU
b) e-Government Development Index/ e-Participation Index (biannual): UN, 2014, United Nations e-Government Survey 2014, UN
c) Network Readiness Index: WEF, 2014, the global information technology report, WEF

As of July 2014, Internet usage rate of the population aged 3 and above (the rate of Internet users within the recent 1 month) is recorded at 83.6%, up by 1.5%p year-over-year and up by 13.4%p for

the past decade. These increases are due to the spread of high-speed Internet for users of all ages. The number of Internet users stands at 41,118 thousand (up by 1,038 thousand year-over-year), which is a three-fold increase of 9,538 thousand users over the past decade (KISA, 2014).

Figure 3- 2 | Development trends in Internet usage rates and Internet users

(Unit: %,thousand persons)

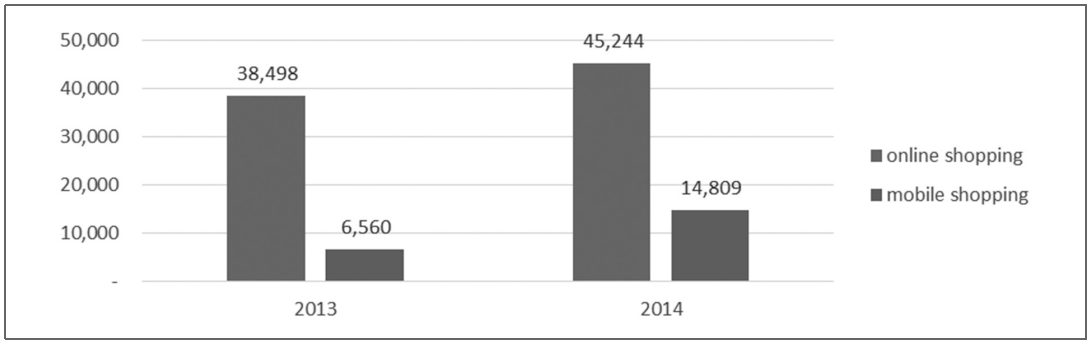


Source: KISA, 2014, Survey on Survey on the Use of Internet, KISA (Korea Internet & Security Agency)

2) Online shopping

Figure 3- 3 | Trends in online shopping and mobile shopping

(Unit: billion KRW)



Source: Statistics Korea, 2015, 2014 online shopping trend, Statistics Korea

The volume of online shopping transactions recorded was 45.244 trillion KRW in 2014, up by 17.5% year-over-year [Figure 3-3]. By comparison, the volume of mobile shopping transactions recorded was 14.8 trillion KRW, up by 125.8% year-over-year. The proportion of mobile shopping transaction amount against that of online shopping increased by 15.7% from 2013. Compared to the same period last year, by category, reservation services (8.412 trillion KRW) increased by 31.1% year-over-year, cosmetics (2.664 trillion KRW) by 26.8%, lifestyle and automobile accessories (5.174 trillion KRW) by 20.9%, and electronic, electrical and communications devices (4.922 trillion KRW) by 19.9%. In terms of transaction volume by merchandise products, comprehensive malls (34.777 trillion

KRW) went up by 16.6% while specialty malls (10.467 trillion KRW) went up by 20.5%. Trends show that for online commerce, shopping malls with specialty experienced a more rapid growth rate.

3) Internet banking in Korea

Internet banking is a system where users can execute banking transactions over the computer network. With an Internet connection, users can perform anytime and anywhere various banking transactions such as remittance, checking deposit/withdrawal details, creation of bank accounts, automatic transfer, and loans through personal verification process. To use the Internet banking service, one must first submit a request for the service in offline bank branches, create an authentication certificate for security purposes, and have one's password registered.

Korea's Internet banking began as a joint move between Korea's IT service providers and three banks - Shinhan Bank, Housing & Commercial Bank, and Hanmi Bank - in July 1999. At that time, Internet banking services were provided by conventional banks, not by Internet-only banks. The adoption of Internet banking in Korea was very rapid; all Korean banks started providing the service within the first year of its introduction to the Korea's financial market. The initial focus was on account transfers and inquiry functions, which largely replaced the manual work processes performed by bank tellers.

From Internet banking service providers' perspective, by adopting Internet banking service, banks were able to save costs on many aspects and redirect the savings for new marketing channels. When compared to paying salaries of bank tellers, the cost of service provision via Internet was smaller. Considering the characteristics of Korea's payment settlement service which mainly dealt with checks and promissory notes, Internet banking was able to significantly reduce the workload of branch tellers at banks. This was compounded by the fact that during the financial restructuring between 1997 and 1999, competition among banks intensified, thus further driving banks to be more profit-oriented. This situation played a role in the expansion of Internet banking in Korea.

From the service consumers' perspective, Internet banking is seen to significantly reduce the financial cost for using banking service. By enhancing banking service accessibility, this greatly increases convenience as well for banking service users. In sum, Korea's advanced information infrastructure, Korean people's tech-savvy nature, and credibility in Korean banks' Internet banking service are strong contributing factors for widespread use and acceptance of Internet banking service.

Statistics compiled in June 2015 show Internet banking (including mobile banking) customer registrations at 18 financial institutions stand at 113.27 million, which was an increase of 4.3 %(4.62 million) from the previous quarter's (186.1 million) [Table 3-2]. This figure includes redundancy or double count, i.e., the same person with multiple Internet baking accounts is counted more than once.

Table 3- 2 | Number of Internet banking users in financial institutions

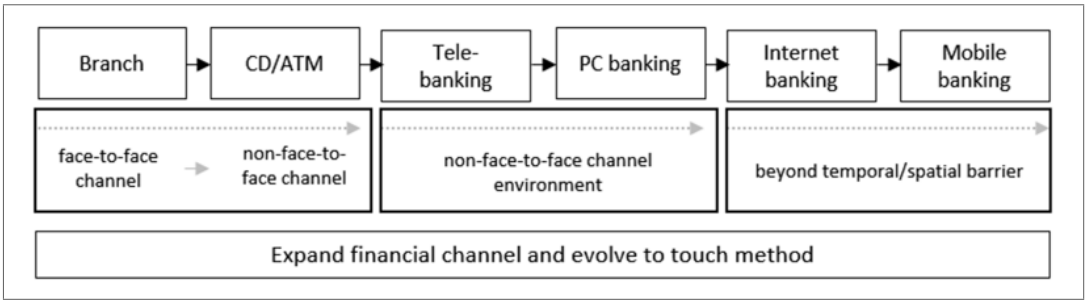
(Unit: thousand persons, increasing rate, %)

Type of User	2014		2015		2015	
	1/4	2/4	3/4	4/4	1/4	2/4
Individuals	91,914	93,472	94,903	96,825	102,056	106,546
	(2.4)	(1.7)	(1.5)	(2.0)	(5.4)	(4.4)
Enterprise	5,831	6,018	6,196	6,363	6,553	6,727
	(2.2)	(3.2)	(3.0)	(2.7)	(3.0)	(2.7)
Total	97,745	99,490	101,099	103,188	108,609	113,273
	(2.4)	(1.8)	(1.6)	(2.1)	(5.3)	(4.3)

Source: Bank of Korea Statistics, 2015, Data compiled by KSP Consultants

According to annual statistics on Internet banking and electronic payment services published by the Bank of Korea, the volume of Internet banking increased from 1.1 trillion KRW in daily transaction amount in 2000 to 33 trillion KRW in 2013. As for electronic payment service, the volume increased from 2007's 4.3 billion KRW in average daily amount to over 20.5 billion KRW in 2013. Trends indicate a sharp increase of the volume of digital finance usage over the last decade.

Figure 3- 4 | Expansion of financial banking channels



Source: assessment of the consultants

In Korea, owing to the advancement of IT technology and Internet growth, customer contact channels are evolving from brick and mortar offline branches to non-face-to-face channels such as CD/ATM, tele-banking, Internet banking, and mobile banking. In particular, a time and space barrier of conducting financial transactions is lower, while the diversity and expandability of financial transaction channels increase, spearheaded by mobile banking. These trends are shown in [Figure 3- 4].

The World Bank at the end of 2011 placed Korea as number 1 in terms of ATM installations. Figures were 282 per 100 thousand adults, which was far ahead of Europe (93), North America (207), and OECD countries (90). Financial institutions in Korea, in an attempt to enhance business efficiency

and customer service level, greatly increased the number of unmanned automation branches, thus opening the era of unmanned branch. As of 2013, there were 39,451 units of CD machines and 84,785 units of ATM machines installed, totalling 124,236 ATM machines. Initially, the use of ATM machines was mainly for the withdrawal of small-amount cash. Over time, credit card payments, Internet banking and smartphone banking took over the functions of ATMs, and this prompted some banks to either reduce the number of ATMs or integrate branches and ATMs while promoting their online banking services (Korea Bizwire, 2015).

Korea's Internet banking system currently relies on its own unique security standard called ActiveX plug-ins. Users have to install ActiveX plug-in program to access the Internet banking service. There are user complaints that the program lacks interoperability with other OS and web browsers and thus reduces user convenience. There are current efforts to establish a system that can replace ActiveX.

4) Mobile banking in Korea

Beginning with the introduction of text message-based mobile banking by NH and Hanmi Bank in 1999, developments in the communications technology have led to innovative methods for mobile banking. This can be seen in the adoption of financial chip method by Kookmin Bank in 2003, mobile VM banking without the use of financial chip by Woori Bank in 2007, USIM cash card service common to the financial industry in 2008, and smartphone banking by Hana Bank in 2009. In addition, the mobile financial service provided by NH Bank offers specialized facilities that provide useful information such as agricultural distribution information, weekend farmland, and enables payment of utility bills (local government tax, utility bill, phone bill, tuition fee, etc.).

Table 3- 3 | Growth of mobile banking users

(Unit: thousand persons/increasing rate %)

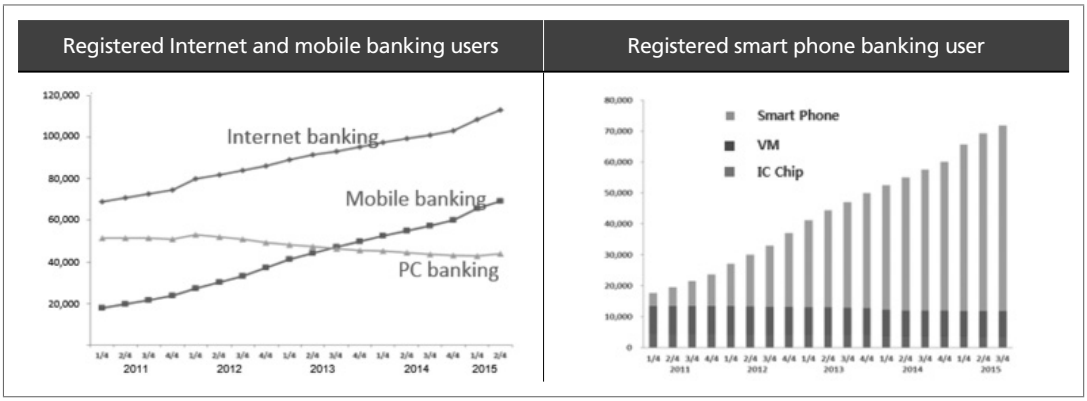
Mobile Type	2014				2015	
	1/4	2/4	3/4	4/4	1/4	2/4
Smart phone based	40,342	42,977	45,593	48,203	53,871	57,524
	(8.5)	(6.5)	(6.1)	(5.7)	(11.8)	(6.8)
IC Chip based	3,843	3,684	3,675	3,645	3,641	3,630
	(-11.2)	(-4.1)	(-0.2)	(-0.8)	(-0.1)	(-0.3)
VM based	8,367	8,327	8,291	8,260	8,213	8,200
	(-0.6)	(-0.5)	(-0.4)	(-0.4)	(-0.6)	(-0.2)
Total	52,552	54,988	57,559	60,107	65,726	69,355
	(5.2)	(4.6)	(4.7)	(4.4)	(9.3)	(5.5)

Source: Bank of Korea Statistics, 2015, Data compiled by KSP Consultants

As of 2Q of 2015, registered mobile banking customers stand at 69.36 million (redundancy accepted in case the same person has multiple accounts), which is an increase of 5.5% (3.63 million) from the previous quarter's 65.73 million. The number of registered smartphone-based mobile banking customers stands at 57.52 million, an increase of 6.8% from the previous quarter, leading the overall growth [Table 3-3].

Figure 3- 5 | Trends of Internet banking and mobile banking users

(Unit: million people)



Source: Bank of Korea, Statistics, 2015, Data compiled by KSP Consultants

The following table, [Figure 3-5], shows a comparison between registered users for Internet banking and mobile banking. The rate of mobile banking users (61.2%) has increased while the number of registered Internet banking users has decreased since 2012.

With the introduction of smartphones, the number of mobile banking users using 2G phones has decreased sharply. Because this first generation mobile banking is more prone to crimes like hacking, its uses are now taken over by Internet and smartphone banking. Owners of 2G phones currently account for a mere 1 percent of the total mobile banking users. At the same time, PC-based Internet banking is on the decline, whereas the proportion of mobile banking is on a dramatic increase, leading to the number of registered mobile banking customers exceeding that of PC banking customers from 2013 onward.

There are numerous success factors accounting for Korea's mobile banking services. The first factor is awareness of service benefit. Owing to proactive marketing activities by banks, customers are made increasingly aware of various benefits and convenience of mobile banking services, thus leading to more users signing up for these services. The second factor relates to mobile banking services' ease of use and convenience. Many mobile banking services are established with customer centricity as priority. By simplifying procedures such as mobile banking subscription, transaction handling and mobile banking site access, service providers have positively improved user convenience. The third reason for high usage of these services is the high credibility associated with mobile banking. The system's focus during establishment is primarily to enhance customer security by putting regulations and checks in place so that a customer's personal data privacy and

confidentiality of customer's transaction details are strictly maintained. The fourth factor is related to cost-benefit consideration, where bank customers feel the low commission fee charged for using mobile banking services is reasonable considering the many benefits of user convenience, variety of services offered, and reliability. The last success factor has to do with usability; the user interface is designed and provisioned from customers' standpoints and needs. Many banks' mobile service providers strategically segmentalize their customer base so that certain mobile banking services can be specially tailored to suit certain customers' requirements or demands.

The impact of introducing mobile banking lies in providing a variety of financial services to customers, supporting various digital finance channels among financial institutions, and offering telecommunications service providers' profits through convergence of finance and telecommunications facilities. Furthermore, by automating banking business, introduction of these services enables banks to induce new customers, retain current ones and reduce operation costs, thus sharpening their competitive edge in many aspects. The extended transaction hours that come with mobile banking provisions also give financial institutions greater profit margins. Unlike Internet banking that mandates the user of computers mobile banking requires only smartphones and Internet connection, so the time and effort taken to complete a financial transaction is seen as greatly efficient and worthwhile.

From the financial institutions' viewpoint, mobile banking services enable them to develop various and unique contents to satisfy customers' requirements to obtain greater customer base. This serves as a means of strengthening competitiveness against other financial institutions.

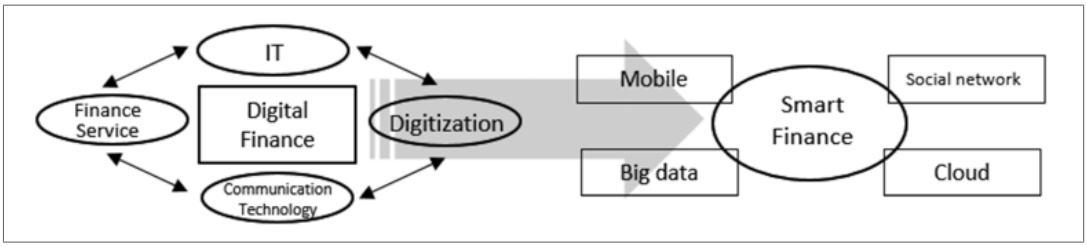
3.1.2 Status of Digital Finance

1) Overview

Digital finance services are aimed at automating and digitizing the banking business by convergence with information and communication technologies to provide financial services and payment settlement functions via a digitized media. PC-based banking such as home banking, company banking and phone-based banking using one's telephone were main means of the digital finance but are today replaced by various new digital finance services. These new services utilize varied information processing technologies and communication technologies, allowing the use of banking service to operate efficiently without time or space barriers.

Digital finance is evolving into smart finance which targets social networks via mobile devices. These services are strengthened or supported by big data and cloud services, as can be seen from [Figure 3- 6] on the next page.

Figure 3- 6 | Development from digital finance to smart finance



Source: Bank of Korea (lecture), 2014, financial trends that change the world, Bank of Korea

Communication technologies associated with the digital finance include wireless communication, Internet, high-speed communication network and digital finance technologies such as IC (integrated circuit) chip, electronic commerce technology, cryptography, and virtualization technology.

All these technologies are radically changing the landscape of digital finance. Some features and uses of these technologies are mentioned here:

- IC chips have much larger memory capacity than magnetic stripes. They can be used for various digital finance-related purposes as they also have the calculation capability. They are commonly used to secure e-payments such as credit cards, debit cards, and e-cash, to verify the user who is accessing the financial transaction via communication network, and to encrypt the financial information during transactions.
- In e-commerce, commercial transactions such as advertisement, order receiving and placing, and payment settlement take place in a virtual space. It is therefore critical to have secured payment method developed for the virtual space to fulfil e-commerce transactions. Payment methods in the virtual space are credit cards, money transfers between banks and recently, emerging e-cash.
- Cryptography technology guarantees security, the most critical aspect of digital finance. Enhanced security in cryptography technology is pivotal to enabling the development of revolutionary digital finance. Various cryptography technologies are used depending on each nation's policies on Internet banking and smart finance practices.
- Virtualization is an information communication technology to eliminate time and space barriers so that customers can use the service they want anywhere, anytime. This technology is used for a variety of devices, and greatly contributes to the spread of Internet banking.

The emergence of digital finance has changed not only the shape of financial transactions but also the direction for developing the financial industry as a whole. The following are some examples of transformations in the finance industry as a consequence of digital finance development:

- The financial industry went through a transition from teller-based brick-and-mortar business to a digital business, as seen in unmanned branches and rise in Internet banking these days. The industry currently is undergoing transformation to develop its business into a high value, technology intensive, and specialized commercial enterprise.

- Development of IC chip in IC Card gave rise to a revolutionary change to the notion of cash, with a move to more widespread use of e-card and e-cash.
- The concept of financial transactions is transformed from "give-and-take" into "touch-based" one, using computers and other touch-screened devices.
- Sophisticated ICT, semiconductor technology and financial engineering are the driving forces of digital finance these days.

2) Development stages of digital finance

Electronic finance provides financial services in a digital manner via an automated and network-driven financial information network (i.e., an inter-connected network system where financial institutions, individually or jointly, collect, store, search, or transmit information to handle financial operation in a digital manner). This network uses up-to-date computing and information communication technology. The financial information network is made up of different components: the internal network of individual financial institutions, the joint financial network where the individual internal networks are interconnected, the customer service network, and the joint financial network open for customers' use.

Figure 3- 7 | ICT and digital finance service development stages in Korea

ICT development	Computerization	Informatization		Intellectualization	Intelligent
	Main Frame Computing	Personal Computing		Web Computing	Ubiquitous Computing
	host server	PC server		Laptop, mobile phone, smartphone, CD/ATM	smartphone, smart home, smart work, Cloud
	- offline banking	- online banking - phone banking		- Internet banking	- mobile banking - mobile Card
Period	1980	1990	2000	2010	2020
e-banking Service development	Automation	Network	Internet-based Digital Finance Service	Smart Finance	Finance-IT Convergence
	- online system between HQ and branches - CD/ATM, Giro	- Joint payment-network by financial sector(banks, securities, insurance common network)	- Various service channels provided by combining the latest ICT technologies		- Fin Tech industry - Non-financial companies offering digital finance services
			- Internet Banking	- mobile Banking	

Source: assessment of the consultants

Advancement in digital finance can be divided into 5 stages, in line with the history of global IT technology advancement.

The first stage refers to the period prior to the 1980s, when mainly banks and other financial institutions introduced mainframe computing and other work-related computing facilities such as personal computers and printers. Back then, these companies established a communication network to implement an internal information system and network between their HQ and branches for automation of financial transactions. This is a stage when each financial institution built their own internal online network and introduced CD/ATMs and giro system to automate bank slip processing to enhance efficiency of branch tellers' work.

The second stage is in late 1980s, when automated work systems established by individual financial institutions were inter-connected on a financial sector-basis to form a financial network (i.e., joint financial network) to offer a common network service. Customers were able to conduct transactions, which were previously supported only by individual financial institution level, in the common network in a fairly rapid and convenient manner. The common network, while allowing each financial participant to maintain legal and economic independence, achieved cohesiveness in the transaction and settlement functionality. Their functions and roles were able to integrate the entire nation into a daily settlement area and contributed greatly to developing a new payment settlement service.

The third stage is after mid-1990s, when Internet adoption started in Korea and customers increasingly began using personal computers and mobile phones. Each financial institution faced a transformational change of Internet-based digital finance service in which financial transactions can be offered anytime, anywhere. At the same time, however, this was when security breaches were rampant in the non-face-to-face channels. Professional hackers committed fraud of all kinds in the digital finance sector, thus raising the alarm on the credibility and security of the digital finance industry. Furthermore, this was an era when many countries developed new electronically payable methods such as e-cash to substitute cash in daily lives; e-cash was at this time regarded readily as a payment method in e-commerce.

The fourth stage was in late 2000, when use of smartphones spread across the world. Korea's digital finance was faced with a new environment where banks, securities, and credit card companies tapped into smartphones to embrace the era of smart financial service. Mobile financial services which utilize highly functional smartphones and mobile Internet to fulfil financial transactions brought about not only digital innovation in our daily lives but also the consumption pattern of digital finance consumerism. Buyers would execute financial transactions on the move (e.g., making purchases on the plane), and the volume of financial transactions surged dramatically.

The fifth stage is during the present time when the industry is witnessing a momentous transformation of non-financial companies. IT and Internet service providers are making inroads into the financial service sector, where advancement of the Internet and mobile financial services successfully obliterate barriers that exist among financial sub-sectors in the digital finance era. This in turn triggers aggressive, borderless service competition in the ever-competitive financial

services industry. To further enhance financial consumers' convenience and efficiency, the Korean government and financial authorities are willing to lift the many regulations imposed by the Digital Finance Transaction Act used to regulate digital finance services and techniques. This stage promotes the Fintech industry through e-banking service development that is merged with intelligent ICT developments.

Fintech, a compound word joining 'Finance' and 'Technology,' refers to a new type of financial service based on information technology, such as mobile reimbursement, remittance, personal asset management, and crowd funding or companies providing such services. After the international financial crisis of 2008, interest in Fintech increased, caused by the emergence of smart phones and start-ups, although this interest was marred to a certain extent with distrust toward financial institutions.

In Korea, the concept of Fintech was mentioned at the Regulation Ministerial Meeting in September 2014, resulting in emergence of terms related to Fintech, such as Internet specialized bank, easy payment, certificate, Active X, and start-up, etc., appearing on the scene on various media. Fintech is receiving attention from many countries' financial systems. It is anticipated that the era of "no need for cash or plastic cards" in financial transactions will arrive with development in Fintech. In actuality, cases of real cash changing hands have declined all over the world, while cases of electronic payment method usage like cards have increased incessantly.

Below are the various services including mobile banking provided by Korean banking sector.

Figure 3- 8 | Digital finance services in Korea's banking sector

Area	Main digital finance services (as of February 2013)
Bank	Banking services (open banking, Internet banking, tele-banking, program services exclusively for banking), mobile banking (VM banking, IC chip banking, WAP banking, PDA banking), CD/ ATM service, Financial IC card service (cash card reimbursement service, electronic bank book, electronic money, and mobile phone ATM), others (POS banking escrow, electronic payment system, and TV-ATM banking, etc.)

Source: Kangyu Cho, Sangshik Min, Jaemo Seung, 2013, Study on technology against digital finance security threat (Digital finance services in Korea's banking sector), KIISC (Korea institute of information security and cryptology

Mobile devices in digital finance serve as an Omni-channel facilitator that connects all customer channels (Internet, smartphones, landline, ATM, POS, and branches, call center) to the mobile screen to generate additional value for customer use. A mobile network is the platform on which ATM cash withdrawal occurs, call center screens are shared, security is strengthened, wait time at branches are notified, alert for non-contact branch visits are given, and mortgage loan via augmented reality is taken out. Below are main transaction types of digital finance services.

- Electronic money

This refers to money or script exchanged electronically, and is also called e-currency (electronic currency), e-money, electronic cash, digital money, digital cash, digital currency, or cyber currency.

Stored-value cards refer to cards in which the monetary value is stored, prepayment cards are those on which the issuer holds a monetary value, and gift cards are equivalent to an unregistered prepayment card. The prepayment methods of a stored-value card, prepaid card, and gift card are similar to electronic money.

- Debit card

This refers to an on/off-line card connected to a deposit account for a financial institution and enabling reimbursement or cash withdrawal. It is further classified into bank cards and check cards.

The online method involves the reimbursement method using a PIN (Personal Identification Number) for each transaction, while the off-line method uses the signature of the owner.

3) Status of mobile banking and Internet use in Korea

The number of mobile banking users during the second quarter was 41.213 million, funds moved amounted to KRW 2.436 trillion, increasing by 2.1% for users and 7.7% for total amounts in contrast to the last quarter's. The portion of balance inquiry and money transfer are 91.8%, 8.2% respectively.

During the second quarter of 2015, the number of mobile banking is 41.21 M, the usage amount is 4.4 trillion KRW with increase of 2.1% and 7.9%, respectively. Major Service usage is linked to balance inquiry (91.8%) and money transfer (8.2%).

Table 3- 4 | Records of mobile banking service use

(Unit: thousand people, KRW 1 billion, (%), <portion>)

		2014				2015	
		1/4	2/4	3/4	4/4	1/4	2/4
Number of use		27,597	29,412	31,805	35,722	40,353	41,213
		(12.8)	(6.6)	(8.1)	(12.3)	(13.0)	(2.1)
(Based on smartphones)		27,369	29,368	31,610	35,498	40,125	41,006
		(14.5) <99.2>	(7.3) <99.9>	(7.6) <99.4>	(12.3) <99.4>	(13.0) <99.4>	(2.2) <99.5>
	Balance inquiry	25,181	26,756	29,020	32,742	37,172	37,844
		(13.4) <91.2>	(6.3) <91.0>	(8.5) <91.2>	(12.8) <91.7>	(13.5) <92.1>	(1.8) <91.8>
	Money transfer	2,416	2,656	2,785	2,980	3,180	3,369
		(7.1) <8.8>	(10.0) <9.0>	(4.8) <8.8>	(7.0) <8.3>	(6.7) <7.9>	(5.9) <8.2>

	2014				2015	
	1/4	2/4	3/4	4/4	1/4	2/4
Volume (Based on smartphones)	1,663.4	1,718.6	1,856.1	2,087.3	2,258.6	2,436.4
	(5.7)	(3.3)	(8.0)	(12.5)	(8.2)	(7.9)
	1,627.6	1,694.3	1,823.2	2,040.2	2,209.5	2,393.0
	(6.7) <97.8>	(4.1) <98.6>	(7.6) <98.2>	(11.9) <97.7>	(8.3) <97.8>	(8.3) <98.2>

Source: Bank of Korea Statistics, 2015, Records of mobile banking service use, Bank of Korea

Table 3- 5 | Records of Internet banking service use

Daily average, (Unit: thousand items, KRW 1 billion, %)

		2014				2015	
		1/4	2/4	3/4	4/4	1/4	2/4
Number of use		63,688	64,665	66,449	70,867	76,942	77,254
		(14.7)	(1.5)	(2.8)	(6.6)	(8.6)	(0.4)
	Balance Inquiry	57,539	58,395	60,058	64,342	70,195	70,249
		(16.6)	(1.5)	(2.8)	(7.1)	(9.1)	(0.1)
		<90.3>	<90.3>	<90.4>	<90.8>	<91.2>	<90.9>
	Money Transfer	6,148	6,269	6,389	6,523	6,746	7,003
		(-0.2)	(2.0)	(1.9)	(2.1)	(3.4)	(3.8)
		<9.7>	<9.7>	<9.6>	<9.2>	<8.8>	<9.1>
	Loan Request	1.5	1.5	1.6	1.9	1.7	1.9
		(-9.6)	(1.5)	(3.7)	(20.9)	(-13.7)	(13.6)
		<0.0>	<0.0>	<0.0>	<0.0>	<0.0>	<0.0>
Amount of use		36,139.4	35,823.9	36,713.1	38,711.7	37,572.4	40,462.7
		(3.9)	(-0.9)	(2.5)	(5.4)	(-2.9)	(7.7)
	Money Transfer	36,128.2	35,813.4	36,698.4	38,690.5	37,537.5	40,414.3
		(3.9)	(-0.9)	(2.5)	(5.4)	(-3.0)	(7.7)
	Loan Request	11.2	10.5	14.7	21.2	34.9	48.4
		(-11.8)	(-6.0)	(40.0)	(43.9)	(64.5)	(38.8)

Source: Bank of Korea Statistics, 2015, Records of Internet banking service use, Bank of Korea

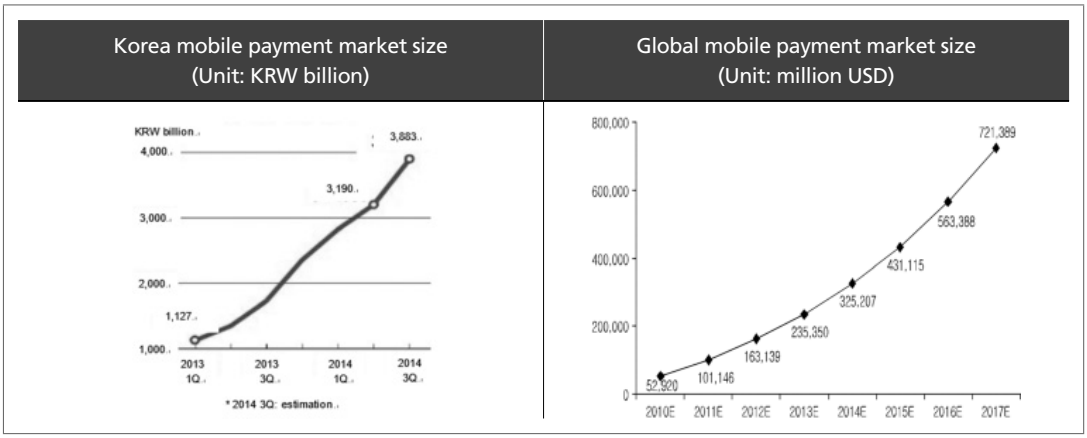
During the second quarter of 2015, the number of Internet banking usage (daily average) stood at 77.25 million, an increase of 0.4% from the previous quarter. However, the usage amount (daily average) record was at 40.4627 trillion KRW, an increase of 7.7% from the previous quarter. If one looks at the service usage volume as of second quarter end of 2015, the inquiry service accounted for 90.0% while money transfer 9.1% showed a slight increase in loan application via Internet banking [table 3-5].

4) e-Payment Service

For Korean consumers, existing online payments are implemented through PKI (Public Key Infrastructure) or certification of text messages. Meanwhile, there are specialized payment reimbursement companies (settlement agency like PayPal), and "Samsung Pay," with easy payment services based on hardware, and also "Kakao Pay" and "Line Pay" based on applications.

As of June 2015, there are 12 payment services that have been or are scheduled to be launched in Korea. Many payments are executed online, while payment via smartphones or other mobile devices can be made at stores.

Figure 3- 9 | Status of mobile payment market in Korea and global markets



Source: 1) Korea Statistics, 2014, Korea mobile payment market size, Korea Statistics
2) Gartner, 2013, Global mobile payment market size, Gartner

Fintech payment and reimbursement is aimed at providing more convenient service by converging financial and information technology. For effective service to take place, there are still some issues needing improvement, such as limited number of member stores, distrust of personal information protection and security, and anxiety regarding smart phone loss or theft. All these cause distrust and inconvenience for the service user. In order to improve these issues, more effort and methods for solutions should focus on quick and effective resolutions when mishaps occur.

With the expanding use of the smartphone banking, the number of customers registered for non-smartphone-based mobile banking such as IC chip (3.64 million) and VM method (8.21 million) is on

a steady decline, and new registration for these services was suspended at the moment.

Owing to the explosive use of smartphones, the mobile payment market is expanding from a PC-based online environment into an offline market which allows the use of mobile devices. Although data security in the mobile environment generates more problems than in the PC environment, consumers still prefer to use mobile devices for its convenience, further escalating security threats. One of the most noteworthy events was the fraudulent use of Samsung App Card in May 2014 when 300 fraud transactions occurred, leaving 60 million KRW in losses.

Due to such potential risks, many users would claim: "I do not feel confident with storing credit card information in my mobile"(59.5%) and "I am concerned about hacking incidents" (56.0%), indicating the concern for using mobile payment service due to security reasons. Hence, security is the most important factor to be addressed if mobile payment service is to further develop, especially with new users.

5) Differences in Internet banking: Comparison between Korea and overseas nations

As Korea and other international countries operate in different Internet banking environments and have different transaction processes, Korea's Internet banking service cannot be generalized to overseas digital financial markets. Korea's Internet banking is customer-centric and focuses on prioritizing real-time transactions and installing technical security programs on individual user's PC; in overseas markets, Internet banking operation is more focused on Fraud Detection System (FDS) where risk management is linked to the transaction process itself (etnews, 2015).

There are also marked differences in banking operational efficiency. Typically, it takes one to two weeks to open a bank account in many countries, a stark contrast to Korea where opening an account and registering for Internet banking service only takes minutes. In overseas markets, banks need to verify the user during registration, and information needed to use the Internet banking is delivered to the user via postal mail. This would explain why it takes an extended period from request for service application to service granted. Furthermore, one's identity check requires not only the applicant's ID card, but also electricity bill, gas bill, tax payment statements to verify the address of the applicant. Also, one of the reasons why overseas countries do not impose installation of security solutions on the user PC is due to an inadequacy in the receiving account registration system. In those countries, information of the remittance recipient must be registered in advance with the financial institution and this system is called receiving account registration system. Money transfer between banks is only allowed for pre-registered accounts, thus preventing wrongful remittance into dummy bank accounts created by hackers.

By contrast, in Korea, electronic money transfers can take place in real time, without any particular limitations, and not only within the same bank but also between different banks. In the case of the USA, intra-bank transfers are executed in real-time but between-bank transfers would still require one to three days. There are some financial institutions that do not even allow remittance to other institutions. In Germany, it takes two to three days for any remittance whether within the

same bank or between different banks. In Japan, same-day remittance can only be fulfilled when the remittance within the same bank is made before 7 pm during workdays and the remittance between different banks is made before 3 pm during workdays. Remittances made outside such specified hours can only be fulfilled on the following business day.

Unlike in Korea, where security solutions are installed in the customer's PC to prevent cybercrime, overseas countries' digital finance transactions have complex processes. Also, due to the nature of non-real-time remittance, both customers and the financial institutions have ample time to take remedial actions such as transaction cancellation and payment suspension once they become aware of a cybercrime possibility. According to the Financial Security Institute, hackers find it extremely difficult to open a dummy account because of the multiple verification processes.

In order to better prevent financial fraud, we need to identify systematic loopholes and endeavor to establish a system that can be reliable and trustworthy while eliminating inconvenience to users.

3.1.3 Types of Cybercrime in Digital Finance Industry

1) IT incidents in digital finance industry

Due to the radical changes in the information technology and environments such as smart devices and development in communications technology, Korea's digital finance industry has undergone changes in many ways. Not all changes are positive; for example, owing to recent hacking attacks targeting financial institutions, hundreds of thousands of personal information details were stolen, raising the potential risk of secondary crimes being committed. In exploiting the public's fear for stolen personal information, many phishing crimes citing security grade promotion mounted. Consequently, methods of digital finance frauds are becoming more sophisticated by the day, thereby increasing monetary damages and losses.

Following the advent of digital finance, more IT related crimes involving financial services were discovered. The table below provides an account of these crimes, with details of calamity effect, perpetrator, and consequences, where applicable.

Table 3- 6 | History of IT related crime in financial institutions

Year	Accident	Actor	Result
1997	Program manipulation (theft of customer deposits)	Insider	Actor criminally charged
2003	Paralysis of Internet banking (1.25 calamity)	Outsider	Actor criminally charged
2003	Card cloning accident (withdrawal of customer deposits)	Outsider	Actor criminally charged
2005	Hacking of Internet banking	Outsider (Korean)	Actor criminally charged
2006	Voice phishing	Outsider (Chinese, etc.)	Actor criminally charged

Year	Accident	Actor	Result
2008	Hacking of Internet banking (theft of customer deposits)	Outsider (Chinese)	Actor criminally charged and arrested in China
2009	DDOS attack (7.7 calamity)	Outsider	Actor not identified (presumed to be hostile)
2011	DDOS attack (3.4 calamity)	Outsider	Actor not identified (presumed to be hostile)
2011	Spilling customer information (H Company)	Outsider	Actor not identified
2011	Paralysis of server (4.12 attack)	Outsider	Done by North Korea
2011	Paralysis of server, terminal (3.20 attack)	Outsider	Done by North Korea
2011	Memory hacking (intercepting transferred amounts)	Outsider	Actor not identified
2014	Spilling customer information from 3 card companies	External worker (employee of the development company)	Actor criminally charged, CEO and executive resigned

Source: assessment of the consultants

In 2014, there was a massive data leak where personal information of 100 million people holding Kookmin, Lotte and NH credit cards was leaked when their personal information was stolen by an insider from the financial system server. This stolen information was then sold to loan advertisers and loan sellers. This incident led to 2.42 million credit card cancellation requests, 4.06 million re-issuance requests, and 4,900 compensation claims. As a result, the three credit card companies involved saw their net profits decline by 30%, with a number of secondary damages expected such as pharming, Smishing, non-face-to-face transaction fraud (involving Internet and mobile payment schemes) and reproduction of magnetic stripe cards.

Other instances of large-scale leakage of personal information took place outside the financial industry, including cases involving Internet service provider Nate/Cyworld (35 million in July 2011) and Telco website (12 million in March 2014). Due to insufficient security measures placed on the stolen data, many types of information owned by Telco landed in the hands of hackers, opening up possibilities that with stolen information sold in the illegal gray market, there would be a rise in secondary crimes being committed with misappropriated data.

The damages from financial frauds increased from 151.5 billion KRW in 2012 to 224.1 billion KRW in 2013 (147.9% from 2012), and then to 240.3 billion KRW as of October 2014 (158.6% from 2012). The damage per capita decreased from 9.1 million KRW in 2012 to 7.4 million KRW in 2013 (81.3% from 2012), but is estimated to turn upwards in 2014 to over 10 million KRW (109.9% from 2012). Considering there are numerous unreported financial crimes that remain unacknowledged

by the Financial Supervisory Service, the damage amount from computer or cybercrime is indeed an exorbitant sum.

Table 3- 7 | Damages from digital finance fraud

(Unit: item/KRW 1 million)

Year	Voice phishing		Pharming		Smishing		Memory hacking		Total	
	Number	Damage amount	Number	Damage amount	Number	Damage amount	Number	Damage amount	Number	Damage amount
2009	6,720	62,100	-	-	-	-	-	-	6,720	62,100
2010	5,455	55,400	-	-	-	-	-	-	5,455	55,400
2011	8,244	101,900	-	-	-	-	-	-	8,244	101,900
2012	5,709	59,500	-	-	-	-	-	-	5,709	59,500
2013	4,749	55,300	3,218	16,424	76,356	4,807	463	2,762	84,786	79,293
2014.6	2,851	36,900	1,628	6,842	4,459	276	97	522	9,035	44,540
Total	33,728	371,100	4,846	23,266	80,815	5,083	560	3,284	119,949	402,733

Source: National Police Agency, 2014, Damages from digital finance fraud, National Police Agency

On the whole, records [Table 3- 7] show that large-amount financial fraud, followed by phishing, Smishing, pharming, and memory hacking have increased rapidly in the past year. During the period from January to October of 2013, the number of large-amount financial frauds was 11, but during the same period last year, the number was 52, a significant increase. The damage amount increased exponentially from KRW 1.5 billion during the period from January to October of 2013, to KRW 7.5 billion during the same period last year. The average damage amount of large-amount financial frauds was a total of KRW 140 million.

In connection, the number of fraudulent deposit bank accounts (fake bank notes) which are core criminal means for financial fraud, have also increased. The number was 33,496 in 2012, 38,437 in 2013, and increased to 53,879 in 2014. In the past, there were mainly damages in account transfers through Internet hacking or Internet banking, such as Smishing and pharming. Recently, however, the trend has switched to tele-banking fraud. At the end of 2014, the number of tele-banking users was about 10 million.

Table 3- 8 | Status of refunds resulting from financial fraud damage

(Unit: KRW billion, %, person, item)

Type		2nd half of 2014	1st half of 2015	July~August 2015
Scale of damage	1. Initial damage amount(A) <monthly average>	2,023 <337>	1,566 <261>	389 <190>
	2. Refunded amount(B) <monthly average>	359 <60>	482 <80>	135 <68>

Type		2nd half of 2014	1st half of 2015	July~August 2015
Scale of damage	3. Refunded amount ratio (B/A)	17.7%	30.7%	35.5%
	4. Net damage amount(A-B) <monthly average>	1,664 <277>	1,085 <181>	255 <122>
	5. Number of victims	29,770 <4,962>	20,510 <3,418>	5,054 <2,527>
Occurrences of fake bank notes <monthly average>		53,879 <8,980>	35,060 <5,843>	8,683 <4,342>

Source: Cyber police bureau, 2015, cybercrime statistics, http://cyberbureau.police.go.kr

Telebanking criminals deploy 'pharming' techniques, a data collection method through a fake website, to collect the users' ID, password, bank account, and security card and then make fraudulent transactions via telebanking. When authentication certificates are obtained, the criminals would typically attempt to steal money through Internet banking and if not, through telebanking. The number of people who fell victim to voice phishing was very high once, but later, owing to the widespread use of personal verification services and increased awareness of voice phishing, telebanking-based crime declined. In particular, these types of cybercriminals are located in overseas market (mainly China), use Internet phones to manipulate the caller's phone number to match the victim's phone number (thus making it hard to track their identity), transfer the money to a dummy account, and withdraw the money from ATM immediately, and then transfer the stolen money to an overseas account.

Below is an update of cybercrime detection record. It can be assumed that the number of cybercrimes that have actually occurred or been attempted would be far greater than the number reported and detected.

Table 3- 9 | Statistics on arrests of cybercrimes

(Unit: people)

Year	Total	Hacking Virus	Internet fraud	Cyber violence	Operating illegal site	Illegal copying sales	Others
2004	63,384	10,993	30,288	5,816	2,410	1,244	12,633
2005	72,421	15,874	33,112	9,227	1,850	1,233	11,125
2006	70,545	15,979	26,711	9,436	7,322	2,284	8,813
2007	78,890	14,037	28,081	12,905	5,505	8,167	10,195
2008	122,227	16,953	29,290	13,819	8,056	32,084	22,025
2009	147,069	13,152	31,814	10,936	31,101	34,575	25,491
2010	103,809	14,874	35,104	8,638	8,611	17,885	18,697
2011	91,496	10,299	32,803	10,354	6,678	15,087	16,275
2012	84,932	6,371	33,093	9,055	3,551	15,111	17,751
2013	86,105	4,532	39,282	7,873	2,953	13,567	17,898

Source: Cyber police bureau, 2015, cybercrime statistics, http://cyberbureau.police.go.kr

2) POS-Related Incidents

POS (Point of Sales) system is defined as a system that manages all sales-related data and collects customer information to enhance added value. It is also called POS system, POS terminal, or point of sales information management system. There are many incidents where customer information is stolen that exploited POS terminals both in and outside Korea. Supervision responsibility and security measure have significant implications in providing and operating the digital finance services to prevent these kinds of crime.

a) Incidents Cases in Korea

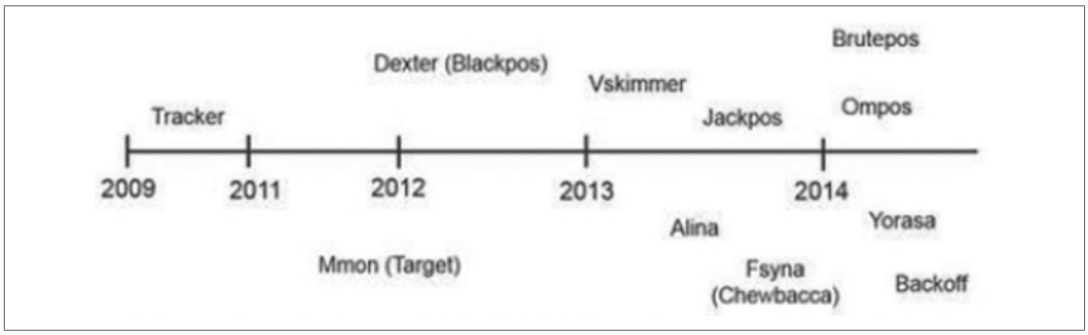
In December 2013, a security incident that involved hacking a POS payment terminal took place in Korea. The hackers hacked the server of the POS terminal operator, stole information from 136,000 credit cards from 85 stores' POS terminal. These criminals withdrew cash by counterfeiting the credit cards, resulting in 120 million KRW in damages.

In Korea, there are around 300 POS system manufacturers and 200 non-Korean POS distributors. Since different industries have different members and the information managed by the POS system, this system is too diverse to control and manage. As a corrective measure, Chip and PIN type (where IC chips are embedded) credit cards are introduced and promoted to replace existing credit cards based on magnetic strips, since the latter are more prone to hackers' attacks. Even POS terminals where payments are executed are upgraded to an IC-embedded version.

However, due to the vague management and supervision rights over POS terminals (where cash dispensers are under the Financial Supervisory Service's responsibility and POS systems are managed by multiple entities such as the Credit Finance Association, credit card companies, credit card agent VAN companies), it is hard to clarify where the responsibility for security lies. At the moment, credit card companies have jointly developed a 100 billion KRW fund to promote IC terminals to provide IC terminals for small-scale businesses, free of charge. However, the IC terminal change rate has not been in line with the IC card change rate, leaving room for hacking attacks. According to Credit Finance Research, IC card change rate stands at 98.8% whereas IC terminal, necessary for IC-based transaction, only has a 58.2% change rate.

In October 2015, credit cards that belong to KAIST students and faculty members were illegally copied and the credit card companies received multiple redundant requests for payments of small amount (1~2 Yen) from a store in Japan. This incident is estimated to have taken place when credit card information was leaked through POS terminals that had low levels of security. According to Credit Finance Association, a total of 39,500 payment requests were made during this incident, of which 963 requests (2.4%) were approved and 38,537 requests (97.6%) were denied by FDS.

Figure 3- 10 | Major POS-targeting Malwares found in Korea between 2009 ~ 2014



Source: AhnLab blog, 2015, POS malicious code found from 2009 to 2014, etnews (http://www.etnews.com/20150123000125)

The first POS terminal attack in Korea was in 2009 when a malware named 'Tracker' was found (AhnLab blog, 2015). Since then, cyber-attacks on POS have diversified.

As most POS terminals have low memory spec of 1GB, small-scale businesses usually run their POS system on OS versions lower than Windows XP with insufficient level of security program installed. POS-related attacks are on the increase as 6 kinds of malwares targeting POS systems were discovered in 2014. Hackers continue to go after POS systems as these terminals typically have low security level whereas the information they contain is of high value.

Another POS malware named 'Cherry Picker' is known to have existed from 2011, and is still active with a unique stealth function that makes anti-virus and malware detection software useless. It parses the memory to steal credit card information and then erases its "footprint" with an embedded cleaner program. According to Boan Security updates, this malware keeps upgrading itself with sophisticated hacking techniques.

b) Cases in Overseas Countries

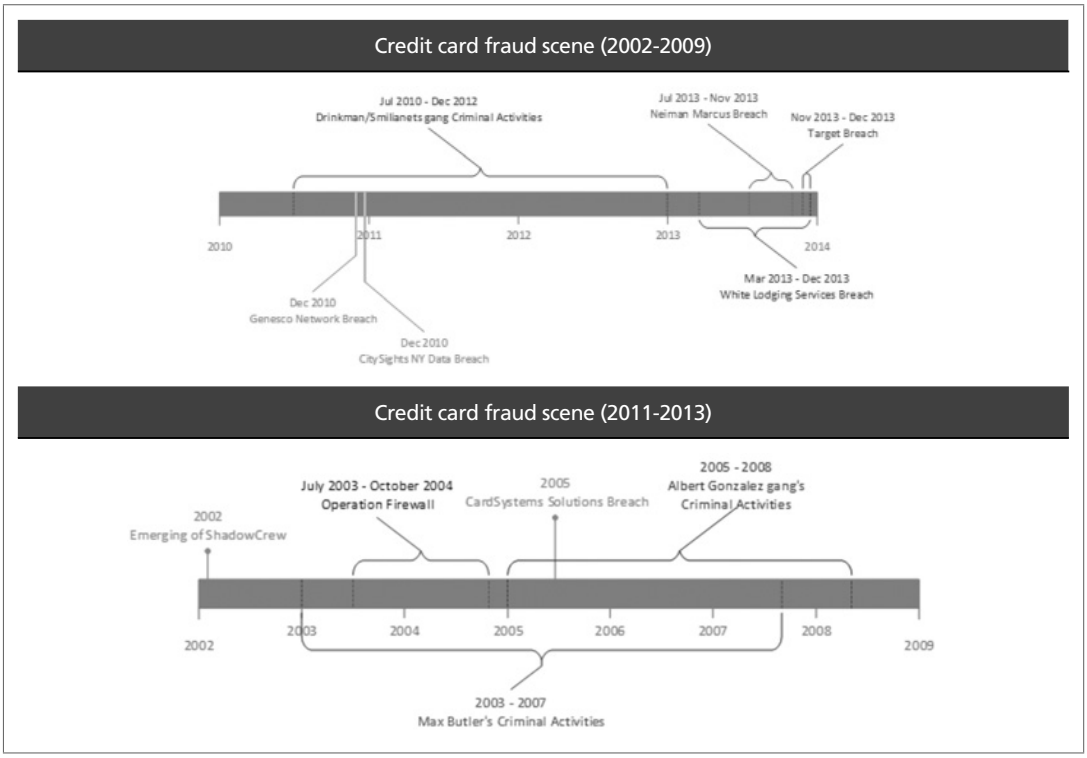
HP publishes a number of credit card-related incidents from 2002 in its blog. One of the most well-known cases is the Target attack in late 2013 when credit cards and personal information were stolen from US' largest discount store, Target. The attack took place during the Thanksgiving holiday season, which is the largest holiday in the States. 70 million credit cards' information was infiltrated between November 27, 2013 and December 15 from the POS system in Target's offline stores (HP blog 2015).

Attacks via POS terminal and card processing network can be traced back to the mid-2000. The information in each credit card is transmitted from the POS terminal to POS network and processing network the moment the credit card is swiped. Infamous hackers are the Max Butler and Albert Gonzalez gangs. While Max Butler mainly attacked POS systems of small restaurants, Albert Gonzalez targeted larger stores. Drinkman and Smilianets gang also penetrates into a large number of networks to steal data and in 2012 they attacked Global Payments to run away with 1.5 million to 7 million card data. Alarmingly, these attacks evolve in sophistication even as the level of

defense heightens. The Target attack in 2013 adopted an advanced memory scrapping attack when information is stolen from a POS application memory even while the system is in action.

In May 2014, 1,478 terminals were found to be affected with the malware named Nemanja. This happened in countries including Australia, Israel, and Zambia and various systems in the US, UK, and Germany, which were severely infected with key logger malwares.

Figure 3- 11 | Credit Card Fraud using POS Terminal (HP)



Source: HP blog, 2015, HP Security Research Threat Intelligence Briefing episode 12 - the evolution of credit card crime, HP blog

Once infected with Nemanja, information in the retailer's back office system and cash register is stolen and payment settlement information and customer information are sent to the hackers' home server and are used for fraudulent activities. Efforts are made to emphasize the need for an end-to-end encryption when sending/receiving or storing sensitive data according to the data security standard (PCI-DSS) in order to prevent security issues of credit-related information.

Stealing credit card information through the POS systems or networks may put at risk the personal information from all financial transactions using end-point terminals, including POS terminals. This calls for the need to have a tight security measure in place regarding POS terminals.

3) Types of digital finance incidents

The development of information technology influences the environment of devices, infrastructure, and communication. Digital environments are gradually becoming smart and convergent. Throughout the world, IT has increased the number of users in digital finance using PCs and mobile devices, and the financial sector promotes growth of financial infrastructure by controlling the field of payment reimbursement as well as online banking services. In particular, as the face-to-face element is removed from financial transactions, financial companies are able to provide more diverse services, such as Internet banking and smart phone banking, at times at great risk to the financial consumer.

As expected, with such diverse digital finance services, various threats exist. Ongoing studies' findings reveal specialized malicious codes are targeting Internet banking, online reimbursements, and other financial services. Cyber-crimes involve mainly cases of external hacking or information leakage from insiders in financial institutions. As there are many challenges in responding to malicious codes and weaknesses simply with vaccine programs, more exploration and trials with counter-malware solutions are needed in order to manage with such problems.

Threats associated with smartphones are divided into loss, malware infection, information exfiltration, monetary damage, and utilization as attack point. As smartphones are by nature prone to leakage of personal information and monetary damage, smartphone users experience the highest level of risk and damage. In particular, the damage caused by loss of a smartphone is irrevocable. For example, criminals can tap into financial transaction applications such as banking or security service apps to enable them to make money transfers and stock trading. Risks are very high especially if data relevant for financial activities are stored inside smartphones, because unlike personal computers which are mainly static and can be protected physically, hacking risks in smartphones are higher due to the very nature of its mobility.

With the global explosion in the use of smartphones comes the increased threat for mobile devices. As the number of Android-based smartphone users soars, where installation and distribution of apps are convenient, security threats targeting Android-based phones are increasing proportionately. These days, 72% of malwares targeting Androids are 'toll fraud' malwares devised to gain monetary profits. Toll fraud malwares, unlike PC-based malwares which are typically used to send spam mails and generate D-Dos attacks, exploit the payment system specialized for mobile devices (e.g. premium SMS) to make monetary gains. The number of smartphone users in Korea is expected to reach 42 million by 2015 from 2012's 32 million. Hence the mobile security threat is on the increase as well, with 51,477 Android-targeting malwares being detected in the third quarter of 2012. This figure is 10 times greater than the previous quarter.

Malicious Smishing codes have exponentially increased in number by 238 times over the past three years. They are defined as cyber frauds that install malicious codes by inducing smart phone users to click on an Internet address within the message, and this allows it to then steal personal information and financial information. The number of malicious applications installed onto smart phones analyzed by KISA in 2014 was calculated to be 4,048, which is an astounding jump from the

17 cases in 2012. Smishing attacks deploy attractive gimmicky phrases that draw social attention such as promotion vouchers, bill cancellation, courier service, driving penalty, and claimed court or police authorities and continuously morph such attack tactics.

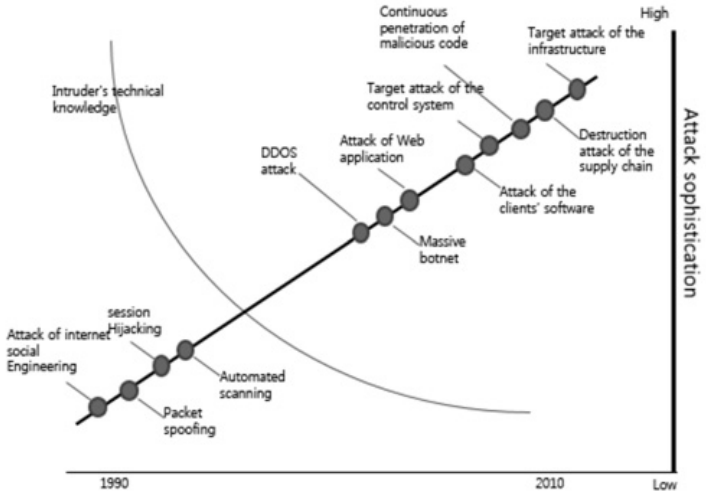
Including the 2,315 examples in 2013 and 927 as of June of this year, the total number of malicious applications analyzed over the past three and a half years was 7,343. It turned out that, among these, 148 remote-control malicious applications were analyzed as of the end of June 2014, instead of just 18 in 2012.

In 2014 alone, according to AhnLab, the number of malwares targeting Android-based smartphones reached an accumulated 1,430,247. This is an increase by 14.2% from 2013 and by 444% (5.4 times) from 2012. Out of 1,430,247 malwares, a total of 10,777 Smishing-type malwares was identified in 2014 alone. This is an increase of 107% (twice) from 2013, 37,062 % (371 times) from 2012 indicating an alarmingly steady increase (AhnLab blog http://asec.ahnlab.com/1018).

Smishing malwares are growing in numbers and becoming more sophisticated in terms of distribution methods and types. Early stage Smishing attacks would basically send simple texts such as gift vouchers or event winning messages and embedded URLs to induce victims to download the malicious apps. However, these are evolving in a sophisticated manner with text messages that are disguised as public claim notification or messages with seasonality greetings that are harder to detect. Furthermore, fake websites that are almost undistinguishable from authentic mobile websites are designed to fool potential victims. In particular, most malwares distributed as Smishing schemes are targeting smartphone banking, capable of incurring actual financial loss. In the future, there will be more advanced methods of deceiving victims and bypassing Smishing-aware security solutions.

4) Evolution of cybercrime threats

Figure 3- 12 | Evolution of cyber threats



Relation between attacks sophistication and intrusion technology

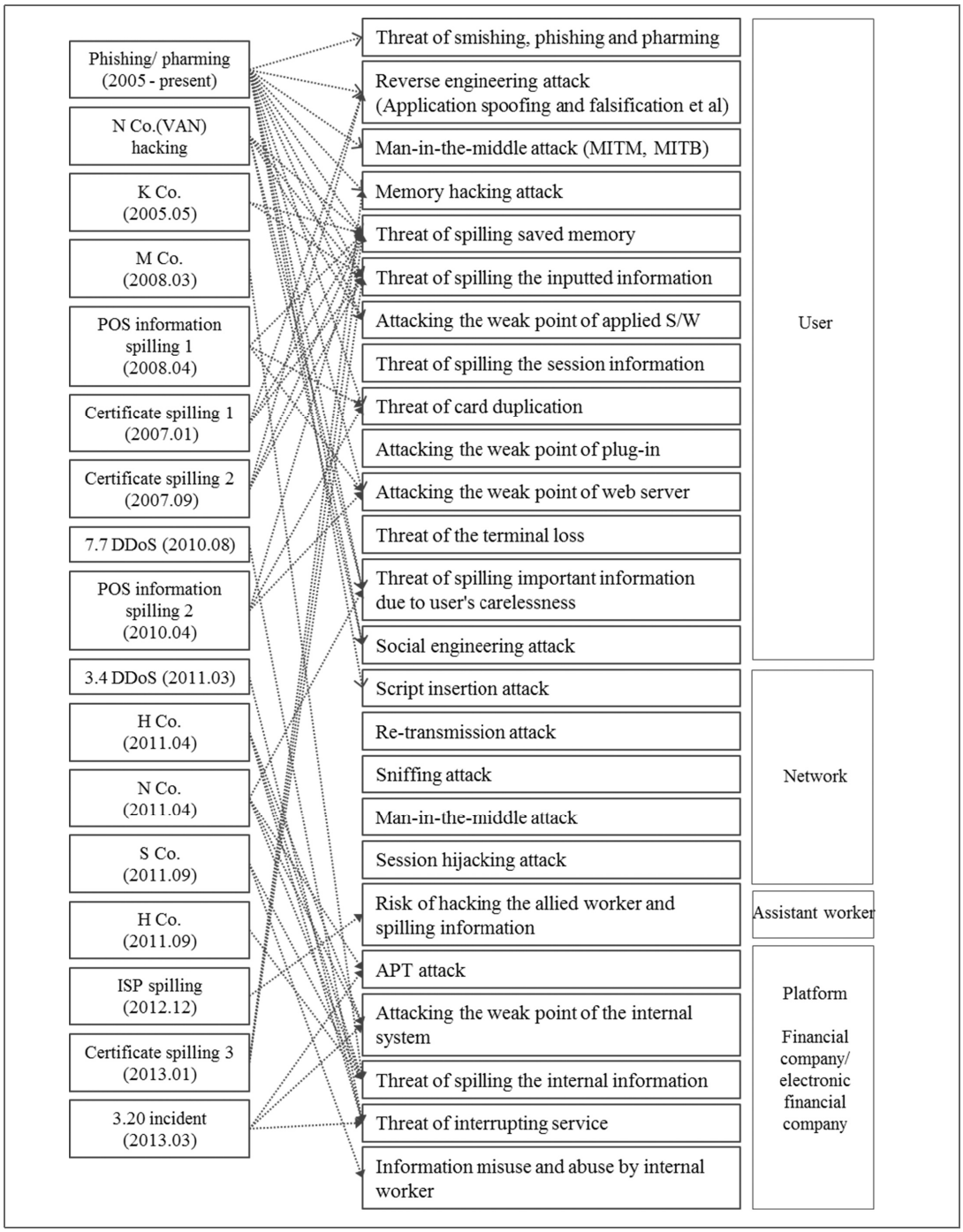
Source: Hyu Keun Shin, Kichul Kim, 2013, relation between attacks sophistication and intrusion technology (Carnegie Mellon University), recompiled by author, KIISC (Korea institute of information security and cryptology)

According to a study from Carnegie Mellon University in 2013, the traditional cyber threats of the 1990s comprised attacks of social technology using Internet, packet spoofing, hijacking sessions, and automated scanning. However, these have evolved into targeted attacks, beginning in the 2010s [Figure 3-12].

Malicious programs used in targeted attacks are developed to collect various kinds of information from the internal network via the infected system through functions like key logging, creation and deletion of files, and OS information transmission. Targeted attacks are intended to steal customers' data from companies in order to manage and destroy the company network, and mainly target employees in charge of managing critical internal data.

Once data processing is digitized, each stage from the device user's contacts - from the communication route to the data storage and management side - can be open to vulnerabilities. Attacks penetrating into such vulnerabilities can take place, creating a massive amount of damage [Figure 3-13].

Figure 3- 13 | Types of security incidents by data processing section



Source: Kangyu Cho, Sangshik Min, Jaemo Seung, 2013, Threat classfication by accident cases, KIISC (Korea institute of information security and cryptology)

Threats have advanced to become continuous and intelligent cyber threats that are commonly known as APT, such as attacks of software, are aimed at targeting attacks on the control system, continuous infiltration of malicious codes, and destruction attacks on supply chains. It is anticipated that after 2010, the threats will develop into sophisticated targeted attacks on core facilities in the country. So far, a majority of attacks would seed malwares in multiple dispersed spots only to attack targets trapped in those spots. With the methods and purpose of attacks evolving, criminals have a specific target and prepare for the attack on a long-term basis through a well-structured systematic organization. Such crimes are emerging as a major business. According to a report published by FireEye Mandiant, 97% of their customers have been the target of attacks of one form or another. 75% of the attacks were tailored to strike the target victim and was only used a couple of times, making it extremely hard to detect.

According to the results of 'Smishing analysis for the first half of 2015' by KISA, malicious applications are continuously evolving. The initial malicious application of Smishing, a compound word from text message (SMS) and Phishing, began with the method of stealing certification texts for small-amount reimbursements to attain device information, simple personal information, or monetary benefits. However, at present, it is evolving into a method possessing the functions to change the address of the server where information is spilled by remote control and saved, or stealing account numbers, passwords, security cards, etc., necessary for Internet banking, and protecting itself in order that the malicious application may not be deleted [Table 3-10].

Table 3- 10 | Types of new and mutant financial fraud

Type	Existing	New and mutant
Phishing	(Using a fake deposit bank book)	(Using a normal bank account)
	After transferring money to the fake deposit bank book by deceiving and threatening the victim, money is withdrawn through the cash dispenser (voice phishing)	Transferring the purchasing amount for a product from the victim's bank account (in spite of himself/herself) to the seller's bank account, then receiving the product, and encasing it by selling it
	(Impersonating National Police Agency or state institution)	(Impersonating communication company)
	By impersonating a National Police Agency or state institution, requiring personal information or financial information (voice phishing)	After changing the dialing number to that of the communication company, requiring personal information or financial information in disguise of delayed payments or communication fees or replacement events for mobile phones
Pharming	(Inducing to a fake Internet site)	(Inducing to the fake portal site)
	By inducing the connection from a regular Internet site to a fake site, stealing and security card numbers.	By inducing the connection from a regular portal site to a fake site, stealing the whole security card

Type	Existing	New and mutant
Memory hacking	(Stealing the security card number)	(Falsifying account numbers and transfer amounts)
	In the process of Internet banking, by opening a fake pop-up window and stealing the first and last digit of the security card, then stealing money	In the process of Internet banking, by falsifying receipt account information and transfer amounts using a malicious code, directly transferring the money to the account of the con artist
Smishing	(Text message of free coupon or impersonating reimbursement)	(False text message impersonating an acquaintance)
	If you click on the text message for a free coupon or details of reimbursement, malicious application is installed, stealing SMS certification numbers for small-amount reimbursements and incurring the damage of small-amount reimbursements by mobile phone	If you click on the text message for a 'Wedding invitation' or 'Birthday event,' a malicious application is installed, stealing personal information and sending the same fake message to all contact numbers recorded in the phone

Source: Digital Finance Fraud Prevention Commission, 2013, Types of new and mutant financial fraud, Digital Finance Fraud Prevention Commission

KISA's recent analysis detected malwares and announced a new type of attack named Qushing (QR + Phishing) which leads victims to connect to a malicious link through a QR code or plants malicious codes directly.

More digital finance security incidents had recently happened involving new attacks using ransomware and spear-phishing. Ransomware implants malware into the PC, encrypts documents or data to turn it inactive, and then ask monetary compensation from the victim for provision of decryption solutions. Unfortunately, ransomware is not difficult to implement and has abundant potential targets and hence is expected to propagate in the future. Spear-phishing, on the other hand, targets certain individuals or companies and sends them emails that appear to be from an organization with authority or from an acquaintance. Once the email is opened, the malware is embedded into the computer to penetrate into the server to steal important data. Mobile hackings are used to exploit vulnerabilities of the mobile devices OS or app to steal personal information. The victim's authentication certificate is copied and misused for financial crimes.

There are other types of security threats that utilize social network services such as Facebook, Twitter, or LinkedIn to disperse malwares and send spam mails. In the past, attackers sent emails that appear to be sent from Facebook and encourage the recipient to click the attachment to change their password. Nowadays, social engineering is used when criminals are disguised as someone the victim knows by using the pictures, notifications, and request for friends and malwares are spread in an organization level. Furthermore, attackers use a shortened URL address to redirect the victim to a malicious website and send a Facebook message that includes a malicious URL so that the recipient would click the website. As users have high levels of trust in social network services and increasingly engage in social activities such as sharing personal information or exchanging item gifts,

the more users pick up purchasing and payment via SNS, the more opportunity cyber criminals have in spotting vulnerabilities within the social network service. SNS account owner's critical information can be leaked by stealing payment information, giving fake gifts, or sending malicious emails requiring the user to provide home address or other personal data.

From the 'Social Engineering' perspective, the criminals impersonate themselves as financial authorities, e.g., the Prosecutors' Office, the National Police Agency, and financial institutions so that victims are convinced and persuaded to enter their personal information, financial information, and password. The traditional attack of voice phishing is combined with SMS text messages and phishing websites and this again evolves into pharming attacks combined with malwares (KRBanker) that directly targets stealing from the Internet banking user's deposit account. In a pharming attack, even if the victim enters a legitimate website address, he is directed to a phishing website.

Cloud services, as well as securely storing the customer information, carries the risk of morphing into a tool hackers can use to attack. The attacker, in order to intercept the user's online banking session and execute fraudulent money transfers in real time, can use the Man-in-the-browser (MITB) method that is combined with the server site script. In 2011, the Lulzsec hacker group used the cloud computing power of Amazon's cloud service, Elastic Compute Cloud (EC2), to attack Sony Pictures and Sony Entertainment to steal the data of around 100 million users.

Cyber-criminal organizations consist of a typical hierarchy with solid organization structure where roles and responsibilities among members are clearly defined from the lead to mules. Cyber-criminal organizations distribute sophisticated malicious programs to set up botnets and are capable of developing false anti-virus software and efficient exploit toolkits. As is the case within legitimate organizations, criminal organizations develop codes, and distribute them through a very stringent verification process. For more sophisticated attacks such as large-scale attacks, these criminal organizations commission external organizations such as hacking groups for development and research or recruit external resources with high technical expertise to enhance their level of technology and develop scenarios that use fraudulent activities to approach the victim in very convincing ways.

In proportion to the increasing economic activities using smartphones, security threats against smartphones are on the increase. Known monetary threats on smartphone are a Russia-born premium small amount payment service malware and its upgraded version, Chest malware, first occurred in Korea in December 2012. In Chest attacks, once the victims install malwares disguised as legitimate apps such as spam blocker or spam guard, the application redirects messages sent from certain sites such as Internet shopping mall or small-amount payment agency. The attackers would simply use this information to execute payment to gain monetary benefits. In both cases, the technique is very simple to intercept SMS messages but carries the risk of evolving into one that can manipulate applications and penetrate into the mobile banking service.

In addition to these threats against mobile banking security threats against mobile e-wallet is also anticipated. In Korea, the e-wallet market is jointly provided by banks and Korea Financial Telecommunications & Clearings Institute and many telecommunication companies are pursuing to

launch new services in association with credit card companies. In some companies such as Google, there is a move to migrate into a cloud-based service model where all information necessary for payment is stored in the cloud server. Equipped with mobility and convenience, the proportion of payment is higher in mobile devices than in PCs and thus the value that can be generated from attacks targeting mobile devices are on a sharp increase and hence needed are sufficient security measures. Furthermore, when planning financial services on mobile devices, security measures on mobile devices must be well thought-out.

The high rate of security incidents happening in financial institutions both in and outside Korea over the last 5 years indicates that in the overseas market, there are frequent malware attacks from outside the system such as hacking attacks. In Korea, the majority of incidents were triggered by employees who take and misappropriated customer data illegally. There is a clear difference between hacking attacks in the Korean and overseas financial markets; in Korea, the focus is on data exfiltration of customer's personal information while in overseas markets, most of the attacks target the banks directly to withdraw cash. The most recent and worst hacking crime was committed by Carbanak, a criminal organization consisting of hackers spread around the globe, when over 100 banks in 30 countries were attacked in the past two years, with monetary damages amounting up to 1 billion dollars.

3.1.4 Preventive Systems, Measures or Services

1) Preventive systems

Prepared as part of the "Comprehensive Countermeasures against Voice Phishing", which was jointly developed in 2012 by the Financial Services Commission, the Financial Supervisory Service and the Korean National Police Agency, preventive measures recommended refer to stricter identity verification procedures adopted in an effort to prevent criminals from illegally acquiring the financial information of customers. These measures would also avoid banking services users from getting their authentication certificates issued in illegitimate ways and having their financial assets swindled by cyber criminals.

Preventive measures and services are designed to stop online banking fraud by making the identity verification procedures stricter, e.g., when PKI (authentication certificates) is re-issued or money is transferred via online banking systems (cumulative amount of up to 3 million KRW per day). Before these services were introduced, the user's identity was verified with security cards or OTPs (one-time passwords) when PKI is re-issued or money was transferred. After the services were in place, additional procedures were adopted; transactions now must be done on designated terminals, and additional procedures, such as SMS verification and two-channel verification, are required when undesignated terminals are used. The services are aimed at preventing damage caused by online banking fraud by putting in place additional verification procedures which can complement the existing verification methods, such as security cards and OTPs.

Since these services were introduced in October 2013, crimes involving online banking have dropped by 72.7 percent. Most common techniques used for these crimes, such as luring to phishing

sites and memory hacking, decreased considerably, even though the use of smartphone applications, and phones, text messages and email have grown by 6.4 percent and 31.6 percent, respectively.

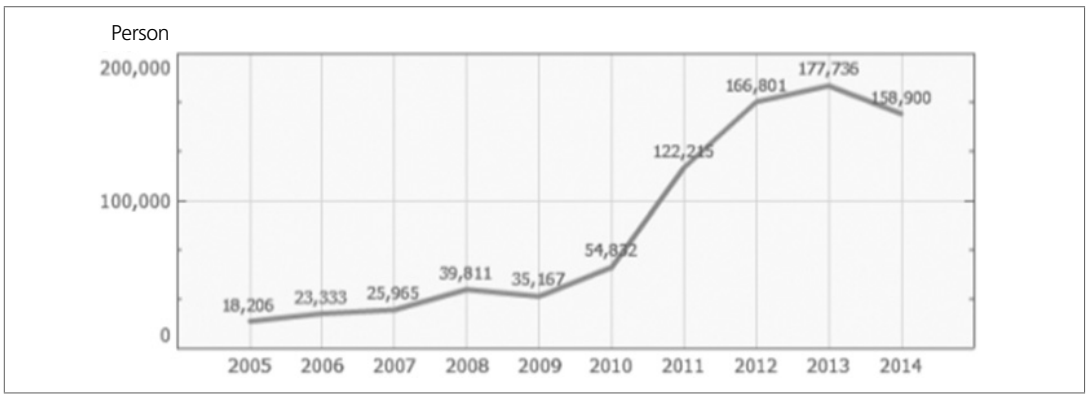
The damage from online banking fraud reportedly decreased sharply since the adoption of the preventive systems. Still, the crimes have not been eradicated and new techniques like detouring or getting through additional verification procedures have emerged.

The preventive systems appear to have limitations in countering ever-evolving criminal techniques. The current prevention systems need to be reinforced to cope with the reality, and different perspectives to improve the current systems in terms of services and infrastructure should be integrated to approach the issue more systematically. The legal system also needs to be improved to support such changes.

2) Information security

The number of reports of privacy infringement increased five-fold, from 35,167 in 2010 to 166,801 in 2013.

Figure 3- 14 | Number of consultations on report of personal information violation



Source: KISA, 2014, Number of consultations on report of personal information violation, KISA (Korea Internet & Security Agency)

The number of consultations on the report of violations of personal information increased five-fold from 2010 to 2013, rising from 35,167 to 166,801. Incidents of mass information leakage committed by the information and communications network occurred continuously. Mass invasions of personal information were the focus of public attention, such as AUCTION in January 2008 (18.63 million), GS Caltex Corporation in July 2007 (11 million), Hyundai Capital in April 2011 (1.75 million), SK Communications in July 2011 (35 million), Epson Korea Co., Ltd in August 2011 (0.35 million), EBS in May 2012 (4 million), and KT in July 2012 (85 million). As for these incidents, some of the victims whose personal information was invaded claimed damages. Some such claims were dismissed, but some were accepted at the level of KRW 100,000 to KRW 300,000.

Information security means any activity to protect information in an effort to prevent possible damage, destruction, falsification and breaches of information that could happen in the process of collecting, processing, storing, searching, sending and receiving data. With the increase of cybercrimes involving online banking, the concept is going beyond the protection of personal information and further expanding and evolving into 'integrated security', which covers cyber security. In the wake of major breaches of customer information, the regulations designed to protect privacy, including the Privacy Act, have become stricter, which has led to growing reports of legal risks of personal information infringement and the resulting criminal penalties and damages. Now information security is considered to be a 'comprehensive risk management tool' and a 'critical factor determining the success of businesses,' and this has put a spotlight on the need and significance of the sweeping reform of compliance management system.

Against this backdrop, the Korean government is acknowledging information security as a critical national task, which is no less important than Informatization. It is also building an organized system to upgrade its practices of information security and implementing diverse national policies related to information security. In Korea, the system of information security is overseen by the National Intelligence Service, and each of major sectors is managed by relevant ministries; the private sector by the Korea Communications Commission, the public sector by the Ministry of Government Administration and Home Affairs, the defense sector by the Ministry of Defense and the sector to promote the information security industry by the Ministry of Knowledge and Economy. The Korea Internet & Security Agency is carrying out various specific projects to improve the practices of information security, based on which other stakeholders, such as professional organizations and businesses, are working together to improve the status of information security.

Major information security policies and strategies include; General Strategies for Ubiquitous Information Security (Dec. 2006), Comprehensive Mid-term Measures for Information Security (Jul. 2008), Comprehensive Plan for Internet Information Security (Jul. 2008), Comprehensive Plan to Promote Knowledge Information & Security Industry (Dec. 2008) and Comprehensive Plan for Smart Mobile Security (Dec. 2010). Under these policies and strategies, analyzes of the status of information security are done consistently, leading to continuous improvement.

Meanwhile, the legal framework for information security began to be established in an effort to counter the side effects of Informatization, which the Korean government has pushed for since the 1980s. Major laws introduced in early days of Informatization include; Framework Act on Informatization Promotion, Act on Digital Signature and Act on the Promotion of Information Network and the Protection of Information. Since the 2000s, when the national and social dependence on IT systems was growing, there have been growing voices for reviewing laws on information security from the perspective of national security. This has led to the establishment or revision of the Act on the Protection of Information and Communications Infrastructure and Act on Promotion of Information and Communications Network Utilization and Information Protection. After that, Information Industry Promotion Act was introduced to promote the information security industry, and other relevant laws have been reviewed, including the establishment of Act on Establishment of Infrastructure for Informatization of National Defense and Management of Informational Resources for National Defense, and most recently, Privacy Act.

Laws to protect online banking consumers include the following: Use and Protection of Credit Information Act (1995), Act on Real Name Financial Transactions and Guarantee of Secrecy (1997), Digital finance Transactions Act (2007), Privacy Act (2011) and Information and Communications Network Act (2008). The financial sector has always been actively collecting and using detailed personal information in a number of ways. However, in the wake of recent breaches of personal information, privacy infringement has emerged as a major issue in this industry.

Under this legal framework, the Korean government is implementing a range of policies designed to reinforce information security; it is working to counter privacy infringement on the Internet, improve the security levels of e-government services, protect major IT infrastructure, certify the information security management system, diagnose the safety of information security, evaluate information security-related products, block email spam and protect privacy and copyrights.

The Korean government is also working to lay the foundation needed to carry out the above-mentioned activities. The efforts include offering information security education and training professionals, developing related industries and technologies and establishing professional organizations such as the Korea Internet & Security Agency. It is also conducting campaigns using media to raise awareness of the importance of information security among the general public.

On the consumer protection front, the protection of personal information is a key target. The principles for personal information protection by the superintendent unit are as follows. Policy and technology would be provided according to these principles.

Table 3- 11 | Comparisons on principles for personal information protection

Principles	TTAK KO-12.0200	OECD	ISO/IEC 29100
Damage Prevention	Damage Prevention	-	-
Responsibility	Responsibility	Responsibility	Responsibility
Legality and Specificity of Purpose	Legality and Specificity of Purpose	Clear Objectives	Legality and Specificity of Purpose
Consent and Choice after Awareness	Consent and Choice after Awareness		Consent & Choice
Limitations on Collection	Limitations on Collection	Limitations on Collection	Limitations on Collection
Limitations on Use, Disclosure, and Possession	Limitations on Use, Disclosure, and Possession	Limitations on Use	Limitations on Use, Disclosure, and Possession
Accuracy & Quality	Accuracy & Quality	Accuracy	Accuracy & Quality
Information Security	Information Security	Procurement of Safety	Information Security
Data Minimization	Data Minimization		Data Minimization
Disclosure, Transparency, Notification	Disclosure, Transparency, Notification	Disclosure	Disclosure, Transparency, Notification

Principles	TTAK KO-12.0200	OECD	ISO/IEC 29100
Participation and Access by Data Subjects	Participation and Access by Data Subjects	Participation by Data Subjects	Participation and Access by Data Subjects
Compliance to Privacy	Compliance to Privacy		Compliance to Privacy

Source: Heung-Youl YOUM, Jae-Nam KO, 2013, Analysis of global privacy principal (Comparisons on principles for personal information protection), KIISC(Korea institute of information security and cryptology)

To protect consumers from these kinds of threats, the Korean government has executed administrative and technical actions. These are the examples of administrative actions taken since 2007.

Table 3- 12 | Administrative actions to protect consumer right in digital finance

Date	Details
JAN. 2007	Established 'Preventative Actions against Tele-financial Fraud'
JUL. 2007	Established governmental level action for tele-financial fraud
JUN. 2009	Established actions to prevent and complementation plan against tele-financial fraud
SEP. 2011	Enforcement of the 「Special Act on Refund of Amount of Damage Caused by Telecommunications Bank Fraud」 since September 30, 2011
FEB. 2012	Establishment of comprehensive action plans for the protection of financial consumers
OCT. 2012	Establishment of comprehensive action plans for the prevention of fraud in digital finance (phishing)
NOV. 2012	Opening of Voice Phishing Protector (a special webpage for prevention and relief against damages by voice phishing)
NOV. 2012	Joint Alarm for voice phishing (FSC, National Police Agency, and FSS)
SEP. 2013	Overall execution of Prevention Services against fraud in electronic finance
SEP. 2013	Establishment of comprehensive action plans against new/alternative forms of fraud in electronic finance
JAN. 2014	Announcement of prevention plans for financial institutions against the leakage of personal information

Source: assessment of the consultants

3) Technical measures

The prevention of online banking fraud requires technical infrastructure to achieve improved financial security as well as the above-mentioned policy measures and management services.

The Comprehensive Measures to Tighten Security of Financial Systems, introduced by the Financial Services Commission and the Financial Supervisory Service on July 10, 2013, recommended the Fraud Detection System be expanded to banks and securities companies and a system are built to help

sharing of information on suspicious financial transactions across the entire financial institutions. The Fraud Detection System can be more effective in preventing online banking fraud only when financial companies share information and use it to alert, detect and block illegal transactions in a timely manner. The detection system is a technical foundation for financial security to support the preventive system and needs to be linked with the preventive system. In other words, the functions of the fraud detection system used at each financial institution (raising alerts, detecting and blocking illegal transactions and sending notices) should be connected with user verification and notices of transaction history offered by the preventive system.

Technical action evolved according to the different forms of cyber-attacks. Devices supplying financial services installed all kinds of security modules to respond to more sophisticated attacks. This is the summary of actions taken against security risks.

Table 3- 13 | Actions against security risks

Concerned area	Actions against security threats
Verification technologies	• Improve verification of credit card payments • Improve user verification • Server authentication (EV SSL authentication certificate)
Password technologies	• Upgrade password technologies for stored information • Improve password technologies for transmission
Service security	• Improve integrity of transactions • Protect information entered • Defend against malicious codes (e.g., ActiveX.) • Verify software integrity and obfuscation
Security of application software	• Security of software development • Improve testing of security software for online banking
Security of smart devices	• Defend against malicious codes (malicious applications) • Improve security and management of smart devices
Monitoring	• Defend against malicious codes (APT attacks) • Collect information on threats of attacks • Monitor suspicious behaviors (transactions, sessions, e.g.) • Detect and block phishing sites • Conduct integrated monitoring across financial institutions
Security management	• Manage operator account • Tighten internal control • Control access (media control) • Review security of partner vendors
Network security management	• Separate networks (virtualization, e.g.) • Tighten security of wireless networks

Concerned area	Actions against security threats
Response to incidents/recovery	• Store and analyze operation logs (forensics, e.g.) • Conduct mock tests against cyber attacks • Service continuity (duplication, backup, recovery, e.g.)
User security	• Tighten security of environment for online banking users • Expand the use of IC cards • Offer education for online banking users
Next-generation security	• Big data, Next generation web technology, Cloud computing, Security Standard • FDS: Fraud Detection System

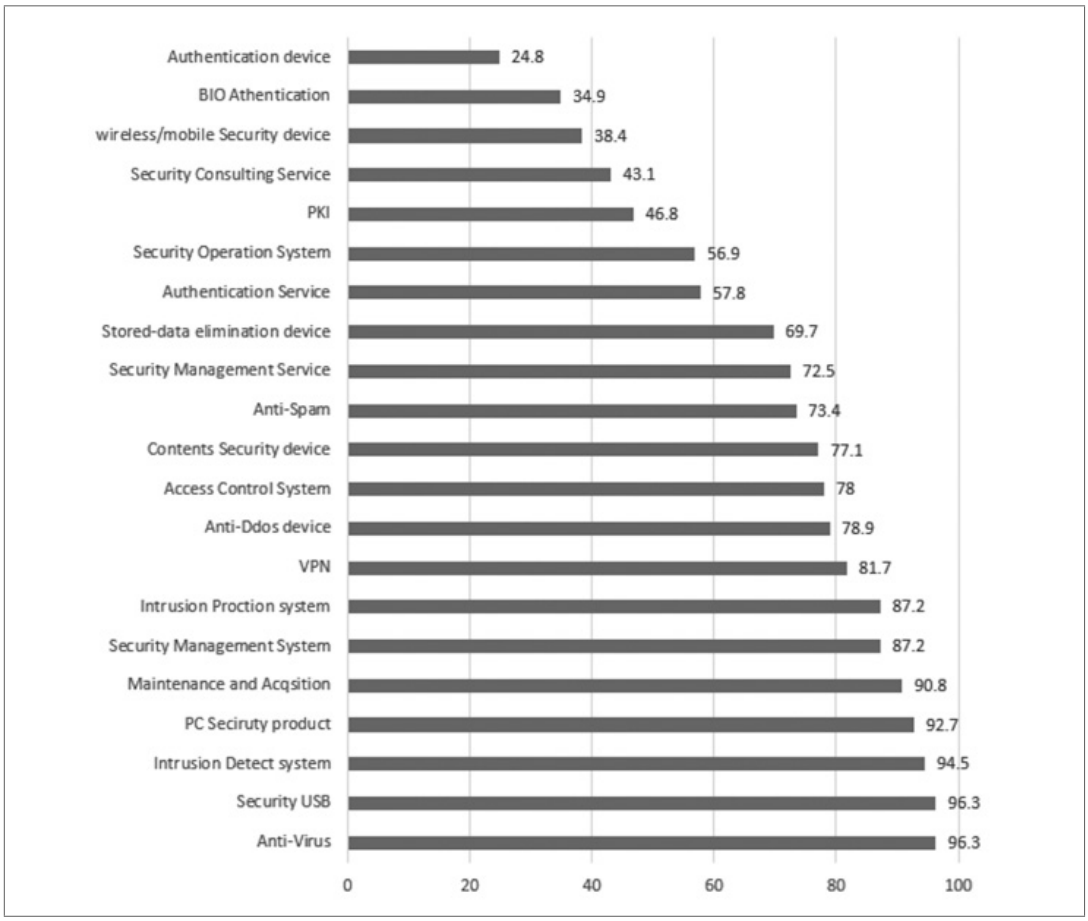
Source: Kangyu Cho, Sangshik Min, Jaemo Seung, 2013, Study on technology against digital finance security threat (Actions against security threats), KIISC (Korea institute of information security and cryptology)

It is necessary to build a system to implement organized and continuous protection of private information so as to minimize the possibility of privacy infringement caused by carelessness and mismanagement, and also to organize trustworthy security teams and build systems for constant management for monitoring and efficient reporting in case of incidents. In addition, systematic management of contractors and vendors is needed to prevent data breaches, and training programs should be offered for internal staff of financial organizations to develop professionals who can integrate financing and security.

Structural improvement needs to be made to prevent the breaches and hacking of private keys by strengthening POS security systems and introducing a new type of cards with internal embedded memory to store critical information encrypted by PUF (Physical uncopyable Function) keys. The PUF is a function to generate values using process transition in the semiconductor manufacturing process. It generates different values from each semiconductor, acting as a semiconductor's fingerprint.

Financial institutions need to take their own measures, such as improving their financial server management systems. Figure 3-15 shows how Korean organizations used information security products and services in 2014 (where multiple answers are allowed). Most of the respondents were found to use several products and services together to counter diverse forms of threats. Over 90 percent of the organizations responded that they were deploying anti-virus, security USB tools, firewall, PC security products and maintenance and support services.

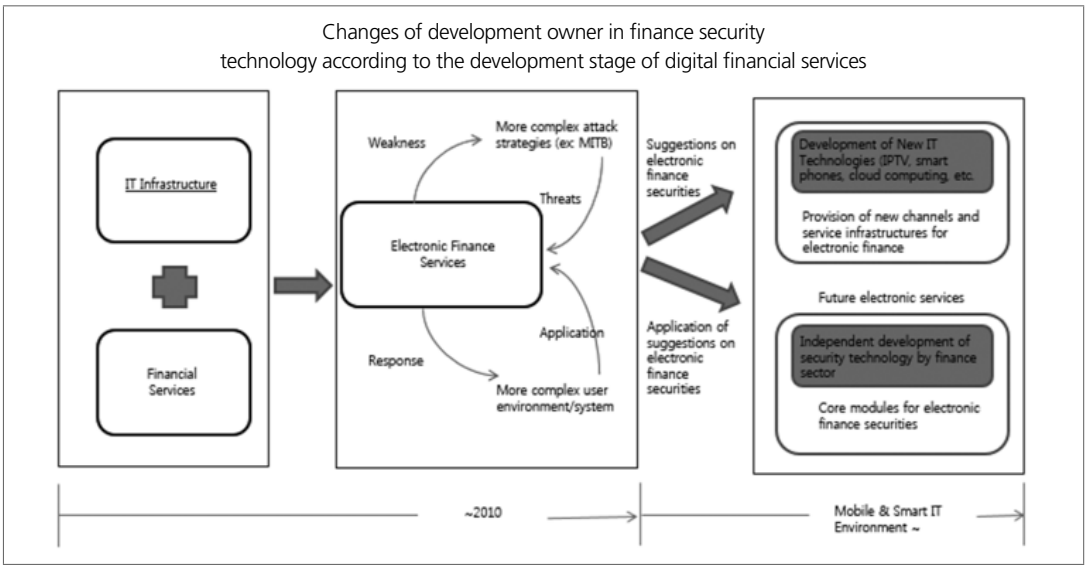
Figure 3- 15 | Use of information security products and services



Source: National Intelligence Service, 2015, White Paper on National Information Security 2015, NIS & KISA

Both online banking users and financial organizations should continue to bear the burden of software management and maintenance. Even though powerful verification techniques such as multi-factor verification have been put in place, complicated and sophisticated attacks did not stop. Meanwhile, more powerful and complex verification techniques run against the demand for more convenient user services.

Figure 3- 16 | Changes of development owner in finance security technology



Source: FSA, 2010, Outlook of the latest overseas financial security technology, FSA (Financial Security Agency)

4) Measures by Individual Organization

Countermeasures against cyber-attacks can be more effective when relevant organizations work together and respond to them in comprehensive and integrated ways.

a) Financial Security Institute (http://www.fsec.or.kr)

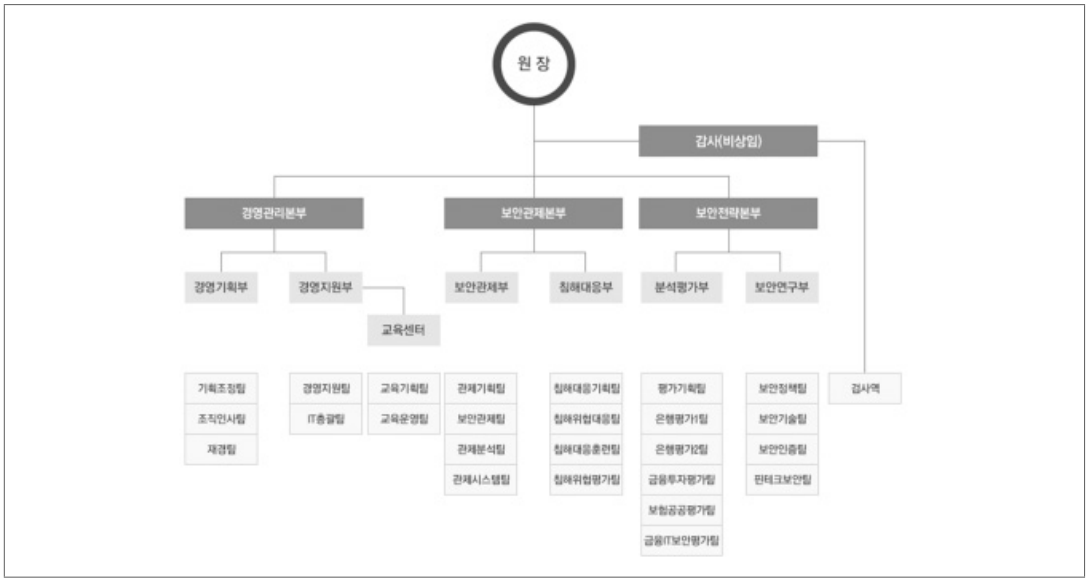
The Financial Security Institute is an organization established to make contributions to more convenient services for financial users and the development of the financial industry by creating a safer and more reliable financial environment. It was founded in April 2015 to offer comprehensive financial security services, ranging from integrated security control and countermeasures against attacks, sharing of information and analysis and evaluation of vulnerabilities to research on financial security policies, verification of financial security and security evaluation of new technologies and services.

Starting in October 2015, the organization begins to build and run a test bed for the analysis and evaluation of vulnerabilities of online banking infrastructure and public websites. The Financial Security Institute will build a test bed similar to the operation systems of financial institutions in an effort to offer more professional and organized analysis and evaluation. The test bed consists of common components of financial systems, such as servers, database, web applications, networks and security equipment.

The Financial Security Institute will use the test bed to understand different circumstances of each financial institution and develop measures to check for new vulnerabilities and security issues, offering fast, efficient and accurate analysis and evaluation of vulnerabilities. The test bed is also

expected to help offer more stable analysis and evaluation of vulnerabilities, provide more advanced technologies for checking and conduct more professional analysis and evaluation of vulnerabilities.

Figure 3- 17 | Organization chart of Financial Security Institute



Source: Financial Security Institute website > Organization Dec. 5, 2015: http://www.fsec.or.kr/info/purpose.jsp

b) Digital Finance Fraud Prevention Commission

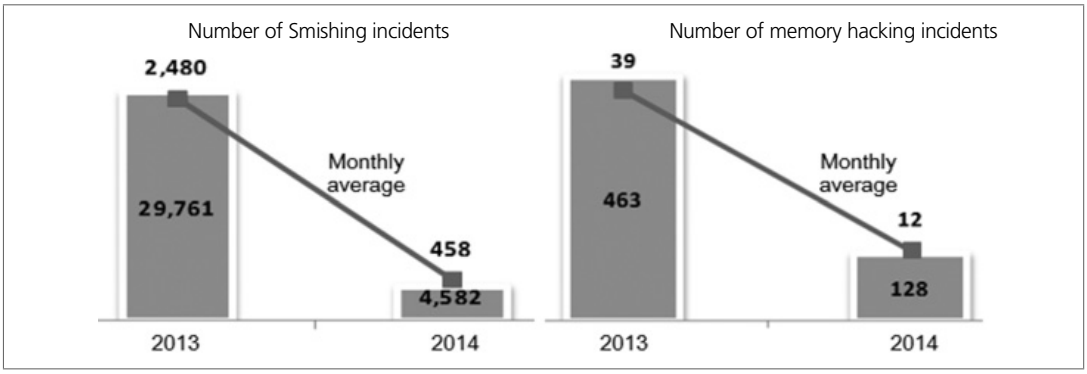
The Online Banking Fraud Prevention Commission was established in 2012 to counter online banking fraud under the partnership of several governmental agencies, which include the Financial Services Commission, the Ministry of Science, ICT and Future Planning, the Ministry of Justice, the Ministry of Public Safety and Security, the National Police Agency and the Financial Supervisory Service. The commission takes measures to prevent online banking fraud. Since the Plan to Prevent New Types of Online Banking Fraud was drawn up in August 2014, several measures have been in place for more powerful fraud prevention in the stages of money transfer and payment, which include the designation of deposit account ('Reliable Bankbook Service') and a new requirement to make it mandatory to use standard payment windows which incorporate so-called reliable payment service. It also works to improve technical capabilities to respond to new types of financial fraud by expanding the scope of its control into Smishing and pharming, and build a fraud response and detection system. In addition, it is collaborating with foreign organizations (Korea-China Police Cooperation Meeting) and conducting public campaigns (subway, KTX).

As a result of these efforts, new types of financial fraud, such as Smishing and memory hacking, which takes advantage of technical vulnerabilities of mobile devices, has decreased remarkably. While the number of Smishing attempts has grown, the actual damage has diminished by over 80 percent over the previous year thanks to such measures as early shutdown of malicious app servers.

The number of memory hacking incidents has also dropped considerably about 70 percent after keyboard security programs have been improved.

Figure 3- 18 | Change in the number of fraud incidents

(Unit : incident case total/monthly average)



Source: National Police Agency, 2014, digital financial fraud prevention measure, Digital Finance Fraud Prevention Commission

However, with preventive measures focusing on technology-based fraud, the number of voice phishing incidents, which has been dropping since 2011, began to grow again in 2014.

* Number of monthly average incident: 200 (Jan. - Oct. 2013) 327 (Jan. - Oct. 2014)

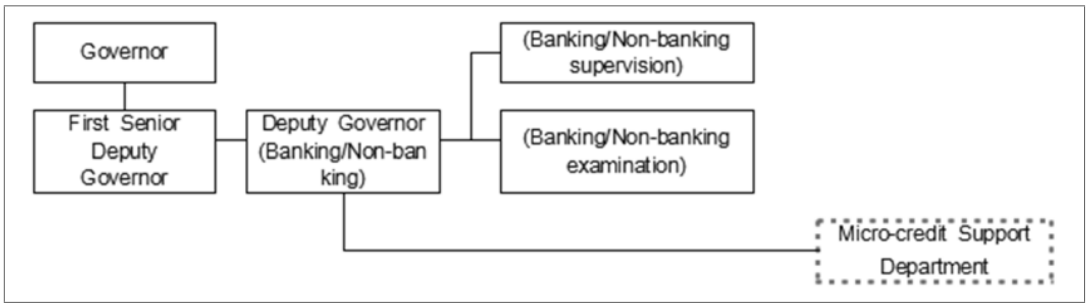
* Number of people arrested: 360 (Jan. - Oct. 2013) 487 (Jan. - Oct. 2014)

c) Financial Supervisory Service (http://www.fss.or.kr)

As part of its efforts to prevent financial scams, the Financial Supervisory Service is working to eradicate the use of fake bankbooks, which are major tools for crimes. The organization implements a plan to block the illegal distribution of fake bankbooks by imposing internal control of new account opening within the financial sector and encouraging the transaction blocking system in accordance with the terms and conditions of financial transactions. It also made a joint declaration together with the law enforcement to prevent damage, running a website (http://phishing-keeper.fss.or.kr) designed to prevent financial fraud so as to offer people an opportunity to experience voice phishing on the website and raise awareness of the fraud among the general public.

The organization is requiring branches of financial institutions to cooperate with the law enforcement in rounding up criminals by introducing a system to stop the withdrawal of illegally acquired funds. It also runs a financial fraud hotline (dial 1332) to prevent damage and secondary damage through reporting.

Figure 3- 19 | Organization chart of Financial Supervisory Service



Source: Financial Supervisory Service > Organization Chart, Dec. 5, 2015, http://english.fss.or.kr/fss/eng/wpge/ eng115.jsp

The efforts to prevent online banking fraud are made mainly by the Micro-credit Support Department, which is responsible for preventing financial scams, eliminating the use of fake bankbooks, monitoring illegal financial transactions and refunding losses from financial fraud. The department is running a website called Micro-credit 1332 Service, which offers information on how to avoid phishing fraud and deal with it and how to get a refund for losses. People can experience how voice phishing works on the website.

Figure 3- 20 | Financial Supervisory Service, phishing fraud site in 'Micro-credit 1332 hotline'

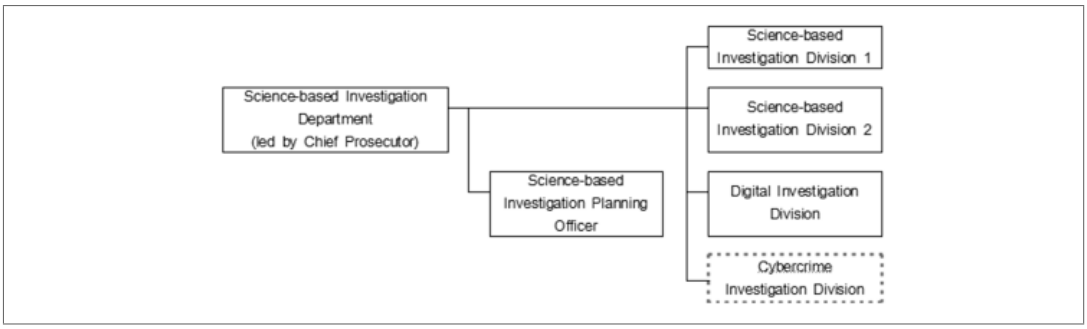


Source: Financial Supervisory Service, Micro-credit 1332 hotline > phishing fraud, Dec. 5, 2015: http://phishing-keeper.fss.or.kr/fss/vstop/main.jsp

d) Cybercrime Investigation Division of Supreme Prosecutors' Office (http://cybercid.spo.go.kr)

The Cybercrime Investigation Division under the Science-based Investigation Department deals with online banking fraud within the Supreme Prosecutors' Office. The Science-based Investigation Department was established to proactively respond to highly advanced crimes which are becoming increasingly intelligent and professional, and to provide more fast and efficient support for science-based investigation at local branches. Established in February 2015, the department has 1 planning office, 4 divisions and 130 professionals. After going through a reorganization process, the Cybercrime Investigation Division can now effectively respond to cyber terror, hacking attempts and other online crimes threatening national security, financing and economy.

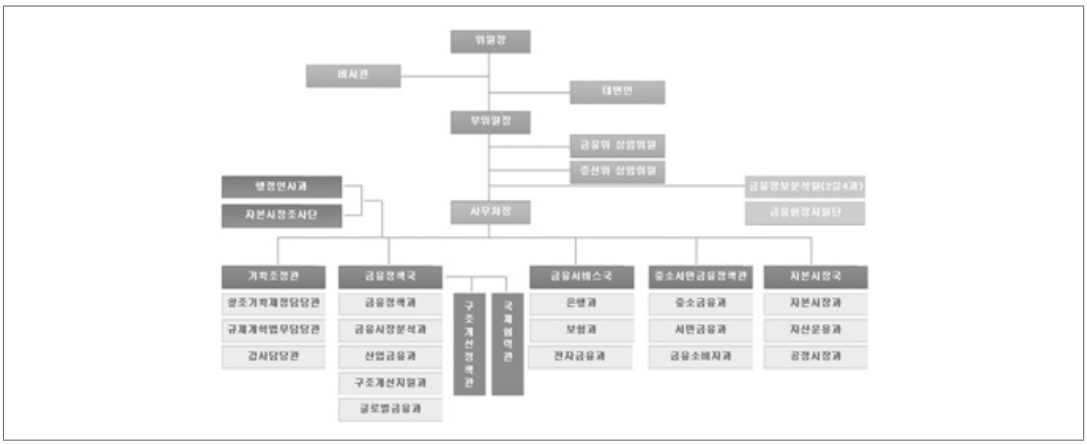
Figure 3- 21 | Organization chart of Cybercrime Investigation Division of Supreme Prosecutors' Office



Source: Cybercrime Investigation Division of Supreme Prosecutors' Office > Organization Chart

e) Financial Services Commission (http://www.fsc.go.kr)

Figure 3- 22 | Organization chart of Financial Services Commission



Source: Financial Services Commission > Organization Chart, Dec. 5, 2015: http://www.fsc.go.kr/eng/new_ about/organization_chart.jsp?menu=08

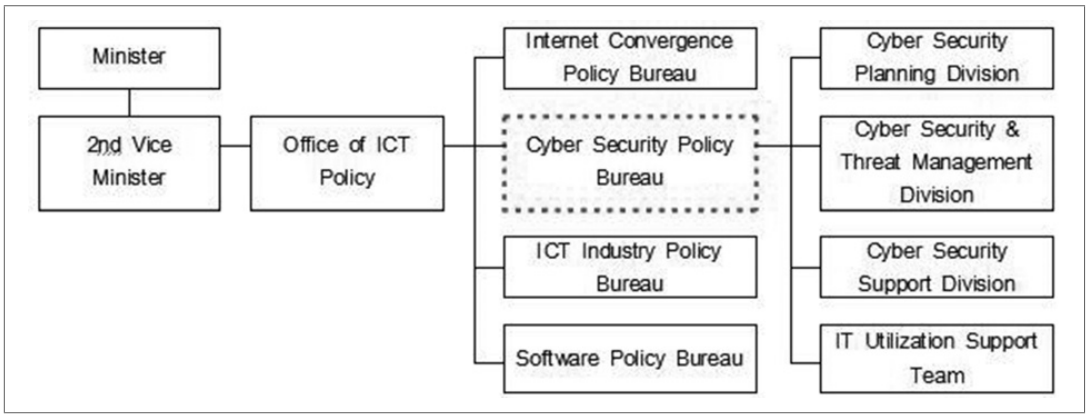
The Financial Services Commission was founded in January 2008. The Electronic Finance Division under the Banking & Insurance Bureau is responsible for issues related to online banking fraud. The division develops policies on online financial transactions and security plans for online banking, and takes care of issues related to system improvement, the permission/ registration/ supervision of online banking industry, the protection of national infrastructure for the financial sector, risk management, the protection of major IT equipment for the financial sector, policy development on the return of damage from online banking fraud and system improvement.

f) Ministry of Science, ICT and Future Planning (MSIP) (http://www.msip.go.kr)

Under the 2nd Vice Minister's Office, which is responsible for ICT-related issues, the Internet Convergence Policy Bureau and the Cyber Security Policy Bureau take care of online banking issues. The Office of ICT Policy has the Internet Convergence Policy Bureau in it to promote convergence services such as IoT and Fintech, and also the ICT Industry Policy Bureau to support the development of Korea's ICT industry. The Cyber Security Policy Bureau is a division specialized in cyber security.

The main responsibilities of the Cyber Security Planning Division include; developing, overseeing and adjusting policies on information security in the private sector, researching and revising laws and systems on information security, providing support for domestic and international cooperation for information security and overseas business, developing and implementing major policies related to the information security industry and encouraging technology development and the growth of industry for information security.

Figure 3- 23 | Organization chart of Financial MSIP



Source: MSIP website > Organization chart Dec. 5, 2015: http://english.msip.go.kr/english/msipContents/ contents.do?mId=Mjg1

The Cyber Security & Threat Management Division is responsible for overseeing information security systems in the private sector, including overseeing policies on the prevention of and response to cyber-attacks in the private sector, protecting major ICT infrastructure in the private sector and authorizing information security management systems.

g) National Police Agency Cyber Bureau (http://cyberbureau.police.go.kr)

The Cyber Bureau classifies cybercrimes into three areas; information network infringement, crimes involving the use of information network and illegal content, and it offers education programs and campaigns to help people avoid losses from cybercrimes, develops sophisticated techniques cooperate with relevant organization and make active prevention and investigation efforts through international cooperation.

Table 3- 14 | Classification of cybercrimes by cyber bureau

Class	Kinds of cybercrimes
Information network infringement	• Infringe computers or information networks (computer systems) without valid authority or beyond permitted authority to access, damage/ delete/ alter system and data programs or cause disruptions (performance impairment, system failure) - Hacking (account theft, simple intrusion, data breaches, data damage) - Denial-of-Service attacks (DDoS, e.g.) - Malicious programs - Other crimes infringing information network (new types of crimes, e.g.)
Crimes involving the use of information network	• Use information networks (computer systems) as tools to commit acts which constitute fundamental components of crimes - Internet fraud (crimes involving direct transactions, online shopping malls, gaming and other Internet fraud using messenger services) - Online banking fraud (phishing, pharming, Smishing, memory hacking) - Privacy and location information infringement - Cyber copyright infringement - Email spam - Other crimes using information networks
Illegal content	• Distribute, sell, lease or display goods, services or information prohibited by law via information networks (computer systems) - Cyber pornography (general, child) - Cyber gambling - Cyber defamation and insult, cyber stalking - Crimes involving other illegal content

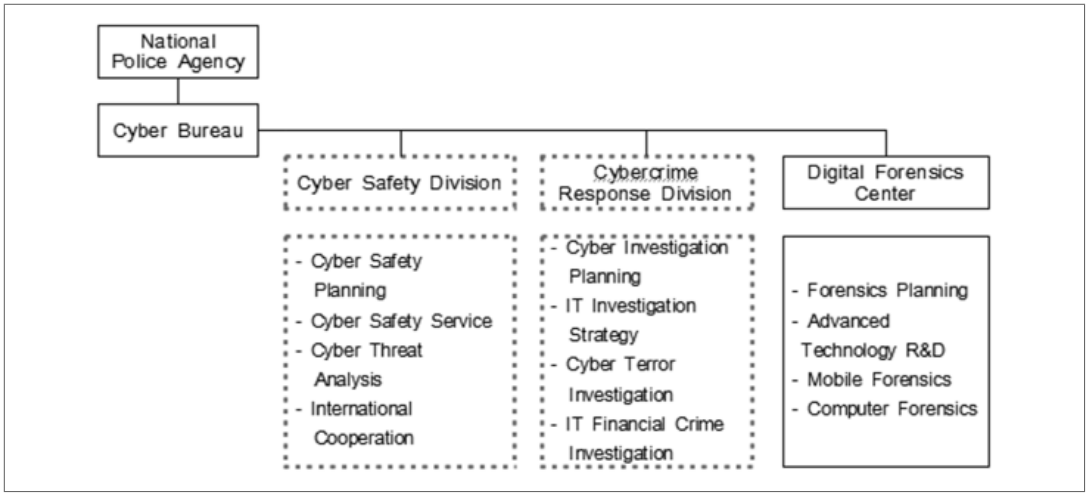
Source: National Police Agency Cyber Bureau website, http://cyberbureau.police.go.kr/index.do

The bureau cooperates with relevant companies and organizations, including financial institutions (banks, securities companies), telecom companies (mobile communications companies) and security companies (vaccines), in order to;

- Issue alerts when threats are detected and prevent damage early
- prepare procedures to cooperate with the private sector in relation to media reports
- have a pool of cybercrime professionals from the private and public sectors
- build a real-time collaborative response system to immediately analyze the type of crimes and malicious codes when new types of crimes are reported

The collaboration systems in place include sharing early alerts (Financial Supervisory Service, Financial Services Commission, Korea Federation of Banks), stopping the spread of malicious codes (Korea Internet & Security Agency, security companies, mobile communications companies), improving the mobile phone micro payment system (Ministry of Science, ICT and Future Planning, mobile communications companies, payment agencies, game companies) and taking care of security of financial systems (Financial Supervisory Service, Financial Services Commission, financial institutions) and smartphones (MSIP, mobile phone manufacturers, security companies).

Figure 3- 24 | Organization chart of National Police Agency Cyber Bureau



Source: Cyber Bureau website > Organization chart, Dec. 5, 2015: http://cyberbureau.police.go.kr/eng/ bureau/sub_3.jsp

h) Korea Internet & Security Agency (http://www.kisa.or.kr)

The Korea Internet & Security Agency is an organization carrying out activities to protect personal information and responding to privacy infringement on the Internet. For online banking, it diagnoses the safety level related to information security, responds to incidents of privacy infringement, certifies information security management systems and conducts activities for the protection of personal information.

The diagnosis of the safety level related to information security is a system that requires major ICT service providers, ICT facility providers and online shopping malls to get verified every year for the compliance of the instructions on the methods, procedures and commissions of information protection measures and safety diagnosis. The organizations to go through the procedure can show the stability and reliability of their ICT networks and services by taking management, technical and physical protection measures and getting verification on their compliance with the related standards.

It runs the KrCERT/CC Korea Computer Emergency Response Team Coordination Center through the Korea Internet Security Center (KISA), which the agency opened in 2003 in an effort to build a

collaborative system for responses to network infringement and network operators and provide a single channel for responding to international incidents. The center is carrying out the following activities.

- Operate a control center for 24 hours round the year to detect signs of incidents and to respond to them in early stages
- Analyze incidents to come up with countermeasures against the security vulnerabilities of software and malicious codes used for hacking attempts and develop response technologies
- Prevent hacking incidents and take responsive measures by analysing hacking incidents, providing technical support and improving response capabilities
- Collaborate with domestic and international organizations in responding to incidents by sharing information and stopping damage from spreading

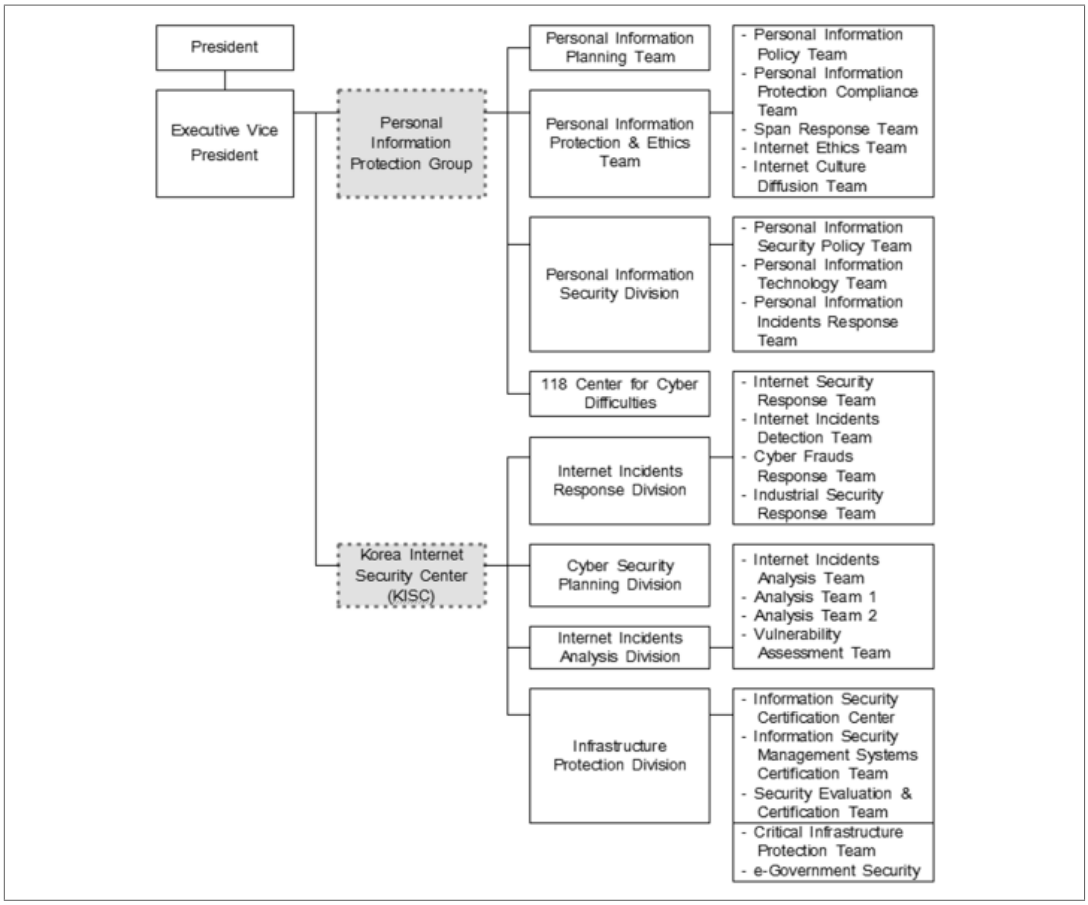
The agency also runs the Privacy Infringement Reporting Center and the Dispute Mediation Commission for fast resolution of incidents and disputes. They are conducting the following activities.

- Distribute i-Pin as a replacement to resident registration number: Introduced an i-Pin service in an effort to prevent identity theft and privacy infringement caused by the excessive collection and use of resident registration numbers on the Internet. An i-Pin is a tool to verify identification without using resident registration number on the Internet. Introduced in 2005 to minimize the collection of resident numbers on the Internet, it helps prevent the breaches of resident numbers as it removes the need to leave them on websites, and it enables the detection of theft as it sends email notices to i-Pin holders in real time whenever it is used.
- Respond to the breaches and exposure of personal information: The personal information exposed on websites can be abused in cybercrimes, such as illegal email spamming and voice phishing. In order to prevent additional abuse and misuse of personal information, a range of policies have been implemented to deal with the breaches and exposure of personal information. It is possible to search for exposure of 9 types of personal information including bank account numbers and credit card numbers on the "Response System to Personal Information Exposure." A joint hotline for responsive measures was opened, and as the resident registration numbers of many Korean people have been exposed on foreign websites, a collaboration system was built to check for exposure of the numbers on websites of 45 nations including China and Vietnam.
- Distribute the Personal Information Management System (PIMS): With recent increases in personal information breaches, it is now needed to offer businesses a management system for systematic and consistent protection activities so as to minimize the possibility of privacy infringement. The PIMS is a personal information protection certification system that the Korea Internet & Security Agency developed by taking into consideration of personal information protection measures specified by domestic and international standards (KISA-ISMS, ISO/IEC 27001, e.g.) and the Act on Promotion of Information and Communications Network Utilization and Information Protection and Korea's unique circumstances. Like the management cycle of

common business control, the management procedure has a cycle of planning stage → execution stage → reviewing stage (review the results against existing plans) → incorporating stage (incorporate the review results into next plans), and this cycle repeats.

Certification of Information Security Management System (ISMS): The ISMS is a comprehensive system for information security activities. The criteria for ISMS certification consists of 3 components; process of information security management, documentation and information security measures. Building and running an ISMS in an organization requires; understanding its information assets, analysing the risks of the assets, selecting and implementing information security measures, and finally, improving the measures through continuous monitoring and internal audits. The certification of ISMS is a system where a business with ISMS applies for certification and a certifying organization determines whether it meets the criteria. It was introduced in 2002, and the Korea Internet & Security Agency is working as a certifying agency.

Figure 3- 25 | Organization chart of Korea Internet & Security Agency



Source: Korea Internet & Security Agency website > Organization chart, Dec. 5, 2015: http://www.kisa.or.kr/eng/ aboutkisa/ organization.jsp

3.1.5 Recent Financial Service Techniques

Security technologies for financial services have been enhancing a security measure related to a mobile device, the Internet of Things (IoT), big data, and a cloud system. Further, a biometric authentication service for individual authentication and verification, a Fraud Detection System (FDS) have been emerging as an analytical method. Also, an Internet primary banking service has been emerging as a financial technique. With this, an integrated security control system for preventing information drain is required.

1) Internet primary bank (Web-based bank)

a) Overview

The difference between Internet primary banks and conventional banks is based in the notion that Internet primary banks use electronic means such as the Internet and ATMs to conduct transactions and other businesses. At the initial stage, these Internet primary bank conducted transactions without any branches, and were called Direct Banks, Pure-play Internet Banks, Internet-only Banks, Virtual Banks, or web-based Banks; however, more recently, with the emergence of mobile channels, these banks are now referred to as digital banks, differentiating themselves as a legal entity from conventional Internet banking services, which provide conventional bank services via the Internet.

Table 3- 15 | Differences between conventional banks and Internet primary banks

Differences	Conventional banks	Internet primary bank
Main channel	Branches	Online (Mobile & Web)
Opening hours	9:00~16:00 weekdays	24/7
Products	Different products for online/offline banking services	No differentiation in products
Services	Full banking service	Specialized mainly Retail Banking
Miscellaneous	Specialty obtained through face-to-face services	Special treatment for interest rates and commissions via cost saving

Source: Woori Financial Research Institute (http://www.wfri.re.kr) & KERI (Korea Economic Research Institute, http://www.keri.org)

The above table shows that an Internet primary bank (IPB) has an advantage in that an interest rate and fee are cheaper than a conventional bank and a transaction without time and space constraints is possible. The benefits which consumers can get through the IPB are described as follows in terms of banking transactions.

Table 3- 16 | Expected effects for Internet primary banks by business process

Type	Before the introduction of Internet primary bank	After the introduction of Internet primary bank	Expected Effects
Opening Bank Accounts	Visit bank branches to open accounts	Open bank account on the web or with Smart phone without visiting any branches	Resolves spatial limits for financial transactions
Payments	Different service providers: banks, payment companies, and shopping malls.	Providing integrated service such as simple payment and saving payment points	Improving consumer payment convenience and benefit
Loans	Credit evaluation by asset	Evaluation by utilization of big data, including information for electronic commerce	Expansion of mid-rate loans for consumers with low credit
Asset Management	Face-to face consultation with professional consultants	Consultation through automatic portfolio analysis and suggestion programs	More consumers can use asset management services

Source: Financial Services Commission (http://www.fsc.go.kr)

However, when an IPB is introduced, initial investment expenses of the IPB are high. Thus, when the IPB fails to attract consumers at an optimal level, the IPB may become insolvent due to profitability degradation. The IPB-related positive and negative effects are like the below.

Table 3- 17 | IPB-related positive and negative effects

positive effects	Negative effects
Increase in consumer utility in terms of interest rate and fee, accessibility and service type	possibility of oversupply according to market entry and expansion characteristics
Change in existing channels, branches and strategies according to rationalization for real name confirmation	Growing apprehension that the IPB will become insolvent when initial revenue model is weak
Facilitating competition between banks and IT availability	possibility of profitability and financial solvency degradation
Activating overseas expansion and compensating the defects of banks short of branches	possibility of decrease in reliability of banking industry when insolvent banks emerge

Source: KERI (Korea Economic Research Institute)

b) Main configuration of Korean IPB (K-IPB)

IPB may mainly consist of financial institutions and ICT enterprises that will supply channels which can be accessed anywhere and products and services can be customized for timely needs of customers. Their key roles are presented in the table below.

Table 3- 18 | Main configuration of Korean IPB and their key roles

Type of companies	Key roles
Financial institution	Auditing, risk management, financial product design, financial transaction of customer, and banking infrastructure building competency
Mobile carrier & IT device manufacturer	Mobile network building/management competency, authentication solution, and precise customer information
Platform service provider (portal, SNS and instance messenger)	Mobile customer platform, search history for each customer and social network information, and big data analysis competency
Product sales innovation	Enhancement of accuracy rate of financial product sales by recommending timely product which customer wants, using big data and mobile technology

Source: Korea Institute of Finance (https://www.kif.re.kr/kif2/main/)

c) Competitiveness of Korean IPB

It is possible for Internet primary bank in South Korea to quickly form customer based system and reach a break-even point by innovation of cost structures and sales of products. Competencies of these Internet primary banks are listed below [table 3-19].

Internet primary banks maximize convenience for customers by enabling money transfers through telephone numbers for smart phones or via messenger instead of account numbers, and by simplifying the certification process using passwords or finger scans instead of conventional certificates or security cards, to offer high level services in money transferring when compared to conventional online or mobile banking.

Here are the main points concerning the competitiveness of Internet primary banks.

Table 3- 19 | Competitiveness of Internet primary banks

Competency type	Main contents
Building customer database swiftly	- Deploy by attracting customers through partnership with ICT service providers within short period
	- Grow swiftly without separated sales networks by allowing customers to open accounts using their smartphones
Innovation of cost structure	- Reduce large-sized marketing expense by sharing customer of partner companies - Provide customer service at low interest rate by reducing off-line branch operation cost
Innovation of product sales	- Using big data and mobile technology, enhance 'accuracy rate of financial product sales' by recommending timely product which customer wants,

Source: Korea Institute of Finance (https://www.kif.re.kr/kif2/main/)

In order for K-IPB to have competiveness power, it should meet the requirements below.

- The K-IPB maximizes customer convenience by allowing customers to wire money using smartphone numbers and instance messengers instead of their account numbers and provides such convenience entirely different from existing Internet and mobile banking-related wiring service by allowing them to simply perform user authentication using their passwords and fingerprints.
- The K-IPB utilizes big data such as search and location information of a site with customers' consent to recommend timely and optimal financial products meeting their moving lines and needs, thereby providing financial services which they need.
- The K-IPB recommends optimized financial products to customers through personalized service corresponding to their financial patterns through intelligent asset management services.
- The K-IPB provides customers with counselling services similar to offline services by allowing them to take counsel with counsellors online in real time, and meets their needs by providing special features to them, such as transferring visualized data to their smartphone screens in real time while they are calling.

2) Biometrics

Personal information protection problems have been emerging as main social issues along with various payments and wiring services, thereby continuously raising the importance of biometrics-related technologies such as fingerprint and iris recognition. The combination of biological characteristics of human beings and ICT technologies has rapidly replaced exiting password-centred identification and authentication systems with biometric technologies for identifying individuals themselves. The biometric technologies are widely applied to industrial fields, such as finance, communication and security, as a means for preventing dishonest user authentication and system use, and an electronic payment through the illegal ways.

Unlike existing password-centred technologies (e.g. user authentication through an accredited certificate, a security card, OTP and SMS), the biometric technologies have an advantage in that the technologies have reduced the risk of information drain, loss and oblivion and a good security level, and are convenient. However, methods for improving laws and regulations for privacy piracy caused by introducing biometric technologies, standardization of the relevant technologies, and use and management of biometric information are required.

Other than a biometric method for smart devices fingerprint recognition, iris recognition and facial recognition methods may be applied.

- Fingerprint recognition scheme

Fingerprint recognition technologies applied to high-end smartphones and tablets are referred to technologies for electronically reading a user's fingers to compare those fingers with pre-stored fingerprint data on a bending or curved point and capacitive sensing, thereby identifying the authenticated user. Those fingerprint recognition technologies provide consumers with

excellent security and convenience to such an extent that they use those technologies as a substitute for password and user verification at the time of unlocking their smartphones and using payment and wiring services. Eventually, a Touch Screen Panel (TSP) which enables people to perform user authentication by only touching a screen itself is expected to emerge. In this case, it will provide excellent user convenience which is an improvement over current versions of this technology.

- Iris recognition scheme

Iris recognition technologies applied to high-end smartphones and tablets which will be released soon refer to the technologies for electronically reading a user's eyeballs through infrared camera and LED to compare eyeballs with pre-stored iris data based on its' shape and colour of irises and shape of retina capillary vessel, thereby identifying the authenticated user. Nokia and Fujitsu have since released a smartphone having iris recognition technologies applied to its device. Unlike fingerprint recognition technologies which were recently commercialized, iris recognition technologies can also identify whether a user is an authenticated user by using non-contact methods. These technologies do not make consumers uncomfortable and provide more excellent security and user convenience thereby they represent excellent means for financial customer protection.

- Facial recognition scheme

Facial recognition technologies have been applied to smartphones and tablets using the 4.4 version of Google Android operation system. It refers to the technologies for electronically reading a user's face through a front camera to compare the face with pre-stored facial data on nose, mouse and eyes of the user, thereby identifying the authenticated user. The security for this kind of technologies is the least reliable among various kinds of biometric technologies. However, the technologies use a non-contact scheme to check whether the user is an authenticated user. Thus, they have an advantage in that consumers have no objections.

The fingerprint recognition scheme has an advantage in terms of low development cost. However, it has not prevented utilization of a replication technology such as modelling in silicone or 3D printer from removal of an authentication barrier. Further, the fingerprint recognition scheme makes a user feel inconvenient in that the user authenticates who he/she is, using a contact scheme. On the other hand, excluding the fact that high development cost may raise a releasing price, the iris recognition scheme has better security and convenience than the fingerprint recognition scheme. Further, the facial recognition scheme has excellent convenience in that development cost is low and the user authenticates who he/she is, using a non-contact scheme. However, since a low-resolution front camera traces the user's face, there may be a security problem in that even a general picture unlocks the user's smartphone screen.

Table 3- 20 | Comparison of biometric technology methods

Type	Fingerprint recognition	Iris recognition	Facial recognition
Security	★★★☆☆	★★★★★	★☆☆☆☆
Convenience	★★★☆☆	★★★★★	★★★★★
Cost	★★★☆☆	☆☆☆☆☆	★★★★★

Source: assessment of the consultants

As major companies tend to import the digital device itself of authentication system such as new sensor, FIDO and touch ID, the biometric recognition method will be widely used in the near future. Activation of biometric recognition security will lead users to enhanced security so as to feel convenient for unlocking a digital device or purchasing and paying for a product. In the midst of this trend, more companies appear to increase introducing a biometric security system in order to reduce dependency on password-based authentication systems.

3) Integrated security control system

The information protection industry has sustainably been growing bigger, based on the need to have enhanced customer protection and to deal with security accidents. Korean enterprises have neglected investment in the information protection until recently. But, since various security accidents such as customer information drain take a heavy toll on their corporate images and material things, they are trying to prevent security accidents by expanding investment in information security. With this, they have introduced various corporate security-levelled security solutions and built separate management systems for easily managing those solutions. As new security solutions are introduced to those companies, inconvenience caused by adding management systems and staff for the solutions is increasing. However, since an integrated security control system can analyze not only the solutions but also correlation between work efficiency in terms of management and collected information together, the companies can efficiently cope with security accidents.

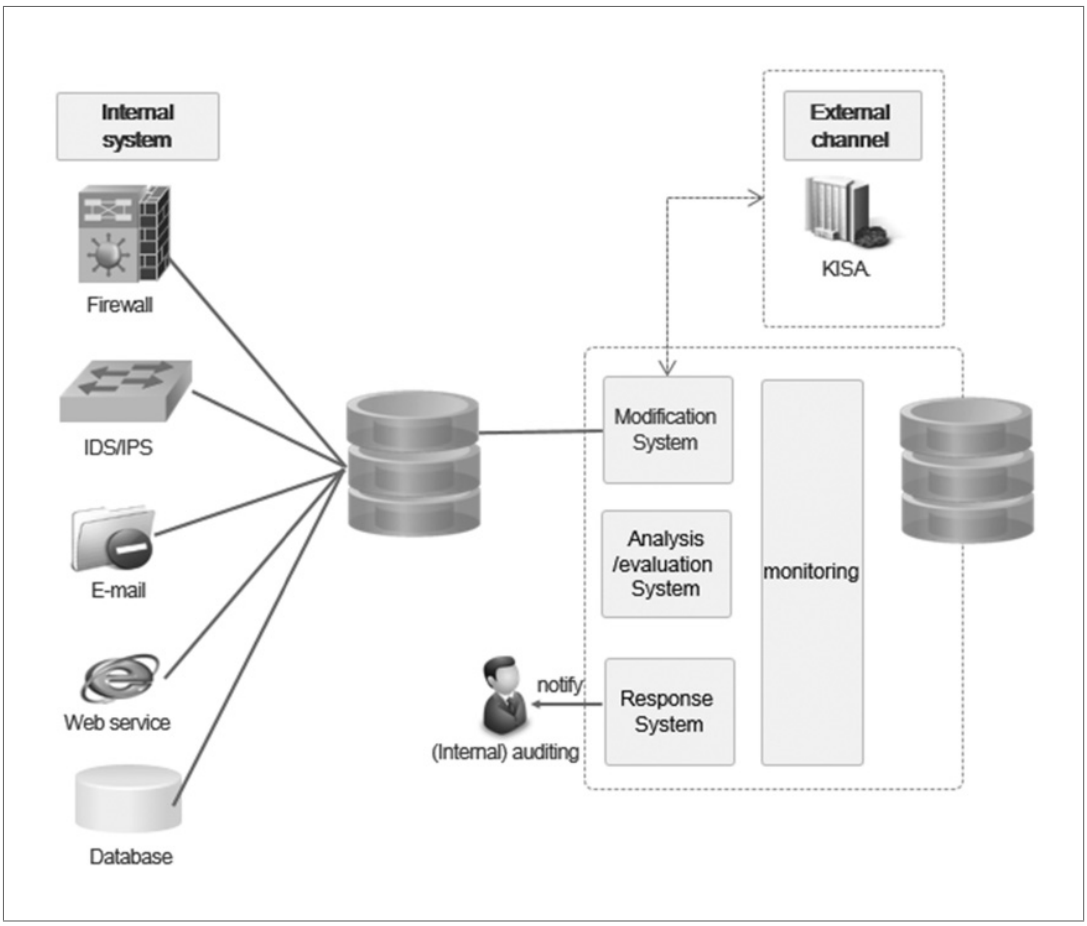
A threat may occur inside a financial institution, variously involving information drain through an Advanced Persistent Threat (APT) and insiders conspiring against their companies, an unauthorized data access, and a random data change. A threat-related act is performed through user terminals such as PC, laptop computer, and smart device, and a security program used for normal use procedure is installed to use an intra-network. Thus, various logs occur and are recorded. Security people can check whether there is a threat through the recorded logs. But, detection accuracy is not that high.

A person in charge of dealing with personal information is detected by an information detection program every time. However, this is a normal task so that it's hard to determine whether he/she performs a wrong act. Thus, it is possible to perform comprehensive threat analysis by checking whether personal information is recorded inside a generated file or by checking whether there is an existing mail list sending history after making a request for releasing an encoded file.

A case where a series of accidents are written based on a scenario and an act is sequentially or similarly performed according to the scenario may be regarded as a fraud act, and a case where the range of a traffic exceeds with a normal figure range such as a case where some person has personal information more than usual or generates a traffic more than usual needs also regarded to be a doubtful case.

The integrated security control system collects and analyzes all information generated inside a financial institution. Thus, the amount of information collected from users may be considerable according to the scale of the users. Some financial institutions use this kind of information as a means of protecting them from a technical threat caused by a financial task. However, those institutions utilize the information by expanding the utilization range of collected information such as an internal auditing. The bigger the size of collected data is, a big data analysis technology is more likely to be required. Therefore, the integrated security control system is configured to allow generated data inserted into big data so as to enable efficient analysis.

Figure 3- 26 | Internal block diagram of integrated security control system



Source: SeungWoo Han, 2015, e-finance and finance security-FDS usage and prospects, FSI (financial security institute)

3.2. Analysis of Laws and Regulations

3.2.1 Status of Laws and Regulations for Financial Consumer Protection in Korea

1) Development of Laws and Regulations

As early as 1980, Korea has enacted laws and regulations for consumer protection regarding financial activities, and amended them in accordance with issues including financial policies and financial crime. Examples of enactments and amendments of these laws and regulations include Framework Act on Consumers (1982), Act on Promotion of Information and Communication Network Use and Protection of Information, depositor Protection Act, Act on Real Name Financial Transaction and its Confidentiality, Electronic Signature Act, Regulations for Digital Finance Supervision, Digital Finance Transaction Act, Personal Data Protection Act, Law for Telecommunication Financial Fraud Prevention and Damage Reimbursement, among others.

Table 3- 21 | Development of laws and regulations on consumer protection in digital financial services in Korea

Period	Key Issue	Laws and Regulations	Summary
1980s	• Movement for consumer protection started in the late 1960s • Establishment of the Consumers Union of Korea in 1970 and Korea National Council of Consumer Organizations in 1978 • Establishment of the national policy for the price stabilization in 1979 • Integration of scattered laws and regulations regarding consumer protection in 1979	Framework Act on Consumers (Enacted as the Consumer Protection Law in 1980, reformed as the Framework Act on Consumers in 2006, and amended in 2011)	• Definition of the consumer, as the law for improvement of consumer rights and interests • Statement of clauses regarding the establishment of the Korea Consumer Agency (KCA) and consumer organizations, consumers' rights and responsibilities, and promotion process of policies for consumers
		Act on Promotion of Information and Communication Network Use and Protection of Information (Enacted as the Dissemination of Computer Network and Promotion of its Utilization Act in 1987, reformed as the Act on Promotion of Information and Communication Network Use in 1999, and amended in 2001)	• Enacted to improve the stability and reliability of security regarding accounts and transaction information • Statement of policies regarding consumer information protection along with the use of information communication services • Statement of clauses regarding standardization, certification methods, and security and stability of the information communication network • Statement of objectives to establish the Korea Internet & Security Agency (KISA) for the promotion of international cooperation, overseas promotion, and the advancement of the information communication network

Period	Key Issue	Laws and Regulations	Summary
1990s	• Publication of the 'Five-Year Plan for the New Economy' in 1993 • Enforcement of the 'Real-Name Financial Transaction System' in 1993 • Accidental leakage of customer credit data from a department store in 1994 • Publication of the 'Plan for Restructuring the Credit Financial Business' in 1996 • Integration of Financial Supervisory Agencies as a recommendation of the International Monetary Fund (IMF) in 1997 • Promotion of the development of technologies for electronic commerce as a national policy in 1997	Use and Protection of Credit Information Act (Enacted in 1995, and amended in 2015)	• Definition of credit information in commercial transactions • Statement of the types of credit business and business licenses or permits • Definition of the collection, search, procedure, distribution, use, and management of credit information • Statement of clauses regarding the protection of credit information
		Depositor Protection Act (Enacted in 1995, and amended in 2015)	• Definitions of deposit protection for depositors and insurance, such as deposit insurance • Statement of procedures when financial crimes occurs
		Act on Real Name Financial Transaction and its Confidentiality (Enacted in 1997, and amended in 2014)	• Enacted for the prevention of the evasion of the law, such as the secretion of illegal property, and money laundering • Statement of regulations for security regarding secret information revealed in transaction • Statement of clauses to use real names in financial transactions
		Act on Establishment of Financial Services Commission (Enacted as the Act on Establishment of Financial Supervisory Organizations in 1997, reformed as the Act on Establishment of Financial Services Commission in 2008, and amended in 2014)	• Definition of the establishment of the Financial Supervisory Commission and Financial Supervisory Service for consumer protection and the advancement of financial services • Statement of the operation and tasks of the Financial Supervisory Commission and the tasks and monitoring targets of Financial Supervisory Service • Statement of the establishment and tasks of the Financial Complaints Resolution Committee in charge of consumer protection in Financial Supervisory Service
		Specialized Credit Financial Business Act (Enacted in 1997, and amended in 2015)	• Definition of tasks and monitoring of financial companies specialized for credit business, e.g., to protect credit consumers and maintain the credit system • Statement of clauses to prohibit credit consumer information leaks and illegal usage, e.g., to protect credit consumer information • Statement of responsibilities of payment companies when credit card users' information is leaked

Period	Key Issue	Laws and Regulations	Summary
1990s		Electronic Signature Act (Enacted in 1999, and amended in 2014)	• Definition of concepts and technical regulations for e-Signatures to secure the stability and reliability of e-Documents and vitalize the use of e-Documents • Definition of the certification authorities in charge of certification, and certifications issued by these authorities
2000s	• Discovery of risk factors such as hacking in accordance with digital financial transactions in 2000 • Popularization of stock trading via digitalized methods in 2006 • Internet banking users exceed 10 million in 2006 • Introduction of new payment methods such as smart cards, mobile, e-Money, e.g., in 2006	Regulations for Digital finance Supervision (Enacted as the Regulations for Digital finance Services Supervision in Financial Institutions in 2000, reformed as the Regulations for Digital finance Supervision in 2006, and amended in 2015)	• Definition of the supervisory authority in digital finance • Statement that the supervisory agency has to regulate required clauses to secure the stability of digital financial transactions and protect consumers • Statement that financial institutions and financiers have to establish and operate an information protection committee to conduct deliberations and decision making regarding information protection
		Act on Registration of Credit Business and Protection of Finance Users (Enacted in 2002, and amended in 2015)	• Definition of the necessities regarding the registration and supervision of credit business • Statement of clauses to determine the standards to protect financial consumers in credit business and to put in place an inspector for the monitoring
		Digital finance Transaction Act (Enacted in 2006, and amended in 2014)	• Definition of digital financial transactions, a system for digital financial transactions, methods of e-Payment, e-Money, e.g., and their applicable scope • Definition of the rights and obligations of consumers and providers in digital financial services • Definition of obligations to protect consumers through the guarantee of stability • Statement of clauses regarding permission, registration, monitoring, and supervision of digital financial institutions

Period	Key Issue	Laws and Regulations	Summary
2010s	• Accidental leakage of users' personal data in an Internet shopping mall in 2008 • Accidental leakage of users' personal data in an oil refinery in 2008 • Increase in the damages resulting from cybercrime, such as voice phishing, with an amount of USD55 billion and more than 5,000 cases by 2010	Personal Data Protection Act (Enacted in 2011, and amended in 2015)	• Definition of personal data (personal information) • Statement of the scope and procedures regarding personal data collection, management, and protection policies • Statement of clauses such as consumers rights regarding personal data collection and roles and responsibilities of the complaints resolution committee regarding the infringement of personal data
		Law for Telecommunication Financial Fraud Prevention and Damage Reimbursement (Enacted as the Law for Telecommunication Financial Fraud Damage Reimbursement in 2011, and reformed as the Law for Telecommunication Financial Fraud Prevention and Damage Reimbursement in 2014)	• Definition of cases and the scope of telecommunication financial fraud • Statement of clauses regarding the conditions and procedures for damage reimbursement in cases of telecommunication financial fraud, e.g. • Statement of the responsibilities for fraud prevention in financial institutions, and the alternatives and obligations for telecommunication financial fraud prevention by the government

Source: National Legal Information Center (http://www.law.go.kr), Reports published by the Government of Korea; Data compiled by KSP Consultants

The Government of Korea has enacted and continuously amended its laws and regulations regarding financial consumer protection, including digital financial services to protect consumers and to supervise the activities of financial institutions. The Government is still working on the enactment and amendment of laws and regulations in accordance with changes in technical trends and economic, political, and social issues.

In addition to the above laws and regulations, applicable details to the regulatory framework regarding financial consumer protection in Korea among the regulatory framework classifications on the report 'Global Survey on Consumer Protection and Financial Literacy' which is announced by World Bank are shown as below.

Table 3- 22 | Regulatory framework for financial consumer protection in Korea

Classification		Application
Institutional Structure for CP Supervision	CP supervision falls under a single supervisory agency	○
	CP supervision falls under multiple agencies	
	CP supervision responsibilities fall under a single agency dedicated to broad financial market conduct supervision	
	CP supervision responsibilities fall under a single specialized FCP agency that does not have broader financial sector market conduct supervisory responsibilities	
	CP responsibilities fall under an agency or agencies responsible for broader CP supervision	
Supervisory Resources	Agency is responsible for implementing any aspect of FCP laws	○
	Agency has a designated unit to work on FCP as part of prudential supervision	
	Agency has a designated unit to work on FCP separate from prudential supervision	○
	Agency is responsible for FCP, but no separate unit exists	
Compliance Monitoring Tools	FIs are required to report statistics on the number of complaints to the agency	○
	FIs are required to report rates and fees for financial services which are posted on the agency website	○
	To ensure compliance, the agency operates a hotline/call center to receive complaints	○
	Responsible agency ensures compliance by monitoring the market, including advertisements and websites	○
	Mystery/incognito shopping	○
	Interviews, focus groups, and research with consumers are carried out to ensure compliance	○
	On-site inspection and investigation of FIs to ensure compliance	○
	Off-site inspection and investigation of FIs to ensure compliance	○
Agency Action in Relation to Complaints	Register/record complaints	○
	Respond to complaints	○
	Analyze/publish complaint statistics	○
	Assist directly in resolution of complaints	○
	Assist indirectly in resolution of complaints	
	Make binding decisions for any of the parties involved	

Classification		Application
Enforcement Actions	Issue warnings to FIs	○
	Require providers to refund excess charges	○
	Require providers to withdraw misleading advertisements	○
	Impose fines and penalties	○
	Issue public notices of violations	○
	Withdraw offending provider's license to operate	○

Source: World Bank, 2014, Global Survey on Consumer Protection and Financial Literacy, World Bank

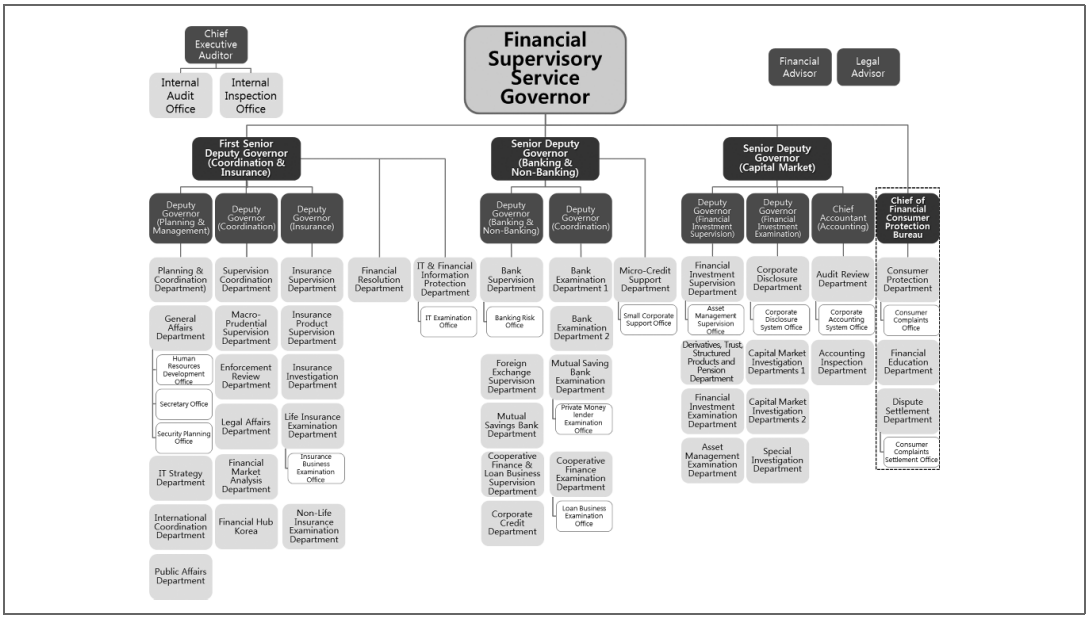
According to the above table, there is only one agency in charge of supervision for consumer protection in financial services. Supervision of consumer protection in financial services is thorough when compared to the cases of Colombia and Paraguay. In addition, the legal sanctions for financial institutions that do not abide by these laws and regulations are strong.

2) Agency for Consumer Protection Supervision in Digital Financial Services in Korea

The Financial Supervisory Service (FSS) is the only supervisory agency regarding financial consumer protection in Korea. It was established in 1999 by the Act on Establishment of Financial Supervisory Organizations (enacted in 1997 and reformed as the Act on Establishment of Financial Services Commission in 2008) through the integration of four separate agencies in charge of financial consumer protection, such as the Bank Supervisory Service, Securities Supervisory Board, Insurance Supervisory Board, and Credit Management Fund. The FSS conducts the tasks such as monitoring and supervising for financial institutions, establishes fair financial activities and a healthy credit market through its monitoring and supervising, and protects financial consumers.

The FSS is composed of Organization Management and Planning, Insurance, Supervision and Monitoring Banking and Nonbanking, Supervision and Monitoring Capital Markets, Financial Consumer Protection Bureau, and other independent directorates. The organizational structure and responsibilities of each directorate are shown as below.

Figure 3- 27 | Organizational structure for financial consumer protection of Financial Supervisory Service of Korea



Source: Financial Supervisory Service of Korea Homepage (http://www.fss.or.kr)

The Financial Consumer Protection Agency and Financial Disputes Mediation Committee are operated under the FSS. The Financial Consumer Protection Agency conducts regulatory planning, research and studies, analysis of trends, civil services, financial education, etc., on financial consumer protection. The Financial Disputes and Mediation Committee handle complaints resolution between financial consumers and institutions.

Table 3- 23 | Responsibilities of each directorate of financial supervisory service of Korea

Directorate		Responsibility
Independent Directorates	Internal Audit Office	• Internal audit of FSS, evaluation of appropriateness of internal control, support for audit by other auditing agencies, e.g.
	Internal Inspection Office	• Inspection of tasks of each staff and the relevant issues, improvement of regulations regarding anticorruption, e.g.
	Financial Advisor	• Provision of advisory service regarding financial supervision
	Legal Advisor	• Provision of advisory service of laws and regulations regarding financial supervision

Directorate		Responsibility
First Senior Deputy Governor (Coordination & Insurance)	Planning & Coordination Department	• Administration, operation, and planning • Organization and budget management • National Assembly and other external affairs
	General Affairs Department	• Personnel management and planning • Employee payroll, benefits, and welfare • Contracts, accounting, and asset management
	IT Strategy Department	• Planning and administration of IT strategies • Development and operation of IT for financial supervision • Procurement and management of IT hardware
	International Coordination Department	• International affairs and cross-border cooperation • Information exchange and MOU with foreign supervisory authorities • Membership in global standard setters and participation in multilateral regulatory organizations
	Public Affairs Department	• Press releases and media relations • Public affairs and communications
	Supervision Coordination Department	• Examination and supervision coordination and planning • Operational management of examination and supervision
	Macro-Prudential Supervision Department	• Macro-prudential supervision • Research on financial supervision frameworks • Financial market monitoring and early warning systems • Supervision and market data management
	Enforcement Review Department	• Review of supervisory inspection, examination, audit, and investigation • Enforcement and sanctions • Operational management of the Sanctions Committee
	Legal Affairs Department	• Legal review of supervisory regulations • Internal legal advisory services • administration of FSS litigations and planning and administration of supervisory regulation works
	Financial Market Analysis Department	• Financial market analysis utilizing financial firm and market data from the FSS financial risk early identification system
	Financial Hub Korea	• Support for inbound foreign financial firms and outbound domestic financial firms • Regulatory and supervisory assistance for foreign financial firms in Korea
	Insurance Supervision Department	• Supervision of insurance companies and intermediaries • Licensing for insurance business • Supervision of auto insurance, reinsurance, and guaranty insurance

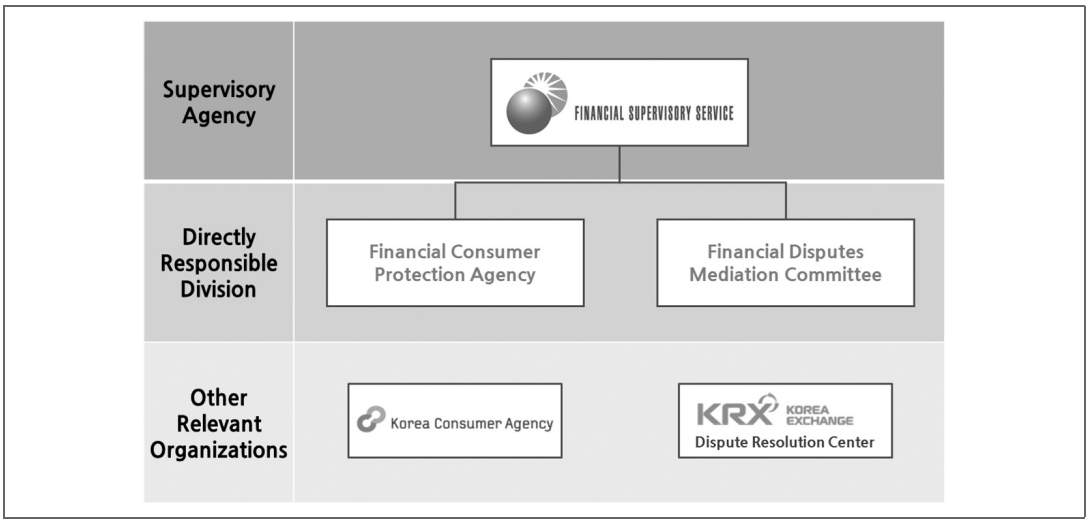
Directorate		Responsibility
First Senior Deputy Governor (Coordination & Insurance)	Insurance Product Supervision Department	• Product premiums • Policy reserves • Product review
	Insurance Investigation Department	• Insurance fraud investigation and collaboration with law • enforcement authorities on insurance enforcement • Insurance crime prevention
	Life Insurance Examination Department	• Examination of life insurance companies • Oversight of sales agents and other intermediaries and industry associations
	Non-Life Insurance Examination Department	• Examination of non-life insurance companies
	Financial Resolution Department	• Consumer-petitioned inspection and examination of financial firms • Mystery shopping for financial products and services Financial firms' conduct risks
	IT & Financial Information Protection Department	• IT support for examination • Financial consumer data protection • Electronic banking and payment settlement
Senior Deputy Governor (Banking & Non-Banking)	Bank Supervision Department	• Authorization/approval of banking businesses • Safety and soundness supervision
	Foreign Exchange Supervision Department	• Supervision of soundness of financial services firms' foreign currency asset-liability management • Investigation of illegal foreign currency transactions
	Mutual Savings Bank Department	• Authorization/approval for mutual savings banks • Review of fit-and-proper test for large shareholders • Support for business normalization of distressed mutual savings banks
	Cooperative Finance & Loan Business Supervision Department	• Authorization/approval for credit unions and credit-specialized finance companies • Safety and soundness inspections
	Corporate Credit Department	• Planning, oversight of corporate restructuring • Safety and soundness oversight of heavily indebted business groups • Enforcement of credit extension restrictions, credit risks
	Bank Examination Department 1	• Examination of commercial banks (Kookmin, Woori, Shinhan, KEB Hana Bank, Standard Chartered Korea, and Citibank Korea)
	Bank Examination Department 2	• Examination of specialized banks, foreign bank branches, and regional banks
	Mutual Saving Bank Examination Department	• Supervision and examination of mutual savings banks • Safety and soundness monitoring and oversight

Directorate		Responsibility
Senior Deputy Governor (Banking & Non-Banking)	Cooperative Finance Examination Department	• Supervision of credit unions and cooperatives • Monitoring of safety, soundness, and risks of credit unions and cooperatives
	Micro-Credit Support Department	• Examination and supervision of micro credit providers, consumer service for misconduct and unlawful credit practices
Senior Deputy Governor (Capital Market)	Financial Investment Supervision Department	• Supervision of financial investment services companies • Licensing for financial investment services
	Derivatives, Trust, Structured Products and Pension Department	• Oversight of structured derivatives and derivatives trading • Supervisory review of asset-backed securities • Pension, licensing for trust services
	Financial Investment Examination Department	• Examination and supervision of financial investment services companies • Off-site monitoring of financial investment services companies
	Asset Management Examination Department	• Examination and supervision of asset management companies • Off-site monitoring of asset management companies
	Corporate Disclosure Department	• Supervision of financial reporting of listed companies • Supervisory review of securities-related filings • Enforcement of disclosure rules and regulations
	Capital Market Investigation Departments 1, 2	• Investigation of unfair securities trading • Enforcement of securities trading rules and regulations
	Special Investigation Department	• Planning, investigation, and supervision of unfair securities trading • Supervision and enforcement actions for unfair trading practices
	Audit Review Department	• Audit and accounting supervision • Quality control for audit of financial statements • Audit inspection of financial filings of listed companies
	Accounting Inspection Department	• Audit inspection of financial reporting of listed and unlisted companies
Financial Consumer Protection Bureau (Financial Consumer Protection Agency)	Consumer Protection Department	• Planning and implementation of consumer protection initiatives • Administration of consumer complaints
	Financial Education Department	• Planning and implementation of consumer financial education initiatives • Dissemination of educational materials
	Dispute Settlement Department	• Mediation of consumer complaints against financial services firms • Prevention of consumer complaint and dispute • Administrative and operational support for Financial Dispute Settlement Committee

Source: Recomposed by the KSP consultants based on the contents on Financial Supervisory Service of Korea Homepage

In addition to the above agencies, there are organizations such as the Korea Consumer Agency (KCA), which was established in 1987 for consumer protection, and the Korea Exchange Dispute Resolution Center (KRX-DRC), which works toward the improvement of stability and efficiency in securities transactions.

Figure 3- 28 | Organizational structure for consumer protection in digital financial services in Korea



Source: Recomposed by the KSP consultants

3.2.2 Comparison of Laws and Regulations on Consumer Protection in Digital Financial Services in Korea, Colombia, and Paraguay

1) Status of Laws and Regulations

The laws and regulations regarding consumer protection in digital financial services in Korea are compared to identify whether there is any need for additional laws and regulations in Colombia and Paraguay. The contents are classified as personal data protection, consumer protection, and digital financial services, the same as for the comparison of cases in Colombia and Paraguay. In addition, laws and regulations regarding financial supervision and financial crime, including financial fraud, are included as an additional classification. The results of the comparison are shown below.

Table 3- 24 | Comparison of laws and regulations regarding digital financial consumer protection in Korea, Colombia, and Paraguay

Classification	Requisite	Korea	Colombia	Paraguay
Personal Data Protection	Scope of personal data, authority of access to data, management agency, etc.	Specifically defined	Specifically defined	Defined by the Constitution
	Obligation of personal data protection, punishment of violation, etc.	Specifically defined	Specifically defined	No specific definition
Consumer Protection	Obligation and principle of consumer protection	Specifically defined	Specifically defined	Specifically defined
	Rights and obligations of consumers	Specifically defined	Specifically defined	Defined by the Civil Code
	Rights and obligations of financial institutions	Specifically defined	Specifically defined	Comprehensively defined
	Scope of consumer information	Specifically defined	Specifically defined	Defined by the Civil Code
	Method and procedure for complaints resolution	Specifically defined	Specifically defined	No specific definition
	Roles and authority of consumer protection supervisory agency	Specifically defined	Specifically defined	Specifically defined
Digital Financial Services	Regulations on financial institutions providing digital financial services	Specifically defined	Specifically defined	Specifically defined
	Regulations on security to use digital financial services	Specifically defined	Specifically defined	Specifically defined
	Regulations on technology for digital financial services	Specifically defined	Specifically defined	Specifically defined
Financial Supervision and Financial Crime	Roles and authority of the financial supervisory agency	Specifically defined	Specifically defined	Specifically defined
	Authority of the financial supervisory agency in digital financial services	Specifically defined	Comprehensively defined	Comprehensively defined
	Obligations of the financial supervisory agency for the protection of consumer information	Specifically defined	Specifically defined	Specifically defined
	Types and scope of financial crimes	Specifically defined	No specific definition	No specific definition
	Condition and procedure for damage reimbursement in financial crimes	Specifically defined	Comprehensively defined	No specific definition
	Obligations and responsibilities for the prevention of financial crime	Specifically defined	Comprehensively defined	Specifically defined

Source: assessment of the consultants

Korea has defined laws and regulations regarding personal data protection, financial consumer protection, digital financial services, and financial supervision and crime, specifically. Under these laws and regulations, the procedures, scopes, agencies, roles and responsibilities are well defined.

However, the laws and regulations regarding financial supervision and financial crime in Colombia and Paraguay are not very clearly defined, especially in terms of regulations regarding the resolution of financial crime and its scope in consumer protection. In addition, Colombia and Paraguay have adapted laws and regulations as applied in general financial services due to the lack of a separate set of laws and regulations for supervisory authorities in financial supervisory agencies regarding digital financial services.

2) Agency for Consumer Protection Supervision

Financial Supervisory Service (FSS), Financial Superintendence of Colombia (SFC) and Banking Superintendence (BCP-SIB) conduct monitoring and supervision functions to ensure consumer protection in financial services, including digital financial services as agencies in Korea, Colombia, and Paraguay respectively. In the case of Paraguay, the management task regarding the license for the issuance of e-money is performed by CONATEL.

FSS, SFC and BCP-SIB in the three mentioned countries are tasked to ensure and enhance consumer protection in financial services, through thorough monitoring of financial activities and financial systems, and dealing with resolution of complaints and disagreements between consumers and financial institutions.

The FSS in Korea divides its organizational structure very specifically to enhance its capability for monitoring and supervision of the financial services including digital financial services. By comparison, the SFC and BCP-SIB conduct a variety of tasks in each directorate, other than monitoring of financial services and handling customers' concerns. This means authorities in the SFC and BCP-SIB may have insufficient time to devote to financial services management. Unlike their FSS counterparts or colleagues, they may also not have built up the professional capacity to ensure needs of financial customers are attended to, especially on concerns regarding consumer protection.

Ⅳ Policy Recommendations

4.1. Recommendations for IT Infrastructure: FDS (Fraud Detection System)

4.1.1 Overview of recommendation

Financial Inclusion is started by holding a bank account however, the digital banking starts from converting physical cash to digital money.

Forming mobile account as a means to replace the bank account and managing payment system to transfer money through mobile phone and pay bills are operated widely at the developing countries starting with the M-PESA. The mobile money transaction system relating with bank account is also used by developing countries as well as developed.

There are various operating models of digital money such as bank-centric model and tel-co centric model whereas access indicator and usage indicator are used to measure the performance of the digital finance system, basically. Access indicator shows how effectively people convert mobile money between physical cash and electronic money using cash-in and cash-out device/ method (mobile phone, ATM, agent system, branch e.g.). Usage indicator shows how efficiently people use electronic money using service product in the daily life (air time top-up, bill payment, remittance, point of service, and P2P transfer).

In the processing of Cash-Digital conversion and electronic Money Distribution, various vulnerabilities and threats have been exposed when it goes through the several phases of agent, branch, devices (access and usage), telecommunications line, operating system, and internal staffs of Service Company. Vulnerabilities and threats can be divided into 3 categories, associated with the digital banking model; environmental factors (card cloning, agent fraud, e.g.) and technical factors (various hacking, information leakage, e.g.), social engineering elements (SMS phishing, pharming, e.g.). It courses monetary, economic and social damages through direct and/or 2nd/3rd crime activity.

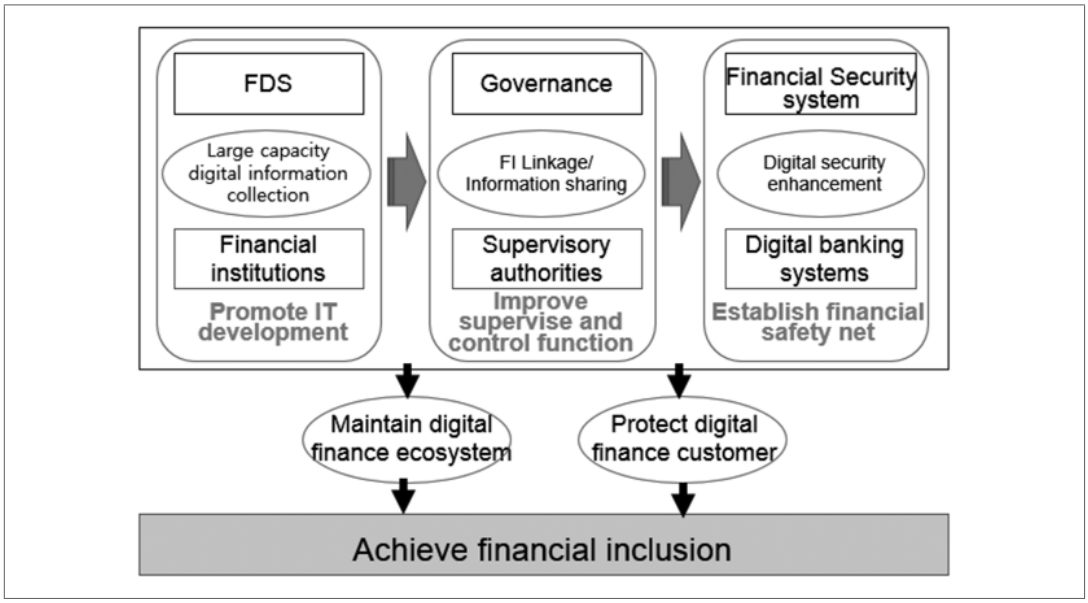
In Latin America and Caribbean, expansion of smartphones and Internet use, the growth of agent activity and the increasing number of active accounts will boost the building of mobile financial ecosystem and bring explosive increase of digital financial transactions in next few years. As the digital transaction increase, a huge transaction data is generated and accumulated. According to it,

fraud, hacking and cybercrime which are growing steadily now will be increased largely, analysis and management of them can be in beyond the control, which can be seen at Korea case study and also many developed countries' practice.

Although organizational control, security system, and prevention education are deployed to manage vulnerabilities and risk, the transaction data is increasing exponentially and crimes and threats are getting intelligent and evolved, so, overall financial sector including bank, card, securities and insurance is promoting establishment of FDS (fraud detection system) as an effective strategy to defend, measure, and detect against all kinds of cybercrimes.

Digital Money or electronic Money is regarded as one of the Fintech by combining digital (technical elements) and Money (economic factors). Therefore, in this digital finance environment it is advisable to resolve cybercrime issue by combining financial engineering methods and IT technology.

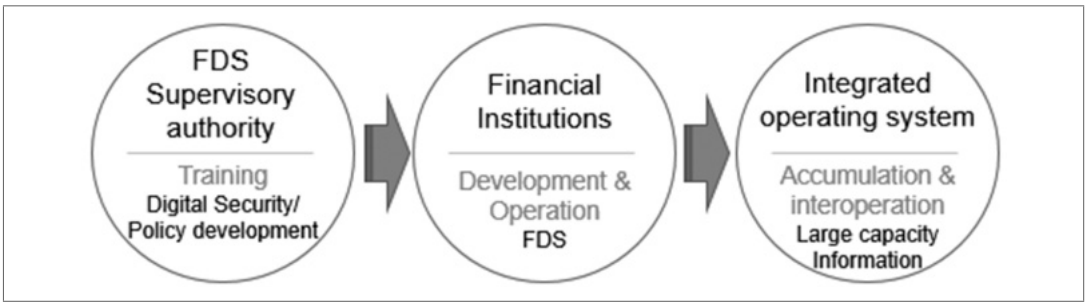
Figure 4- 1 | Overview of FDS operation environment



Source: assessment of the consultants

There are pathway with 3 steps to build FDS in Latin America and Caribbean. First, training center with a security infrastructure provides financial security education and policies development training and Financial Supervisory Authority will draw a roadmap for integrated operation of FDS in the future. And, each financial institution will build their own FDS based on this training and roadmap. At the time that national-level integrated management is required, the operating agency under the control of regulatory agencies will operate the integrated operating system listed in the roadmap. For construction of training center with training course and integrated operation center, consulting from assistance agencies can be considered, if necessary.

Figure 4- 2 | Pathway to develop integrated FDS



Source: assessment of the consultants

FDS center may bring effects in various areas:

- provide the capacity to build its own security system and facilitate the ICT development of financial institution
- improve supervisory functions of the supervisory authority through the governance policy setup
- enhance financial safety net through operating integrated FDS and establishment of financial security system
- reduce gap between rich and poor countries in the ICT and banking area by introduction of the latest international financial system
- make it possible to be transferred security, IT, and banking technology through the training supported by developing countries
- realize quick response to cyber-crime through regional-connected information sharing

4.1.2 Establishment of FDS

1) Financial security system Trend

In South Korea's financial industry, financial companies have launched an Information Technology (IT)-based service coupled to financial services techniques (such as mobile payment and wiring, personal assets, and crowd funding) under the name of Fintech.

Fintech industry uses some common terminology, such as electronic finance fraud which refers to a crime generated that involves online financial services and related to acts of fraudulently obtaining money or financial benefit using online methods. Fraud Detection System (FDS) refers to a fraud activity detection system designed to detect and prevent financial loss due to crimes committed such as leakage of online consumers' data.

In the early days of the above-mentioned Fintech-based service, since many consumers using the service did not trust banking security and feared the risk of losing their smartphones, financial companies therefore focused on ensuring improved security by having various security programs

installed on user terminals. However, although Fintech teams may be able to determine whether some digital finance transactions are indeed generated by unauthenticated users and thereafter prevent financial accidents by adding transaction-blocking, supplementary authentication procedures or reinforcing its fraud detection system, the FDS cannot prevent leaks of financial information input if these acts are due to user's carelessness, for example, by releasing personal information to a pharming scheme. In this regard, while prevention measures are vital, it is perhaps more critical to ensure financial customers are educated on the risks of using online financial services and can therefore take necessary measures to protect their personal information from being misused.

Currently, financial companies in the Fintech industry are trying to expand the range of technology use for consumer protection. There is a pattern of use that is akin to a vicious cycle. When a crime like fraud is continuously committed, new counter measures are bound to emerge as corrective actions, but this is likely to give rise to new fraud methods being devised to avoid detection by the new counter measures.

It is expected that in Fintech industry, new technologies for predicting and detecting new cyber threat will be developed from time to time. The key resolution to online crime prevention is to make sure any effective method or counter measure is quickly shared with others in the industry.

The FDS is currently used for credit card accident prevention and banking fraud prevention by applying detection techniques utilized in the past, such as firewall, Intrusion Detection System, and Intrusion Prevention System. By utilizing these technologies, we can prevent financial loss for consumers or companies. We can also prevent or detect activities causing security problems such as confidential information drain, and take steps to prevent recurrences. As time makes this kind of financial fraud become increasingly intelligent and professionally conducted, specialists in the Fintech industry need to come together and combine persistent efforts to reduce the proliferation of cybercrime and to protect their consumers.

2) Introduction of FDS core functions

As shown in the diagram below [Figure 4-3], the basic organizational flow of the FDS consists of three core functions: information collection, analysis and detection, and response.

- Collection refers to information generated at the time of using user terminal (e.g., PC and smartphone) information, network information, user information, and the like, and information stored in a company.
- Analysis refers to a technique for determining whether a fraud activity exists through variously surveyed analysis methods, such as correlation analysis, statistical analysis and scoring analysis.
- Response refers to a scheme of updating a user's analysis data information by the FDS under normal circumstances, and also a scheme for preventing further fraudulent activity when the FDS first detects a crime. It also refers to the need to be responsive, e.g., by informing management of a fraud activity when detection is affirmative.

Figure 4- 3 | Flow of FDS core functions

① Information Collection	▷ ② Analysis & Detection	▷ ③ Response
Collection of information on users and their activities	Performance analysis related to fraud activities through collected information	Distinguishing between right and wrong, and being responsive to fraud activities

Source: SeungWoo Han, 2015, e-finance and finance security-FDS usage and prospects, FSI (financial security institute)

Precautions exist throughout the running of a FDS. When information is leaked due to hacking, the damage caused by the hacking can be substantial. Therefore, in order to minimize damages regardless of information drain, we will have to consider the need to exclude sensitive information and instead utilize encoded or alternative identification information. This is the process of analysis and response. Though well-intentioned, we may receive customers' complaints due to zealous efforts in over detections and misdetections. It is recommended therefore that in policy making under these circumstances, we respond to incidents in appropriate ways and at an appropriate degree of intensity, for example, enforcing stricter precautionary measures or allowing excessive blocking, which may affect user convenience and ease of use. It is recommended that Fintech experts respond to incidents by using an organic relationship method, which involves modifying applied analysis methods and applying the right modified analysis method.

The above-mentioned model or approach is widely used by the FDS, the Insurance Fraud Prevention System, the Credit Card Fraud Exposure System, and others in the financial industry. Aside from the above-mentioned systems, the technology is widely used in comprehensive security fields such as insider fraud exposure and personal information abuse prevention.

Digital finance services include various services such as Internet banking, smartphone banking, and phone banking. Users use various channels such as a PC, a smartphone, a phone, and a CD/ATM in order to access those services. Via the various channels, information on different terminals, network information, transaction information and the like are created to help generate users' profiles needed to access the digital finance services. A case where a consumer normally places small amount-based transactions but now suddenly conducts a large monetary transaction by wiring a large amount may be regarded as possible fraud.

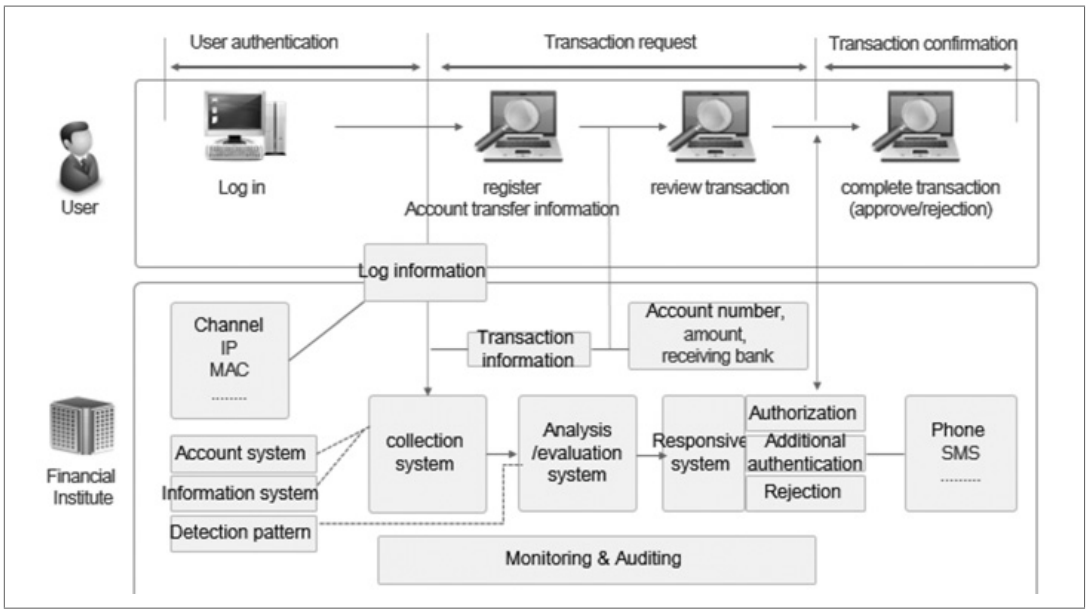
We can determine whether a user is a normal user through reviewing methods and algorithms of use, for example, when a consumer uses transactions above the usage average, carries out transactions with a dubious recipient, or get on the Internet from overseas, these are considered acts warranting scrutiny. Even though we have yet to determine that the user is involved in a fraud activity, it is better to perform additional authentication for the user in consideration of misdetections and then to regard all subsequent transactions as fraudulent.

The FDS is run in a similar pattern based on interworking procedures [Figure 4-4]. Since money transfer should be performed in real time, a user should determine whether it is normal before it is completed and a financial company should determine whether it is normal before a transaction ledger is generated.

The FDS may be differently applied according to the policy of a financial company running it, and the FDS may respond to a fraud by blocking a user when the user's terminal is registered in a black list or accessed through a network. But, the FDS may reject the access of the terminal before the FDS regards the user's activity as a fraud activity to record the corresponding activity and a final ledger is generated.

Furthermore, when some users intensively access banking system or the banking system does not function normally due to a system error, the banking system will affect money transfer transactions. Thus, the money transfer transaction is not generated, thereby causing a system failure. In case of system failure happening, the FDS may be configured as a dual system, or may detect a system error later in a form of ex post facto detection when a predetermined analysis time passes. The ex post facto detection is performed in a state in which the system does not receive lots of workloads after operation hours, and is performed only when a new rule or analysis time is required.

Figure 4- 4 | Interworking procedures between FDS and financial transactions



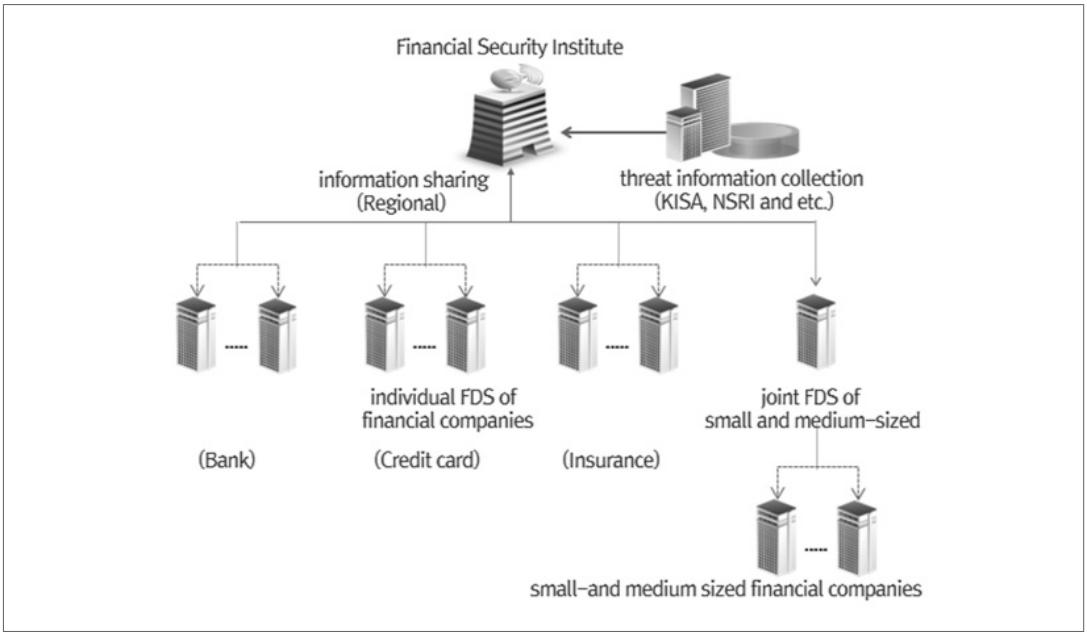
Source: SeungWoo Han, 2015, e-finance and finance security-FDS usage and prospects, FSI (financial security institute)

The FDS may be differently applied according to environmental conditions of a financial company and may be run in a form in which it is coupled to a big data system for effectively analyzing variously collected information within a short time.

In South Korea, each financial institution builds and runs its own FDS. But, as of December, 2014, FSS teams are given a leading role in forming a consultative group for advancing FDS in order to build and upgrade the system based on the release of the Financial FDS Upgrade Roadmap 1.0. The roadmap refers to a plan for sharing the FDS operational and technical know-how among financial companies and establishing a common standard for the FDS in Fintech industry. These measures

will improve digital finance accident detection and also upgrade the response system of a financial company.

Figure 4- 5 | FDS information sharing system



Source: SeungWoo Han, 2015, e-finance and finance security-FDS usage and prospects, FSI (financial security institute)

The Financial Security Institute (FSI) is in the process of carrying forward a plan for building a FDS information sharing system that will allow fraud activity information or suspicious information detection by each financial institution to be shared among financial institutions. Furthermore, the FSI enables institutions to effectively and pre-emptively respond to a fraud activity by collecting and sharing cyber threat information from/with relevant institutions and companies. To this end, the FSI sets transmission standards for detection information of a fraud activity and allows efficient information sharing to be performed [Figure 4- 5].

As a characteristic of digital finance transactions, when elements between various areas (technology, service and channel) are combined, prediction and response for derivable threats applied at the time of the combination are required. A banking system is always concerned with weakened security caused by an illegal transaction through a mobile device and a simple payment introduction policy. Thus, there are growing calls to introduce the FDS as compensation means. Further, it is required for relevant institutions to not only build the FDS, but also maintain close collaboration systems for effectively detecting a fraud activity during the operation of the FDS, with the common goal to share FDS information to reduce and mitigate financial risks.

4.2. Recommendations for Laws and Regulations

Based on the comparison of laws and regulations for digital financial consumer protection in Korea, Colombia, and Paraguay, it can be seen that the laws and regulations in Colombia and Paraguay are quite specifically defined. However, there is room for modification and improvement in this aspect.

Currently, some laws and regulations for the vitalization of digital financial services, such as those concerning financial supervision and financial crime in Colombia, and personal data protection, consumer protection, and financial supervision and financial crime in Paraguay, are only comprehensively defined or remain undefined. This aspect needs to be reviewed to ensure clarity and transparency so that prescribed regulations can be better adhered to, particularly in the area of protecting consumers' rights to privacy and security.

Table 4- 1 | Comparison of laws and regulations on digital financial consumer protection in Colombia and Paraguay

Classification		Requisite	Colombia	Paraguay
Core Laws and Regulations	Digital Financial Services	Regulations on financial institutions providing digital financial services	Specifically defined	Specifically defined
		Regulations on security to use digital financial services	Specifically defined	Specifically defined
		Regulations on technology for digital financial services	Specifically defined	Specifically defined
Additional Laws and Regulations	Personal Data Protection	Scope of personal data, authority of access to data, management agency, etc.	Specifically defined	Defined by the Constitution
		Obligation of personal data protection, punishment of violation, etc.	Specifically defined	No specific definition
	Consumer Protection	Obligation and principle of consumer protection	Specifically defined	Specifically defined
		Rights and obligations of consumers	Specifically defined	Defined by the Civil Code
		Rights and obligations of financial institutions	Specifically defined	Comprehensively defined
		Scope of consumer information	Specifically defined	Defined by the Civil Code
		Method and procedure for complaints resolution	Specifically defined	No specific definition
		Roles and authority of consumer protection supervisory agency	Specifically defined	Specifically defined

Classification		Requisite	Colombia	Paraguay
	Financial Supervision and Financial Crime	Roles and authority of the financial supervisory agency	Specifically defined	Specifically defined
		Authority of the financial supervisory agency in digital financial services	Comprehensively defined	Comprehensively defined
		Obligations of the financial supervisory agency for the protection of consumer information	Specifically defined	Specifically defined
		Types and scope of financial crimes	No specific definition	No specific definition
		Condition and procedure for damage reimbursement in financial crimes	Comprehensively defined	No specific definition
		Obligations and responsibilities for the prevention of financial crime	Comprehensively defined	Specifically defined

Source: assessment of the consultants

The three financial supervisory agencies in Korea, Colombia and Paraguay, i.e., the FSS (Korea), SFC (Colombia), and BCP-SIB (Paraguay) respectively are in charge of supervising and monitoring financial consumer protection in their countries. Their roles include monitoring the financial systems and financial activities, receiving consumers' claims and resolving the claims. There are 47 main directorates in the FSS for the supervision of financial systems and financial activities, and to oversee financial consumer protection. Considering this large difference in terms of responsibilities per directorate and the increasingly complex task entailed by digital finance, it is recommended that both the SFC and BCP-SIB consider further analyzing whether an adjustment to their organizational structure is merited in order to strengthen and concentrate expertise through a larger number of directorates with specific responsibilities. The BCP-SIB also plays an additional role as one of the directorates of the Central Bank of Paraguay, so its staff should conduct more tasks than other supervisory agencies. Taking into account the experience of Korea and the additional factors entailed by the emergence of digital finance, an evaluation of institutional changes that could strengthen the authority for the monitoring and supervision of digital financial services in both institutions is recommended.

In order to reinforce digital financial consumer protection, the recommendation for Colombia is to first define the supervision authority of the SFC in the following roles: (i) monitor digital financial services as well as clarify types and scope of financial crimes, and (ii) conditions and procedures for damage reimbursement in financial crimes. The government should also support the obligations and responsibilities of the SFC and financial institutions for the prevention of financial crimes, specifically, through the improvement of the laws and regulations. In particular, the SFC should be given the authority and capabilities to be able to resolve complaints from financial consumers using judicial power, but this is currently not defined in the existing laws and regulations.

In the case of Paraguay, there are specific definitions for digital financial services provided by agencies, security, and relevant technologies which are core clauses in the laws and regulations regarding digital financial services. However, the additional clauses of the laws and regulations that relate to personal data protection, consumer protection, financial supervision and financial crime prevention could be improved to strengthen the legal binding power accorded to designated parties or authorities. The laws and regulations regarding personal data protection were defined by the constitution, but these needs to be updated to include, for example, sanctions for personal data protection. The laws and regulations regarding consumer protection had not been defined specifically, so these also need to be amended to include relevant clauses that apply to financial consumers and financial institutions. In addition, the definitions regarding the supervision authority of the BCP-SIB, types and scope of financial crimes, condition and responsibilities for damage reimbursement in financial crimes are not clearly specified. In sum, it is recommended that the laws and regulations regarding personal data protection, consumer protection, and financial supervision and financial crime need to be enacted and amended to strengthen the law that ensures consumer protection in digital financial services.

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