

TOPIS: Seoul's Intelligent Traffic System (ITS)

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Seoul TOPIS (Seoul Transport Operation & Information Service) is an integrated traffic management center that operates and manages Seoul's traffic situation and collects traffic information from traffic-related organizations – these include Bus Management System (BS), traffic card system, unmanned enforcement systems and traffic broadcasting, the National Policy Agency, and the Korea Expressway Corporation.

“Seoul TOPIS (Seoul Transport Operation and Information Services)” refers to an integrated traffic center that plans, constructs, and operates Seoul's Intelligent Transport System (ITS). The Korean name can be literally translated as ‘Seoul Traffic Information Center’. However, the English name of Seoul TOPIS is more familiar to the public. The traffic information situation control room, which is an important part of Seoul TOPIS, is sometimes easily mistaken for the entire Seoul TOPIS. However, Seoul TOPIS actually refers to the intangible functional organization that manages Seoul city's ITS, which applies advanced IT to traffic, as a practical department of Seoul city composed of 4 divisions and 90 employees. Over its evolution of the past 15 years, Seoul TOPIS has come to obtain various functions and equipment. In 2015, the functions of Seoul TOPIS were systematized to launch a new platform. Its components include the six platforms of center platform (the traffic information control room), the bus platform (BIS/BS), the unmanned enforcement platform, the freeway traffic management system (FTMS), the advanced traffic management system (ATMS), and the big data platform (traffic predictions, information support).

Seoul TOPIS continually collects a wide variety of traffic information: information such as highways and freeways, 9000 buses, current traffic situations from public traffic card systems, vehicle violations (parking and stopping, speeding, driving on bus lanes), and accidents. Then, based on these platforms, it analyzes the traffic demands or causes of traffic congestion and provides real-time traffic information required by traffic facility users and public transportation operation managers. With respect to unmanned enforcement, it has an automatic penalty management system that collectively manages the imposition and collection of penalties and bills.

¹ Translation by ESL®

With the use of advanced IT, detailed information on the massive Seoul traffic system can be collected in real-time and a remarkable amount of data can be gathered and analyzed by the one center of Seoul TOPIS. This is done to increase the accuracy of the information. Furthermore, by sharing such analysis results with private corporations and the people, it allows for the development of various derived information products. Ultimately, Seoul TOPIS works toward the goal of constructing a traffic system having maximized satisfaction by the users and enhanced safety of traffic users, as well as minimizing traffic congestion by optimizing the efficiency of existing traffic facilities.



Figure 1: Seoul TOPIS Platform
Seoul Traffic Information Division (2016)

1. Policy Implementation Period

Here, a summary of the historical process for Seoul city's building of the current ITS system is provided. It was not planned and developed as a single system, but each part was gradually initiated based on the formation of the conditions and needs. Based on these individual experiences, the entire process and system was integrated and consequently reconstructed into six platforms. As a result, the temporary construction of each of the six platforms was possible in different geological and spatial contexts.

- Institution of Namsan region traffic management system (10.6km): 1998
- Institution and expansion of the urban highway traffic management system: 2000
- Inauguration of Seoul TOPIS (the situation control room) and introduction of traffic card system: 2004
- Introduction of the unmanned enforcement system: 2005
- Pilot installation and expansion of the bus information terminal (BIT): 2008
- Launching mobile traffic information service: 2009
- Traffic data open to the public: 2010
- Introduction of Standard design (VMS, VDS) of the ITS facility

- Launching combined (traffic + disaster + general affairs) urban management situation control room: 2013
- Launching Seoul TOPIS platform (ITS Solution): 2015



Figure 2: History of Seoul TOPIS
 Source: Seoul Traffic Information Division (2016)

2. Background Information Before 2004

In the 1950s and 1960s, before Korea’s economic development had officially begun, the traffic facilities and infrastructure in Seoul city were very weak. It was difficult even to catch buses and the roads had no traffic signals, which resulted in a dependency on hand signals. The surface car (also known as a streetcar or tram) constructed in the early 20th century was almost the only form of public transportation. In addition to the expansion of the city, the route network gradually extended. However, there were restrictions to handling the increasing number of users along with the rapid economic growth. In addition, with the remarkable increase in the use of motor vehicles and the introduction of buses, which allowed free movement, the surface car whose installation and expansion was a relatively difficult naturally began to decline. In 1968, the last route of the surface car was terminated.

At the time of the termination of the surface car, Seoul’s public transportation comprised of the surface car and buses, each of which transported half of the population. The official growth of Seoul began at this time, and it began to section and compartmentalizes itself by gradually constructing roads from the nearest regions from the heart of the city using buses as the main form of transportation.

Throughout the era of high speed urban growth after the 1970s, road construction was performed for the expansion of bus services and the infrastructure of Seoul’s road systems was formed by constructing the Gangbyeonbuk-ro and Hangang bridges as a series of expanding the weak traffic facilities. Furthermore, in 1974, Seoul’s subway era began along with the opening of subway line number 1.

However, the continual increase in income of the Seoul citizens, due to the rapid industrialization, resulted in a surge in the use of vehicles. The increase in road transport facilities actually further caused increases in the operation of vehicles and this resulted in a lack of roads. At the time, therefore, there was no seemingly practical resolution of the road congestion.

In a situation where the general role of public transportation was decreasing and the use of personal vehicle increasing, the status of the subway rose in comparison to buses in the public transportation market in early 2000s. This is not irrelevant to the institutional support of setting the subway as the main axis of Seoul transportation. However, due to the excessive use of vehicles, the level of road services declined, and the service competitiveness of buses, which depends on roads, weakened in relative terms. This then caused an outflow of users to other mode of transportation and the allocated rate of passengers on buses continually decreased from 30.1% in 1996 to 26% in 2002 (Seoul Statistics 2016).

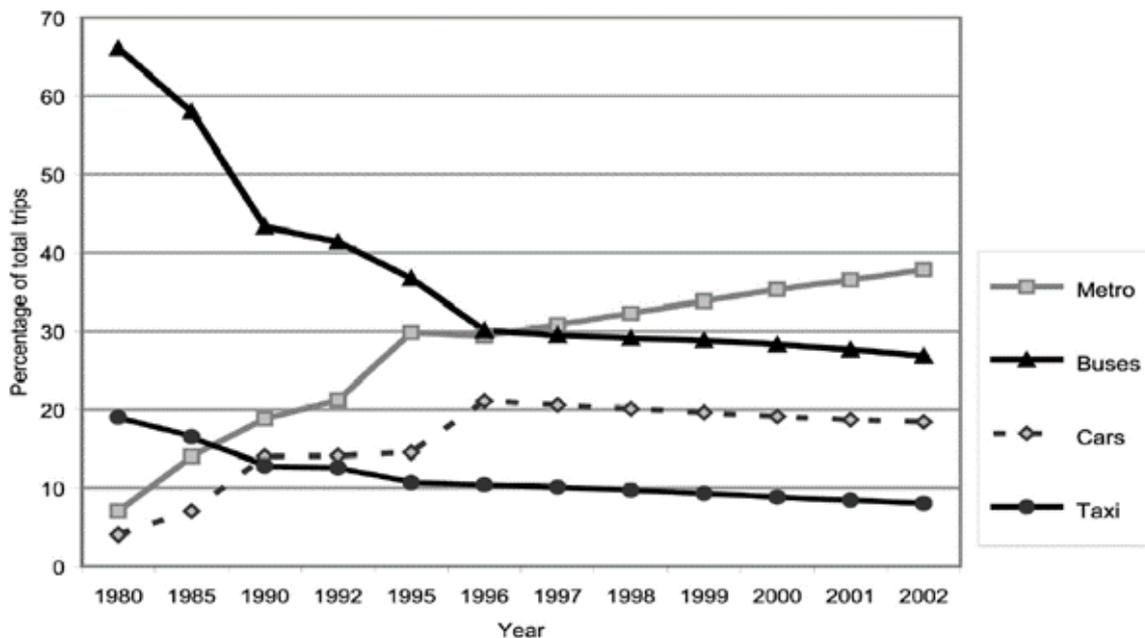


Figure 3: 1980-2002 Trends of Allocated Passengers for each Method of Transportation

Source: Seoul City 2004; The Seoul Institute 2003

After 2004

Together with the notion that the supply of roads cannot resolve traffic problems, particularly the problem of traffic congestion, the public found the role of public transportation ever more important. Seoul needed to revitalize a bus industry which was visibly declining. There were several attempts by the city to partially improve the operation of buses. However, the extensive reformation of the public transportation system was finally conducted in 2004.

The two main essence of this reformation are as follows:

- 1) The public transportation service was unified by combining the subway and bus systems in order to reinforce the competitiveness of public transportation.
- 2) The bus industry at the time was privatized, but a so-called semipublic bus management system was established to control the market price in areas of operation and management. This was determined as essential to meet the strategic goal of combining public transportation.

In order to obtain competitiveness of public transportation, the qualitative of public transportation services needed to be enhanced. The central bus lane, smart traffic card, and the public transportation information system (BMS/BIS) were introduced as a part of the reformation in the public transportation system, which all composed Seoul TOPIS.

3. The Importance of the Policy

Seoul TOPIS is a management system that ties Seoul transportation with advanced technology and plays two significant roles in terms of traffic policy. The first significant role is that it grants competitiveness to public transportation by providing convenience and allows communication through bus lanes, smart traffic cards, and the public transportation information system. This greatly helps maintain the allocated number of passengers in public transportation at a consistent level. The second role is that a reasonable level of service throughout the entire road traffic system can be maintained by helping the communication of vehicles through various road management systems, automatic illegal parking control systems, and unexpected situation control systems. The result is a generally higher level of user satisfaction with no relation to the suitable allocation of passengers or method of transportation.

4. Relevance with Other Policies

As displayed in the platform composition of Seoul TOPIS, the following policies provided as a part of the current manual series are each a platform that handles the operation of the real-time traffic system of Seoul TOPIS.

- 1) Bus information system (BMS/BIS)
- 2) Unmanned enforcement system
- 3) Freeway Traffic Management System (FTMS)
- 4) Advanced Traffic Management System (ATMS)

5. Policy Objectives

The goal is to provide a forum for sharing an advanced traffic system or public transportation operation management and, from this, provide scientific traffic administrative support, real-time communication management and citizen traffic information services through the connection and combination of traffic information and traffic systems.

As specific achievements, the following are to be achieved through optimized efficiency of the existing traffic facilities, including the roads.

- 1) Improved urban traffic speed by minimizing traffic congestion
- 2) Reduce traffic accidents
- 3) Reduction of negative effects arising from unexpected situations
- 4) Prediction of traffic situations and support of other traffic policies by analyzing traffic big data
- 5) Enhanced consumer satisfaction through punctuality of public transportation and the sharing of traffic information
- 6) Maximized road utilization through unmanned enforcement and contribution to the right parking culture
- 7) Enhanced profits based on the imposition of penalties and fines (Used for the construction of parking lots)

6. Main Policy Contents

Seoul TOPIS is an integrated traffic center that plans, constructs, and operates the advanced traffic of Seoul city and is operated by 150 employees and 4 teams. The main functions of Seoul TOPIS can be largely categorized as follows:

First, a wide variety of information from the urban highways and freeways is collected and analyzed through advanced IT devices. And then, real-time traffic surveillance and management on traffic situations is performed to increase the efficiency of road use.

In view of the types and scales of IT devices used by Seoul TOPIS, speed information is collected in real-time from roads reaching 1,268 km through 1,181 video and loop detectors installed on site and 35,000 GPS devices installed in taxis. Further, 832 surveillance cameras

installed for traffic and disaster monitoring are operated, as well as 326 virtual memory systems (VMS) 3,600 real-time signal controllers, local control stations (LCS) installed in 33 areas, and remote manipulator systems (RMS) installed in 13 areas are used to operate road communication, along with information collection.

The drawing below displays the statistics related to the types and quantity of various IT devices obtained by TOPIS.

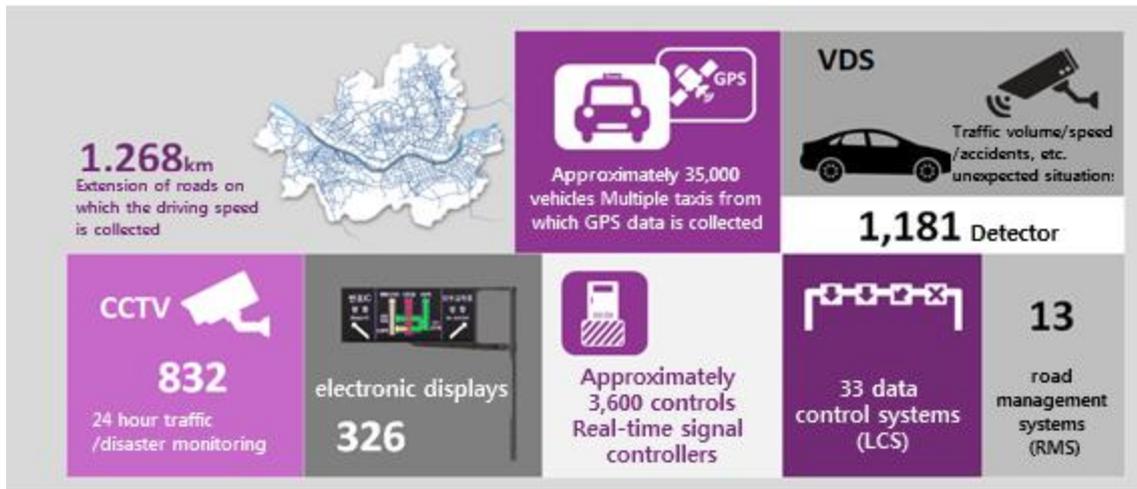


Figure 4: Current state of Seoul TOPIS' road traffic management devices
Seoul Traffic Information Division (2016)

After processing the traffic information collected from these devices, Seoul TOPIS provides the data to drivers and manages the traffic situation. First, a whole host of different technologies are employed to collect speed, traffic volume, unexpected situations, weather, and other necessary and relevant information.

Fundamentally, the locational information of taxis installed with GPSs is collected in real-time to calculate the passing speed on the roads. This is collected through wireless communication between the GPS in standard vehicles, wireless communication devices, and road-side base stations.

Advanced vehicle detection systems, such as loop detectors and video detectors, are installed every 250m to 500m on highways, and thus, the traffic speed and volume are collected from these on-site systems. Surveillance cameras allow the monitoring of communication and unexpected situations, and the road weather information system collects and provides climate information, such as the road state, temperature, and visibility. Moreover, information on traffic situations or unexpected situations is obtained through the National Police Agency, the Meteorological Administration, and citizen reports.

The road and traffic information collected through these various channels is gathered at Seoul TOPIS, processed in real-time, and then provided to traffic users in real-time through various media channels, such as mobile applications, ARS, navigation, SNS, the TOPIS website, road electronic displays, and traffic broadcasts.

Upon occurrence of an unexpected situation on the road, the situation is detected by a video or

automatic detector and automatically displayed on an electronic display. The road control system controls, operates the roads based on the needs, and provides bypass roads so as to control the traffic flow. Furthermore, the connection road control system is operated upon need to prevent any increase in traffic congestion, and the signal control system assists in smoothing the traffic by prolonging the duration of green signals and lights on roads with severe congestion.

Seoul TOPIS also has the function of preparing for the full closure of a road due to any unexpected situation, such as a large scale rally or bad weather, by carrying out various simulations.

Second, Seoul TOPIS manages approximately 9,000 Seoul buses in real-time, and operates a public transportation information system that provides assistance with public transportation information to the users.

Bus-related information is collected in real-time by installing bus information collection terminals that use bus management systems (BMS) and traffic card functions on all buses in Seoul. Through the combined terminals installed on 9,334 buses, all detailed information related to buses is collected - such as all bus operating situations from the point of departure to the point of arrival, real-time speed, location of buses, sudden acceleration, sudden stops, no-stop passing, breaking away from the route, and driving with the door open. Furthermore, these bus information collection terminals also checks traffic card information, and thus, can collect the information of passengers in real-time. The terminals collect approximately 85 million cases of traffic card information each day.

The collected information is provided to the citizens by automatically calculating the bus arrival times and returning passengers by the Seoul TOPIC bus information processing technology. The bus operation management records (including various operation acts that may harm the safety of the citizens) are systematically stored, analyzed, and managed to be used as an important index in the regular evaluation of bus corporations, and the bus route is managed by adjusting unreasonable routes and constructing new routes to support the establishment of the optimum public transportation policy.

There are diverse means of providing bus information. First, bus information terminals (BIT) are installed at 52% of bus stations in Seoul, to assist the passengers with the bus arrival time in real-time and provide bus information, as well as subway arrival information. The bus passengers are provided with a wealth of information, such as the predicted bus arrival time, information related to buses for the disabled, the last bus of the day, congestion due to accidents, and the predicted time of arrival of the nearest subway through bus information terminals installed at these bus stations.

Furthermore, all information at Seoul TOPIS is 100% open, where 24 million cases of information is provided to the public in an open API method. Private corporations may reprocess this information to suit different types of consumers to directly provide public transportation information to the users. Currently, a significant number of public transportation users that use the internet or smart phones receive public transportation information through portals, websites or mobile applications of communications companies or mobile applications

launched by personal developers. Thus, the users do not depend only on bus information terminals installed at bus stations, but can plan their use of public transportation anywhere and at any time.

All of this bus information, as well as the user-customized information (such as a safe arrival service which helps accompany vulnerable pedestrians to their destination via text, and an alarm function notifying the arrival at a destination) can be provided on smart phones. Detailed information and websites can be used by accessing a QR code attached to bus stops, as well as an automatic response service for bus passengers who are unfamiliar with smart phones.

Such bus information collected and provided through advanced devices displays an accuracy of 98%. The accuracy of this information is evident by the use of the combined public transportation information that surpasses 1.4 million hits, and achieves satisfaction levels of 96%. Fig. 4 below displays the number and statistics related to the information collected at terminals by the public transportation information system.

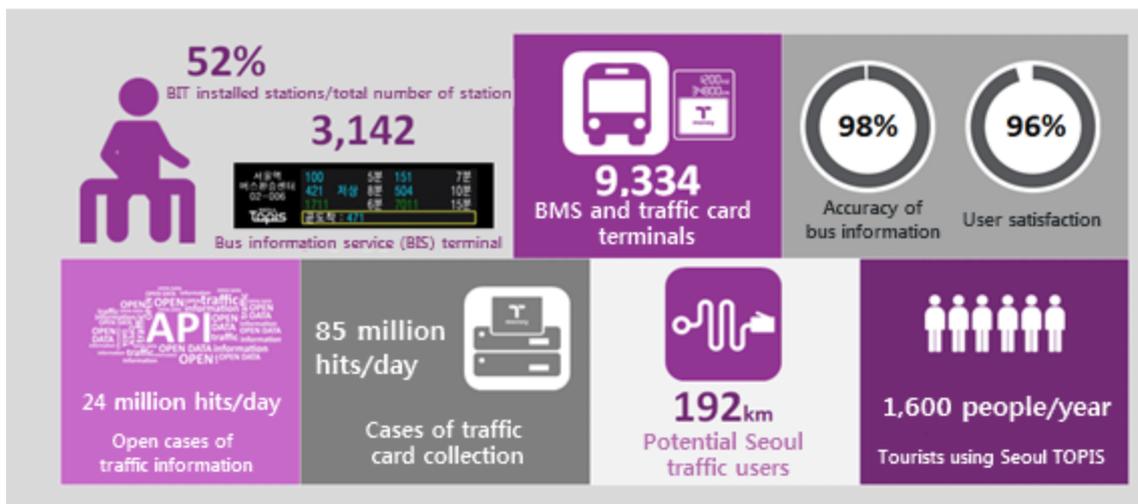


Figure 5: Current status of Seoul TOPIS bus information system

Seoul Traffic Information Division (2016)

The electronic payment system, which allows the payment of various public transportation fares with a single card, is also linked with Seoul TOPIS. The bus information collection terminal previously explained is constructed so that it combines the bus operation information system and the traffic card system. The traffic card information collected thereby is becoming an important element of the public traffic information system of Seoul TOPIS.

Traffic cards are used by almost all public transportation users, including 100% of subway users and 98.7% of bus users. Taxi passengers also display an increasing use of traffic cards each year and currently stand at 53.5%.

Seoul's combined electronic payment system follows the distance proportion system within the metropolitan area: a distance within 10km can be transferred to for free using any method of public transportation within a time limit of 30 minutes. The distribution of the fare is calculated based on the basic fare for each method of transportation.

The usage of the traffic card is expanded to distribution, dining, culture, and traffic safety services, and thus, is breaking the boundary of the electronic payment system, and can also be used via pre-paid card, credit card, or the mobile phone. The traffic card was previously only available for use in Seoul, but the use of the traffic card is now permitted and functional in most regions of Korea. In addition, the mobile payment compatibility service is also operated in Singapore. There are plans for it to be expanded to other countries, including Japan, Hong Kong, Thailand, and Malaysia.

Seoul TOPIS controls illegally parked or stood vehicles in bus lanes, which cause traffic congestion through the unmanned enforcement system.

Since 2005, Seoul TOPIS has been constructing and operating an unmanned enforcement system, which automatically controls illegally parked or stopped in bus lanes and thus is not reliant on any labor force.

Currently, the automatic unmanned enforcement system uses two types of devices. First, the fixed unmanned enforce system installed on roads uses a detector which can automatically control vehicles illegally parked or stopped or vehicles that drive in bus or bicycle lanes within 200m of the detection device.

The portable unmanned enforce system is simply a camera equipped on buses or monitoring vehicles that records the number plate of a vehicle in violation when such vehicle is detected during the running of the relevant buses or monitoring vehicles. This information is then transferred to Seoul TOPIS. The fixed unmanned enforcement system is restricted, however, in not being able to control vehicles in violation outside of the installed point of the device, whereas the portable unmanned enforcement system can supplement this weakness as drivers are unaware of the point of installation.

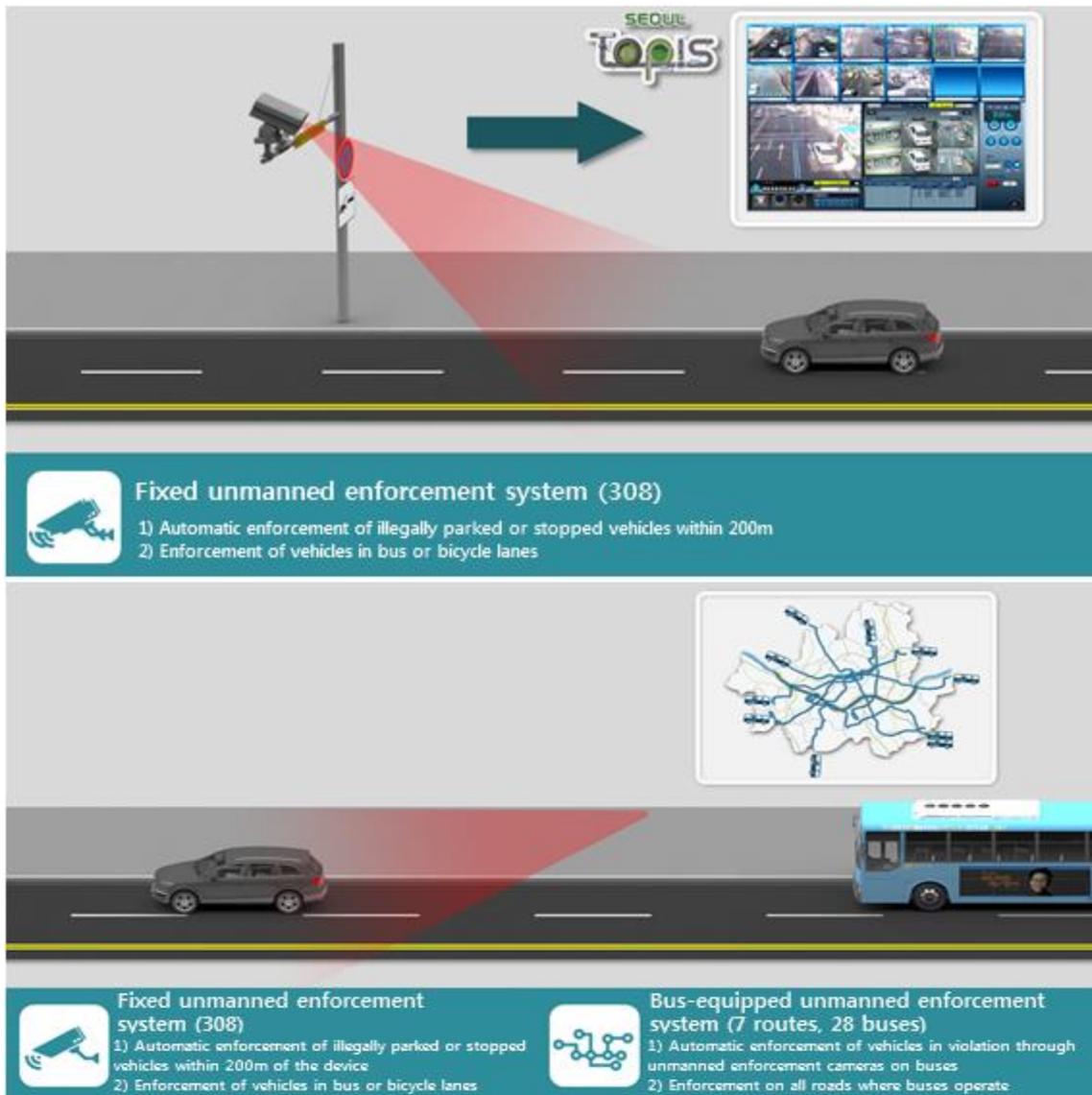


Figure 6: Seoul TOPIS unmanned enforce system

Source: Seoul Traffic Information Division (2016)

The unmanned enforcement system not only exposes vehicles in violation, but is the world’s first automatic penalty management system that automatically transfers a penalty notice to the owner of the vehicle in violation.

First, when a vehicle in violation is detected, the registration of the vehicle is searched to automatically record the owner and address of the vehicle. It then sends a penalty report providing photograph evidence and ownership information of the vehicle to the post office in electronic form. The electronic penalty notice is then automatically delivered to the address of the owner of the vehicle. All processes from the detection of violation to the delivery of the penalty notice are automatically performed, and thus, only takes two to three days. Before the successful automation of this process, it often took 10 to 15 days to complete. Thus, the amount

of labor force and resources saved is evident by the automation of this process.

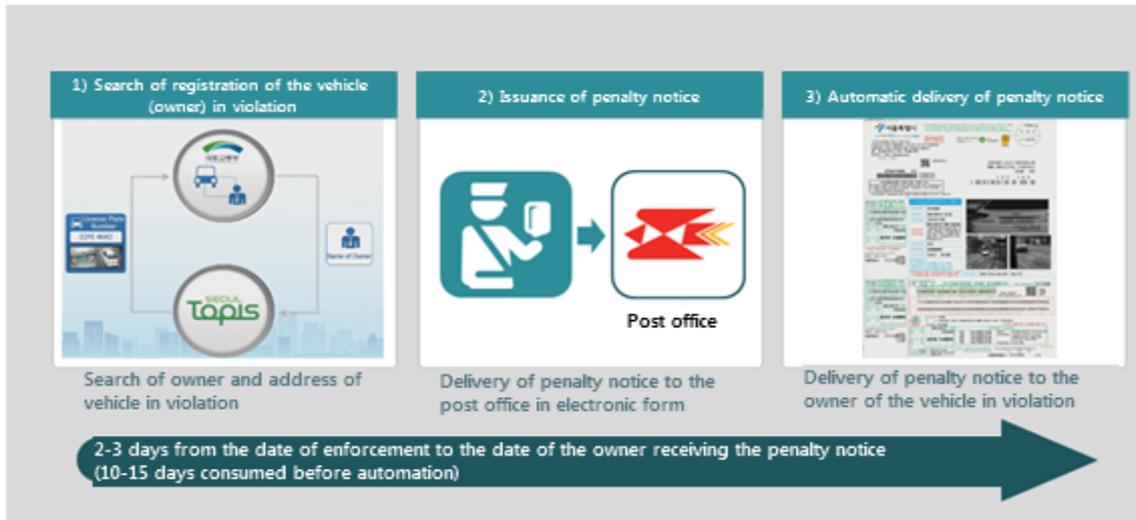


Figure 7: Seoul TOPIS automatic penalty imposition system

Source: Seoul Traffic Information Division (2016)

Seoul TOPIS operates 308 unmanned enforcement systems, and enforces approximately 1.8 million illegally parked or stood vehicles as well as vehicles in bus lanes through this system.

Fourth, Seoul TOPIS is constructing and operating a traffic prediction system that prevents traffic congestion. Currently, traffic prediction is conducted in the 157km highway region, and is scheduled to expand to the main freeways.

In addition to real-time traffic information services, data related to the traffic flow on each road, weather, and accidents, accumulated over the past five years is analyzed to predict the traffic situation of each road in 15 minute, 1 hour, and 1 day units. Furthermore, if or when an unexpected situation arises, such as an accident, the traffic simulation is used to predict the outcome of the situation. A congestion alarm is used to allow the citizens to know both the region and times of congestion in advance. This helps drivers avoid using certain roads at certain times and provides great benefits.

The traffic prediction technology was developed by the Korea Transport Institute, and an accuracy of 90% of the traffic prediction was verified based on the urban highways. Seoul TOPIS intends to expand the traffic prediction system on the main roads of Seoul for the citizens to use traffic predictions in a similar way to how they use weather forecasts in everyday lives.

Furthermore, the traffic prediction system can be used to prevent accidents that may occur, based on communication between vehicles, i.e., the V2V technology, and bilateral wireless communication can be used between a vehicle and a communication-based infrastructure (V2I) to provide roadside assistance reflecting real-time road situations, signal changes, and the prediction of crosswalks.

Seoul TOPIS: Organization and Operation

Seoul TOPIS is an organization that plans, constructs, and operates intelligent traffic. It is composed of 32 public servants in 4 divisions. A total of 150 employees work at Seoul TOPIS where they monitor, control, provide maintenance, and carry out the management of the traffic situation.

The operation of Seoul TOPIS requires an annual budget of 17 trillion won. Most of the budget is used for site facilities and the maintenance and management of the labor force.

Fig. 8 below provides a summary of the statistics related to the operation of Seoul TOPIS, the unmanned enforce system and other related aspects.



Figure 8: Seoul TOPIS organization and operation, and other related statistics

Source: Seoul Traffic Information Division (2016)

8. Technical Details

1) Main system of Seoul TOPIS

The center system accounting to the brain of TOPIS collects, combines and processes all information in real-time and then allows for an immediate response by providing the information to the operator.

The operator is supported and able to control all traffic and disaster situations from the center by providing the necessary information to the citizens and taking all relevant precautions – these include detecting the symptoms of unexpected situations and disasters by monitoring all information, and controlling the on-site equipment such as the traffic signals and electronic

displays.

Furthermore, the system is constructed so as to allow rapid contact and cooperation with related organizations.

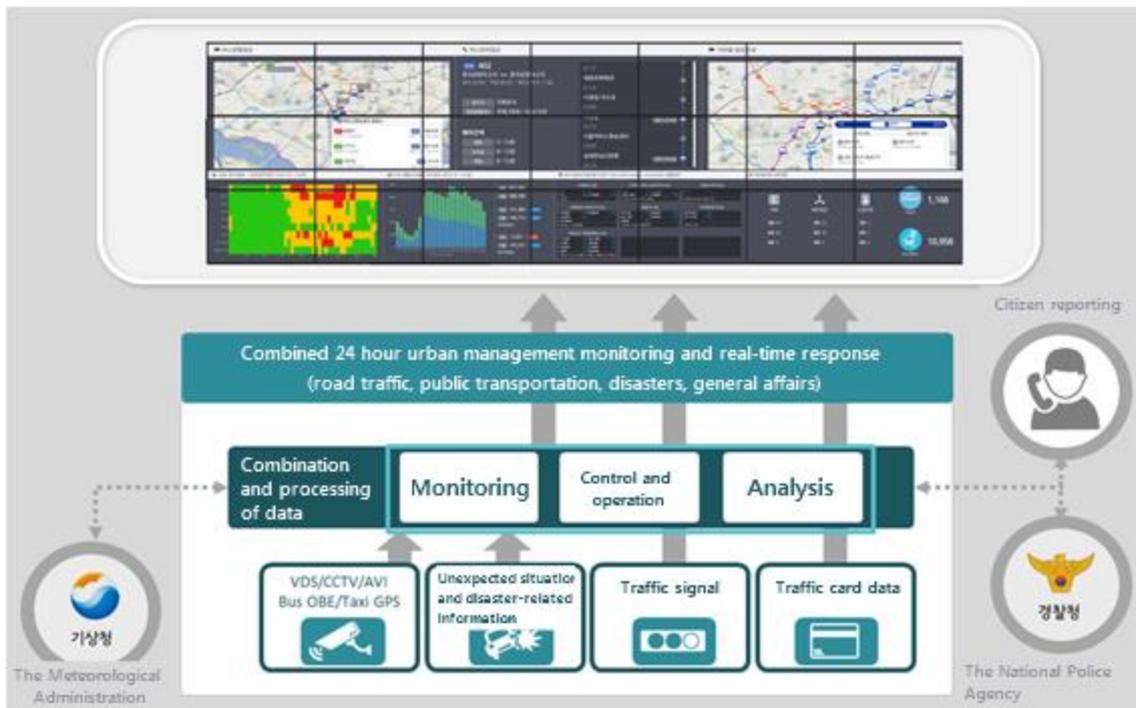


Figure 9: Seoul TOPIS center system

Source: Seoul Traffic Information Division (2016)

2) Bus Information System

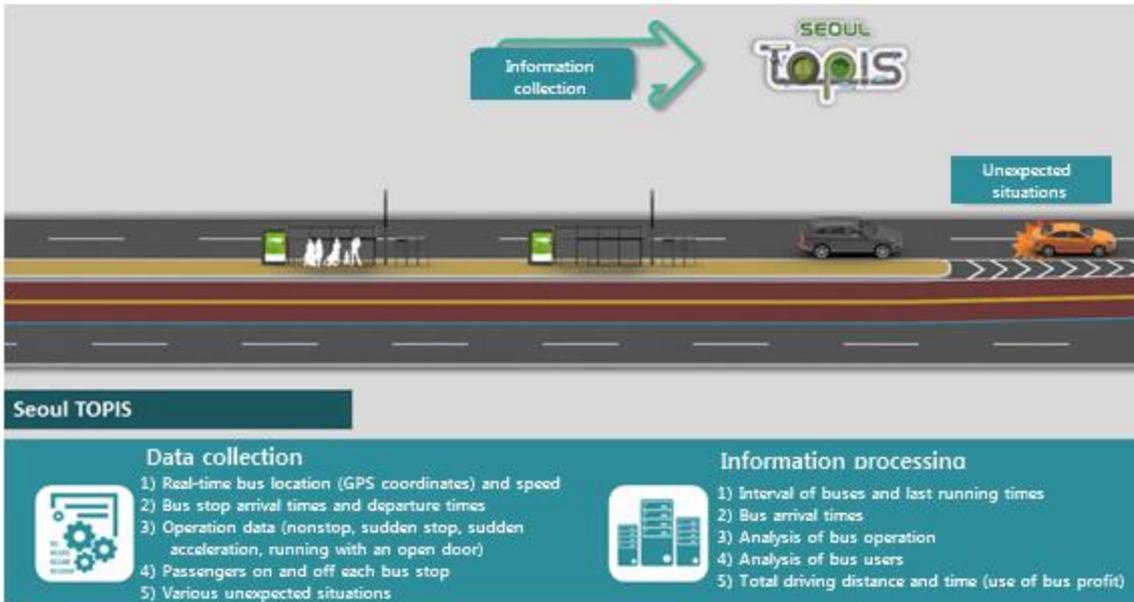


Figure 10: Seoul TOPIS bus information system

Source: Seoul Traffic Information Division (2016)

Operation of all 9334 buses in Seoul, from the point of departure and arrival, is collected in real-time through the Seoul TOPIS bus information system. Each bus has an integrated bus terminal installed therein combining bus operation information and the traffic card function. It collects all bus-related information, such as the passengers and running of the bus (including factors such as sudden accelerations, sudden stops, and nonstop passing) in addition to real-time speeds and locations.

The collected information is provided to the citizens by automatically calculating the number of returning passengers and the arrival time of buses based on the Seoul TOPIS bus processing technology. From this, various actions that may cause harm to the safety of citizens are stored and analyzed for use in the evaluation of bus corporations.

Bus Management System (BMS)

Through the construction of the BMS center for real-time public transportation operation management, the enhancement of bus competitiveness was initiated by enhancing bus punctuality, improved operation orders, providing a wider range of bus information, and promoting a rational public traffic policy bill based on operational historical precedents. The combined bus control room is in charge of the role as the main body in relation to the majority of strategies and is in the center of all bus operation management strategies. The BMS collects bus operation information using location tracking technology and processes the information as bus operation policy data in order to provide the data to operators, bus companies, and drivers.

Bus Information System (BIS)

This system collects bus location information to process bus arrival predictions using algorithms and to provide the information to users and related organizations. To achieve this, personal information services, such as internet websites, ARS and mobile services, were initiated and the bus information terminals (BIT) were installed. Thereafter, bus information is fully disclosed to the public. This led to the introduction of various products focused on internet and mobile applications, and a selection of services that better suit the consumer's needs and preferences.

3) Unmanned enforcement system

The advanced unmanned enforcement system constructed for the management of the communicative situation by Seoul TOPIS detects and punishes illegally parked or stopped vehicles on urban highways as well as vehicles driving in bus lanes through the use of unmanned enforcement cameras.

The unmanned enforcement cameras cover all vehicles within a 200m radius in all directions on all roads. Vehicles captured by the unmanned enforcement camera are confirmed in as little as five minutes.

Portable or bus-equipped unmanned enforcement systems have the advantage of detecting vehicles on all roads of the pertinent route. Of the four cameras equipped on buses, two cameras equipped at a 45 degree angle detect illegally parked vehicles on the shoulder of the road.

Currently, fixed enforcement cameras are installed in all regions of Seoul, and the bus-equipped cameras are able to detect vehicles on main freeways in real-time.

Enforcement can also be confirmed by the public in real-time.

When a search is performed on the owner of the vehicle and the penalty is imposed using the number plate and photograph sent to the traffic violation management system, the notice is printed and sent to the post office. Here, it is automatically connected to the nearest post office of the owner of the vehicle and duly sent out.

All phases of Seoul's unmanned enforcement system are automatically performed, from the enforcement to the receipt of the penalty.

A sum of approximately 120 billion won, from 3 million cases of enforcement each year, is used for the maintenance and operation of public parking lots. Accordingly, the unmanned enforcement system contributes to the relief of urban traffic congestion as well as a lack of parking spaces.

8. Policy Effects

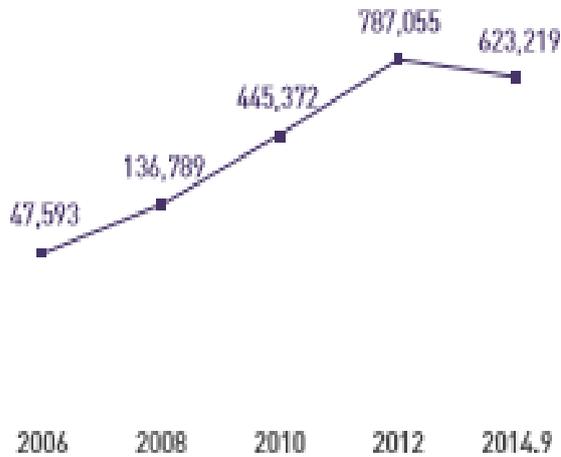


Figure 11: Current status of Seoul TOPIS information in use

Source: Seoul Traffic Information Division (2016)

The usage of the combined public transportation information is 1.4 million cases each day. The total accuracy of the bus information is approximately 98% and the satisfaction rate of public transportation is 96%.

Traffic cards are used by almost all public transportation users, including 100% of subway users and 98.7% of bus users. Taxi passengers also display an increased use of traffic cards each year and 59% of the taxi passengers use traffic cards. (Seoul Urban Traffic Division 2016).

Increase in the Bus Allocation Rate

Table 2: Increasing Rate of Public Transportation Use Each Year, 1996–2014

	2004	2005	2006	2007	2008	2009	2010	
Subway	4,567	4,540	4,533	4,532	4,577	4,730	4,835	
Bus	4,782	5,451	5,662	5,603	5,647	5,681	5,719	
Total	9,349	9,991	10,195	10,135	10,224	10,411	10,554	

Source: Seoul City 2016

- 4.6% increase in the accuracy of bus arrival times (from 87.3% in 2006 to 91.4% in 2013)
- 26% increase in the average speed of buses (15 km/h to 19 km/h)
- 2.6% increase in the average daily bus passengers by 150 thousand passengers (from 5.6 million in 2007 to 5.75 million in 2013)

Source: Seoul Traffic Information Division (2016)

9. Challenges and Solutions

At the time of policy implementation, there was an increase in the general understanding and interest on ITS due to the national initiation of the ITS project. With respect to the policy plan and implementation process, there were no obstacles or technical difficulties related to the interest group that may be recorded as direct beneficiaries, such as Seoul city, bus companies, drivers, or bus passengers.

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