Inter-American Development Bank

International Case Studies of Smart Cities

Namyangju, Republic of Korea

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NAMYANGJU
REPUBLIC OF KOREA

IDB-KRIHS Joint Research

IDB

THE REPUBLIC OF KOREA

KRIHS Korea Research Institute for Human Settlements

GDPC Global Development Partnership Center

Abstract

This case study is one of ten international studies developed by the Korea Research Institute for Human Settlements (KRIHS), in association with the Inter-American Development Bank (IDB), for the cities of Anyang, Medellin, Namyangju, Orlando, Pangyo, Rio de Janeiro, Santander, Singapore, Songdo, and Tel Aviv. At the IDB, the Competitiveness and Innovation Division (CTI), the Fiscal and Municipal Management Division (FMM), and the Emerging and Sustainable Cities Initiative (ESCI) coordinated the study. This project was part of technical cooperation ME-T1254, financed by the Knowledge Partnership Korean Fund for Technology and Innovation of the Republic of Korea. At KRIHS, the National Infrastructure Research Division coordinated the project and the Global Development Partnership Center provided the funding.

Namyangju, a city of 650,000 populations in Korea has been promoting smart city project since 2008 as a response to recent growth of population, increased share of transport and crime rate. Namyangju offers various civic services especially via smartphone such as customized real-time road CCTV images, traffic flow and incident information, as well as application for senior resident protection. Namyangju is also equipped with security system at bus stops and multifunctional 'smart pole' which combines street light, CCTV, and traffic signal controller to promote efficient use of roadside facility. The city promotes local economy through online market system making use of its local organic farms and actively utilizes bus stops and roadside VMS in attracting advertisement to raise regular profit. Namyangju is in the process of installing 101km fiber-optic network and plans to complete the construction of Integrated Operation and Control Center (IOCC) by 2016. The city's current focus is on citizen interaction and further business model development.

JEL Codes: L86, L91, L96, O18, Q55, R41

Keywords: Smart city, intelligent transport system, crime prevention, incremental system implementation, urban management, real-time information, business model

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Executive Summary

Namyangju city has a population of 650,000 and is located 25km northeast of Seoul in the Republic of Korea. Namyangju has been continuously promoting smart city project since 2008 with a target of becoming a low-carbon green transport city by 2020. This city has recently experienced rapid growth of population followed by large scale housing development which has increased the share of public transport to 60% as well as crime rate by 50% in the past 5 years. As a proactive response to such societal demand, the smart city project in Namyangju took place with focus on the implementation of intelligent transport system and crime prevention system.

Namyangju offers various civic services especially via smartphone that has rapidly increased its penetration in the past 5 years. The city offers real-time road CCTV images, traffic flow and incident information on frequently used routes through customized mobile service which enables the citizen to choose best route in real-time. Also, to secure the safety of its large senior population, the city offers services such as sending the protector the bus arrival information of the senior resident and emergency alert when the elderly leaves the safe zone to enable prompt response. Cutting-edge crime prevention system is installed at bus stops with emergency bells and CCTV to enable prompt connection with the crime prevention center in the outbreak of emergency. Another innovative solution of Namyangju includes the multifunctional 'smart pole' which combines street light, CCTV and traffic signal to promote efficient use of roadside facility.

Perhaps the smart city service of Namyangju that attracts attention the most as a benchmark is the city's effort to promote local economy through online market system. Being a city that has both urban and agricultural regions, e-commerce of local organic farm products is realized through the smart city system. The city's active utilization of bus stops and roadside variable message signs in attracting advertisement to raise regular profit is another impressive factor that draws attention. Through such smart city system operation, the average traffic speed within the city has increased by 7.2km/h and the average delay time at intersections got reduced by 43 seconds. The citizen satisfaction level on the real-time traffic information provided by the city has yield an 80% survey result which demonstrates Namyangju's strive to provide substantive benefits to citizens.

Namyangju has now reached the maturity phase of the smart city project, having been through the periods of initiation and expansion. The current focus of the city is on the implementation of smart city infrastructure in order to provide more effective and beneficial smart city services in a more stable and efficient manner. The city is in the process of installing the fiber-optic communication network of 101km and plans to complete the construction of integrated operation and control center by 2016. Other areas that the city is increasing its focus are citizen interaction and business model development to raise operation and maintenance cost of the smart city system. It is anticipated that Namyangju will continue to develop its reputation as a model case study for smart city implementation under close collaboration among the city officials, related agencies and citizens.

Namyangju, Korea (source: internal data)

NAMYANGJU, Korea

1. Introduction

1.1 General city overview

Namyangju is a city located in the northern-east part of Gyeonggi province. It is located 25km east of Seoul and 65km northeast of Suwon where the provincial government exists. The city combines both urban and rural areas and has a population is 642,958 as of June 2015 with an increasing trend of approximately 4.3% annually. 217,110 cars are registered as of December 2014 and is increasing by approximately 5.9% each year. The city is divided into 3 sections, south, north and east. The southern section is the center of administration, education, and culture while the northern section is the center of residence, distribution and industry. The eastern section is planned to be developed into a tourist and vacation area by networking cultural tourism resources. The city is developed around national highway #46 but limitations exist due to the expansion of limited development districts. As a result the density of the city is currently increasing.

Namyangju city's financial scale for 2015 is 885.6 billion won. Jungang and Gyeongchun railway lines, and Seoul Ring expressway and Seoul Chuncheon highway passes through Namyangju. The city is a transportation hub of the northern east part of Gyeonggi province as the Suseok-Hopyeong expressway and Sinnae-Namyangju expressway passes through the region as well. The road is extended to 311km with 92.8% of it being paved. This is higher than Gyeonggi province's average road pavement ratio of 83.6%.

1.2 Smart city overview

1.2.1 Development Background and History

Namyangju city is undergoing the smart city project with a goal to build a 'Citizen participating safe city' through ubiquitous computing. It plans to make a convenient and safe city by building a cutting-edge service that can meet the requirements of its citizens. The smart city project is based on the following three backgrounds.

First, according to a survey of Namyangju citizens the need to build and implement a cutting-edge service that is suitable to manage transportation needs, regenerate and develop the city, and activate the local economy, was emphasized. Second, the problem of traffic congestion and safety due to rapid city development came to focus. Following the massive development of housing land, a large population inflow occurred. As a result, the

usage rate of public transportation grew to approximately 60%, hence a transportation service centered on public transit is necessary. The crime rate in crime-prone areas has indicates that over the past 5 years, it has increased by 50%. Third, citizen participation in campaigns such as 'small shops & wide streets', 'invigoration of shopkeepers' co-op' has increased to revitalize the local economy. Tourism demand has increased after designating the area around Bukhan River as a slow city, reorganizing the bicycle road, and hosting international contests. Therefore, there is now need for a cutting-edge technology service that can correspond well to the special traits of 'urban-rural integrated cities', and lead citizen participation.

Based on these backgrounds, the following four categories have been prepared to proceed with Namyangju city`s smart city project. First, a plan to build a citizen based project promotion organization and project plan has been made. In other words, citizens will participate as a working group and project plans have been made in connection to citizen projects. Second, a cooperative system with related institutions has been built. Extreme care has been devoted to receive national and provincial subsidies. As a result, the city has attracted various demonstration/model projects. Third, service models that can differentiate Namyangju from other local governments have been discovered and made. In other words, services are made where the ICT technology is converged with the plans and alternatives regarding traffic, crime prevention, and local economy revitalization. Also, efforts were made to actively implement services that are citizen centered and tangible. Fourth, a group that is exclusively in charge of the traffic sector has been formed and the U-Integrated Traffic Information Center has been established. The Traffic Planning Division and Public Transportation Division have been made and 7 new professionals have been scouted. In addition, A U-Integrated Traffic Information Center that comprehensively manages transportation, crime prevention and disasters has been fully established.

Namyangju city's smart city project has been divided and carried out into 3 categories. The 'Intelligent Transportation Service (ITS)', 'Bus Information Service (BIS)', and 'Ubiquitous' project. Up to now the city has built an ITS system, including Advanced Traffic Management System (ATMS), that covers approximately 101 km of major national highways and 50km of local roads. The city plans to continuously carry forward with related projects and expand ITS to broader areas including housing zones.

Duration	Project	Budget (million won)	Project content	Progress Status
2009	2009 1st stage ATMS Establishment	Total: 4,000 National: 2,000 Provincial: 600 City: 1,400	○ Project area : total 28.9km - Local road #383 & 2 others ○ Project Quantity: - 4 DSRC, 8 AVI, 9 VDS, 15 CCTV, 4 VMS, 25 New signal systems , 20km of Private Network , Center System etc.	Completed
2010	2010 2nd stage ATMS Establishment	Total: 2,000 National: 1,000 Regional:1,000	○ Project area : total 22km - Local road #387 & 2 others ○ Project Quantity: - 2 DSRC, 7 VDS, 5 CCTV, 4 Intersection web cameras, 3 VMS, 22km of Private Network, Center System etc.	Completed
2012	2012 3rd stage ATMS Establishment	Total: 3,000 National: 1,500 Regional:1,500	○ Project area : total 25km - State Supported Local Road #86(17.1km) & 3 others ○ Project Quantity: - 4 DSRC, 7 VDS, 7 CCTV, 5 VMS, 4 Intersection web cameras, 25km of Private Network, Center System etc.	Completed

2007 ~ 2008	1st stage BIS	Total: 1,531 Regional: 1,531	○ Project area : Within Namyangju jurisdiction ○ Installed Quantity (30 Bus Information Terminals, Establish Bus Information Center)	Completed
2008 ~ 2009	2nd stage BIS	Total: 2,400 Provincial: 600 Regional: 1,800	○ Project area : Within Namyangju jurisdiction ○ Installed Quantity (66 Bus Information Terminals, Improve center facility)	Completed
2009 ~ 2010	Metropolitan Area BIS	Total: 7,522 National: 1,507 Regional: 6,015	○ Project area : Within Namyangju jurisdiction ○ Installed Quantity(219 Bus Information Terminals, Provide Seoul & Town bus info.)	Completed
2011 ~ 2012	Namyangju~Gapyeong BIS	Total: 2,797 National: 897 Regional: 1,900	○ Project area : Within Namyangju jurisdiction ○ Installed Quantity(55 Bus Information Terminals, Digital information guides in 5 subway stations etc.)	Completed
2012 ~ 2013	Namyangju~Gapyeong~Chuncheon BIS	Total: 2,000 National: 1,000 Regional: 1,000	○ Project area : Within Namyangju jurisdiction ○ Installed Quantity(42 Bus Information Terminals, Establish Integrated Center etc.)	Completed
2013 ~ 2014	Namyanjgu~Gapyeong BIS	Total: 1,000 National: 300 Regional: 700	○ Project area : Within Namyangju jurisdiction ○ Installed Quantity(25 Bus Information Terminals etc.)	Completed
2010 ~ 2012	Urban Traffic Information System(UTIS) Expansion Project	Total: 9,100 National: 9,100	○ Project area : total 101km - Around major national roads - Road Side Equipment in 45 sites - CCTV in 24 sites etc.	Completed
2012	1st stage U-city	Total: 400 National: 200 City: 200	○ Project area : Within Namyangju jurisdiction ○ Crime Prevention services in 44 Sites, 8272 Software for processing civil complaints etc.	Completed
2013	2nd stage U-city	Total: 2,000 National: 1,000 City: 1,000	○ Project area : Within Namyangju jurisdiction ○ Online market system development (homepage, smart phone application), Software development of safety guides regarding transportation, crime prevention, natural disasters etc.	Completed
2014	3rd stage U-city	Total: 1,600 National: 800 City: 800	○ Project area : Within Namyangju jurisdiction ○ Build integrated city management platform regarding transportation, crime prevention, natural disasters, Develop business service, Build musical fountain etc.	Completed
2012 ~2015	Build Namyangju U-City	Covered by private enterprise	○ Plan to establish ITS in Jingeon, Jigeum and Byeollae district	In progress

Table 1 List of Namyangju's smart city-related projects

1.2.2 Vision, current and future projects

Namyangju city's goal is to build a smart traffic city that leads the way of low-carbon green traffic by 2020. The city plans to establish a smart city with ubiquitous cutting-edge technology so that it can enhance the living quality of its citizens and identify with them. In order to achieve this, it is focusing on building systematic traffic management, strengthening the connection and flow of traffic information, and establishing a pleasant traffic environment. Namyangju's smart city project can be chronologically divided into 3 stages.

The first stage is the introductory period from 2008 to 2011. During this period demonstration projects took place and infrastructures were built. Unit-based systems were established around major roads. The second stage is the expansion period from 2012 to 2015, where services are being expanded and connected systems are established. In terms of space, the systems built at stage 1 have expanded to all of Namyangju and in terms of contents, unit systems have been integrated and expanded along with service scope.

Step 1: Introduce(2008~2011)	Step 2 : Expend(2012~2015)	Step 3 : Stability(2016~2020)
Pilot project and infrastructure construction stage	Service expansion and preparation for linkage stage	Service expansion and modification stage
- Building system unit -Building major transport target system - Integrating existed system	- Unit system integration and diffusion - Service range extension - Modifying the system and complement	- In conjunction with other systems and organs - Diversification of providing media - Advanced technologies applied
Major road	the whole area in Namyangju extension and linked main road	Guri, Hanam, Uijeongbu, Gwangju linked transportation area

Table 2 Namyangju's smart city implementation stages

The third stage is from 2016 to 2020 where the city plans to continue expanding services from stage 2 and improve the system by modifying and supplementing existing systems. In terms of space, Namyangju plans to connect with close traffic zone areas such as Guri, Hanam, Uijeongbu and Gwangju etc. Also, it plans to strengthen information exchange and connections with centers of Gyeonggi province, Seoul, and Gangwon province. As the technology of smart phones and individual owned devices continue to advance, the city plans to diversify mediums to provide information and to implement new high technology such as C-ITS. The Namyangju smart city project is participated in by its citizens. Through this the city looks to activate the local economy. Economic effects are maximized as local industries are developed by citizens and local cultures are reinvented. Also, communication with citizens is endlessly ongoing with no restraints of time and space whatsoever due to the ubiquitous platform. Namyangju city has made a service brand called 'i-bbang bbang' and is working to expand it.

The city is progressing to build a new U-Integrated Traffic Information Center building. The building is located at Byeollae new town and is planned to open in 2016. The integrated center will support the safe and convenient lives of Namyangju citizens through efficient management and operations.

Figure 1 Components of Namyangju Smart City Services

2. Service Spectrum

2.1 Overview of the smart services and high level functions

Service rea	Services
Smart Traffic	Real time traffic information
	Bus information terminals
	Real time bus information
	Parking Space information
	Facility locations and traffic use information
	Fast route information
	Traffic signal control
	Speeding, traffic signal violation, illegal parking crackdown
Smart Safety	Smart phone safety helper service
	Intelligent crime prevention service
Smart Disaster Prevention	City facility management
	Forest fire surveillance
	Flooded river and flooded area surveillance
	Winter snow conditions surveillance

Table 3 Namyangju Smart City Provided Services

Namyangju city has continuously pushed forward with the Bus Information System (BIS) and U-city business starting with the Intelligent Traffic System in 2009. In September 2012, the existing integrated traffic information center was expanded and combined with the crime prevention control center and illegal parking & stopping management center. Through this, the U-Integrated Traffic Information Center was established. Combined operations and management has unified tasks and increased overall efficiency. Namyangju city's U-Integrated Traffic Information Center is in charge of traffic, safety, and disaster prevention.

2.2 Transportation and urban mobility

2.2.1 Intelligent transportation system

Namyangju city's intelligent traffic system (ITS), is establishing a basis for future transportation that can provide ubiquitous services customized for residents, by establishing ties with Urban Traffic Information System (UTIS), advanced traffic control system that uses DSRC (ATMS), Bus Information System (BIS), a new signal system, and U-T (transportation). It is an advanced green traffic system that can improve traffic efficiency and safety in general, by using cutting-edge technologies, not only to automate operation and control of the traffic system, but also to collect, process, and provide various traffic information.

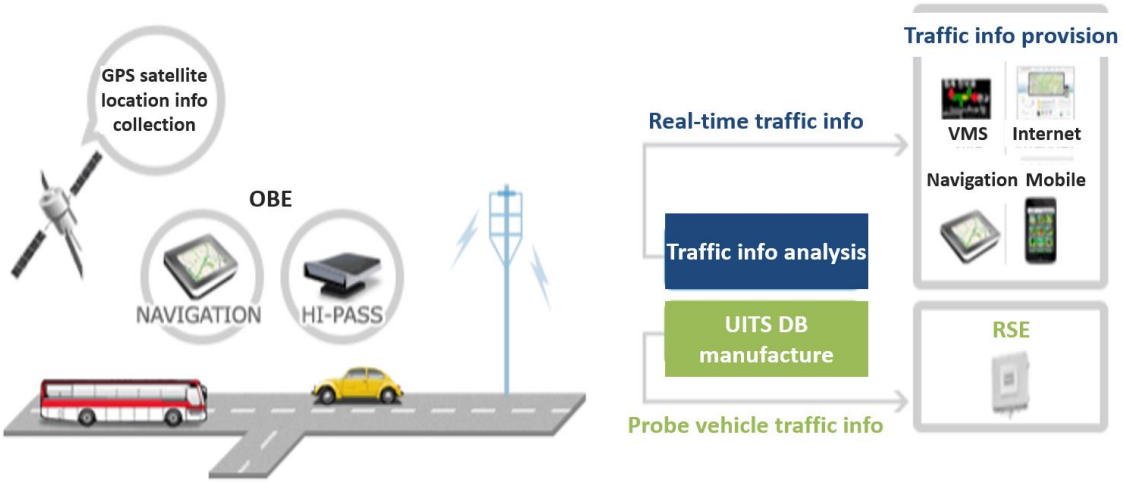


Figure 2 Outline of traffic information collection & services provided

Menu	Services
ITS introduction	Namyangju ITS introductory page
Traffic information	Provide real time traffic information of major Namyangju city roads
CCTV footage	Provide CCTV footage information of major Namyangju city roads
Fast route search	Guide to fast routes by designating starting & arrival points
Unexpected Events/Control	Provide information on road control and unexpected events such as accidents, car breakdowns etc.
Bus information	Connect to Namyangju city's bus information website
Traffic signal information	Provide information on new traffic signals within Namayangju
Twitter on traffic congestion section	Connect to Namyangju city's twitter
User information	Provide information on how to use the mobile web

Table 4 Mobile traffic information services

As can be seen in Figure 2, Namyangju ITS collects and processes real-time running information via RSE (Road Side Equipments) installed on main roads of cities and wireless communications between OBE (On Board Equipments), and also provides real-time traffic information (Sectional traffic flow, CCTV footages, and local area information) via car terminals, variable message signs(VMS), and the internet. By establishing a system where real time traffic information around major roads can be collected and provided to its citizens, Namyangju city is enhancing the efficiency of traffic management.

Approximately 96 sites of cutting-edge technology traffic facilities are built and operated over a 50.9km road section. Also, through 17 variable message signs, the U-Integrated Traffic Information Center sends real time traffic information and local government PR to citizens. By using smart phones, users can easily and conveniently access real-time traffic information, unexpected situation information, road control information, route information, CCTV footage, and real time bus information. Citizens can set up road sections that they use frequently and gain information regarding such sections without having to search every time they use the mobile service.

2.3 Safety and citizen security

Namyangju city is providing its citizens with fully integrated and unified information regarding traffic, crime prevention, environment, and disasters through channels such as 500 bus information system sites, 3,900 OBEs, 18 VMSs.

The services are provided by utilizing existing advanced traffic equipments and infusing new technology. Thus, construction and management costs are cut by approximately one billion won. Also, mobile applications are used to provide 'S.Net service' in order to prevent crime which is currently continuously increasing. The S.Net service allows for guardians to manage urgent emergencies regarding those under their custody (elderly, children, disabled). The smartphone user's location information is used to notify the guardian with emergency alarms, provide bus arrival information, and notify when those under guard have left the safety zone (designated by the guardian).

2.3.1 Intelligent crime prevention

Namyangju offers several intelligent crime prevention services to citizens. For bus arrival notification service, a push message is sent to the guardian(parents) when those under protection(child) arrive at the designated bus stop. The guardian can check the amount of time it takes to arrive at the bus stop. For safety zone service, a push message is sent to the guardian when those under protection either enters or leaves the safety zone that is designated by the guardian. For emergency notification service, a push alarm is sent to the guardian when an emergency occurs to those under protection. The service periodically tracks the smartphone user's moving route from the origin of the emergency and provides the information to the guardian. Also, the guardian can immediately report to the police if he/she chooses to do so. Namyangju city then swiftly sends the urgent situation to related organizations and actively takes action.

For the first time in Korea, Namyangju city is also running a crime prevention service by utilizing electronic communication facilities installed at cutting-edge bus stops when establishing the bus information system (BIS). Crime prevention alarms and CCTVs are installed at 99 bus platforms. In case of crime or emergencies these facilities connect with the crime prevention center to swiftly take action.

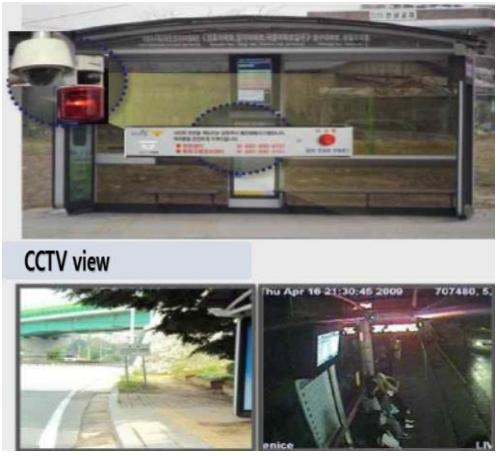


Figure 3 Crime prevention bell and CCTV

By using the bus information system, electronic and communication facilities, and platform poles, costs have been significantly reduced. A regular crime prevention CCTV costs approximately 20 million won to install at each site whereas the crime prevention system installed at cutting-edge platforms cost only 2 million won per site.

2.4 Environment

Figure 4 Street light, signal and CCTV in one pole

Aesthetic elements have also been added when modernizing the city's facilities. The city not only looks to secure the convenience of its citizens but also seeks to enhance the aesthetic feature of the city. For example, the 'Road Traffic System Poles' and 'Electronic Displays' have been recognized for its superiority and is a registered patent. Rather than indiscreetly building street furniture, by integrating and installing all systems into a single pole, the beauty of the city is enhanced and installation costs are reduced along with increased maintenance efficiency. Approximately KRW 5.5 million worth of installation costs has been reduced per site.

Namyangju city is the first in Korea to run a system that detects illegal advertisements placed at cutting-edge platforms by monitoring through mobile applications. Once pictures are taken by the application that is exclusively made for this purpose, image and location information is automatically sent and registered at the center database. The operational manager then confirms the information and takes action on site and impose fines, thus contributing to the improvement of the city environment.

Figure 5 Process of illegal advertisement control system

2.6 Energy efficiency

Namyangju city is the first in Korea to develop an integral model of bus platform and bus information terminal. By installing the two facilities simultaneously approximately KRW 3 million worth of initial construction costs per site could be saved. In addition to this, monthly electricity and communication costs are also reduced. This integral model is a registered technology and design patent. The representative types are as follows.

A. Basic type cutting edge platform

This is the standard platform model that is installed in areas where the sidewalk width is more than 2m and where there are no shops to interfere with the user's sight.

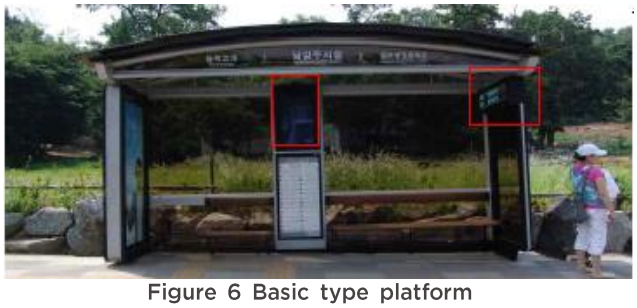


Figure 6 Basic type platform

B. Open type cutting edge platform

This type is installed in areas where the sidewalk width is less than 2m. The glass width of the glass side is reduced in order to acquire space for pedestrians

Figure 7 Open type platform

C. Reversed type cutting edge platforms

This type is installed in areas where installing the platform can give damage to shops nearby. In order to provide better view of the shops, the glass side is removed.

Figure 8 Reversed type platform

2.7 Citizen interaction and communication mechanisms

Namyangju city is running an '8272 Civil Complaint Processing System'. The number '8272' has the meaning 'swift handling and processing'. The system is managed and operated based on location information (zip code) and is connected to the traffic CCTV images. Through this, the system identifies and processes civil complaints in real time. The city is also operating a smartphone application that can process complaints and notify citizens with traffic information, water supply cut off information, events information, and road construction etc. The application recognizes the NFC, QR codes that are installed in approximately 2,300 sites all across the city and provides people with the relevant traffic and administrative information.

Namyangju city is also operating a citizen centered working group that works to successfully carry forward with the advanced technology traffic project. The working group gathers the opinions of citizens and finds ways to best provide traffic information. Currently there are 15,255 and 2,095 people who have joined twitter(@nyjtraffic) and facebook.

2.8 Profitable advertisement and local economy activation

By attracting profitable advertisements in 80 bus platforms sites and 17 VMS sites, the city is acquiring approximately 78 million won non-tax receipt annually. The parliament of Namayangju city amended an ordinance for this. Through annual contracts, the advertiser is allowed to advertise and operate the amount within the contract. At the same time, the advertiser is given the responsibility to clean and maintain 80 bus stops. This idea was awarded at the '2012 Gyeonggi Province Research on Non-tax Receipt Contest'

Namyangju city is looking to revitalize the old city area by connecting the 'small shops & wide streets' project with the U-service. For this purpose, homepages and mobile applications are made to promote local shops and online markets are being operated. By developing a tool that produces promotional homepages, an online market system homepage is built for approximately 1,600 stores in the city. Also, a smartphone application has been developed and propagated for citizens to use.

Figure 9 Online market for activating local economy

3. System Configuration

3.1 Overview

Namyangju city's U-Integrated Traffic Information Center is operated 24 hours by various field equipments that are connected to wired and wireless communications. These field equipments are installed by the ATMS, UTIS, BIS, BRT and U-city projects that the city has been carrying forward. They collect and provide information that is necessary. The U-Integrated Traffic Information Center at current 2015 can be divided into traffic, crime prevention, and Bus Information System. The services are operated based on wired and wireless communication network infrastructure that is established by the Traffic Division. Also real time sharing and application of information is maximized by using a common GIS map and system clock. The U-Integrated Traffic Information Center is in charge of assessing and managing all situations within the city including traffic, crime prevention, disaster prevention and safety as the smart city control center.

	2008	2009	2010	2011	2012	2013	2014
Advanced Traffic Management System (ATMS)	-	-	1st stage ATMS	2nd stage ATMS	Installation Business	3rd stage ATMS	-
National Highway ITS /Wide Area Traffic Information System (UTIS)	National Highway ITS	-	-	UTIS	-	-	-
Bus Information System (BIS)	1st stage BIS	2nd stage BIS	Metropolitan Area BIS	-	Namyangju-Gapyeong-Chuncheon BIS	Namyangju-Gapyeong BIS	-
BRT	-	-	Namyangju-Guri BRT	-	-	-	-
U-city	-	-	-	-	1st stage Model City	2nd stage Model City	2nd stage Model City

Table 5 Namyangju city's yearly smart city establishment

3.2 Level of physical system integration and interoperability

Namyangju city's U-Integrated Traffic Information Center collects, manufactures, provides, stores and manages all information that is formed within the city. Information on expressways, national highways outside of the city, and information manufactured in other areas of Gyeonggi province are provided to the Namyangju U-Integrated Traffic Information Center by the Gyeonggi Province Traffic Information Center.

The Namyangju U-Integrated Traffic Information Center manufactures the information it receives and provides it to the city police station, fire station, and disaster management department. Currently, there is possible time-lag when receiving information from Gyeonggi Province Traffic Information Center and then manufacturing the information. Therefore, a way of connecting and collecting information directly from relevant systems, without having to go through Gyeonggi Province Traffic Information Center, is being revised. The city is in the process of discussing administrative details with relevant institutions.

All the information that is linked is strictly guarded by the Korean government's designated

technical information exchange standard according to type, definition, characteristic, exchange method, information provider's rank, and authorization. Information sharing and connecting is operated based on the standard node system defined by the Korean government. Depending on the characteristic of linked information, the exchange cycle can range from second unit cycles when short to 5 minute cycles when long. Of course in an emergency situation, swift response system through immediate transmission is considered. The linked information varies from real time dynamic information to manufactured static information. The table below shows government institutions that exchange information with Namyangju U-Integrated Traffic Information Center.

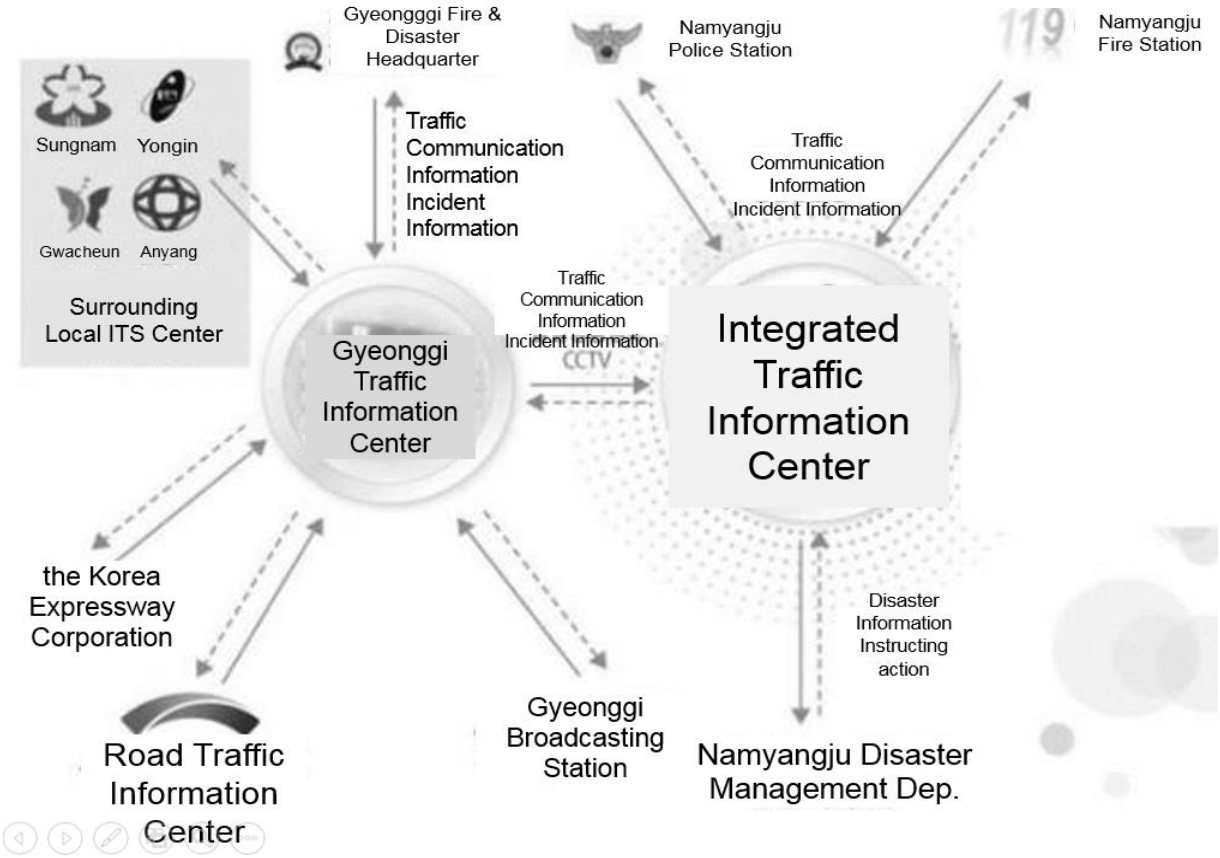


Figure 10 Data sharing structure between related agencies

Information Exchange Institutions	Information
Gyeonggi Province Traffic Information Center	- Provide Namyangju city with information by collecting and linking information with Seoul - Regional Construction Management Administration, Korea Expressway Corporation, Gyeonggi - Province Fire Services, and news channels
Namyangju Police Station	- Traffic flow information, Unexpected situation information
Namyangju Fire Station	- Traffic flow information, Unexpected situation information
Namyangju Disaster Management Department	- Order action for disaster

Table 6 Information exchange institutions and contents

3.3 System architecture

3.3.1 System layout

Namyangju Smart City System is connected to various on-site equipment and the U-Integrated Traffic Information Center through Dedicated Fiber Optic Communication Network. Some of the on-site equipment that are too far away to access the fiber optic communication network use a rented network to link to the center. On-site equipment connected to the center include CCTV, VDS, AVI, VMS, traffic signal controller, DSRC-RSE, BIT, Web-Cam etc.

Namyangju U-Integrated Traffic Information Center collects in real time various detection data on site. Collected data undergoes supplementary and smoothing process to provide useful and worthy information to citizens. The data is then made into statistics and saved. In addition, Namyangju U-Integrated Traffic Information Center exchanges information with connected institutions in a designated method. Figure 11 depicts the overall Namyangju Smart City System composition. The communication network consists of UTIS Ring and ATMS Ring.

The center system consists of situation board system, operation server, terminal sector, network, and security system as can be seen below in Figure 11.

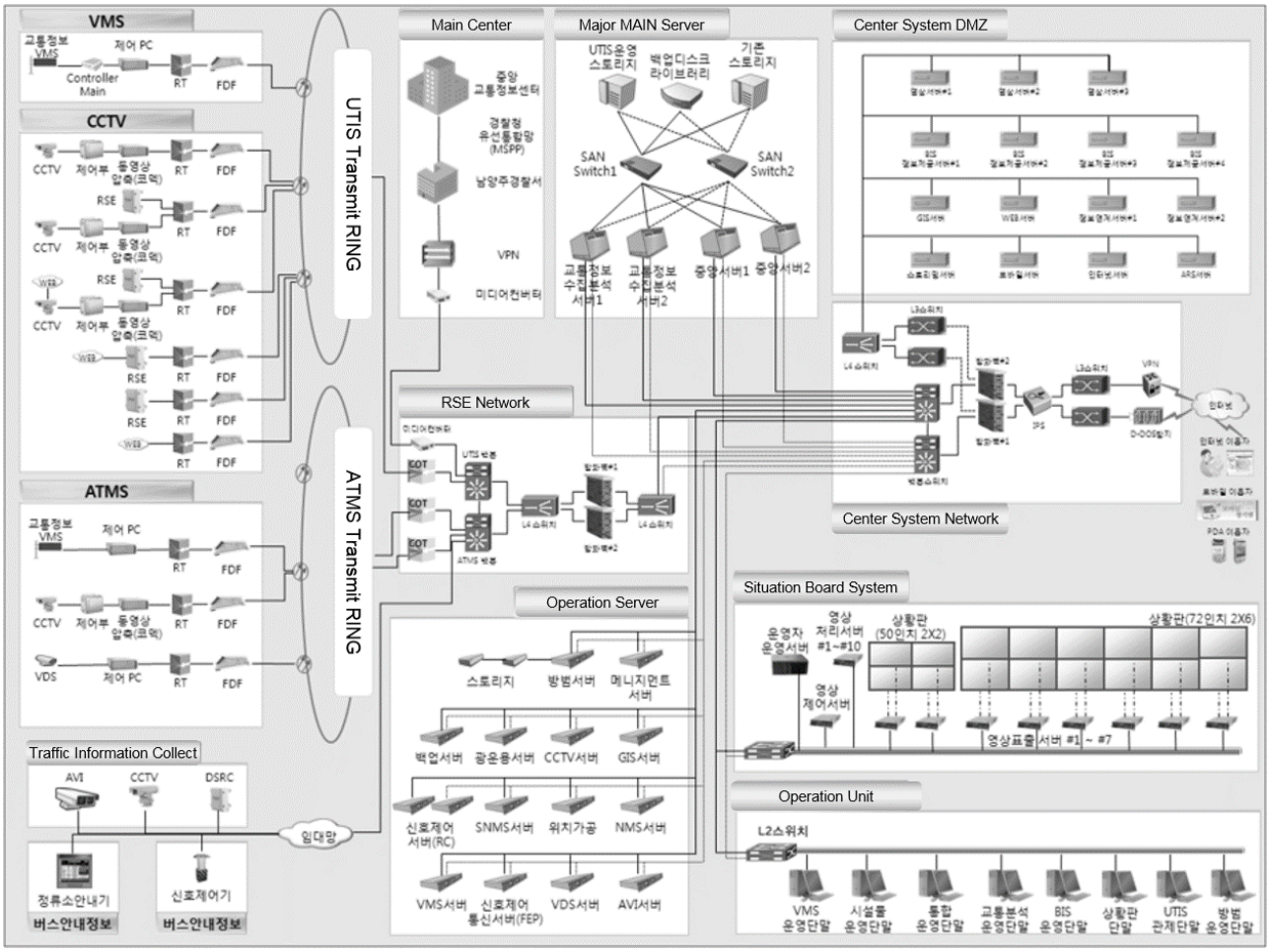


Figure 11 Namyangju smart city system composition

3.3.2 Information flow

In order to manage Namyangju Smart City, numerous information flow through the core of the U-Integrated Traffic Information Center. In other words, information is bilaterally transmitted in real-time amongst the city center, field equipment, and related agencies.

First, countless information is collected towards the U-Integrated Traffic Information Center – field equipment such as traffic signal controller, CCTV, AVI, receive terminals installed in vehicles, collect various types of information on traffic, city, and the condition of on-site equipment. Second, information sent from the U-Integrated Traffic Information Center towards field equipment is mainly control signals from operators at the center, Last, useful information that is manufactured and provided by the U-Integrated Traffic Information Center is sent to information providing equipment installed on the field – such as, VMS, BIT, receive terminals installed in vehicles, and mobile terminals used by citizens.

Similar with the information collecting devices, information providing devices installed on roads also send their operation condition related information in the direction of Namyangju U-Integrated Traffic Information Center, which helps provide normal system operating conditions and failure occurrence situations. Figure 11Figure 12 roughly depicts information collection, processing analysis, and construction for information providing systems that are necessary for Namyangju city's smart city service.

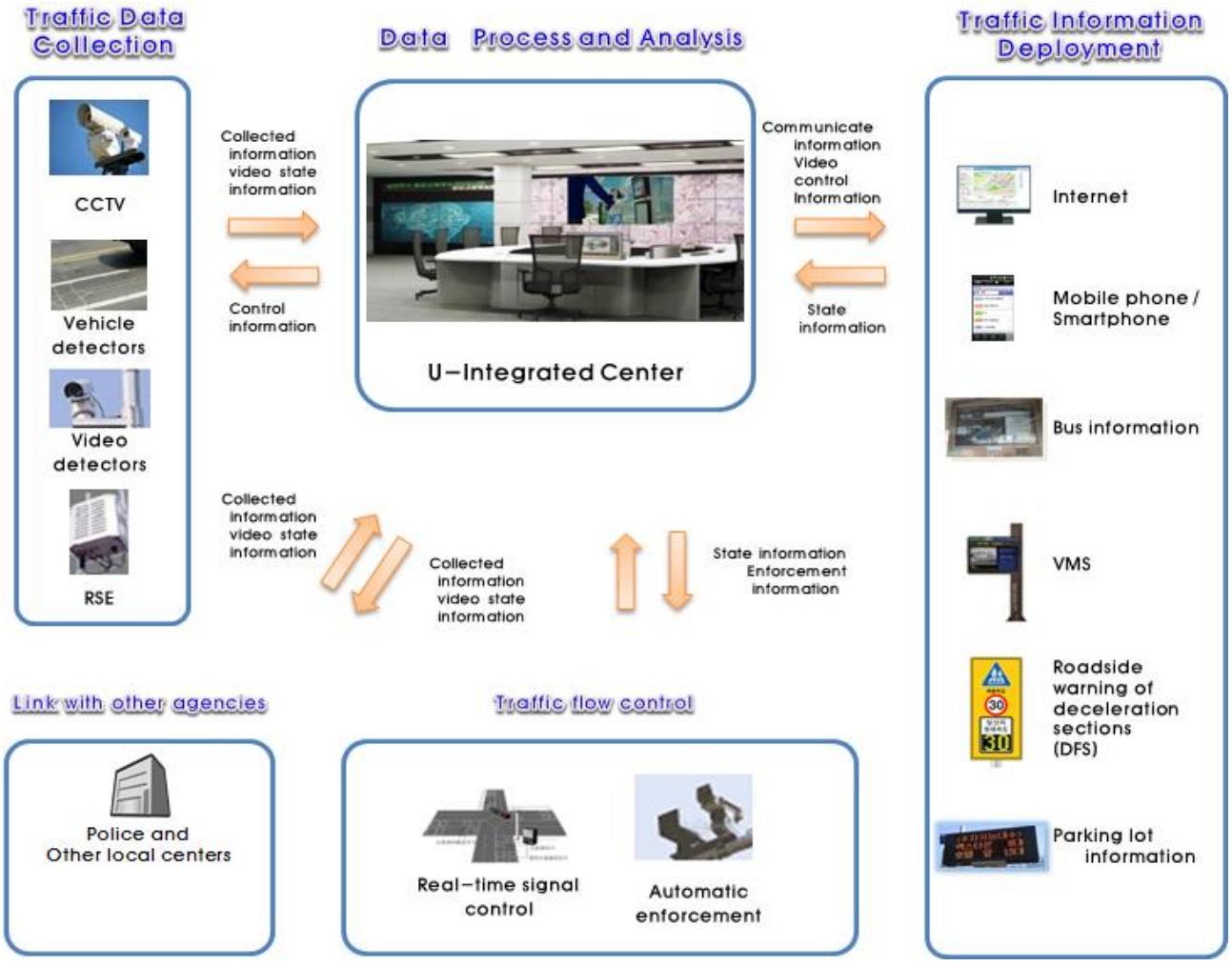


Figure 12 Information flow for namyangju smart city service

3.4 Integrated center system

Monitoring functions regarding traffic, crime prevention, disaster prevention, and city safety are all integrated into the U-Integrated Traffic Information Center. Namyangju city's situation board is built to change display according to the operator's control. Therefore, according to the relative importance of each time period, the board display can automatically show what has been designated, or in case where a situation arises the operator can intervene and operate the board. With the exception of downpour, heavy snow or other emergency, a 24-hour work shift is not operated. Consequently, there are no conveniences separately prepared for 24 hour workers.

Namyangju U-Integrated Traffic Information Center is located in the city hall building. As a result, efficient usage of space is difficult for the center to function. For this reason, the city is in process of building a new U-Integrated Traffic Information Center building. The new center will be located at Byollae new-town and is aimed to open in 2016. The new U-Integrated Traffic Information Center will efficiently manage and operate not only new-town but all of Namyangju city which has the form of urban-rural integrated city. Thus, supporting the safe and convenient lives of its citizens.

Figure 13 View of Namyangju U-Integrated Traffic Info rmation Center

3.5 Field System

3.5.1 CCTV

CCTVs are installed on major roads of the city. The equipment collects video information on unexpected situations and traffic conditions. CCTVs are not only useful for monitoring traffic conditions but can be used to monitor fire, disasters and unexpected situations. Swift location search and monitoring takes place by using the preset function and by setting areas that are prone to road floods and mountain fires. CCTV has different operation strategies based on traffic conditions.

Traffic Condition	Ordinary	Repeated Congestion	Unexpected Situation	Equipment Malfunction
CCTV Management Strategy	·Real time monitoring of major roads ·Concentrated monitoring of frequent accident locations, poor road line locations	·Check repeated traffic congestion sections ·Check traffic congestion and flow through detection data ·Check if traffic congestion situation has ended	·Check locations where potential unexpected situations can occur ·Confirm emergency, identify status and seriousness ·Check for various urgent situations	·In case the vehicle detection fails to collect information, the operation is carried on my the operator

Table 7 CCTV management strategy by traffic condition

Figure 14 Namyangju City's CCTV Locations

Figure 15 Namyangju's surveillance camera image

Furthermore, surveillance cameras are installed in intersections where traffic accidents occur frequently and are monitored. Intersection cameras are divided into VDS type, which provides vehicle footage, and the AVI type that recognizes vehicle plate numbers. The two systems are linked to provide information for 24 hours.

Category	Specifications
Pixel	2Mega
Resolution	16 : 9 1920(H) x 1080(V) 4 : 3 1600(H) x 1200(V)
LENS	6.3mm ~ 63mm (Optics x10, Digital x16)
Lowest Illumination Intensity	2.0lux(color), Below 0.1 LUX (black&white)
Signal Post Noise (S/N)	More than 50dB (color more than 42dB)
Power	AC24V
Power Consumption	35W
Pan/Tilt	360° Endless Pan / -20°° ~ +200° ° Tilt
Pan/Tilt Speed	420° °Sec Pan / 360°Sec Tilt

Table 8 Namyangju's CCTV technical specification

3.5.2 VMS

Variable Message Signs (VMS) installed at the city's major roads, provide real time traffic information regarding the road ahead and areas near the road by using letters and graphics. The information provided by VMS enables users to find the best route thus enhancing traffic efficiency and maintaining smooth traffic flow. The VMS displays information in the order of information that can influence the driver's pass through the section the most.

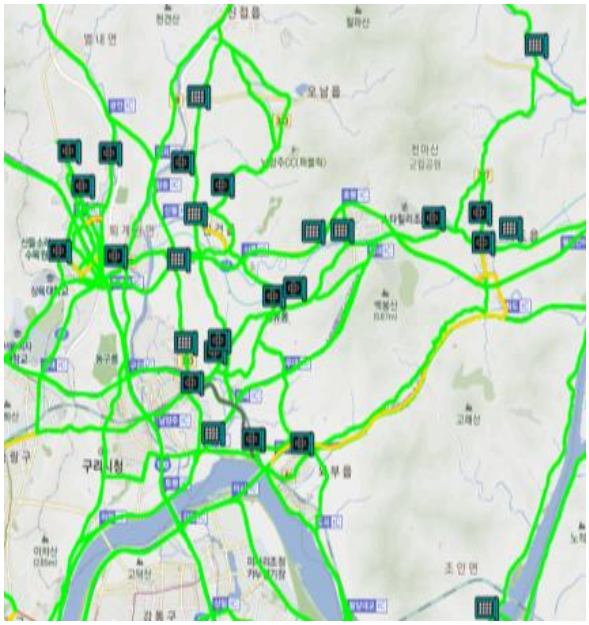


Figure 16 Namyangju's VMS installation locations

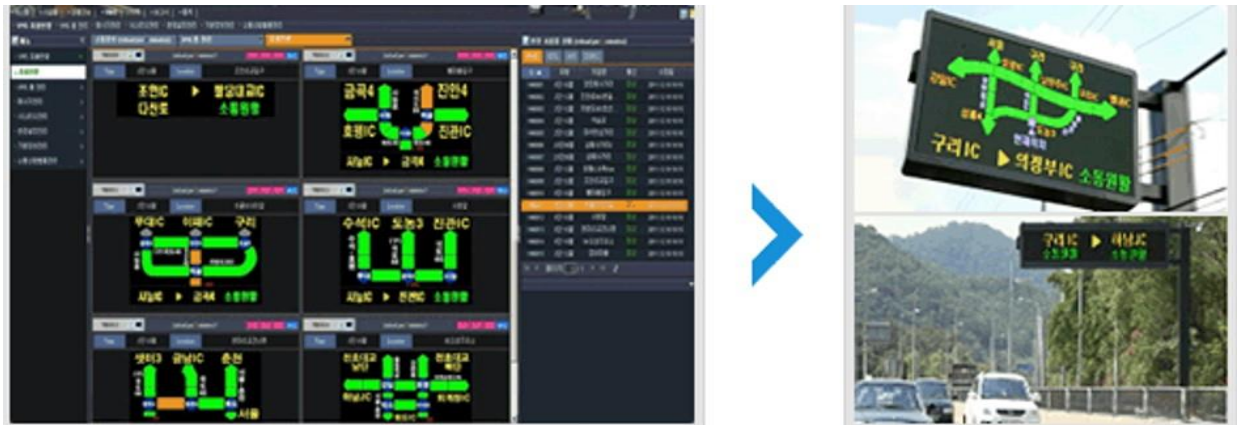


Figure 17 Processing of VMS traffic info (left) and provision of traffic info via VMS as RSE (right)

Display Priority	Traffic Condition	VMS Information Providing Method
1st	Traffic control & Unexpected Situation	· Provide information on accident area to prevent secondary accidents · Display control and accident type to alarm the driver of severeness
2nd	Chaotic Condition	· Provide traffic flow and congestion information to driver through speed information · Help driver to find different route by providing information on sections that are prone to traffic congestion
3rd	Smooth Flow	· If all sections show smooth traffic flow, provide only the information of relevant section
4th	Others	· Display major events and municipal government information

Table 9 VMS Display for Each Traffic Situation

3.5.3 Car Navigation System (CNS)

The Car Navigation System (CNS) is an OBE (on board equipment) that has high pass function added to it. The CNS receives traffic information through wireless communication with Road Side Equipment (RSE) and Dedicated Short Range Communications (DRSC). The information is sent to the Traffic Information Center and provided to drivers in forms of traffic flow information, CCTV footage, SMS etc.

Figure 18 Car navigation system

3.5.4 Intelligent Signaling System

Namyangju city has an urban-rural integrated city form. Due to this characteristic and the city's street network, intelligent signaling systems were installed in certain intersections with large traffic volumes. The Central Control System built within the Traffic Information Center, controls signaling durations according to increases/decreases in traffic volume. Likewise, to most cities in Korea, the traffic signaling control system is built and operated according to the standards of the Korean National Police Agency. In the future, a new signaling system will be introduced to maximize the efficiency of the intersection and improve traffic congestion. The city is also planning to actively adopt the 3rd generation 'Smart Signal System', which is currently being developed by the national government, once it is commercialized.

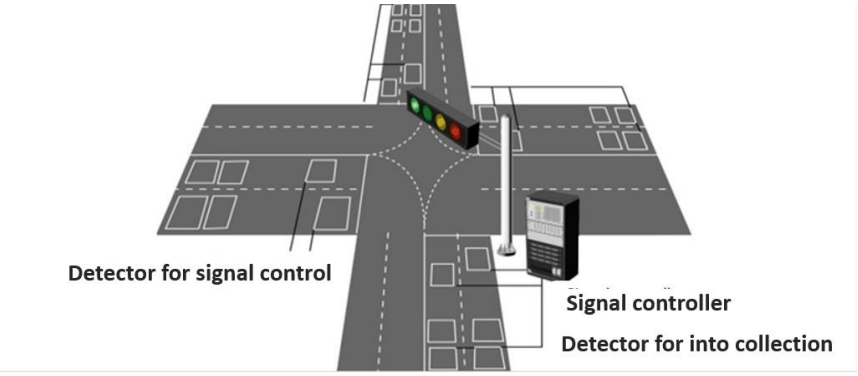


Figure 19 Intelligent signaling system

3.5.5 Bus information device

Figure 20 Bus Information Device in Donog Station

The bus information devices placed at stations are Digital Information Display (DID) devices that provide subway users with various information on Namyangju city's traffic and culture contents. DID is composed of one 70 inch and one 46-inch screen. The 70-inch LCD screen displays traffic information, transfer information, weather, news etc. and the 46-inch LCD touch screen enables users to search for tourist information, airport bus information, transfer information, traffic information, service route information, and history information. The bus information device is not merely an information display equipment but is a hybrid digital information display equipment that users can use to search for information themselves.

3.6 Communication system

Namyangju city has established a total 196km of high-speed Dedicated Fiber Optic Communication Network from 2010 to 2014 and it is currently in use. In 2010, the city established a total 101km of network through the Police Station UTIS project. Since then, 19km~25km of Dedicated Communication Network has been established each year through the ATMS project. In Figure 21, it shows the current state of established network.

Currently, the capacity of the main core (Gyeongchun road Donong trisection ~ Namyangju City Hall) is not sufficient. Therefore, establishing a communication network is necessary if additional equipment is to be installed.

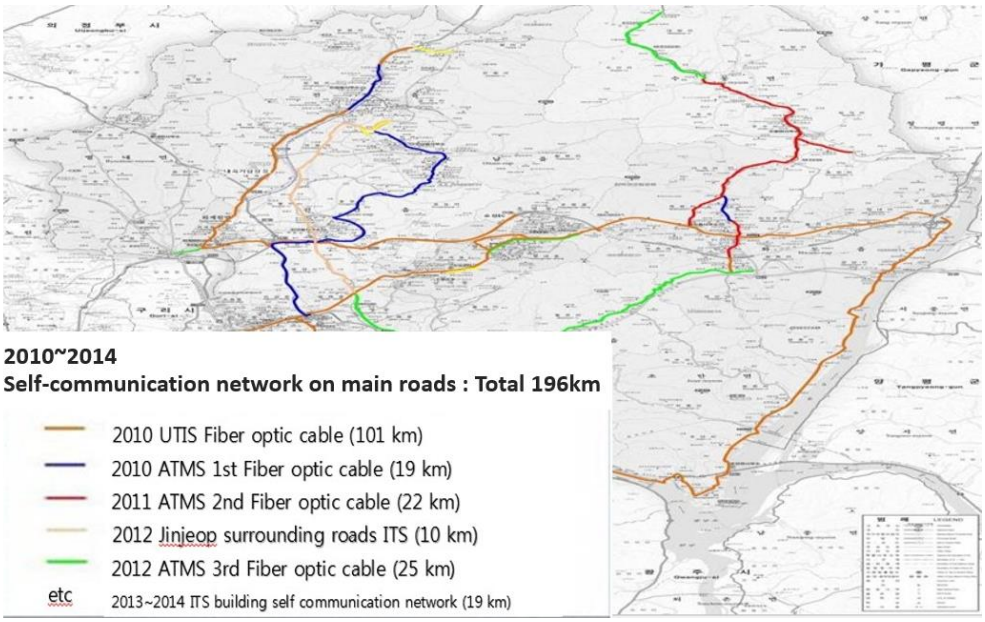


Figure 21 Current Dedicated Fiber Optic Communication Network

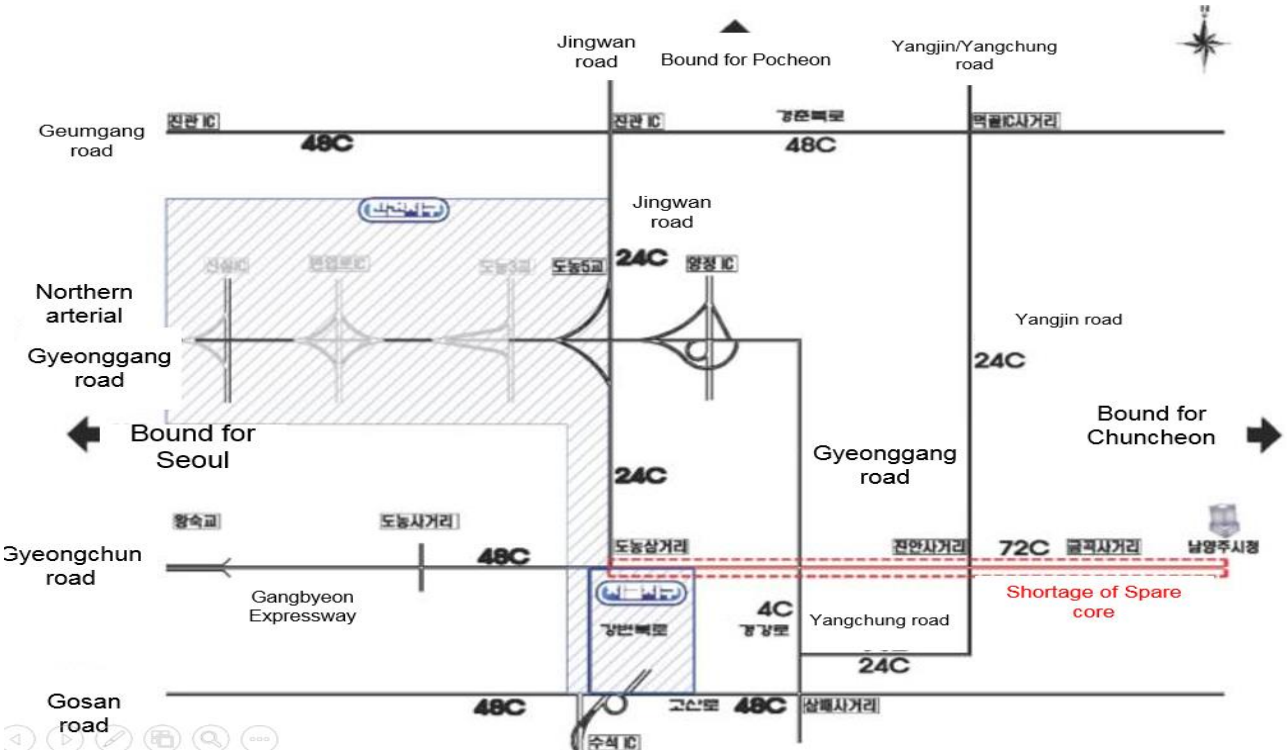


Figure 22 Namyangju city's communication network topology

3.7 Sub-systems and functions

3.7.1 Transportation and urban mobility

A. Bus Information System

Bus information system collects bus operations information on real-time and provides accurate bus arrival time by using the wireless transmitter-receivers installed at bus stops. The system is established to maximize the convenience of bus users, activate bus usage, and acquire operation punctuality.

Through the BIS system, real time bus information such as predicted arrival time, route information etc. is provided to all the bus information devices installed at major stops. The system induces citizens to use public transportation and enhances the convenience of buses.

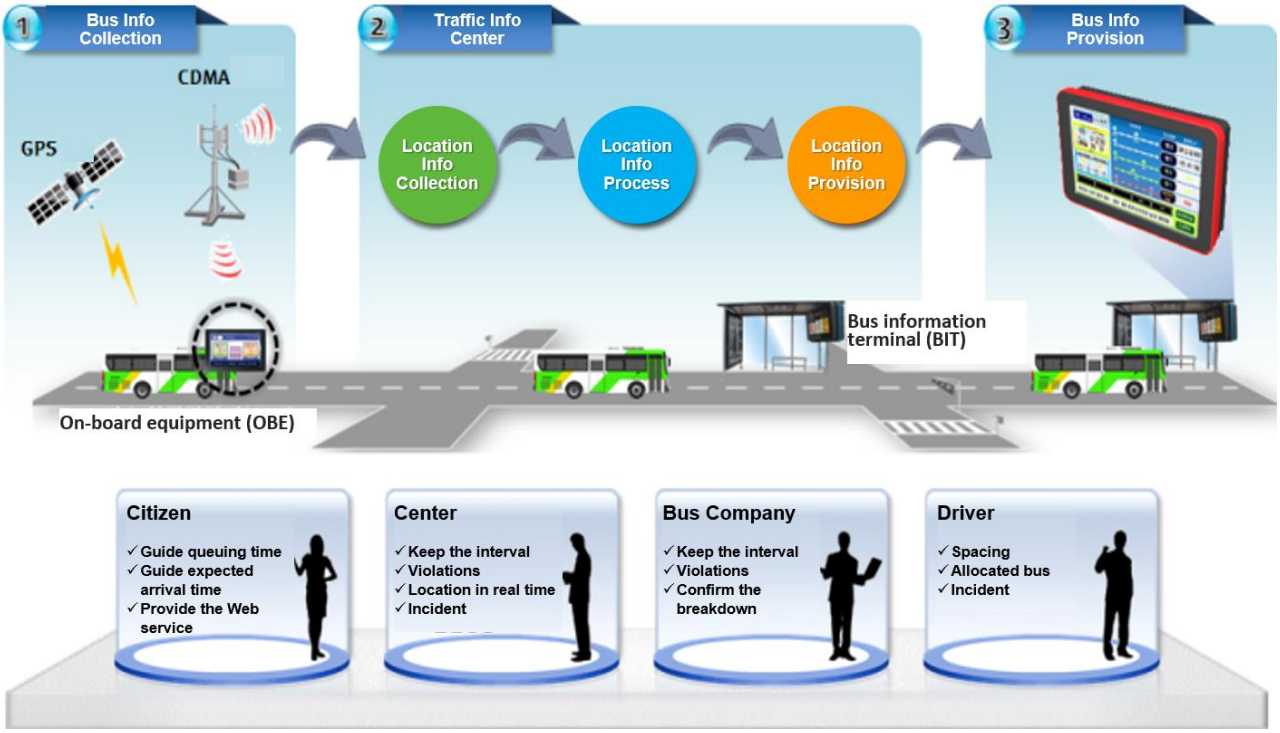


Figure 23 Concept Map of BIS

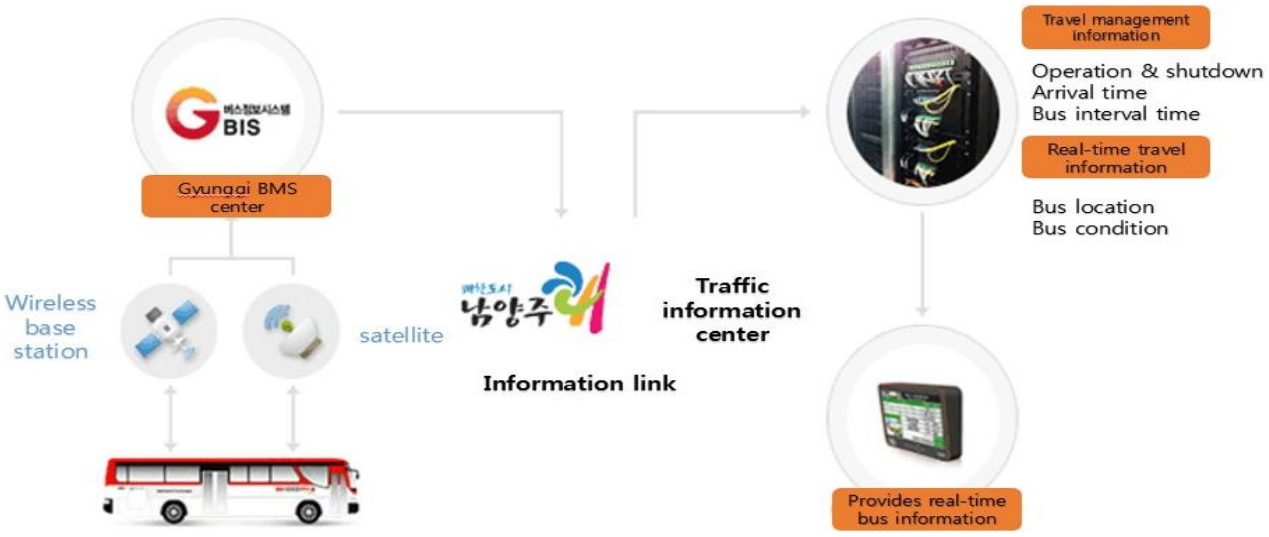


Figure 24 Information link between traffic information center

B. Parking Information System

Parking Information System works to increase the efficient use of parking lot and the convenience of drivers, by collecting, processing, and providing parking lot information, parking location information, and parking lot situation information to drivers.

Depending on the information collection method, the Parking Information System can be divided into 1) Labor force based, 2) Vehicle entry & exit based, 3) Detection sensor based systems. Namyangju city is running a vehicle entry & exit base parking information system at public parking lots of Sareung station. Parking lot information is provided to users through two VMSs installed at major locations leading to the parking lot.

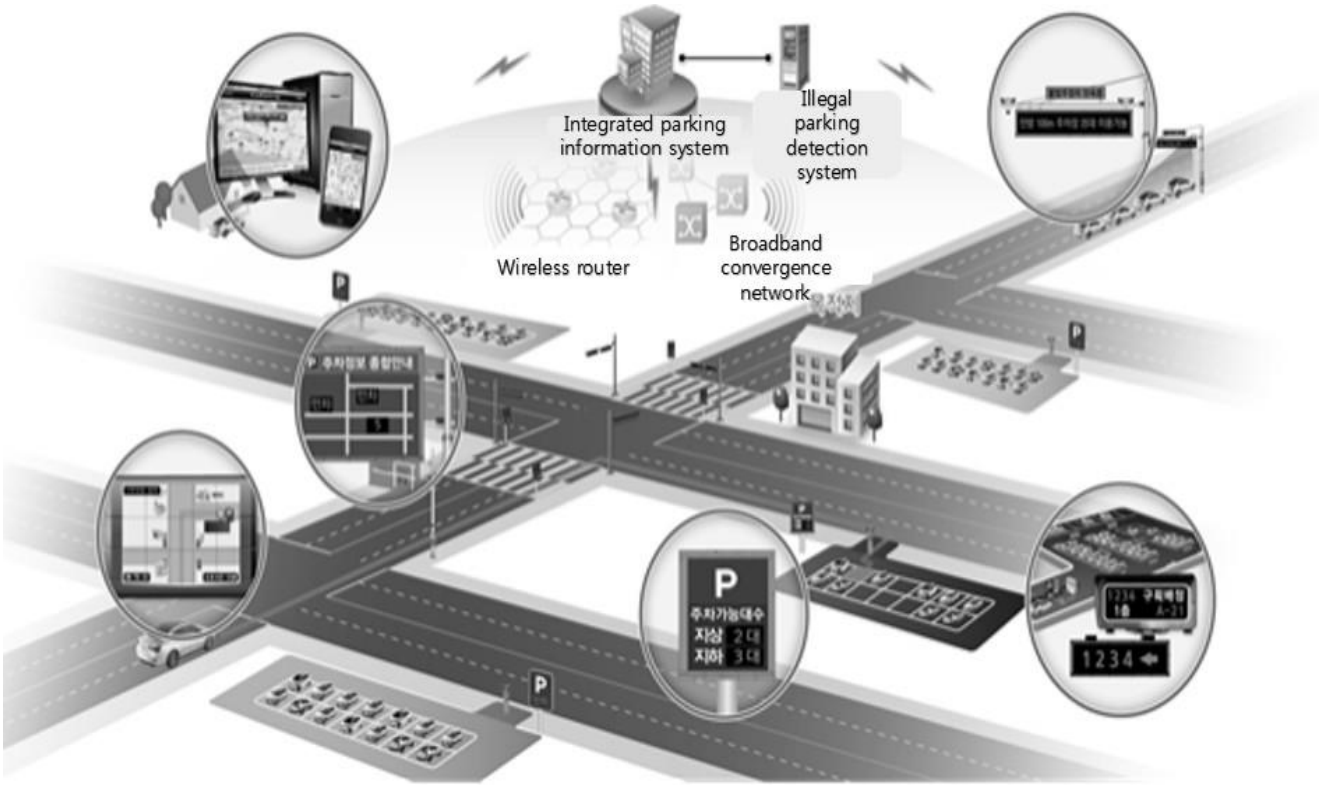
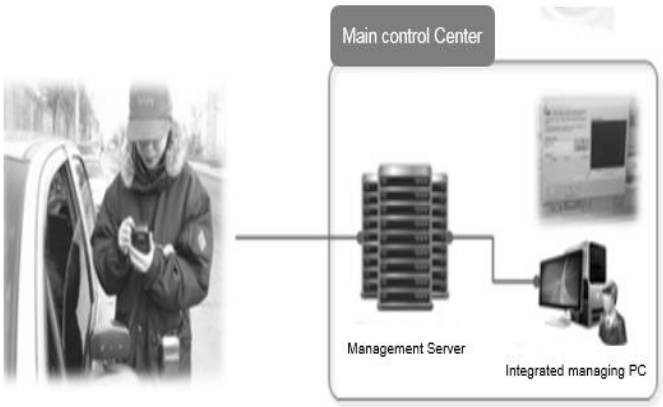


Figure 25 Block Diagram of Parking Information System

Info. Collection Method	Collection Technology	System Composition
Labor Force Based	Collecting and manufacturing parking lot information by using the PDA used for collecting parking fees	

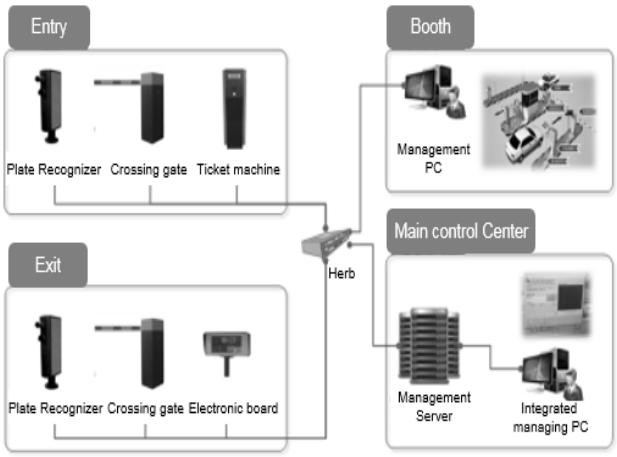
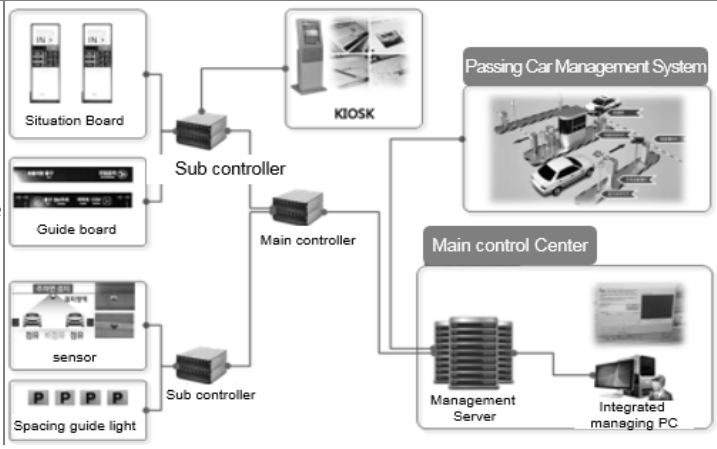
Vehicle Entry & Exit Based	Calculating real time available parking space by using entry and exit gates to count the number of vehicles	
Detection Sensor Based	Collecting parking lot information per parking space unit by installing detection sensors	

Table 10 Comparison of Information Collection Method

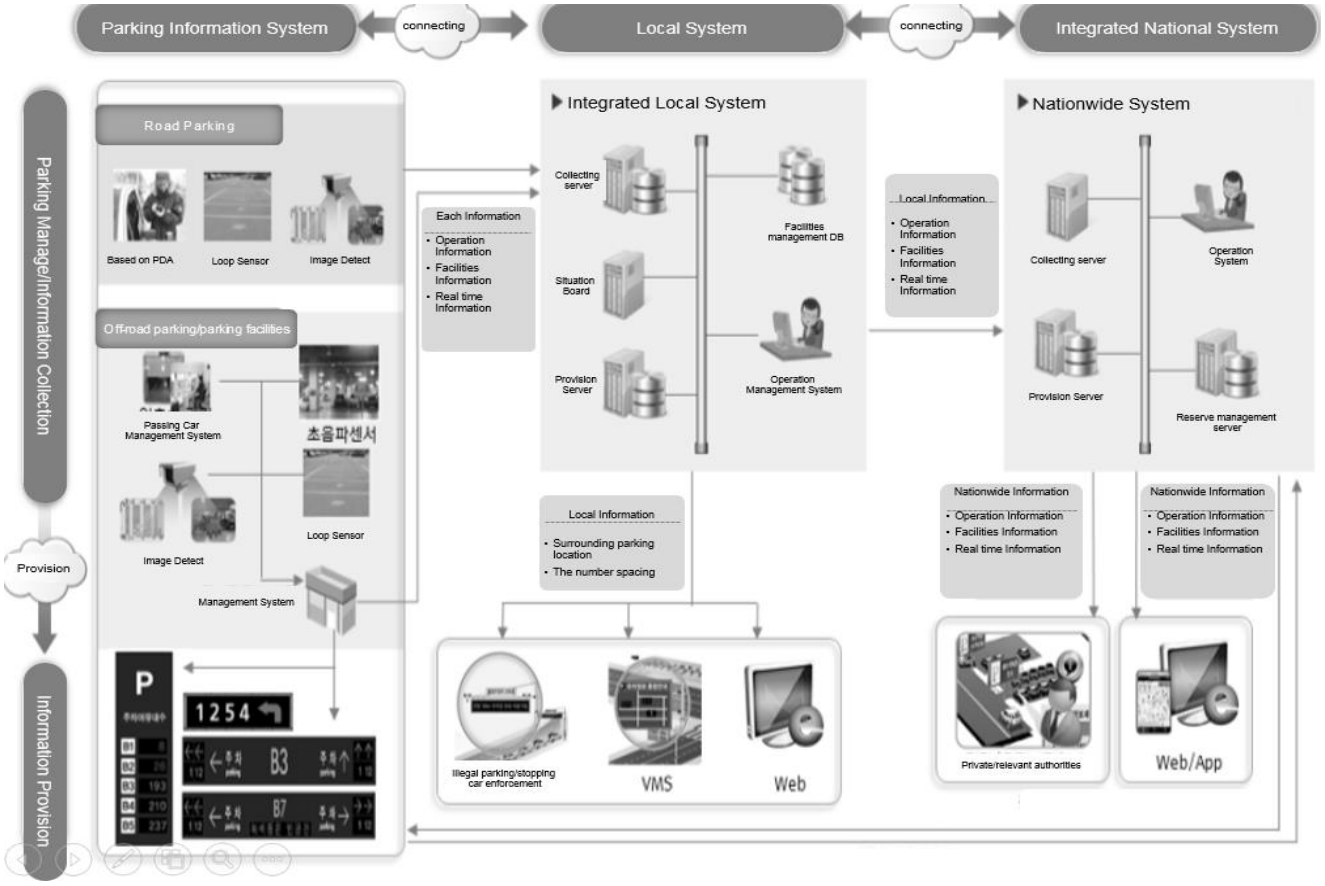


Figure 26 Plan for National Level Integrated Parking Information System

Parking information consists of information on each parking lot such as, parking lot facility information, real time information, and information on regional parking lots such as, parking lot location information, and availability information. Such information is planned to be linked on real time at province level and nation level, according to the Parking Information Exchange Standards. The system will also be linked to private and relevant institutions to provide users with parking reservation and approval services.

3.7.2 Safety and citizen security

Figure 27 Security system operation method

Crime prevention bells and CCTVs are installed in 99 bus platform sites at Namyangju city. The crime prevention system is established to enable swift action by linking the equipment to the crime prevention center in case of crime or emergency. If a situation occurs near a platform and a citizen pushes the SOS button, the CCTV nearby automatically turns to record the relevant site. While filming and recording the situation on site, the video footage is simultaneously sent to the operator at the crime prevention center and a real time voice communication channel starts to operate. Then, depending on the type and seriousness of the situation, the information is sent to relevant institutions such as police stations or 119 for action and resolution.

3.7.3 Emergency and response

Traffic management of irregular situations is operated by collecting, manufacturing, providing information, depending on traffic conditions that are divided into repetitive traffic congestion, unexpected situations, special situations. Repetitive traffic congestion is managed by designating the section on hand as a focused control section and selecting detours. Also, traffic volume decrease during rush hours can be induced by dispersing traffic to different time periods through traffic congestion forecasts.

It is decided that repetitive traffic congestion is occurring if the traffic speed falls below the speed limit for longer than 30 minutes. The fact that different conditions occur depending on the time and day of the week is considered. Therefore, a section is selected as a repetitive traffic congestion area if traffic jam occurs at the same time and same day of the week for more than 3 weeks. In case of unexpected situations, the situation is managed in the order of identifying the situation, providing detour information, and ending situation.

Stage	Situation	Center Operator's Duty
1st Stage	Identification	・Figure out unexpected situation location & accident scale ・Figure out areas influenced by unexpected situation ・Predict duration of unexpected situation
2nd Stage	Provide Detour Information	・Figure out intersections where detour is possible ・Provide detour information and select detour spots ・Provide information on detour routes and unexpected situation
3rd Stage	End Situation	・Confirm end of situation and provide information ・Manage data of unexpected situation

Table 11 Emergency management plan by stage

If an unexpected situation occurs, various information regarding the situation is recorded and managed as data. The information includes, location, time, emergency type, control and management used to resolve the situation.

Action plans are made beforehand to deal with special situations such as roadway construction, events (parade, VIP movement etc). On the day of the construction or event, real time response and post management plans are considered.

Pre Management	Action Plans Made Before Event	**Post Management**	Real time response during event/ Continuous update of management strategy
Build Plans for managing traffic	・Traffic control section, time, detour route ・Build information providing strategy for each information providing medium ・Build strategy for controlling traffic signals near event road sections	**Traffic Management & Operation**	・Provide information before and the very day of the event ・Apply detour strategy ・Control traffic signals according to traffic information management measures
		Real time Monitoring	・Real time monitoring on the day ・Real time response to traffic situations

Table 12 Management plan for pre and post special situation

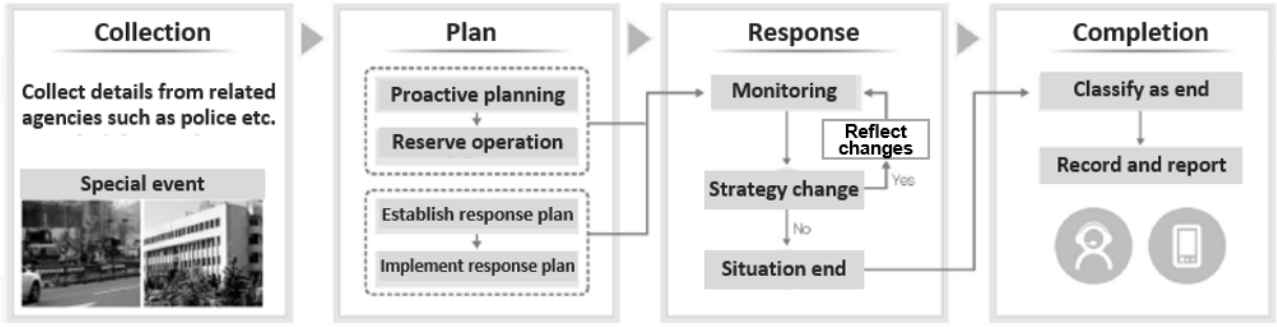


Figure 28 Information collection, plan building and response process in special event steps

3.7.4 Citizen interaction

Like other local governments of Korea, Namyangju city provides citizens with participation opportunities by utilizing the city homepage. Through the city homepage, citizens can not only access local government news, but can also take care of businesses regarding taxes, passports and other various civil services online. Real time traffic information can be found through mobile devices and 'S.Net service' can be provided through a mobile application.

The current city hall homepage provides almost all necessary information regarding politics, economy, social, culture, law, and employment to citizens. Recently, ticket reservation services and employment information were added to the city homepage to help solve the small inconveniences in the daily lives of citizens.

Menu	**Citizen Participation**	**Civil Service Application/Confirmation**	**Municipal News**	**Disclosure/Open**
Provided Contents	Citizen Opinion Request to mayor Report corruption of public officers Report Center Let's Compliment Survey	Service Guide Electronic civil service application Electronic civil service confirmation 24 Complaints Application Views(Other)	New Notice Announcement Press release Main events Municipal news Monthly work plan	Footage Living/Statistics 3.0 Government/ Public Data Administrative information disclosure Real name policy

	Communication channel	8272 Complaints Center Tax services Passport services Unattended service devices Other complaints Online consultation	News of other institutions	Contract agreement disclosure Audit/Finance Source Namuangju city newsletter Autonomy laws
Menu	**About Namyangju**	**Sectoral Information**	**Mobile**	**-**
Provided Contents	City introduction Namyangju history Vision & Strategy Organization/ work guide Building information Directions	Welfare/Education Cultural tourism Slow life City/Traffic Living/Sports Enterprise/Economy	Mobile service guide Mobile service	-

Table 13 Namyangju city homepage menu and contents

3.8 Knowledge Generation

Namyangju city is developing a service to utilize the big data collected at the U-Integrated Traffic Information Center. The technology being developed, either manually or automatically searches and collects relevant information from all different data sources within and outside of the U-Integrated Traffic Information Center. The technology is not simply about securing information, but is about the overall technology of acquiring information including, search process, collection process and, conversion process. Once the technology for utilizing big data is implemented, considerations have to be made for defining the data managed, acquiring data management conditions, building data collection methods, acquiring security and efficiency. The big data system is composed of data integration system, data storage system, and data management system. Various services such as traffic safety, traffic information, traffic analysis, weather information can be deducted by utilizing public and private information. In addition, services supporting traffic policy is expected to be made possible by scientifically analysing various information.

Requests of users (operator, citizens etc.) will be taken into account when introducing the big data management technology. Based on this, a recorded traffic information management system and recorded data user system will be established. Through this, the big data will be used in establishing traffic policy, analysing and responding to each traffic situation, producing chronology of traffic statistics, and thus create various services by opening big data information (use OPEN-API).

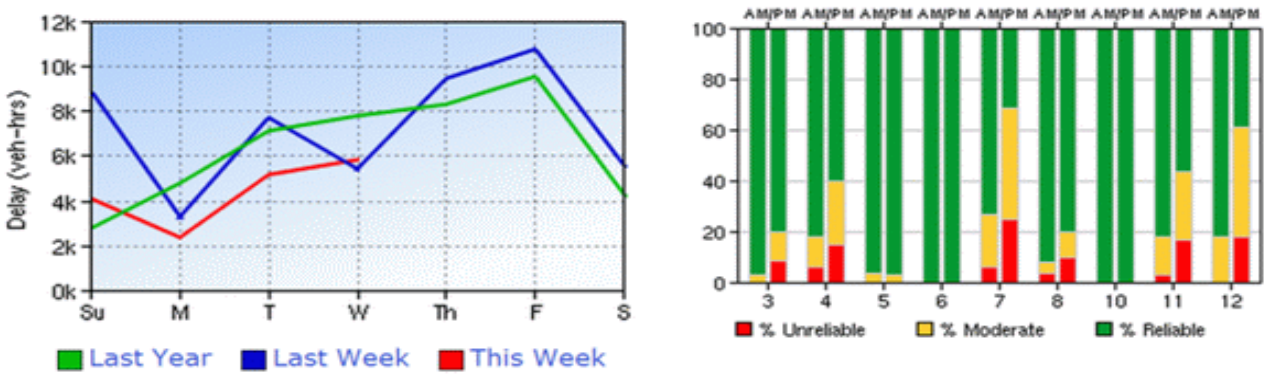


Figure 29 Analysis of traffic congestion level of each time period of each day (sample)

Also, plans are made to build a data base of maintenance and management information in

order to use as a decision making support tool through data mining. the information will be used when deciding where new on-site equipment is necessary, and when equipments should be changed.

In line with the Korean government's 3.0 generation, Namyangju city plans to disclose traffic and facility information through the public data portal (OPEN-API) and produce various services, in order to activate the distribution of traffic information.

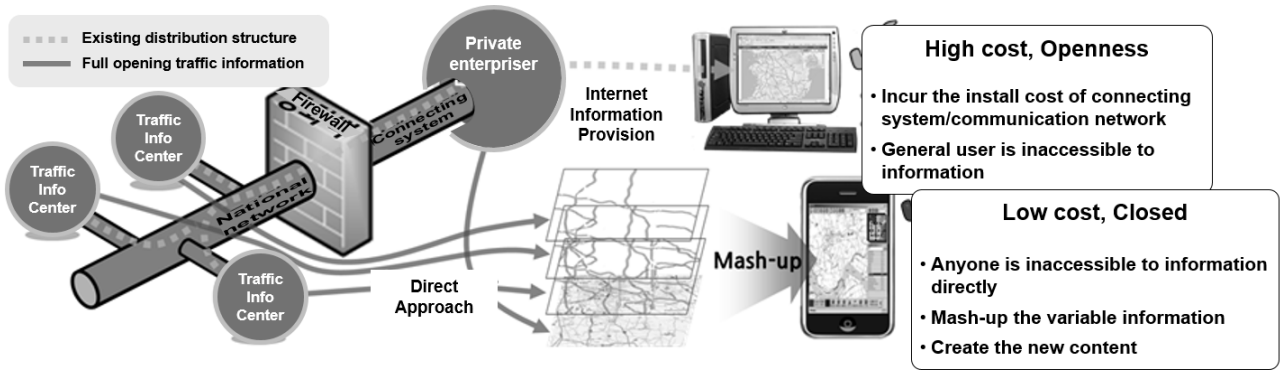


Figure 30 Information Distribution Structure through Open API

4. Organizational Structure

4.1 Governance Model

Namyangju U-Integrated Traffic Information Center is directly operated by the Traffic Planning Division under Namyangju City Road Traffic Office. The U-Integrated Traffic Information Center Team is composed of 1 team manager, 2 traffic section planners, 1 electronic/communication constructor, and 1 center operator. The following figure depicts Namyangju U-Integrated Traffic Information Center's organization chart.

4.2 Human Resource

With the exception of special situations, Namyangju city does not run a 24-hour work shift. Therefore, separate workforce for center operations is not arranged.

Position	Tasks	Sector
Team Manager	Overall management of Center	Administration
Team Member	Carry out ubiquitous work project	Communication
	Establish ATMS, Private capital led ITS etc.	Traffic
	Operate center data processing, Carryout BIS	Data Processing
	Carry out center maintenance	Traffic

Table 14 Work division of U-integrated center.

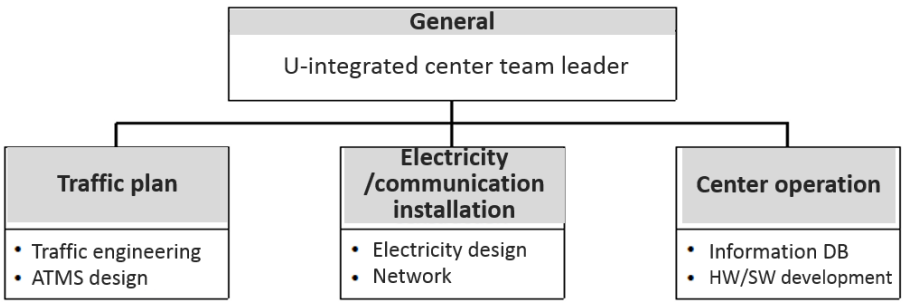


Figure 31 Organization chart

4.3 Information control, ownership and sharing

As expressways such as the Seoul Ring expressway, Seoul-Chuncheon highway and #6, #43, #45, #46, #47 national highways pass through Namyangju city, close connection and information integration with other related systems is vital.

Currently, expressway and national highway traffic information manufactured by other local governments within Gyeonggi province is collected by Gyeonggi Province Traffic Information Center and sent to Namyangju U-Integrated Traffic Information Center. Namyangju U-Integrated Traffic Information Center then manufactures the information received and provides it to police stations, fire stations, and disaster status control center.

4.4 Protocols of decision making between agencies

Namyangju U-Integrated Traffic Information Center is solely operated by the Traffic Planning Division. Due to the physical size and structure of the center, joint service with related departments is difficult. Therefore, the U-Integrated Traffic Information Center carries out real time work regrading traffic and crime prevention. If situations other than traffic and crime prevention occurs, the operator at the center immediately spreads the information to related departments to support swift decision making and response.

4.5 Cost system

The maintenance costs of Namyangju Smart City are largely composed of outsourced labor costs, system maintenance costs, electricity and communication costs. The overall maintenance of on-site facilities and data processing equipment is carried out on a yearly basis by private enterprises that have been chosen through competitive bidding. The Traffic Planning Division manages outsourced service companies and annual costs for Namyangju Smart City is 609 million won in 2014.

Year	Tasks	Division in charge	Costs (KRW million)	Others
2012	Maintaining U-Integrated Traffic Information Center	Traffic Policy Division	570	Maintain BIS, ITS (On-site facility, data processing equipment etc.)
2013			600	
2014			609	

Table 15 Operations Costs for the Past 3 Years

5. Monitoring and control

5.1 Benefit items by selected smart city sectors

5.1.1 Transportation and urban mobility

Figure 32 Change in average speed on local roads (left) and change in waiting time at intersections (right)

Since the establishment of 3rd stage ATMS in 2012, Namyangju city has analyzed the effects of providing real time traffic information. Based on field investigation, a comparison of before and after the smart city project has been made. Average traffic flow speed has increased by approximately 7.2km/h after providing real time traffic information, dispersing traffic volume and inducing detours. Average waiting line length at 4 main intersections within the smart city business area, has decreased by 6~12m where average waiting time due to control has decreased by 43.2 seconds. As citizen usage rate of traffic information increases, citizen awareness of cutting-edge traffic system has increased by 18% from 64% to 82%. Also, citizen satisfaction rate regrading traffic information has increased significantly by 50% from 30% to 80%. Approximately 68% of users choose to use detours by using the information on VMS and 82% of drivers requested for additional VMS installment.

6. Lessons Learned

Namyangju U-Integrated Traffic Information Center is all in once incharge of traffic, safety and disaster prevention. Like other smart cities in Korea, Namyangju city first built a common platform such as ITS and BIS and has extended functions starting from this.

Namyangju city has prepared largely 4 categories for the smart city project. First, a plan to build a citizen based project promotion organization and project plan has been made. In other words, citizens will participate as a working group and project plans have been made in connection to citizen projects. Second, a cooperative system with related organizations has been built. Extreme care has been devoted to receive national and provincial subsidies. As a result, the city has attracted various demonstration/model projects. Third, service models that can differentiate Namyangju from other local governments have been discovered and made. In other words, services are made where the ICT technology is converged with the plans and alternatives regarding traffic, crime prevention, and local economy revitalization. Also, efforts were made to actively implement services that are citizen centered and tangible. Fourth, a group that is exclusively in charge of the traffic sector has been formed and an U-Integrated Traffic Information Center has been established. The Traffic Planning Division and Public Transportation Division have been made and 7 new professionals have been scouted. In addition, A U-Integrated Traffic Information Center that comprehensively manages transportation, crime prevention and disasters

has been fully established.

The city has experienced several trial and errors while establishing the current system. First, establishing systems can be difficult from a long term perspective if it is difficult to acquire project budget. Due to the municipal government's lack of financial budget, it is realistically difficult for the city to carry out the smart city project without the financial support of the central government. As a result, the project cannot but be influenced by the support plans of the central government. Thus, making it difficult for local governments to expand and acquire project solutions exactly when they need them. For these reasons, Namyangju city completed the system by first establishing various infrastructure such as communication network by first building traffic platforms and later adding on crime prevention, disaster prevention solutions.

Second, a separate center building is necessary for it to function as a city management control tower. City management includes traffic, crime prevention, disaster prevention, water disposal, environment management etc. The various functions need to be linked and operated in real time. However, many local governments lack budget or have difficulty acquiring land. So, most cities are remodeling existing buildings to use as centers. Currently, Namyangju U-Integrated Traffic Information Center is using a part of the city hall building and will move to a newly built separate building in 2016. Remodeling existing buildings can cause many problems. Most importantly, due to the nature of center tasks, the operator has to work 24 hours everyday. So, center buildings need to be built while considering ergonomic factors. However, existing buildings are limited in this way. Moreover, system moving costs arise when the center is moved to a newly built building.

Third, there is the problem of investment overlap. This is caused due to the different viewpoint between institutions that manage roads and local governments that try to provide citizens with relevant information. In other words, the information that Road Management Administration needs and the information that local governments need are different. As a result, there are cases where on-site facilities are overlapped and duplicated at several road sections. Therefore, discussion and adjustment among related institutions is vital starting from the information demand analysis and system construction stage.

7. Conclusion

Namyangju's smart city project has been promoted since 2008 with the objectives of effectively embracing the population inflow from Seoul and pursuing the harmony with the existing agricultural regions within the city. The city is actively utilizing information communication technology to realize its goal to become a green transport city and is putting large efforts in developing mobile services and local economic development through e-commerce.

Namyangju is now in the mature phase of smart city project, having been through the periods of initiation and expansion. The current focus of the city is on the implementation of smart city infrastructure in order to provide more effective and beneficial smart city services in a more stable and efficient manner. The city is in the process of installing the fiber-optic communication network of 101km and plans to complete the construction of integrated operation and control center by 2016. Other areas that the city is increasing its focus are citizen interaction and business model development to raise operation and maintenance cost of the smart city system. It is anticipated that Namyangju will continue to develop its reputation as a model case study for smart city implementation under close collaboration among the city officials, related agencies and citizens.

ANNEX A - Bibliography

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Interviewed stakeholders

1. Mr. Jaeyeong Lim, U-integrated Operation Center, Namyangju City


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