Contents

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One Card Fits All: Integrated Public Transport Fare System

1. Policy Implementation Period

The integration of modal fares between public transportation means and services within public transportation means was initiated in 2004 as part of the series of reform of the public transportation system in Seoul.

2. Background Information

<u>Seoul Traffic</u>

The population of Seoul jumped from 2 million to approximately 10 million over a 30 year period from the 1960s to the 1980s. Based on the economic development plan initiated under the supervision of the government, the inflow of population to Seoul as the central area of economic activities was not unexpected within the flow of industrialization. Thus, the need for the construction of a subway system as a mass transportation facility that suited the demand for transportation and the expansion of population in Seoul was recognized. However, a subway system requires a long planning and installation period, and thus, it will take approximately 30 to 40 years to develop it into the main means of public transportation in Seoul.

In view of the progress of the mass transportation in Seoul, the surface car constructed in the early 20th century was the main means of transportation in modern Seoul, and although the line network expanded following the expansion of the city, the use of cars significantly increased since the 1950s. Buses allowing free commuting, which resulted in the natural declination of the surface

[1] Translation by ESL®

car which was relatively difficult to install and expand. In 1968, the last surface car line was closed. The historical flow of transportation is in tune with large cities of many other countries, including the USA, with the only notable difference in the time period.

At the time that the surface car line was closed, the share of surface cars and buses out of public transportation was 50% respectively. Seoul began to grow in earnest during this era, and Seoul used buses as the main means of transportation to gradually construct roads from areas close to the down town. This illustrated a clear distinction from western metropolitan cities that formed urban districts surrounding railroads.

However, while going through the era of rapid urban growth, the increase in road facilities and road construction for the expansion of bus services caused a rise in the use of cars and consequently resulted in a lack of road. Furthermore, the continuous rise in personal income meant corresponding rise in the increased usage of cars, which led to the road congestion, reduced travel speed of buses. However, expanded road spaces, as a solution to the congestion and speed issue, failed to meet the ever rising demand for roads. Such vicious cycle repeated over and over again.

The increased usage of cars continued regardless of the construction and expansion of the subway since the early 1970s, and in the early 2000s, 72% of Seoul traffic was accounted by cars, with 79% of these cars being drive-alone cars. The shift in modal share signified an annual consumption of 4 trillion 100 billion won, and the social cost due to traffic congestion reached an annual cost of 5 trillion won.

Public Transportation in Seoul

The mode share of the subway increased relative to that of buses in the early 2000s, where the overall role of public transportation declined along with the sudden increase of personal car usage. Although this was not irrelevant to the institutional support of making the subway the main axis of transportation in Seoul, the decreasing level of road services caused by the excessive use of cars relatively reduced the service competitiveness of buses, which depend on roads, and this declination of the level of service produced an outflow of traffic users to other transportation means. This change resulted in the vicious cycle of the bus industry accelerating in terms of the deterioration of the bus service industry.

In 1997, the number of bus corporations in Seoul reduced from 103 to 57, and the remaining bus corporations operated within a structure of excessive competition toward profitable routes, the unilateral closing of low-profit routes, and the connection of the number of passengers to profit. With this structure, the bus corporations were left on a path of decreasing quality of service, such as head-running, violent driving, the rejection of elderly or disabled passengers, and violation of traffic signals.

The declining level of road service not only caused a reduction in driving speeds, but also poor quality of bus services in various forms. As a result, the modal share of buses displayed a continual decrease from 30.7% in 1996 to 26.7% in 2002. The reduced number of passengers led to poor management, which caused increase in fares, and a combination of poor service and increased fares became sufficient causes for citizens to use buses less as a main means of transportation.

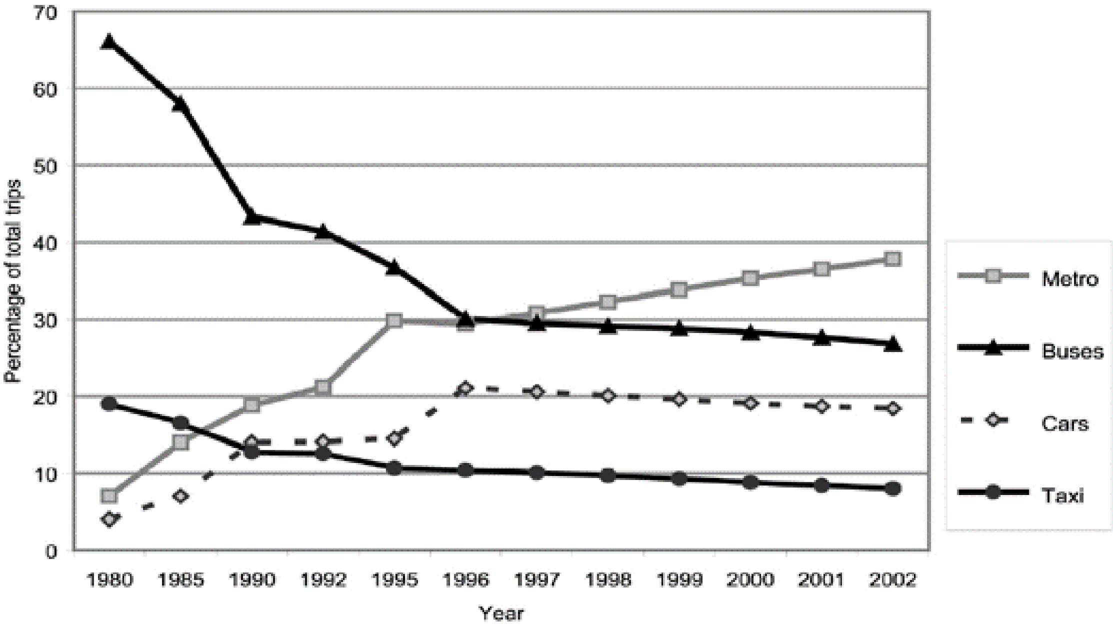


Fig. 1. 1980-2002 Progress of the Delegation of Public Transportation

Source: The Seoul Metropolitan Government 2004; Seoul Institute 2003

Reform of Public Transportation in Seoul City

As with most cities in the 21st century, Seoul has stated a goal of establishing a traffic system that achieves sustainable transportation by enhancing traffic mobility by relieving traffic congestion, and increasing individual accessibility so as not to leave any groups isolated socially or spatially. In addition, with the growth of civic awareness and their income, the demand for public services and expectations of administration has increased in the 2000s.

Seoul displayed relatively reasonable services and modal share compared to certain overseas cities, particularly in North America, where the citizens overly depend on personal cars. However, within the trend of the 21st century where the share of buses has increased as an environmentally friendly and sustainable method of transportation, the problem of traffic congestion caused by increased cars and the declination of the bus industry remains a task to be solved. Although the city has partially attempted several means of improvement related to the operation of buses, a noteworthy achievement has as of yet been reached. When a new mayor was elected in 2002, however, a public transportation reform plan for improved traffic within the city was conducted on an extensive scale.

The two main facets of this reform are as follows:

1) Contribution to the integrated public transportation network, which connects the subway with the bus system in order to improve competitive edge over car, and

2) Structural change. At the time, the bus industry was in the form of a privatized market. However, a so-called quasi-public bus operation system was established, wherein the city government intervenes within the operation and management, which is a portion that is deemed essential for the strategic goal of the integrated public transportation network.

The quasi-public bus operation system is considered an essential tool for achieving the integration of the bus-subway network. In other words, this was a logically reasonable determination to have buses supplement the subway, which was already the main public transportation means, rather than maintaining a competitive relationship. Furthermore, reorganization of bus routes was essential to plan a supplementary traffic service system. However, this was impossible when bus corporations remained completely private. Thus, there was a need to redirect the right of planning bus lines to the city.

Furthermore, in order to increase the competitiveness of public transportation over cars, it was necessary to connect buses and subways, which fundamentally have different characteristics and advantages, and to provide enhanced services at competitive prices. Thus, in order to truly integrate the services, the integration of fare was essential, and thus, it was necessary to return the right of determining the travel fares to the city.

The quasi-public system is focused on recovering the right of designing the bus lines and the right of determining the fare to the city, and also includes the preparation of a frame of amicable cooperation between private businesses and devices surrounding financial assistance from the city. It’s only natural for bus corporations not to welcome the intervention of the city government with significant authority in the private market. To make the ‘quasi-public operating system acceptable to the bus industry, subsidies from the government are essential. The median bus lanes, which became one of the most distinguished features of the public transportation system in Seoul, were a very successful product for reinforced competitive edge over cars. However, it is an element of policy that can be enforced without reform of the entire system. Although, since the extensive reform of public transportation was simultaneously enforced, there has been a great contribution of this reform on the increased effects of the policy.

Against this backdrop, the integrated fare system of public transportation was introduced, and in 2004, a determinate element was initiated within the great frame of initiative called the public transportation reform. Although the traffic card had been used since 1996, there were problems concerning fare including restrictions in the capacity of data processing, and excess charges (22.4 trillion won annually). Ultimately, therefore, the integrated fare between different means of public transportation (bus-subway) was not realized.

3. The Importance of the Policy

Public transportation largely contains two significances in regard to urban traffic. First, it provides accessibility to the citizens so as not to miss the opportunity of participating in the economic, social, educational, and leisure activities within the city due to a lack of transportation means. Second, it is an environmentally friendly means of transportation that generates less social costs around issues, such as traffic congestion, atmospheric contamination, and traffic accidents, compared to private transportation means.

These two aspects are closely connected. In cities where public transportation is not properly developed, its residents naturally depend on personal transportation means, such as going on foot, bicycles, and cars. When a city physically expands, and the role of environmentally friendly transportation means (such as going on foot or bicycles) is reduced, and cars are not financially viable, motorcycles and other small vehicles are gradually depended upon, which rapidly increase social costs for issues such as traffic congestion, atmospheric contamination, noise pollution, and traffic accidents. Once the public tend to prefer private transport, it gets extremely hard to make them prefer the public transportation. In cities relying on the motorcycles due to economic pinch, a huge population will naturally prefer private cars once their income level raises based on the economic growth.

The city of Los Angeles, where most citizens commute on personal transportation means including cars invested a large sum in public transportation means, such as subway and rail transit, in order to reduce the proportion of personal transport in the 1990s. However, the awareness and attitude of the citizens toward traffic and the urban spatial structure had already settled around cars. Thus, a great change could not be achieved in the modal share of transportation, and other North American cities, as well as cities in Australia and Europe also had similar experiences.

Personal transportation means provide remarkable flexibility demanded in complex spatial structures of the modern city. Also, in most of the times, the important advantage of speed efficiency allows drivers to reach their destinations in less time. Some cities' experience of belated investment into public transportation suggest once the public gets accustomed to the use of personal cars, it's extremely difficult to make them use the public transportation due to such benefits.

With this trend, some cities have succeeded in raising the modal split to some extent while reducing the dependency on cars. The cities are similar in that they have made extraordinary efforts to enhance competitive edge of public transportation over cars rather than merely supplying public transportation services.

Furthermore, there are many cases that have targeted the goal of integrated services between buses, bus-subways, and public transportation-personal transportation means.

With respect to integration between transportation means, there are four aspects of information integration, service integration, fare integration, and physical integration. Among which, cities (including London, Paris, Hong Kong, and Seoul) that have achieved the integration of fares using smart cards, all displayed an increase in the number of passengers of public transportation.

There have been many studies on the reason as to why passengers choose public transportation when they are asked to make two choices between public transportation and personal transportation. The most common and notable reasons were the relatively long commute times and the transfer penalties incurred. The latter, specifically, includes the psychological cost in addition to the quantitative index of time - such as increased fares due to transfer from the obtained information of transfer fares, the time consumed to pay the fare, the time and effort for purchasing the ticket, and preparing the exact cash for the fare, which forms the recognition that 'the use of public transportation is inconvenient'.

The Seoul Metropolitan Government's reform of public transportation in 2004 was focused on enhancing the competitiveness of public transportation with the minimization of this transfer penalty, and accordingly, the integration of bus services and the integration of different transportation means (bus-subway) were included as the most important aspect of this reform.

To enhance public transportation facilities, we may consider increasing network density by constructing additional subway lines. However, unlike the cities in the early 20th century, which had a linear structure with the growth of the railway era, the official growth and expansion of the road and car era were achieved, and a spatial structure was gradually formed. Thus, the construction of a system that depends only on the single means of the subway operated on a fixed track is not an efficient public transportation plan in Seoul. This particular system is applied to the least-developed industrial cities that grow based on tire-based traffic network without having a railway-based linear structure.

Furthermore, it takes at least 10 years to construct one subway line, and at a cost of 130 billion won for 1km of track. Thus, supplying the accessibility of public transportation to all residents with a dependence on the subway does not demonstrate realistic financial feasibility.

It is evaluated that integrated fares of public transportation was an extremely perceptive institutional choice in that the quality of public transportation was enhanced to have 'competitiveness in comparison to cars' through the use of existing facilities and services without resource-concentrated investment, such as with the subway. This has had a great implication on the cities of other countries displaying rapid growth within the era of cars and roads after the late 20th century in a similar manner to Korea.

4. Relevance with Other Policies

According to the general principle of the integration of transportation, the integrated fare is one of four aspects of integrating public transportation. All four aspects were initiated upon reform of the public transportation system in Seoul. The four aspects of unifying public transportation are as follows:

- Service integration
- Fare integration
- Information integration
- Physical integration (transfer centers)

The integrated fare system is closely related to the other three integration aspects.

Among which service integration was formed between bus-subway systems, bus-bus systems, and different types of bus systems, and mainly emphasizes the technical and planning aspects. The roads were divided into feeder lines covering short roads within the region and trunk routes covering mid-to-long distances between regions to dualize the function of buses. They were further categorized and bus lines were systematized to four categories of inter-regional, trunk, feeder, and circular routes based on their function. Furthermore, the colors of the categories were varied to distinguish the types more easily. The inter-regional and trunk routes were formed in linear roads and reduced, to decrease overlapping lines, thereby focusing on enhancing the efficiency of operation, and the formation of the feeder and circular lines were focused on enhancing accessibility and transfer with the inter-regional line.

As a policy for physical integration, transfer centers were installed to assist with convenient transfers between buses and between buses and the subway, at main regions including Cheongryang-ri. Policies that represent information integration include the Seoul Metropolitan Government's TOPIS (traffic management center), BMS (bus management system or bus control room), and BIS (bus information system). The Seoul Metropolitan Government constructed a real-time integrated information system for bus operators and users upon reforming the public transportation system, and combined all traffic-related information to establish a traffic management center that monitors all transportation information. Among which, the BIS policy is covered as an element of this policy package under the title of 'consumer-focused traffic information'.

Public transportation fare integration, specifically, the entire payment system for payment, collection, and distribution, was digitized, which allowed the collection of real-time bus operation data, one of the most important sub-effects. Bus users touch the terminal once upon boarding the bus and once again upon departing the bus for correct calculation and payment of the fare. This has resulted in the accurate and uniform recording of data related to bus usage patterns that had not been expected previously. With the use of the accurate and detailed data on transportation usage behavior, the accurate demand for each route, region, and time was then more fully-understood, and information on the traffic flow at each time period was apprehended, in order for bus corporations to form demand-focused scheduling in response to the demands. Furthermore, the efficiency of route operation increased in order to enhance profitability. Since such data is already digitized, it is possible to perform data mining and profit optimized modeling (profit maximization model based on the wait time and other constraints). That is, the smart card constructed in order to achieve integrated modal fare is able to greatly contribute to providing direct feedback and increasing the efficiency of bus operations through the collection and the use of big data.

5. Policy Objectives

The goals of fare integration using the smart card can largely be divided into four aspects:

1) Contribution to the minimization of transfer penalties

- Reduction of transfer time by allowing integrated payment of the fare regardless of transferring, by integrating the fare between bus-bus and bus-subway.
- Reduction of transfer time by digitizing the payment and collection of fares.

2) Increased usage of buses by enhancing the efficiency of transferring

3) Reducing traffic congestion caused by the improved modal split

4) Encouraging safe driving by removing the incentive of optimizing the number of passengers as in the past distance-based fare system

6. Main Policy Contents

1) Introduction of the distance-based fare system and reallocating the right of determining the fare to the city

In the past, where a passenger used more than one form of public transportation service (*i.e.*, bus-subway on two or more bus lines, or subway and bus on two lines, and other various combinations), the passenger had to pay the fare of each public transportation service, and the fare was fixed regardless of the travelled distance. Thus, the passenger had to pay the entire fare for traveling one station, whereas with the integrated fare system, the total fare is calculated proportionate to the travelled distance irrelevant of the number or transportation modes used. That is, transfer between transportation means is free, and the passenger is only required to pay the fare for the distance travelled on public transportation. As shown in Fig. 1 below, compared to the formula that was applied to past calculations of individual fares for traveling the same distance, the new system is devised to calculate less fare, and so to decrease the average public transportation fare by 30%.

Fare imposition method **Bus** **Subway**	**Before enforcement**	**After enforcement**
5km (bus) + 4km (bus)	900 + 900 = 1,800 won	900 won (basic fare for distance less than 10km)
5km (bus) + 7km (subway)	900 + 900 = 1,800 won	Basic fare + 100won (additional fare for 10km-15km) = 1,000won
6km (bus) + 8km (subway) + 4km (bus)	900 + 900 + 900 = 2,700 won	Basic fare + 200won (additional fare for 10km-20km) = 1,100won

Fig. 2. Comparison of fares before and after enforcing the public transportation unity fare system

Source: Ko, J. H. (2015)

2) Joint transportation agreement on the joint management of profits between bus operation corporations.

Unlike the individual operation of bus lines and management of profits by each transportation corporation under the former privatized operation system, the operation of buses and the management of profits therefrom were separated under the integrated fare system. To achieve this, the Seoul Metropolitan Government and the Bus Operation Business Cooperative concluded an agreement for the joint management of profits on February 4, 2004. At the time, the Bus Operation Cooperative comprising 68 members, and the city jointly managed the profit. This agreement includes terms on the guarantee of a set profit based on the standard transportation prime cost, a reasonable reward on surplus vehicles based on the reform of the bus operation system, amendment of the ordinance for financial support for loss, enforcement of the bidding system on the 10 main routes, and the guarantee of the existing business license of the 57 bus corporations.

3) Establishment of the transportation card company to construct the smart card system, so as to realize integrated fares between transportation means

First, it was decided that the policy would be initiated in the form of a joint investment by the city and a private corporation, where the corporation was selected through a public competitive bidding. As a result, LG CNS Consortium was selected as the company to be transferred 35% of the shares from the Seoul Metropolitan Government at no cost.

On October 6, 2003, a corporate body, Korea Smart Card Co., Ltd. was jointly established by the Seoul Metropolitan Government and LG CNS Consortium to commence the development of the traffic card and the traffic card terminals.

Thereafter, Korea Smart Card Co., Ltd. came to perform the role of the profit calculation and management center, where all profit was collected so as to compare the total profits and transportation costs of all bus corporations' profitability of bus routes, and support any losses. Any surplus was also collected.

4) The Seoul Metropolitan Government implemented a route plan by supplying subsidies and managing the profits.

5) Bus operation consulting bodies

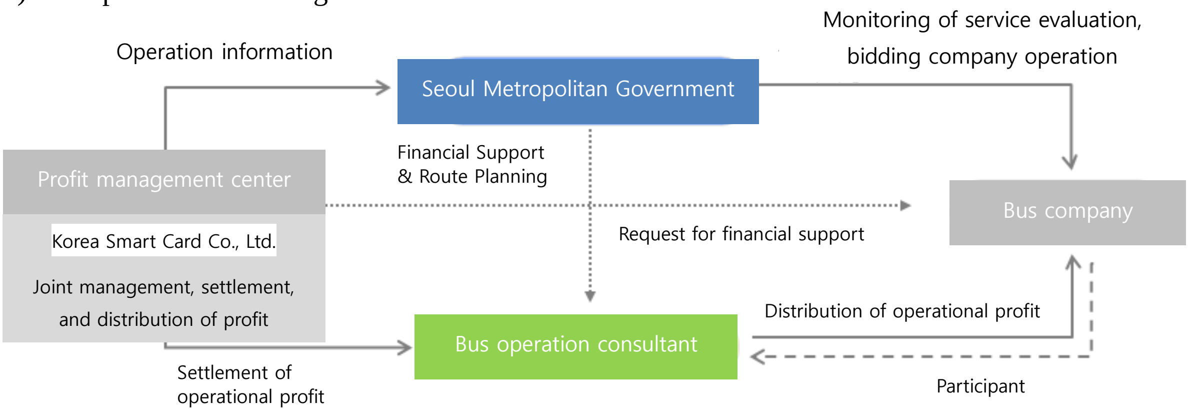


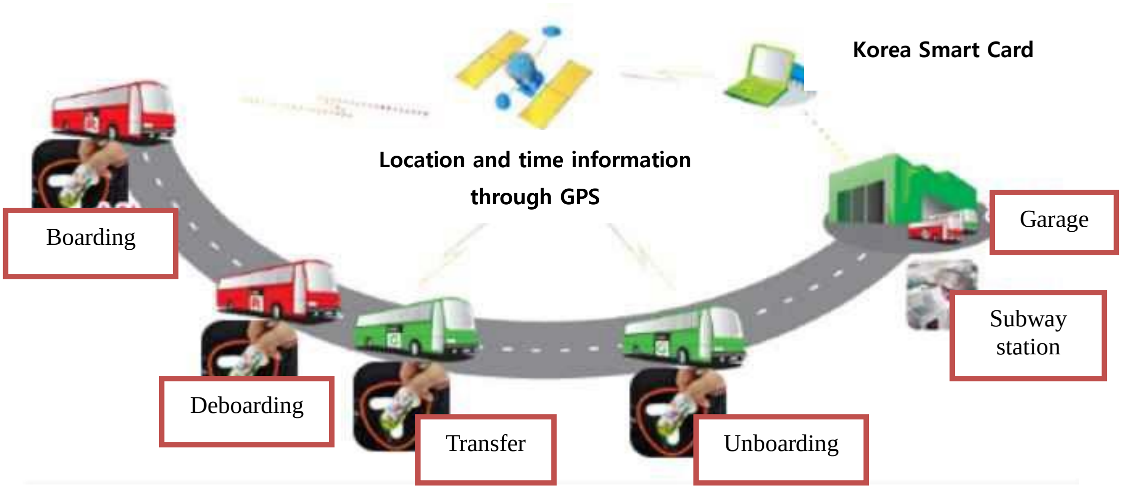
Fig. 3. Construction of a cooperative system required for the integrated fare of public transportation

Source: Ko, J. H. (2015)

7. Technical Details – T-money

The T-money card is used to pay transportation fare. When a t-money card embedded with a smart chip is brought into contact with a terminal (card reader), the terminal immediately receives the locational information from a satellite. Through radio frequency (RF) communication with the card reader, information is received and sent, such as the location of boarding and whether any transfers were made, thereby completing payment of the fare.

Furthermore, when the bus approaches a certain distance of the garage, the payment statements are wirelessly transmitted to a bus aggregation system by a wireless access point (AP) and an aggregation PC. For subways, the payment statements are stored within the card reader. All statements are transferred to and managed by the calculation system at Korea Smart Card, Co., Ltd. for the calculation of fares.



* Boarding: The location and time information is received through GSP to be stored with the fare information on the terminal(card reader)

* Deboarding: The location and time of deboarding is stored on the card reader, and the time of deboarding is recorded on the card.

* Transfer: The deboarding time recorded on the card is reviewed to apply a discounted fare for transfers made within 30 minutes.

* Subway station: The operation information and boarding/deboarding information are collected from the subway station terminal and transmitted to the aggregation PC.

* Garage: The operation information and boarding/deboarding information are transmitted from the bus card reader to the aggregation PC.

Meanwhile, the statements of the T-money card used in various places are collected at the calculation center of Korea Smart Card Co., Ltd. from each transportation organization and distributor, which is then calculated each day to generate and provide the current profits and other additional information categorized into each vehicle, route, company, and location of payment.

The T-money card is Korea's first non-contact smart transportation card realized in accordance with the international standard (ISO 14443), having the specifications of central processing unit (CPU) and memory within the card, operation system, and communication module. Within the card, an RF chip and an RF antenna are embedded for close range radio frequency (RF) with the card reader. Accordingly, when the card is charged, the amount is stored on the RF chip, and the RF chip makes the payment of the fare via communication with the card reader through the RF antenna. When the RF chip or RF antenna are damaged, communication becomes impossible, and the card can no longer be used.

T-money is largely divided into prepaid and post-payment forms. The prepaid form allows the user to charge a certain amount using cash or a credit card, and when the charged amount is used, the card is additionally charged. Meanwhile, the post-payment form involves embedding a traffic card chip on an existing credit card, which adds the payment function of transportation fares. The amount used for a month is paid at the end of the month in a lump sum.

Table 1. Currently available products

Type of Card	Basic Function
Basic Card (market/special)	- Prepaid standard/student/children card - Various forms (standard card, mini card, accessory)
Internet T-money	- Can be charged/paid on the internet by connecting the device to a PC through an USB connector
Mobile T-money	- Financial USIM allowing the use of t-money is embedded into a mobile phone - Standard charging, mobile charging, automatic charging - Internet payment, mobile payment - Issuing organizations: SKT, KT, LG Telecom
Corporate Taxi Card	- Taxi payment card for the purpose of business - Operated as an affiliated form with corporations
Automatically charging T-money card	- When the charged amount falls below a certain amount, a set amount is automatically charged at the next use of a card reader. The card is automatically charged within the set maximum monthly chargeable amount. Issued by affiliate financial organizations (Shinhan Bank, Post Office, Nonghyup, Foreign Exchange Bank)
Corporate Taxi T-money	- Card exclusively for taxi payments for the purpose of business - Operated under affiliation with a corporation
Disposal Traffic Card	- Card allowing use of the subway one time
Free Pass T-money Card	- Replaces the former free MS pass (free subway, paid bus ride) - For veterans, disabled, elderly passengers - Issued by The Seoul Metropolitan Government/Incheon City
Seoul Metropolitan Government Pass Plus	- Joint use of the standard card infrastructure - Discounted fare on the Seoul Metropolitan Government tour bus

	- Discounted payment of the main tourism landmarks in Seoul
Affiliate Prepaid Card	- T-money function added to affiliate cards
Affiliate Post-payment Card	- Post-paid t-money function embedded to a card - Issued by affiliate credit card companies
Subway Regular Pass	- 60 rides within a month. Cards are divided into Seoul line cards and distance proportionate cards - Purchase/charging/refunds can be made at each subway station
Traffic Exclusive Card	- Only allows traffic payments
Public Transportation Security Card	- Card that secures the remaining amount upon misplacement or theft of card

The T-money card could be used throughout the country. Traffic cards of a region had previously been limited to the region, but the traffic cards have become compatible in 60 cities throughout the country.

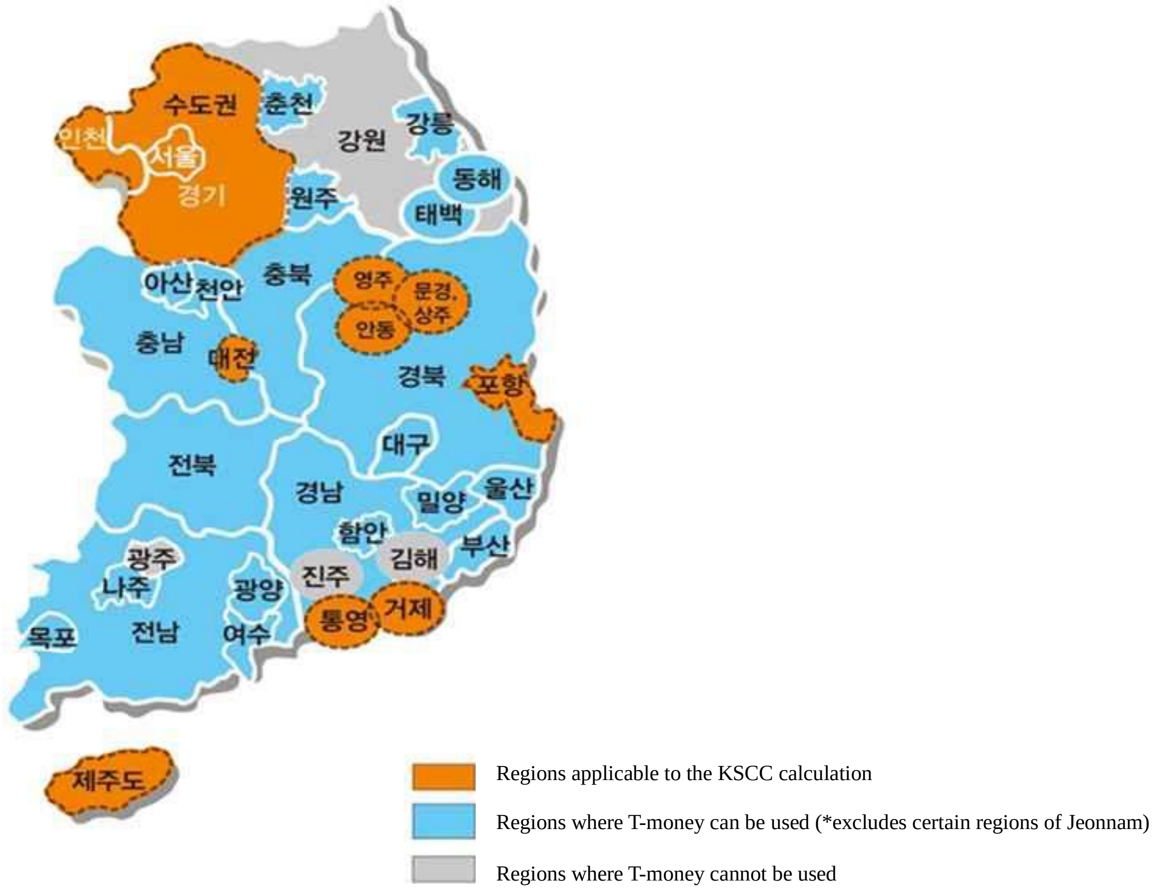


Figure 4. Regions where T-money could be used

The T-money card can be used to make payments for various services other than payment and calculation of the transit fare.

First, there are various charging services. Cash charges can be made at T-money distributing convenience stores, street stalls, unmanned subway charging stations, and bank ATMs in the amount of 1,000 won units, from 1,000 won to 90,000 won each time (up to 50,000 won at GS25, CU, and Seven Eleven convenience stores). The maximum amount that can be charged is 500,000 won. The mileage can also be used to charge the card when there are more than 1,000 points of T-mileage. The card can be charged using mileage in 1,000 point units at Seoul Metro (Lines 1 to 4) station offices and Metropolitan Rapid Transit (Lines 5 to 8) I-center and NICE cash dispensers, bank ATMs, and mobile environments using the T-money application. When the cash balance runs out below a certain amount, T-money could be automatically charged a certain amount of moneh with credit card you registered before. If you use mobile T-money, it could be chargedwith mobile cash payments, internet banking, and the credit card payments. Meanwhile, the card can also be used on the internet charging terminal T.P.O.P or through a USB internet card.

Second, there are payment services which utilize the T-money card. Based on the compatible use between traffic cards, the T-money card can also be used in public transportation means and taxis in 60 cities around the country. In other words, T-money could be used for the subway, bus, taxi and distribution payment service. Particularly through the distribution payment service, payments can be made using the T-money card at 60,000 distributors around the world at affiliate convenience stores, large supermarkets, and various franchise stores, public parking lots and unmanned devices.

Meanwhile, refund services are also provided, wherein the remaining balance on a damaged or misplaced card, or a usable card is refunded. Specifically, with respect to refunding the remaining amount on a usable card, when the remaining amount is less than 20,000 won, the amount can be refunded at a T-money affiliate convenience store. When the remaining amount is less than 50,000 won, the balance can be refunded at a subway customer service center. In order to receive a refund of more than 50,000 won, a bank account refund must be applied at a bank ATM, and in such case, the amount excluding a commission of 500 won is refunded. When the remaining amount of a damaged card cannot be checked on a terminal, a refund cannot be made at the terminal. In such cases, the user can request a refund by submitting the card and an envelope with a return address. The remaining amount on the card is checked using the card number, and the remaining amount is refunded into the customer's bank account. Furthermore, if the damaged cards were purchased in 2 years, a refund could be made on the remaining amount as well as the cost of any damaged cards .

All payments made with the T-money card are subject to the same income tax deductions of credit cards by registering the T-money card as an income tax deductible card on the T-money website or smart phone t-money application. All payments made with cards registered for the income tax deduction service are added up to be reported with the National Tax Service once a year. In the case of wage earners, income tax deduction is applied to 25% of payments made with the T-money card, which exceeds 25% of the total wage, along with the usage of credit cards and debit cards during the year-end tax adjustment. Also, payments made with a popular card are calculated with the amount of cash receipt.

Any points gained by using public transportation or converting points saved at affiliate distributors with T-money into mileage are known as T-mileage. The mileage can also be used as cash by charging the card. After registering the T-money card as a mileage card on the T-money website or smart phone T-money application, points equating to 0.2% of the payment are saved bimonthly when using public transportation. The points obtained from the 1st to the 15th of every month are accumulated on the 1st of the following month, and the points obtained from the 16th to the last day of every month are accumulated on the 16th of the following month. Furthermore, any affiliate points of a T-money website member can be converted into T-mileage, which may impose a fee upon conversion based on the affiliate's policy. The mileage can be used at minimum 1,000 point units, and can be charged after registering pin number at the T-money website. T-mileage can be given to other users registered in the mileage service, which may impose a fee. There is also a public benefit program that donates the mileage to underprivileged youth or children of the deceased from car accidents, where the donated T-mileage is converted to cash, and donated to the Beautiful Foundation each quarter.

Meanwhile, the remainder transfer service is also provided, which refunds all remaining balance in, for instance, card "A" to charge card "B". This service is in a form that can charge a specific card without paying an additional fee. This service can be used at Seoul Metro (Lines 1 to 4) station offices, Metropolitan Rapid Transit (Lines 5 to 8) I-Center, GS25 and Korea Smart Card Co., Ltd. headquarters.

There is also a service that registers changes on a non-divisional card that is categorized as neither standard, nor student, nor children card. If a non-divisional card has been charged into student or children's card, the card must be registered on the T-money website to receive student or children discounts. This service can be used at Seoul Metro (Lines 1 to 4) station offices, Metropolitan Rapid Transit (Lines 5 to 8) I-Center, T-money affiliate convenience stores or the Korea Smart Card Co., Ltd. headquarters.

8. Policy Effects

The Integrated modal fare system can be summarized as the having achieved the following five effects:

1) Reduced public transportation costs for users

2) Increased efficiency in operation due to reduced times in the payment of bus fares

3) Enhanced connectivity between public transportation means

4) Increased number of public transportation users

5) Increased user satisfaction of public transportation services

Since the integrated modal fare system has been promoted along with other policies such as bus routes integration and the exclusive median bus lanes in the large context of the public transportation reform, it is difficult to single out the effects of the integrated fare system from overall improvements. Given the difficulties, we need to consider the following quantitative indices represent the comprehensive effects of the public transportation reform.

- Jan to May, 2005 increased bus passengers: 1,000,000 per day
- Jan to Mar 2005 bus-related accidents: reduction from 669 to 468
- Jan to Mar 2005 bus-related injuries: reduction from 993 to 694Dec 2004 travel speed of bus on main roads: increased by 33-50% (direct effect of the median bus lanes system)

Table 2. Bus accidents by year (December 2015)

	2009	2010	2011	2012	2013	2014	2015
Accidents	1,119	1,080	1,030	983	1,090	877	709
Injured	1,527	1,581	1,452	1,419	1,624	1,197	992
Deaths	26	17	12	21	13	19	13

Source: Koroad, Korea Transportation Safety Authority

9. Main Challenges and Solutions

1) Objections of Seoul bus corporations

The integrated modal fare in Seoul faced extreme objections from related parties as a policy that was enforced within a large context of the public transportation reform – including the change in the ownership of bus operation corporations and the operation system.

Seoul bus corporations presented opposing positions saying the reformviolated private property rights. Bus drivers also voiced strong opposition to the construction and effect of the median bus lanes, which were a main element of the reform. These parties expressed their opposition and resistance using various methods, such as filing petitions, appearing in media, appointment of lawyers, spreading propaganda, and protesting. The regional residents, local districts, and the National Policy Agency also expressed their objections based on the effects of the median bus lanes and changes in the bus usage pattern.

Thus, the Seoul Metropolitan Government held overnight workshops by gathering Seoul Institute (‘Seoul Development Institute’ at the time) members, representatives of bus corporations and the bus cooperatives, to persuade, mediate, and finally to build consensus. Ultimately, an agreement was concluded on February 4, 2004 between the Seoul Metropolitan Government and the Bus Transportation Business Cooperative for the joint management of profits.

2) Conflict with public transportation corporations of other metropolitan cities

The residential zone of Seoul is a broad concept that covers the city of Incheon, Gyeonggi-do and their adjacent cities. Thus, the integrated modal fare of Seoul in its true sense needed to include the buses and railway of these cities. Furthermore, the railway service in Seoul is supplied by many corporations, including Seoul Metro, Metropolitan Rapid Transit, and Korea Railroad Corporation. Accordingly, the Seoul integrated modal fare required the consent of multiple organizations, including The Seoul Metropolitan Government bus companies, Seoul Metro, Metropolitan Rapid Transit, Korea Railroad Corporation, Incheon City bus organisations, Gyeonggi-do bus organisations, and the Incheon Subway Corporation.

In order to enforce the integrated modal fare system, there was a need for an increase in the standard fare. According to the principle of the public transportation economy, increased fare signifiies reduced demand. The Korea Railroad Corporation initially expressed objections toward the integrated fare for this reason. In contrast, the Incheon Subway Corporation indicated that the fare for long-distance passengers will increase, if the fare system is changed to a distance-based fare system. Ultimately, through persistent persuasion and negotiations, the Seoul Metropolitan Government was able to obtain the consent of the Korea Railroad Corporation and the Incheon Subway Corporation. However, the consent of Gyeonggi Bus and Incheon Bus was achieved under the condition of enforcing the integrated fare in phases. It was negotiated that the Seoul Metropolitan Government would apply the integrated fare only within the Seoul area in July 2004, which would later be expanded to the Gyeonggi-do region in July 2007, and then to the Incheon region in 2009.

3) Legal Issues

Bus corporations initially objected to the integrated fare system. However, through the process of persuasion and mediation, the bus corporations ultimately consented. The most persuasive advantage was that a reasonable profit was guaranteed to allow stable operation regardless of the number of passengers, through the joint management of profit under the new system. The guarantee of reasonable profit was possible only through the city’s subsidies. However, at the time, the ‘Passenger Transport Service Act’ regulated that public financial support could only be provided to the operation of unprofitable lines. The Seoul Metropolitan Government requested a legal amendment from the central government, and the central government expressed a view that it would be difficult to reflect the specificity of the Seoul Metropolitan Government to national law. Under the integrated modal fare system, through persistent persuasion and discussion, the SMG could offer subsidies to bus corporations regardless of profitability of the bus routes by adding ‘where the bus transportation system is improved to activate public transportation’ to the scope of financial support within the ‘Passenger Transport Service Act.’

The joint management of profits was necessary to implement integrated modal fare system. Furthermore, the standardization of the fare was also an essential prerequisite for the joint management system which distributes profit according to individual performance and operation expenses. At the time, it was determined that the standard prime cost would be decided through discussions between the Seoul Metropolitan Government and the bus cooperatives after calculating prime cost. However, there were difficulties in negotiating such cost. Thus, the third party of the subcommittee of the Bus Reform Citizen Committee ultimately determined the standard transportation prime cost. The Citizen Committee for Bus Reform (CCBR) was formed on August 26, 2003 for fear that opportunity to improve transportation system could disappear faced with severe opposition from the relevant stakeholder groups. Committee comprised 4 people from civic groups, 8 scholars or professionals, 3 from bus-related corporations, and 5 representatives of the provincial assembly and related organizations.

Consumer-Oriented Bus Information System

Shin Lee, University of Seoul[2]

1. Policy Implementation Period

- Commencement of bus information system construction: Year 2000
- Bus management system: Year 2003-2005
- Bus information system: Year 2006-2011 (pilot project in 2006-2008)

The construction of the bus information system was initiated with the establishment of Seoul city's intelligent transport system (ITS) in 2000. The contents of the public transportation sector from among a total of 5 ITS projects was to gather and analyze public transport information, allow bus operators to take advantage of the data for efficient transit operation and management to provide the users of public transit with the necessary information, and thus to enhance the transit service quality. Towards this end, the Bus Management System (BMS) for the operators and Bus Information System (BIS) for the users were pushed ahead separately: BMS was built up from 2003 to 2005 while BIS emerged as a fully-fledged system in 2009 after implementing its own pilot project from 2006 to 2008.

2. Background Information

Seoul City's Traffic

Seoul has experienced a great leap in population from 2 million people up to approximately 10

[2] Translation by ESL®

million for more than 30 years from the 1960s to the 1980s. In the midst of a wave of industrialization promoted in accordance with the state-initiated economic development plan, the population influx into Seoul as the heart of all economic activity was not beyond expectation. However, it was widely accepted that subway construction was necessary due to the mass transit facility system suitable for the population expansion and transit requirements in Seoul resulting from the industrialization era . Despite this obvious need, however, it actually took about 30-40 years for the subway system, which obviously requires a very long period of planning and installation, to be large in scale enough to serve as the backbone of the Seoul transit system.

Looking at the trends of public transportation system in Seoul, the street car in the early 20th century was the main means of transportation in Seoul and its network went on to expand alongside the city's population growth. From the 1950s, however, automobile use increased significantly and freely moving buses began appearing on the streets and roads. This led to a natural course of decline in the use of the street cars –the decline took place as they were relatively difficult to install and extend and thus the last streetcar route was closed in 1968. Differing only in time, the trend is exactly in line with the transit history of big cities of many other major countries, including the United States.

At the time of the streetcar route's closure, the Seoul public transportation system was split fifty-fifty between both the streetcar and bus. With the start of full-blown growth of Seoul during this period, and by using buses as major means of transportation, metropolitan Seoul went on forming urban districts with the construction of the roads gradually taking place from near the center of the city. This differentiates Seoul from other western metropolises where metropolitanization came earlier during the railroad-centered era, and this then allowed the formation of the urban area to be centered on the railway station.

However, whilst experiencing an era of high speed growth, Seoul city experienced a rapid growth of road construction and road facilities for the increased bus services, which in turn caused an increase in vehicles on the streets and road shortages. This industrialization resulted in the continuing income growth of Seoul citizens and a corresponding increase in car utilization – this led to a repetitive vicious cycle involving road congestion, the resulting reduction of bus speeds, and an increased road capacity which was intended as a solution, but failed to deal with the increased demand for roads.

The use of automobiles continued to grow despite the ongoing subway construction and expansion which continued since the beginning of the early 1970s; at the beginning of the 2000s, passenger cars came to account for 72% of Seoul traffic, and, more specifically, drive-alone cars accounted for as much as 79%. This modal share rate signified an annual energy consumption amounting to 4.1 trillion won, and social costs due to traffic congestion amounted to approximately 5 trillion per year.

Seoul public transportation

In a situation where the use of automobiles soared and the overall role of public transport went downhill, the status of the subway surpassed that of the bus in the public transport market in the early 2000s. Although this phenomenon was not unrelated to the policy support aimed at making the subway system the backbone of all transportation in Seoul, it was also the outcome of a so-called vicious cycle centering on the bus industry; the excessive use of cars resulted in a drop in road service level, which in turn led to weakened competitiveness in bus services with a reliance on the roads, which again induced the outflow of transport users to other means of transportation.

In 1997, the bus companies reduced in number from 103 to 57; to make matters worse, the service quality kept on worsening with many problems including head-running, wild driving, passenger refusal against the slow-moving elderly or persons with disabilities, and traffic signal violations. These problems arose mainly due to excessive competition for profitable routes, the unilateral abolition of routes with low profitability, and a vulnerable business structure in which earning was determined primarily by the number of passengers. The fact was that a variety of qualitative degradations were occurring in addition to reductions in traffic speeds due to the worsening level of road services. As a result, the mode share of bus continued to decline from 30.7% in 1996 to 26.7% in 2002. This decline in the number of passengers then led to management aggravation, which caused fare increases. Ultimately, the combination of worsened service and increased fares served as sufficient reasons for citizens to use the buses less.

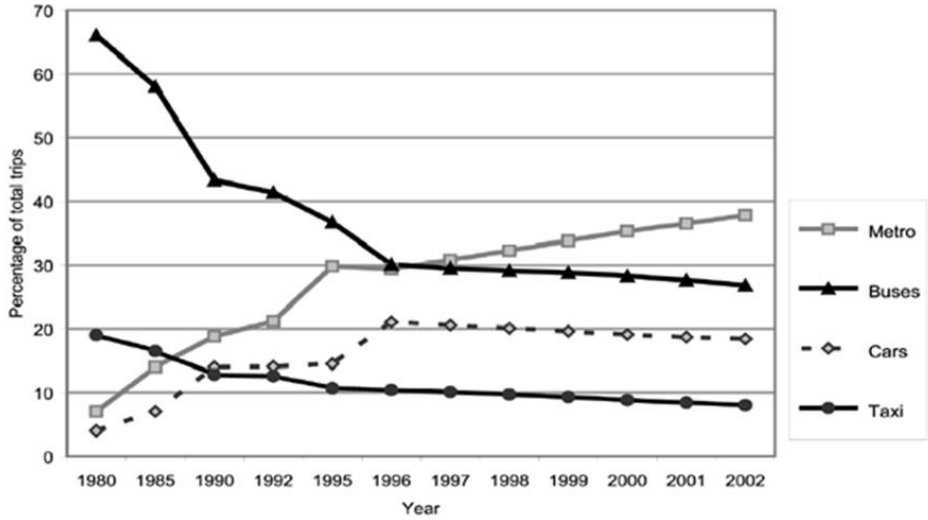


Figure 1: 1980-2002 Trends in mode shares of each transport mode

Source: Seoul Metropolitan Government 2004: The Seoul Institute 2003

<u>Seoul public transportation reform</u>

As with most of the cities in the 21st century, Seoul aims to achieve sustainable transportation in ways to enhance the mobility by relieving traffic congestion and to improve individual accessibility by making sure no group is marginalized either socially or geographically. Moreover, with the growth of civic consciousness along with household income in the 2000s, citizens' expectations toward the municipal administration and their demands for service quality continued to increase.

The city of Seoul has maintained and provided relatively better public transport services and mode shares on the whole in comparison with some overseas cities including North America which showed an overly high dependence on automobiles. In the 21st century buses secured the position as a means of eco-friendly and sustainable transport. However, the decline of the bus industry and traffic congestion owing to an increase in the number of cars emerged as challenges for Seoul to address. At the city level, on a few occasions, partial improvement measures in relation to bus operations were attempted but these failed to yield any noticeable outcomes. Meanwhile, when new mayor took office in 2002, the public transportation reform plan, a part of his election pledges, was pushed ahead with great force and enthusiasm.

Two main issues of this reform were:

1) To unify public transit services through the integration of the subway and bus systems in order to reinforce competitiveness against cars, and

2) To establish as so-called ‘semi-public bus management system’ in which the city would intervene in the operation management sectors judged essential for strategic objectives, such as the unification of public transportation system

In fact, BMS/BIS falls into a variety of initiatives taken to improve the public transit service quality separately or along with the reforming efforts to ensure competitiveness against cars as mentioned above. It is also seen as one of policies that played the most pivotal role in changing users’ awareness and perception of buses.

3. The Importance of the Policy

There are several limitations for public transit to overcome in order to ensure competitiveness against cars, among which is the notion that it would typically take more time to travel the same distance by using public transit instead of a car. In the field of traffic-behaviour related research, it is said that rather than the empirical travel time, the time felt or perceived by travellers has a more decisive effect on their individual preference for mode of transport.

In general, the time taken to travel via public transport has four phases - access, standby, run, and egress. The “access” time is the time taken to move from the departure point to the destination under the public transport system; the “standby” time is that spent waiting for a bus or train to arrive at the pick-up spot; the “run” time is that spent travelling via the bus or train; the “egress” time is that spent in moving from the pick-up spot under the public transport system to the final destination. In this process, the standby time is seen as most uncertain from the user's point of view. According to research findings people usually perceive unpredictable times as being longer than they actually are.

Taking into account the reasons why more time is spent in travelling via public transport, the complicated combinations of the following are likely to work together. First, it may be due to the low frequency of service. Secondly, it may happen when the waiting time becomes longer due to the delayed arrival of a bus. Thirdly, public transport is fundamentally different from a ' door-to-door ' service so the steps of access and egress are usually carried out through low-speed means of transport such as walking on foot. Of course, in cases where transfers are required because the single use of public transport is not enough to arrive at the ultimate destination, the standby time as well as the access time may be extended.

The research findings suggest when passengers are provided with accurate information about travel time of public transport and thereby allowing the passengers to make an accurate prediction on the arrival time, the perceived time shorten. The perceived time shortens even without taking measures to increase the service frequency, to integrate the pick-up spots, or to ensure increased number of service routes. It can therefore be understood that there are many possibilities in which accurate information about public transport travel can contribute to the improvement of users' satisfaction. In fact, when provided with exact public transportation information, passengers can choose to make better use of and overall waiting time, thereby improving both personal and social benefits.

From a larger perspective, BMS/BIS for the buses in Seoul has contributed to making Seoul city's transit a more efficient and state-of-the-art system as a key element of the entire ITS. In particular, the construction, sustainable development, and management of BIS have been of great significance in the change of perspective from a provider-centered system to a consumer-oriented system. It suggests a new policy perspective from which humanistic elements - such as human perception, psychology and other factors - are taken into account, specifically those which have never previously been involved in transit policy. It also has its significance as a full-fledged beginning of the municipal administration taking care of individual welfare and as a transition toward other dimensional objectives for the realisation of traffic welfare beyond mere efficiency-centered policy goals.

4. Relevance with Other Policies

According to the general principles of transport integration, fare integration is one of the four elements of the public transport integration. During the course of reforming the public transport system of Seoul, the promotion was taken in the four following elements of the public transport integration.

- Service integration
- Fare integration
- Information integration
- Physical integration (transfer center)

The fare integration system has a very intimate relation to the remaining three integration-related policies. Among those mentioned, the service integration was conducted between bus and train, bus and bus, and one type of bus and other types of buses in terms of bus system, and it was the policy that primarily highlighted the technological and innovative aspects. In addition to dualizing the functionality of buses by separating the feeder lines covering short-distance traffic within a region from the trunk lines handling mid- and long-distance traffic between the regions, it was ultimately able to systemize the bus routes by dividing them into four different categories depending on their functionality: inter-regional line, trunk line, feeder line, and circular line. Moreover, the color of car bodies was differentiated in order to help users to identify the respective categories. The wide range line and trunk line were focused on improving their traffic efficiency by straightening, shortening, and reducing the duplicate routes while the branch line and circular line were improved with an emphasis on easiness of transfer and accessibility.

As far as the physical integration policy is concerned, transfer centers were installed at main locations such as Cheongnyangni transfer center to provide easier bus-bus and bus-train transfers. There are also representative policies of information integration, such as TOPIS (Transport Operation and Information Service), BMS (Bus Management System or Central Control Room), and BIS (Bus Information System). In a related move, the city of Seoul has established a real-time integrated information system for bus operators and bus users, and founded a traffic management center in charge of monitoring the traffic by pulling all transportation-related information together. Among those, the BIS policy is featured as a theme of this policy package under the title "Consumer-oriented Traffic Information."

The 'Bus Information System' (BIS) is most closely associated with the bus management system (BMS), and both are linked to TOPIS (Transportation Management Center). In addition, both systems are deeply involved in the ITS construction policy of Seoul city as s key elements of ITS.

One of the most important collateral effects of public transportation is fare integration - more precisely, the policy of digitalizing the entire payment system for payment, collection, and allocation - which enabled the collection of real-time bus operation data. Bus users are to touch the card reader once upon boarding and once again when getting off in order to make payments and calculate the applicable bus fare. Therefore, data including actual bus demand and usage patterns, which had not previously been utilised, have become recorded accurately and uniformly. Such detailed and accurate data about passengers' traffic pattern made it possible to figure out the actual demand based on specific routes, regions, and time, and to grasp temporal information about traffic flow. Therefore, bus companies have been able to make demand-driven scheduling in sensitive response to any demands and to operate routes more efficiently, which resulted in improved profitability. This data has already been digitalized, which enables data mining as well as revenue maximization modeling.

5. Policy Objectives

1) To improve bus punctuality.

2) To upgrade operation order.

3) To enhance bus competitiveness in ways to offer a variety of bus information and to draft reasonable public transport policies based on operation history.

6. Main Policy Contents

1) Bus Management System (BMS)

Seoul has made strenuous efforts to enhance the competitive edge of bus by establishing reasonable public transportation policies which improve bus punctuality, operation system, and provision of bus information. To that end, Seoul built BMS center to provide real-time operation and management of public transportation. The general situation room is at the heart of any bus service management strategy, and serves as a principal agent in implementing most strategies. The Bus management system (BMS) collects bus operation information by taking advantage of location tracking technology, process the collections of information into bus service policy data, and provide operators, bus companies and drivers with the processed data.

2) Bus Information System (BIS)

This system serves to gather bus location information, process the information into bus arrival information using algorithms, and utilize such processed information in order to provide users with information and link it with the relevant institutions. To this end, personal information services (such as internet homepage, ARS, mobile) have been promoted, and bus stop terminals (BIT: Bus Information Terminal) have been installed. In particular, the installation of bus information terminals (BIT) has been promoted step by step since 2006 by splitting the pilot project phase and the main project phase in consideration of the stabilization status of the BMS. The phased promotion strategy for Seoul bus information system is summarized in < Table 1 >.

Meanwhile, with the broadening phenomena of transport demand and increased inflow/outflow traffic volume, the importance of providing information about the inter-city buses has increased. Under the leadership of the Ministry of Land, Transportation and Maritime Affairs, a project focused on establishing the metropolitan inter-city bus information system (BIS) has recently been promoted in collaboration with Seoul city, Incheon city, Gyeonggi-do, Gyeonggi-do and 21 municipalities within Gyeonggi-do. The capital region metropolitan inter-regional bus information system (BIS) was designed to provide the public with easy access to all sort of bus information via electric boards installed at bus stops, internet, cellphone and ARS regardless of administrative districts;

The following figure shows a conceptual diagram of the metropolitan bus information system services.

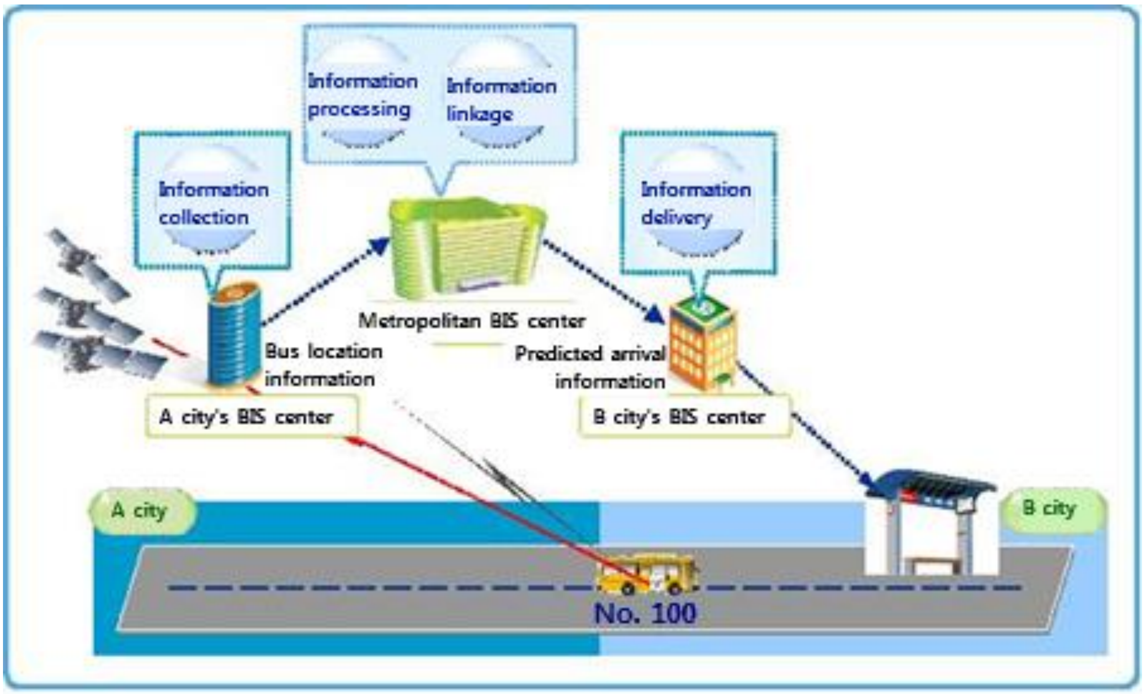


Figure 2: A conceptual diagram of the metropolitan bus information system services

Source: Seo, Byung-min, et al. (2012)

7. Technical Details

The bus management system (BMS) refers to a service system designed to secure the real-time management of bus service operations and thereby enhances service qualities for users and operators by taking advantage of bus location data and other related operation information. This can be collected through advanced bus location tracking devices such as GPS (Global Positioning System) or the Beacon system. In addition, bus information system (BIS) is a part of the public transport information system, which provides bus users with all sort of information on bus operation- - such as current bus locations, routes and dispatch time - via wired/wireless Internet, mobiles, and ARS.

Accordingly, BMS and BIS differ from each other in their purposes or components as shown in <Table 1>. Typically, bus information systems has been established in consideration of the securing reliable bus information, efficient operation following the establishment, and utilization; however, when taking a step-by-step expansion approach depending on the size of the city or the municipalities, more emphasis is put on BMS in the early stage, and later on BIS.

Table 1: Seoul bus information system promotion strategies: in comparison between BMS and BIS

System classification	Information utilization strategy			Major projects	Time-phased schedule
	Collection	Processing	Delivery		
Bus Management System (BMS)	Bus operation data	Bus operation policy data	Operators, bus companies, drivers	-Establishing central bus control center (BMS Center) - Installing terminals for operators, bus companies, Seoul city	2003-2005
Bus Information System (BIS)	Bus location information	Bus arrival prediction information	Users, related institutes.	-Installing but stop terminals -Creating internet homepage	Pilot phase: 2006-2007 Main project phase: 2008-2011

Source: Seo, Byung-min, et al. (2012)

The following figure shows a conceptual diagram of the metropolitan bus information system.

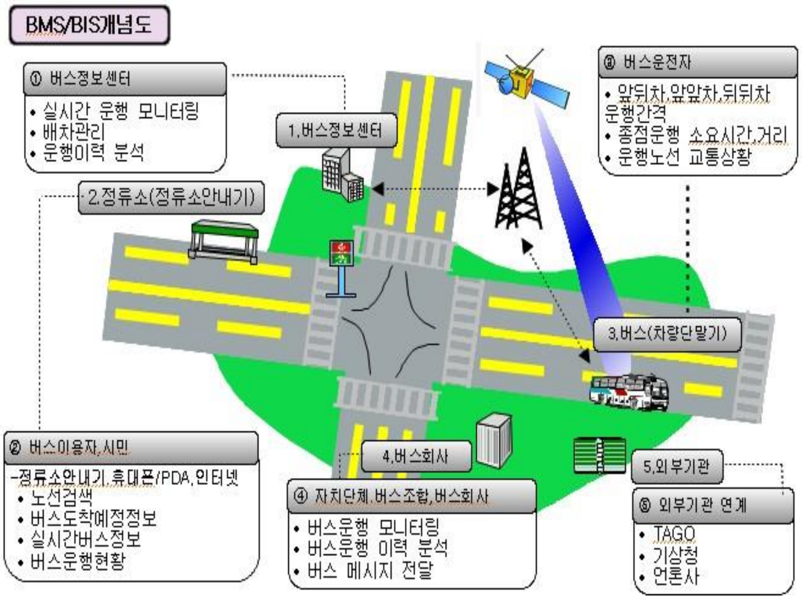


Figure 3: Conceptual drawing of the bus information system

8. Policy Effects

The most important policy effect is changes in public attitude and awareness on bus that new bus information has brought about. Three years after implementing the bus information system, the Seoul Transport Operation and Information Service(TOPIS) conducted an equivalent quota sampling survey targeted at Seoul citizens aged 19 or over who use buses twice a week or more and confirmed the following contents

1) Satisfaction index on using the bus information appeared to be overall high - 81.4% for bus stop guide terminals, 77% for mobile wireless Internet, 73% for website of Transport Operation and Information Service, and 72.8% for ARS services.

2) 85% of the respondents cited bus arrival time as the most useful information.

3) 91.9% of the experienced users answered that the bus arrival time information is "accurate."

4) 67.2% of the respondents answered that an average waiting time was 10 minutes while 10.1% said it was longer than 10 minutes, which indicates that the perceived waiting time is relatively short. Based on this, it can be inferred that the reliable information about waiting times helped reinforce positivity of the surrounding environment and the waiting experiences while waiting. That is, the results suggest human psychology will make the uncertainty surrounding the waiting perceived as longer.

5) 85.4% of the respondents answered that they are “satisfied” with bus information terminals (BIT), which is equivalent to 3.9 points out of 5. 96.5% of the respondents responded positively regarding the additional installation of the bus information terminal.

The following table outlines policy effects derived from the survey.

Table 2: Citizens' satisfaction index of the Seoul bus information system

Survey contents	Survey results	
Satisfaction index about the level of bus information	Bus stop information terminals (BIT)	81.4%
	Mobile wireless Internet	77.0%
	Traffic information center homepage	73.0%
	Phone (1577-0287)	72.8%
The most useful information of bus information system (BIS)	Bus arrival time.	85.4%
	Bus route change	6.8%
	Dispatch interval	5.4%
	Service hours of the first or last bus	1.6%
	Guides around bus stops	0.5%

	Bus passage information	0.3%
Accuracy of bus arrival time information	Positive	91.9%
	Moderate	7.0%
	Negative	0.8%
Difference between actual bus arrival time and information	2 min.	66.7%
	3 min.	33.3%
Average waiting time at bus stops	Less than 10 minutes	67.2%
	Less than 5 minutes	22.7%
	Less than 15 minutes	6.3%
	More than 20 minutes	2.9%
	Less than 20 minutes	0.9%

Source: Seo, Byung-min, et al. (2011)

Seoul may find it difficult to accurately ascertain how much the bus information system has contributed to the improvement of the overall bus service quality, other than user's awareness and satisfaction level. It took about 10 years for the overall information base to be built and developed into consumer-oriented information networks; during this period, many other changes took place in Seoul city's public transport system. The major changes include the bus service integration, cross-service integration between bus and subway, bus median line construction, public transportation fare integration and so on. For example, the bus service performance outcome in 2011, when user-centered information system was built in earnest, reflects not only the effects of the user-centered information system, but also the comprehensive policy effects of several elements that contributed to the improvement of Seoul's public transport system. Although it is hard to check the effect of each element, the direction of the effects could be identified through changes in the overall performance indicators as listed below (Park, 2010).

1) Improved bus punctuality: 18% increase

2) Improved bus regularity: 0.54 (2004.10)→ 0.49 (2004.12)→ 0.37 (2005.5)

Decrease in number of complaints about irregularities: 75%→ 25%

3) Number of traffic violations decreased by 80%: 4005 (2004.8.1)→ 815 (2005.6.27)

4) Bus traffic accidents decreased by 24%: 657 (2003.7-2004.5)→ 496 (2004.7-2005.5)

5) Increased bus passage speed via median bus lanes: maximally increased by 11km/hr

6) Increased profitability: operating costs reduced by 9% maximally, number of passengers increased by 20%.

7) Increased level of satisfaction

The followings are other empirical data related to the above indicators.

1) Increased bus speeds via median bus lanes

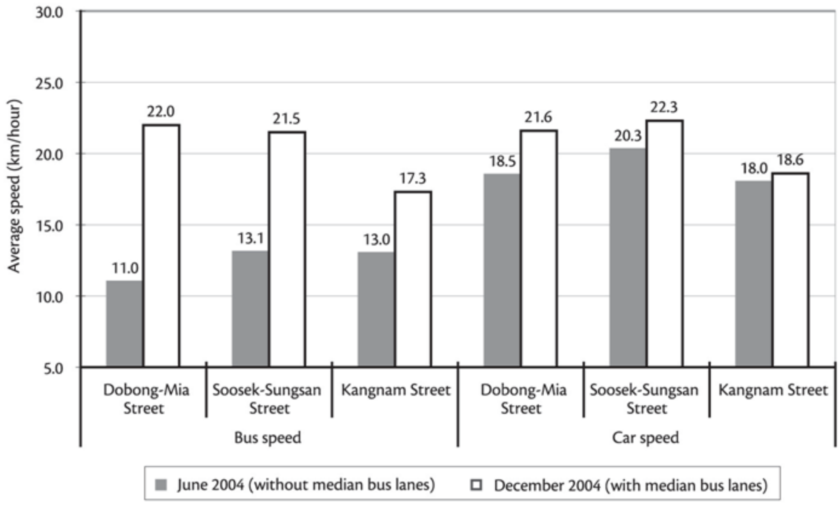


Figure 4: Increased bus speeds via median bus lanes (Average bus speeds before and after the implementation of Exclusive Median Bus Lanes)

Note:7-9am,towards the city center.

Source: Seoul Metropolitan Government (2005)

2) Increased number of public transit users

Table 3: The increasing trend in the use of public transportation by year, 2004 – 2010

	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

(Unit: 1,000 persons / day)

Source: Seoul city 2011(quoted from Park 2010, Table 3. Increase in passenger ridership across the public transport system)

3) Reduction in Bus-related traffic accidents

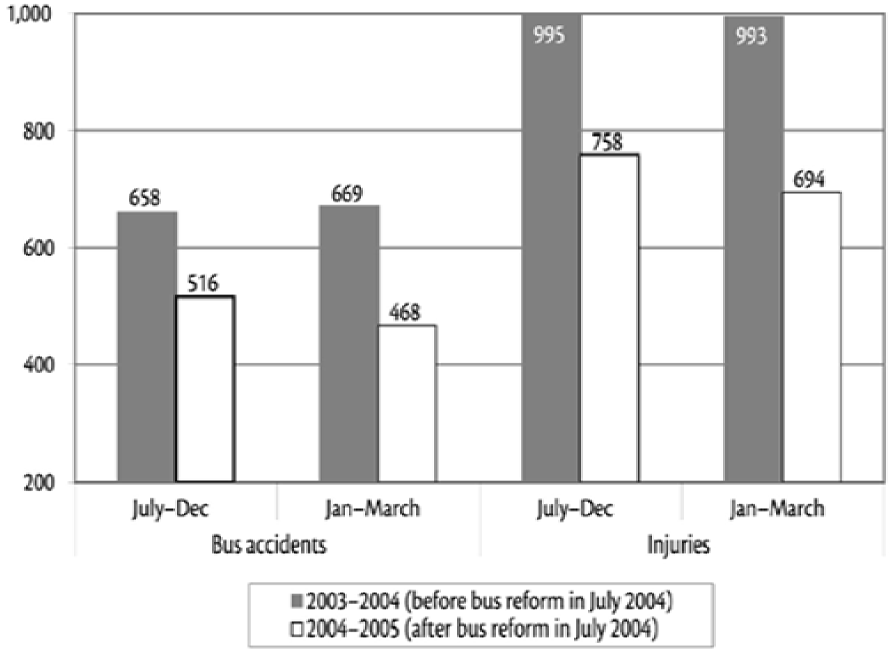


Figure 5: The decreasing trend in bus-related traffic accidents by month, 2003-2005

Source: Seoul Metropolitan Government 2004: The Seoul Institute 2003

9. Challenges and Solutions

While policy has been implemented, the overall understanding of and attention to the ITS has continually increased During the process of policy planning and implementation, there were no notable conflicts among stakeholder groups or technical obstacles since the city of Seoul, bus companies, drivers, and bus users were all direct beneficiaries of the process.

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Unattended Illegal Parking Enforcement: The Power of Fines and Physical Evidence

Shin Lee, University of Seoul[3]

1. Policy Implementation Period

- Automated Parking Enforcement Service: System built in 2004
- Pilot project from April to September 24 (32 cameras installed)
- A total of 156 unattended enforcement cameras additionally installed by March 2008

- May - November 2004: Commissioned the basic/working design for the illegal parking enforcement service / selected locations for additional cameras to be installed under the expansion project, and finalized the system specifications
- December 2004 - August 2005: 53 additional cameras installed as part of the expansion project
- August - October 2005: additional 32 cameras installed along Cheonggyecheon-ro
- August 2006 - February 2007: additional 51 cameras installed along Cheonhodae-ro and other locations
- September 2007 - March 2008: additional 20 cameras installed along Songpadae-ro and other locations

2. Background Information

Traffic enforcement refers to processes concerning the enforcement of criminal and

[3] Translation by ESL®

administrative laws and regulations against violators of traffic laws and regulations, to ensure safe and efficient traffic movement and prevent the disruption of road traffic. Enforcement efforts had been undertaken exclusively by human enforcers at the police and local government level until the introduction of the automated enforcement system in 2004.

As the number of public officials is a finite resource, full-time enforcement cannot be expected through the use of human-only traffic enforcement. Outsourcing such enforcement services will not provide a viable or ultimate solution, either. In sum, human-only enforcement is virtually incapable of uninterrupted, continuous implementation. This situation has led to some violators thinking they simply had “bad luck” and thus have expressed their dissatisfaction about the punishment imposed. For such reasons, human-only enforcement has suffered from a multitude of frequent civil complaints regarding the overall fairness of traffic enforcement. The limited scope of a single person’s cognitive ability also raises questions about the unfairness of the enforcement and other unjustified practices in the course of carrying out such enforcement.

Another issue with human-only traffic enforcement is that it often causes traffic accidents, and can lead to or even exacerbate traffic congestion. However, traffic regulation violations (including that of illegal parking) disrupt the efficient use of traffic facilities in various ways, resulting in serious disruption of both traffic and circulation. In this sense, traffic enforcement is as crucial an element as the building of more traffic facilities.

State-of-the-art automated traffic enforcement services were introduced as a way to overcome the limitations of human-only traffic enforcement and thereby realize the full potential effect of traffic enforcement.

3. The Importance of the Policies

Seoul overhauled its public transportation system in 2004. It was preceded by Seoul’s plan for ITS construction in 2000. The announcement of the ITS plan spread the notion that efficient traffic systems can be achieved through innovative approaches using cutting-edge technology. The sweeping reform of the public transportation system resulted in the introduction and wide use of various means and tools seen as capable of radically improving traffic efficiency and the overall quality of road services- including the integration of bus services, the integration of traffic information, and the introduction of the bus-only lanes. However, if those traffic facilities and tools cannot operate properly or carry out necessary tasks because of rampant violations of traffic laws and regulations, any additional investments and facilities would seem to be nothing more than a waste. From this perspective, the automation of parking and bus-only lane enforcement may play a critical role in ensuring the effectiveness of the policy means and tools aimed at improving the quality of road services and the efficiency of traffic.

Such efforts can be understood in the context of transportation system management (TSM), a system that Western countries have emphasized since the late 1980s. In other words, the automation of traffic enforcement is consistent with the principle of balancing traffic demands and supply by ensuring the efficient management of existing facilities so as to improve their capacity, rather than introducing additional facilities.

4. Relevance with Other Policies

Unattended enforcement services are also applied to the enforcement of bus-only lanes. This represents a policy approach based on the same principles and purpose as the unattended parking enforcement. Its purpose is to improve the efficiency of bus-only lane management and monitoring. Similar policies aimed at economical management and efficient punishments include the speed enforcement services. The drive-by unattended parking enforcement system has been attracting significant attention, in addition to the previous fixed parking enforcement system.

Furthermore, unattended enforcement services may be used for multiple purposes rather than simply the remote enforcement of parking regulations; services such as traffic monitoring and the collection of traffic information. More specifically, they can be used to inform the city's traffic policies through the video link function and integrated monitoring by TOPIS as well as the effectiveness analysis of installation locations.

- TOPIS
- Speed Enforcement Service
- Related to reducing traffic accidents
- Drive-by Parking Enforcement System

5. Policy Objectives

The automated traffic enforcement services are provided through automated systems to identify vehicles violating the traffic laws and regulations using various imaging and automated recognition technologies. Ultimately, the services are aimed at preventing traffic accidents and ensuring traffic safety in a more efficient manner.

By providing these services, the city seeks not only more efficient enforcement, but also fairer and more transparent enforcement.

The agencies in charge of traffic enforcement can use such services to manage their manpower more efficiently. It can also facilitate the handling of other related work– such as the manual enforcement and issuance of parking tickets.

6. Main Policy Contents

1) Legal Basis

The Road Traffic Act (June 13, 2008, Act No. 9115) provides the definitions of ‘standing’ and ‘parking’, the regulations concerning standing and parking, and the appropriate method of enforcement.

Article 87 (2) of the Enforcement Decree of the Act stipulates that evidence may be gathered using unattended equipment when identifying parking violations through the parking enforcement services.

Article 87 (Special Exceptions, etc. to Parking Regulations with Delegated Authority)

① Notwithstanding the provisions of Article 86 (2) 2, a Special Metropolitan City Mayor or a Metropolitan City Mayor may directly take necessary measures under Article 35 of the Act against vehicles violating parking regulations for the smooth flow of traffic and civilian safety.

Where a Special Metropolitan City Mayor or a Metropolitan City Mayor directly discovers and regulates a vehicle violating parking regulations pursuant to paragraph (1), he/she shall make known such instances with evidentiary materials, such as photographs of a vehicle on which a sign of vehicle subject to imposition of an administrative fine is attached or photographs, videotapes, or any other visual recording medium of the vehicle violating parking regulations taken by an unattended monitoring device (hereinafter referred to as "photographic evidence”),a document that describes the place where the violation occurred, the details of the violation, and the license plate number of the vehicle to the district leaders and country headmen that have jurisdiction over the location where such violations occurred.

2) Authority of Enforcement

Government officials of the cities and counties as well as the police have the authority for parking enforcement.

If each mayor of special and metropolitan cities may delegate its enforcement authority to the district leader and county headmen, the enforcement officials of each autonomous district have the authority for enforcement.

Article 86 (Delegation or Entrustment of Authority) ② Pursuant to Article 147 (2) of the Act, each mayor of special and metropolitan cities shall delegate its following authority to the district leader and county headmen under his/her jurisdiction: <Amended on June 20, 2008>

1. Authority to appoint and dismiss traffic enforcement officials (belonging to each district and county) under Article 12 of the Act, and the authority to take measures against vehicles violating parking regulations referred to in Article 35 of the Act;

2. Authority to have the task of towing, possessing and returning vehicles vicariously performed by an agent pursuant to Article 36 (1) of the Act, and the authority to place an order to take measures and conduct the education necessary for the vicarious performance of works pursuant

to Article 36 (3) of the Act;

3. Authority to impose and collect fines under Article 161 (1) (3) of the Act (limited to violations falling under any of Articles 32 through 34 of the Act)

3) System Structure

The automated parking enforcement service system is comprised of on-site subsystems and the center subsystem. Specific components may vary depending on equipment specifications and enforcement methods. However, a typical system composition is as indicated in Figure 1 below. Figure 2 shows Seoul's parking enforcement system.

On-site subsystems should be fitted with the equipment necessary for identifying parking violations and collecting evidence. Ideally, the enforcement agency (center) should be able to monitor the parking enforcement areas and the current status of enforcement in real time.

The enforcement agency (center) should have the necessary equipment for imposing fines on the owners of the violating vehicles based on the evidence produced by the system.It is also recommended that they possess a server for the real-time monitoring of the enforcement sites and operation of the parking enforcement services.

The enforcement agency (center) may also choose to build a DB or link the relevant information from other agencies, and build a DB server or linkage server for those purposes.

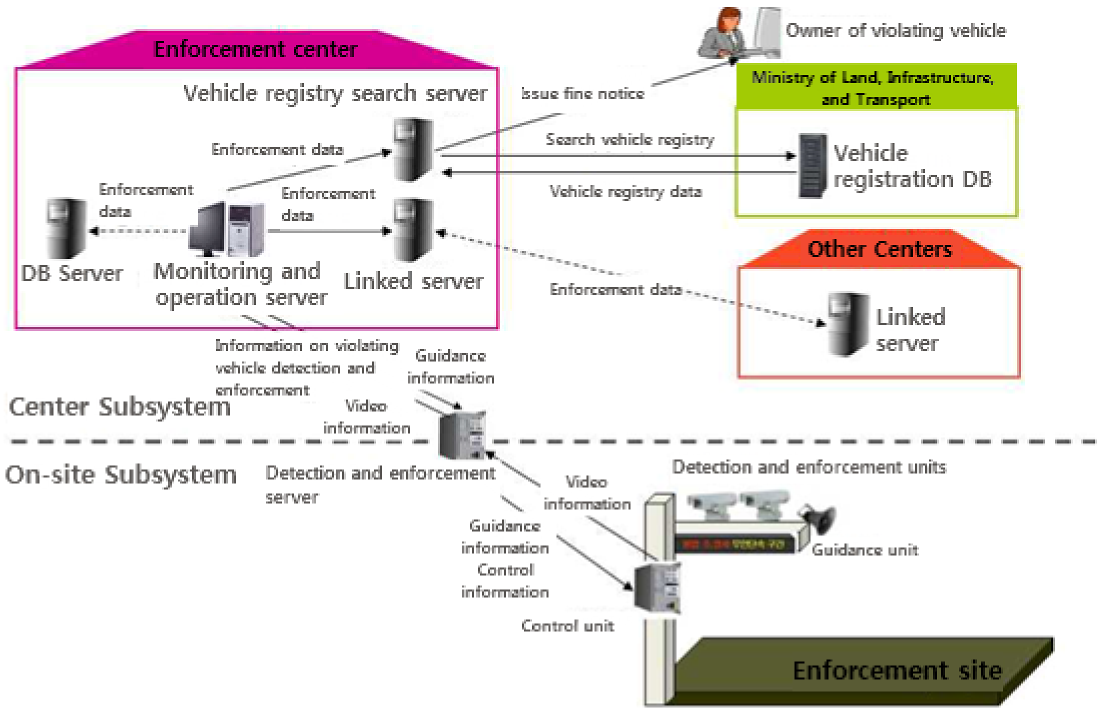

Figure 1: Illegal Parking Enforcement System

Source: Ministry of Land, Infrastructure, and Transport (2009)

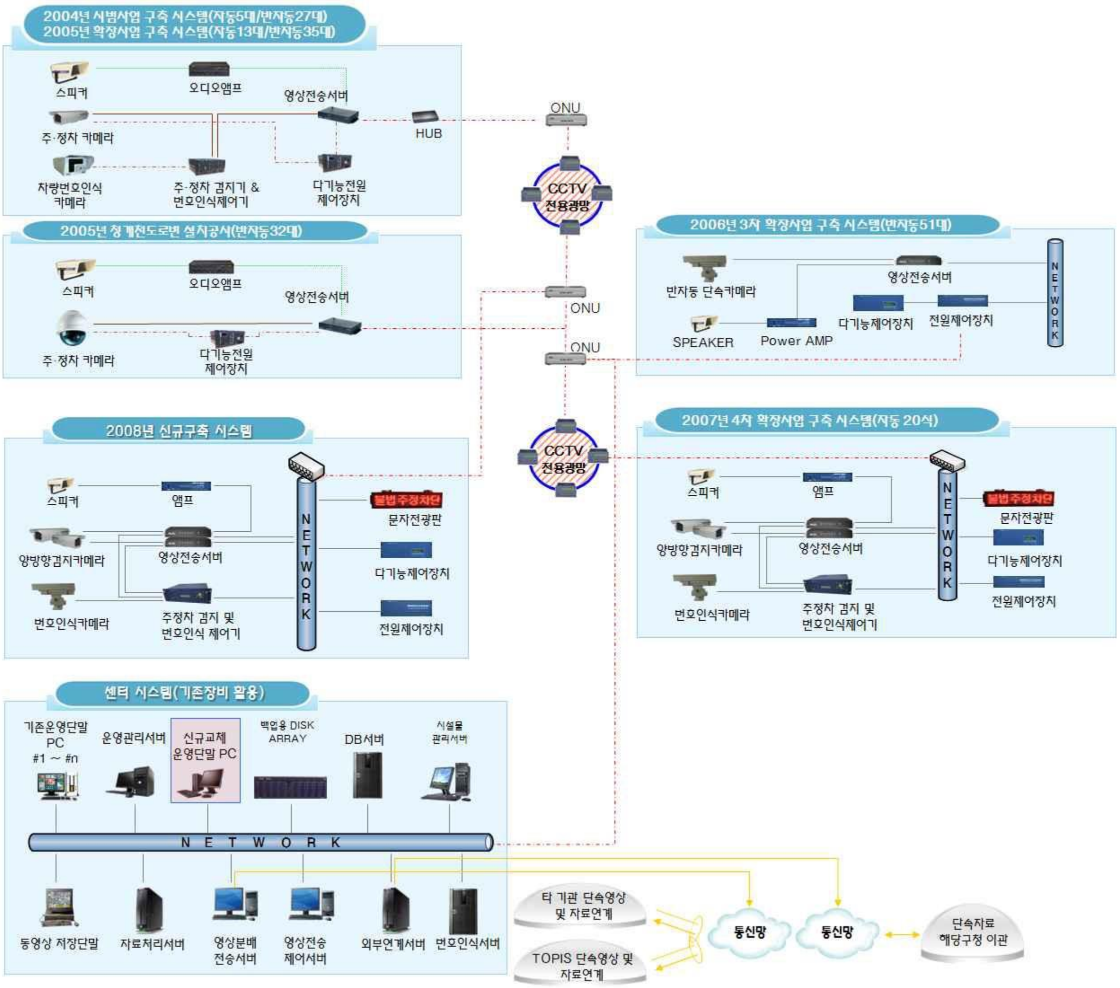

Figure 2: Seoul’s Illegal Parking Enforcement Systems

Source: Ministry of Land, Infrastructure, and Transport (2009)

The table below lists the components of on-site subsystems and the center subsystem.

Table 1: Components of Illegal Parking Enforcement System at Enforcement Sites

Component	Function
Detection Camera	Automatically records the entry, movement, and exit of vehicles in and out of the enforcement site.
Enforcement Camera	A high-definition digital camera which records evidence of parking violations. Operated via control signals from the on-site control unit.
Zoom Lens	This lens adjusts the detection area of the camera so as to enlarge or shrink the collected images within a specific range.
Housing	Protects cameras and lenses from vibrations and sunlight
Image Server	Compresses images collected from the site and transmits them to the center in real time. The center transmits audio data to guide the violating vehicles at the site. Transmits serial signals for various on-site control functions.
Control Enclosure	Designed to maintain components at optimal conditions and protect them from vibrations, sunlight, smoke, and other interference.
Pan/Tilt	Controls the direction of the cameras so as to take photos of violating vehicles Provides accurate and stable position control and high-speed control.
Power Control Unit	Provides a stable supply of power to on-site equipment, and allows for remote power control.

Table 2: Components of Parking Enforcement System at the Center (Control Room)

Component	Function
Operation Terminal PC	On-site monitoring, control of on-site equipment, display of status information, issuance of guidance, and printing of violation notices Performs various functions for viewing, editing, revising, and registering DMBS [3].
Operation & Management Terminal	Monitors enforcement status and real-time traffic situations, and stores information in a DB
Data Processing Server	User account management, plate number recognition system data management, system operation and management, on-site equipment management, enforcement information list management, database link, system management (shutdown, plate number recognition data)
Video Storage Terminal	Allows for storing, searching, and displaying videos from the site. Allows for videos to be searched by time, date, and time zones in case

		of a civil complaint. Performs event log and enforcement list management.
Database Server		Stores and backs up enforcement data, updates detection areas and parameters, controls recording commands and vehicle detection functions.
DISK ARRAY[4)]		Stores and manages data in preset folders at a specific cycle Backup software consists of Master Module, Client Module, and Disk Backup Module
Required [a)]	Plate number recognition server	Automatically recognizes plate numbers from the photographs of vehicle number plates
Optional [b)]	Video Distribution and Transmission Server	Distributes and transmits enforcement videos from each site to departments and agencies that require them.
	Video Transmission Control Server	Processes videos from the Video Distribution and Transmission Server in formats required by the respective departments, and manages the information on the history and display status of on-site videos transmitted to each department.
a) Required: Must be set up either in the onsite system or the center subsystem. b) Optional: To be selectively implemented as required		

3) Operation Organization

The automated enforcement services require a specific space to conduct the monitoring of the enforcement status. Semi-automated or manual enforcement systems require manpower to monitor and operate such systems.

The overall system of parking enforcement consists of two parts: one in charge of direct operation of the enforcement services and the other responsible for the administrative handling related to the imposition of fines. Therefore, each part should be manned with the suitable personnel.

4) Current Status of Unattended Parking Enforcement Systems in Seoul

In Seoul, parking enforcement systems are installed on 42 four-lane (or less) roads (22%), 50 six-lane roads (27%), and 96 eight-lane (or more) roads. Seoul's enforcement systems are concentrated around the city's main roads. Specifically, parking enforcement systems are installed on 42 four-lane (or less) roads (22%), 50 six-lane roads (27%), and 96 eight-lane (or more) roads.. The table below shows the status of parking enforcement systems across different roads and autonomous districts. The total number of systems in the entire city increased from 188 in 2007 to 252 in late 2014.

Table 3: Current Status of Unattended Illegal Parking Enforcement Systems Installed on Roads (In 2007)

Road	Number of Systems Installed	Road	Number of Systems Installed	Road	Number of Systems Installed
Gangnamdaero	7	Miaro	20	Wangsimnigil	6
Gangseoro	4	Banporo	1	Ujeonggukro	2
Gyeonginro	7	Bangbaedaero	1	Euijuro	4
Gongdanro	1	Bongcheonbokgaedoro	1	Itaewongil	5
Gwanakro	3	Seogangro	1	Jayangro	1
Namdaemunro	8	Songpaadaero	9	Cheonhodaero	10
Dobongro	3	Susaekro	4	Cheonggyecheonro	32
Dong2ro	2	Siheungdaero	5	Cheongjindonggil	1
Dongjakdaero	2	Sinbanporo	1	Tongilro	4
Deungchonro	4	Sinwolro	3	Toegyero	4
Maporo	6	Sinchonro	3	Hangangro	1
Manguro	5	Yangchongil	1	Hwagokro	1
Mokdongdongro	1	Yanghwaro	5	Hwarangro	1
Mokdongro	1	Yeonseoro	2	Hunryeonwonro	1
Mugyodonggil	1	Yeongdungporo	2	Heunginmunro	1

Table 4: Current Status of Unattended Parking Enforcement Systems Installed in Autonomous Districts (End of December 2014)

Name of autonomous districts	Number of Systems (units)	Illegal Parking	Bus-only Lane	Installed in Bus	Public (Yonseiro)
Total	329	252	45	28	4
Jongno-gu	30	29	1	-	-
Jung-gu	37	36	1	-	-
Yongsan-gu	4	4	-	-	-
Seongdong-gu	5	4	1	-	-
Gwangjin-gu	6	6	-	-	-

Dongdaemun-gu	9	9	-	-	-
Jungnang-gu	8	2	2	4	-
Seongbuk-gu	10	10	-	-	-
Gangbuk-gu	28	15	1	12	-
Dobong-gu	9	9	-	-	-
Nowon-gu	10	4	6	-	-
Eunpyeong-gu	16	9	3	4	-
Seodaemun-gu	16	7	5	-	4
Mapo-gu	16	14	2	-	-
Yangcheon-gu	20	15	1	4	-
Gangseo-gu	7	6	1	-	-
Guro-gu	1	1	-	-	-
Geumcheon-gu	8	8	-	-	-
Yeongdeungpo-gu	14	14	-	-	-
Dongjak-gu	10	9	1	-	-
Gwanak-gu	11	11	-	-	-
Seocho-gu	22	10	12	-	-
Gangnam-gu	6	2	4	-	-
Songpa-gu	23	15	4	4	-
Gangdong-gu	3	3	-	-	-

Note) Bus-installed type systems are based on the bus depots.

8. Policy Effects

The automated enforcement system, introduced for the purpose of dealing with the chronic issue of illegal parking, offers highly effective enforcement while reducing resistance or complaints from drivers. The system, therefore, eliminated resistance from, and conflict with, drivers on the roads. The system even works in situations where the driver stays inside the vehicle. This absence of personal interaction reduces complaints and conflict, and also reduces burdens associated with the bureaucratic process of paperwork and forms.

1) Installation, Before and After Effects

An article published in Volume 8 and Issue 3 of Seoul Urban Studies (2007) assessed the effect of the unattended automated parking enforcement service by looking into the case of Seocho-gu. The following table provides a comparison between traffic volume and the number of illegally parked vehicles before and after the installation of the enforcement system.

Table 5: Comparison of Traffic Volume before and after the System Installation

Target Location	2004	2005	Rate of Increase/Decrease
Seoul Art Center Nambu Circular Road	119,230	120,516	1.08%
Gangnam Taegeukdang (Gangnamdae-ro)	83,454	85.511	2.46%
Express Terminal (Sjinbanpo-ro)	111.661	113,197	1.38%
Total	314,345	319,224	1.55%

Table 6: Comparison of Changes in the Number of Illegally Parked Vehicles

Target Location	Equipment Size	Illegal Parking Before	Illegal Parking After	Change	Rate of Increase/ Decrease
Nohyeon Station → Kyobo Tower	3 locations	163 units	47 units	-116	-71%
Kyobo Tower → Gangnam Station	1 location	144 units	90 units	-54	-37%
Gangnam Station → Woosung Apartment	1 location	116 units	66 units	-50	-43%
Total	5 locations	432 units	203 units	-220	-52%

After the introduction of the automated parking enforcement system, the traffic volume increased by 0.12% - 3.10% or, 1.55% on average. The number of illegally parked vehicles per day significantly decreased from 37% to 71%, showing 52% on average.

The following table illustrates the gradual and continuous decrease following the introduction of the system.

Table 7: Number of Illegal Parking Enforcement by Year

(Unit: 1,000)

Division	2007	2008	2009	2010	2011	2012	2013	December 2014
Total	3,956	3,776	3,511	2,820	2,662	2,709	2,649	2,162
Seoul	902	907	804	608	441	450	427	328
Autonomous Districts	3,054	2,869	2,707	2,212	2,221	2,258	2,222	1,834

Source: Seoul Metropolitan Government, 2014

The following table shows the amount of fines imposed on, and collected from, illegally parked vehicles by year. The amount of imposed and collected fines all recorded gradual decreases until the end of 2014. The fines imposed for violations of bus-only lanes also largely decreased until recently.

Table 8: Amount of Fines Imposed and Collected from Traffic Enforcement

(Unit: million won)

Division	Parking Violation		Bus-only Lane	
	Imposed	Collected	Imposed	Collected
2008	136,917	105,721	4,122	3,270
2009	131,704	107,839	5,464	3,601
2010	101,317	85,822	3,472	1,843
2011	97,200	81,474	3,713	2,014
2012	96,874	79,485	4,291	2,559
2013	93,650	70,547	3,559	2,145
December 2014	44,736	26,702	2,116	1,419

Source: Seoul Metropolitan Government, 2014

Wonju-si Data

The City of Wonju announced on the 20th day of last month that it had completed the replacement of existing monitoring cameras at 10 locations - including Rodeo Street, Nonghyup Wonju, and Dangu-dong GS Mart- with fully automated systems. The systems, according to the city hall, are now operating around the clock, catching 128 illegal parking practices per day on average. Wonju has installed monitoring cameras at 26 locations with severe traffic congestion to great effect. However, illegal parking practices continued at nights as well as on holidays, when monitoring personnel is scarce. Therefore, the city hall announced that they had replaced them with automated monitoring systems capable of 24-hour operation. Wonju plans to apply the 24-hour enforcement capability to the other 16 locations by the first half of next year.

A Wonju official said, "the fully automated system is capable of unattended enforcement around the clock, allowing for parking enforcement at night or on holidays. This resulted in a 6-times increase of illegally parks vehicles identified." He also added, "We will also operate two vehicle-mounted cameras to enforce paring regulations at night, focusing on areas where illegal parking has been disrupting traffic flow." (Korea Economic Daily, November 20, 2008).

2) Effect Analysis through Demand Survey

The Analysis and Assessment of Suwon's Intelligent Traffic System (ITS) surveyed the citizens' satisfaction with the parking enforcement systems. The following diagrams show the perceived effectiveness of the enforcement parking services derived from the findings of the survey.

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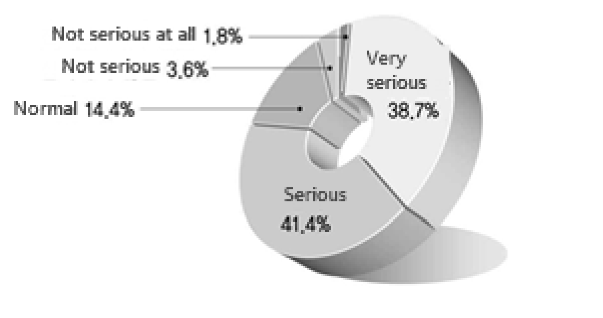
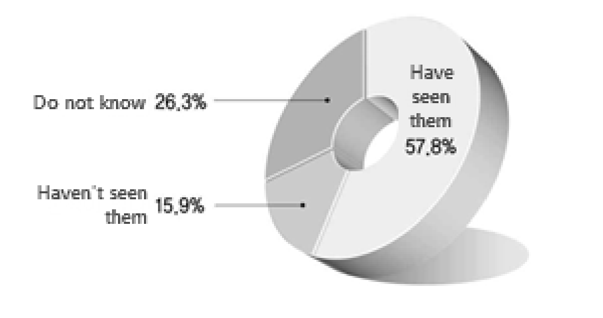
<tr><td>
</td><td>
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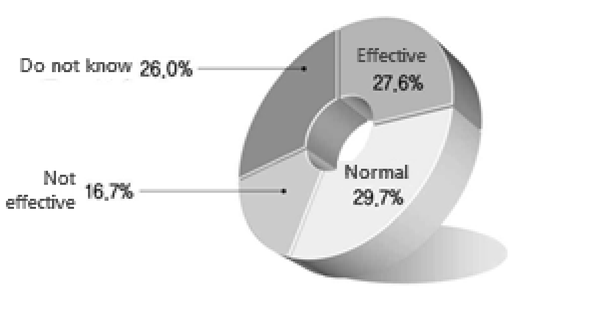
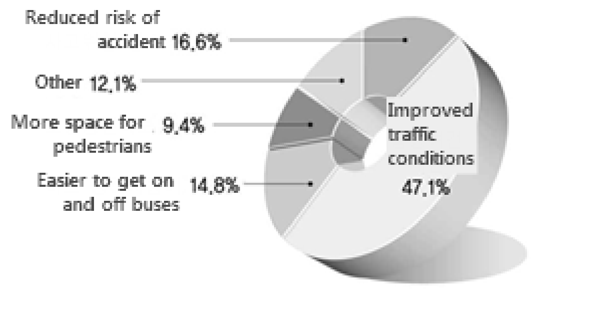
<tr><td>
</td><td>
</td></tr>
<tr><td>Effectiveness of Parking Enforcement Service Improvement</td><td>Effects of Parking Enforcement System Installation</td></tr>
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Figure 3: Findings from the Suwon demand survey

3) Allows for significant reduction of on-site dispatches and workload while preventing illegal parking with great effectiveness - automated plate number recognition with monitoring cameras (more than 100m away) (Geonah Information Technology, 2016)

9. Challenges and Solutions

1) While the automated systems contributed to an unprecedented increase in cases of illegal parking being identified and also proved to be highly effective in preventing illegal parking, it has been pointed out that an excessive number of parking regulation violators have been declared exempt from the punishment following enforcement.

The following table shows a gradual decrease of the collection ratio of parking fines since 2011, and commentators point out that the decrease has been caused by excessive exemption.

Table 9: Amount and Ratio of Fines Imposed and Collected for Parking and Standing Violations by Year

(Unit: million won)

Division	Parking Violations		
	Imposed	Collected	Collection Ratio (%)
2008	136,917	105,721	77.2
2009	131,704	107,839	81.9
2010	101,317	85,822	84.7
2011	97,200	81,474	83.8
2012	96,874	79,485	82.0
2013	93,650	70,547	75.3
2014.12	44,736	26,702	59.6

Source: Seoul Metropolitan Government, 2014

2) Fixed CCTVs face limitations in that drivers who know the locations and ranges of the devices can predict or avoid any traffic enforcement. Therefore, drive-by enforcement equipment is expected to be used more widely as a way to overcome the shortcoming of the previous systems.

Mobile automated enforcement equipment has proved its effectiveness in several cities. As a piece of all-weather removable enforcement equipment, it has a monitoring camera installed on the roof of the vehicle. The camera rotates 350 degrees and is capable of taking up to 30 photographs per second. It can take photographs at a speed of 40km per hour, and maintains its effectiveness at night or under adverse weather conditions using its infrared device.

In 2007, the equipment was installed in four districts of Ulsan, except for Ulju-gun, and the results were notable since its enforcement achievements accounted for 27% of the total number of parking violations detected in a month (including enforcement by personnel and fixed-type equipment).

Three Innovations of Subway Line 9: Financing, Speed Competitiveness and Social Equity

Shin Lee / Yoo Gyeong Hur, University of Seoul[4]

1. Policy Implementation Period

- 1994: Established route network
- 2009: Opened the 1st (Phase 1) section from Gaewha to Shin Nonhyeon stations
- 2015: Additionally opened the 2nd (Phase 2) section of Eonju, Seonjeongneung, Samsung Jungang, Bongeunsa and Sports Complex stations
- 2017: Expected to open the 3rd (Phase 3) section from Samjeon Jct. to Seoul Veterans Hospital stations

Source: JoongAng Ilbo [Cover Story] Daily lives changed by Subway Line 9, in 9 months after the opening of Seoul's Subway Line 9 extension

Seoul Subway Line 9 is a route that connects the southern part of the Han River from the east to west. The first (Phase 1) section, completed in 2009, stretches 25.5kmand connects Gangnam and Gangseo, Seoul by being operated from Gimpo Airport to Banpo through Yeoui-do. The second (Phase 2) section of Eeonju, Seonjeongneung, Samsung Jungang, Bongeunsa and Sports Complex stations were additionally opened in March 2015. Subway Line 9 is connected to most of the lines in the city (except for Subway Lines 6 and 8), and it is the only line in Seoul that operates an express line in the entire system.

It was constructed through private investment for the first time in Korea as an urban rail transit and promoted by a public-private partnership (PPP) project in the Build-Transfer-Operate (BTO) that transfers the ownership of the facilities to the Seoul metropolitan government after the completion and allows private investors to gain benefits from investment for 30 years of operation in accordance with the agreement with the Seoul Metropolitan Government.

4 Translation by ESL®

2. Background Information

Seoul experienced an unprecedented population explosion from 2 million to 10 million people due to highly compressed urbanization and industrialization for about 30 years from the 1960s to 1980s. In the early 1990s, when a plan for Subway Line 9 was established, the high-speed growth still continued and Seoul's population peaked at about 11 million in 1992.

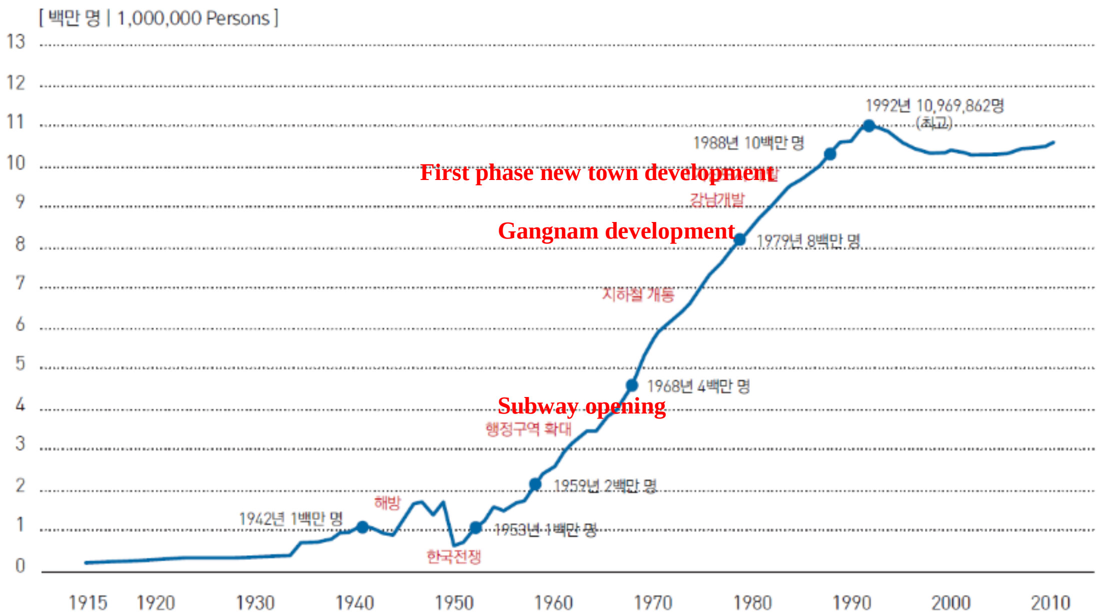

Figure 1: Population change in Seoul, 1915-2010

Source: Seoul viewed by map (2013)

Seoul Subway, which started with a full-scale economic development plan in the 1960s, took the form of a public transportation network in the early 1990s through the first subway construction of lines 1, 2, 3, and 4 and the second subway construction of lines 5-8; its transport share reached about 32%. However, with the continuous population growth and increase in demand for subway use in a positive way, there were discussions regarding a third subway construction of lines 9-12 as well as the extension of the existing subway line 3 in accordance with the city's policy to make the subway a central means of urban transportation that would account for more than 75% of Seoul's traffic volume, followed by the Basic Plan for Seoul Subway in November 1993.

However, the subway is an expensive infrastructure that requires the highest costs (as it has the highest transport capacity) among all public transportation systems. Therefore, the subway construction policy has a lot of controversies in terms of politics, economy and society and is mostly affected by the surrounding situations and circumstances. The third Seoul Metropolitan

Subway plan, which included the construction of subway line 9, was in an international context of the Asian financial crisis in terms of economy and faced with a critical situation of a reduction in finance due to the Korean financial crisis (1997-2001) - known locally as the 'IMF crisis'. This financial situation brought about a lot of changes in the overall plan, along with the inauguration of a new mayor in 1998.

Prior to this, there was a gas explosion incident at the Daegu subway construction site in April 1995, which caused 101 deaths and 202 casualties. As a result, policies for the re-evaluation of an on-going subway construction plan and a readjustment of the construction period were formulated and the completion of the second subway, which was under construction, was delayed. These factors had a considerable impact on the third subway plan.

Eventually, as the third subway plan was reviewed and delayed, measures to secure financial resources emerged as a key issue, and the feasibility of the project was adopted as a main virtue of selecting government-related projects- including PPP(public-private partnership). And thus, it was determined that subway line 9 was to be constructed in the form of a private investment business, or BTO (Buy-Transfer-Operate) after a feasibility study was carried out.

3. The Importance of the Policy

In general, public transportation facilities are essential for sustainable transportation and sustainable city construction. The construction and extension of a subway in a city, however, is a decision that requires special attention in relation to the financial sustainability of the city, given the enormous financial resources of the subway facilities as well as special fixedness and semi-permanent trait of the railway. In achieving the main goal of increasing the use of public transportation, whether new investments will have an effect on the net increase in the public transit share, or how these affect the decline in the use of automobiles, which has a relatively large negative external effect, need to serve as the basis for investment decisions.

In addition, the subway policy is accompanied by the investment of large financial resources, and thus has a characteristic in which tension is heightened by disputes about the detailed decisions of routes – especially in the present urban society where the participation of the general residents increases in relation to the redistribution of wealth over the distribution of the benefits and costs. Actually, in Korea, the construction of large-scale infrastructure has actively been carried out through the PPP since the end of 1990, based on the Act on Private Investment in SOC facilities amended in 1998; however, many questions on whether the private investment will reduce the national treasury and affect financial efficiency have been raised.

Of course, in a government with a weak financial structure, the prospects for affordability and financial sustainability of finances required for subway construction is a much more critical standard of judgment than typical virtues such as financial efficiency or secondary virtues like transit share.

In relation to these considerations, Seoul Subway Line 9 encompasses three important points.

First, in a situation where new means of finance are required due to the situational characteristics of the economy and finance in the period when the construction of Subway Line 9 was undergone, the investment and construction were promoted as a BTO (Buy-Transfer-Operate) project (unlike traditional government-invested projects), and therefore the financial burden of the government could be significantly reduced.

Second, as a decision that is not irrelevant to this, high-quality transportation services had to be provided to maximize demands in a situation with the precondition of receiving benefits, and the focus was on travel speed as the most important characteristic that would determine the quality of urban transportation services. As a result of operating express services, Seoul Subway Line 9 Express has achieved a decisive competitive edge in terms of speed, as compared to automobiles.

Third, it contributed to mitigate the access imbalance in the city by designing a route that provides access to the south-eastern region, which emerged as a traffic-neglected area through the first and second subway construction phases.

In other words, the importance is highlighted in that it has produced three remarkable achievements: a reduction in financial burden through PPP, the provision of public transportation service that obtains the competitive edge over automobiles and a reduction in regional imbalance of accessibility.

4. Relevance with Other Policies

Subway line 9 was planned as a part of the third Seoul subway construction project. The third plan was devised to continuously expand the subway network in Seoul with the construction of subway lines 9-12 and the extension of the existing subway line 3. However, the plan was reexamined all the way due to the Daegu subway fire and the Korean financial crisis, and it is one of the two components that maintained the route plan along with the plan for the third line extension. However, in the process, Subway Line 11 was shortened to the Shinbundang Line, and the rest of the lines were changed to light rail, monorail and connection lines of the first and second subways.

The construction of the first subway began in 1961 (when the city's population approached 2.5 million)as a result of formal discussions, and the subway construction plan was included in the 10-year plan of Seoul City Government. In 1966, the plan for lines 1-4 appeared in the basic plan for Seoul city. In 1970, as a result of rapid industrialization according to the national economic plan, as the population concentration and traffic congestion were intensified in the city of Seoul, the then President Park Chung-hee instructed that the public transportation construction plan be set up as a solution to the traffic congestion in Seoul. The Seoul subway construction project was jointly promoted by the Ministry of Transportation and the City of Seoul as one of the state projects. Although economic development had already helped to accumulate various technologies necessary for subway construction, Korea lacked some particular special technologies related to subway construction and was still preparing for the economic leap it would later take. Thus, it had to depend on foreign countries for some technologies and financial resources to construct the first subway line 1. Japan, with its experience of subway construction, provided special technologies and loans.

Starting with Subway Line 1(Seoul Station-Cheongnyangni) constructed from 1971 and opened in 1974, the construction of the remaining three lines (such as Line 2 (Circular Line), Line 3 (Gupabal-Yangjae) and Line 4 (Sanggye-Sadang)) was completed in 1985, and thus the first Seoul subway construction was finalized with the subsequent opening of the four lines.

The plan for the second subway construction was established in 1989 by the Korea Research Institute for Human Settlements, and it was notable that various axes of movements centering on the trunk lines that connect base areas of Seoul were suggested instead of planning the extension of the existing four lines and branch lines. It was a route plan that aimed at the quick connection between the bases in the southern and northern parts of the Han River as well as the minimization of subway-neglected areas. Through this plan, a submarine tunnel was constructed across the Han River. In order to make full use of the existing route network, the principle of transfer was adopted, and thus the second subway construction included the development of specific routes based on a clear spatial planning goal. This included Line 5 that connects Gimpo Airport to Yeoui-do, which is the center of business functions, Line 6 centering on a neglected area in subway services, such as the area north of the Han River, Line 7 between Sanggye and Gangnam that enhances the subway network density of Gangnam with increased concentration, while mitigating the regional imbalance and Line 8 that connects Seongnam, which has emerged as a powerful satellite city, along with Bundang New Town.

Through these first, second and third periods, Seoul's subway was developed as a system globally superior in terms of network density and service quality. However, there exists a fundamental limitation in railway transportation that the subway alone is not capable enough of meeting the citizens' traffic demands in the structure of urban development led by automobiles, a means of transportation with flexibility. A variety of factors inherent in the subway policies contributed to the success of Seoul's subway system. But above all else, the clear vision of Seoul city has had a crucial role in making the subway a backbone of urban transportation, and Seoul's recent bus policies(aiming at subway-bus integrated services), especially the bus reforms implemented in 2004, cannot be overlooked. In other words, the Seoul metropolitan transportation system was fully reorganized as a system centering on public transportation, and the public transportation integration and Quasi-Public Bus management system that connects the subway to buses were established.

In addition, policies such as light rail and high-speed trains, which are centered on the neglected areas in the supply of urban railways (Seoul Development Institute 2010), also expanded opportunities for integrated public transportation services.

5. Policy Objectives

- Reduce the regional disparities of accessibility to Seoul by connecting the neglected areas in services even after the second subway construction
- Mitigate traffic congestion due to the sharp rise in the number of automobiles by increasing the subway transport share to 75%

6. Main Policy Contents

1) Introduction of private investment

Attracting investment from private companies

In the late 1990s, as the Korean economic crisis led to a lack of public funding, innovative ways of financing were sought, and investments and operations through the BTO method were determined. The central government would invest 33.3% of the total project cost, Seoul metropolitan government 51%, and the private sector 15.7%, respectively. Moreover, the private sector was determined to be in charge of the first 30 years of operation. The main issues of operation regarding the private risk-free solution, investment method and subway fares were decided through business agreements. However, as it was pointed out that the first business agreement is too favorable to the business operators, renegotiations needed to be done.

For example, initially, the minimum revenue guarantee (MRG) was adopted as a way to alleviate private risks. In other words, if there is a shortage of freight income due to differences between real demand and forecast demand, the Seoul metropolitan government will make up for 90% of the deficit for five years from the starting date of the operation, 80% from six to ten years, and 70% from 11 to 15 years. In addition, the private business operator also has the right to decide subway fares. Regarding this, there was a case in which the business operator announced a price hike in subway fares unilaterally in April 2012 during the period of fare negotiations with Seoul Metropolitan Government. The notification and guidance of rate hikes by the business operator without consultations with subway operating agency was in fact a violation of the urban Railway Act and Concession Agreement(Subway Line 9 Business Restructuring Brochure, p.44).In this regard, the Seoul Metropolitan Government set up a task force (including lawyers, accountants and transportation experts) to promote renegotiations with the private business operator and established a series of deliberations on the draft of the convention with verification and review processes conducted by professional institutions such as Seoul Public and Private Infrastructure Investment Management Center, contract judging panels and consultation with the Ministry of Strategy and Finance.

Concession agreement to change the private investment project

The restructuring of Subway Line 9 business, which has been underway for over a year, was finalized on October 23, 2013 by the conclusion of a concession agreement with Seoul Metro Line Nine Corporation. As a result of the convention, shareholders that constitute the existing private business operators were replaced entirely. That is, seven construction investors, including Hyundai Rotem, who had completed the construction of the first section of Subway Line 9, sold off their shares and withdrew from the operation of Line 9, and Macquarie, a financial investor and a Small and Medium Industry Bank also sold off their shares and withdrew from the operation of Line 9.

In addition, the existing conventions allowed for a structure in which the fare increases rapidly every year. However, as the right to decide on the fare was transferred to the Seoul Metropolitan Government through the restructuring of the business, the continuous hike in fares could be prevented. That is, in the decision of fares, the Article 27 of the Concession Agreement stipulated that '③the business operator should have approval from the Seoul City in advance for the payment and collection of fares and charges. Accordingly, the fare for Subway Line 9 came to be applied in the same way as other subway lines, and the period of the hike in fares could be determined in consideration of the efficient linkages with routes and means of public transportation including buses (Subway Line 9 Business Restructuring Brochure, p.93).

Besides, with the spread of negative perceptions on the minimum revenue guarantee (MRG) introduced to attract private investment in railway, road and tunnel infrastructures during a foreign exchange crisis in 1998, the government abolished the private proposal business MRG in 2006 and government notice business MRG in 2009, respectively. With MRG, the financial burden was great because of the need to maintain long-term profits (p.94).In particular, Subway Line 9, one of the government notice businesses whose agreement was concluded in 2005, was originally supposed to support MRG; however, the MRG was switched to the minimum cost compensation (MCC) that covers the operating costs with the actual business income and only supports the shortage (p.94) through the restructuring of the business, thus securing the opportunity to significantly reduce the financial burden and long-term effects. The minimum cost compensation (MCC) is a method that subtracts the interest, operating expenses and depreciation amount of quarterly management and operation right values from the total amount of various incomes (such as the quarterly operating income) and maintains the rest. Therefore, the value of management and operation rights gradually decreases and becomes 0 won in 2039, and thus the financial burden of Seoul City is reduced due to a reduction in interest. Through this method, the financial burden was reduced, and the support for private business operators could be rationally implemented (p.94) According to the existing agreement, the Seoul Metropolitan Government had to pay a total of 5.1745 trillion won in financial aid, including 783 billion won in MRG and 4.3915 trillion won in subsidies for not increasing fares. With the switch to the minimum cost compensation (MCC), the burden of Seoul City was sharply reduced to 1.9,816 trillion won (Subway Line 9 Business Restructuring Brochure, MGR abolition 94p, positive effects, p.100).

Meanwhile, Seoul City has strengthened its control authority to reduce management and operational expenses by 10% from the level set in the existing agreement and adjusted operating costs, which could not be changed for 30 years, to reexamine them every five years. As a result, the financial burden could be reduced through a downward adjustment that guarantees the operating company only the same 4-5% return rate as the new investor. In addition, it has realistically adjusted the costs of electricity, insurance premiums and alternative investment costs, which are partly affordable, to the extent of assuring service levels and stable operations and made a structure to reduce the financial burden of the city by changing the agreement so that it can include the incomes from affiliated businesses – such as the rental income of the commercial quarter and advertisement in the income of the subject who proceeds with the business and manages them (Subway Line 9 Business Restructuring Brochure – Strengthening the control authority of Seoul City, p.96).

Another remarkable point is that in the process of restructuring, Seoul City has introduced and managed a new financing method called the 'Citizen Fund'.

The business restructuring brought about positive effects which include the effect in management and operation, financial savings and clean-up of the controversy over subsidies for not increasing fares.

In terms of management and operation, the problem of conflicts over the increase in fares was completely solved at first. After this, the fare of Subway Line 9 has remained the same as the basic fare of the other subway lines, and the period of the hike in fares has been reasonably determined at the same level as the other Seoul public transportation systems. In addition,the financial structure has changed into a solid structure by completely eliminating the 15% high interest rate subordinated loan through the business restructuring and constructing the loan structure only with the senior loan. Third, as the conflicts with the business operator, such as the two administrative lawsuits, were resolved, the anxieties of citizens were thus reduced. The fourth effect is that a minimal safety device was provided so that the financial aid supported by Seoul City can be used appropriately. That is, its control authority over the operation and management of private investors has been strengthened. Finally, the burden of Seoul City was reduced by including the revenue from the subsidiary business in the business income structure, along with the income from fares.

The biggest effect of restructuring the Subway Line 9 business is regarding the financial cutbacks. Abolishing the MRG and applying MCC was effective. Through the business restructuring process, Seoul Metropolitan Government reviewed the operation costs of Subway Line 9 for five years from 2009 and found that there are cost saving items to the extent that the subway service is maintained. As a result, it was able to save 350 billion won, about 10% of the existing management and operation costs.

Finally, the resolution of issues over subsidies for not increasing fares is also a main effect. Through the restructuring business negotiations, it was agreed not to pay subsidies for not increasing fares, which amounted to about 10 billion won each year from 2009 to 2013.

(Subway Line 9 Business Restructuring Brochure – Positive effects by business restricting process, p.98-103)

Creation of Citizen Fund (p.106-115)

This is a model in which citizens invest in Subway Line 9 bonds and receive profits higher than the interest rates of commercial banks, and its total scale is 100 billion won. It is divided into 4, 5, 6 and 7 year-types depending on the period. It is possible to invest up to 20 million won per citizen, and the average rate of yield is set at about 4.35%. In order to protect investors, Korea Financial Supervisory Service exercises supervisory authority, and mid-course sales were made possible. A total of 5,508 citizens joined the Citizen Fund, and the number of citizens who invested in the fund were highest in the six year-type and lowest in the five year-type (p.114). As a new window for financing, which is always a hindrance to the supply of large-scale public goods, this Citizen Fund was highly appreciated as an innovative model that could not only contribute to the reduction of the government's financial burden, but also improve the economic productivity of citizens through the profitability of public goods. The Citizen Fund was an innovative attempt to provide a win-win situation for both Seoul City and citizens and has its significance in that citizens invested in funds and made private investment business practices. Therefore, it is expected it will continue to provide a good example to solve various problems that have been dealt with in the administrative area with citizens (p.115). In recent years, it has been used in environment-related businesses such as renewable energy. In particular, Seoul City constructed the first Seoul Citizen's Sunshine Power Plant through a Citizen Fund in 2015. The total amount of 8.25 billion won collected through the public fund competition was invested in the construction of a 4.242MW solar power plant. As can be seen in this case, the Citizen Fund has a number of possibilities and enormous implications.

http://mediahub.seoul.go.kr/archives/926005

2) Step-by-step construction

Subway Line 9 has a total length of 38km, and the whole section was divided into three sections to proceed with the construction sequentially. Since the route was designed around areas vulnerable to subway services, the construction was completed from the section that is expected to have the greatest demand among three sections so that citizens' benefits, or social benefits could be created prior to the opening of all sections.

Figure 2: Subway Line 9 construction phase

Figure 3: Subway Line 9 route map

Source: Seoul Metropolitan Government (2016)

3) Express line service

Subway Line 9 provided an express service for the first time in the Seoul subway system. The additionally provided express service is to limit the number of station stops (in addition to a normal service that stops at all stations), and thus to significantly increase traffic and transport speed. For example, of the 25 stations of the first-phase section, the subway stops only at nine stations – those considered major stations, such as subway transfer stations. The express service is 40% faster than the general service, and the service frequency of express trains is increased in the rush hours compared to at other times.

In this regard, Subway Line 9 has achieved a very significant accomplishment in that it obtained a competitive edge against automobiles in terms of the travel time of the express service. For the section from Gimpo Airport to Shin Nonhyeon Station, it takes about 40 minutes to get there by car and 64 minutes by bus. However, when using the general service of Line 9, it takes about 47 minutes to travel on the same section, and it takes about 30 minutes when using the express service.

With respect to the transition from car to public transport, which is the common goal of contemporary cities, automobiles retain certain comparative advantages in terms of the quality of transportation services(such as speed, comfort and convenience) and this makes it impossible or difficult to achieve a successful transition between the means of transportation. In particular, given that the travel time penalty of the general public transportation is the biggest factor of non-competitiveness, even if a time competitiveness that the express service of Subway Line 9 has achieved is not the time competitiveness against the total travel time on the door-to-door dimension, it can be said to be a very significant achievement, considering the contemporary challenges in terms of global urban planning, which is the shift to sustainable transportation mode. In addition, after Subway Line 9, Line 1(Bundang Line and Gyeongui Jungang Line) introduced express services, which demonstrated the positive influence and success of Subway Line 9.

4) Organization for subway operation

In order to maximize the efficiency of the subway operating organization, the operation of Subway Line 9 is based on the principle of eliminating five existing facilities and manpower, such as a stationmaster, a station office, a ticket office and a night duty room. Instead of drastically reducing ticket office personnel, transportation cards can be recharged and purchased at convenience stores within the station. In addition, the operational efficiency was enhanced by performing car maintenance, maintenance of elevator facilities and other management tasks in the form of commission. Subway Line 9 operates the same number of facilities with much less manpower than other subway operating organizations. For example, Seoul Metro requires a manpower allocation of about 70 employees for every 1km of operation, and Korea Railroad Corporation about 40 employees, whereas about 15 employees are placed on Subway Line 9.

7. Technical Details

The part that allows the participation of the private sector in the construction phase includes tracks, electric power, electric cables, vehicle manufacturing, signaling, communication, equipment automation, vehicle supervision facilities, other facility construction works, finishing work for stations, screen doors, vehicle bases and general command room construction. The outline of the project is shown in Table 1 below.

Table 1. Outline of Subway Line 9 Project

Division	Description
Total Length	25.5km (Gaewha-dong, Gangseo-gu – Nonhyeon-dong, Gangnam-gu 1st Phase section)
Project Cost	899.5 billion won(January 12, 2003, constant price basis, business expenses for the upper part
Project Period	30 years from the start date of the public use 2001-2008
Promotion Method	BTO (Build Transfer Operate) After the completion of construction, the ownership belongs to the state, and private business operators recover investment costs through 30 years of operation

Source: Korea Transport Institute 2011

In the early days of the business agreement, it was negotiated as a zone fare system. However, as the public transport integrated fare system was implemented in 2004, the system was included in the Metropolitan Unity Fare system, and therefore the Seoul Metropolitan Government provides financial support for the fare reduction and transfer part. The Metropolitan Unity Fare system has a pricing rule based on the integrated distance proportional system with the entire sections of the metropolitan subway as the target, and the fare system for Subway Line 9 is shown in Table 2 below.

Table 2. Fare system for Subway Line 9

Division		Transportation Card	Single-use transportation card
Basic fare	Public	1,250 won	1,350 won
	Youth	720 won	1,350 won
	Children	450 won	450 won
Fares for additional distance		o every 5 kilometers from 10km to 50km 5km: 100 won o from 50km to 8km: 100 won	

Source: Metro Line 9 website
http://www.metro9.co.kr/site/homepage/menu/viewMenu?menuid=001001004001

Subway Line 9 is composed of four passenger cars in one train, and a total of 144 vehicles (in 36 trains) shuttles in the entire section. By the end of 2016, there will be 32 new vehicles (in eight trains), which will increase to a total of 176 vehicles (in 44 trains). One train is expected to be added in 2017, whose composition is four vehicles (in 28 trains) and six vehicles (in 17 trains), which totals 214 vehicles, showing an increase of 38 vehicles compared with the number of vehicles in 2016. In addition, according to the plan of Seoul City, 49 vehicles will be added by 2018, and the total number of vehicles is expected to increase up to a total of 294 vehicles. Therefore, the current 144 vehicles (in 36 trains) will increase to 294 vehicles (in 49 trains) in 2019 when the third-phase subway line is opened. Thus, the plan is to solve the current congestion problem that Subway Line 9 has through an expansion of the number of trains (vehicles) in stages (Seoul internal data 2016).

Division	Present		’16 (+8Trains)		’17 (+1Trains)		’18 (+4Trains)	
	Trains	Vehicles	Trains	Vehicles	Trains	Vehicles	Trains	Vehicles
Total	36	144	44	176	45	214	49	294
4 vehicles	36	144	44	176	28	112	-	-
6 vehicles	-	-	-	-	17	102	49	294

8. Policy Effects

1) Reduction in public finances

Seoul City not only saved public finances by encouraging private business operators to pay 15.7% of the total investment costs by attracting private investment, but also achieved financial savings of 3 trillion won through the success of business restructuring. In addition, it achieved a 10%

operating cost reduction by increasing operational efficiency. One thing to keep in mind is that the Subway Line 9 business has become an example of a successful private investment project because a strong demand for services already exists. The lesson that the business whose economic feasibility is not secured cannot be a successful business even if it saves the current finances and can use advanced devices to ensure profitability was well accepted in the PPP field through the demonstrated application of many examples.

2) High traffic volume

After only one year since its opening on July 24, 2009, the average daily traffic volume reached 97% of the forecasts in 2010 and has increased steadily. In 2012, it exceeded the forecasts by 3.8% in 2012 and continued to increase steadily thereafter. Looking at the number of users, the average daily number increased from 227,882 in 2012 to 400,000 in October 2014, and to more than 450,000 in October 2015 after the second-phase subway line was opened. Figure 3 shows the trends in the yearly total traffic volume according to the frequency of getting on and off the subway train.

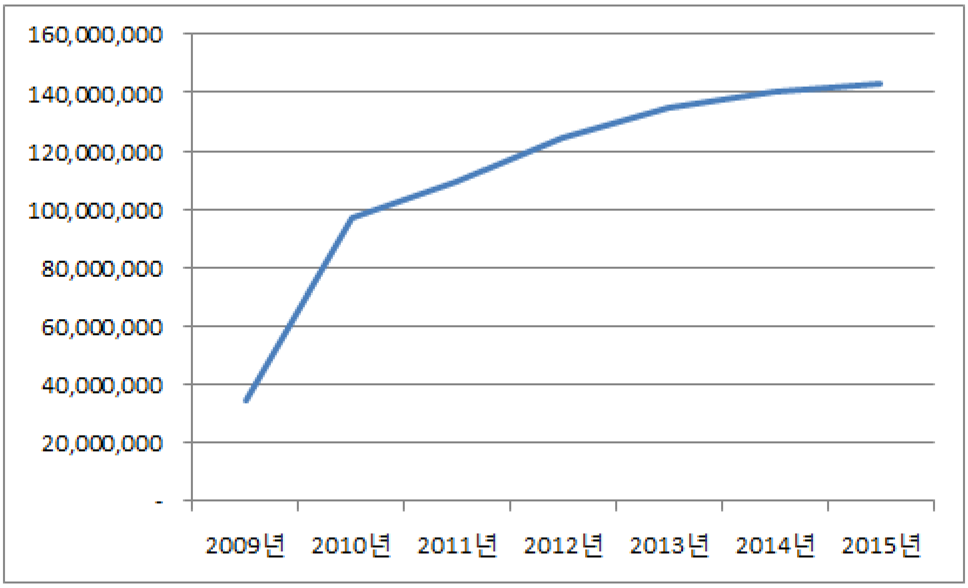

Figure 4: Yearly total traffic volume of Subway Line 9(transfer included), 2009-2015

Source: Seoul Metro 9, 2016(https://www.metro9.co.kr)

4) Promoting equity in society through improved access to public transportation of neglected area in public transport services

In the first two months since its opening, Subway Line 9 recorded more than 135,000 net passengers, except for transfer passengers. This figure is close to the expected traffic volume of 165,625, and there are not so many cases in which the actual traffic volume reached more than 80% of the expected traffic volume so quickly immediately after a subway opening. As there was a consensus that a route that directly connecting the areas of Gangseo and Gangnam was required before the construction, it resulted in providing service in a section where the accessibility to the subway was relatively low. According to Seoul 2010 data, users of Subway Line 9 reduced travel time and transportation costs of about 100-200 won, which is estimated to be a customer benefit of 4.1 billion won per year.

5) Activation of neighboring commercial districts

Subway Line 9 has left behind remarkable achievements in terms of the number of passengers and the development of subway station areas, called the second golden line after Subway Line 2. Moreover, the opening of the second-phase section in 2015 invigorated commercial districts around the subway station. According to the Gangnam District office, the number of new buildings around Bongeunsa-ro, which started construction last year, totaled 24, four times as many in 2013. Even in the neighborhood of Eonju Station which houses Cha Hospital, buildings related to medical facilities have been constructed. This is due to the expectation that as Gangnam District Office has recently designated the vicinity of Cha Hospital crossroads as a medial tourism zone, rental demand for the medial industries will increase (JoongAng Ilbo 2015).In addition, since the accessibility to the Gangnam area is expected to be improved if the third-phase section is implemented, various plans for developing station influence areas are currently underway. If the economic activity of the southwestern region of Seoul is increased due to the prosperity of Subway Line 9, it may prove very helpful at solving the imbalance between regions in Seoul as intended.

9. Challenges and Solutions

1) Lack of experience in business agreements

As described above, Subway Line 9, which was the first PPP project on the urban railway, led to unsatisfactory results for Seoul City and citizens in the original business agreements. However, the Seoul Metropolitan Government soon established a plan for restructuring the Subway Line 9 business, set up a task force that included judicial officers, accountants and transportation experts, and promoted renegotiations with private business operators. In addition, it made all the necessary preparations for the private investment project convention through the verification and screening processes of special agencies such as Seoul Public and Private Infrastructure Investment Management Center, contract judging panels and consultations with the Ministry of Strategy and Finance. In particular, Seoul Metro Line 9 Corporation’s unilateral price hike in fares raised citizens’ resistance. However, the Seoul Metropolitan Government secured the pricing rights through a business restructuring and eliminated the possibility of similar problems occurring in the future.

2) Problem of congestion due to continuous increase in demand for express service

According to Seoul Subway Line 9, the congestion rate of the general trains of Gayang, Yeomchang, Dansan, Yeouido and Noryangjin stations at 7-8 a.m. at the end of March last year before the opening of the second-phase section was an average of 112%, and the congestion rate of September after the opening of the second-phase section was increased to 117%. The congestion rate of the express train in the same time period was also increased from 193% to 206%. The number of Subway Line 9 passengers increased from an average of 400,000 per day in October 2014 to 450,000 in October 2015 after the second-phase section was opened.

Changes in congestion rates in the 2nd phase section of Subway Line 9(Sports Complex Station – Eonju Station) after its opening

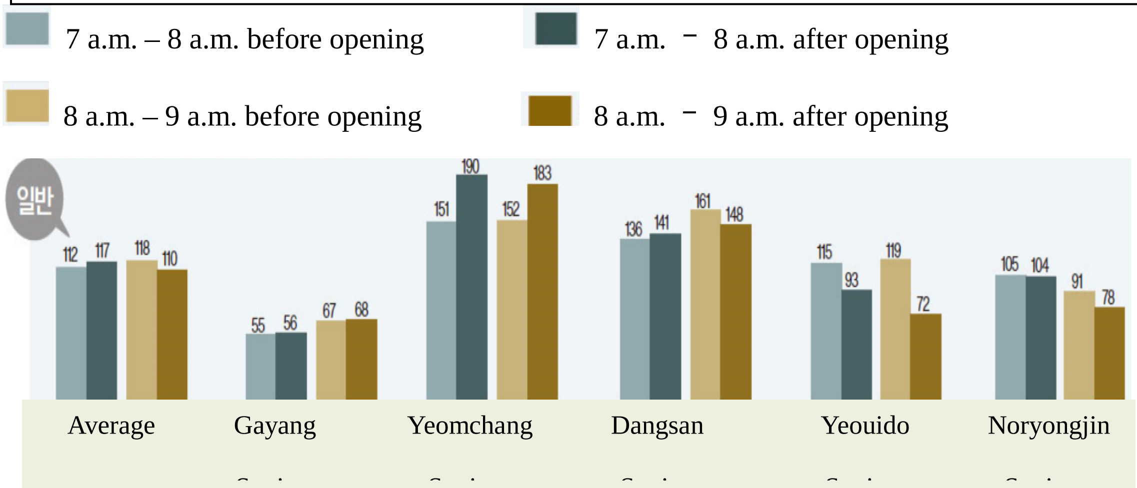

Figure 5. Changes in congestion rates of Subway Line 9
Source: JoongAng Ilbo 2015

Seoul Metro Line 9 Corporation analyzed that the reason for the surge in traffic congestion rate was that despite an increase in the number of users at the time of the opening of the second-phase section, as the number of trains was not increased, and only extended operations were conducted, the number of operations was reduced from 540 to 484. After that time, the Seoul Metropolitan Government first added three new trains in June, out of 32 vehicles (8 trains) to be increased by the end of 2016. By the end of December, as the number will be increased from 144 vehicles (36 trains) to 176 vehicles (44 trains), showing an increase of 32 vehicles and 22% (trains), more convenient use is expected. In addition, it is planned to increase 16 trains out of the existing 4 vehicles (one train) by two by the end of 2017, introduce a total of 38 vehicles with 6 vehicles (17 trains) into the express train with higher congestion rate, along with test vehicles, operate a total of 6 vehicles (49 trains) by introducing a total of 80 vehicles until the opening of the third-phase section of Subway Line 9 in 2018, and thus reduce the overall congestion rate. By 2018, it plans to increase the number of vehicles for Subway Line 9 to 294. To do this, the Gaewha vehicle base track extension project to additionally introduce trains is expected to be initiated in January 2016 and completed by August of the same year.

(Source – http://infra.seoul.go.kr/archives/31245) /

10. Details on the Business Restructuring of Subway Line 9

1) Key points (p.88-103)

First, business restructuring is designed to change business implementation conditions, such as MRG, rate of yield and fares in the concession agreement through renegotiations between the competent authority and private business operator in order to alleviate the financial burdens. The main contents are as follows: 1) full-scale replacement of private operators and shareholders 2) downward adjustment of earning rates to the level of commercial interest rates 3) transfer of rights to decide fares for Seoul City 4) the abolishment of MRG payment, which was absolutely advantageous for private operators 5) agreement on the value of management rights of Subway Line 9 to be 746.4 billion won 6) strengthening of the control authority of Seoul City 7) reduction of management and operation costs by 10%, cost savings.

The first is to withdraw the existing investors (including Macquarie) and attract new investors. Seven construction investors, including Hyundai Rotem, who completed the construction of the first section of Subway Line 9 sold off their shares and withdrew from the operation of Line 9. Macquarie, a financial investor and Small and Medium Industry Bank also sold off their shares and withdrew from the operation of Line 9. Instead, two asset management companies with the status of trust business operators and 11 financial investors including Kyobo Life Insurance, Hanwha Life Insurance and Hungkuk Life Insurance participated in the business. In other words, 13 construction and financial investors were changed to financial investors investing through funds.

The second is to adjust the private operator’s current rate of return from 13% to 4.86%. The rate of return adjusted through the restructuring was determined to be 4.86% by applying an added interest rate of 1.75% in consideration of operational risks and fund management fees with the yield on the 5-year Treasury bond. This is similar to earning rates from the BTL project, which was drastically lowered compared to the existing post-tax earnings rate from actual business of 8.9% (current rate of yield 13%). The method of determining the rate of return has also changed from the fixed rate of return to ‘fixed rate of return + variable rate of return’ structure. The proportion of the fixed rate of return to a variable rate of return was set at 5:5 so that risk factors caused by interest rate fluctuations could be reduced, and financial market changes could be flexibly reflected. Accordingly, the fixed rate of return will be fixed for the next 26 years, and the variable rate of return will be adjusted every year at the rate of 5-year Treasury bond plus a 1.89% additional interest rate. The change in financial structure was also a factor in lowering the rate of yield. The loan structure was changed from the existing high-interest subordinated loan to low-interest senior loan, and some of the fixed loans were issued to the Citizen Fund to create a citizen participation environment. As a result, the high-interest subordinated loan was eliminated, and the high interest rate was adjusted to a level that is not disadvantageous.

The next is to transfer rights to decide the fares of Subway Line 9 to Seoul City. According to the existing contract, fares were determined autonomously within the fare rate set in the concession agreement by private operators. However, as conflicts over fares revealed that the surprise decisions of such fares by business operators lead to great confusion, and through restructuring, the Seoul Metropolitan Government is now to give approval in relation to the issues regarding fares and fare imposition, collection and modification. Ultimately, the actual authority on decisions related to fares was transferred to Seoul City. In addition, the restructuring has also corrected the malfunctioning structure of the hike in fares. According to the original concession agreement, the fares are to be raised by applying the rate of inflation and increase rate of fares every year, which resulted in a constant increase in fare rates. However, as the actual right to decide the fares was transferred to Seoul City, the same subway fares could be applied to those of Line 9, and the period of hike in fares could also be determined through linkages with other routes and public transportation systems such as buses and other subways.

In addition, MRG was abolished, and MCC was adopted. The greatest significance of the restructuring is that the MRG payment has been abolished. The MRG was introduced to private investment in SOC projects, such as railways, roads and tunnels during financial crisis in 1998, but it served as a factor that caused a financial burden due to long-term conservation of earnings. The minimum cost compensation changed from the MRG is to cover the operating expenses of the business with actual business income and support only the deficiency. Through this, it was possible to reduce the financial burden and rationally promote support plans for private operators.

Meanwhile, the value of management and operation rights of Subway Line 9 was agreed to 746.4 billion won, lower than the standard of payment at the time of termination due to the nonpolitical force majeure. This was an agreement by the Maginot line which specifies that if this business is terminated before the commencement of negotiations on the value of the management and operation rights between the existing shareholders and new investors, the Seoul Metropolitan Government approves the change of investors only in cases where the value is determined to be at a lower price than the payment at the time of the termination due to nonpolitical force majeure that Seoul City should make.

The rights to decide fares that cause inconvenience in use from the management aspect of private business operators as well as consultations on the appointment of president and the director general nomination rights were transferred to Seoul City, and thus its control authority was also strengthened. In addition, management and operation costs have been reduced by 10% from the level set in the existing agreement, and the operating costs that were unable to be changed for 30 years have been adjusted to be reviewed every five years. As a result, financial resources have been able to be reduced by guaranteeing a rate of yield ranging from 4 to 5% for operating companies as in the case of new investors. The electricity, insurance premiums and alternative investment costs, which are partly affordable to the extent of assuring service level and stable operation, were also adjusted realistically. In addition, the financial burden of Seoul City was reduced by changing the agreement to include the earnings from rental business and advertisements in the income of business operators and manage them accordingly.

2) After the restructuring (118-119p)

The restructuring of Subway Line 9 was a process in strengthening the public, and demonstrated the power of citizens and the efforts of Seoul City and related experts. The effect of reduction in finances became clear after the restructuring of the business. That is, additional savings of about 7.5 billion won were achieved by 2014 thanks to the continued efforts of the Seoul Metropolitan Government to increase the earnings by identifying additional items that could generate revenue.

In addition, the Seoul Metropolitan Government appointed a technical expert in the urban railway sector as an executive director of the business operator to strengthen management supervision. The appointment of the CEO was also carried out through consultations with the Seoul Metropolitan Government.

In addition, the business restructuring of Subway Line 9 has affected other businesses as a positive precedent. The second circular road of the Gwangju Metropolitan City, Machang Bridge of South Gyeongsang Province, Misiryeong Tunnel of Gwangwon Province are all now inquiring and showing a significant interest in the Citizen Fund. Regarding the Citizen Fund, there has been a growing interest in private investment projects especially in transportation facilities, power plant construction and LED lighting.

3) Promotion process

- 12. 7. 6 Business trip for benchmarking to Daegu City
- 12. 7. 13 Business trip for benchmarking to Daegu City
- 12. 7. 23 Review meeting on the non-application of Subway Line 9 restructuring case (city council)
- 12. 9 ~ 12 Coordinated opinions on the intention to sell Subway Line 9 shares
- 12. 12. 4 Signed MOU between new investors and submitted LOI (Letter of Intent) to shareholders of Subway Line 9
- 13. 2. 13 Submitted the restructuring promotion proposal for Subway Line 9
- 13. 2. 26 Mcquarie indicated its intention to cooperate in the restructuring
- 13. 3. 15 Submitted the amendment (draft) to the Subway Line 9 convention
- 13. 3. 22 Requested support negotiating team for changes in the Subway Line 9 private investment project convention
- 13. 3. 28 [Policy] Seoul Metropolitan City Subway Line 9 phase-1 section private investment project concession agreement negotiation team composition and operation plans
- 13. 3. 29 Initiated negotiations to change the restructuring agreement
- 13. 6. 5 Notified the resumption of fare negotiations on Subway Line 9
- 13. 6. 5 Advance notice on the termination of concession agreement on the phase-1 section of Subway Line 9
- 13. 6. 12 Reply to the notice on the renegotiations of Subway Line 9 fares
- 13. 6. 19 Concluded a trading agreement between existing shareholders and new investors
- 13. 7. 3 Request for consultation on amendment to concession agreement for phase-1 section of Subway Line 9
- 13. 7. 4 Notified the commencement of formal consultations for the amendment of the concession agreement of Subway Line 9 phase-1 section private investment project

- 13. 7. 17 Requested the first review (examination) of an amendment (draft) to a concession agreement on phase-1 section of Subway Line 9
- 13. 7. 23 Requested to submit plans to coordinate the business restructuring consultations and business implementation conditions
- 13. 7. 23 Requested to comply with the agreement on the sale of shares in relation to the private investment project of Subway Line 9
- 13. 7. 24 Submitted a plan for coordination of private investment project implementation conditions for phase-1 section of Subway Line 9
- 13. 7. 25 Visited the Ministry of Strategy and Finance for preliminary consultations
- 13. 7. 27 [Policy] Subway Line 9 business restructuring promotion plan
- 13. 7. 29 Requested to review the plan for the coordination of project implementation conditions and amendment (draft) to the concession agreement on Subway Line 9
- 13. 7. 31 Submitted the concession agreement to change the private investment project for phase-1 section of Subway Line 9
- 13. 8. 8 Reviewed fund manager’s suggestions regarding the Citizen Fund
- 13. 8. 12 Request for cooperation to change the concession agreement on private investment project for phase-1 section of Subway Line 9
- 13. 8. 13 Notified a change (draft) in implementation deposit related to the modification of Subway Line 9 management and operation trust agreement
- 13. 8. 14 Reply to the first review request of the amendment (draft) to the concession agreement on phase-1 section of Subway Line 9
- 13. 8. 21 Request for consultations to review the plan for coordination of project implementation conditions and amendment (draft) to the concession agreement on Subway Line 9.
- 13. 8. 22 Sent written opinions of Seoul Public and Private Infrastructure Investment Management Center on the amendment (draft) to the concession agreement on Subway Line 9
- 13. 8. 23 Business consultations with the Ministry of Strategy and Finance
- 13. 8. 27 Sent written opinions on reply results of review request for amendment (draft) to the concession agreement on phase-1 section of Subway Line 9
- 13. 8. 29 ~ 9.6 KDI business consultations
- 13. 9. 9 Notified the review results of the contract review team
- 13. 9. 11 Reply to the Seoul City’s opinion on the review of the amendment (draft) to the concession agreement on Subway Line 9 phase-1 section of Public and Private Infrastructure Investment Management Center
- 13. 9. 24 Reflected the verification results of Seoul Public and Private Infrastructure Investment Management Center, contract review team and the Ministry of Strategy and

Finance

- 13. 9. 27 Completion of consensus on the details on the stock purchasing and sales agreement between seller and buyer
- 13. 9. 30 Consultations with fund manager regarding the Citizen Fund
- 13. 10. 2 ~ 8 Business consultations with the Ministry of Strategy and Finance
- 13. 10. 17 Report to Seoul City Council
- 13. 10. 22 Concluded the stock purchasing and sales agreement between existing shareholders and new investors
- 13. 10. 23 Concluded the stock purchasing and sales agreement and amendment to the concession agreement

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Night Bus: Route Design Using Big Data

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1. Period of Policy Enforcement

The night bus, or so-called ‘Owl Bus’, was first enforced in 2013. It provides bus services at night time, as needed by the citizens, at affordable prices by designing routes using big data. Already having an interest in the use of big data, Seoul city analyzed data obtained by the Dasan Call Center, which demonstrated that citizens had considerable interest in the traffic field. Furthermore, communication with citizens via the internet displayed that there was a demand for public transportation that could be safely used at night time when bus services normally end. These led to the initiation of this policy.

Two demonstrative routes were operated from April to July of 2013, and from September 12, 2013, the system was expanded to 9 routes.

2. Background Information

1) Night Bus

Economic activities in Seoul are carried out 24 hours a day, in reality. Countries that display a considerable amount of traffic at night time mostly rely on taxis. However, these are not a sufficient alternative due to a lack of supply compared to excessive demand, poor service (rejection of passengers), safety problems, and high costs during peak night hours. Some of the citizens that participate in night economic activities are service consumers, including restaurants and entertainments, and while others include low income workers, businessmen and company workers, as well as students. Thus, a lack of public transportation at night time signifies the restriction of economic activities at night.

In certain night service corporations, such as ‘clubs’ in large cities of England, leased buses are

[5] Translation by ESL®

individually operated to provide transportation to the citizens who reside in adjacent suburbs or small cities. Seoul city is reputed as a 'city that is not outdone' by these European cities in terms of its active night economic activities, including entertainment and pleasure services. Thus, although the chauffeur service is broadly used and somewhat established based on a firm demand without depending only on taxis, taxis or chauffeurs are not reasonable means to the young class and those of a low income, and thus, the selection of night transportation means is insufficient.

The citizens expressed this inconvenience through an electronic governmental communication channel, and the city assessed the introduction of night buses.

Meanwhile, since Seoul city was interested in using big data in administration, the intention of the application of big data in the transportation field was a reflection of the citizens' interest. Upon analyzing 600 thousand cases at the '120 Dasan Call Center', one of the Seoul citizens' complaint channels, it was displayed that the citizens had the greatest interest (25.5%) in the transportation field. Other than establishing the night bus route, big data was also used in the reduction of traffic accidents.

2) Reducing Traffic Accidents

The number of deaths from traffic accidents in Korea is the highest among OECD countries, which is two to four times the amount of the generally perceived advanced countries. The number of deaths per 100 thousand of the population (2009) was 4.8 in Seoul, 2.4 in London, 1.6 in Tokyo, and 1.4 in Berlin. However, this number of deaths has been decreasing over the past three years due to the initiation of improvement projects in areas with frequent accidents. Consequently, the number of deaths decreased from 501 (2009) to 378 (2013), and the number of injured decreased from 63,584 (2009) to 56,761 (2013). This is the result of the 24.5% reduction of casualties with the improvement project in 266 areas of frequency accidents over the past three years. Various policies have been initiated in attempts to reduce traffic accidents, in relation to the initiation of the customized traffic safety measures for the elderly and children. This is a support project of luminous vests and safety indicators on handcarts for all elderly citizens collecting waste paper (6,354 people) and the expansion of elderly protection zones (more than 20 zones each year), and policies establishing traffic safety experience classes for the elderly. The obligation of traffic safety education upon renewing driver's licenses has also been initiated. With the expansion of children protection regions (more than 50 regions each year), safe commutes to and from schools is supported by the operation of traffic safety instructors for elementary school students within these regions. Furthermore, policies such as the expansion of pedestrian crossings (105 crossings including 50 diagonal crossings) and intensive control of illegal stopping on sidewalks (138 regions), contribute to reducing traffic accidents involving children.

3. The Importance of the Policy

Implications from Developing Countries:

Seoul is a city that competes for its position among the top in the world in terms of the level of planning and supply of public transportation. However, at the time the demand for night buses was recognized, an additional budget for the service was not prepared. As a result, the means devised from the mission and condition of supplying customized services diligently responding to the demands of the potential users without wasting the budget in the standard plan and supply of the bus routes was the provision of an incremental service expansion of services by assessing the revealed preference and route design using big data. In this sense, there are remarkable implications to the policy makers of cities that are unable to provide public transportation services within situations where such need has been verified, due to financial restrictions and of cities that have poor traffic information required for public transportation service supply plans.

First, poor data infrastructure is a problem that is commonly faced by most developing countries. Regular surveys on passengers are conducted in countries with abundant resources and where the traffic count on roads comprises the basis of constructing traffic data. Since such research costs are very high, it is difficult for traffic data to be properly carried out in poor countries or developing countries.

Second, even if resources are not particularly weak, if mobile phone usage data can be used to provide consumer-customized bus routes, the city government could provide multiplied convenience to the citizens by using the resources to be used in the construction of traffic data on the development of other public goods. The means of using mobile phone data on traffic plans is a field that is interested and developed more in advanced countries than in developing countries.

Even in developing countries that do not have the data required for city planning, including traffic data, the users display a mobile phone possession rate of near 100%, particularly in large cities. These countries have the basis for similarly using big data on city plans, including public transportation planning.

The large cities of developing countries have a relatively low number of cars and, thus, have a greater need for public transportation than rich cities. Regardless of this, bus networks are not properly formed in most cities. The commonality of the cities, such as Jakarta, Hanoi, Phnom Penh, and Kigali, is that there is a significantly high number of motorcycles over public transportation. Motorcycles have much greater flexibility and convenience than cars in certain aspects, and provide reasonable speeds to be depended on as a transportation means in a large city. However, motorcycles do not have the efficiency of public transportation and this could reduce traffic energy and the usage of roads by transporting a large number of passengers at one time. Thus, the excessive use of motorcycles is already becoming the main cause of worsening atmospheric contamination and traffic congestion in mega cities of developing countries where various city problems are surging.

Motorcycles are the method of transportation selected by the citizens as a means that most proficiently satisfies the needs of transportation with restricted resources and the absence of adequate public transportation. However, if a suitable method of public transportation is not provided at an opportune moment by considering motorcycles as an appropriate long-term measure, the traffic in these mega cities will gradually face a serious problem. That is, various cities will experience growth and development where individual commute patterns become permanent, and as the residents' incomes increase, motorcycles in the city will soon change to cars, which will restrict sustainable development.

Seoul's night buses, which provide optimal services at affordable costs through route plans that use big data, lack official data, but are part of a policy that has a high value of application in developing countries with a very high possession rate of mobile phones. The bus routes are planned using already existing mobile phone history data, and the service is gradually expanded to prepare a basis of public transportation. Thus, there is a need to change the direction of the current unsustainable move.

There has been a case in which the IBM research team devised a bus route in Abidjan, the capital of Ivory Coast, where there were no previous bus route networks, using the mobile phone data provided by the global communication company of Orange in 2013 (BBC 2013).

Planning a Consumer-focused Policy

There is significance in that the demand of the service users was reflected and big data was newly applied in understanding their behavioral patterns during the process of planning the transportation service. The use of big data enabled the service to directly capture the actual properties or behavioral patterns of the 'population' and not a 'sample' data collected according to the purpose of the supplied. User and consumer-based policy can therefore be planned through the attempt of using the collected data, and ultimately, it achieves increased usability, effect, and service quality of the policy.

Most existing policies did not attempt in understanding or considering the main body of society and delivery system using public services due to the planning and execution of the supply under the supervision of the government. The policy also has a special value in preparing an opportunity that can more accurately reflect human social perspectives to a scientific approach by designing a service focused on big data which observes and analyzes the behavior of the main body of society, exceeding the traditional restrictions of planning. It is also noteworthy that private information and public information were combined, unlike existing policies that usually depended only on public data. There is also a significance in that this is Korea's first case of attempting to plan an optimized policy using big data in a city traffic policy, and simultaneously, it proposes various possibilities for the use of big data.

Ahn, Y. J. and Kim, S. I (2014) analyzed the cases of use of big data, including overseas cases, by recomposing Peter Morville's honeycomb model for the verification of user experience, wherein Seoul city's night bus was evaluated as a case that satisfies all aspects of usefulness, usability, credibility, accessibility, and public value as shown in Table 1 below.

Table 1: User Experience Evaluation Table on Using Big Data in the Public Sector of Seoul's Night Bus

Usefulness	The demand of night buses was recognized after analyzing data from Dasan Call Center, and it was determined that this service would be provided
Usability	After demonstratively implementing two routes, the number of routes was expanded to 9 routes
Credibility	The predicted values obtained by analyzing the arrival/departure points from the traffic card and 3 billion cases of telephone calls were almost accurately consistent with the actual population at night time
Accessibility	High accessibility where anyone can access and obtain necessary information
Public Value	Focus on the purpose of public value and not on the purpose of private profit

Source: Ahn, Y. J. & Kim, S. I. 2014 Partial editing of p.447

4. Relevance with Other Policies

Seoul city has great interest in using big data throughout its administration. The prioritized intention of applying big data in the traffic field was a reflection of the citizens' interest. Upon analyzing 600 thousand cases of data from the '120 Dasan Call Center', one of the Seoul citizens' complaint channels, it was displayed that the citizens had the greatest interest (25.5%) in the traffic field. Big data was also used in the reduction of traffic accidents, in addition to establishing the night bus route. Big data and information communication technology are diversely used in the electronic governmental field in an attempt to promote citizen participation and the efficiency of city administration.

5. Goals of the Policy

Night Bus

1) By concentrating services in areas with high demand of night transportation, high bus usage is achieved in order to enhance user satisfaction and support night activities (this service can easily be cancelled if the usage rate is low)

2) Safe return of citizens to their homes during night time (midnight to 5am)

Reduction of Traffic Accidents

Reduction of fatal traffic accidents -> Deaths from traffic accidents is reduced by less than 1/6 (430-> 70)

1) Combined repair of the traffic environment in the residential zone / introduction of the garage verification system in the residential zone

2) Improved safety of public transportation / reinforced security (prevention of crime) in public transportation

3) Reinforced speed restriction of vehicles on the main roads in the city (60-> 50km) / Construction of a system that immediately responds to all fatal traffic accidents

4) Operation of 'Seoul EYE' the dynamic control management system / 24-hour operation of the Seoul safety situation room

(Seoul Traffic Vision 2030)

6. Main Policy Contents

Night Bus

- Decision Making Group: Private Cooperative
- Policy Participating Group: Seoul city, KT (communication company)
- Other Parties of Interest: Taxi corporations, bus corporations, chauffeur corporations, citizens
- Process of Decision Making:
- Began at the request of citizens and developed as a service product through the cooperation of private and public organizations

Due to restricted resources in the beginning of the service and in a situation where there was no public night bus service, a demonstrative operation of restricted routes was necessary. And, in order for the demonstrative operation to perform its role as an accurate test, it was most important to apprehend the demand of night buses to plan optimum bus routes. Although there might be a demand, if the optimal locations are not properly understood to result in a poor usage rate of the test, there will occur the risk of arriving at the conclusion that night buses are unnecessary.

Here, rather than depending on existing bus operation data or the intuition of professionals, Seoul city decided to apprehend the actual demand of night buses using big data, particularly, taxi smart card data and communication history from mobile phones, which had been discussed locally and internationally for its usability at the time. Through several meetings between Seoul city employees and private professionals, the usability of big data was examined, and a joint initiation strategy was prepared. Specifically, the call location information was processed as 'destination data' and the billing address was processed as 'destination data' to deduce a floating pattern, which resulted in the determination of the night bus routes.

To achieve this, Seoul city concluded an MOU with KT Corporation and prepared a method of obtaining personal location data from mobile phone call history. Although KT Corporation recognized the value of call history, KT could not use the data due to the issue of the violation of privacy. Thus, the opportunity of using this data within the frame of a project for public benefit was welcomed by KT, and they decided to provide the call records to Seoul city, under the condition that the privacy of the consumers would be protected through methods of separating data field related to personal profiles.

After successfully operating the demonstration run of 3 months, 3 billion cases of calls from KT over the month of March 2013 were analyzed. As a result, it was indicated that the greatest floating population at night time was in Hongdae, followed by Dongdaemun, Shillim, Gangnam, Jongno, Garak Market, Shinchon, Nambu Terminal, Kondae, and Apgujeong. Upon analyzing the data of taxi rides during night time, Gangnam displayed the highest demand, followed by Shillim, Hongdae, Kondae, Dongdaemun, Gangbuk Office, Shinchon, Cheonho, Jongno, and Youngdeungpo. The call data and 5 million cases of taxi rides at night time were combined to visualize a pattern of the floating population on a map using the geographic information system (GIS) of Korean ESRI, which was analyzed on the 'Night Bus Route Establishment Support System' developed by the city.

The entire region of Seoul was divided into 1,250 cells of 1km radii, to indicate the floating population and traffic demand, and the existing bus routes, floating population at different times and days, and the pattern of traffic demand were analyzed. In addition, a reanalysis process was conducted, including a calculation of the weight of the floating population near the routes, to deduce the optimum routes and intervals (Seoul City, 2013). As a result, the routes were selected by constructing a radial network connecting 9 suburbs surrounding Gwanghwamun (Fig. 1). The results of the simulation verified that the predicted values obtained from the big data were approximate to the actual values, and thereby, the night bus routes were finalized.

Although N61 had been planned to pass through Nambusunhwan-ro and Dongil-ro at the beginning of the planning phase, the results of the analysis displayed that there was a high floating population in Hyoryeong-ro and Neungdong-ro, near Kondae and Nambu Terminal Station. Therefore, the route was modified, and N13, which was planned to pass through Jangchungdan-ro, was also modified to pass through Dongho-ro. With respect to the route number, N refers to night and the two numbers indicate the locations of departure and arrival. Seoul city was divided into 7 areas, with each area allocated with numbers from 0 to 6.

Visualization of the concentrated area of the floating population	Optimization with simulation of each route	Final route plan

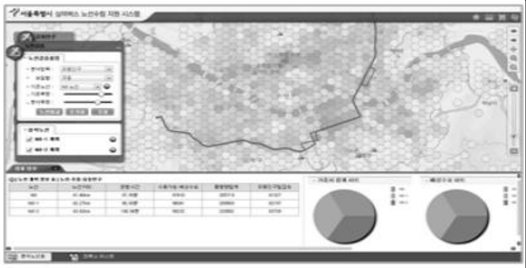
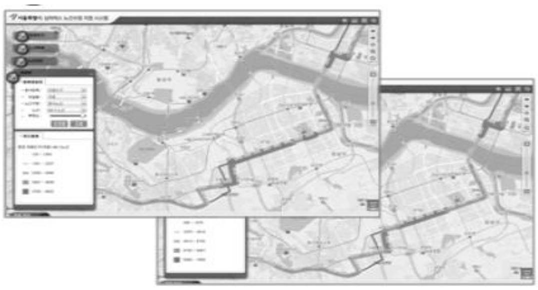
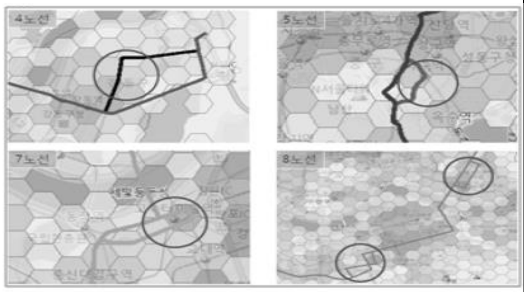
1. Analysis of the concentrated area of the floating population	2. Verification and optimization of the routes based on the floating population
	
3. Adjustment of the interval of buses based on the floating population	4. Reflection of the night bus routes based on the analysis result
	

Figure 1: Process of determining routes, intervals, and stations of the night bus

Source: Ma, K. K. 2015; Seoul City, 2013 (Seong, J. E., et al., recited from 2014)

<u>Main Features of the Service</u>

1) Demonstrative operations were conducted on two routes for three months from April 19, 2013, and as a result, it was displayed that the number of accumulated passengers was 218,212, which was higher than expected. This was calculated to a daily average of 2,098 night bus passengers,

with an average of 175 passengers per bus per day. This is 65 higher than the average of 110 passengers per day on standard buses.

After officially initiating 9 routes in September 2013, the official data was published in November 2013. According to this data, a total of 304 thousand passengers used the service for 50 days, which equates to an average of 6,079 passengers per day. Among which, 64.6% users were office workers, 23.5% were chauffeurs, and 11.9% were students (Seoul City, 2014).

With respect to the days of the week, the usage rate was the highest on Saturday morning, with 55.2% of the users concentrated within the 2 hours from 1am to 3am. The usage rate was relatively low during 12am to 1am and 4am to 5am, when subway and local buses were in operation. The usage rate was also affected by the distance of operation, and whether the route passed through subway stations, Jongno, and Gangnam. That is, the five routes where the number of passengers exceeded the average number of passengers had operating distances of over 70km, passed through more than 20 subway stations and passed through Jongno or Gangnam.

All 9 routes are displayed on Fig 2 below.

Figure 2: 9 Night Bus Routes
Source: Seoul City 2014.

The operating time of each route can be checked on the bus information terminal (BIT) installed at each bus station, the traffic information center mobile application (http://m.bus.go.kr), the TOPIS internet website (http://topis.seoul.go.kr) or the smart phone application ('Seoul Traffic Portal'). Meanwhile, the current transferrable regions are restricted to Seoul Station, Dongdaemun, Jongro, and Gangnam Station, where there are many passengers.

Three routes pass through Seoul Station, five routes pass through Dongdaemun, three routes pass through Jongno, and three routes pass through Gangnam Station.

3) The interval between buses is 40 to 45 minutes, which is rather long, but the buses would arrive and depart at the exact times in comparison to night buses. The fare is 2,150 won (Seoul City internal data, 2016) when paid with the traffic card. Buses on the four routes with the longest distances were planned to leave simultaneously from the garages on both ends, in order to minimize the space between intervals in both directions. Buses on the four routes with the shortest distance were planned to drive the full routes by turning at Seoul Station.

4) Through an open contest in June 2013, the brand name 'Owl Bus' was selected, and a character image of an owl driving a bus was designed. For the Owl Bus to be easily distinguished, the character is indicated beside the route number on the LED display on the front and sides of the bus.

Owl Bus N37 Night Bus

Figure 3: Logo selected in an open contest and the night bus electronic display

5) In a survey conducted on 500 passengers after three months of operating two routes, the night bus received a service satisfaction score of 80.15 points (74.3 points for standard buses), and 88.4% of 1,000 respondents indicated that they wanted 'the expansion of the service' in an additional survey. Thus, the service was expanded to 9 routes from September 12 of the same year.

6) The additionally selected 7 routes used the updated big data, as a result of which displayed that the floating population was concentrated in Gangnam, Hongdae, Dongdaemun, Shillim, and Jongno during night time. Thus, the initial plan was modified on six routes. Conclusively, a radial network that passes across the city from Gangnam was composed.

7) As a safety device, the speeding prevention device, which restricts the speed of the buses to 70km, was equipped on all night buses, and a partition wall was installed for the safety of the driver. Furthermore, an emergency contact network was constructed with nearby police stations in case of emergencies.

8) In order to prevent the drivers from participating in other work during the day time, night time exclusive drivers were employed, with an increase in their wage from 1.75 million won to 2.14 million won, and it is planned to allow the transfer of the night time drivers to day time based on their work evaluation.

9) A method of returning the profit to the operating corporations is being examined.

10) Illegal operation of cars on the bus routes that may conflict with the night buses are to be intensively controlled with the cooperation of the police (pursuant to Articles 81 and 82 of the Passenger Transport Service Act).

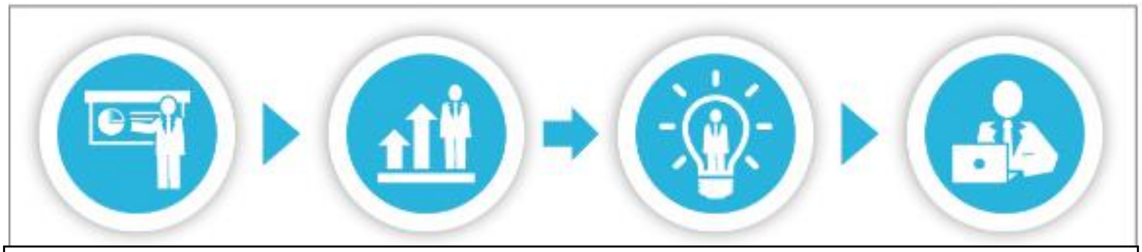
- Reduction of Traffic Accidents

Seoul City has established a traffic accident measure by analyzing various big data of 140 billion cases regarding the traffic accident history, weather, vehicle speeds, digital operation gauge, and floating population obtained by public and private organizations, and will be officially enforcing a traffic accident measure from early this year.

The traffic accident measure was prepared based on the results of intensively analyzing the five categories of traffic accidents of children and elderly pedestrians, traffic accidents on island bus road stations, drunk driving, and dangerous driving behavior. These five categories are specifically examined below.

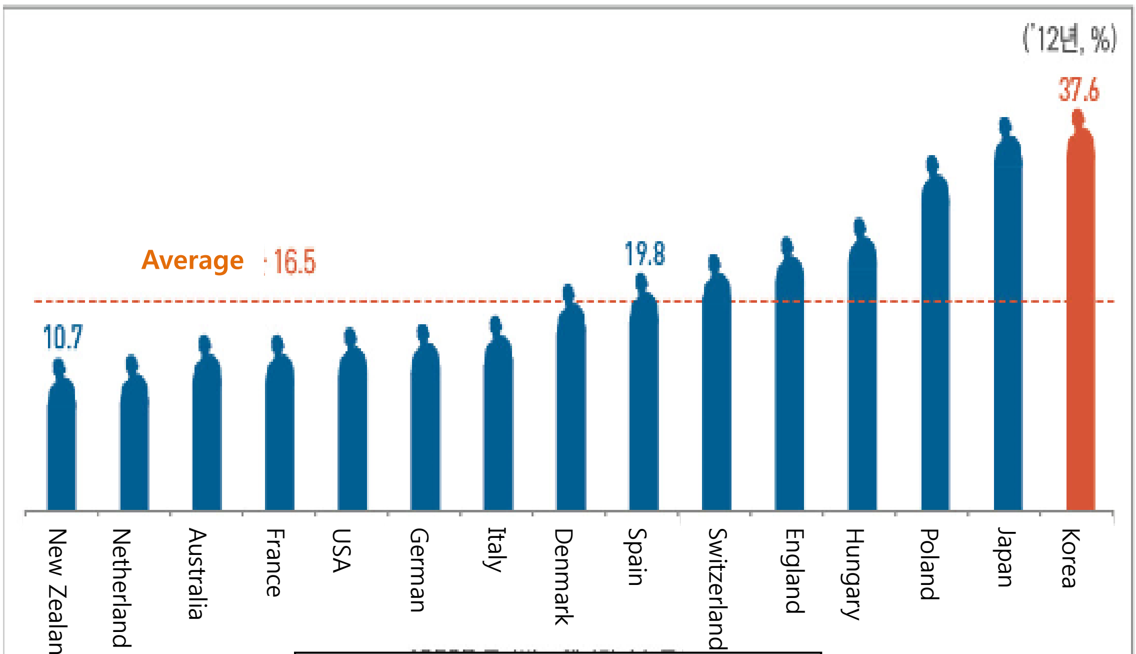
- Preparation of the Traffic Accident Measure through Big Data Analysis

The analysis of big data comprises an integrated analysis of the floating population, weather during relevant time periods, and surrounding traffic safety facilities, after reviewing the location and time of an accident from traffic accident history. To accurately analyze big data, Seoul city has composed the TF team for the collection and analysis of big data for one year. The TF team analyzed the correlation between data that were scattered, to reveal patterns in traffic accidents, and established a traffic safety measure based on the 'analysis result of the five categories'.



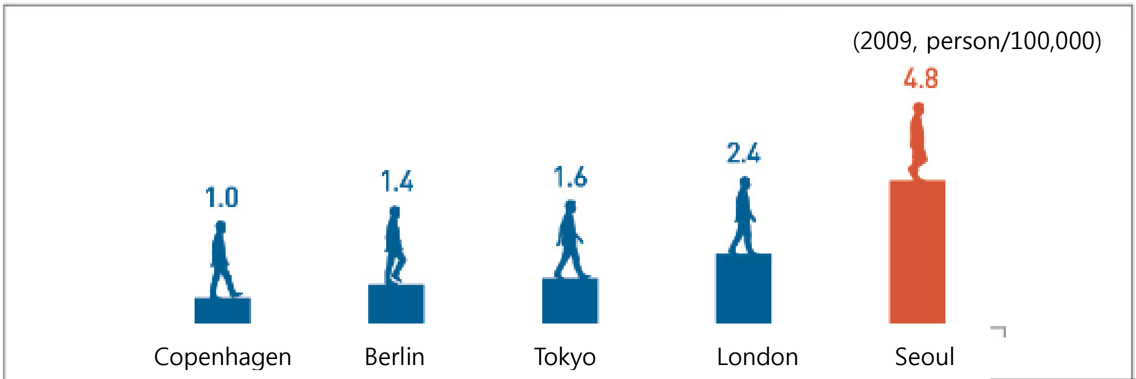
Data	Pattern	Insight	Policy

- Highest number of pedestrian deaths among OECD countries



Pedestrian deaths in each OECD

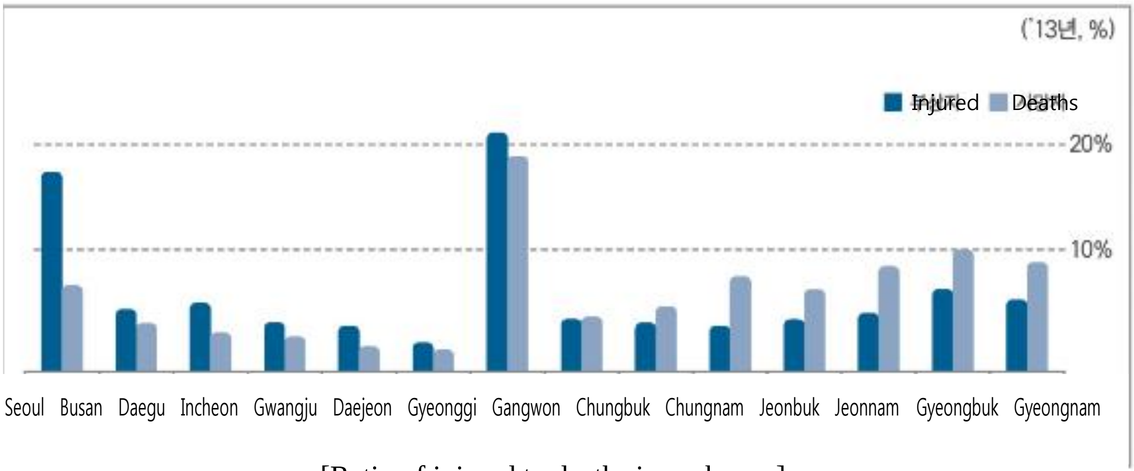
- Two to Four Times the Number of Deaths from Traffic Accidents in Comparison to Main Cities of the World



Number of Deaths from Traffic Accidents per 100,000 people in Different Cities of the World

* OECD average: 6.5 deaths
* National average (2013): 10.1 deaths
* Seoul average (2013): 3.8 deaths

- Remarkably high ratio of injured compared to deaths among Korean cities

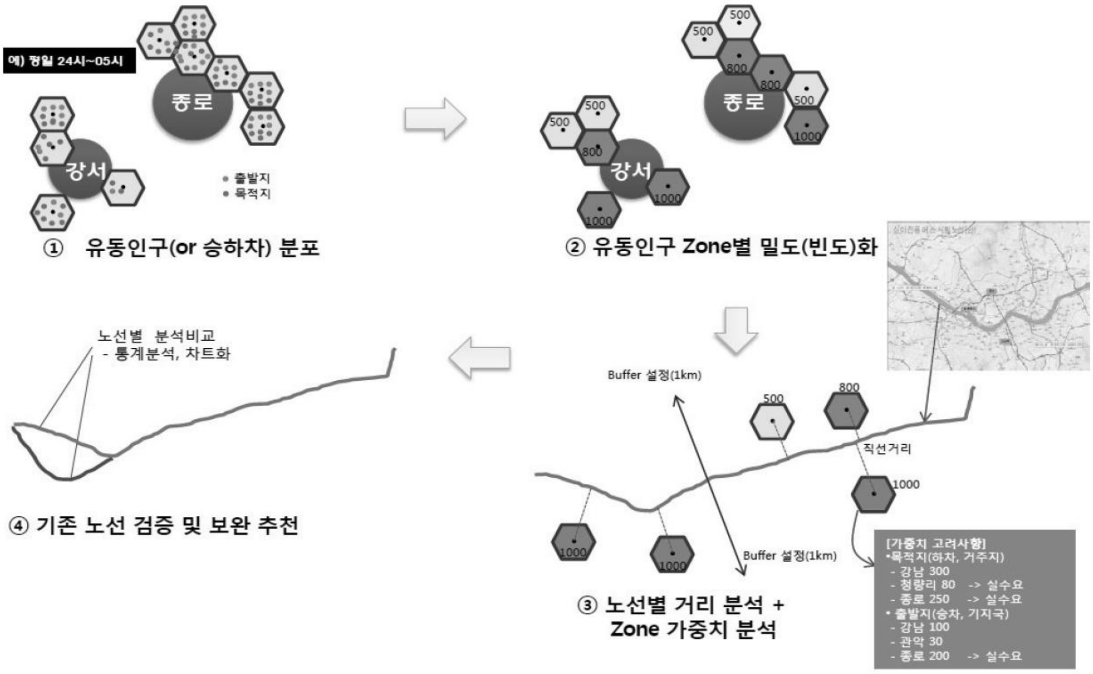


[Ratio of injured to deaths in each area]

7. Technical Details Night Bus

In view of the process of determining specific routes, the route analysis was conducted by creating a density map based on the starting point and destination, and a relevant buffer was set to calculate the actual demand on the hexagon within the buffer. Here, the weight of each distance was calculated, and the difference between existing routes and the routes formed as a result of the statistics were verified. The amount of transportation was indicated by a hexagon at each bus stop, and the buffer was set, followed by the application and calculation of data for each destination and starting point.

Furthermore, the spaces between each bus stop were connected with a line, and any overlapping lines were thickened to visualize the system. Here, the demand for the night bus was calculated by reflecting the floating population. During this process, the modification of bus stops and routes was proposed concerning 8 routes, which was partially accommodated. Through cooperation with bus policy organizations, routes with greater demands and floating populations were created (Seoul City, 2013).



1. Distribution of floating population (or boarding / deboarding)	2. Density of floating population per zone
4. Recommended verification and supplementation of the existing routes	3. Analysis of distance for each route + analysis of weight of each zone

Figure 4: Seoul City Night Bus Intensive Analysis Chart

Source: Seoul City, 2013

- Reduction of Traffic Accidents: http://www.slideshare.net/crashs/ss-45876300

8. Policy Effects

<u>Night Bus</u>

1) The night bus route, which was designed with the use of big data, achieved an amount of transportation that exceeds 5 to 10% of existing routes.

2) The citizens that participated in night activities saved transportation costs, and the usefulness of a safe, convenience, and affordable night transportation means is estimated to have increased the participants' night activities (verified by the research of sales at night spots near the routes). In fact, the female population participating in night activities increased by 11% (Seoul City 2014).

3) There is the effect of preventing night crime (possibility of collecting substantive data).

4) The rejection of passengers by taxis reduced by 8.9% as an additional effect.

5) Within the increasing domestic and international interest in the usability of big data, this became a very practical case that noticeably relieved the inconvenience of the citizens at a small cost. Thus, it displayed a future-oriented aspect of administration that moves with innovation and dynamicity.

6) This policy was selected as the second place in the top 10 policy vote during the first half of 2013, and was reported in various national and international media outlets.

Currently, there are increasing domestic and foreign organizations and public officials that wish to share Seoul city's big data administration and place Seoul city as an informatization benchmarking city model. As an example, the CEO of NESTA, the British National Science, Technology and Arts Foundation visited Seoul city to inspect the night bus route establishment system, and visited other cities and organizations, including Taipei in Taiwan, Jakarta in Indonesia, and the World Bank to disclose a case publication in relation to using big data.

Reduction of traffic accidents

http://www.slideshare.net/crashs/ss-45876300

(Composition of institutional effect/response means for each group in the link below)

- Traffic accidents involving child pedestrians
- Traffic accidents involving elderly pedestrians
- Traffic accidents in island bus road stations
- Accidents from drunk driving
- Analysis of dangerous driving behaviors

9. Challenges and Solutions

Challenges in the administrative procedure to use big data

IT technologies are necessary in the use of big data in policies. However, the administrative procedure for the practical use of big data may be more complicated and difficult. Hardware and software technologies that process big data can be procured through global IT technologies, and thus, it may be a rather simple problem, whereas the administrative procedure is fundamentally much more complex.

During the early phases where experience was insufficient, trials and errors were unavoidable. However, based on the experience accumulated by conducting various projects related to big data, such as the selection of the night bus routes and the analysis of the elderly welfare facility sites, Seoul city developed an administrative framework that can efficiently manage big data-related administrative procedures. This was completed in five stages, and divided into 14 activities and 41 tasks. Through this framework verified by the execution of actual projects, Seoul city was able to more efficiently find resolutions by systematically operating the relationship of various parties of interest in any succeeding big data-related projects.

For instance, an intimate cooperation between the department obtaining data and the IT department handling big data was important. Through several education programs and workshops, a bond of sympathy and the will to actively cooperate with one another was formed between the departments and these formed the core elements of achieving a successful project. Furthermore, the priority task was deduced by conducting a big data curator nurturing course, and the problems and difficulties were shared with various external organizations, such as private organizations, academic organizations, and research institutes, in order to collect opinions, and thereby constructing a cooperation network (seoulsolution.go.kr).

Burden of Financial Support

According to the quasi-public bus system agreement, which enforced service enhancement through guaranteed stable management of bus companies and enhanced usage of public transportation by Seoul city from 2004, financial support was provided. The amount of financial support provided to supplement the deficit of local buses reached 1 trillion 469.4 billion won from July 2004 to July 2014. The deficit compensation increased from 94.2 trillion won in 2003 before the enforcement of the quasi-public system to 230 trillion won in 2014, which continually increased since the enforcement of the quasi-public system. It is indicated that one of the reasons for the increase in the financial support cost is that there is no longer a need to modify or cancel the routes of buses displaying poor usage, since financial support is guaranteed for deficits of local buses.

Night buses also display a concentrated usage rate during 1am to 3am, and thus, it is possible that a deficit will result during other times on certain routes. In order for the night bus system to become establish as a system that has steady institutional effects and has the advantage of preventing any additional financial consumption, there would be a need to adjust the interval of buses by considering the time periods.

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Exclusive Median Bus Lane Network

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1. Policy Implementation Period

Buses have been serving citizens for decades as one of the most typical public transport modes along with subways; however, irregular service intervals due to traffic congestion have caused inconveniences and led to citizens gradually avoiding bus use. As a consequence, the exclusive median bus lane system was first introduced in the second half of 1986 as part of the bus priority policy, one of the ways to induce the transition from private cars to public transport modes in the wake of a vicious cycle of increasing the use of private cars and increasing traffic congestion.

Since the first exclusive median bus lane system was implemented by installing roadside exclusive bus lanes on Wangsan Road in 1986, the total length of exclusive bus lanes reached 224.5km in 1999. The exclusive median bus lane system designating the median lanes of road as the exclusive median bus lanes was first introduced to Cheonho-daero in 1996, and it has been regularized since the time of reorganizing the popular transportation system by Seoul Metropolitan Government in 2004.

Since its introduction in July 2004 to Dobong-Mia-ro, Susaek- Seongsan-ro and Gangnam-daero, it has been expanded on average by 15km per year mainly on roads with heavy traffic congestion.By the end of 2014, 117.5km of exclusive median bus lanes have been built and operated thus providing fast and safe bus services by connecting major arterial roads without clogging.

As of 2016, 119.3 km of lanes designed for the exclusive use of buses, in an effort to increase efficiency and customer satisfaction, are operated throughout the city of Seoul.

2. Background Implementation

[6] Translation by ESL®

Until the 1960s, bus transportation served as a central role in public transportation. However, its role had gradually declined due to the increase in private cars following the continuous economic growth since the 1970s and the development of other public transportation systems resulting from the expansion of urban areas. The rapid increase in private cars caused traffic congestion problem in large cities. Among the traffic system management techniques that appeared to solve this problem, the exclusive median bus lane system reaffirmed the importance of the bus.

The Traffic System Management Act, which has been enforced since the early 1970s, was a short-term low-investment method designed to curb traffic demand and to optimize the use of existing traffic facilities, while the existing method was a long-term high-investment method focused on increasing traffic facilities. The exclusive median bus lane system is one of these traffic system management techniques, and is a way predicted to anticipate the transition from the demand for private cars to that of buses through the improvement of bus and its services, in particular, as a method of simultaneously reducing the demand and supply of traffic.

Such an exclusive median bus lane system enables the same transportation capacity as light rail transit at a much lower investment cost than a subway system; moreover, it can be easily improved or restored during operation. Most of all, it is effective in encouraging the conversion from the demand for private cars to that of buses.

In South Korea, since the exclusive median bus lane system was implemented for the first time by installing a roadside exclusive bus lane on Wangsan Road in 1986, a total of 218.5km exclusive bus lanes have been installed in 59 sections.

- Full-time - 23 sections, 46.1km (07: 00-21: 00)
- Part-time - 18 sections, 44.6 km (07: 00-10: 00, 17: 00-21: 00)
- Exclusive median lane - 12 Corridors, 119.3km

3. The Importance of the Policy

The importance of exclusive median bus lane policies had previously been theoretically emphasized by US and UK traffic scholars (Downs 1977; Mogridge and Williams 1985). In other words, according to the theory, if a road is expanded or newly established to mitigate traffic congestion, it will have a short-term effect on improving the travel speed first. However, the capacity of the expanded road will encourage new traffic and the speed will increase again in the long-term while the policy that increases only the travel speed of public transportation can have a positive effect on relieving traffic congestion by increasing the travel speed of both public transport modes and private cars through attracting traffic users to public transportation.

In fact, it was observed that not only bus travel time but also the speed of the normal lane was improved in the exclusive median bus lane system which was carried out at the time of reorganization of public transportation in Seoul. In other words, this policy is an example of exemplary policy implementation that realized the theoretically proven effect of increasing public transport speeds. It has thus been seen as one of the main policies that has enabled movement among the various means of transportation, which was at the time very difficult due to an ever increasing use of private cars. It is difficult to separate the effects of individual policies because public transport reorganization is being achieved as an overall blend of diverse policies, but in the absence of such a series of popular public transport policies, automobile owners would have continued to use their cars, then as in other cities confronted with similar situations, the car-centered culture would have persisted as ownership and use of cars continued to rise. Such a dependence on cars would have continued, making the conversion of the transportation means extremely difficult. This is an important policy that has contributed greatly to the Seoul-style flexibility in the modes of transport where the car owners do not solely rely on their cars but also on public transportation depending on situations as a mixed result of the overall policies that have increased the competitiveness of the bus when compared to car – such as the integration of bus routes, integration of fares and automation of traffic information.

4. Relevance with Other Policies

The establishment of exclusive median bus lanes in Seoul has made the most remarkable progress within the larger framework of the transition level of public transport system reform, as is widely known. Therefore, it is closely related to major policy factors that constitute the public transportation system – such as the integration of bus service routes, integration of fares, transfer center, traffic information integration and planning. In particular, the exclusive median bus lanes that were installed together with these means of 'integration' were able to have a clearer effect compared to the previous roadside exclusive median bus lanes partly because of the physical difference between the median lane and the roadside bus lane, naturally. But this policy was related to a series of policies that enhance the competitiveness of buses in general in that a single policy that strengthens the competitiveness of buses when compared to cars has limited effects and users are able to detect the effect only when it was generated in combination with other policies. This policy is most closely and directly related to the policy measures that can shorten bus travel times.

The direct policy objective of exclusive median bus lanes is to shorten these travel times. This is the ultimate goal of car users when switching from a car to a bus. However, bus travel times from a user’s point of view also includes the time getting to the bus stop, bus waiting time and bus stop departure time as well as the time spent on the bus. It may also include the time while the bus itself waits to comply with bus timetables after boarding. In addition, exclusive median bus lanes (with the aim of maintaining relatively higher bus running speeds than those of other vehicles) are only effective in overcoming a drop in driving speed due to congestion; however, the cannot control other factors such as signaling systems and accident vehicles. Therefore, this policy is closely related to overall policy measures that can reduce the total travel time of the buses such as the integration of charges mobilized in public transportation integration and, in particular, electronic freight payment means, service linkage with other public transport modes, bus stop connections and the automation of public transport information as well as having a close complementary relation with a series of TSM (Transport System Management) such as signaling system synchronization, bus priority signal system, control and management of bus stops and surveillance of illegal parking and illegal use of exclusive median bus lanes.

5. Policy Objectives and Processes

The policy objective of the exclusive median bus lane system is to secure lanes that can only be used by buses in the regions where the average travel speed is habitually low due to traffic congestion, thereby allowing the bus to maintain a superior travel speed when compared to cars using the remaining lanes as well as to actively encourage the people who use cars to switch to buses.

The following conceptual flow chart shows well how the installation of exclusive median bus lanes can lead to the transition from cars to public transportation and contribute to the improvement of overall road conditions.

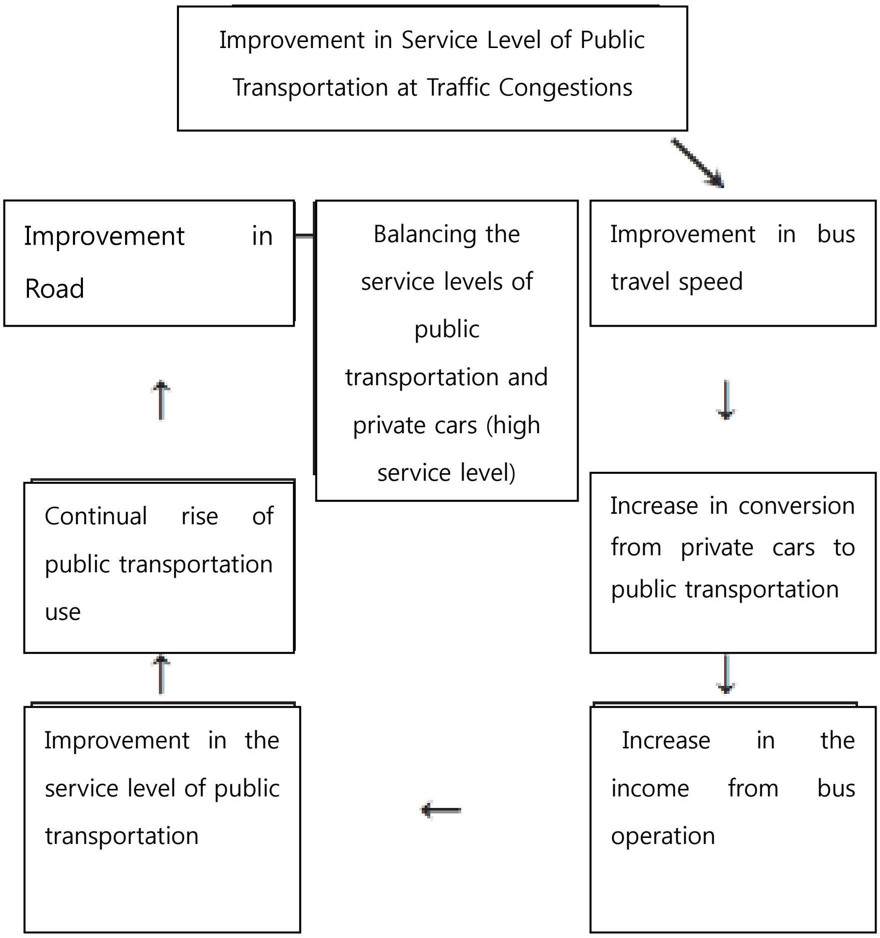

Figure 1. Improvement in Congestion by the Introduction of Exclusive Median Bus Lanes

Source: Han, Sang-Jin (2007) Opinion

<u>Installation Process of Exclusive Median Bus Lane by Year</u>

The following three figures show the gradual expansion and distribution of exclusive median bus lanes

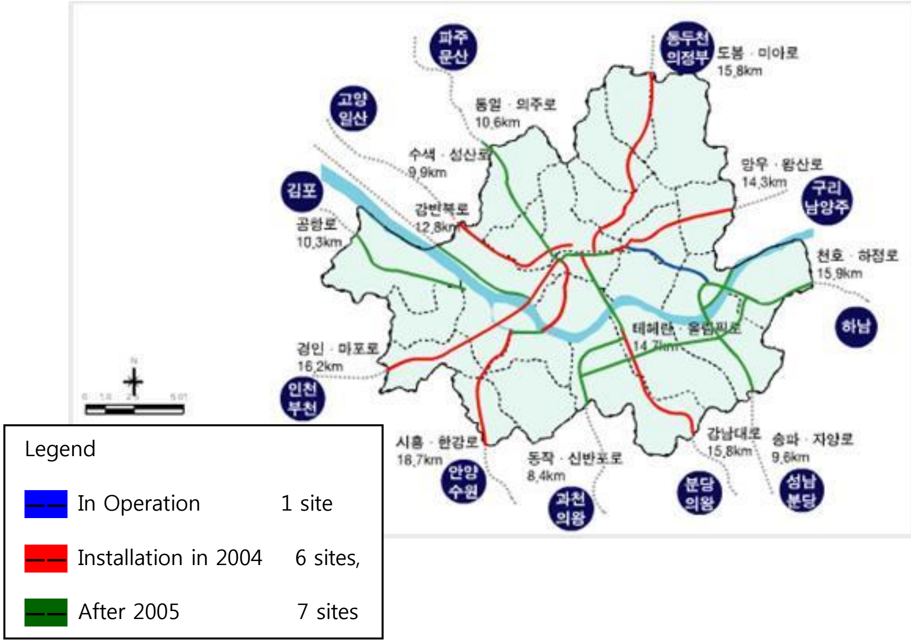

Figure 2: Installation Planning Map of Exclusive Median Bus Lanes in Seoul Metropolitan Government, Ministry of Land, Transport and Maritime Affairs, 2004

Figure 3: Installation Planning Map of Exclusive Median Bus Lanes in Seoul Metropolitan Government, Ministry of Land, Transport and Maritime Affairs, 2008

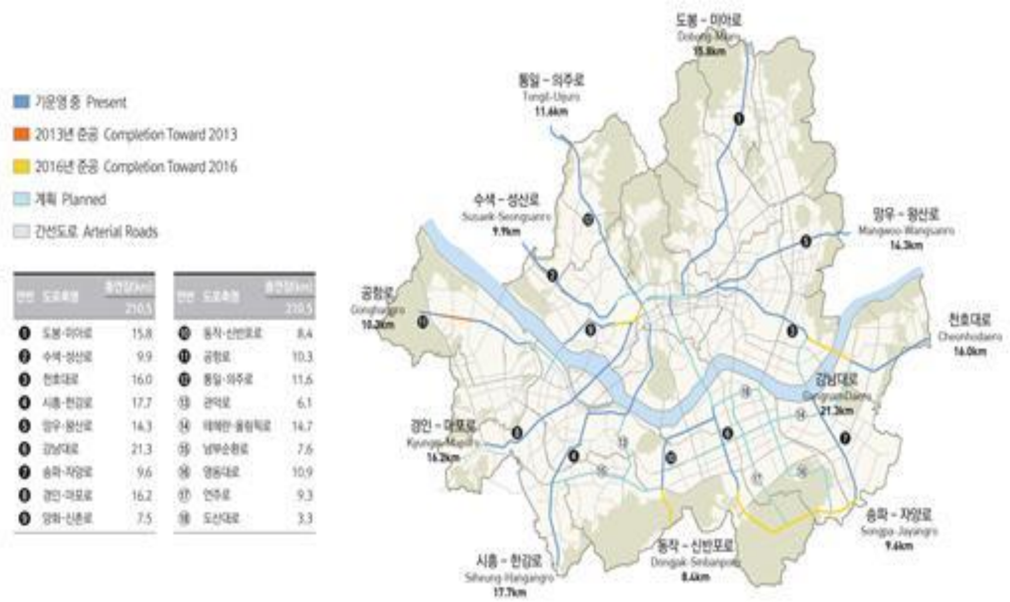

Figure 4: Installation Planning Map of Exclusive Median Bus Lanes in Seoul Metropolitan Government, Ministry of Land, Transport and Maritime Affairs, 2013

6. Main Policy Contents

The exclusive median bus lane system in Seoul was first introduced in 1986 based on the Road Traffic Act, and a total of 218.5km exclusive bus lanes have been installed in 59 sections since first appearing on Wangsan Road and Han River-daero.

As for exclusive median bus lanes, there are roadside exclusive bus lanes and exclusive median bus lanes. For the roadside exclusive bus lanes, the length of the exclusive bus lanes decreased from 224.5km in 1999 to 89.3km in 2011, while the number of exclusive median bus lanes increased from 4.5km in 1999 to 121.1km in 2011, which is more than 30 times increase. The roadside exclusive bus lanes are installed on the roadway on the roadside, divided into full time (07:00 to 21:00 on weekdays) and part time periods (07:00 to 10:00 and 17:00 to 21:00 on weekdays), and are not in operation on Saturdays, Sundays and public holidays.

The exclusive median bus lanes provide exclusive lanes to the median lane of existing roads and may also be equipped with protective fences to prevent the entry of other vehicles. While the smooth driving on the roadside exclusive lanes is often interrupted by parked vehicles or vehicles turning right, there is no need to reduce the speed while driving on the exclusive median bus lanes because of far fewer interventions from other vehicles. Therefore, there has been a tendency to reduce the number of roadside exclusive bus lanes and to increase the number of exclusive median buses because achieving the primary purpose of maintaining a superior driving speed is more certain. The first 24-hour exclusive median bus lane on the common road was opened on Cheonho-daero, and in 2004, the exclusive median bus lanes were put into full operation in Gangnam-daero and so on along with the Seoul Metropolitan bus reorganization.

The exclusive median bus lane was introduced as part of the public transport system reorganization project in 2004 and has been continuously expanded for more than 10 years.

The Seoul Metropolitan Government has already been building radial median exclusive median bus lanes with its center downtown, and will further establish an east-west connection system linking the sub-downtown areas (see Figure 4).

Currently, the Seoul Metropolitan Government is working toward increasing the current distance of median exclusive median bus lanes in operation in 12 corridors from 115.3km to 134.5km adding 19.2km by 2016. Moreover, it will also improve the connectivity of the median lanes by examining the construction of the exclusive median bus lanes on the arterial roads that connect sub-downtowns east and west.

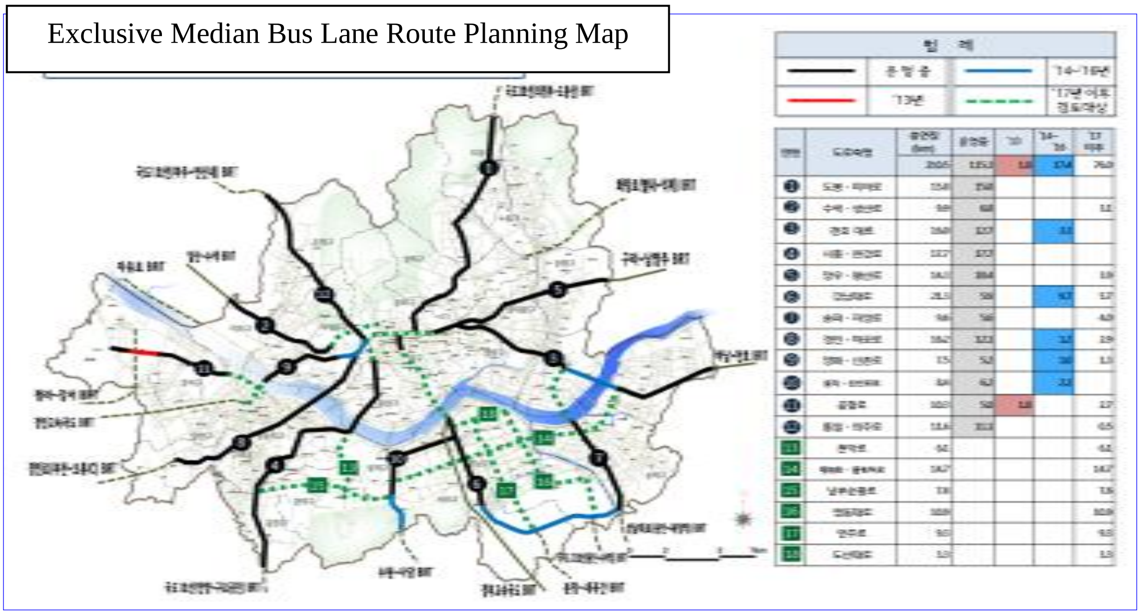

Figure 5: Seoul Metropolitan Government Exclusive Median Bus Lanes Planning Map

Source: Traffic Operation Information Service, 2013

First, five additional sections will be installed by 2016, which will increase the efficiency of the existing exclusive median bus lanes by linking the disconnected sections among the already existing sections or by being built on the visual sections and other areas linking the metropolitan BRT (arterial bus express system) routes that are being pursued by the central government.

For the first time, all sections of the exclusive median bus lanes on Gonghang-ro that connect Gimpo Airport to Yanghwa Bridge were connected.

In 2013, 1.8km of exclusive median bus lanes were installed in the Magok district section (Airport Telephone Station ~ Balsan Station), which had not been installed with exclusive median bus lanes. In addition, the connectivity of downtown section bus lanes was enhanced in 2014 by additionally installing 2.2km of exclusive median bus lanes on Yanghwa-Sinchon-ro that were installed only from the northern end of Yanghwa Grand Bridge to EwhaWomans Univ. in order to stretch them to Seodaemun Intersection (Chungjung-ro section).

❍ Installation of exclusive median bus lanes: Expansion by adding 4 routes of 18.4km by '17

- By 2017: 4 routes of 18.4 km

(Cheonho-daero 3.3 km, Hyeong-ro 9.7 km, Jong-ro 4.0 km, and Namdaemun-ro 1.4 km)

In addition to these additional connecting sections, the Seoul Metropolitan Government plans to expand the exclusive median bus lanes for the corridors that link sub-downtown areas east and west. In the meantime, the system has been configured with radial exclusive median bus lanes consisting of 12 road corridors stretching to all directions with its center in the downtown area in which the 'Sadaemuns' are located. However, an examination of the feasibility of installing exclusive median lanes to connect the sub-downtown areas such as Gwanak-ro and South Circular Road is scheduled to take place.

Table 1: Exclusive Median Bus Lane Promotion and Planning

Year	Name of Route	Extension (km)	Promotion & Planning	Remark
2013	Extension of Gonghang-ro (Magok District)	1.8km	Dec. 2013 Opening plan	In connection with Magok district businesses
2014	Chungjeong-ro	2.2km	In connection with the dismantling of the elevated highway	dismantling of the elevated highwayin 2014
2015	Cheonho-daeroExtension	3.3km	In connection with the extension of Cheonho-daero	Extension construction
2016	Dongjak-daero Extension	2.2km	Connecting Namtaeryeong~Sadang Section	
	Heonreung-ro	9.7km	Promoted in terms of Wirye New City project progress status	
Total	-	19.2km	-	

Source: Traffic Operation Information Service, 2013

7. Technical Details

Seoul Metropolitan Government is currently taking the volume of bus traffic and the number of bus transportation passengers as criteria for the types of new installation and the operation of exclusive lanes. The installation criteria are as follows:

For one-way three-lane roads

- Roadside exclusive lanes considered if:
- 60 cars per hour or more and 1,800 people per hour or more
- Roadside exclusive lanes considered if 100 cars perhour or more and 3,000 people per hour or more, it is possible to provide contra-flow exclusive lanes
- It is possible to provide median exclusive lanes if 150 cars per hour or more and 4,500 people per hour or more, overtaking lanes at the bus stops provided.

For one-way four-lane roads:

- Roadside exclusive lanes and overtaking lanes at the bus stops offered if 100 cars per hour or more and 3,000 persons per hour or more.
- It is possible to offer median lanes and overtaking lanes at bus stops when 150 cars per hour or more and 4,500 people per hour or more

8. Policy Effects

Bus travel speeds increased by about 30% compared to pre-construction time of the exclusive median bus lanes, while the average number of passengers increased by 4 - 7%

According to the results from the analysis of the effects of installing median bus lanes in Seoul Metropolitan Government area, the speed of bus travel has been seen to be slightly different for each road. However, the installation was analyzed to be effective in enhancing the convenience of citizens using public transportation because of an approximately 30% improvement in the average speed of travel at peak times.

The average speed of buses was improved by about 30% from about 15km / h before the opening to about 20km / h.

Particularly, in the case of Dobong-Mia-ro, which used to suffer from serious traffic congestion, the average speed of buses was improved by 9.0km / h (81.8%) from 11.0km / h before the installation of exclusive median bus lanes to 20.0km / h,

Table 2. Increase / Decrease Ratio of Median Bus Lane Travel Time

Opening Date	Road Name	Extension(km)	Speed before Opening (km/h)	Speed after Opening (km/h)	Increase / Decrease Ratio of Travel Time
‘04.07	Dobong-Mia-ro	15.8	11.0	20.0	81.8%
	Susaek-Seongsan-ro	6.8	13.1	19.9	51.9%
	Gangnam-daero	4.8	13.0	17.3	33.1%
‘05.07	Mangwu-ro	4.8	17.6	20.9	18.8%
	Kyeongin-ro	6.8	14.3	19.3	35.0%
‘05.12	Siheung-Daebang-ro	9.4	15.5	20.7	33.5%
‘06.12	Hangang-ro	5.5	17.4	21.9	25.9%
	Mapo-ro	5.3	14.5	19.1	31.7%
‘08.01	Songpa-daero	5.6	17.1	20.3	18.7%
‘09.04	Gonghang-ro (Level 1)	2.5	16.5	18.5	12.1%
‘09.05	Noryangjin-ro	2.8	16.4	21.6	31.7%
‘09.06	Sinbanpo-ro	3.5	18.4	20.9	13.6%
‘09.11	Dongjak-daero	2.6	17.2	21.0	22.1%
‘09.12	Yanghwa, Shinchon Road	5.2	16.2	18.6	14.8%
‘10.08	Gonghang-ro (Level 2)	2.3	14.8	19.6	32.4%
	Mangwu-roExtension	2.2	18.7	21.2	13.4%
‘10.12	Tongil-Uiju-ro, (Level 1)	3.3	18.6	20.9	12.4%
‘11.03	Cheonho-daero (BRT)	5.1 (excluding Hanam-si Section)	17.9	18.7	3.9%
‘11.12	Tongil-Uiju-ro, (Level 2)	5.4	12.3	19.0	55.1%
	Wangsan-ro	3.4	15.8	18.7	18.4%

Source: Traffic Operation Information Service, 2013

Secondly, it was shown that the exclusive median bus lanes contributed greatly to securing the accuracy of the arrival time of buses. The travel time deviation of the buses passing through the exclusive median bus lanes turned out to be at the level of ± 1 ~ 2 minutes, which means that there was much less deviation when compared to vehicles traveling the same distance using regular lanes. For example, in the case of Dobong-Mia Road (15.8km), where the average travel time for buses is 44.3 minutes, the buses have a deviation in travel time of ± 2.7 minutes, while the level of private cars is at ± 15.3 minutes.

As a result, the buses of the same route did not move around in groups, they were properly arranged according to the bus stops, and the jagged arrival intervals were eliminated. It thus became possible to provide citizens with more convenient public transportation services at regular time intervals.

Table 3. Travel Time Deviations of Bus Median Lanes

Road Name	Extension (km)	Average Travel Time of Vehicle (min)	Deviation of Travel Time (min)	
			Bus	General Vehicles
Dobong-Mia-ro	15.8	44.3	± 2.7	± 15.3
Susaek-Seongsan-ro	6.8	18.1	± 1.2	± 15.6
Gangnam-daero	4.8	16.7	± 1.3	± 4.6
Mangwu-ro	4.8	14.8	± 1.4	± 4.9
Kyeongin-ro	6.8	16.9	± 3.1	± 9.2
Siheung-Daebang-ro	9.4	22.7	± 1.2	± 4.6
Hangang-ro	5.5	15.1	± 1.1	± 5.4
Mapo-ro	5.3	16.4	± 1.0	± 5.6
Songpa-daero	5.6	15.7	± 1.6	± 4.1
Gonghang-ro (Level 1)	2.5	5.8	± 0.4	± 0.7
Noryangjin-ro	2.8	6.8	± 1.2	± 3.0
Sinbanpo-ro	3.5	9.0	± 3.0	± 6.2
Dongjak-daero	2.6	7.7	± 0.9	± 1.8
Yanghwa, Shinchon Road	5.2	13.4	± 1.8	± 3.4
Gonghang-ro (Level 2)	2.3	15.1	± 1.4	± 1.8
Mangwu-roExtension	2.2	6.3	± 0.9	± 1.0
Tongil-Uiju-ro, (Level 1)	3.3	10.9	± 1.0	± 1.6
Cheonho-daero (BRT)	5.1 (excluding Hanam-si Section)	30.2 (including Hanam-si Section)	± 2.1	± 1.0
Tongil-Uiju-ro (Level 2)	5.4	15.3	± 2.8	± 5.4
Wangsan-ro	3.4	10.3	± 0.4	± 1.4

Source: Traffic Operation Information Service, 2013

The number of bus passengers increased by 4-7% on average compared to the pre-construction time of exclusive median bus lanes even if there were still slight differences depending on the road.

Table 4. Transition Trend of the Bus Passengers on the Exclusive Median Bus Lanes by Road Opened Since 2009

(Unit: thousand persons / month)

Name of Road	Extension (km)	Before Opening	After Opening	Increasing Rate of Passengers
Dongjak-daero	2.6	2,491	2,679	7.0%
Yanghwa-Sinchon-ro	5.2	16,228	16,342	0.7%
Gonghang-ro (Level 2)	2.3	11,072	13,743	24.1%
Mangwu-ro Extension	2.2	11,023	11,501	4.3%

Source: Traffic Operation Information Service, 2013

In particular, as a result of comparing the numbers of bus passengers in Tongil-ro (Eunpyeong New Town –Seodaemun-intersection, 11.1km), which was fully opened in December, 2011, the number after the opening was analyzed to have increased by about 15% compared to that of before the opening.

Table 5. Transition Trend of Bus Passengers on Tongil-ro Exclusive Median Bus Lanes

(based on weekdays, unit: persons)

Before Opening (‘10. 4)[A]	After Opening (‘12. 4)[B]	Variation [B-A]
78,218	89,304	11,086(15.1%)

※ Average daily passengers on five routes (701,703,704,706,720) from Gupabal to Seoul Station

Source: Traffic Operation Information Service, 2013

The daily total number of bus users in Seoul was 4.78 million in 2004 during the early stage of the introduction of the exclusive median bus lanes; however, it increased to approximately 5.8 million (an average 21% increase on a daily basis) in 2011.Therefore, Seoul Metropolitan Government regards the establishment of exclusive median bus lanes as having been effective in the activation of public transportation use.

9. Challenges and Solutions

Transient Increase in Traffic Accidents

In the early days of the implementation of the exclusive median bus lane system, traffic accidents tended to increase temporarily due to the unauthorized crossing of pedestrians and public transportation users who were as yet adjusted to the newly changed traffic system and speed of buses. However, the number of accidents has been decreasing every year along with the continuous expansion of exclusive median buses as a result of the increase in citizen awareness and the settlement of orderly traffic culture due to the continuous promotion of the exclusive median bus lane system.

In addition, in order to reduce traffic accidents, the installation of safety fences around the exclusive median stops and crosswalks, shock absorbers at road junctions, photovoltaic rechargeable raised pavement markers for guiding the lanes and speeding prevention facilities at the stops were carried out along with regular safety education programs for bus transportation service workers.

Insufficient Capacity of Exclusive Median Bus Stops

For some bus stops and general traffic congestion points where build up occurs due to the concentration of passengers getting on and off after the operation of the exclusive median bus lanes, Seoul Metropolitan Government will strive to resolve the inconvenience of the citizens using buses as well as general vehicles by carrying out various projects to enhance the capacity of bus stops as well as traffic improvement projects to relieve traffic congestion. It will also continue to complement the factors of traffic safety inhibition and communication obstacles by observing traffic situations in sections within the exclusive median bus lanes.

Measures to Overcome Problems and Implementation Status

In its early days, the traffic accidents on the exclusive median bus lanes tended to increase temporarily due to the unauthorized crossing of pedestrians and public transportation users who were as yet adjusted to the newly changed traffic system and speed of buses. In the meantime, the number of accidents has been decreasing every year along with the continuous expansion of exclusive median buses as a result of the increase in citizen awareness and the settlement of orderly traffic culture due to the continuous promotion of the exclusive median bus lane system.

Since 2009, the Seoul Metropolitan Government has been improving 40 exclusive median bus lanes in the city – including the expansion of exclusive median stops (11 places) on Gangnam-daero– by promoting the 'Improvement Project for Exclusive Median Bus Lanes'.

In 2011, the exclusive median stops (11 places) on Gangnam-daero with high air-density due to a small stop compared to the citizens using it was extended (stopping lane 4 → 5, the platform width 3m → 4m), and last year, a bus stop was newly established in front of Suyu Station on Dobong-Mia-ro to enhance the convenience of the transfer with Subway Line 4.

In the future, Seoul Metropolitan Government will continue to improve the operation of the exclusive median bus lanes efficiently in accordance with the changes in the local environments and traffic conditions by promoting improvement measures such as optimizing the intersection signal times and promoting bypass routes in order to alleviate the congestion in the exclusive median bus lane on Wonsan-ro, which runs from Shinseol-dong to Cheongyang-ri. It will also look toward expanding the stop of the exclusive median bus lane in front of Gyeongin Road dome stadium following the opening of the dome stadium in southwestern region.

In order to reduce traffic accidents in other sections, the installation of safety fences around the exclusive median stops and crosswalks, shock absorbers at road junctions, photovoltaic rechargeable raised pavement markers for lane guidance and speed prevention facilities at the stops were carried out along with the regular safety education programs for bus transportation service workers. In addition, for some bus stops and general traffic congestion points where build up occurs due to the concentration of passengers getting on and off after the operation of the exclusive median bus lanes, Seoul Metropolitan Government will strive to resolve the inconvenience of the citizens using buses as well as general vehicles by carrying out various projects to enhance the capacity of bus stops and traffic improvement projects to relieve traffic congestion. It will also continue to complement the factors of traffic safety inhibition and communication obstacles by observing the traffic situations of the sections within the exclusive median bus lanes.

In the future, Seoul Metropolitan Government plans not just to construct exclusive median bus lanes, but even to improve the function of exclusive median bus lanes by continuing to find out the points from the existing sections which are in operation where traffic congestion occurs and incontinences in using the buses incur.

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Reduction of Car Travel: Transportation Demand Management (TDM)

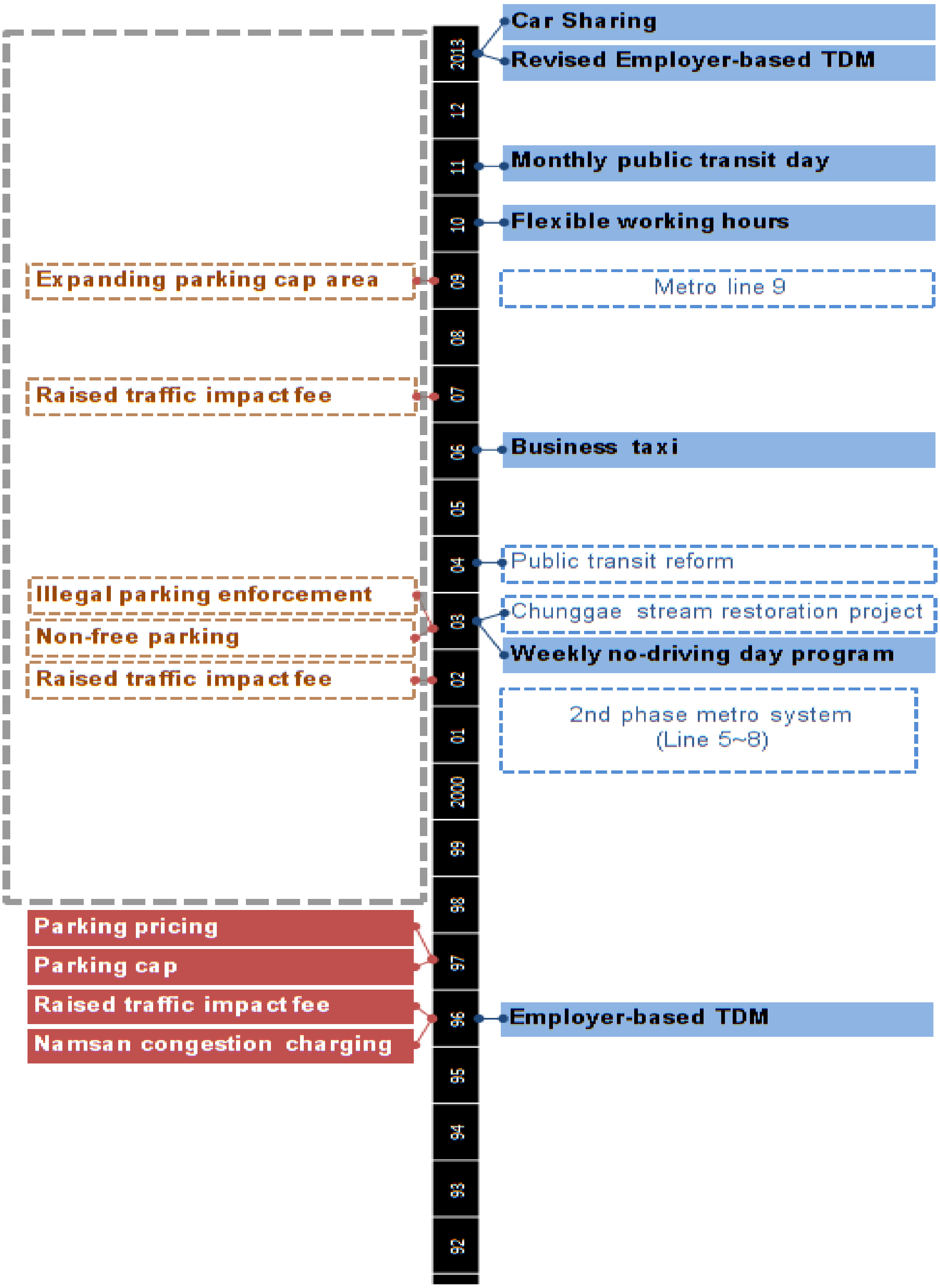
Shin Lee / Yoo Gyeong Hur, University of Seoul[7]

1. Policy Implementation Period

Up until 1960s, public transportation had played a crucial role as major urban transportation. However, since 1970s a sharp rise in the number of personal cars coupled with continuous economic growth had caused severe traffic congestion. Transportation Demand Management (TDM), which emerged as a strategy to resolve such traffic congestion, could be seen as an alternative approach to optimize the transportation demand by changing and attuning the demand patterns for each transportation means and time slot, which broke away from conventional approaches including transportation policy focusing on supply-side policy.

Since the introduction of congestion impact fee system in 1990s, various types of TDM approaches have been implemented including Namsan tunnel congestion charge, the parking threshold, and mandatory charging of parking lot fees in 1990s and Weekly No-Driving Day Program and car sharing in 2000s on a gradual basis. Figure 1 gives chronological view on Seoul's TDM programs.

[7] Translation by ESL®


Car Sharing
Revised Employer-based TDM
Monthly public transit day
Flexible working hours
Metro line 9
Business taxi
Public transit reform
Chunggae stream restoration project
Weekly no-driving day program
2nd phase metro system
(Line 5~8)
Employer-based TDM
Expanding parking cap area
Raised traffic impact fee
Illegal parking enforcement
Non-free parking
Raised traffic impact fee
Parking pricing
Parking cap
Raised traffic impact fee
Namsan congestion charging
2013
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08
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06
05
04
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02
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2000
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Figure 1. Seoul's TDM Programs by Year

Source: Seoul Archive 2015(https://seoulsolution.kr)

2. Background Information

From 1970s to 1990s, Korea's transportation policy was tuned to the supply side, with much emphasis on construction and expansion of road networks to make up for the absolute shortfall in capacity. In that period, gap between supply and demand widened as rapid economic development led to sharp rise in transportation demand.

The number of personal cars registered in Korea had risen eight fold to 2,075,000 units in 1990s from 249,000 units in 1980 but 20% of road expansion for the same period fell far short of meeting the explosive demand. For those reasons even during the 1990s tremendous amount of efforts had been made to expand facilities by promoting private investment in transportation and construction at the government level.

In Seoul alone, the number of registered cars had risen to two million units in 1995 from one million in 1990 in just five years. Although expansion of street networks had been continuously promoted due to a soaring rise in the number of cars, road supply failed to catch up with the demand. Therefore, traffic congestion in the downtown in 1980s had been part of daily routine and in the 1990s traffic congestion in the major arterial roads had become more serious. In order to provide traffic facilities, large-scale road constructions had been conducted including expanding urban arterial roads and interregional expressway network, connecting City of Seoul and new town.

Despite such a massive road expansion, the traffic congestion aggravated even further due to a soaring rise in the number of personal cars even after 1990s, leading to a continuous slower travel speed in Seoul. Advanced cities across the world also shared the view that additional supply of traffic facilities alone would not solve traffic congestion. In line with the times, the SMG has introduced TDM since 1990s as a strategy to mitigate traffic congestion.

In the era of low-carbon green growth when the importance of sustainable development has been highlighted in order to reduce green gas, TDM methods and their importance have become ever more important. TDM, in general, refers to various policy attempts which change the selection patterns of passengers' choice of transport means, reduce number of car travels, and induce effective use of passenger cars. The Urban Traffic Readjustment Promotion Act defines TDM a policy mitigating traffic congestion by inducing reduced share of car travel, dispersing trips in terms of time and space, and shifting travel mode share. TDM is defined in 'the Urban Traffic Readjustment Promotion Act' as a policy designed to mitigate traffic congestion by reducing car travel, and encouraging people to utilize forms of transport other than their personal vehicles. Act No.10599 --'The Urban Traffic Improvement Promotion Act', Chapter 4 Traffic Demand Management, Article 33 Implementation of Traffic Demand Management ([Enforcement Date 15. April, 2012.] [Act No.10599, 14. April, 2011, Amendment by Other Act]) stipulates mayors of each city may implement TDM for smooth traffic flow, air quality, efficient use of transportation facilities at certain area within the city's jurisdictional boundary by reflecting public opinions through the public hearings.

While observing the Urban Traffic Improvement Promotion Act, the SMG has developed and implemented various TDM programs, reflecting urban characteristics of Seoul.

3. The Importance of the Policy

Korea was not alone in its heavy dependence on the supply of transportation facilities as a means to resolving urban transportation challenges. Advanced industries including the U.S. and U.K. had taken supply-focused approaches, focusing on accommodating rising demand until 1980s. As doubts had been broadly raised on the previous transportation plan method and direction of transportation policy in the U.S. (in the 1980s) and the U.K (in the late 1990s), limitations in the supply-oriented approach had been widely accepted.

Such doubts had been supported by theories: 'The law of traffic' explained in 1977 by Anthony Downs 1977 and 'induced traffic' conceptualized by Mogridge MJH and Williams HCWL in 1985. According to those theories, expansion of roads or construction of new roads at a severely congested region will have temporary effect, leading to a faster travel speed for a while. However, improved road service will induce more use of car travel of people who have refrained to do so due to heavy congestion. Latent demand caused by heavy congestion will convert to a real demand to the pre-expansion or pre-construction level, once congestion gets relieved.

Even without theoretical supports, the general public in the U.S shared the idea of "We can't build our way out of congestion." In the U.K., people expressed their understanding on the limitations in road construction with the term 'New Realism.' Both meant roads might not be constantly constructed to meet the rising demand for cars

To keep abreast of global trend, SMG introduced TDM. TDM could be longer perspective approach than supply-oriented one in the sense that it could prevent and control heavy dependence on cars by changing traffic pattern when implemented effectively.

When is a good timing to shift from supply-oriented policy to demand-oriented one in the case of developing countries whose road rate is noticeably low? Isn't it necessary to focus more on supply when traffic facilities are in absolute shortage? These are questions that could be raised when discussing TDM. The right answer depends on what level of travel mode share is determined to be optimal. The crucial thing is that supply and demand is not a matter of choice between the two. If supply is done enough, it greatly matters to manage demand and supply properly.

Some argued that congestion impact fee system did not work. Recently, it's been said that there has been noticeable effect by combining it with TDM involving/for companies.

4. Relevance with Other Policies

While keeping in mind of the limitations in the supply-focused transportation policy including expansion of transportation facilities and construction of roads, policy concept of transportation system management (TSM) emerged. Transportation system includes both physical system and passenger, the human element.

Transportation system management could be divided into two: transport system management (TSM) which highlights effective operation of traffic facilities, and transport demand management (TDM) which focuses on managing demand of road use by transportation facility users. Some management approach belongs both to TSM and TDM as demand for cars could drop by changing the patterns of using facilities. For example, 'bus-only lanes' reduces demand and supply of transportation, which was designed to induce the personal car owners to use bus by improving bus service.

TSM and TDM by nature have common denominators and various approaches belonging to each system management have synergy effect to each other. If those mutually beneficial approaches are combined and implemented after thoroughly checking such relations with various approaches, it will bring about much better outcome than implementing them separately. The combination of 'bus only lanes' and 'bus priority signal system' could create synergy effect. Along with the combined approaches, when the time-saving transit center, real-time bus information, bus only lanes violation enforcement are well utilized so the reduced bus travel time is big enough, then majority of car owners will prefer taking bus as desired.

After all, a series of TDM approaches have close relations with policies which make public transportation more appealing while making the use of personal cars harder and inconvenient. As mentioned earlier (part 3), it is such an irony that TDM is closely related to supply-oriented transport policies. That is because TDM could contain negative effect of additional supply only when implemented along with supply-focused transport policy especially when the supply is unavoidable.

5. Policy Objectives

TDM has been designed to induce changes in individual's decision on means of transportation, travel time, traffic volume and travel area by changing overall elements affecting individual's decision making. Ultimately, TDM aims to resolve traffic congestion, change it into sustainable transportation system which leaves less negative impact on the environment and society and maintains the sustainability by changing the quantity and structure of transportation demand,

6. Policy Contents

Congestion Impact Fee System

In the 1980s and 1990s, transportation problems got severer as the increase in transportation facilities failed to keep up with the skyrocketing rise in transportation demand, resulted from sharp rise in the number of personal cars and improved public income level. In particular, buildings including wedding halls and department stores caused a heavy traffic demand at specific hours and caused a serious congestion, which led to significant social and economic costs. The congestion impact fee system, a part of Seoul's TDM policy, was introduced in 1990 in order to levy burdens to buildings causing massive transportation demand and to utilize the money in expanding and improving transportation facilities.

Enforcing the congestion impact fee, as defined by the Urban Traffic Readjustment Promotion Act, resulted in facility owners paying a fee in accordance with the "causer-pays" principle so as to indirectly rein in the concentration of facilities that cause congestion in the city and to secure funds for improvement of the city traffic situation. While some facility owners have objected to this additional financial burden, public consensus was reached on the necessity of a system designed to reduce the social and economic losses caused by the traffic congestion and to provide quality transportation services to the public.

The legal basis for the congestion impact fee was in the Urban Traffic Readjustment Promotion Act revised and promulgated on January 13, 1990. The target areas were cities with populations of 100,000 or more and cities where the Minister of Land, Infrastructure and Transport acknowledged it necessary to levy the Act. The levied fees were deposited in a special account for the local city transportation program, to be used to improve transportation systems and facilities such as implementation of bus-only lanes.

The City of Seoul fundamentally follows the enforcement rules concerning the impact fee as prescribed in the Urban Traffic Readjustment Promotion Act, but it also set up its own ways to levy the fees, which are calculated by multiplying total floor area of the facilities, the unit congestion impact fee, and the congestion coefficient. The unit congestion impact fee is 700 to 800 Korean won per m^2 of floor area; the congestion coefficient varies by location and use of the facilities – from at the minimum 0.47 for a factory to at the maximum 10.92 for a department store. The congestion impact fee is levied on owners of facilities with a total floor area of 1,000 m^2 or more. In the event a facility is owned by multiple entities, each pays proportional to their share of ownership.

Table 1. SMG, Ordinance on the Congestion Impact Fee Discount [Attached Table 3]

Total floor area of the facilities	(Congestion Impact) Fee	
3,000 m^2 and smaller	Area smaller than 3,000 m^2 × 700 × congestion coefficient	
Over 3,000 m^2 ~ 30,000 m^2 and bigger	2014	Area smaller than 3,000 m^2 × ₩ 700× congestion coefficient
	2015	[₩2.1 million+(Total floor area -3,000 m^2×₩ 800)]× congestion coefficient
	2016	[₩2.1 million+(Total floor area -3,000 m^2× ₩ 900)]× congestion coefficient
	2017	[₩2.1 million+(Total floor area -3,000 m^2× ₩ 1,000)]× congestion coefficient
	2018	[₩2.1 million+(Total floor area -3,000 m^2× ₩1,100)]× congestion coefficient
	2019	[₩2.1 million+(Total floor area -3,000 m^2× ₩1,200)]× congestion coefficient
	2020 ~	[₩2.1 million +(Total floor area -3,000 m^2× ₩1,400)]× congestion coefficient
Over 30,000 m^2	2014	[₩2.1 million+(Total floor area -30,000 m^2× ₩800)]× congestion coefficient
	2015	[₩23.7 million+(Total floor area -30,000× ₩1,000)]× congestion coefficient
	2016	[₩26.4 million+(Total floor area -30,000×₩1,200)]× congestion coefficient
	2017	[₩29.1 million+(Total floor area -30,000× ₩1,400)]× congestion coefficient
	2018	[₩31.8 million+(Total floor area -30,000× ₩1,600)]× congestion coefficient
	2019	[₩34.5 million+(Total floor area -30,000× ₩1,800)]× congestion coefficient
	2020~	[₩39.9 million+(Total floor area -30,000× ₩2,000)]× congestion coefficient

In Seoul, the number of facilities paying the congestion impact fee and the amount collected has grown every year. Since 2007 when data on the collection of congestion impact fee started to be established, the number of times the fee was levied reached 100,634 times in 2013, and the amount totaled about ₩ 105.542 billion.

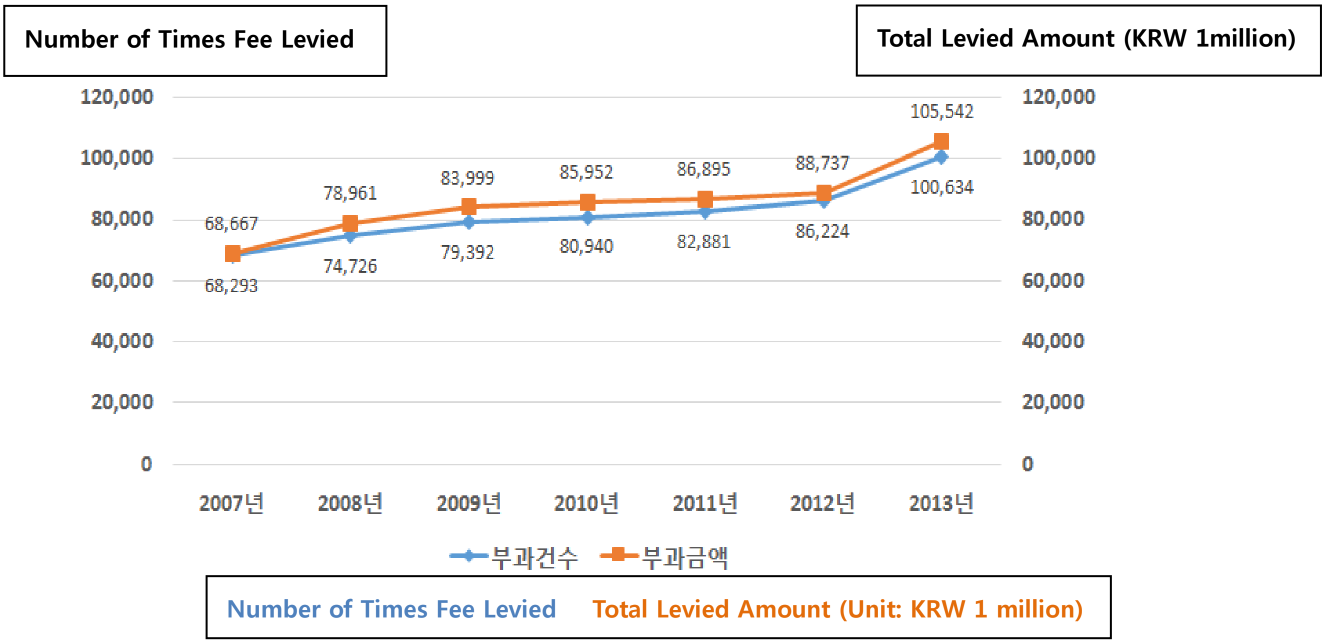


Figure 2. Congestion Impact Fees Levied in Seoul

Source: The Korea Transport Institute (2014)

Transportation Demand Management Policy for Companies

To further drive the congestion impact fee system and encourage companies to get on board, the City of Seoul introduced a TDM system for companies, designed to get them involved in reducing traffic volume on a voluntary basis. This allows companies to participate in traffic volume reduction programs, the outcome of which determines the discount on (or even exemption from) the congestion impact fee for which the business is responsible. In the early days of introducing the program in 1995, companies were required to impose parking fees on cars using their parking facilities, but this mandatory requirement was soon abolished in 1999. After the abolishment, it became easier to participate in the program or implement the program, thus the participation rate rose. This TDM for companies is positive for individual residents, as it targets the facilities and companies that create large traffic volumes.

The TDM policy for companies stems from Regulation 15, adopted as part of Southern California's Clean Air Act. The major difference is that California imposes penalties on non-complying companies but Seoul offers discounts/incentives instead for those that participate.

This system was first proposed in the Study on Transportation Demand Management in Seoul conducted by the Seoul Development Institute (currently The Seoul Institute) in 1993. In 1994, feasibility was tested in preliminary research on 6 companies located in Jongno-gu, and the Ministry of Land, Infrastructure & Transport revised the Urban Traffic Readjustment Promotion

Act and officially announced the TDM system for companies. In May of the following year, the Seoul Metropolitan Council enacted the Seoul Ordinances on the Congestion Impact Fee Discount, Etc., and by August 1, 1995, the TDM policy for companies was launched. This policy targets buildings with a total area of 1,000 m^2 or more, providing varying discounts (2% - 30% by program) on the congestion impact fee based on participation and performance. If one company participates in multiple programs designed to reduce traffic volume, the discounts are added together. The traffic reduction programs that companies can choose include mandatory parking fees, voluntary road space rationing, and commuter buses and etc.

Table 2. Congestion Impact Fee Discounts by Traffic Volume Reduction Activity

Activity		Target	Discount Rate (Unit : %)
Voluntary Road Space Rationing	5th day No Driving	Facility Employees and Users	20
	Odd-Even No Driving Day		30
	Weekly No-Driving Day		20
Mandatory Parking Fees		Facility Employees and Users	30
Parking threshold		Facility Owner	20
			30
			50
Parking information provision system		Facility Owner	10
Use of bicycle		Facility Employees	20
Phased hours		Facility Employees(50 ppl and more)	20
Operation of commuter bus		Facility Employees(100ppl and more)	25
Operation of shuttle bus		Facility Employees and Users	15
Call cab		Facility Employees	20
Car-sharing		Facility Employees and Users	10

Others	Facility Employees and Users	10

Source: SMG, Summary of the Seoul Ordinances on the Congestion Impact Fee Discount, Etc.

The TDM system for companies, introduced in 1995, offered highly attractive incentives, and the number of participating companies and the total discount amount have grown steadily. As of 2015, some 23.2% of the facilities subject to the 'TDM program for companies' are involved.

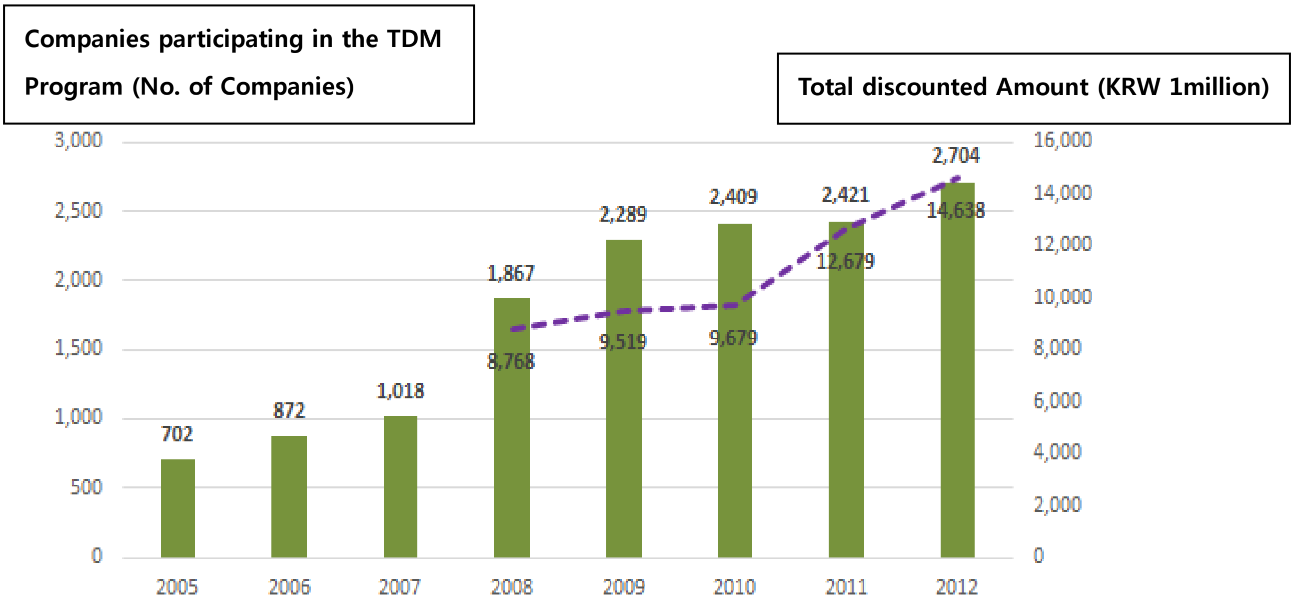


Figure 3. Companies Participating in the TDM Program (2013)

Source: Internal data, Seoul Metropolitan Government

The demand management programs for personal cars such as the Weekly No-Driving Day Program, and mandatory parking fees and programs to encourage the use of bicycle account for 70% of all programs. These programs are easier than others for companies to participate in, so the participation is high. On the other hand, phased commuting hours or restrictions on the use of personal cars by target facility employees may not be applicable due to specific business circumstances. Operation of commuter/shuttle buses and installation of parking guide system are costly, so the participation is low. Installation of facilities may have a short-term effect but not a lasting one required for overall traffic demand management.

Congestion Charging at Namsan Tunnel 1 and 3

Singapore was the first city to implement the congestion charge followed by others like London, Rome, and Stockholm. Some States of the U.S. have run toll roads which applied the concept congestion impact fees to the congested segment of the expressways. In Seoul, discussions began in the late 1980s, but it was not introduced for circumstantial reasons. With the explosive growth in the demand for cars in the 1990s came a great need to contain the use of personal cars, so the congestion impact fee system has been implemented for Namsan Tunnel 1 and 3 since November 1996.

According to the Urban Traffic Readjustment Promotion Act, a congestion charge is to be levied on road segments according to travel speed and average delay. Targets are arterial roads or adjacent zones under the influence of such roads where the average travel speed is less than 21 km/h (for 4 lanes or more, one way) or 15 km/h (for 3 lanes or fewer, one way) on weekdays only (excluding weekends and holidays) for 3 or more time periods per day. The charge may also be imposed on intersections or adjacent zones under the influence of such intersections where the average control delay time is 100 seconds or more (at signaled intersections) or 50 seconds or more (at unsignaled intersections) for 3 or more times a day. By this standard, most major roads in Seoul at the time when the charge was being discussed for introduction were subject to the congestion charge. Knowing that the sudden introduction of the charge in most or all of Seoul would likely meet severe opposition, the city aimed to phase in the system.

At Namsan Tunnel 1 and 3, the city began with a levy of KRW 2,000 for both directions from 7:00 – 21:00 Monday to Friday excluding Sundays and public holidays, based on the City of Seoul Ordinance (no charge on Saturday currently). The charge is levied against vehicles with only 1 or 2 occupants, while vehicles used by people with disabilities or for public purposes (ambulances etc.) are exempt.

According to studies by The Seoul Institute (2012), traffic volume on roads linked to Namsan Tunnel 1 and 3 dropped by 24.2% a month after the charge was implemented. Beyond that, the rate of decrease slowed; a year later (in November 1997), the decrease rate was 13.6%. Until August 1998, the daily average traffic volume was 77,000 vehicles, maintaining on average decrease rate of 14% . In the meantime, the volume of passenger cars at peak hours fell by 30% a year after introduction, with cars occupied by 1 or 2 people dropping substantially by 40.2%. Four roads near Namsan Tunnel 1 and 3 can be used as detours, and there had been concerns that the congestion charge would simply cause congestion in other areas as cars moved to the detour roads. According to a year-long study after the introduction, traffic volumes on the detour roads rose by only 5.7%. At the same time, average travel speed increased by 11.8%, from 24.5 km/h to 28.3 km/h.

Table 3. Collection of Congestion Impact Fees in Other Countries

City	Purpose	Details	Effect
Singapore	-Relieve traffic congestion	-Introduced in June 1975 📫 Downtown around 07:30 ~ 19:00	-44% drop in traffic volume
London	-Relieve traffic congestion -Reduce air pollution	-Introduced in Feb 2002 -Downtown (22 km^2) around 07:00~18:00	-20% drop in congestion -83% rise in the number of bicycle users -16% drop of CO_2
Stockholm	-Relieve traffic congestion -Reduce air pollution	-Introduced in Aug 2008	-22% drop in congestion -14% drop of CO_2

Seoul	-Relieve traffic congestion	-Introduced in Nov1996 -Namsan 1&3 tunnel around 07:00~21:00	-16.8% drop in traffic volume

Source: Mokwon University, Climate change, public transportation revitalization, and transportation demand management (2014)

One of the most important outcomes from the congestion impact charge was that cars with only 1 or 2 occupants stayed away from the tunnels and the occupants began resorting more to public transport such as buses or taxis. Studies by The Seoul Institute (2012) indicate that personal cars passing through Namsan Tunnel 1 and 3 dropped by 25.8% while buses increased by 4.7% in 2010 compared with those figures in 1996, the first year the congestion impact fee system was implemented. At peak commuting hours, the share of buses and taxis soared from 3.3% and 7.8% to 8.0% and 26.4% respectively.

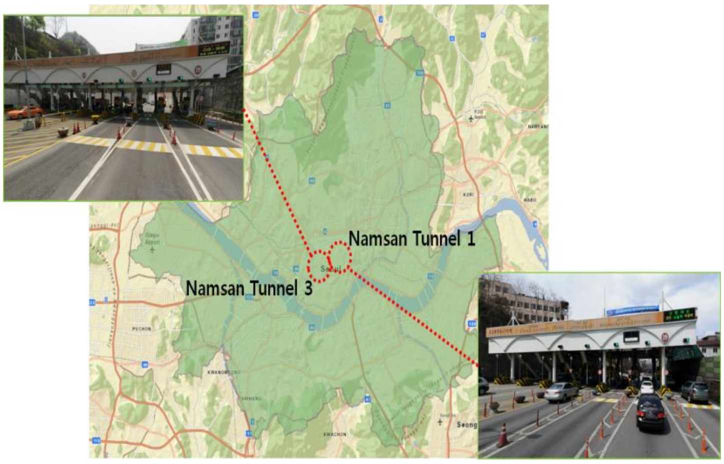


Figure 4. Levying the Congestion Charge at Namsan Tunnel

Source: Street view, Naver.

Parking Lot Restrictions for Facilities in Certain Areas (Parking Threshold)

Before 1990, Seoul's parking policy was keen on supplying more parking spaces to accommodate the increasing number of cars. However, such policies began to change with the growing importance of TDM in the 1990s. In line with the policy trend, Korea adopted a system of restricting the creation of parking lots (also called the parking threshold) for facilities in congested areas to curb the parking demand. Seoul set up its own parking threshold system and relevant bylaws for implementation to incorporate the unique circumstances of the city in restricting parking lots pursuant to the Parking Lot Act. With Seoul's parking threshold regulations in place, parking lots for department stores and other commercial and business facilities in congested areas were limited to 50% of the parking lots located in non-congested areas.

Through the Parking Lot Act, the City of Seoul came up with parking threshold regulations via the City of Seoul Ordinance on the Installation & Management of Parking Lots. Seoul defines "Class 1 areas as defined in the public parking fee table" as "areas that are congested with automobile traffic", as stipulated in the Parking Lot Act, The City of Seoul Ordinance also sets different standards for the installation of parking lots by the type of facility.

Seoul's parking threshold program was first launched on January 15, 1997, was extensively revised on March 18, 2009 and remains effective to date. In the beginning, there were seven Class 1 target areas as defined in the public parking fee table, but this number grew to 10 due to the revised Ordinance in 2009. In the beginning, the target area was limited only to commercial areas but currently it's been expanded to 'commercial areas and quasi residential areas.' With the parking threshold program in effect, the City of Seoul was somewhat successful with the TDM in reducing transportation demand.

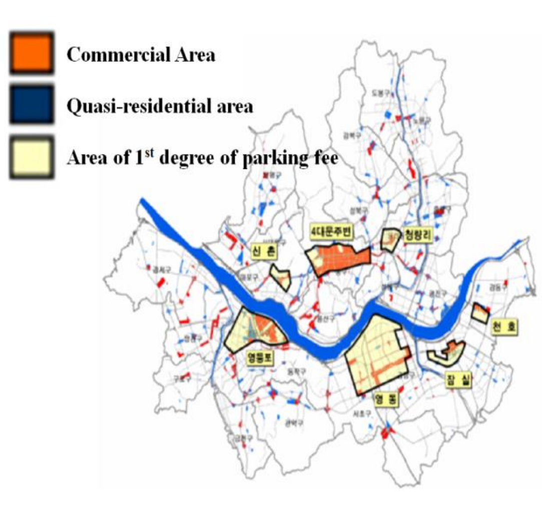
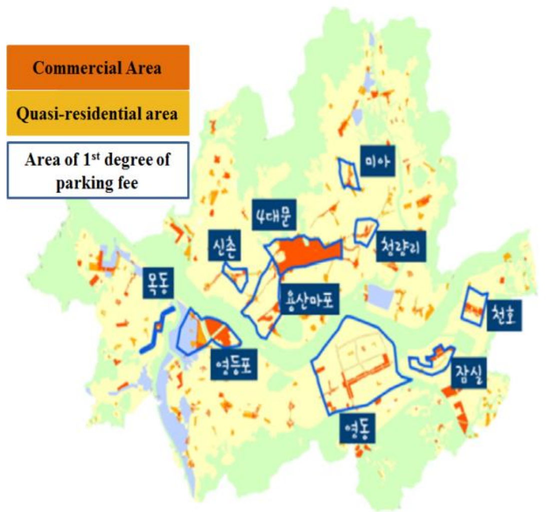
<table>
<tr><th>Beginning of the Introduction (1997~2008)</th><th>Present (2009~)</th></tr>
<tr><td>· Commercial areas out of seven Class 1 target areas defined in the public parking fee table</td><td>· commercial and quisi-residential areas out of ten Class 1 target areas defined in the public parking fee table
· Congestion Management Zone with Easy Access to Public Transportation</td></tr>
<tr><td>
</td><td>
</td></tr>
<tr><td>· 13.8km2
- 2.3% of Seoul
- 60% of the commercial areas in Seoul</td><td>· 16.2km2
- 2.7% of Seoul
- 58.7% of the commercial areas in Seoul</td></tr>
</table>

Figure 5. Areas subject to Parking Threshold in Seoul

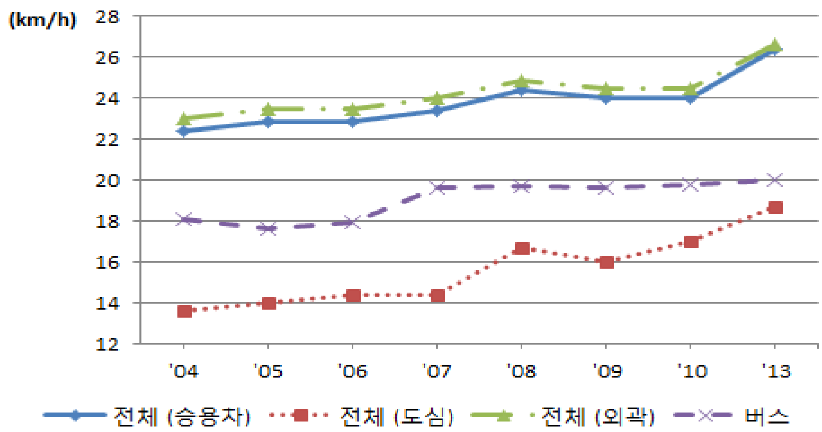
Source: The Seoul Institute (2014)

7. Policy Effects

Travel Speed

Transport share of personal cars in Seoul has shown continuous drop since 1990s due to the TDM policy implemented in various ways while the share of public transport has steadily risen from 61% in 2004 to 66% in 2014. The average travel speed on major and downtown roads, in turn, has increased. In the early 2000s, the average travel speed in downtown Seoul was 22.4 km/h, rose to 26.4 km/h in 2013. A similar phenomenon has been observed in the outskirts of Seoul and on major arterial roads.

Average Travel Speed for Each Transport Share and Area



Average Travel Speed for Each Type of Roads

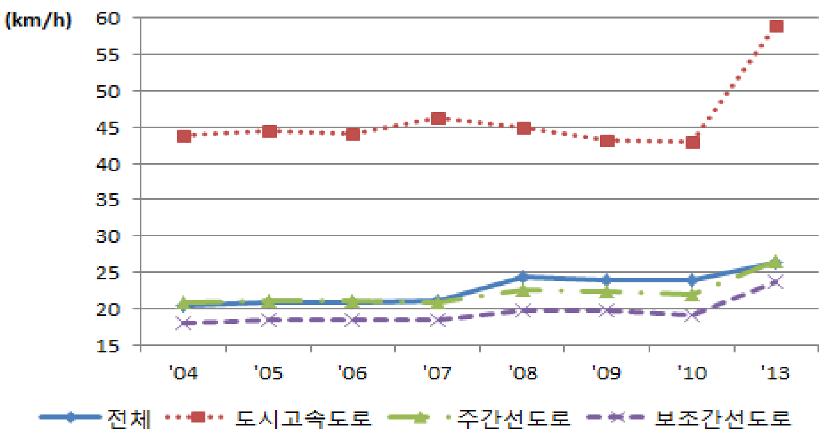


Figure 6. Changes in Average Travel Speed in Seoul

Source: Seoul Statistics

Air Quality

Seoul's air quality has also improved thanks to the increased average travel speed, decreased transport share of personal cars, and increased share of public transport. The concentration of fine dust – a cause of respiratory diseases and a hotly debated social issue – was 60µg/m³ in 2004, higher than Seoul's permissible level of 50µg/m³. However, the decrease in personal cars and other elements helped reduce the concentration each year, and by 2013 it had fallen to 44µg/m³.

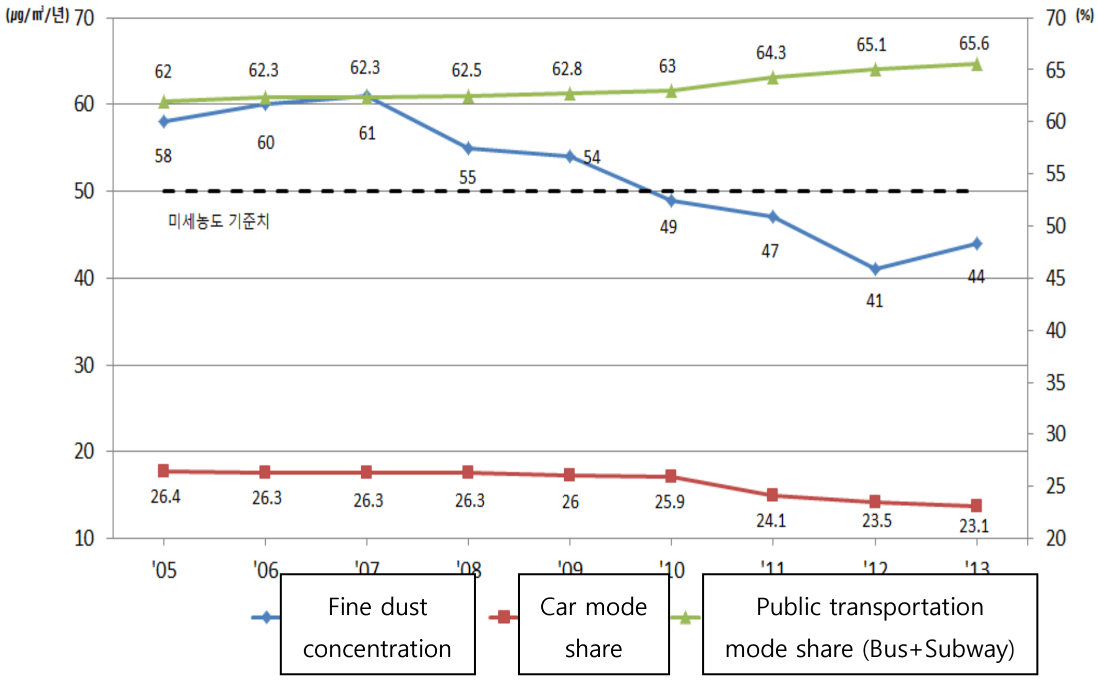


Figure 7. Changes in Fine Dust Concentration and Transport Mode Share

Source: Seoul Statistics

Priority on Pedestrians in Urban Transportation Policy

As the TDM policy encouraged drivers to switch to public transport or walk, the city also began to shift its policy focus from cars to pedestrians. In line with this trend, Seoul created a "Walk-Friendly Seoul" by reducing the 4-lane Gwangjingyo Road to 2 lanes in 2007 and expanding the pedestrian walkway. In January 2014, the city created its first transit mall on Yonsei-ro. Many zones busy with pedestrians on weekends (e.g., Cheonggye Stream, Hongik University) were turned into pedestrian-only areas. The TDM policy has significantly helped Seoul become a more walk-friendly city.

8. Challenges and Solutions

A Need to Differentiate Coefficients

The congestion impact fee system has long attempted to differentiate the congestion coefficients by city size and facility to make them more realistic. However, the fees are unnecessarily levied on some areas where congestion is insignificant because the characteristics or specific conditions of the locations have not been taken into account. On the other hand, it has been suggested that the impact fee has little effect on heavily congested areas as the congestion impact charge is too low to bring about any differences. The congestion coefficients need to be differentiated in multiple steps and reflect the level of congestion as well as the unique characteristics of the region. For instance, upward adjustment of the congestion coefficient must remain within the 100% range of the coefficient set out in the Urban Traffic Readjustment Promotion Act; this needs to be revised so that upward adjustment can go beyond 100% for those facilities that significantly add to traffic congestion of an area. For those areas where public transit is inadequate, the coefficient should be lowered, even if the congestion increases due to certain facilities. At the moment, the differentiated congestion coefficients are actively promoted.

Enhancing Effectiveness of Congestion Impact Fee System

The congestion impact fee, adopted in 1990, is now over 20 years old and constitutes a major transportation policy in Seoul. However, questions have recently been raised about its effectiveness. The unit congestion impact fee has been recently adjusted in order to factor into the inflation rate as there has been criticism that practically the unit fee is too low to make difference as policy. The City of Seoul has revised the relevant ordinances in 2014 and has given the fees greater influence by applying pressure on companies that do not participate in the transportation demand management program and by providing attractive incentives to those that do.

Improvement of the Parking Threshold System

Currently, Seoul’s parking threshold is the same regardless of the intended use of the land, buildings, and surrounding areas. This one-size-fits-all program runs counter to the fundamental purpose of the system and is inefficient and illogical to some extent. Many large buildings allow parking outside or find parking spaces that get around the parking threshold. Opinions on the parking threshold vary greatly by facility type. For improved operational efficiency, the system needs more specifics in its design. The SMG has commissioned a research and service project to come up with ways to improve parking threshold system.

Improvement of the Congestion Charge Rate & Method at Namsan Tunnel 1 & 3

As part of the TDM policy designed to decrease the number of vehicles entering the city center and therefore mitigate congestion, the City of Seoul began to levy the congestion charge on 10-person vehicles and smaller if they carried only 1 or 2 people (including the driver) at Namsan

Tunnel 1 and 3 from November 1996. However, the effect of the congestion charge in reducing traffic has gradually slowed, probably because the congestion impact fee is the same during peak and off-peak hours and has never been adjusted upward. Meanwhile, discount benefits had increased for compact cars and for the participants of Weekly No-Driving Day Program. Considering how overall prices and other transport costs have risen, the congestion impact charge should also be adjusted to a more suitable level and be differentiated by the time of day to have the desired effect on traffic volume.

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ITS on Seoul's Urban Expressway

Shin Lee, University of Seoul[8]

1. Policy Implementation Period

The freeway traffic management system (FTMS) of Seoul's urban expressway was first designed by the Seoul Development Institute (currently known as Seoul Institute) in the mid-1990s, and implemented in the 18 km leg of Olympic Expressway in July 1997. After six-month operation as pilot project, the FTMS was used in earnest since February 1998.

Since then, FTMS project has been implemented and expanded in phases. In the phase 1 (from May 2000 to June 2002), the FTMS was introduced to the 40.1 km stretch of the Naebu Inner Beltway. During phase 2, the transportation management system had been established in the 21.7 km segment of the Gangbyeon Riverside Expressway and the Bukbu Northern Arterial Road during November 2001 and June 2004. In addition, segments stretching 49.3km in the Olympic Expressway and Nodeul Road & Han River Bridge also had been equipped with FTMS from October 2003 to September 2005. In Phase 3, the FTMS was installed on the 45.7 km of Dongbu Eastern Arterial Road and Gyeongbu Expressway (managed by the City of Seoul) which began in April 2005 and completed in April 2007. Phase 4 dealt with arterial roads rather than urban expressway. (refer to page 4 Relevance with Other Policies). Phase 5 is in its implementation covering 12.4 km of Gangnam Beltway. Table 1 below gives a summary of Seoul's FTMS project.

In December 2000, Seoul developed a plan to build "Urban Expressway Traffic Control Center" and in April 2001 it established operation plan for the "Urban Expressway Traffic Control Center."

[8] Translation by ESL®

Table 1. Seoul's Urban Expressway FTMS Projects in Phases

	Segment	Start	Completion	Segment Length
Initiation	Olympic Expressway	1997.7	1998.2	18km
Phase 1	Naebu Inner Beltway	2000.5	2002.6	40.1km
Phase 2	Gangbyeon Riverside Expressway/Bukbu Northern Arterial Road	2001.11	2004.6	21.7km
	Olympic Expressway/ Nodeul Road & Han River Bridge	2003.10	2005.9	49.3km
Phase 3	Dongbu Eastern Arterial Road/Gyeongbu Expressway	2005.4	2007.4	45.7km
phase 5	Gangnam Beltway	2015.5	2016.5	12.4km
Total				187.2km

2. Background Information

Rapid development of Korean economy and the car manufacturing industry in 1980s had brought about a sharp rise in the traffic volume. The number of passenger cars exceeded 1 million and in the year 1990 it was over 2 million units. A half of those passenger cars, about 1 million units, were used in Seoul. In less than five years, the number of cars owned by Seoul citizens almost doubled to 2 million. Such a surge in the car ownership had led to snowballing social costs including road congestion and traffic accidents in the City of Seoul.

The decision-makers of transportation policy in that period shared the view that supply-oriented approach, which focused on expanding facilities including expanding transportation system or road construction, might no longer be effective and started seeking a new approach away from the conventional transportation policies. At that time, other countries showed keen interests in intelligent transportation system (ITS), which applied cutting-edge technology to transportation facilities. ITS was an innovative approach and very appealing to the policy makers as it helped efficient management of existing traffic facilities by enabling efficient traffic flow at much more affordable costs compared with the provision of infrastructure facilities including road construction. For that reason, increasing number of cities in other countries showed interest in adopting ITS. South Korea pursued various ITS research and development programs and pilot projects in the 1990s. In line with such a move, the City of Seoul also promoted to adopt advanced overseas ITS. In the initial period, the urban expressway FTMS started to be promoted in large scale. Urban expressway FTMS was one of the most representative ITS projects that had dramatically improved the efficiency of Seoul's urban expressway. With the introduction of the project, urban expressway FTMS started to be established and extended.

Article 77 Implementation of Project for Establishment of Intelligent Transport Systems of the National Transport System Efficiency Act([Enforcement Date 15. Jul, 2014.] [Act No.12248, 14. Jan, 2014., Amendment by Other Act]) provides legal grounds for the project establishing urban expressway traffic control system.

3. The Importance of the Policy

Implementation of FTMS on Seoul Urban Expressway started in mid-1990s when Intelligent Transportation System (ITS) was gaining a huge attention and it meant Seoul's introduction of ITS in earnest.

The Intelligent Transportation System (ITS) is an advanced traffic management system which enhances the efficiency and stability of transportation and conducts scientific and automatic operation and management of transportation system and provides traffic information and services by applying cutting-edge technology including electronic technology, control technology and communications technology to the means of transportation, transportation facilities and infrastructure.

Implementation of FTMS enabled real time traffic control and automatic information/data collection of urban expressway, leading to providing prompt response in traffic condition/emergency and to the improvement of efficiency of traffic system which was previously manually operated.

4. Relevance with other Policies

Seoul's FTMS Project in 4 Phases

Phase 4 was designed to improve major bypass of urban expressway and FTMS had been installed in a total of 82.5 km between period of August 2011 and August 2013.

During the first to third phase FTMS projects, as mentioned earlier, FTMS had been successively implemented in Olympic Expressway, Naebu Inner Beltway, Gangbyun Riverside Expressway/Bukbu Northern Arterial Road, Nodeul Road & Han River Bridge, Dongbu Eastern Arterial Road, Gyungbu Expressway (managed by City of Seoul). In the 4th phase, FTMS, the advanced management system was installed on major arterial road of urban expressway which aimed to disperse traffic volume and enable optimal dispersion of traffic volume based on real-time FTMS implemented on major bypass. The followings are the arterial roads that implemented FTMS:

- 1st group: Banporo, Hannamro, Gangnam dae-ro, Heolleungro, Dongjak dae-ro, Doomoogae road and etc (42km)
- 2nd group: Hwarangro, Jeongneung-ro, Segeomjeonggil, Jinheungno, Tongilro and etc. (23km)
- 3rd group: Dongilro (18km)

FTMS System Advancement

Installation of FTMS on arterial roads set the corner stone for the ‘FTMS System Advancement’ project which highlighted the integration and linkage of urban expressways and arterial roads. The goal of FTMS System Advancement project is to promote closer linkage of traffic data between urban expressway and arterial roads, integrated linkage control and to provide risk alert service that warns risk factors in safe driving. More details will be covered at the last part (Limitations and Resolutions) of this article where policy and future is discussed.

FTMS on Expressway

FTMS had been installed not only on urban expressways in Seoul but had been promoted to be installed in expressways across the nation managed by Korea Expressway Corporation. Due to the widespread implementation of the FTMS on expressway across the nation, Intelligent Transportation System (ITS) is most well or even perfectly realized on the expressway among all types of roads in Korea.

In order to provide efficient management of the expressways based on ‘intelligent’ expressways across nation, KEC has deployed and operated high-speed optical communications network in a total of 2,646km of the 24 expressway routes including in Gyeongbu Expressways since 1993.

The communications network provides on-site IT infrastructure for the KEC’s work and has been used as field communications network for FTMS, toll collection system (TCS), hi-pass system (toll payment system) and emergency call.

5. Policy Objectives

FTMS aims to enhance the efficiency of expressways and more specific policy goals could be summarized as below:

① To check transportation and road situations of urban expressways, identify the cause of congestions and how to improve, and eventually promote efficiency in traffic management system.

② To guarantee mobility of urban expressways (maintaining travel speed of 40km/h or faster)

③ To guarantee safety of urban expressways(zero traffic fatality)

④ To reduce travel costs by removing the cause of irregular traffic congestion based on automatic detection of unexpected incidents and prompt responsive measures.

⑤ To establish convenient and pleasant traffic environment by offering traffic information to road users and

6. Main Policy Contents

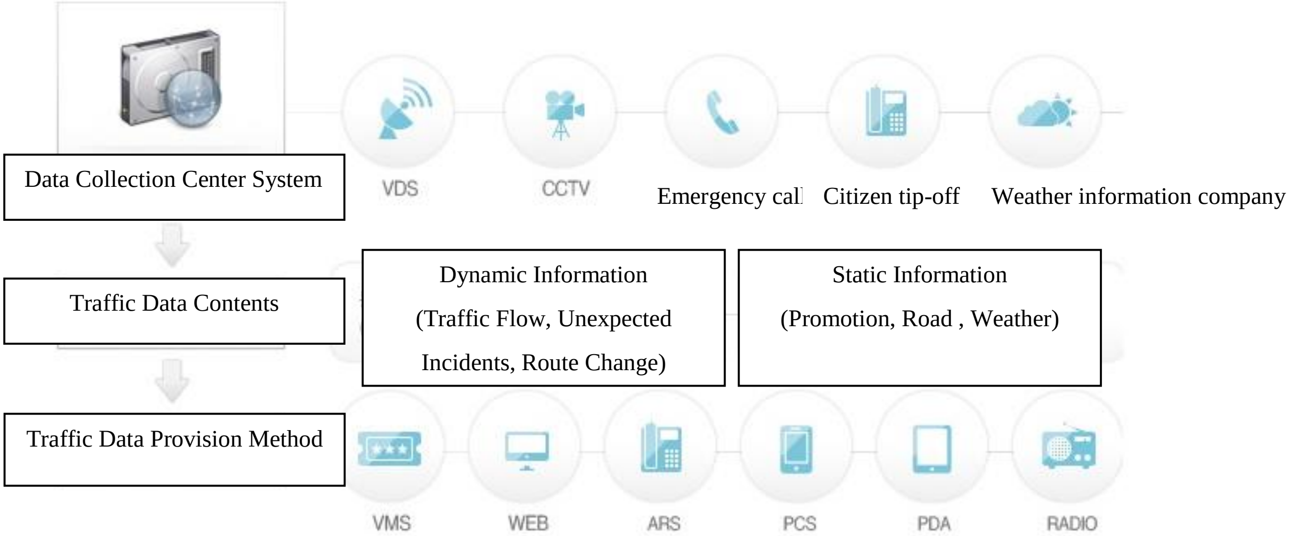
FTMS is the short form for the Freeway Traffic Management System and Seoul Urban Freeway Traffic Management System is a intelligent transportation system (ITS) for expressways, installed by SMG to centrally manage traffic situations and to provide detailed traffic information real-time to the drivers on the expressways.

ITS efficiently manages traffic flow through a combination of technologies, both “hardware” (road, construction, transportation, communications, electricity, electronics, automobiles, etc.) and “software” (operating methods, information processing techniques, etc.) without resorting to huge manpower. The goal of deploying ITS is to provide optimal route to the individual passengers, to induce convenient and safe passage, to detect the cause of delays including unexpected incidents, to provide solution, and ultimately to maximizes the efficiency of overall transportation system.

After all, the main function of FTMS is to collect various traffic situations’ information and to process and use the collected data. Information is gathered using loop vehicle detector, installed under the road and detects traffic flow, and video vehicle detector, which identify traffic flow based video recording, as well as CCTV and emergency phone calls. In addition, tip-offs from the road users provides good source for information. Figure 1 schematically and substantively shows devices and information media used for data collection, data process and information provision.

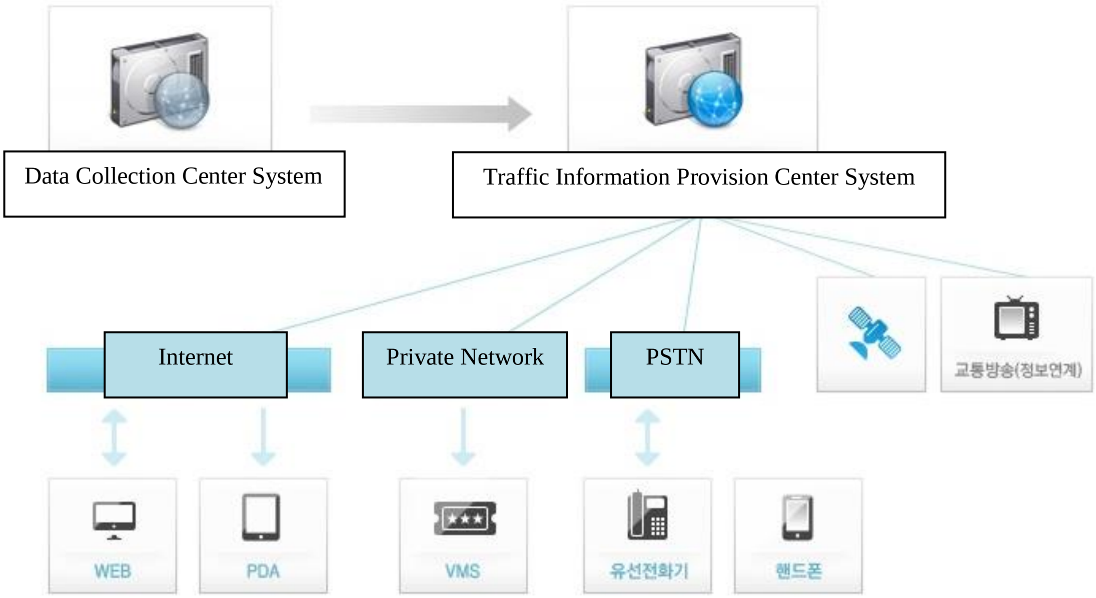
Transportation Data Collection System

Transportation Data Collection System collects traffic flow, weather changes, unexpected incidents that happen on expressway using VMS, CCTV and emergency call.



Traffic Information Provision Center System

Traffic Information Provision Center System promptly provides information on expressway with drivers and users by processing collected traffic information via VMS, LCS, ARS, emergency broadcast system, WEB and etc.



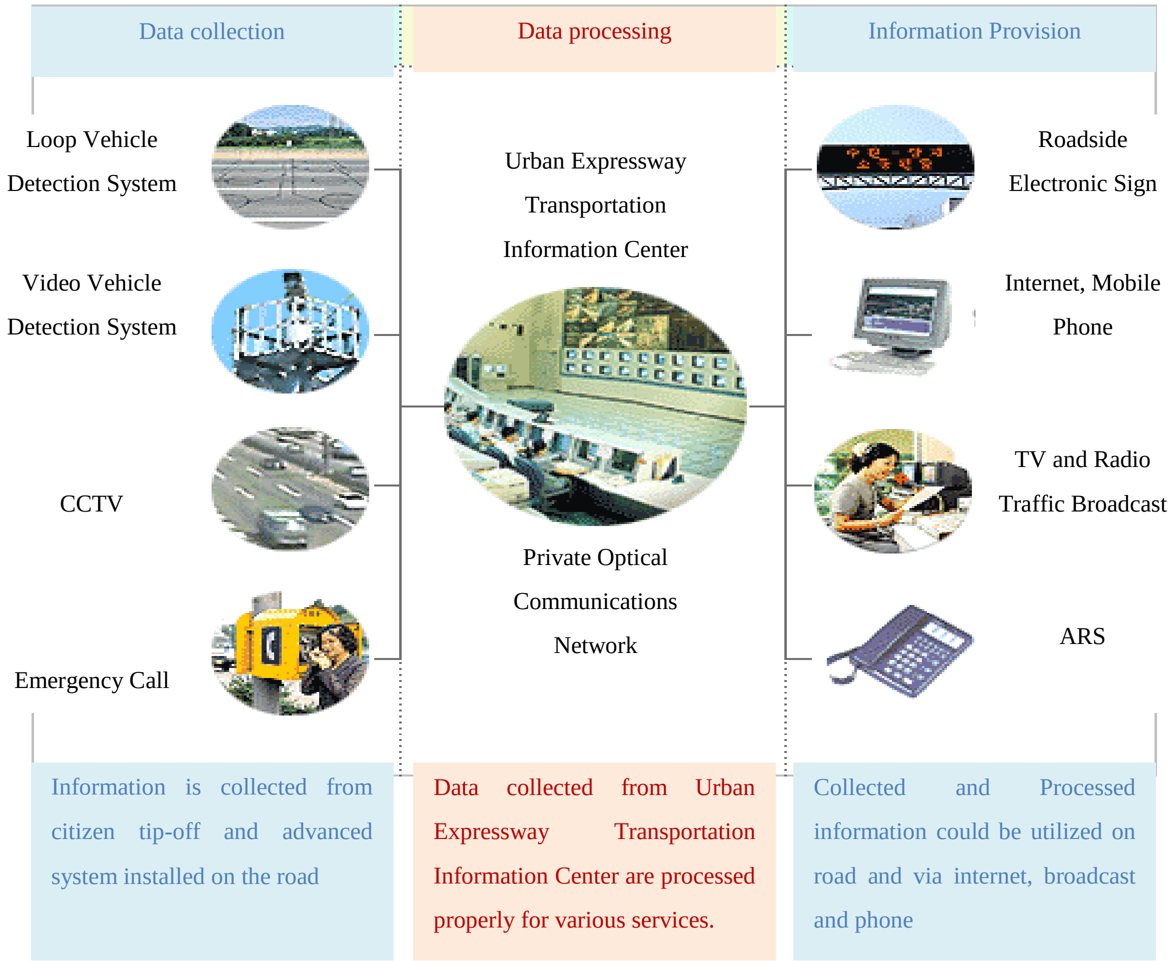


Figure 1. FTMS Data Collection Processing Provision

Source: Seoul Metropolitan Government (2013)

As of 2013, a total of 1,193 units of traffic data collection devices are installed across the urban expressway in Seoul, which includes 1,047 units of Vehicle Detection System (VDS), 144 units of CCTV, 2 units of Road Weather Information System (RWIS). Media providing traffic information includes 260 units of Variable Message Signs (VMS) as well as the websites of the Seoul Urban Expressway Traffic Control Center, ARS and fax. On top of these, traffic flow control devices are installed such as 30 units of RMS (Ramp Metering System), 33 units of LSC(Lane Control System) and 2 units of cutting-in controller.

Table 2 below shows how many on-site data collection devices, which compose Seoul's urban expressway FTMS, has been in operation for each phase FTMS project. The collected data goes to the Urban Expressway Traffic Control Center where all traffic information is supposed to be collected. The center provides collected data directly to the users or sends it with other relevant institutions. It also receives information from other institutions and offers them to users via various media, which is well summarized in table 3.

Table 2. Installation of FTMS in Seoul Urban Expressway

<table>
<tr><th rowspan="3">Category</th><th colspan="4">Data Collection Devices</th><th colspan="6">Data Provision and Control Devices</th></tr>
<tr><th colspan="2">VDS</th><th rowspan="2">CCTV</th><th rowspan="2">RWIS</th><th rowspan="2">VMS</th><th rowspan="2">RMS</th><th rowspan="2">LCS</th><th rowspan="2">cutting -in</th><th rowspan="2">Internet</th><th rowspan="2">Others</th></tr>
<tr><th>Video</th><th>Loop</th></tr>
<tr><td>Phase 1</td><td>213</td><td>24</td><td>38</td><td>-</td><td>62</td><td>12</td><td>-</td><td>-</td><td rowspan="4">web page</td><td rowspan="4">ARS/ FAX</td></tr>
<tr><td rowspan="2">Phase 2</td><td>120</td><td>2</td><td>22</td><td>-</td><td>43</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>218</td><td>124</td><td>40</td><td>2</td><td>81</td><td>-</td><td>19</td><td>-</td></tr>
<tr><td>Phase 3</td><td>194</td><td>10</td><td>36</td><td>-</td><td>61</td><td>19</td><td>14</td><td>2</td></tr>
<tr><td>Phase 5</td><td colspan="10"></td></tr>
</table>

Source: Seoul Metropolitan Government (2013, 2014)

* Acronym
VDS: Vehicle Detection System
RWIS: Road Weather Information System
VMS: Variable Message Sign
CCTV: Closed-Circuit Television
RMS: Ramp Metering System
LCS: Lane Control System

Seoul Metropolitan Government has installed FTMS in 9 segments of the urban expressway, stretching 180.4 km (April 2007) based on a high-speed communications network. As of 2013, a total of 1041 units of vehicle detection system (VDS), 144 units of CCTV and 260 units of roadside electronic sings are installed across Seoul's urban expressway for collection and provision of traffic data.

Seoul Urban Expressway Traffic Information Center serves an information source on the Korea Expressway Corporation that provides effective and proactive traffic management 24/7 and accurate and real-time traffic information. The information center provides prompt traffic management in times of unexpected emergencies including traffic accidents, disasters happening on the expressway and helps smooth traffic flow by swift provision of traffic data after the collection and analysis of real-time traffic data. In particular, it helps drivers find optimal route by offering integrated transport information including national highway and urban roads as well as expressway information. Integrated traffic data are provided in real time to various broadcasting media including TV, radio station and DMB and to mobile phone, PDA, navigation devices, ARS and internet. Drivers on the expressway may figure out traffic information from the roadside electronic signs.

Table 3. External Information Links to the FTMS

Category		Information Details	Frequency	Use of the Information
From	Seoul Metropolitan Police Agency	Traffic flow at a fixed point (1 min interval), traffic flow at a fixed segment (1 min interval), unexpected incidents	1 min	-
		CCTV feed	-	-
	Korea Expressway Corporation	Traffic flow at a fixed segment (1 min interval)	5 min	-
	Traffic Broadcasting Station (TBS)	CCTV feed	-	-
	Seoul Transport Operation & Information Service (TOPIS)	Traffic flow at a fixed segment (1 min interval)	5 min	-
		CCTV feed	-	-
	Expressway to Incheon International Airport	Traffic flow at a fixed segment (1 min interval), unexpected incidents	5 min	-
To	Expressway to Incheon International Airport	Traffic flow on the Incheon Airport Expressway (Bukno JC – Airport)	10 min	Traffic information provided online
		Traffic flow on the Gyeongbu Expressway (Hannam – Shingal), Oegwak Outer Beltway (Toegyewon – Ilsan)	5 min	Traffic information provided online, displayed on operation devices and online maps
	Seoul Metropolitan Fire & Disaster Headquarters (Seoul Emergency Operations Center)	Weather data	1 min	Weather information provided online
		Data on dams, Han River level, and precipitation	-	Operation devices
	Namsan Zone Traffic Data	Traffic flow at a fixed segment (1 min interval)	1 min	Traffic information on the Namsan Zone via VMS

Source: Seoul Metropolitan Government (2013)

7. Technical Details

FTMS is composed of ‘field system’, which is to collect and provide traffic information, and ‘center system’, which manages process and analysis traffic data, system operation and integration of external links to FTMS. As shown in Figure 3, information on weather and transportation collected by vehicle detection system, CCTV (Closed-circuit television), RWIS (Road Weather Information Systems) are processed and analyzed by information processing system, a part of center system, and are offered to users via ARS and internet, or even displayed on the variable message signs (VMS). Also, FTMS exchanges information with organizations including Korea Expressway Corporation, Seoul Metropolitan Agency and Seoul Emergency Operations Center, which are linked via information network.

Figure 2 below schematically shows elements of urban FTMS and their relations.

Figure 2. The Structure of the Urban Expressway Traffic Management System

Source: Seoul Metropolitan Government (2016)

As of 2013, a total of 1,193 units of traffic data collection devices are installed across the urban expressway in Seoul, which includes 1,047 units of Vehicle Detection System (VDS), 144 units of CCTV, 2 units of Road Weather Information System (RWIS). Media providing traffic information include 260 units of Variable Message Signs, VMS as well as the web sites of the Seoul Urban Expressway Traffic Control Center, ARS and fax. On top of these, traffic flow control devices are installed such as 30 units of RMS (Ramp Metering System), 33 units of LSC (Lane Control System) and 2 units of cutting-in controller.

8. Policy Effects

Social Benefits

A report (SMG,2007), released by the end of 2007 when Phase 3 FTMS was completed, provided analysis on the effect of FTMS in terms of social benefits as shown in the table 4 below and the criteria evaluating benefits are specified as shown in the table 5. In other words, social benefits were evaluated in terms of reduced travel time, reduced travel time due to bypass, reduced time responding to unexpected incidents, reduced energy consumption and improvement in air quality in the section where FTMS was implemented. Table 4 shows benefits from reduced travel time accounts for more than 66%, energy reduction 13% and reduced time responding to unexpected incidents 15%.

In the meanwhile, extended networks in general turns out to lead to bigger benefits, which is grounded by figure1s of 2003 when the Phase 1 FTMS project was completed and the system stabilized and the fluctuations of benefits in 2003 and after. In 2007, benefits from energy reduction and improved air quality showed temporary drop over the year, as rise in travel distance and traffic volume, which directly determines energy consumption and air pollutant emissions amount failed to offset benefits generated from rise in travel speed.

Table 4. Social Benefits Generated by FTMS

(Unit: 1 Million Won)

Category (Year/ Benefits)	Reduced Travel Time in Mainline	Route Change (Bypass)	Reduced Time In Responding to the Unexpected Incidents	Reduced Energy (Operation Costs)	Improved Environment (Air Quality)	Sum
2003	16,634	472	3,910	5,647	565	27,229
2004	16,673	532	4,906	5,709	597	28,418
2005	25,181	765	6,201	9,579	963	42,689
2006	45,319	4,935	7,739	10,769	1,053	69,815
2007	72,382	7,793	10,942	6,679	649	98,445
Total	176,189	14,497	33,697	38,383	3,829	266,595
Percentage (%)	66.1	5.4	12.6	14.5	1.4	100.0

Source: Seoul Metropolitan Government, 2007, Recited by Ministry of Land, Transport and Maritime Affairs 2009

Table 5. The Criteria of Effectiveness for Each Benefit Item

Category	Benefit Items
Direct Benefits	• Reduced Vehicle Operation Costs • Reduced Travel Time (Mainline, Bypass) • Reduced Time for Responding to Unexpected Incidents (Traffic Accidents, Breakdown and etc.) • Reduced Traffic Accident • Increased Pleasantness, Punctuality and Safety
Indirect Benefits	• Reduced Environmental Costs • The Effect of Regional Development based on Improved Transportation System • Expanded Market Area

Source: Ministry of Land, Transport and Maritime Affairs 2009

The Price Consumer/User is willing to pay

User satisfaction on the information provision was computed by quantifying qualitative evaluation items based on the survey on ‘the price user is willing to pay’ to the FTMS information provision media (excluding Variable Message Sign). Qualitative benefits were calculated by multiplying average price that the ‘user is willing to pay’ to each information providing media and the number of annual usage for each media together. As shown in table 6, internet traffic information whose usage had been by far more frequent than other media turned out to have generated the biggest benefits.

Table 6. The Price Each Media Is Willing to Pay for the Data from the Urban Expressway FTMS, Annual Usage and Benefits

Category	Internet	ARS	SMS	FAX	Cell Phone	PDA
The Price that User is Willing to Pay (won/case)	55	38	38	24	57	

Category	Internet	ARS	SMS	FAX	Cell Phone	PDA
Usage	3,932,823	320,999	170	625	16,742	4,764
Benefits (1,000 won)	216,305	12,198	6	15	954	272

Source: Ministry of Land, Transport and Maritime Affairs 2009

Usage of variable message signs (VMS) was not included in the target of survey above as the usage is not optional. Instead, reliability was checked in the survey and users, in general, turned out to find the information on the VMS reliable. For each type of information, users find the information on delayed and congested area on the expressways (3.64 point out of possible 5 point) the most reliable, followed by information on unexpected incidents and situations (3.54 point). SMG 2007.

More recent survey shows drivers in 2013 used FTMS information by 11.7 million times, a sharp rise from 4.6 million times in 2007. While use of the FTMS information via internet remains high, the number of searching the information using mobile phone was about 5.8 million times in 2013 due to surge in the use of mobile devices including smart phones. Table 7 below indicates annual use of Seoul's FTMS transportation data for each media.

Table 7. Use of Seoul's FTMS Transportation Data for Each Media

(Unit: No. of cases/Year)

Category	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Total No. of usage	2,256,940	2,780,286	3,026,974	4,276,123	4,593,626	4,862,232	5,930,403	10,449,609	18,117,411	13,612,320	11,777,260
Internet	2,025,411	2,584,203	2,822,365	3,932,823	4,059,065	4,294,350	5,337,458	9,904,212	17,759,764	13,364,052	5,726,604
Mobile	Uncounted										5,811,771
ARS/FAX	222,342	185,664	192,151	321,624	501,039	528,204	545,110	491,263	316,693	178,101	122,922
Telephone Inquiry	9,187	10,419	12,458	16,742	16,493	14,335	12,955	10,077	7,709	6,226	4,972
Feature Phone, PDA	-	-	518	4,934	17,029	25,343	34,880	44,057	25,155	54,753	7,794
Tiwitter	-	-	-	-	-	-	-	-	8,090	9,188	9,584

Source: Seoul Metropolitan Government (2013)

9. Challenges and Solutions

SMG's experience in deployment and operation of FTMS for the past 20 years is by and large positive but there remains some room for improvement in three aspects as follows.

① Performance of applied technology

② Securing budgets to replace deteriorated transportation management system

③ Linkage of ITS with arterial roads

Performance of Applied Technology

The performance of devices and facilities collecting traffic information needs to be supplemented. The traffic information bureau of Seoul Metropolitan Facilities Management Corporation has established master plan for the ITS performance evaluation of FTMS and has laid a foundation for the accuracy test of traffic volume and speed measuring for each detector through complete enumeration of vehicle detection system, video frame analysis, relative inspection on traffic volume or reconfiguration (recalibration or change setting) of video-based vehicle detector. (Seoul Metropolitan Facilities Management Corporation, 2014). Along with the performance test, thorough management will be necessary for measures taken to facilities that failed to meet the standard.

Also, in regards to some FTMS section, 'simultaneity' or 'real-time' provision of the information has been pointed out to have some limitations. That means it takes long time or update frequency is long for the commercial data to be utilized or for the information to appear on the electronic map of the traffic information center after collecting vehicle data from the vehicle detection system on the road. Therefore, more efforts are needed to provide information in real-time by shortening update frequency and by reducing time required for data processing based on increased and dispersed server load.

Securing Budgets to Replace Deteriorated Facilities

According to the operation and maintenance plan of Seoul's FTMS, 2015 detailed plan included plan to achieve no-failure in system through exhaustive FTMS pre-inspection activities. On top of regular inspections, the 2015 plan also covered performance of special inspection to prevent any failure and to raise service satisfaction level in preparation for the period including national holidays and monsoon seasons when there is a surge in the use of the traffic information. However, difficulties in securing budgets to replace deteriorated FTMS had been argued. The 2016 Plan includes maintenance of system facilities of center and field, conducting performance test of vehicle detection system and improving the performance of dilapidated FTMS. On top of this, SMG has earmarked to the tune of 2.69 billion KRW for the performance improvement of deteriorated FTMS. Maintenance of the facilities has been delegated to the Seoul Metropolitan Facilities Management Corporation. (Ministry of Land, Infrastructure and Transport 2015).

FTMS System Advancement Plan

FTMS system advancement is included in Seoul transportation master plan (SMG 2014) and

Seoul ITS master plan (SMG 2013) which outlines the provision of integrated operation of FTMS both in urban expressways and arterial roads in order to upgrade the efficiency in operation based on the successful operation of the FTMS so far. The master plans also cover the establishment of information service provision for safety.

In Phase 4 FTMS project (2011-2013), FTMS had been deployed in arterial roads, the main bypass of urban expressways, whose goal is to optimally disperse traffic volume to bypass from the urban expressway.

On the basis the FTMS implemented even to the arterial roads, FTMS advancement project will be conducted according to the three ways as specified below.

- To improve linkage of traffic information between urban expressways and arterial roads
- To extend the entrance/exit control to the urban expressways by implementing integrated control and linkage with arterial roads in response to the real-time traffic situations.
- To offer risk alert service that warns risk factors in driving safety including risky section on the expressway.

Besides, SMG plans to promote smooth traffic flow by implementing variable speed limit (VSL) and lane control system (LCS) in the mainline of urban expressway. Variable speed limit designates desirable speed, determined by traffic situations and weather information, in order to maintain optimal traffic flow, which guarantees safe passage and maximizes possible road capacity. This, in turn, leads to smooth traffic flow in the mainline of the urban expressway. Lane control system (LCS) designates optimal route and speed in the case of unexpected incidents or emergencies that needs the dispatch of emergency vehicle. (Seoul Metropolitan Government 2014). Table 8 provides FTMS system advancement plan for each year.

Table 8. FTMS System Advancement Plan for Each Year

<table>
<tr><th>Progress/Year</th><th>FTMS System Advancement</th></tr>
<tr><td>2013</td><td rowspan="2">• Design and System Improvement</td></tr>
<tr><td>2014</td></tr>
<tr><td>2015</td><td rowspan="4">• FTMS system deployment and control strategy development
(Installation of 96.7 km of field system each year)
- Control Strategy Development and System Establishment in Mainline and Ramp Segments
- Establishment of Intelligent Safety System with its focus on risky segment</td></tr>
<tr><td>2016</td></tr>
<tr><td>2017</td></tr>
<tr><td>2018</td></tr>
<tr><td>2019</td><td rowspan="3">• Implementation of Integrated Linkage and Control between Urban Expressways and Arterial Roads
• Widespread Installation of Intelligent Safety System and Advancement using communications technology used between cars.</td></tr>
<tr><td>2020</td></tr>
<tr><td>2021</td></tr>
</table>

Source: SMG, Urban Transportation Master Plan, 2014

More efficient management of traffic flow is expected if 1) performance test and replacement of deteriorated facilities are effectively performed, 2) FTMS system advancement project is conducted in accordance with its plan, and 3) FTMS information is effectively exchanged with information collected and provided from the private sector.

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Transport System Management (TSM)

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A majority of large cities that simultaneously experienced both physical and economic growth in the late 20th century are now experiencing a rapid increase in the use of motor vehicles and, as a result, have faced with the problem of urban traffic congestion. One traditional method of resolving this problem is to increase new traffic facilities, such as roads. This method of continually constructing roads between the 1960s and the 1970s with various extensions was often seen as the answer – particularly in the USA. However, most countries cannot depend on the construction of new roads due to the financial restrictions needed for road construction or the limits of usable land. The so-called 'TSM method' has a also been rather diversely used to increase the efficiency and accommodating skills as a means of resolving traffic congestions in large cities by improving the existing transport system - based on the principle that the extension of roads itself causes more traffic demands. Furthermore, the city of Seoul has also gradually been conducting TSM since 1980. Recently, the approach of TSM has become more systematic and integrated based on ITS through Seoul TOPIS. The main components of Seoul TOPIS, i.e., Advanced Traffic Management System/Traffic Signal Operation System, Freeway Traffic Management System, Bus Information System/Bus Management System, and Unmanned Regulation System/Automatic Penalty Charging System all follow the principles of TSM. That is, there is a clear objective of resolving traffic issues through the optimization of the efficiency of existing facilities, and not the construction of additional traffic facilities.

1. Policy Implementation Period

Seoul city has undertaken the Backside Road Repairs Project and the Transport System Management (TSM) Project from late 1980s onwards, and since then, interest in traffic safety has increased. This has led to the performance of the annual project of the improvement of areas with frequent accidents since the late 1980s. Meanwhile, the Highway Traffic Improvement Project,

[9] Translation by ESL®

which was selected as a means of improving the traffic congestion problem, was performed as a type of special improvement project, and a series of TSM projects were diversely initiated in different forms, such as the Habitual Traffic Congestion Point Improvement Project in 2004.

2. Background Information

The rapid growth of the Korean economy and the development of the motor vehicle industry of the 1980s resulted in a sudden increase of traffic volume. The total number of motor vehicles surpassed one million vehicles, and in 1990, the number surpassed two million vehicles, wherein approximately half of those (i.e., one million vehicles) were concentrated in Seoul.

Since then, the total number of motor vehicles in Seoul had increased to twice the amount, i.e., two million vehicles, within the last five years. This rapid increase in the number of motor vehicles in Seoul had led to diseconomy - with problems such as increased commute times due to traffic congestion and traffic accidents. Thus, the intensified problem of traffic congestion had been recognized as a serious social problem.

The number of registered motor vehicles in Korea between 1980 and 1990, meanwhile, had increased by eight-fold from 249,000 to 2,075,000, wherein the width of the roads was merely increased by 12.5% from 47,000 km to 56,700 km. The government initiated road construction projects to resolve the imbalance of such demand and supply, while also introducing a policy of using private capital in the extension of information facilities, including roads, by enacting the Private Capital Attraction Promotion Act related to indirect social capital facilities in 1994.

However, in the 1990s, the traffic policy professionals and decision makers shared an awareness that there were restrictions in the method of approach concerning facility supply, such as the extension of traffic systems or road construction, and sought new traffic problem resolution means beyond the more traditional and dated traffic policies.

In Western countries, with a focus on both the USA and England, the recognition of the environment and the effect of budget reduction policies had gradually increased since the 1980s. Attention was therefore gathered on the concept of increasing the accommodating skills of traffic facilities by increasing the efficiency of existing facilities rather than resolving traffic problems by depending on the new construction of traffic facilities, i.e., TSM, which was already regionally being used in the 1970s. From the perspective of a similar goal, another alternative method of approach that was soon noted was the Transport Demand Management (TDM) method, and both the TSM and TDM methods represent a new paradigm in the traffic policy field of the end of the 20th century, which brought on an extensive change in the methods of approach that depended on the construction and supply of existing facilities.

In Korea, the TSM method had been mainly used under the name, ‘Traffic (System) Improvement Project’ from the late 1980s, and in the 1990s, projects that were not necessarily called ‘Improvement Projects’ diversely accommodated these approach methods with the goal of expanding the accommodation through the increased efficiency of the operation of existing facilities, i.e., following the concept of TSM. Such projects began with the government’s introduction of the transport system management method (TSM) in the process of pursuing a new means of resolving the serious traffic congestion that had become gradually metropolized in the 1980s.

3. The Importance of the Policy

The Transport System Management (TSM) Project was initiated to reduce chaos by additionally obtaining roads and applying the method of efficient operation by improving existing road facilities, such as the top of the roads and central islands for improved functions of the more turbulent traffic regions.

4. Relevance with Other Policies

The Intelligent Transportation System (ITS) fuses advanced technologies to traffic facilities-the bus exclusive road system granting priority to efficient traffic means rather than increasing the number of lanes, the traffic signal management system, the automatic illegal parking control system, and the freeway traffic management system (FTMS) applying ITS to urban freeways are all examples of the TSM method. Accordingly, Seoul TOPIS, which supports and comprises these various components, is directly related to traditionally and locally performed TSM.

ITS itself is an innovative means that strongly appeals to policy makers as merely a small cost is required compared to much larger physical infrastructure facility supplies needed for basic road construction, while allowing smoother traffic flows and enabling the efficient operation of existing traffic facilities. Even in Korea, various research and development projects and demonstrative projects were initiated in relation to ITS in the 1990s. In Seoul, overseas ITS advanced technologies were introduced, and the Freeway Traffic Management System (FTMS) was initiated as a part of this project. Accordingly, FTMS is a representative ITS project that has enhanced the efficiency of the urban freeways, and is an important part of the TSM project.

Seoul city established the government's 1997 'National ITS Master Plan' in addition to the 'Comprehensive Plan for ITS in Seoul' in 2000, and overseas countries are also now classifying ITS as a pioneering project in the traffic field and are expanding its areas of activity to live traffic information and safety fields in terms of traffic management, such as the flows between vehicles and roads.

Currently, almost all cities are experiencing extreme traffic congestion due to the rapidly increasing volume of traffic and are, therefore, concerned with various traffic problems. Particularly, since the Seoul metropolitan area includes 46.6% of the entire population of Korea, and the central economic, social, cultural, and educational functions are excessively concentrated therein. Thus, it is experiencing more serious traffic chaos than any other city in the world. Furthermore, the significant economic, social, and environmental loss and national health problems are surfacing, which is leading to efforts for the resolution of such problems. Focusing on the national industrial complex regions concentrated with small and medium businesses that urgently require traffic improvements, means of resolution are proposed centered on TSM, optimizing the efficient operation of existing traffic facilities, such as traffic demand management, improved operation of traffic signals, and improved parking management, which can display a rapid effect with a low budget and immediate enforcement, in comparison to the expansion of facilities, which require a much higher budget and take a far longer time .

This is similar in other countries, where various forms of TSM are performed through diverse policies and systems in each country. Among which, let’s take a look at the case of the US as below.

- Surface Transport Program (STP) - USA

The Surface Transport Program includes the improvement project of roads such as Rural Major Collectors among main or district roads, and is largely categorized into four different types as seen below.

Table 1. Types of Surface Transport Program

Category	Program	Features
Type I	STP-Urban	* Regulated to use more than 50% of the STP fund * Distributed to the main government and local governments based on the regional population * Can be used for the improvement of the transfer skill of the relevant road, such as road expansion, public transportation and reconstruction, joint pass, intersection/bottleneck improvements, signal optimization, and most TSM projects * Ratio of financial support: Federal government (80%), main or local government (20%)
Type II	STP-Rural	* Can be used for the improvement of roads ranked above distribution roads in district regions * Financial distribution based on the driving distance * Ratio of financial support: Federal government (80%), main or local government (20%)
Type III	STP Anywhere	* Can be used irrespective of region (urban, rural) * Can be operated under the determination of the main government * Ratio of financial support: Federal government (80%), main or local government (20%)
Type IV	STP Enhancement	* Can be used for the improvement of a connective traffic system between means * Use on road improvement projects, such as facility expansion projects for pedestrian and bicycle paths, and roads with high landscape or historical value * Ratio of financial support: Federal government (80%), main or local government (20%)

5. Policy Objectives

The intended goal through the improvement of the road traffic facility system is the efficient use of the road. The TSM project initiated in Korea, including Seoul, aims to resolve traffic congestion by improving unreasonable traffic facilities by targeting regions that suffer particularly severe traffic congestion.

For the relief of traffic congestion, there are multi-angled forms of TSM methods, including the improvement of bottleneck and intersection regions, efficiency of traffic operations, signal management, demand management, and ITS, wherein the specific goal is to enhance the driving speed by effectively combining these methods.

Next, the types of improvement policyofroad traffic facilities are categorized in phases. Thus, each policy sets a different goal. However, the ultimate goal is to relieve congestion by constructing a database capable of apprehending the roads prone to traffic congestion, institutionalizing related legislations, and initiating the TSM project.

Table 2. Road policy initiation road map for relieving traffic congestion on urban roads.

Responsive Policy	Short Term	Mid to Long Term
Deduction of implications and analysis of existing similar projects (traffic congestion project, TSM project in Seoul and Gyeonggi)	O	
Reestablishment of the concept of traffic congestion reflecting the properties of urban roads	O	
Preparation of a means to resolve traffic congestion in urban roads	O	
Development of a manual for initiating the means to resolve traffic congestion on urban roads	O	O
Evaluation and documentation of traffic congestion of the main roads in all cities		O
Construction of a database related to traffic congestion on urban roads Construction of a reliable system for researching the rate of road congestion Construction of a reliable database of the rate of road congestion		O
Development of projects resolving traffic congestion on urban roads	O	O
Regular initiation of projects resolving traffic congestion on urban roads		O
Institutionalization of laws related to projects resolving traffic congestion on urban roads	O	O

6. Main Policy Contents

Transport system management, i.e., TSM, is a means of understanding and increasing the harmony between traffic demands and facility supplies by efficiently operating and managing the existing facilities rather than by supplying new road traffic facilities.

In Korean cities, the concept of this transport system was introduced in the mid-1970s to be applied to urban traffic improvement studies. Furthermore, in the early 1980s, the Seoul Traffic Improvement Master Plan was established as a loan project with the International Bank for

Reconstruction and Development by the Korea Advanced Institute of Science and Technology's Regional Development and Research Center, and conducted the TSM demonstrative project on three roads (Cheonhodae-ro, Mangwoo-ro, Jongam-dong-gil) in 1984 to 1985.

Primarily by the Korea Transport Institute which opened on 1986, the urban TSM project and the Banpo-axis, Mapo-Yeongdeungpo axis improvement projects had been performed. Thereafter, this remarkable innovation resulted in vast improvements on the formerly unreasonable and inefficient road operation system by conducting the TSM project and research for improved flow and enhanced traffic capacity in main regions of congestion in district cities (Busan, Daegu, Gwangju) as well as sub-urban areas (Gangnam, Yeongdeungpo, Shinchon, Cheongryangri) in the 1990s.

The TSM project conducted in the 1980s to 1990s redistributed roads, adjusted signals, installed traffic islands, and even reduced pedestrian paths with the goal of increasing the capacity of vehicles in most existing supply facilities. However, the priority of pedestrian safety and public transportation was partially violated. Recently, the goal of road traffic improvements, such as the creation of walking paths, has also come to emphasize the qualitative aspect and balance of the entire road traffic environment. Upcoming transport system projects reflect the demands of various road usage classes and focus on the conversion to intellectual traffic improvement projects that can enable the road traffic environment to reach that of the standard of advanced countries.

Seoul TOPIS has enabled the automatic control of a safe distance for vehicles, providing all public transportation information on the internet of mobile phones, as well as traffic predictions by incorporating such advanced electronic communication technology to TSM. These are the measures being taken by Seoul city to not only contribute to promoting the traffic capacity, safety, and demand management, but also to form comfortable roads and an improved urban environment.

After 2010, the following methods has been frequently applied to Seoul's traffic system improvement projects: geometry structure, signal system, three-dimensional intersection project

Axis improvement project: Bottleneck region improvement, signal linkage, bypass development, partial capacity increase project, etc.

Construction of infrastructure for improved bus services: bus transfer facilities, BRT route installation, etc.

Urban Freeway Congestion Mitigation

Seoul recently conducted a function improvement construction on the representative habitual congestion secion on urban freeways. As a series of urban freeway function improvement projects, a road was expanded using the extra space, such as the central division and top of the road from November 2012 to May 2013. The comparison of the travel speed in rush hours before and after the construction shows, travel time had shortened the most during the evening rush hour. The speed during 7 am to 9am increased by 59.6% from 27.2 km/h to 44.1 km/h, and the speed during hours 18 to 20 increased by 195.9% from 21.8 km/h to 64.5 km/h. It appears that the speed during the afternoon hours dramatically increased due to the relief of the bottleneck effect caused by the extension of suburb roads where the traffic volume is concentrated during evening rush hours.

Category	Morning Rush Hour (07 to 09)	Evening Rush Hour (18 to 20)	Daily Average (05 to 23)
Before Enforcement	27.7 km/h	21.8 km/h	33.1 km/h
After Enforcement	44.1 km/h	64.5 km/h	58.6 km/h
Increase Rate	16.5 km/h		

Furthermore, it appears traffic flow has been improved partially by the provision of real-time traffic information and bypass information based on the intelligent transportation system (ITS) integrated by 6 road billboards, 6 video detection systems (VDS), and 8 dedicated short-range communications (DSRC) on all regions of the western arterial roads in 2012.

The two areas where construction was completed in 2013 were the Bukbu Arterial Road toward the Muk-dong route and the Dongbu Arterial Road toward the Seongsu route. These areas applied the TSM method, which efficiently operates and additionally secures roads through improving existing road facilities, such as the top of the roads and central divisions, without construction that requires significant financial investment.

The existing route in the downtown direction surrounding the Bukbu Arterial Road toward the Muk-dong IC lacked the necessary road capacity, and resulted in traffic congestion up to the main route of the Bukbu Arterial Road. The broad space used as the shoulder of the Muk-dong IC was used to extend the two lanes to three lanes, and the road and traffic signals on the Hwarangdae intersection located on the end of the route were adjusted to improve the traffic flow.

Upon analyzing the traffic flow before and after the construction, the Dongbu Arterial Road toward the Seongsu route displayed an enhanced flow of vehicles of 29.2% and the Bukbu Arterial Road toward the Muk-dong route displayed an enhanced flow of vehicles of 71.2%. When converted to currency, this signifies an annual reduction of 1.62 billion won, and accounts for twice the total TSM construction cost.

With respect to the Dongbu Arterial Road, the Yongbi Bridge expansion construction (Yongbi Bridge-Haengdang road construction), which began in March 2007, temporarily opened on November 11, 2015 and was completed on May 31, 2016.

The region on the Dongbu Arterial Road (descending direction), beyond the Yongbi Bridge ramp and toward Seoul Forest and Seongsu Bridge, is a chronically congested area, the congestion of which was to be relieved by increasing the road capacity through the extension of the road. In the past, habitual traffic congestion occurred, such as excessive traffic volumes in comparison to the flow of vehicles and the crossing of vehicles due to the incorporation of the Naebu Beltway, the Dongbu Arterial Road, the Gangbyeon Expressway, and the Dumugae Highway, respectively. However, the extra space near the road between the northern intersection of the Seongsu Bridge on the Yongbi Bridge route was used to extend an extra lane as a short-term means to relieve the congestion between the Yongbi Bridge and the northern end of the Seongsu Bridge. The exclusive right-turn lane toward Seongsu Bridge was also extended from one to two lanes. Furthermore, the four lanes on Yongbi Bridge were extended to six lanes to construct a Northern-Eastern region freeway network

This is an example of the TSM method that increased the road capacity without changing the entire structure of the road network, and was intended to resolve the problem of the traffic chaos through the efficient traffic operations including the use of right-turn lanes.

Figure 1. Yongbi Bridge Extension Construction (Yongbi Bridge-Haengdang Road Construction)

Source: Yongbi Bridge-Seongsu Bridge

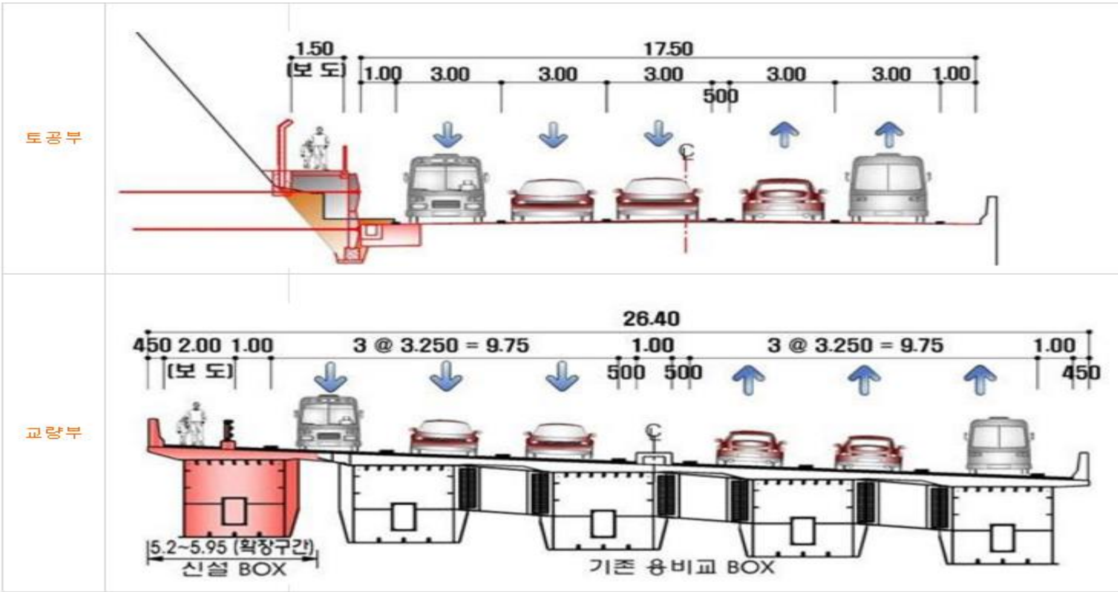

Figure 2. Cross-section Diagram: Yongbi Bridge-Seongsu Bridge

The construction to improve the traffic flow as performed by Seoul city from 2013 to 2014 included the Jangan Bridge route on the Dongbu Arterial Road and the Gunja Bridge route as seen in the drawing below.

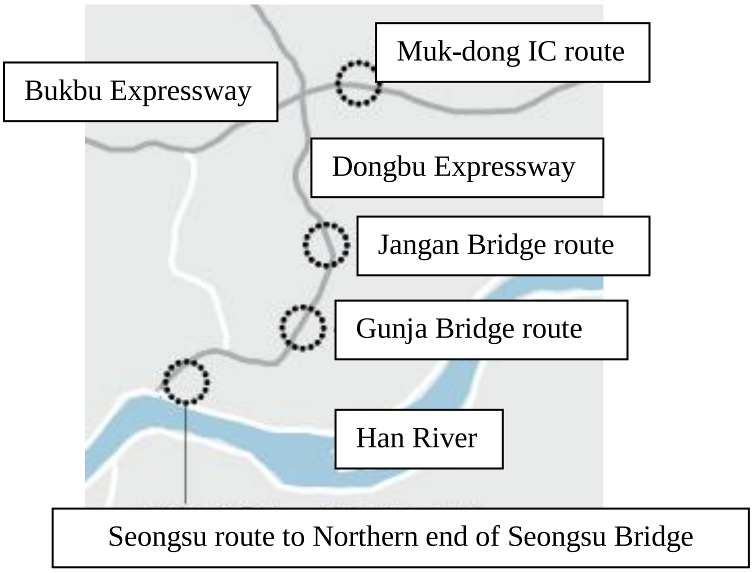

Figure 3. Urban Highway Congested Region Improvement

Source: Kyunghyang Shinmun (2013)

Dongbu Arterial Road Extension Construction

Seoul city entirely controlled the linkage ramp toward Seongsu on the Dongbu Arterial Road on Nowon Bridge from 10:00 on January 5, 2015 to expand the Surak overpass within the region of the Dongbu Arterial Road extension construction.

The demolition of the Nowon Bridge linkage ramp, which was constructed in 1994, began on January 5, 2015, and was completed on March 10; its reinstallation will be completed in late May of 2017. The extension construction of the Surak overpass was completed in late-May 2016. In order to minimize the inconvenience and discomfort of the regional residents due to the noise and du demolition st demolition caused by noise and dust, special construction methods using the diamond wire saw was performed to cut the structure. The removed parts were then moved to another region to be disintegrated.

Meanwhile, the Dongbu Arterial Road expansion construction began in February 2008 with a budget of 383.5 billion won and is planned to be completed in December 2017.

Business Outline

- Location: Dongbu Expressway Surak overpass

- Nowon Bridge linkage ramp (toward the Dongbu route) demotion and reinstallation

- Extension of the Surak overpass

4-lane, 6-lane

- Construction period: 850 days after commencement (Jan 2015 – May 2017)

- Constructor: Sewon Constructor Co., Ltd.

Figure 4. Outline of the Dongbu Expressway Surak Overpass

Source: Seoul City (2014) https://infra.seoul.go.kr/archives/20999

8. Policy Effects

The effect of improving traffic congestion based on the traffic operation technique was verified by the signal improvement project (traffic flow increased by 17%) to relieve the congestion in the

Ansan Banwol Industrial Complex route. A study reportedly demonstrates that the transportation improvement program aiming to build synchronized system had increased traffic speed to the entrance ramp from 36.6 km to 42.9 km by changing signal order at the Doil intersection, optimizing the signal timing at Ansan Intersection, and minimizing the vehicles' waiting queue on the road.

(Banwol Shinmun 2011).

The transport system improvement projects conducted by Seoul city in the habitual congestion regions also displayed noticeably reduced congestion and improved the overall traffic flow.

1) Yongbi Bridge Extension Construction (Yongbi Bridge-Haengdang Road Construction)

An effective flow between the regions was achieved by resolving the bottleneck effect in the northern end of Seongsu Bridge, a region of habitual congestion, and the traffic flow was thereby enhanced by 29% from 22.7 km/h to 29.3 km/h.

2) The effect of improved traffic flow from the Bukbu Expressway Muk-dong route and the Dongbu Expressway Seongsu route

Seoul city analyzed the change in traffic flow and volume at different times for two weeks before and after construction and, from this, calculated the socioeconomic profit based thereon.

The morning traffic flow toward the Hwarang University intersection increased by 71.1% 32.5km/h → 55.6km/h, 23.1km/h) by the Bukbu Arterial Road Muk-dong route construction and the traffic flow toward Yongbi Bridge increased by 29.1% (22.7km/h → 29.3km/h, 6.6km/h) by the Dongbu Arterial Roadto Seongsu route.

This saved time is tantamount to an annual reduction of 1.62 billion won, which is exceptional in terms of cost when seen against the construction cost of 830 million won.

In addition to the profit from the time reduction, the effect of cost reduction in the following items was also analyzed:

- Commuting time: 1.6 billion won
- Vehicle driving cost: 0.21billion won
- Atmospheric contamination cost: 90 million
- Reduced accidents: -460 million won

3) The Road Surrounding the Seocho IC, Seoul

Nambu circuit road operation improvement surrounding Seocho IC in Seoul

The region on the Seoul Arts Center three-way intersection around the Secho-gu Office three-way intersection of the Nambu circuit road is a habitually congested region of approximately 2km. It is also known to cause delays and congestion on the main Gyeongbu expressway and Banpo lanes.

It was observed and understood that a lack of road capacity during rush hours and delays based on the crossing of vehicles in the lower regions of the Seocho IC were the main causes of habitual congestion.

As a means of improvement, the Korea Transport Institute proposed a ‘2.53 billion won’ road operation improvement project comprising the following:

- The width of the lanes was adjusted from 2.9-4.0m to 3.0-3.25m in order to add another lane. Another lane was added by adjusting the width of the lane of the Nambu circuit from Seocho IC to the Seoul Arts Center and partially setting back the pedestrian path.
- Separation of the crossing of vehicles in lower Seocho IC and extension of lanes.

Separation of the main line in the region where vehicles frequently cross one another in lower Seocho IC and enhanced traffic flow by increasing the number of lanes in certain regions

Smooth traffic flow in the main lane obtained by constructing lanes on the Gyeongbu highway entry-exit ramp region (achieved by the relocation of subway ventilation facilities)

The analysis of the effect of traffic relief of the Nambu circuit surrounding the Seocho IC shows the average delay before the improvement in the region was 287 seconds, which has been reduced by 13.2% to 336 seconds upon improvement. Furthermore, the average traffic flow has been improved from 13 km/h to 15.7 km/h. The region near the Seocho IC of the Gyeongbu Expressway also displayed a positive reduction of 42.5% from an average delay time of 40 seconds per vehicle to 23 seconds upon improvement, and the average traffic flow improved from 34.5 km/h to 43.0 km/h.

Table 3. The effect of flow relief on the Nambu Circuit in Seocho IC

Category		Average Delay Time (Sec)	Average Traffic Flow (km/h)	Average Traffic Time (Sec)
Before	Nambu Circuit	387	13.0	488.8
	Gyeongbu Highway	40	34.5	68.5
After	Nambu Circuit	336	15.7	386.1
	Gyeongbu Highway	23	43.0	55.9
Effect	Nambu Circuit	-51(13.2%)	+2.7(20.8%)	-102.7(21%)
	Gyeongbu Highway	-17(42.5%)	+8.5(24.6%)	-12.6(18.4%)

Upon analyzing the economic effect of the Nambu circuit surrounding the Seocho IC, an annual profit of 52 trillion won occurred, and thus, the improvement effect in the congested region is significant.

Table 4. Annual profit on the Nambu circuit surrounding Seocho IC

Category	Annual Benefit			
	Relief of Traffic Flow	Reduced Energy Consumption	Reduced emission of Air Pollutants	Total
Improvement	50,218,898	1,166,297	640,065	52,025,260

The traffic congestion in urban CBD causes significant economic loss at a national level. The cost of Korea's national traffic congestion is 27.9 trillion won (as of 2009) - among which 17.6 trillion won is consumed in the six metropolitan cities, including Seoul. In this context, central and local government should join hands to mitigate congestion at the chronically congested section. Given the 'cost to congestion improvement effect', it will be desirable to continue public transportation improvement program and transportation operation program instead of construction new roads.

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TOPIS: Seoul's Intelligent Traffic System (ITS)

Shin Lee, University of Seoul[10]

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.

[10] 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 he urban highway traffic management system: 2000
- Inaugruration 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).

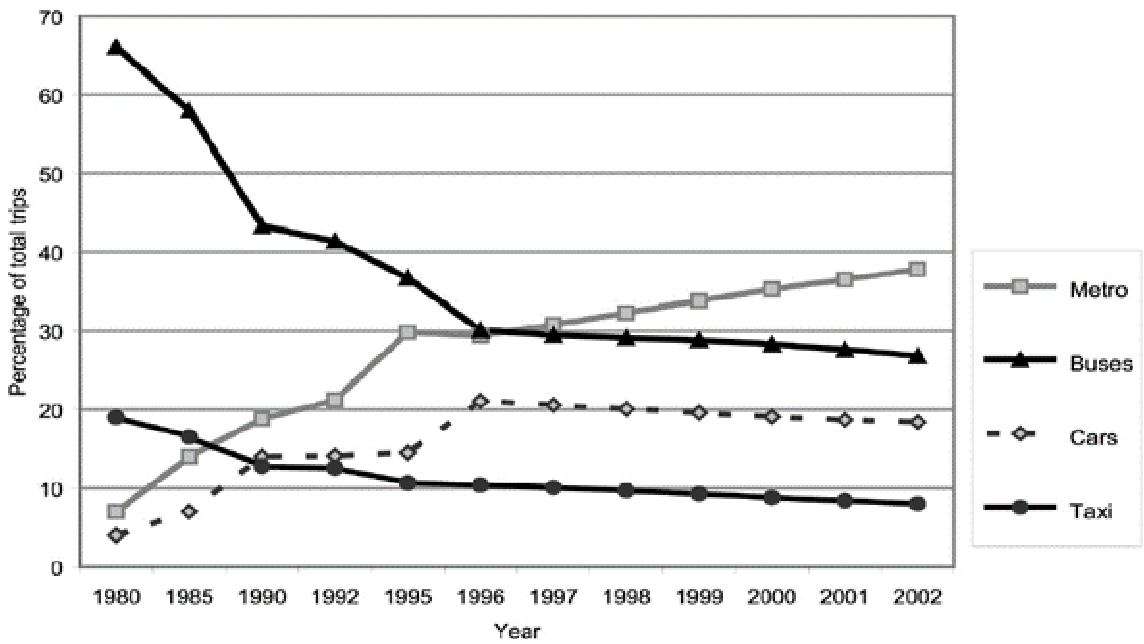

Figure 3: 1980-2002 Trends of Allocated Passengers for each Method of Transportation

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 inthe 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 cultrue
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.

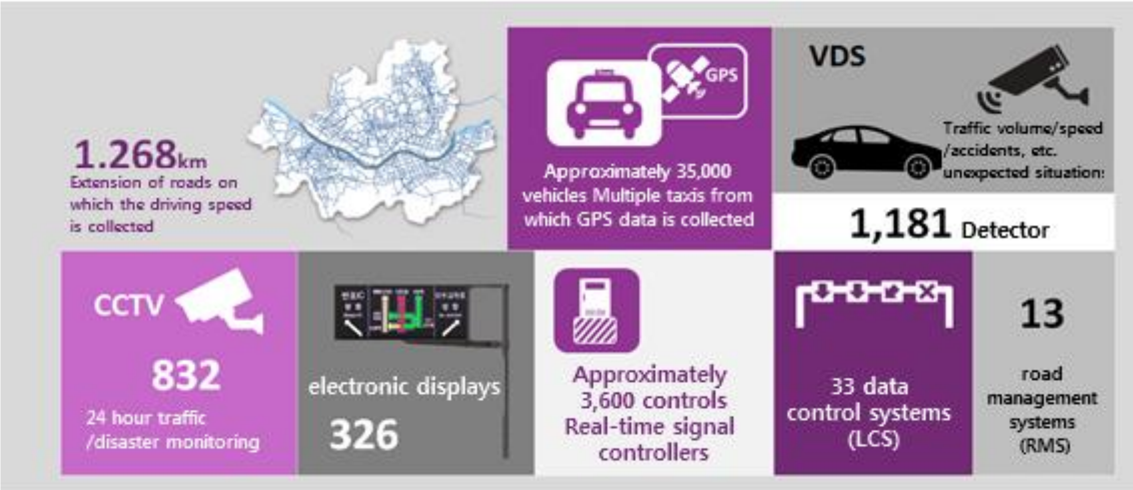

Figure 4: Current state of Seoul TOPIS' road traffic management devices
Seoul Traffic Information Division (2016)

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.

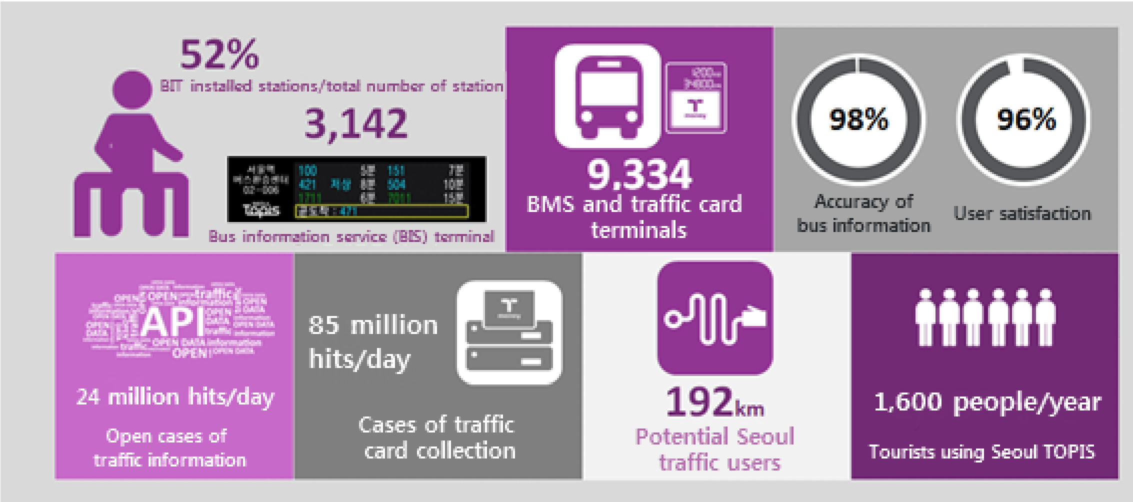

Figure 5: Current status of Seoul TOPIS bus information system

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.

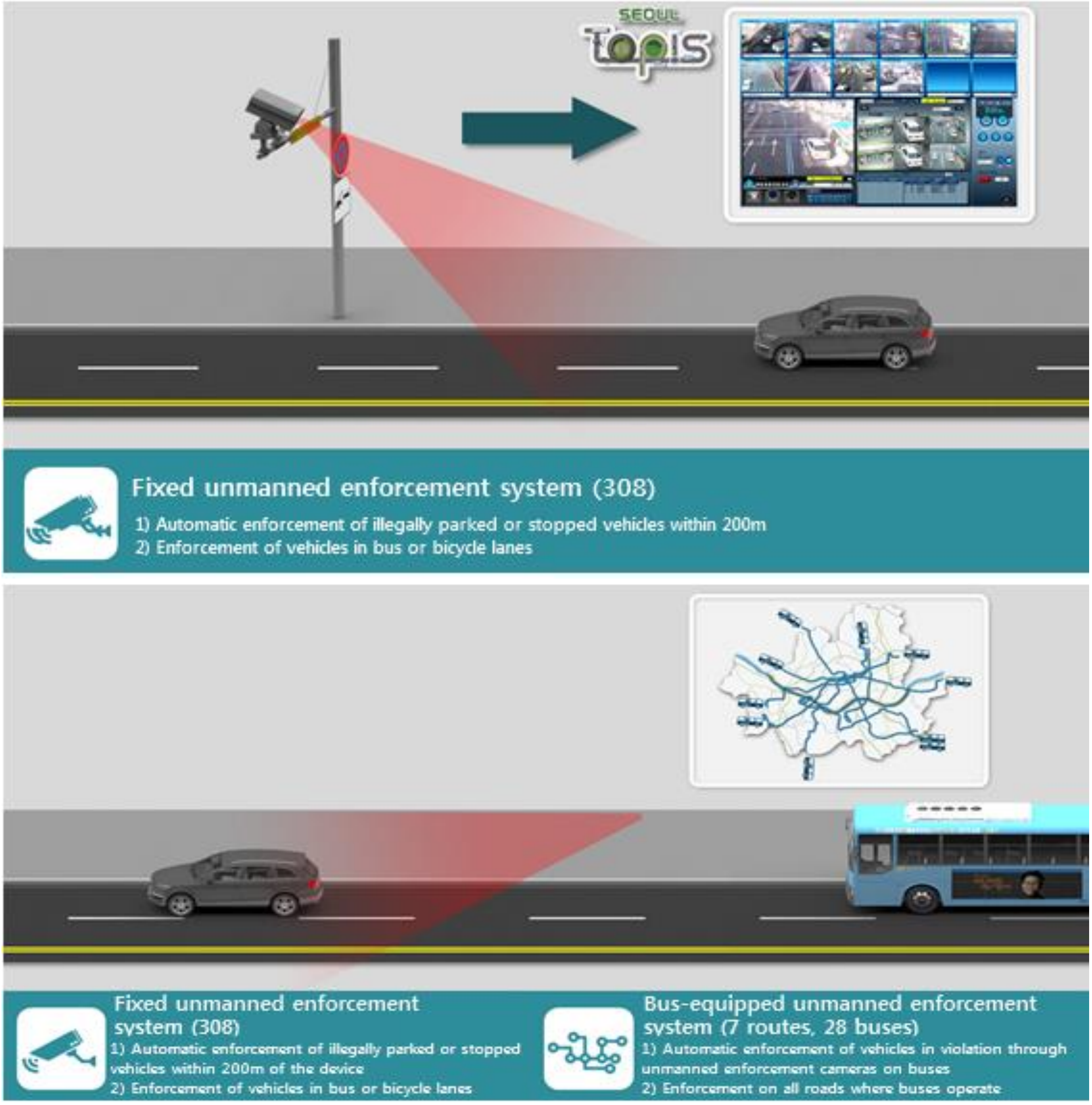

Figure 6: Seoul TOPIS unmanned enforce system

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.

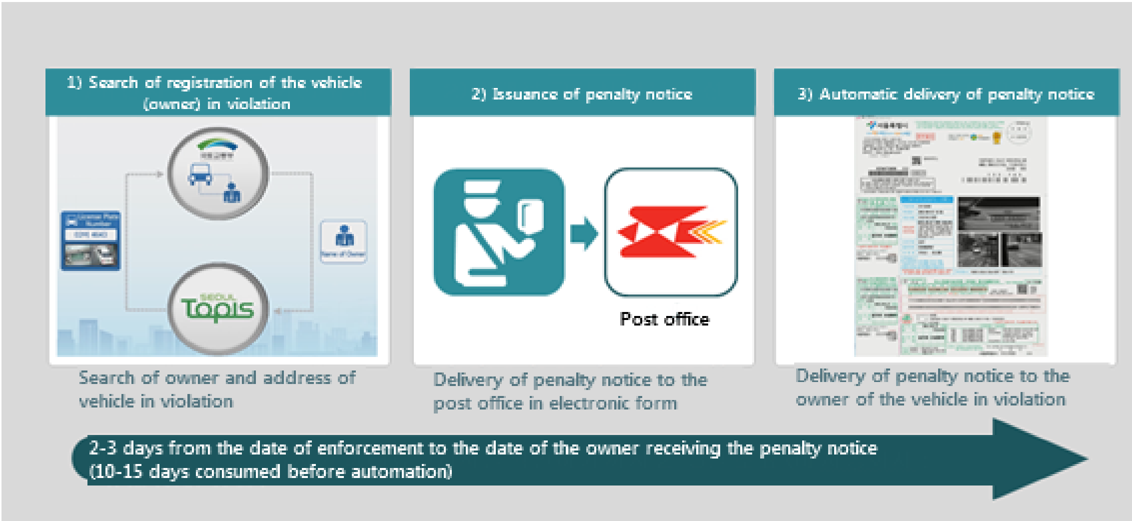

Figure 7: Seoul TOPIS automatic penalty imposition system

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.

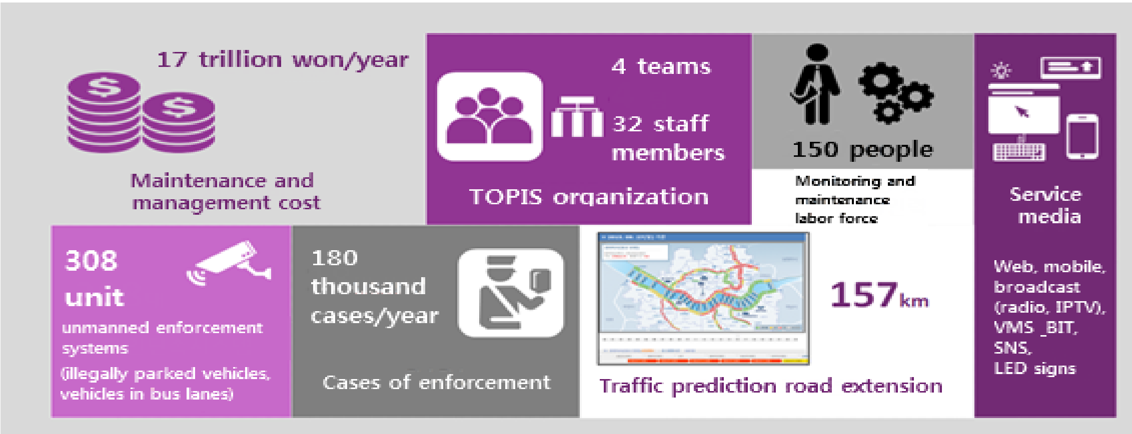

Figure 8: Seoul TOPIS organization and operation, and other related statistics

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

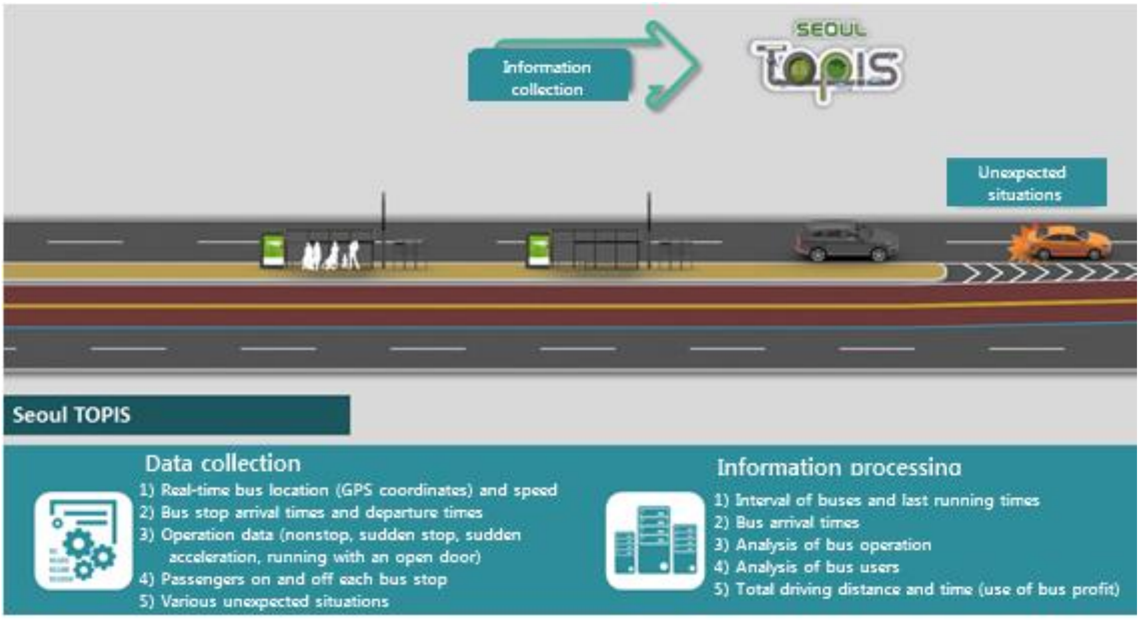

Figure 10: Seoul TOPIS bus information system
Source: Seoul Traffic Information Division (2016)

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

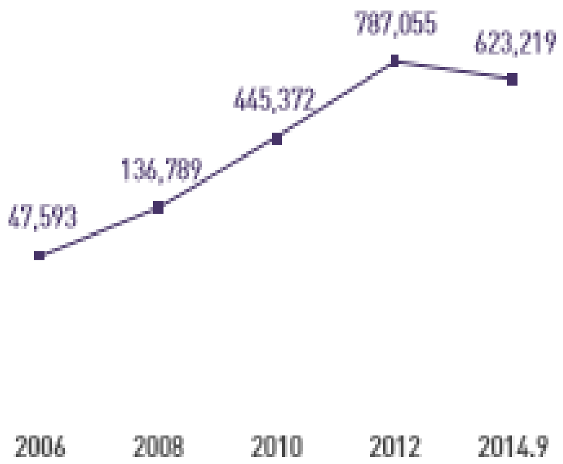

Figure 11: Current status of Seoul TOPIS information in use

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).

<u>Increase in the Bus Allocation Rate</u>

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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