ICT Good Practices of a Smart City Incheon Metropolitan City

Case Study

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Case Study

ICT Good Practices of a Smart City: Incheon Metropolitan City

APCICT ASIAN AND PACIFIC TRAINING CENTRE FOR INFORMATION AND COMMUNICATION TECHNOLOGY FOR DEVELOPMENT

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Executive Summary

Entering the era of the Fourth Industrial Revolution driven by the convergence of digital, biological and physical innovations, the 21st century has demonstrated a change in the paradigm of urban planning and development with the rapid progress in Information and Communication Technology (ICT) development which has been changing people's lives in business, economy, culture, art, and society. However, the rapid urbanisation has presented many human development challenges. First, the efficiency of current cities has been declining owing to the insufficient provision of public services, which has resulted in the deterioration of the quality of lives of the citizens. Second, the existing urban infrastructure has been saturated due to the urban concentration of population, which has led to a surge in demand for the development of new cities. Furthermore, urbanisation has caused many social and economic problems such as energy over-consumption, environmental pollution, traffic congestion and crimes.

That being said, the emergence of drawbacks with the rapid urbanisation has invoked a growing interest in smart cities which are considered the solution to the challenges facing urbanisation. Given Incheon Metropolitan City has been regarded as one of the world's leading smart cities, this Case Study provides perceptive insights into the development and utilisation of a smart city through examining the establishment of the Smart City Integrated Platform as well as the good practices of Smart City infrastructure and services in Incheon Metropolitan City, followed by a review of its performance and challenges.

Incheon Free Economic Zone (IFEZ) was designed in Incheon Metropolitan City as a smart city concept from the early stages of development and construction of urban infrastructure. At the heart of the City is the integrated operation centre which controls the whole IFEZ. It is the Smart City Integrated Platform serving as the brain that operates the centre. Composed of the software (SW) platform called Smart City Platform and the hardware (HW) platform which is a Cloud Data Centre, the Smart City Integrated Platform works to collect, store, process and provide information in real time from the target city areas through various smart city devices and facilities. In other words, the Smart City Integrated Platform serves as the brain and neutral core of the City, and provides real time decision support information to operate and manage the entire City safely. It also offers an intelligent integrated control solution which ensures effective information collection, storage, processing, distribution and analysis.

Utilising ICT technologies such as Internet of things (IoT), Cloud Computing, Big-Data and Mobility, as well as communication technologies such as 5G, WiFi, Artificial Intelligence (AI) and robotic technologies, Incheon Metropolitan City is equipped with various smart devices, facilities and telecommunication networks, and provides both public and private smart city services. In terms of the physical infrastructure, Incheon Metropolitan City is powered by bus information terminals, variable message signboards and traffic signal detectors for traffic management, multi-channel closed-circuit televisions for crime prevention, and fire response cameras for disaster prevention, to name but a few. Public Smart City services, such as BARO BUS and Drone-Platform, are also provided for traffic management, crime prevention, facilities management, information provision and so forth. Private Smart City services provided apply smart ICTs in various aspects such as residences, office buildings, school, healthcare and renewable energy, in an attempt to enhance the value of the City and the quality of lives of the citizens.

On the whole, Incheon Metropolitan City reduced the construction cost of its operation centre by one third solely through the Smart City Integrated Platform in IFEZ areas. Indeed, IFEZ has solved many incidents and accidents with the operation of the Smart City Integrated Platform. However, due to the early stage of the development of the Platform, more tangible outcomes showing the improvement of the quality of lives of its residents, the enhancement of the efficiency of the city operation as well as the impacts on the environment are needed in the future to assess its performance.

Chapter 1. Introduction

1.1 Introduction

The scope of each topic of the case study covers

(i) a brief description (what is commonly understood by the term);
(ii) the kind of technologies involved and a brief mention of their characteristics;
(iii) the impact/influence the technology has had until now especially in the context of governance/development and;
(iv) some opportunities/challenges the technology presents going forward.

1.2 Incheon Metropolitan City

Geographically, Incheon is located at approximately 126°37′E, 37°28′N. Incheon faces the Yellow Sea and sits at the mouth of the Han River. It is located 28km away from Seoul, the capital city of the Republic of Korea. Incheon has the same latitude as San Francisco, Washington D.C., and Madrid.

The expansion of Incheon Harbor and opening of Incheon Subway (October 1999), opening of the Incheon International Airport (March 2001), landfill of public waters, construction of various industrial and logistics complexes, construction of tourism and leisure complexes and new residential areas, upgrade of highways, expansion of education and cultural facilities, development of Songdo New Town, opening of the Free Economic Zone (October 2003), construction of Incheon Bridge (October 2009), development of Cheongna and Yeongjong districts and urban restoration projects, and the successful execution of the 2014 Asian Games show that Incheon continues to develop and grow.

1.3 ICT good practices in Incheon Metropolitan City

The ICT environment of Incheon Metropolitan city is well-developed. More specifically, the Incheon Free Economic Zone (IFEZ) is the earliest smart city which is called a 'ubiquitous city' and now one of the most advanced smart cities in the world. Moreover, the Korean central government focuses on the smart city development strategy as one of the growth engines of future economy. With sustainability in mind, IFEZ was designed as a smart city powered by the best IT infrastructure and systems from the strategic planning stage. Under the strategy of "One Space, One System and One Service", IFEZ is serving as an icon of the smart city in the Republic of Korea and becoming a global smart city reference. IFEZ as a global city is innovatively expanding the future of the world.

1.4 Process of selecting ICT good practices

The selection process for ICT good practices in Incheon Metropolitan City has been conducted in a variety of ways as follows:

- Analyzing the ICT projects in 2019, the data and information of which were collected from the Main Office of Incheon City, the affiliated organizations, and the Gu-office, which is a local government.[1]
- Conducting interviews with several experts including officials from the Incheon Metropolitan Government and obtaining a variety of relevant material from Incheon Smart City Co., Ltd.
- Finally, the good practices were selected in consultation with APCICT and the Department of Incheon City International Cooperation.

[1] There are 224 projects in the Main Office of Incheon Metropolitan City and 289 projects in the affiliated offices-Gu Office.

1.5 Selected good practices for Case Study

The 21st century is entering the era of the Fourth Industrial Revolution, where a new paradigm is underway with the rapid progress in ICT development. It is changing people's lives in business, economy, culture, art, and society, and changing their way of thinking.

On the other hand, urbanization, which has been rapidly progressing, faces two major challenges to solve. One is the deterioration of the efficiency of existing cities due to urbanization and the insufficient provision of public services accordingly, which has resulted in a deterioration of the quality of lives of the citizens. Another challenge is the saturation of existing urban infrastructure spurred by urban concentration of populations, leading to a surge in the demand for new cities development.

Demonstrating the representation ranging from its ICT technologies such as IoT (Internet of Things), Cloud Computing, Big-Data and Mobility, to its communication technologies such as 5G, WiFi, AI and robotic technologies, the city is at the center of improving the quality of future life. A smart city is one type of such future city.

Incheon Metropolitan City is one of the world's leading smart cities, designing the Incheon Free Economic Zone as a smart city concept from the early stages of development and building urban infrastructure. Various research institutes around the world have introduced IFEZ as a prime example of smart cities.

The common characteristics of smart cities are hyper-connectivity, interoperability and integration. A platform to ensure that these smart cities work technically well is the City Operations Center, i.e., the Smart City Integration Platform, and a variety of smart city services are provided to citizens on this integrated platform. Therefore, this Case Study introduces ICT good practices in Incheon Metropolitan City with IFEZ's ‘Smart City Integration Platform’ and the various smart city services of Incheon Metropolitan City, the world's leading smart city.

1.6 Structure of Case Study

The ICT Good Practices of a Smart City, Incheon Metropolitan City was divided into two parts. Part I analyzes the IFEZ's Smart City Integrated Platform which converges advanced ICT technologies. Part II researches selected smart services in Incheon Metropolitan City as the 4th Industrial Revolution platform.

Chapter 2. Good Practices

Part I: IFEZ Smart City Integrated Platform

2.1 Background

2.1.1 Urbanization and challenges

Urbanization has rapidly spread across the Western world since the 1950s due to the tremendous growth of two industries. One is the development of the automotive industry that enabled people to commute long distance, which led to the expansion of urban boundaries. The other is the steel industry which enabled people to build high-rise buildings, and increased urban population density.

Globalization has made urbanization spread to the developing countries in Asia and Africa since the 2000s. According to the United Nations reports, to date 55 per cent of the world's population lives in urban areas, a proportion that is expected to increase to 68 per cent by 2050.

Urbanization has also caused many social, economic problems including energy over-consumption, environmental pollution, congestion, crimes and urban operation in old cities in the world. There are several key issues and trends in modern cities such as the rapid urban population growth across developing countries, the growing number of megacities, the inadequate basic civil services due to the lack of sources, as well as the environmental degradation resulting from the destruction of ecosystems.

2.1.2. Growing interests of Smart Cities

Under such circumstances, cities are now faced with several challenges such as sustaining urban areas as engines of growth, managing urban growth, bridging supply and demand gap on infrastructure services, strengthening urban management capacity, decentralizing urban administration, responding to globalization, and making realizing urban resilience through sustainable and livable cities.

In order to solve two big issues related to urbanization, which are to meet the continuing construction demand of new cities and to suggest the solution from intrinsic troubles of urban management, there have been various trials. For instance, such initiatives include sustaining urban growth through suggesting the ideas of green city, digital city, sustainable city and even ubiquitous city to the United Nations and other international organizations.

Meanwhile, the 4th Industrial Revolution has taken the center stage at the World Economic Forum's (WEF) annual meeting in Davos, Switzerland since Klaus Schwab advocated it in 2016. New converging markets are about to be created, based on the information and computer technology which can remove industrial barriers. 'Internet of Things (IoT)', 'Cloud Computing', 'Big Data' and 'Mobility' (ICBM) technologies are leading the shift of paradigm of technologies and advancing hyper-connected societies. The 4th industrial revolution will be largely driven by the convergence of digital, biological and physical innovations, building on the widespread availability of digital technologies. The 4th Industrial Revolution's technologies, such as Artificial Intelligence (AI), genome editing, augmented reality, robotics and 3D computing, are rapidly changing the way humans create, exchange, and distribute value.

The 4th Industrial Revolution has also changed the paradigm of urban planning and development. For the previous urban development and solutions, it is not easy to unlimitedly increase urban infrastructure due to the lack of land and resources. However, a smart city, which maximizes the efficiency of existing urban infrastructures embedded by ICT technologies, is focused as an alternative of the future city. The concept

of the Smart City is a sort of ideal city that provides safeness, pleasantness and convenience to residents through ICT development, and it has emerged to solve various urban problems by a qualitative solution rather than a quantitative one. For example, in the past, if traffic jams occurred, the capacity of the roads would be increased and the signal system would be changed in response. Nowadays, problems are solved in another way. Through autonomous driving, car sharing, and traffic information exchanged between vehicles, the road condition can be managed more efficiently. The Smart City can be adopted as a useful tool to solve urban problems and enable sustainable development. Now, various countries around the world are researching and adopting smart city development methods.

2.1.3 Smart City concept and components

In the Republic of Korea, the "U-City Act"[2], which was enacted in 2008 and applied to new urban development, was completely expanded to the "Smart City Act" in March 2017. Since then, several revisions have been made, including deregulation and expanding coverage of this act to enable the creation of smart cities to be private sector-centric.

There are several definitions of the smart city defined by states, cities, institutions or organization. However, there is no general definition of the smart city, because every city is under different purposes for smart city and phases of city development. In spite of such situations, the Korean government defines smart cities in the "Smart City Act"[3]. "The term "smart city" refers to a sustainable city where various city services are provided based on city infrastructure constructed by converging and integrating construction technologies, information and communications technologies, etc. to enhance its competitiveness and livability"[4]. There are differences between the existing U-city development methods and the new smart city's development methods in the following.

Table 1. Differences of development methods between Smart City and U-City

Smart City (New approach)	U-City (Previous approach)
Urban utilization and revitalization	New City Development
Consumer – centric	Provider – centric
Led with citizen	Led by public or state
Commercial, cultural and business creating	Residential house and public services
General aspects	Propulsion righteousness characters

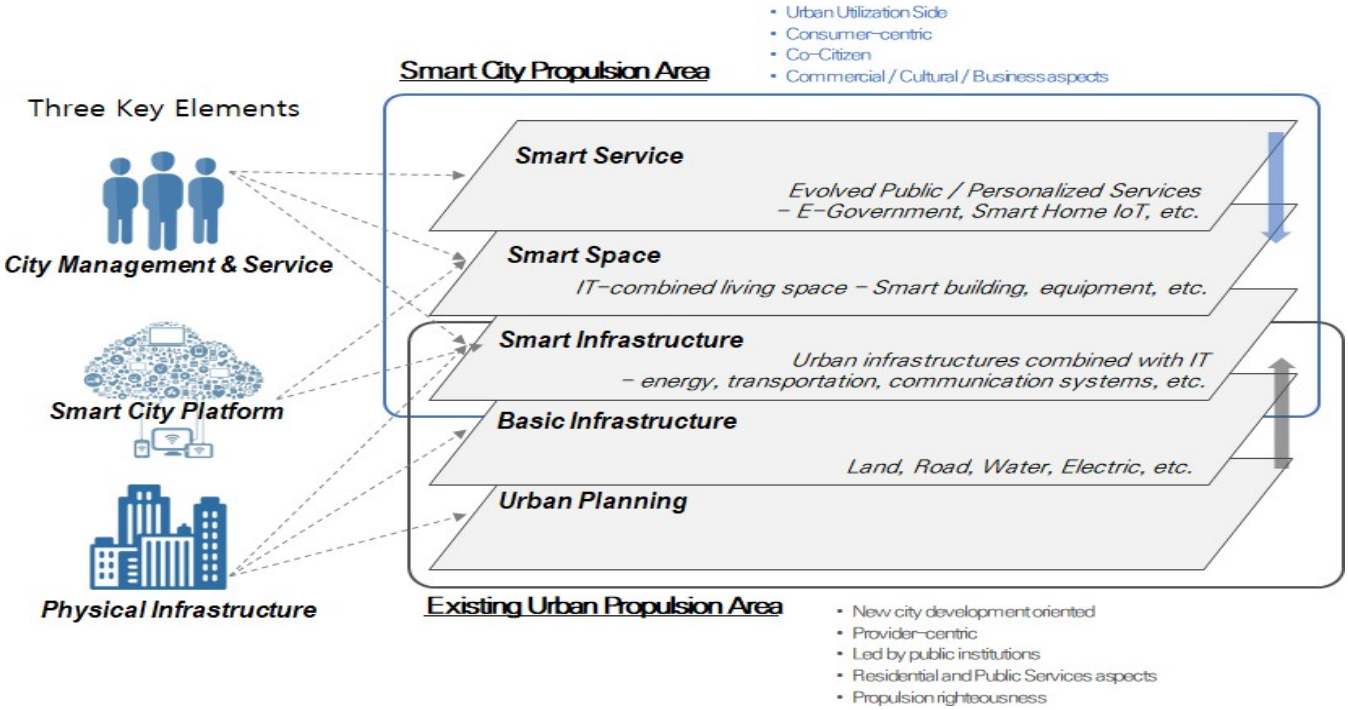
Smart city construction can be explained by a 5-layer approach, namely the underlying urban planning (first), the existing urban infrastructure technology (second layer), smart city infrastructure (third layer), smart space (fourth layer), and smart services (fifth layer), which can be described as three key elements: physical infrastructure, smart city services, and smart city platforms. Figure 1 shows the major components in smart city construction.

[2] "Act on the Development of Ubiquitous City" (2008.3.21)

[3] "Act on the Promotion of Smart City Development and industry" (2017.3.28)

[4] "Act on the Promotion of Smart City Development and Industry" - Article 2 (definition)

Figure 1. Major Components of the smart city construction



Source: Incheon Smart City Corporation, 2019.04

Figure 2. Public and private services in the smart city

Source: Incheon Smart City Corporation, 2019.04

Physical infrastructures include various devices, such as CCTV, sensors and traffic detectors which generate various information and data. These information and data are transferred to smart platform and stored in big data set through various telecommunication methods such as Zigbee, RS-232C, Bluetooth,

NFC Wi-Fi, or LPWA. The smart platform is an intelligent operating center as the brain of the city, which manages the whole city operations and controls all related systems. The smart city platform collects, stores, processes and provides information in real time from the target city through the IoT devices. The smart platform can provide useful services to residents through public and private applications to enhance the quality of life. Public services include Smart Mobility, Smart Crime and Disaster Prevention, Smart Environment Management and Smart Facilities Management, etc. Private Services include Smart Healthcare, Smart Education, Smart Energy Management, etc. The smart platform is an aggregate set of ICT practices such as all sort of devices including smart devices, systems and emerging technologies. Smart services aim to enhance the efficiency and management of urban environments and to improve the quality of citizens' lives by using various information and telecommunication infrastructures in the public and private sectors. The public smart city services comprise smart traffic, smart crime prevention, smart facilities management, smart disaster prevention, smart energy, smart water and so on. The private smart city services include smart home, smart education, smart healthcare, smart stores, smart buildings and so on. Figure 2 illustrates public and private services in the smart city.

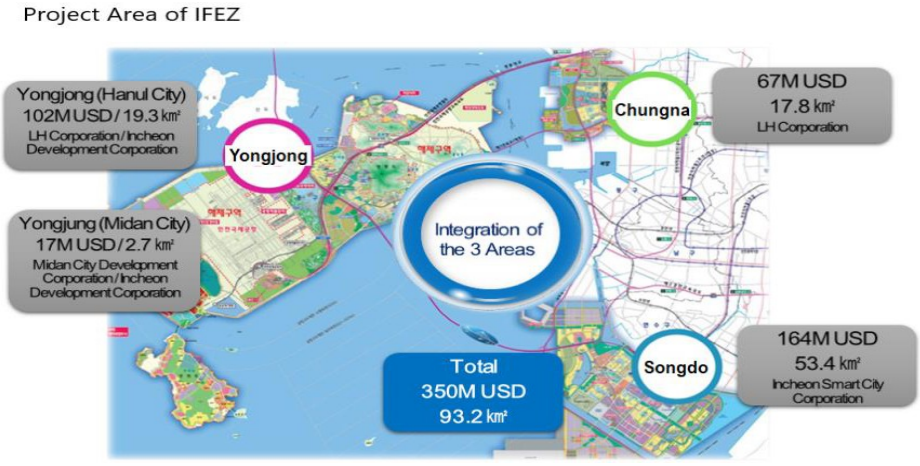
Meanwhile, the Korean Government has mostly developed smart services in the public sector, such as smart traffic, smart crime and disaster prevention and smart facility management.

2.2 Incheon Smart City

2.2.1 History of Incheon Smart City

In 2003, the Korean Government designated the first free economic zone in Incheon Metropolitan City to overcome the Asian financial crisis at the end of the 20th century and to strengthen national competitiveness.

Figure 3. The three areas of IFEZ



Source: IFEZ website homepage

While envisioning a sustainable future city with a focus on people, capital and materials, the concept of smart cities was introduced during the development planning and design phases, and recently, with the breakthrough development of ICT technology, the IFEZ is undergoing the construction of a global smart city. IFEZ is divided into three zones, namely Songdo International City (53.45 km^2), Cheongna International City (17.8 km^2), and Yeongjong International City (52.48 km^2), and is attracting domestic and foreign

investors and businesses to achieve its vision of creating a global business city. Figure 3 shows the three areas of IFEZ.

Incheon is located at the gateway to Seoul and the metropolitan area, which forms a large-scale hinterland of 25 million people and the starting point of the West Coast region, which is the axis of land, economic and industrial development. The IFEZ is located 8 km away from Incheon city center, 50 km away from Seoul central area, and is adjacent to Incheon International Airport and Incheon Port, making it accessible within 60-90 minutes from the metropolis.

IFEZ's Smart City Project is divided into three phases from 2007 to 2022. The first phase is the U-City Infra composition, which established an information strategy and communications infrastructure from 2003 to 2009. Phase 2 is the time to build a full-fledged U-city service from 2010 to 2016. The U-City pilot project was implemented, established U-city infrastructure in the three free economic zones, and laid the foundation for public-private cooperation. Phase 3 is a period for smart-city modernization and new service expansion from 2017 to 2022. This period serves as a time for modernizing smart city development projects, operating smart cities in earnest, and identifying municipal and revenue services.

2.2.2 IFEZ Smart City concept and structure

IFEZ has a total budget of more than 360 billion won. Since 2007, smart city infrastructure has established wired (communication channels, optical cables), wireless networks, and self-network construction dedicated to smart cities. Five public services (smart transportation, methods / disaster prevention, environment, facilities management, public information provision, etc.) are implemented, and the urban integrated operation center (integrated platform) has been established and operated.

In May 2018, the Korean Government announced a grand initiative of 13 innovation growth engines which are ‘Big Data’, ‘Next Generation Communication’, ‘Artificial Intelligence’, ‘Autonomous Vehicles’, ‘Drones’, ‘Smart City’, ‘Virtual and Augmented Reality’, ‘Customized Healthcare’, ‘Intelligent Robot’, ‘Innovative New Drugs’, ‘New and Renewable Energy’, ‘Intelligent Semi-conduct’, and ‘Advanced Materials’, dedicated to finding solutions to the future challenges faced in the 4th Industrial Revolution era. Among those growth engines, the smart city is highlighted as a platform of technological convergence where various urban solutions can be tested and developed. The Korean Government formed a Special Sub-committee on Smart City under the Presidential Committee on the Fourth Industrial Revolution (PCFIR). In order to get a competitive position in the global smart city market, the Korean Government launched two smart city pilot projects in early 2018, and many other smart city initiatives followed.

Meanwhile, Incheon Metropolitan City established Incheon Smart City Co., Ltd. to provide and manage services by developing a smart city integration platform so that the IFEZ can function as a smart city.

Through data collection and analysis, the Smart City Integrated Platform’s unique public and private services can function properly in smart cities, and reflect on policies and functions as a key function for the sustainable development of the Smart City.

Smart City Integrated Platform manages and provides public services for crime prevention, disaster prevention, transportation, environment, urban facilities integration management, as well as private services such as smart buildings, smart energy, education, smart home, smart farm, smart healthcare, etc.

The Incheon Smart City Integrated Platform was completed in 2017. It manages and operates throughout the IFEZ. It is applied in various cities in the Republic of Korea but is also exported to Vietnam and other countries.

2.2.3 Smart City infrastructure of IFEZ

In order for IFEZ Smart City to work well, it should be equipped with various smart devices, facilities and telecommunication networks. The information generated from various devices and facilities such as CCTV, sensors and traffic detectors, is stored in the database of the smart city platform. It also provides integrated monitoring services to the smart city control center and provides smart city services to residents, individually and collectively.

Figure 4. Smart city infrastructure on-site in IFEZ

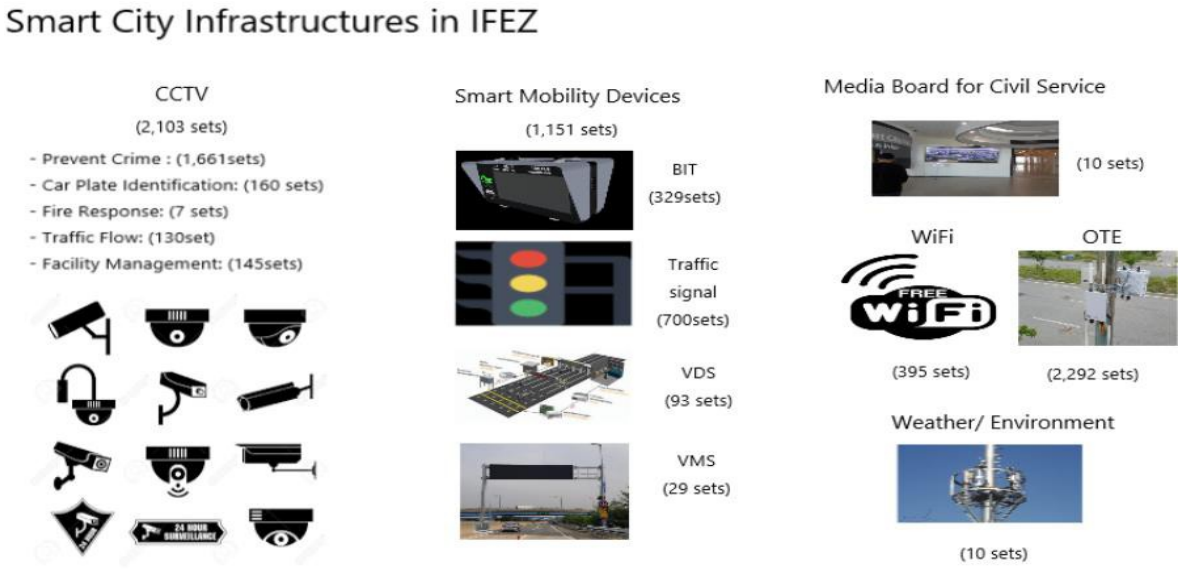


Table 2. Smart city infrastructure on-site in IFEZ

Source: Figure 4 and Table 2 are made by the authors based on data from IFEZ

Smart City Infrastructure on-site in IFEZ

(Unit: set)

			CCTV						Mobility					Media Board	WiFi	Environment	OTE
		Total	Crime	Car Plate	Fire	Traffic	Facility Management	Sub	BIT	Traffic Signal	VDS	VMS	Sub				
Total		**5,967**	**1,661**	**160**	**7**	**130**	**145**	**2,103**	**329**	**700**	**93**	**29**	**1,151**	**10**	**395**	**16**	**2,292**
Songdo		2,774	837	24	3	82	116	1,062	167	292	16	10	485	6	349	10	862
Cheongna		1,587	366	78	4	16	21	485	119	168	40	12	339	3	41	6	713
Young jong	**sub**	1,606	458	58	0	32	8	556	43	240	37	7	327	1	5	0	717
	Midan	324	132	8		8	3	151		52	14	2	68	1	5		99
	Young Jong	1,282	326	50		24	5	405	43	188	23	5	259				618
2019.12.31		**4,873**	**1,335**	**110**	**7**	**106**	**140**	**1,698**	**286**	**700**	**70**	**24**	**1,080**	**10**	**395**	**16**	**1,674**

According to data from IFEZ, there are approximately 6,000 on-site devices and facilities for smart city in IFEZ area. Onsite devices and facilities include CCTV (Closed Circuit Television), Smart Mobility devices, Media Board for civil services, WiFi, OTE (Optical Terminal (or Termination) Equipment) and integrated street poles for weather and environment. CCTV has various purposes such as preventing crime, identifying car plates, responding to fires immediately, detecting traffic flow and facility management. Smart Mobility devices include BIT (Bus Information Terminal), traffic signals, VDS (Video Detection System) and VMS (Variable Message Signboard), etc. Media signboard is a sort of urban signage for informing and advertising information for citizens. IFEZ also provides public free WiFi zones in IFEZ area. OTE transfers electronic signals into optical signal and receives and/or sends optical signals to the opposite side devices through optical communication cables. Devices for weather or environment include environment integrated poles, sensors for detecting pollution and road for climate condition, as well as media board for weather and environment information. Those devices and facilities have been installed or located individually or aggregately by their purposes. Figure 4 and Table 2 illustrate on-site smart city infrastructure in IFEZ.

2.3 Physical infrastructure for smart mobility

2.3.1 BIT (Bus information terminal)

Information such as bus arrival time or current bus locations is displayed on a bus information terminal (LCD or LED types) installed at a bus stop. The bus information terminal provides other useful information including weather conditions and news. Figure 5 shows BIT examples in IFEZ Area.

Figure 5. Bus information terminal in IFEZ Area

Source: Incheon Smart City Co., Ltd.

2.3.2 VMS (Variable message signboard)

VMS informs drivers through a display system of traffic condition, traffic accident information, lane usage guidance and weather forecast. By being informed on traffic conditions, drivers can take proper actions more quickly and efficiently, which guarantees the stability of road traffic management. Figure 6 shows VMS examples in IFEZ Area.

Figure 6. Variable message signboard in IFEZ Area

Source: Incheon Smart City Co., Ltd.

2.3.3 Multi-channel CCTV (Closed-Circuit Television) for situations of traffic incidents

CCTV camera images are an important means of traffic surveillance that complements other traffic control measures. Operators rely on images from CCTV cameras to detect and monitor traffic incidents and assess the number of running lanes affected. From this, it may be possible to estimate the likely duration of a traffic incident based on previous experience and traffic modelling techniques. Video image processing is used to alert control room operators to stationary vehicles and other unusual events. Operators often wish to see a sequence of images from successive CCTV cameras, in the form of a “video tour”. Figure 7 is an example of Multi-channel CCTV (Closed-Circuit Television) for incident situations.

Figure 7. Multi-channel CCTV (Closed-Circuit Television) for incident situation

Source: Incheon Smart City Co., Ltd.

Many newer systems therefore use images from CCTV to detect events such as stationary vehicles, vehicles driving the wrong way or the presence of pedestrians and automatically detect through digital

processing of video streams. An Automatic Incident Detection System is capable of detecting incidents happening around the coverage area and helping to prevent or follow-on accidents. The Automatic Incident Detection system relies on video image processing to calculate the average speed, count, and occupancy of each lane of travel.

2.3.4 Traffic signal detectors

Traffic Signal Detectors are facilities that present information regarding vehicle and pedestrian detection systems used in modern traffic signal control. Vehicle detection is used for a variety of traffic control purposes.

Detectors are used to:

- Count vehicles
- Operate gates at exits of parking garages and other restricted entrances
- Control vehicles entering a freeway ("ramp metering")
- Provide incident detection on freeways by measuring speeds and other traffic characteristics
- Provide Automatic Vehicle Identification (AVI) for automatic toll collection
- Provide emergency vehicle detection for use in signal preemption, and
- Control actuated traffic signals

Figure 8 is an example of a Traffic Signal Detector.

Figure 8. Traffic Signal Detector

Incheon Smart City Co., Ltd.

2.3.5. Physical infrastructure for smart prevention of crimes

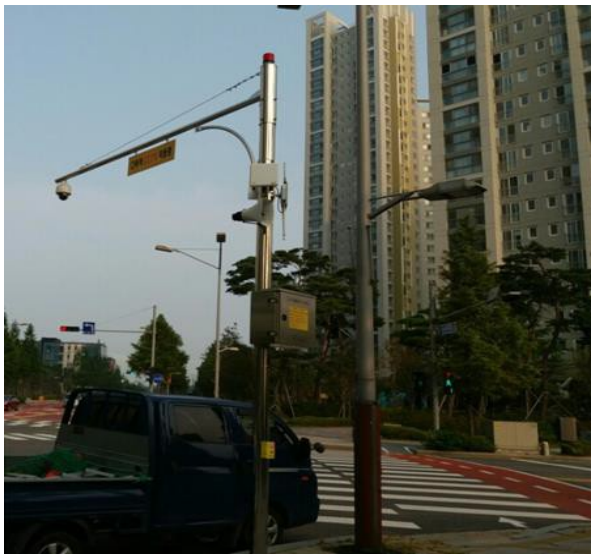
In order to prevent crimes and disasters, several kinds of CCTV are installed in IFEZ areas such as school zones, public parks, commercial areas and residential areas. Figure 9 shows CCTV examples of preventing crimes in IFEZ Areas.

Figure 9. CCTV for preventing crimes in IFEZ Areas

CCTV in School zones

CCTV in commercial areas

CCTV in Public parks



CCTV in Residential areas

Source: Incheon Smart City Co., Ltd.

Figure 10 shows examples of cameras used for disaster prevention in IFEZ Areas.

Figure 10. Cameras used for disaster prevention in IFEZ Areas

Fire response cameras (installed at G-Tower)

Fire response cameras control box

Fire response camera pole

High-magnification camera for fire response

Source: Incheon Smart City Co., Ltd.

2.3.6 Physical infrastructure for smart environment

Figure 11 is an example of physical infrastructures for smart environment.

Figure 11. Physical Infrastructure for smart environment

Metrological measuring equipment pole

Metrological measuring sensors

Road sensors for climate

Source: Incheon Smart City Co., Ltd.

2.3.7 Physical Infrastructure for smart facilities management – RFID Tags

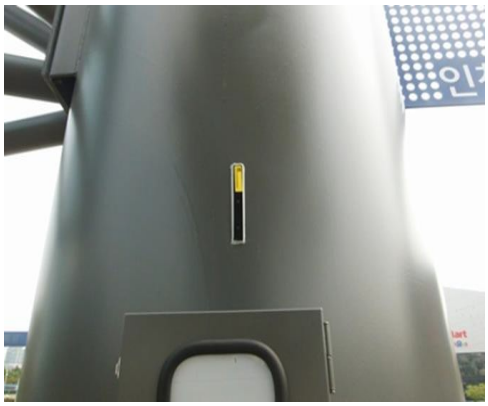
Figure 12 shows examples of cameras used for disaster prevention in IFEZ Areas.

Figure 12. Cameras used for disaster prevention in IFEZ Areas

RFID tag for traffic control signal

RFID tag (CCTV for preventing crimes)

RFID tag for BIT



RFID for digital media board

Source: Incheon Smart City Co., Ltd.

2.3.8 Physical infrastructure for others

- ❖ Wireless network Mesh/AP

Figure 13 shows wireless network Mesh/AP.

Figure 13. Wireless network Mesh/AP

Source: Incheon Smart City Co., Ltd.

- ❖ Digital signage

Figure 14 shows various examples of digital signage.

Figure 14. Digital signage

Residential area

Street

Park side

Commercial area

Source: Incheon Smart City Co., Ltd.

- ❖ IFEZ Public WiFi

IFEZ has been building 395 wireless Mesh WIFI networks in IFEZ Areas: Songdo, Cheongna and Yeongjong international cities, and operates civic services, which are also used to connect and manage facilities within IFEZ. In addition, the wireless Mesh WIFI network was built separately from the existing smart city network for security reasons. Thereby, IFEZ also plans to develop public smart services.

2.4 Smart City Integrated Platform of IFEZ

2.4.1 What is the Smart City Integrated Platform?

In general, there is no single framework that defines smart cities, but it is rather universal to have various definitions depending on the degree of development, economic level, and urban policy of the city. Key terms commonly mentioned when discussing smart city concepts include ‘Sustainability’, ‘Openness’, ‘Mobility’, ‘Integration’, ‘Innovation’, ‘Partnership’, ‘Governance’, ‘Intelligence’, and ‘Digital’.

The ideal smart city integrated platform would probably be a platform that enables the operation of a sustainable smart city by connecting with artificial intelligence, digital, IoT-based smart devices, collecting and analyzing data, integrating and interoperating systems within the city to improve the quality of citizens’ lives by efficiently implementing the features and roles of smart cities.

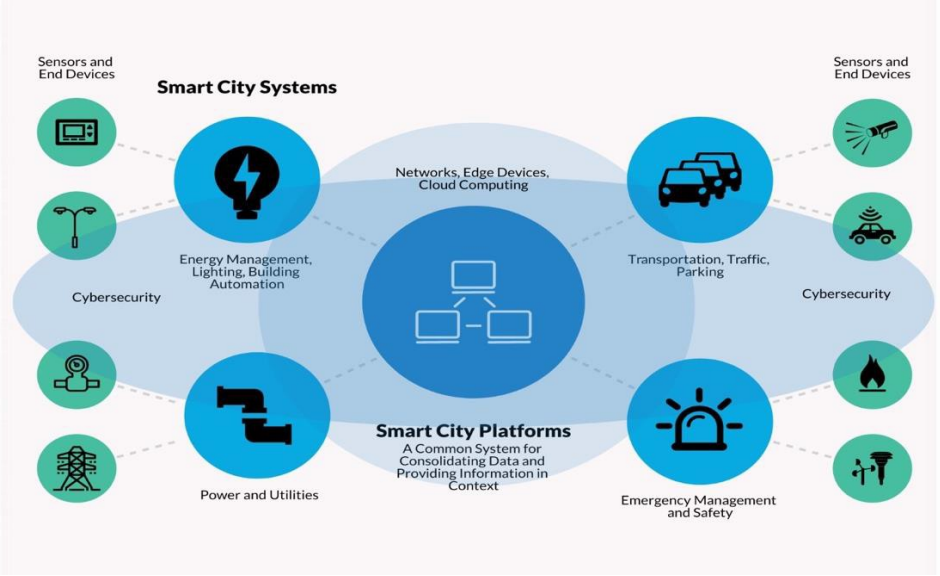
There can also be various definitions of a ‘Smart City Integrated Platform’. According to NAVIGANT Research, the concept of the smart city platform combines an ambitious vision for the integration of urban services and for the more pragmatic development of foundational layers that will enable that vision. Smart city platforms are part of a wider transformation in urban infrastructure and services that is being driven by the deployment of IoT solutions and other smart city technologies. Citywide sensor networks, ambitious data platforms, and integrated approaches to issues like urban mobility, energy management, and public safety are laying the foundation for city platform strategies. A city platform offers the integrated capability to coordinate data, applications, and services at one or more levels across operational domains for multiple stakeholders. Diverse sets of platform technologies enable the smart city. The capabilities provided by these technologies can be combined in multiple ways to create a smart city platform suiting specific needs.

Cities need to develop capabilities that enable them to manage resources and deliver services in the world shaped by platforms such as Uber, Airbnb, Amazon, Google, or Facebook. The concept of "City as a service" is the natural development of this move to a platform approach. Developing the right platforms will be key to cities building the partnerships they need to ensure that their economies, environment, and services are fit for the future.

In addition, Beecham Research conceptualizes the smart city platform into the intelligent core of smart cities and defines a smart city platform as a framework for sensing for communication, integration, and intelligent decision-making. The IoT will be central to this structure, being made up of a multiplicity of diverse use of applications. A smart city aims to provide a unified platform for city operation and services[5].

There are also various roles of smart city integrated platforms as a system of systems. These can include smart lighting systems, building automation systems, emergency management systems, security and access control systems, intelligent grids, renewable power, water treatment and supply, transportation, and many more. The smart city concept is not new; many of these systems existed well before the term "smart cities" was coined. However, many end users are now attempting to integrate information from these disparate systems into a unified whole to provide a holistic view of the overall performance and state of the city and its various functions. Smart city platforms provide a common level of abstraction and manage information from multiple smart city systems. Figure 15 shows a simple diagram of a smart city platform.

Figure 15. Diagram of smart city platform



Source: Iiot-world.com/smart-cities/what-is-smart-city-platform

The age of the IoT has brought an increasingly broad range of sensors and IoT platforms. Many of these have made their way into the smart cities sector. In many ways, IoT technology holds the best promise for providing unification and context to the huge array of data generated by smart cities and turn this data into actionable, contextualized information that can be used to reduce energy consumption and operational costs while improving the safety and quality of life of citizens.

The smart city platforms perform many functions, including analytics, remote asset monitoring, performance

[5] Smart City Platforms: The Intelligence Core of Smart Cities

management, decision support and/or presentation components. At a minimum, the functionality of a smart city platform must include 'Visualization', 'Application enablement' and ''Data management'. The platform may also include functions or requirements such as 'Cybersecurity', 'Device management', 'Network management', 'Application development', 'Analytics', 'GIS', 'Mobility', 'Reporting', 'Simulation', 'Back office', and many more.

Smart city integrated platforms may be deployed in a private, public, or hybrid cloud, via remote server, or on-premise. Cities cannot be "smart" unless the right people are empowered to make good decisions. Large networks of legacy systems, combined with new IoT-based sensors and systems, can make it challenging for smart cities to manage all these different data sources and turn the data into useful, actionable information. However, providing common actionable context for data from those myriad sensors and systems creates many opportunities to improve performance, increase safety, reduce lifecycle cost, and improve citizens' quality of life.

Information in context means providing the right information to the right people at the right time in a well-understood and actionable manner. Information in context is an urgent requirement in today's smart, connected cities. Data from 20-or 30-year old legacy systems exist alongside data from brand new systems for smart lighting, air quality management, and many other subsystems.

In a data-driven society, the sheer volume of data is accelerating on an upward slope. Our reliance on human-machine collaboration to be successful will require the velocity, veracity, security and the universal interoperability of data. The explosion in hardware vendors, the number of communication protocols, and the lack of standardization of metadata and labeling among system integrators have created an environment in which data brokering between devices may be lost in translation or broken. The desired flow of data back and forth between databases, levels of the technology stack, applications, industries, regions, countries and freely throughout the global economy does not yet exist. The vision of machines flowing seamlessly around us and enhancing our lives sounds wonderful, but this utopia will remain a fantasy if communication barriers remain and the data the sensors are collecting cannot be used to provide contextual awareness.

2.4.2 The structure of IFEZ's smart city Integrated Software platform

At the heart of the smart city is the integrated operation center which controls the whole IFEZ smart city. It is the smart city platform as the brain that moves this integrated operation center. The smart city platform works to collect, store, process and provide information in real time from the target city areas through various smart city devices and facilities. In other words, the smart city platform serves as the brain and neutral core of smart cities and provides real time decision support information to operate and manage the entire city safely. It offers an intelligent integrated control solution which ensures effective information collection, storage, processing, distribution and analysis. IFEZ smart city platform is composed of the software (SW) platform which is called normally Smart City Platform and the hardware (HW) platform which is a Cloud Data Center.

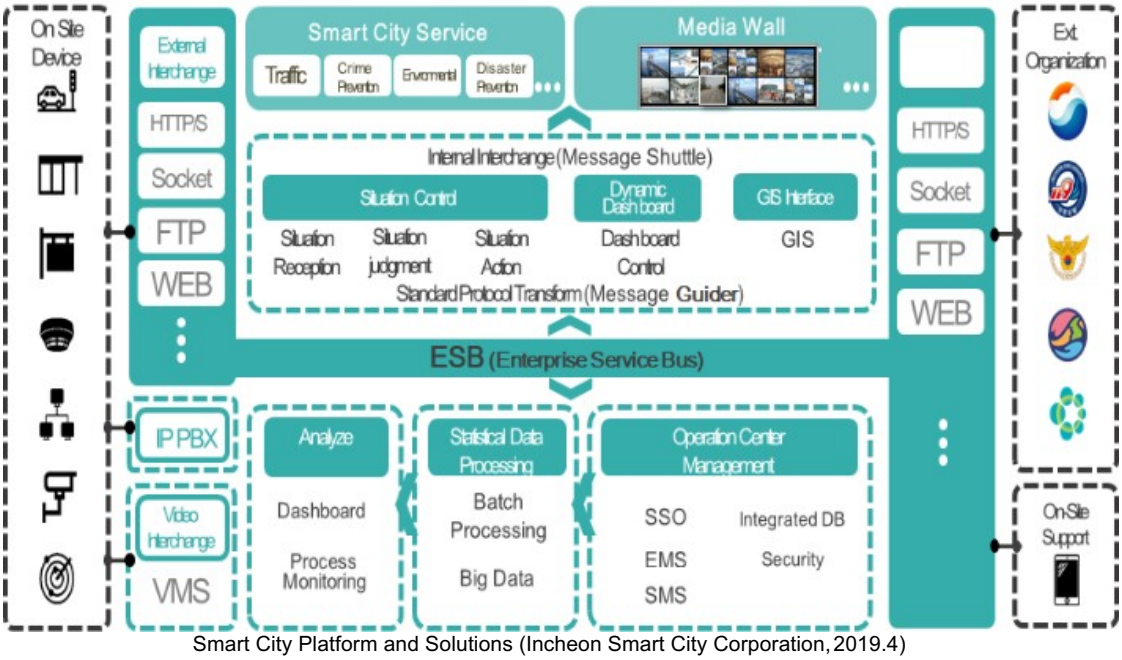
The IFEZ Smart City Platform was developed using the E-government standard framework. The solution uses flexible technology and provides scalability and dependability, while also being optimized for the Cloud. The IFEZ Smart City Platform was designed to be simpler to operate compared to other complicated city systems, as it has lower building and operating costs, and allows real-time decision-making and information sharing. Quick and effective decision making, rapid responses to a variety of events and big data analysis lead to a complete intelligent integrated control solution for a safe and happy city life.

The IFEZ Smart City Platform is a faster multi-purpose Smart City made possible through a combination of Software and Hardware platforms.

First, the Software platform should be examined. The Software platform provides fast and easy smart city services through a variety of common modules. Smart City Services link together countless devices in a variety of ways. If this system can collect information from a variety of devices, what kind of devices can it connect to? The interface management system applies standardized Enterprise Service Bus (ESB) technology to make anything possible (i.e. any platform without issue, any device with ease, efficient device connections and widespread compatibility). There is a constant flux of information in cities. A control system that can keep up with each situation and area is necessary. The integrated control system is a total control system that allows an integrated management of a city system. Cities have countless CCTV cameras and because of that, there is a massive number of videos. The automated intelligent video management system can use that information to monitor a variety of situations. For the first time, the system can connect to all CCTV systems and monitor them in real time. Using a variety of systems also leads to a massive amount of data. The IFEZ Smart City Platform can analyze big data and sort out valuable data which is in turn utilized in city management. A variety of services can be quickly and easily developed for any platform, and additional services like Traffic Information Centers, Disaster safety Centers and Smart City Centers can be constructed as well. U-Service Systems, Geographic Information System, Dashboard System and Smart Facility Management System are also available.

All the data collected from sensors and deployed in the IFEZ areas are stored, transmitted and processed through the IFEZ Smart City SW Platform. The IFEZ Smart City SW Platform supports real-time decision-making necessary to operate and manage the entire city safely. Figure 16 shows IFEZ's smart city Integrated Software platform.

Figure 16. IFEZ's smart city Integrated Software Platform

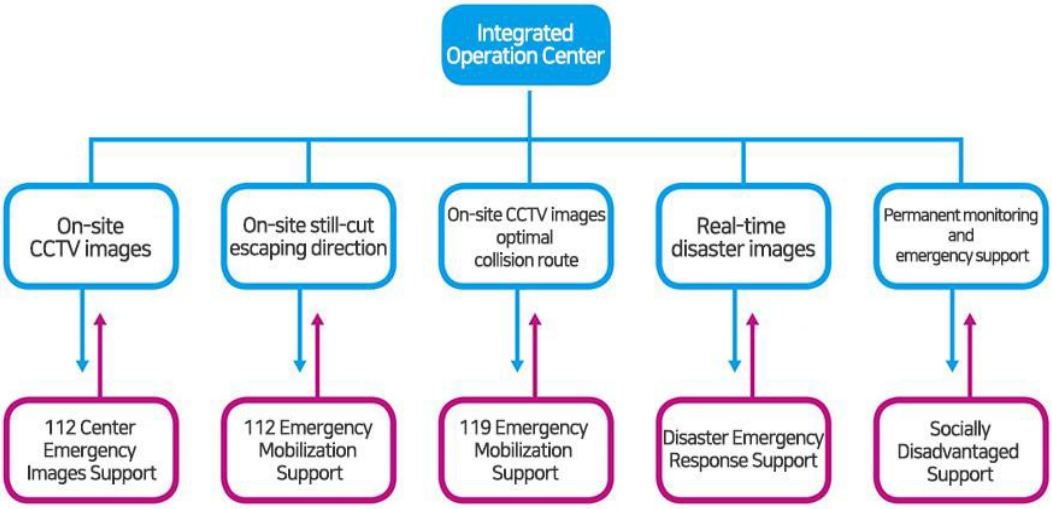


Smart City Platform and Solutions (Incheon Smart City Corporation, 2019.4)

The IFEZ Smart City SW Platform was developed using the Korean e-government standard framework platform[6], which can efficiently upgrade or add existing or new services based on the e-government standard framework platform. It also uses the Standardized SOP[7] to enhance operational efficiency with the ruleset analysis which enables collected data to be easily uploaded on the system and Standard Operating Procedure (SOP), which are part of the system. The solution uses flexible technologies and provides scalability and openness. It can handle various complicated events with the minimum number of operation personnel supported by automated per-event work distribution and transfer. It can also minimize corrections and maximize scalability by supporting interface to various standards (DB, File, FTP, Web, one M2M and so on) when it comes to adding onsite smart facilities. It is independent from individual solution vendors with open source architecture.

The main characteristics of IFEZ Integrated Platform can be defined as 'Platform as a Service (PaaS) and 'Infrastructure as a Service (IaaS)' based on the 'Cloud Environment'. For PaaS characteristics, it can support 'Integrated Operating Environments', guarantee 'On-site Equipment Scalability', and adapt 'Function Integrated Structure'. For IaaS characteristics, it can adapt 'Virtualization Technologies', support 'Cloud Data Center (DC)' and manage 'Integrated Configuration Management'. It also provides connection to 'five services by the Ministry of Land, Infrastructure and Transport'. Figure 17 shows the 'five services by the Ministry of Land, Infrastructure and Transport'.

Figure 17. Five services by the Ministry of Land, Infrastructure and Transport



Sources: IFEZ Website

As the system of systems in smart city, IFEZ Smart City Integrated System includes many systems for city operation such as 'Integrated Control System', 'Linkage to Korean Government Smart Service (U-City) System[8] ', 'GIS (Geographic Information System)', 'Dashboard Editing System', 'Image Management System', 'Video-conferencing System', Integrated Management system for Output of Server and Networks', and 'Linkage Management System to the Ministry of Land, Infrastructure and Transport''.

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6 The e-government standard framework is a platform-specific standardized development framework for IT public sector projects in the Republic of Korea. It is developed by the Republic of Korea and can be used by every person all over the world. Details about the e-government standard framework platform can be referred to website: www.egovframe.go.kr/uss/eng/EgovIntro.do.

7 SOP stands for a Standard Operating Procedure, which is defined by the International Council of Harmonization (ICH). A SOP is a set of step-by-step introductions compiled by an organization to help workers carry out complex routine operations. SOPs aim to achieve efficiency, quality output and uniformity of performance, while reducing miscommunication and failure to comply with industry regulation.

8 The project of Smart city (U-City) Integrated Platform is a local government supporting project to link several existing information

IFEZ Smart City Integrated Platform also loads several major functions[9] such as monitoring, 'situation control', 'task process management', 'Operation Environment based GIS', 'Integrated Dashboard', and Linkage management through ESB.

2.4.3 The structure of IFEZ smart city hardware platform

Introducing hardware employing multi-purpose virtualization technology, sophisticated Smart City Systems continue to present the same difficulties and concerns: an exponential increase in data from an increase in devices along with the complex operation of equipment and high level of difficulty, not to mention huge related costs. The IFEZ Hardware platform chose virtualization as the solution. Virtualization services utilize cloud computing technology and provide support for resource distribution to a variety of devices. The inefficient use of multiple server resources is a thing of the past. Now, resources can be shared efficiently through a single integrated save space. Through the virtualization of network functions, functions can be loaded, changed, and deleted easily. The most important factor when constructing a server room is the use of space and the management of equipment. The enclosure rack system allows easy isolation and configuration of each module, allowing server rooms to be constructed as needed. All racks are grouped into container units, allowing for an efficient cooling system and greater energy efficiency.

In the world of IoT, information is endless. An optimized platform is not the standard for a pleasant future. The IFEZ Smart City Platform can reduce overlapping functions through common modules, provide integrated operations management, reduce transcendental building and operational costs, and can be easily scalable and reliable.

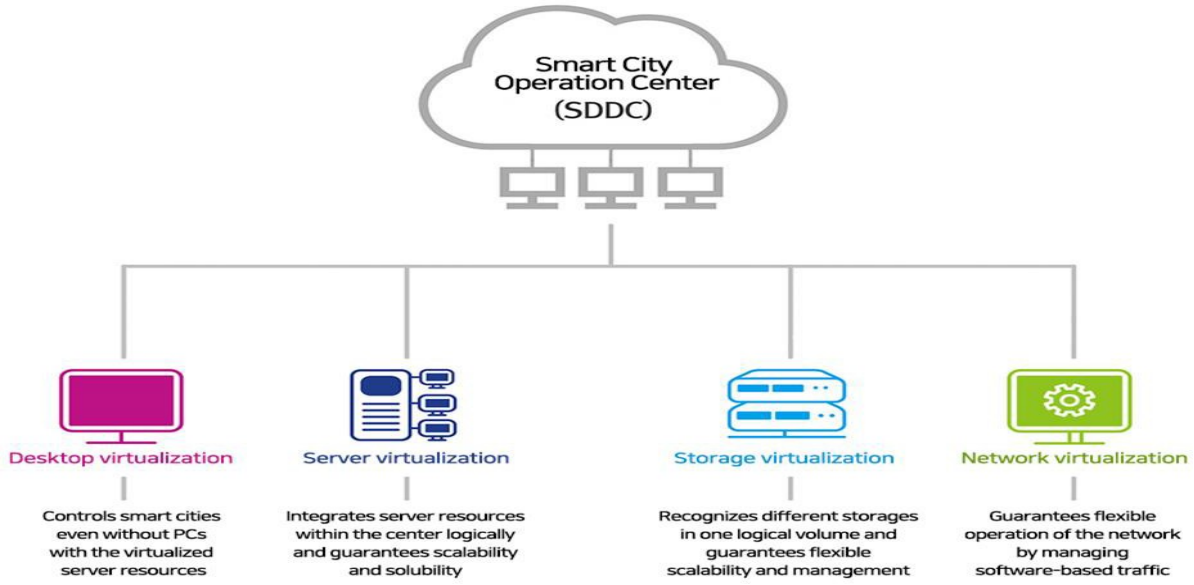
The IFEZ smart city HW platform is the heart of the smart city. It is composed of IFEZ smart city cloud center and Smart city operation center facilities. The system which underpins the smart city operation is the Software Defined Data Center (SDDC). The IFEZ Smart City HW Platform virtualizes the server, desktop, storage and network, ensuring scalability and flexibility of the system operation on the cloud environment.

Desktop virtualization enables monitoring and controlling functions through virtualized server and network resources without physical PCs in place. Server virtualization ensures scalability and availability with virtualization and logical segmentation of server resources. Storage virtualization enhances flexibility and scalability with virtualization software which aggregates partitions in a single logical volume. Lastly, the network virtualization can minimize operation costs with software-based controller which manages network traffic in an efficient manner. The structure of IFEZ Cloud Operation Center is shown in Figure 18.

systems and centers for managing U-Service and urban management, such as prevent crime and disaster, mobility, environment and urban initiated by Korean Government. (Building Smart City (U-City) Integrated Platform, The Ministry of Land, Infrastructure facilities and Transport, press release 2017.1.19.)

[9] For further information, refer to Incheon Smart City Corporation website: www.incheonsmartcity.com

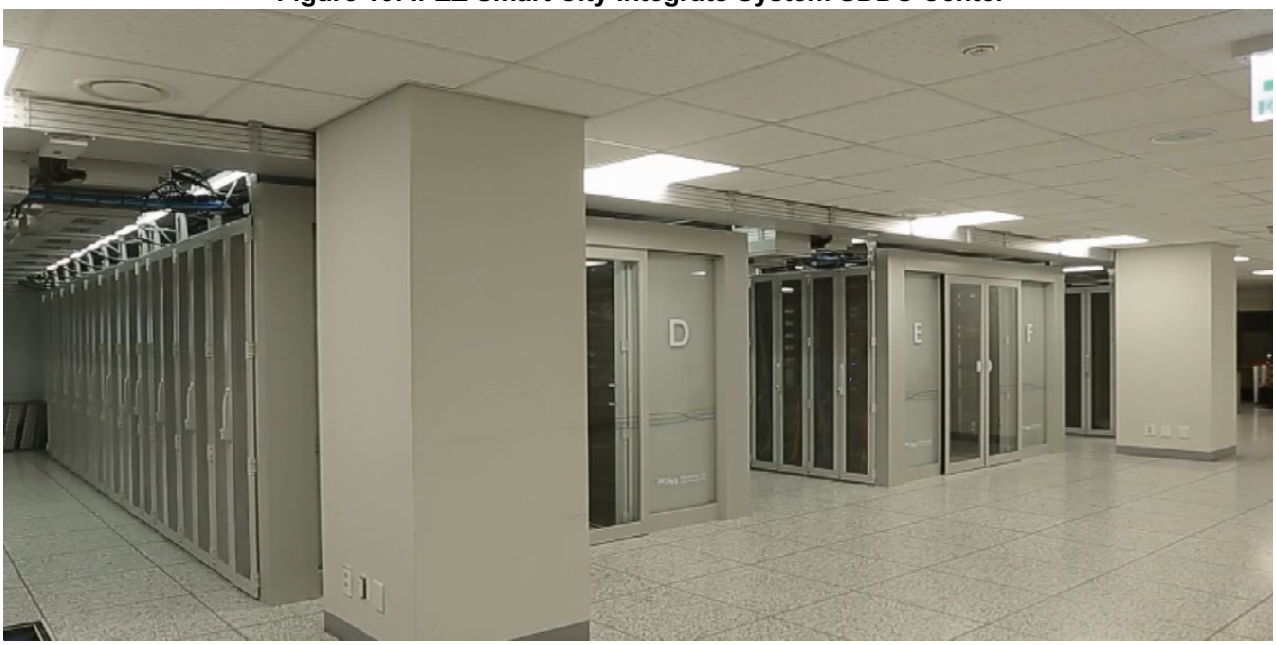
Figure 18. IFEZ Cloud Operation Center



Sources: IFEZ Website

IFEZ is the first to build a software-defined data center for public sector in the Republic of Korea. Through virtualization, IFEZ has been able to reduce the maintenance cost. It also designed server containers that provide a better cooling mechanism and reduce the overall energy consumption of the data center. Figure 19 shows physical HW room of IFEZ Smart City Integrated System, which is called SDDC.

Figure 19. IFEZ Smart City Integrate System SDDC Center



Pictures from Incheon Smart City Corporation

2.5 Smart City services of IFEZ

IFEZ enhances its brand value by enabling citizens to enjoy a safe and convenient life with smart services available for everyone. Currently, IFEZ is implementing smart city services with a focus on public services and will be expanded to smart services in the private sector in the future.

2.5.1 Public Smart City services in IFEZ

Public Smart Cities provide public services such as traffic, crime prevention, facilities management, environment, information provision, etc. Incheon Smart City is aimed at creating a safe and comfortable city for citizens and transforming cities into an innovative space of the 4th Industrial Revolution by sharing, connecting and analyzing information based on its platform. The following Figure 20 shows the public smart city services which are currently provided to citizens.

Figure 20. Public Smart City devices in IFEZ

Sources: IFEZ Website

The following Table 3 is the status of the IFEZ providing smart city-related services.

Table 3. IFEZ Smart City service delivery status

Smart Service	Middle classification service	Detail classification services (Contents)
Mobility (BARO BUS)	Real-time Traffic information	Segment traffic information (supplying traffic information separately regarding Highway-Incheon region, City-Highway, National Road, City road, respectively)
		Emergency Information (supplying real-time emergency information)
		CCTV information (location)
	Public transportation (BARO BUS)	Bus (bus number, searching bus stop by map)
		Subway station (location, facilities)
		Airport (Incheon International airport information – not operated yet)
		Shipping information (Incheon Port

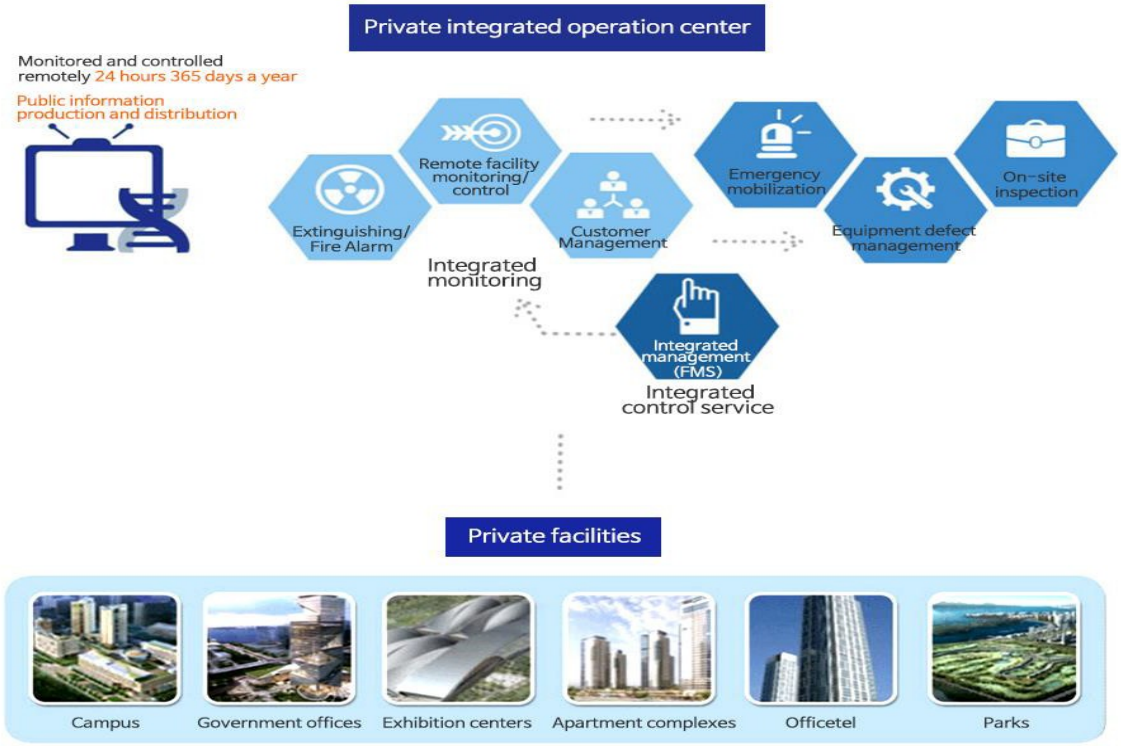
		information – not operated yet)
Environment (Drone-Platform)	Air Pollution Information	Fine dust (ultrafine dust), Ozone measurement (9 spots in Incheon, 4 spots in IFEZ)
	Road Condition Information	Road condition, collecting the coefficient of friction value – on the 4 bridges
	Climate Information	Temperature, humidity, weather (weather forecast in Songdo, Yeongjong, Cheongna and Midan-city)
	Living Environment Information	Food Poisoning Index, Sensible Temperature, Fiber Index, Discomfort Index, Ultraviolet ray Index
	Water Quality Information	Kongchon Stream, Crystal zone (Cheongna only)
Disaster	Disaster Situation	Real-time disaster situation
	Action Tips	Heavy snow, heat wave, cold wave, heavy rain, living security, natural disaster, marine pollution accident, etc.
	Shelter	Shelter information (location – Songdo (28 places), Yeongjong (10 Places), Cheongna (4 places))
Security	Bicycle accidental area, walking children accidental area, walkers unauthorized accidental areas, school zone accidental area (currently not operated).	
Living Information	Hospital & clinique center, pharmacy, bicycle, park, culture events, tourism and restaurant, free Wi-Fi, car park, public organizations, education, shopping centers.	
Operation Center	IFEZ Smart City Operation Center (G-Tower, 3rd and 4th Floors) is a key infrastructure which provides all the services and infrastructures such as mobility, security, environment and living information to citizen in IFEZ.	
Experience Zone	G Tower 33rd Floor	
Bicycle Rental	Free Bicycle Rental Service as a pilot public bicycle service after hosting GCF	

Source: Jong Tae Kim, Urban solutions in smart cities market research working paper sponsored by Royal Danish Embassy in the Republic of Korea (2019)

In the meantime, IFEZ has experience as a smart city business implementer in Songdo International City, Cheongna International City, and Yeongjong District, has experience five times in carrying out a pilot city project organized by the MOLIT (Ministry of Land, Industry and Transport), and is undergoing the development of new technologies to improve the completeness of smart cities.

2.5.2 Private Smart City services in IFEZ

Figure 21. Private integrated operation center



Source: GLOBAL LEADING SMART CITY, Incheon Free Economic Zone

Private smart cities provide private services related to homes, offices, buildings, schools, etc. Smart ICT is applied in smart homes, smart buildings, smart healthcare, smart renewable energy, etc. and provides operation, control and management services of private facilities. It provides additional services directly related to the life of citizens and tries to increase the value of the city and the quality life of citizens in general.

Smart building enhances operational efficiency with lower costs through intelligent and integrated management of facilities and systems related to heating, ventilation, air conditioning, lighting and so on.

Smart home provides a comfortable living environment by adding intelligence to electronic devices, air-conditioning, heating and lighting systems enabled by IoT.

Smart energy streamlines energy generation, distribution and utilization with solar energy generation, new renewable energy use, Microgrid and so on.

Smart farm promotes production, distribution and consumption of small-scale farm products within the city using ICT technology and self-sufficient and environment-friendly urban life.

Smart healthcare offers remote medical examination and customized health management through AI, augmented reality, wearable healthcare devices and cloud-based hospital information systems.

Virtual currency builds a blockchain-based financial transaction platform for local traditional markets, small and medium businesses and the public sector, etc. and activates the local economy.

The Private integrated operation center is shown in the following. Figure 21 can support these kinds of private smart services.

Figure 22 shows Smart City Operation Center of IFEZ and Showroom. The Operation Center operates 24-hour and the showroom hosts visitors who want to see IFEZ Smart City Plation and Operation Center.

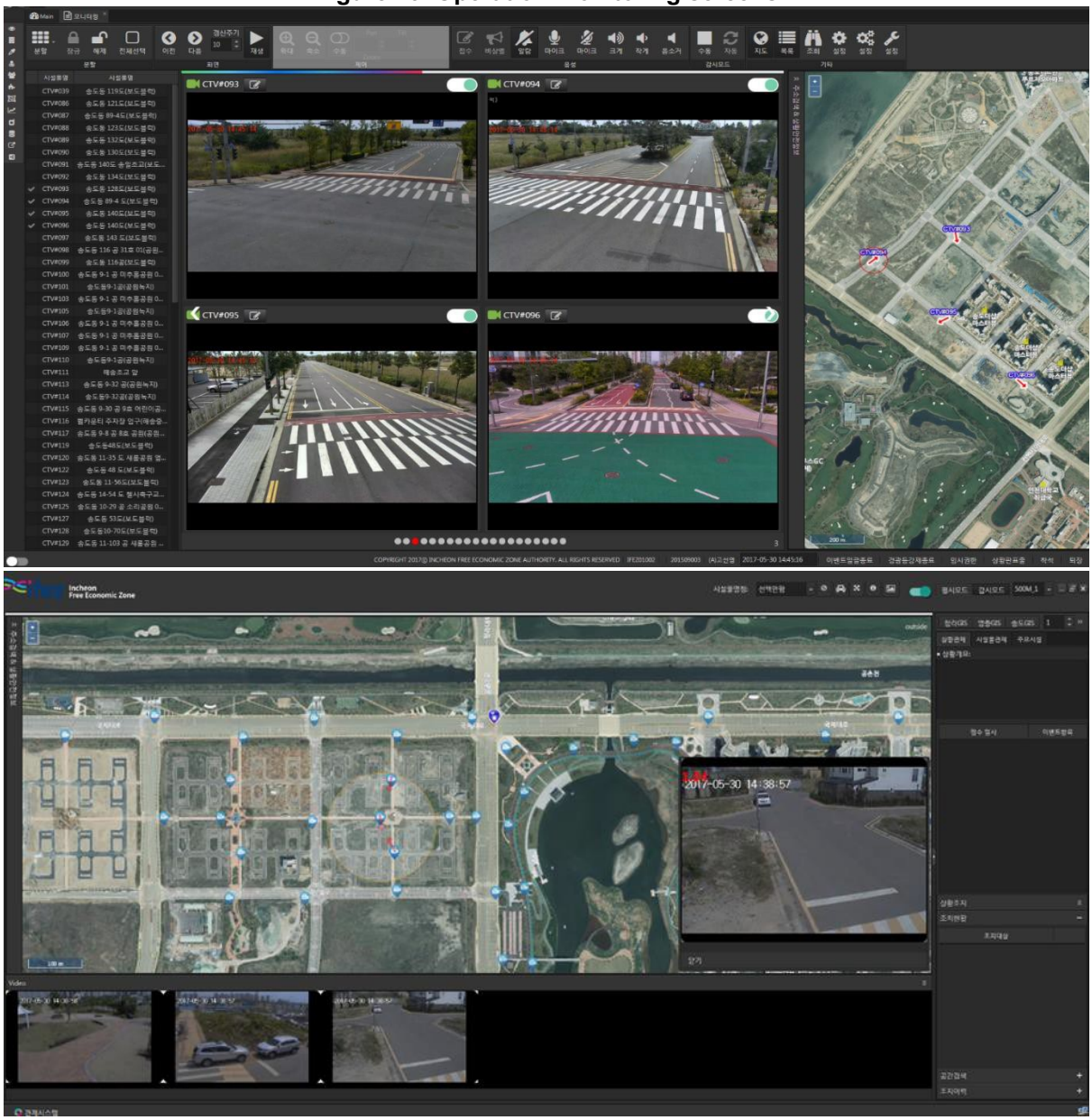
Figure 22. Smart City Operation Center of IFEZ

The IFEZ Smart City Operation center is a core infrastructure bureau providing smart services such as traffic, prevention of crimes and disasters, environment, and information provision for citizens of Songdo, Yeongjong, and Cheongna.

Source: Incheon Smart City Corporation internal material

There are some more figures to help understand IFEZ Smart City Integrated System operation. Figure 23 shows examples of operation monitoring screens.

Figure 23. Operation monitoring screens



Control incident through monitor screens based on GIS

Source: Pictures from Incheon Smart city C., Ltd.

2.6 Business opportunities

In 2017, the IFEZ Integrated Smart City Platform (Operations Center) received the Smart City Asia Pacific Award (SCAPA) from the global market research firm IDC (International Data Corp), and "IFEZ Smart City" was selected as one of the good practices of electronic government by the Korea Ministry of Public Administration and Security. In August 2017, it was also selected as the winner of the Asia Geospatial

Awards 2017 in the smart city sector. In addition, it has several intellectual property rights (copyrights, patents) for smart city platforms.

In August 2018, IFEZ Integrated Smart City Platform was certified from the TTA (Telecommunication Technology Association) as an Integrated Platform for 5 Smart City Services connection.

IFEZ Smart City Integrated System is deployed in several municipalities in the Republic of Korea such as Paju city, Naju city, Seosan city, Gochang-gun, Pohang city, Gyeongsan city, and Cheongju City. It is also exported to India, Colombia, Ecuador, and Vietnam.

IFEZ and Incheon Smart City Corporation are now trying to develop various kinds of advanced smart city services using big data analysis and AI. Various and comprehensive information and topography can be created through big data analysis, real-time local information, SNS and open data analysis linking to multi-sphere. They are also trying to construct an open ecosystem based on citizen participation by providing data and open API for publicly available information. Another effort is to discover various smart city service models and to promote citizen smart city services participation through living labs and other innovative tools.

Part II: ICT Smart services in Incheon Metropolitan City

2.7 BARO BUS information system

2.7.1 Background

In a smart city, smart mobility is one of the key technologies and services. Incheon Metropolitan City has been working to develop a variety of private smart services based on the IFEZ Smart City Integrated System.

Existing bus information system installed at the bus stop was developed as a supplier-oriented. BIT (Bus Information Terminal) installed at the bus stop was also operated differently depending on the manufacturer system. In addition, the closed system structure made it difficult to connect the data, and immediate maintenance is difficult in the event of frequent failures.

In March 2018, Incheon Metropolitan City launched the development of the IFEZ-type WEB Bus Information System based on the IFEZ Smart City Integrated Platform, which improves accuracy and management efficiency and reduces deployment costs by improving these problems and integrating them into internet-based consumer-oriented solutions. The Bus Information System was completed in July 2018 and started its service under the name BARO BUS Information System.

2.7.2 Concept

The BARO BUS Information System is based on smart city infrastructure such as Wireless Internet Access, Public Transportation Information and Subway Information which are linked to each other. Therefore, it is possible to connect with Bus Information Terminal (BIT) Display, Shell Terminal Safety functions and Multi-Language Support.

"BARO BUS" deploys a technology that is created on the IFEZ Smart City platform and provides a bus stop guide in the form of a web service. The developed system is applied to all bus stops in IFEZ areas and the bus arrival information at targeted bus stops can be easily obtained by anyone via the Internet through open data.

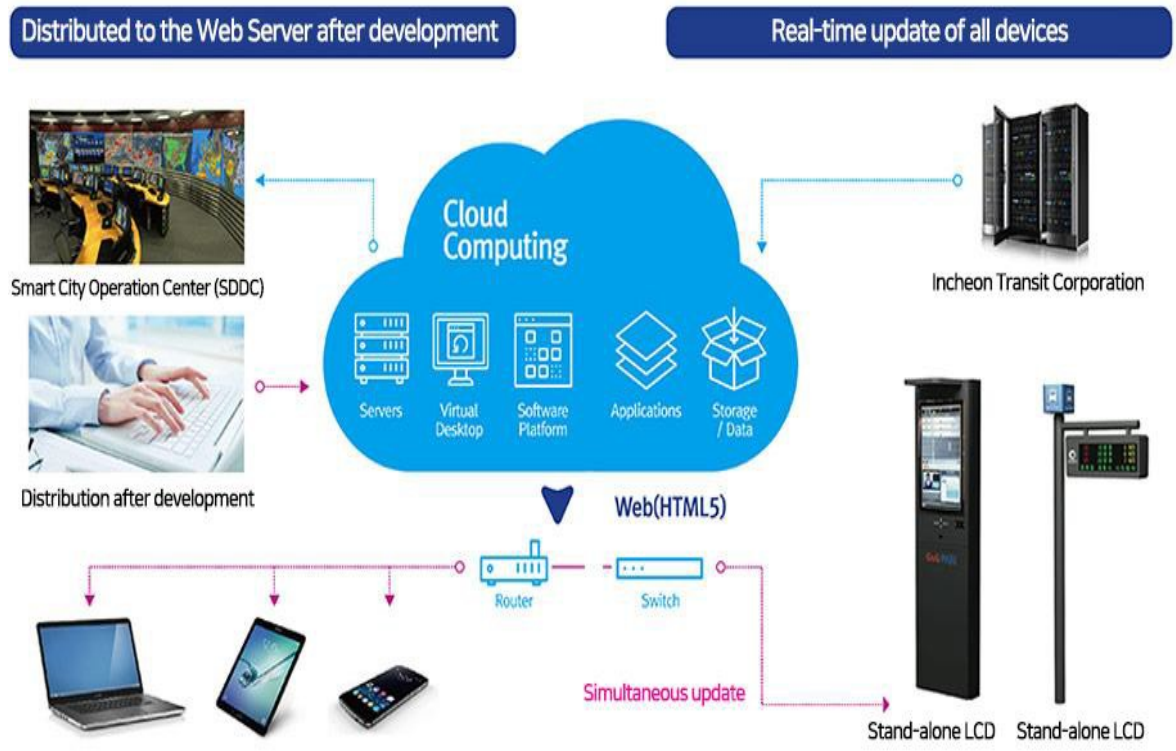
This makes it easy to provide and utilize the bus arrival notification service of the targeted stop in real time. Therefore, the IFEZ smart city can be evaluated as a further advanced urban structure through the Internet-based, entry-level bus information system.

The 'BARO BUS' system does not have to rely on the manufacturer of the bus information terminal, so it costs less to introduce and manage and has the advantage of being able to provide immediate information and maintain it. BARO BUS information is produced at the IFEZ Integrated Platform and provided directly to on-site BIT.

2.7.3 Structure: Platform-based bus information system

The structure of 'BARO BUS' information system consists of information gathering devices, Smart City Platform (Cloud Server) and BIT (Bus Information Terminal). Figure 24 illustrates the Structure of BARO BUS system.

Figure 24. Structure of BARO BUS system



Source: Incheon Smart City Corporation. www.incheonsmartcity.com

The arrival information of the buses and subways is provided not only in Korean but also in various other languages. Bus stops are equipped with CCTVs that show not only the facility issues but also abnormal situations around it; they also automatically notify the urgency to the center. At night, motion sensors

operate with the automatic sleep mode when no one is around, and automatically turn on when a movement is detected. There are many systems, facilities and device supports which are connected to ‘BARO BUS’ information system such as public transportation information system, Subway Information System, BIT (Bus Information Terminal) and Wireless Internet.

Figure 25 shows the relationships surrounding the ‘BARO BUS’ system.

Figure 25. Relationships surrounding BARO BUS system

Source: Incheon Smart City Corporation

2.7.4 Characteristics and functions

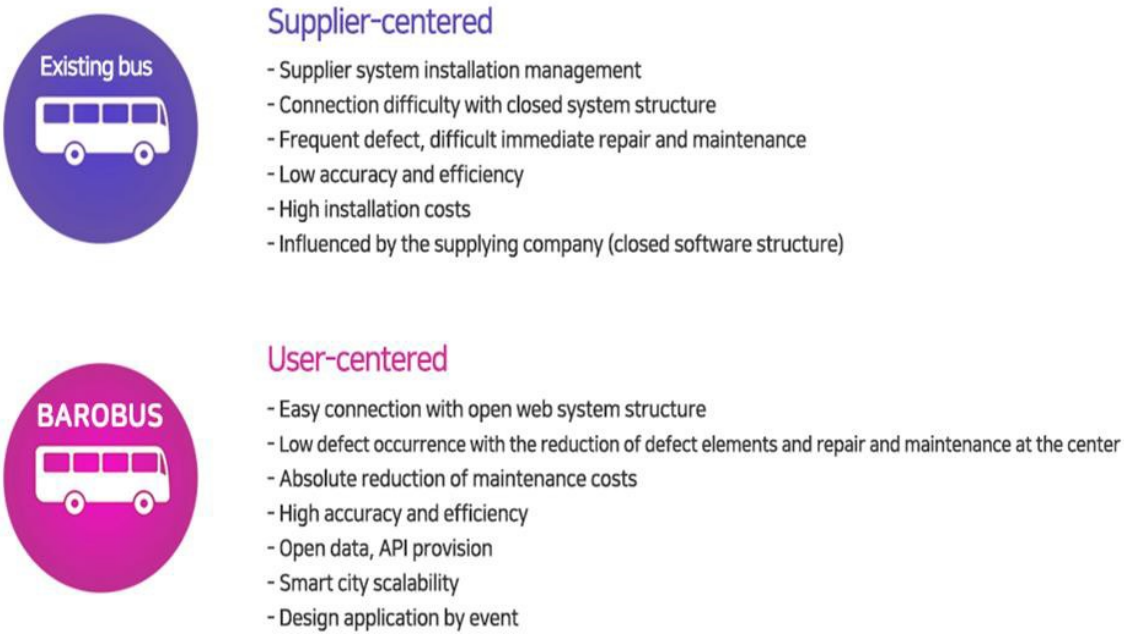
The ‘BARO BUS’ information system has four major characteristics, the first one being a system structure which uses a single platform within the IFEZ Smart City Operation Center. The second characteristic is information connection while the third one is a lower implementation cost through the separation of software and hardware. The last characteristic enables to handle defect through simplified defect management in the IFEZ Smart City Operation Center. Figure 26 shows the main characteristics of ‘BARO BUS’.

Figure 26. Main characteristics of BARO BUS

Source: Incheon Smart City Corporation. www.incheonsmartcity.com

Figure 27 shows the differences between BARO BUS and existing bus information systems.

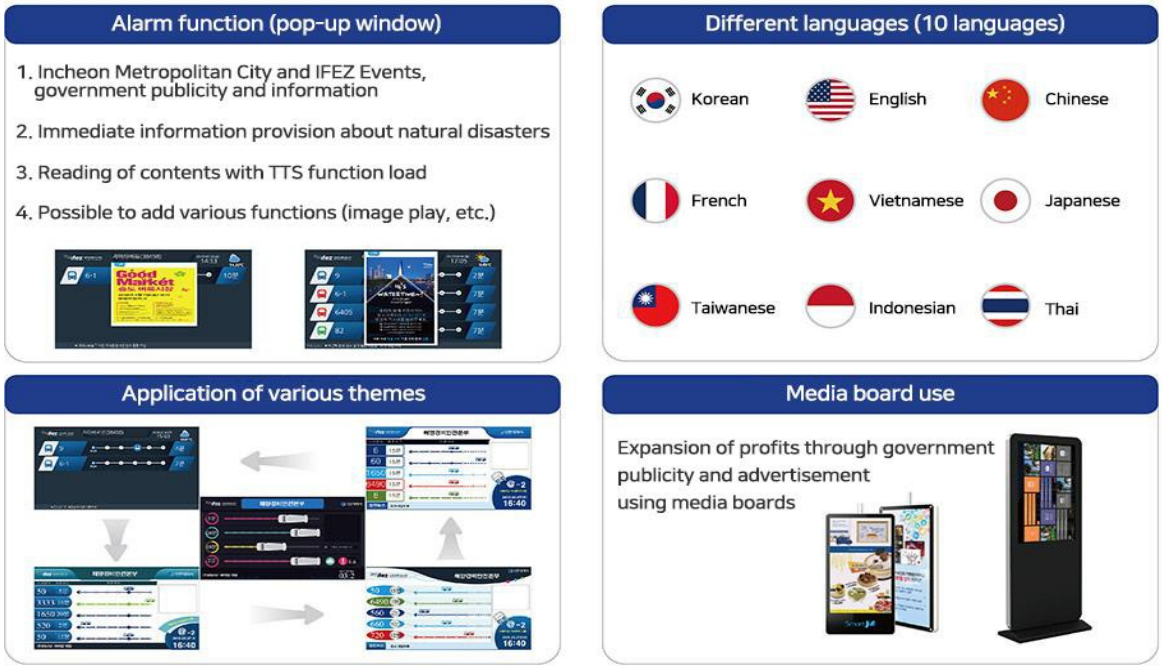
Figure 27. Differences between BARO BUS and existing bus information system



Source: Incheon Smart City Corporation, incheonsmartcity.com

Figure 28 showcases additional functions of ‘BARO BUS’.

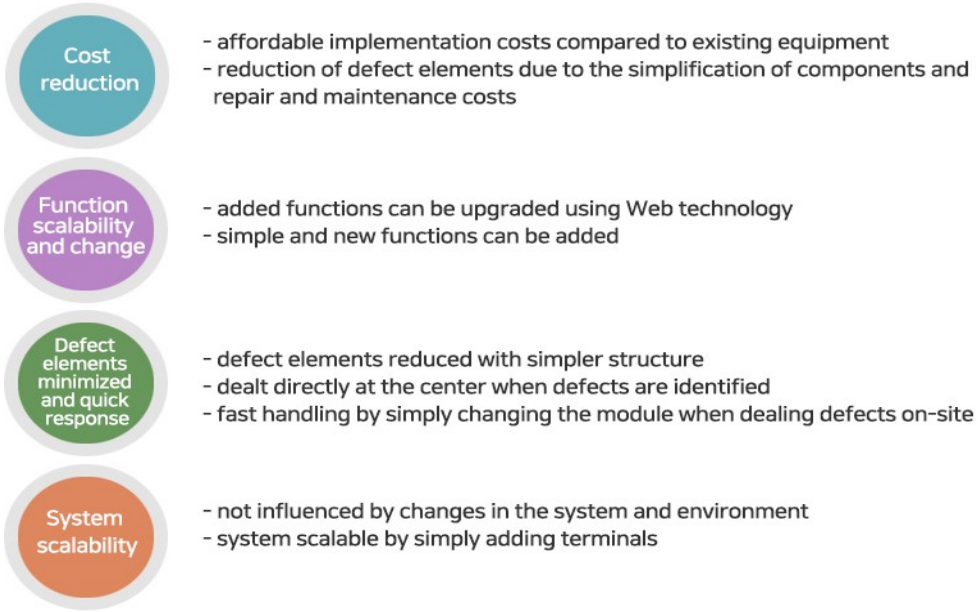
Figure 28. Other functions of BARO BUS



Source: Incheon Smart City Corporation. www.incheonsmartcity.com

According to several characteristics of ‘BARO BUS’ information system, effects shown in Figure 29 can be expected.

Figure 29. Expected effects of BARO BUS



Source: Incheon Smart City Corporation. www.incheonsmartcity.com

2.7.5 Business opportunities

BAROBUS V1.0 is a public bus operating system of IFEZ, which got the ‘Certificate of software Quality’ from KTI (Korea Testing Laboratory) in March 2019.

The IFEZ Bus Information System "BARO BUS" was also distributed to one local government in the Republic of Korea 2019 and it is expected to be exported overseas.

2.8 Environment Drone Platform

2.8.1 Background

Environmental pollution is a very important urban problem. Water pollution, air pollution and fine dust are the pollutants that affect people's quality of life. Recently, unmanned aerial vehicles, namely using drone technology to extract the source of contamination early, and the technological advances that can transmit such information to citizens in real time have been made.

Cutting-edge technologies such as drones, information and communication technology, the Internet of Things, big data, and sensors contribute to the world as well as the environment. Recently, drones have been used in various fields such as leisure, broadcasting, construction, agriculture, surveying, and monitoring, and the importance of using them in conjunction with various sensors to solve environmental problems is emerging.

Incheon Metropolitan City is able to measure the fine dust using a drone, and in particular, to measure the fine dust at sea, as it has developed an environmental drone platform in order to detect and cope early with the air pollution source or water source.

2.8.2 Concept

Although it is generally regarded as a drone, it is legally defined as a "drone that can fly without a pilot”. In the future, we expect new aircrafts to emerge in accordance with technological development trends such as drone taxis and market changes.

The drone industry is a convergence of high-tech technologies such as aviation, ICT, software (SW), and sensors. It is now the most promising market industry in the open market, and competition for market pre-emptive points in the United States, China and Europe is intensifying.

It is changing from simple shooting of low-cost, small-size centers to high-priced, medium-sized centers for carrying out missions such as agriculture, surveillance, surveying, and delivery. In the future, it is expected that new markets will be opened in the transportation and transportation sectors, given the emergence of large unmanned aerial vehicles and the commercialization of autonomous flying drones as a means of personal transportation.

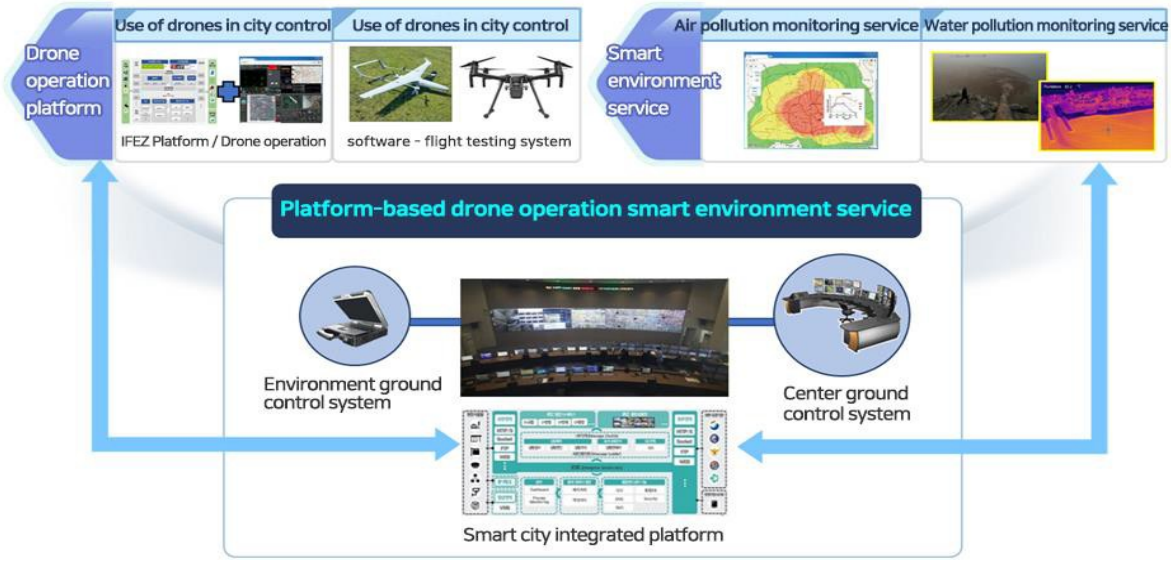
Drones monitor urban environment and temperature, count wildlife populations, monitor ocean warm water, ecosystem changes and trends, and water temperature, and analyze river or wetland pollution. Its use varies in environmental fields such as shooting using thermal imaging cameras and spectroscopic cameras.

2.8.3 Structure

The environment drone platform is a system that monitors sensor data and images from drones, remotely and in real-time, and controls drones within a web-based environment.

It provides environment monitoring services like air and water pollution using drones, web-based ground control system related to various drones. Figure 30 shows the structure of an Environment Drone Platform.

Figure 30. Structure of an Environment Drone Platform



Source: Incheon Smart City Corporation. www.incheonsmartcity.com

The drone operating platform consists of the IFEZ platform, drone operating software and test aircraft. Drone operating platform and IFEZ Smart City integrated platform are linked to each other to provide platform-based drone operating environment services such as air pollution monitoring and water pollution monitoring.

2.8.4 Main functions

It provides 3D airspace verification, 2D flight path configuration, and EO/IR (Electric Optical/Infra-Red) images real-time monitoring. It collects environment data through sensors and analyzes them at Environment Drone Platform.

2.8.5 Future drone technology

Drone technology is constantly evolving, so future drone tech is currently undergoing groundbreaking progressive improvement. According to 'airdronecraze', an Amazon Services LLC affiliate advertising program website, drone technology has seven potential generations, and the majority of the current technology sits in the fifth and sixth generations.

Here is the breakdown of the technology generations:

2.8.5.1 **Generation 1:** Basic remote-control aircraft of all forms

2.8.5.2 **Generation 2:** Static design, fixed camera mount, video recording and still photos, manual piloting control

2.8.5.3 **Generation 3:** Static design, two-axis gimbals, HD video, basic safety models, assisted piloting

2.8.5.4 **Generation 4:** Transformative designs, three-axis gimbals, 1080P HD video or higher-value instrumentation, improved safety modes, autopilot modes

2.8.5.5 **Generation 5:** Transformative designs, 360° gimbals, 4K video or higher-value instrumentation, intelligent piloting modes

2.8.5.6 **Generation 6:** Commercial suitability, safety and regulatory standard-based design, platform and payload adaptability, automated safety modes, intelligent piloting models and full autonomy, airspace awareness

2.8.5.7 **Generation 7:** Complete commercial suitability, fully compliant safety and regulatory standards- based design, platform and payload interchangeability, automated safety modes, enhanced intelligent piloting models and full autonomy, full airspace awareness, auto action (takeoff, land, and mission execution)

The next generation of drones, Generation 7, is already underway, as 3DRobotics announced the world's first all-in-one Smart Drone called Solo. Smart drones with built-in safeguards and compliance tech, smart accurate sensors, and self-monitoring are the next big revolution in drone technology that would provide new opportunities in transport, military, logistics, and commercial sectors. As these technologies continue to evolve and grow, drones will become safer and more dependable. This would allow their subsequent mass adoption, provided that the strict USFAA legislation surrounding drone technology and usage is loosened to some degree.

2.9 Smart city services

Information collected, transmitted and stored from Smart City facilities in IFEZ can provide various smart services such as traffic, environment, crime prevention, disaster prevention, and facility management. This section explores some smart city services based on cutting-edge ICT technologies.

2.9.1 Smart crime prevention

"Integrated CCTV Control Service" to provide citizens with safe city environment will be one of the best safety services in Incheon Metropolitan City. When an incident or accident occurs, the surrounding CCTVs can automatically monitor the area. IFEZ Smart City is in the position to respond immediately to any problem citizens might encounter. Figure 31 illustrates the flow of detecting crimes using Integrated CCTV Control Services.

Figure 31. Flow of detecting crimes using Integrated CCTV Control Services

Source: Incheon Smart City Corporation. www.incheonsmartcity.com

The automobile plate number recognition cameras are installed everywhere in IFEZ. Those cameras distinguish wanted vehicles and those with defaults so that the police officers or civil officers will dispatch right after receiving the relevant information from the cameras. Figure 32 shows the flow of detecting vehicles through automobile plate number recognition cameras.

Figure 32. Flow of detecting vehicles through automobile plate number recognition cameras

Source: Incheon Smart City Corporation. www.incheonsmartcity.com

Similar to the crime prevention system, when abnormal behavior is detected, it will create alerts and set up a CCTV mesh. The video monitoring will keep distinguishing the person with the abnormal behavior and finally report the location and situation to the police office. Figure 33 shows the flow of detecting abnormal behavior.

Figure 33. Flow of detecting abnormal behavior

Source: Incheon Smart City Corporation. www.incheonsmartcity.com

The technologies and services depicted in the famous future movie ‘Minority Report’ might come true and possibly lead to a futuristic society in which police officers arrest people before they commit crimes, because of the following factors:

2.9.1.1 With the development of advanced ICT technologies such as advanced CCTV, various sensors, and IoT-linked devices, data collection and transmission technology is developed.

2.9.1.2 With the development of AI, edging computing, cloud computing technology as well as data storage and processing, technology is also rapidly developing.

2.9.1.3 With system hardware technology, big-data technology, data science, and blockchain technology, data processing and analysis is highly advanced.

2.9.2 Smart city disaster system

Various disaster information is provided to citizens through mobile, VMS, speakers, and websites, and environmental information is also provided via mobile, VMS, and the Web. With the development of AI, edge computers, and clouding computing technology, data storage and processing technologies are also rapidly developing. The following Figure 34 showcases smart disaster information services.

Figure 34. Smart disaster information services

Source: Incheon Smart City Corporation. www.incheonsmartcity.com

2.9.3 Facility management services

When an abnormality occurs in the U-facility located in IFEZ, the center remotely senses the condition, collaborates with stakeholders to put maintenance personnel on site, and manages the facility's history. In case of maintenance of facilities such as disposal of on-site facilities, all concerned parties are notified about the inconvenience. These services shown in Figure 35 are the most basic public sector smart city services.

Figure 35. Smart facility management

Source: Incheon Smart City Corporation. www.incheonsmartcity.com

2.9.4 Public civil services

Various kinds of sensors and information from CCTV will be able to be collected, analyzed and utilized through the big data solutions. Based on the database, Incheon Metropolitan City provides various civil services through media boards based on big-data analysis. Figure 36 illustrates services provided for citizens.

Figure 36. Services for citizens

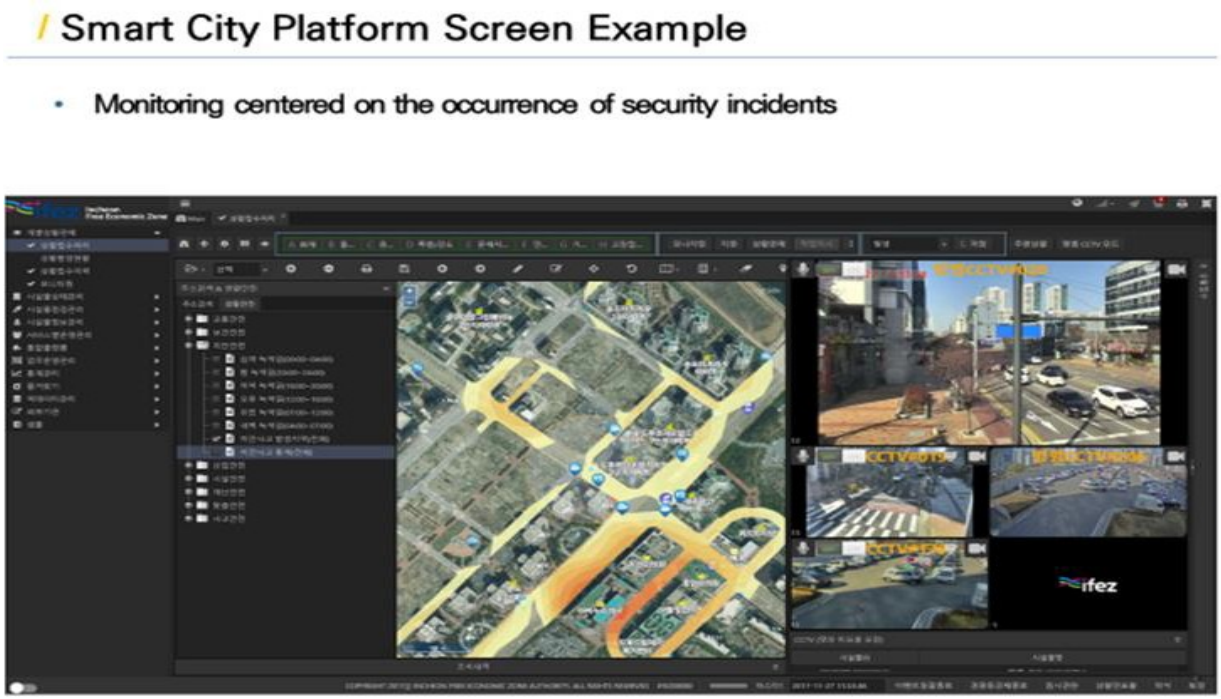
Source: Incheon Smart City Corporation. www.incheonsmartcity.com

Incheon City government recognizes the importance of data collected in Smart City and strives to provide citizens with various lifestyle tips.

2.9.5 Real examples of smart city services

Some real examples of smart city services are showcased in below Figure 37, in which real screen captures of IFEZ Smart City Integrated Operation Center are presented. The area marked red on the screen is a crime-ridden neighborhood. Center operators can strengthen monitoring or establish intensive patrols in that area. When the problem occurs, the surrounding CCTV can automatically be arranged to focus on one spot.

Figure 37. Smart city screen examples



Source: Incheon Smart City Corporation. www.incheonsmartcity.com

Chapter 3. Conclusion

Incheon Metropolitan City develops and operates IFEZ which is one of the smartest cities in the world. IFEZ is being developed based on advanced ICT technologies and smart devices, from urban development design to infrastructure construction and urban civil service delivery.

Smart City Integrated Platform study found the following in Part I:

1. Incheon Metropolitan City established Incheon Smart City Co. Ltd. to create its own Smart City Integrated Platform.
2. Under the strategy of “One Space, One System and One Service”, Incheon Metropolitan City has built and operated Smart City Integrated Platform. Now IFEZ, which is being operated by Smart City Integrated Platform, is serving as an icon of the smart city in the Republic of Korea and becoming a global smart city reference.
3. Smart City Integrated Platform has obtained many patents and certificates, applied to various local governments in the Republic of Korea, and exported to various countries overseas.
4. Incheon Metropolitan City is continuously developing services based on its development know-how and operational experience in the Smart City Integrated Platform.

Incheon Metropolitan city reduces one third of the city operating center construction cost through one Smart City Integrated Platform in IFEZ areas. IFEZ has solved many incidents and accidents while operating Smart City Integrated Platform. The following results were reported from IFEZ until the end of 2018.

a) 1,695 cases were investigated, reported and prevented through security CCTVs.
b) 1,188 cases were handled for requesting and enforcement by prosecutor and police authorities.
   - The rate of capture and arrest were 37.8 per cent.
c) 507 cases of CCTV monitoring and processing complaints from citizen.

The following Figure 38 shows some examples of the above-mentioned incidents.

Figure 38. Examples of incidents captured by the Smart City Integrated Platform

a) Rescue emergency patient (2015. 2.13, 05:26)	b) Rescue fall accident (2017.05.30, 17:24)
	
c) Rescue drunken citizen (2017.6.25, 05:57)	**d) Theft arrest (2017.8.3, 15:45)**

e) Report fire prevention at construction site (2015.02.13, 03:12)

f) Report fire proof (2015.10.17, 23:04)

g) Report of female assault and arrest (2016.3.12, 13:49)

h) Prevention drinking driving system (2017.08.17, 00:19)

Source: Incheon Smart City Corporation Ltd.

Furthermore, IFEZ Smart City Integrated Platform is sold and exported to the other municipalities in the Republic of Korea and abroad. The total sales amounts were up to five hundred fifty million won (KRW). However, IFEZ Smart City Integrated Platform is still at a very early stage, so there are not many tangible results for the evidence showing improvement of the quality of life of its residents or efficiency of city operation or even the impact on the environment.

Therefore, IFEZ has many tasks for enhancing the function of Smart City Integration Platform and improving the quality of life of its residents as follow.

a) IFEZ is still undergoing to develop more private smart services including smart traffic, smart education and smart healthcare for its residents based on the open platform with participation of its residents.

b) IFEZ has to build the capability of analyzing Big data for serving useful information for its residents and city officials.
c) IFEZ needs to discover various smart city service apps or models and to promote participation of its residents through hackathon, surveys, contests or even living labs, etc.

In Part II regarding smart service research, the following results were also found:

1. Incheon Metropolitan City adapted the concept of Smart Mobility, developed the 'BARO BUS' system and deployed cutting-edge ICTs applicable at the current stage. The 'BARO BUS' system works in a way that collects data from the smart devices and IoT sensors and transmits it to the Smart City Integrated Platform. Afterwards, this platform analyzes and processes data using Big-data to eventually transfer the information to citizens through BIT at Bus stops. The 'BARO BUS' system is the first smart mobility service using the Smart City Integrated Platform in real world. The technology and operational know-how gained from this example can be used to build a more advanced smart mobility service in the future.
2. In order to detect air pollution, water pollution and fine dust, Incheon Metropolitan City has created an environmental platform using drones called 'Environment Drone Platform'. Although it is still in its infancy, it is possible to collect a variety of information using drones in the future. This will be taken to the next level in combination with Smart Mobility.
3. Incheon Metropolitan City operates Smart Crime Prevention services, Disaster Detection services, and Smart Facility Management services, and offers various smart public services to citizens through Digital Signage.

Meanwhile, private companies which are interested in smart city business, are developing a variety of private services using data collected and processed through the Smart City Integrated Platform. Typical private smart city services include Smart Healthcare, Smart Education, Smart Building Management, and Smart Energy.

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