TITLE: THE SEOUL TRANSPORT OPERATION AND INFORMATION SERVICE (TOPIS): THE DIGITAL BRAIN BEHIND SEOUL'S TRANSPORTATION SYSTEM

ISSUE AREAS

X ICT and SMART technology X Sustainable mobility ☐ Land use and nature-based solutions
☐ Clean energy ☐ Sustainable solid waste management ☐ Building energy efficiency
X Innovative urban governance X Behavioural change

OVERVIEW

The Seoul TOPIS (Seoul Transport Operation and Information Service) is Seoul Metropolitan's digital brain that gathers and processes real-time road and public transport traffic information to enable the city to effectively manage the different transportation modes to alleviate road congestion, respond to emergencies, and support informed decision making while developing public transportation policies. While TOPIS is an Intelligent Transport System (ITS) and functions as an integrated traffic management centre in the control room, its functionality is beyond the platform or advanced Information Communication and Technology (ICT) system. Another core component is the functional organization that facilitates data sharing and collaboration from the different transport entities and modes (bus, subway, carsharing and bike-sharing information). The successful implementation of TOPIS not only increased Seoul's public transport ridership satisfaction and improved the transport planning process, but it is also replicated and localized in other international cities.

THE CHALLENGE - WHY HAS THE CITY TAKEN ACTION

Increasing automobile ownership leading to traffic congestion: Along with the breakneck economic growth of Seoul is the car ownership boom. Between 1980 and 2009, car ownership staggeringly increased by 1,341% in Seoul and 2,907% in the metropolitan area. By 2014, vehicles on the road dramatically increased by 130 times, although the road network expanded only 1.2 times in the same period, leading to severe traffic congestion and the social cost of traffic is estimated to be USD 7 billion in 2009. Besides, it is also closely associated with other urban challenges, including air pollution, inefficient use of public space, and declining use of public buses.

Unattractive public transportation system: Public transport ridership declined between 1980 and 2009, particularly public buses, due to the competition with cars and subways (the first subway, Line 1, was introduced in 1974). Traffic congestion also led to unreliable public bus arrival times, while the private bus operators were only serving lucrative routes, making the public transportation services very unreliable and unattractive.

Lack of comprehensive traffic management system: Prior to the introduction of TOPIS, there was no central system managing the road traffic and public transportation system, including illegal parking, penalties and fines, traffic control, emergency response, amongst others. Private and public traffic information was scattered without a systematic way of analysis and management. Furthermore, the coordination between transport stakeholders was mainly ad-hoc, leading to piecemeal policies and interventions with minimal impact. For example, the Seoul Municipal Government, the Traffic Broadcasting System, and the Korean Expressway Corporation operated their respective systems. There was a need for a coordinated and systematic way of managing traffic

data for enhanced decision-making through stakeholder collaboration in emergency response and long-term urban transportation policymaking.

GOALS AND OBJECTIVES

As part of the overhaul of the public transportation system to combat traffic congestion, Seoul began to introduce the ITS system in 1998 with limited use at specific stretches of the city and gradually led to the first official introduction of the Seoul TOPIS in 2005. As a result, there are different functionalities of the Seoul TOPIS, which gradually evolved and developed over the years. Nonetheless, the overall goals for the Seoul TOPIS are:

- ***Public transportation management systems***, including the bus routes, bus operation intervals, smart transport cards, arrival and departure information, ridership, and others
- Provision of a scientific and data-based ***traffic administration support***
- ***Real-time communication and management of the road traffic control***, including automatic illegal parking control systems, traffic violation control, unmanned traffic control system, traffic flow control and traffic signals management
- ***Integral to emergency response management***, traffic accidents, security, natural disasters, or even war-time response to strengthen urban resilience and disaster response
- ***Better informed transportation policymaking*** based on big-data analysis

As Seoul TOPIS is more than just the platform or the control centre, it enables collaborative city management involving the Seoul Police Agency, Seoul Traffic Broadcasting, Korea Meteorological Administration, Regional Construction and Management Administration, and the Korea Expressway Corporation. Predicting and forecasting prompts science-based judgments and translates into real-time responses by mobilizing the necessary responses or parties on-ground.

Ultimately, the TOPIS is a means to support Seoul's Transportation Vision 2030, which envisions a Liveable Seoul – without relying on cars, anchoring on three main pillars: (1) human-centric; (2) sharing; and (3) environment.

HOW DID STI PROVIDE A LOW CARBON AND CLIMATE-RESILIENT SOLUTION?

(STI as a means of implementation)
X Improved decision making ☐ Offering a low-cost solution ☐ Inclusive decision making
☐ Improved governance ☐ Behavioural change

(STI as a direct technical solution)
☐ Cleaner/more eco-friendly infrastructure ☐ Cleaner/more eco-friendly equipment
X Faster/better/larger data availability/processing

- **How was it innovative? (What enabling policies were employed? What were the local/national government's policy targets, goals and strategies? Were new S&T approaches developed or existing S&T approaches enhanced? Was the cities geography/culture capitalised upon?)**

Seoul Transport Vision 2030

Seoul implements a consistent and strategic transport planning paradigm with a clear vision of minimizing private vehicle use and maximizing multimodal transportation to build a "Liveable Seoul – without relying on cars," as stipulated in the Seoul Transport Vision 2030. Seoul's

Masterplan listed the Seoul Urban Planning Charter in 2014 for the development in the next century as the foundation for urban planning administration and also included consistent messaging and strategies for the transport sector. The Seoul Transport Vision 2030 listed six principles for implementation to achieve human-oriented, shared, and environmentally-friendly mobility, in which technology is one of it. The mobility plan frames the implementation actions in the long-term to achieve the "Triple 30" goals:

- 30% increase in the use of active and public transportation;
- 30% reduction of personal vehicle use; and
- 30% reduction in public transport commuting time.

Technology is recognized as one of the key pillars that enable the city to manage traffic better. As described in the sections above, the core Seoul TOPIS's functionalities are customized to boost public transportation use and smooth traffic flow, consistent with the Seoul Transport Vision 2030.

A progressive approach in ITS implementation

Seoul developed a keen interest in developing ITS to promote efficient traffic management at a reasonable cost since the late 1980s with traffic congestion. At the same time, the Korean national government also invested in ITS research and development programs in the 1990s, leading to the first introduction of ITS to detect private cars driving illegally on exclusive bus lanes in 1995. Another key milestone is the first Freeway Traffic Management System (FTMS) in Seoul by piloting at the 18-kilometers stretch along the Olympic Expressway in 1997 (Lee, et al., 2014). The FTMS is an integral part of the Seoul TOPIS by collecting, analyzing, and managing traffic data focused on the urban expressway to relieve traffic congestion and improve traffic management. It is operated by the Seoul Metropolitan Police Agency, the Seoul Metropolitan Government, and the Seoul Metropolitan Facilities Management Corporation (Seoul Solution, 2017). In this period, Seoul developed the Comprehensive Plan for Seoul's ITS Projects in 2000 by identifying 16 ITS projects encompassing: traffic information, public transportation, road and traffic maintenance, traffic management, and the pedestrian safety system. Today, the ITS evolved to an integrated approach to manage the entire transportation ecosystem with a functioning organizational structure to fulfil the Seoul Transport Vision 2030.

- **What science and technologies were used? (What does it do? How does it work? How does it address the challenge?)**

Seoul TOPIS is a real-time and round-the-clock traffic information and communication system to provide science-based traffic administration support. It collects traffic information from the Bus Management System (BMS), the Smart Transportation Card System, the unmanned surveillance system, and traffic authorities and institutions. Operated by four teams and 150 employees, the TOPIS system underwent three main phases of upgrading, from "Cutting-edge" era (TOPIS 1.0) to "Openness" (TOPIS 2.0), to what Seoul operates today under "Collaboration" (TOPIS 3.0) with more specifications continuously enhanced:

(1) 2005: Establish the Traffic Information Integration system to connect the traffic information control centre to manage the general traffic situation
(2) 2006 – 2007: Expand the TOPIS support system for strategic decision-making process by integrating the operating system for subway and public bus services, connecting the traffic signal systems, and expansion of public services

(3) 2008 – 2009: Enhance the TOPIS system to be an intelligent metropolitan management hub for transportation, disasters and security-related incidences, also known as TOPIS 3.0

The core of the Seoul TOPIS processes can be summarized as data collection, data processing, and information provision through various communication channels and responses with different functionalities.

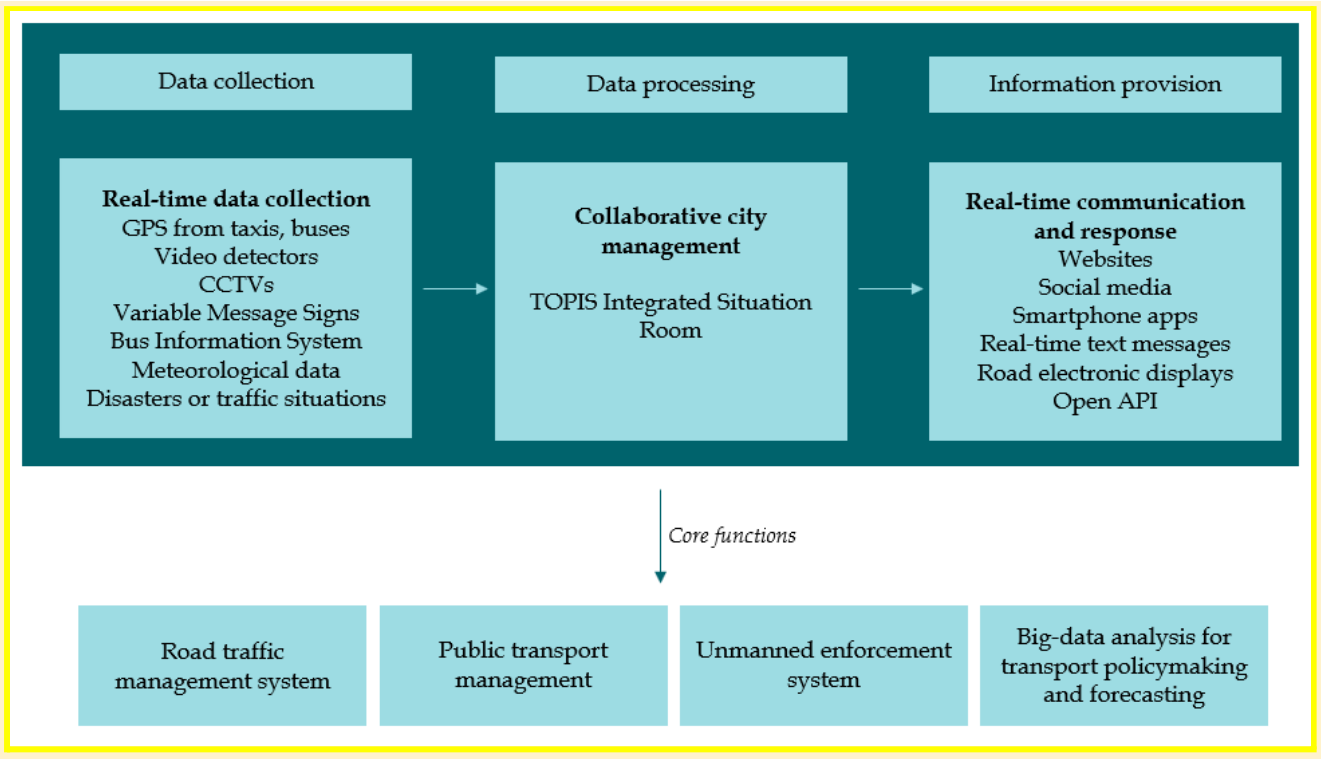

Figure 1: How the Seoul TOPIS work and the core functions

Road Traffic Management System

Data collection

Basically, the transportation information system collects data from the smart transportation card, the Global Positioning System (GPS) of buses and 70,000 taxis, 1,955 video detectors, 849 CCTVs, 341 Variable Message Signs (VMS), bus information system to process the data and information in the TOPIS Integrated Situation room or the control centre located at the Seoul City Hall. The #5 Lane Control System (LCS) is also operated at 95 locations. Information about the speeds, locations of buses, taxis, subways, traffic volume and flow, meteorological conditions, unexpected situations, and others are all part of the collection system. The GPS installed in taxis collects real-time information to calculate travel speed, collected through wireless communication between the GPS in vehicles, wireless communication devices, and road-side monitoring and detection systems (Lee, 2017). The vehicle detection systems are installed every 200 to 500 meters (m) on highways, such as loop and video detectors, to collect the traffic volume. Coupled with surveillance cameras and the meteorological information system, the system collects integrated climate information, the state of the road, temperature, and visibility from the National Police Agency, the Meteorological Administration, and civilians.

Data processing

Seoul TOPIS conducts big data analysis at the control center through a series of information analysis, processing and diagramming to provide a scientific operation plan and basis that prompts judgements and responses on the ground. Through this approach, sound diagnosis and responses based on predictions and extensive data analysis enable the prevention of transportation issues on-site before they occur.

Information provision: Communication and response

The resulting information and decisions are communicated and illustrated through websites, social media, smartphone applications, real-time text messages, electronic displays on the roads, and open API. Through a real-time and interactive display of traffic information, road users are able to select alternative routes or transport modes. In the event that an unexpected road situation occurs, it will be automatically detected through video or detector and displayed electronically in the control room. The road control system will be activated to redirect traffic flows through bypass roads or orienting the traffic signal control system to adjust the duration of traffic signals. Users can also go to the Seoul TOPIS website or the smartphone application to get real-time information on road transport, public transport, car- and bike-sharing systems.

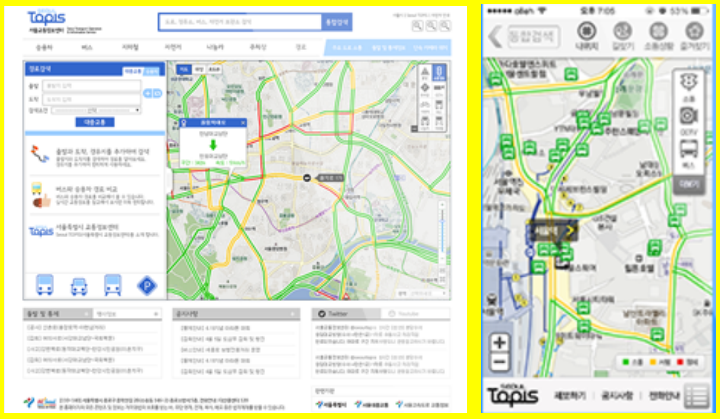

Figure 2: TOPIS System service display on the website and mobile phone (Photo: topis.seoul.go.kr)

Public transport management

As part of the Seoul TOPIS, the Bus Management Systems (BMS) has a two-fold function:

- ***Enhance the policymaking process*** by evaluating the public transportation companies' operation and passenger travel information to optimize the bus and subway routes, bus stop location and overall service quality.
- ***Manage bus operation information in real-time*** (Bus Information Terminal) to improve the service quality of public transportation.

The city installed the Bus Information Terminal (BIT) at 78.2% of all bus stops to provide commuters with real-time bus location information, arrival and departure time, seat availability, and bus route information. In the event of congestion, the system also recommends commuters a detour to enhance the commuting experience. In addition, bus arrival information is installed in all the buses with an accuracy level of 99% and a satisfaction level of 96% (Seoul Solution, 2021).

In addition to the BMS, the carsharing and bike-sharing systems provided by the Seoul Metropolitan Government are centrally managed through Seoul TOPIS by providing users with essential information, such as docking stations and availability in real-time. However, the city has

yet to leverage the city bikes and spatial data collection to optimize bike routes, a potential area to enhance cyclability.

Unmanned Enforcement System

Seoul TOPIS operates about 336 unmanned enforcement systems to strengthen enforcement in road traffic regulation violations. The system detects the number plates of the cars at the no-parking or no-car lanes and automatically searches the car owner's details and address through the Vehicle Registration Management System of the Ministry of Land, Infrastructure and Transport to issue the electronic fine physical photographic evidence via the Post Office. From detection to the ticket issuance process, the entire process takes only two to three days, making Seoul one of the fastest enforcement systems.

Similarly, the Seoul TOPIS also automatically detects and imposes fines on Grade 5 vehicles that should not be in the Green Transport Zone (GTZ). The GTZ is a low-emission zone, whereby Grade 5 vehicles[1] are prohibited from driving, except for emergency vehicles, vehicles for people with reduced mobility (PRM), and other exceptional cases. Again, Seoul enforces it for real-time monitoring and notification.

Big data analysis for transport policymaking and forecasting

Around 100 million road and public transportation traffic data is collected daily. Smart transportation cards (known as T-money transport cards) are used about 13.9 million times each day, transacting about KRW 225.2 billion of transportation fares in buses (98.7%), subways (100%) and taxis (67.4%). The smart transportation card is another big data source, with about 85 million transportation card data collected daily, of which are approximately 26 million real-time data from operations (speed and locations) of buses, taxis, and subways. Coupled with socioeconomic indicators (e.g., automobile ownership trend, landuse), a large amount of big data is used to diagnose bottlenecks in congested areas and optimize public transportation services or create new services. For example, adjusting the bus route or the subway time interval based on commuters' travel patterns or creating the night bus routes (Seoul Solution, 2021).

KEY AREAS OF CONSTRAINT/SUPPORT

INFRASTRUCTURE REQUIREMENT

Today, with the world's fastest internet services and advanced information communication and technology (ICT), Seoul is internationally recognized as the best electronic government. Under the brand Smart City Seoul and the Seoul Digital Plan 2020, Seoul is building new connectivity and new experience to empower open governance and adoption of the latest technology to solve urban issues.

For high accuracy prediction and information processing, high-quality big data is necessary and this is only possible through installing sufficient GPS devices, video surveillance, and other data collection channels throughout Seoul. Seoul began by looking at individual road and expressway stretches and gradually expanded it citywide over the years.

[1] Grade 5 vehicles refer to small- and medium-sized diesel cars before July 2002 or a gas-powered vehicle made before 1987. For heavy duty vehicles, it refers to a diesel vehicle released before July 2002 and a gas-powered car before 2000

The metropolitan smart transportation card is another vital data source, which is made possible through the Metropolitan Unity Fare System, which allows commuters to pay on a distance basis, covering Gyeonggi Province and Incheon Metropolitan City. Two of these neighbouring Province and Metropolitan City are crucial sources of incoming and outgoing traffic, therefore the data is also essential for intercity travel.

POLICIES AND REGULATIONS

The ITS is based on the National Transport System Efficiency Act to improve efficiency, integration and connectivity of the land, sea, and air transportation systems and policies. It also facilitates the establishment of the ITS Plan and development.

~~THE SCALE OF THE PROGRAMME/PROJECT~~
~~TECHNOLOGY CAPACITY~~

COST AND FINANCING /BUSINESS MODEL

The initial budget to develop the system was approximately 200 billion KRW in 1998, entirely financed by SMG. As the benefits become more apparent, the national government subsidizes additional projects (Cities Alliances, N.A.). The operation of the Seoul TOPIS requires about 17 trillion KRW annually, primarily used for site facilities, maintenance, and employment. At the start of the system, it was entirely funded by SMG.

HUMAN RESOURCE CAPACITY

With 32 civil servants and four divisions, 150 employees work at the Seoul TOPIS Centre managed under the City Transportation Bureau and Transportation Planning Division under SMG. The organizational chart for the Seoul TOPIS team is reflected in Figure 3.

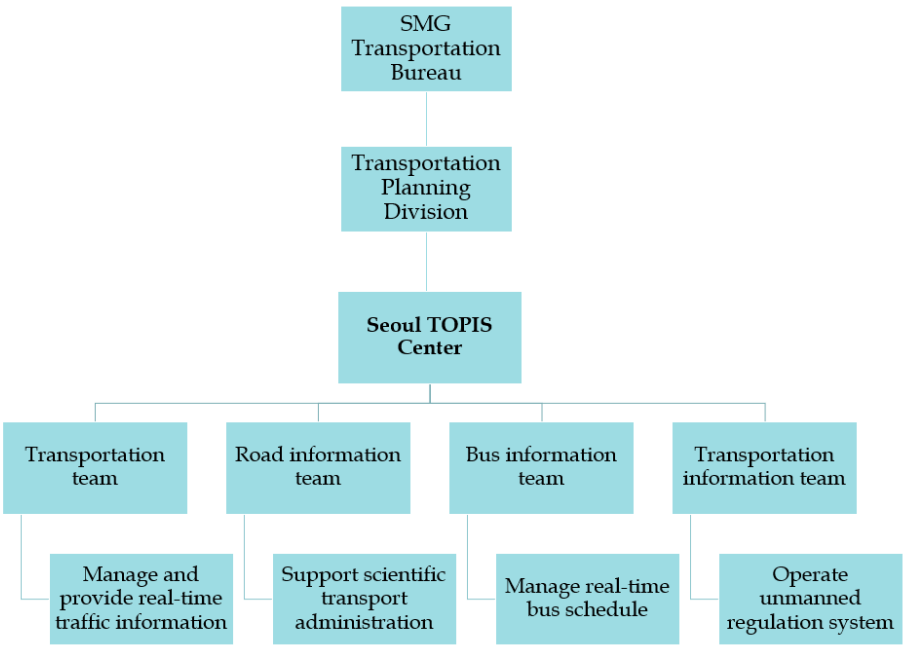

Figure 3: Organizational chart of the Seoul TOPIS team (Adapted from: topis.seoul.go.kr)

POLITICAL COMMITMENT

A comprehensive public transportation system reform, particularly the public buses, was undertaken in 2004 as traffic congestion worsened and public bus ridership drastically reduced. Before the extensive public bus reform in 2004, bus operators were only serving profitable routes, resulting in poor public bus services, although the metro system had a competitive edge in reliability. The public transport reform in 2004 led to a semi-public bus management system so that the Seoul Metropolitan Government (SMG) could better manage and control the operation and service management. Furthermore, integration of the subway and public bus services reduced inter-modal competition and enhanced public transport services. The public transportation information system (Bus Information System, BIS or Bus Management System, BMS), smart transport card, and exclusive bus lane were among the measures gradually introduced and are integral to the Seoul TOPIS.

In 2019, SMG also announced the Information Strategy Plan (ISP) to connect the entire Seoul with the Internet of Things (IoT) sensors and set up smart poles in downtown Seoul. The Smart Pole is a combination of streetlight or traffic signals equipped with Wi-Fi, CCTV, IoT sensor or display, facilitating live updates of the public internet services, public security and environmental information. Complementing that, SMG is actively working on the IoT-based city data management system by creating a joint public-private big data platform as part of the smart city project. As a pilot project, SMG collaborates with two districts to set up ten smart poles with KRW 600 million investment (USD 507,000) (Korea IT News, 2020). Once successful, this will be the pioneer of the Seoul TOPIS Portal, which SMG plans to launch in November 2021. The Seoul TOPIS Portal is a comprehensive big data open platform for integrated transport data disclosure, sharing, and utilization in real-time with data from both the public and private sectors to provide a one-stop service and real-time utilization (Seoul Metropolitan Government, 2020). The continuous investments reflect SMG's political commitment to continuously upgrade the smart city management system to address transportation issues in an integrated manner.

INSTITUTIONAL SETUP

The Seoul TOPIS can also be perceived as an institution that plans, develops, and operates an intelligent traffic system because the successful software use hinges upon a functioning institutional setup that enables collaboration. The institutional arrangement involves 13 parties, as illustrated below, joining forces in terms of data sharing, response team, maintenance, information processing, and information communication. While private sectors are not actively involved, they also use the Seoul TOPIS data to create online map services for traffic forecasting and live traffic updates in smartphone apps.

Figure 4: Institutional setup of the Seoul TOPIS (Source: https://topis.seoul.go.kr/eng/page/service_1.jsp)

KEY BENEFICIARIES

The key beneficiaries are the Seoul commuters as road traffic and public transport service improves; bus companies and passengers; and drivers. Indirect beneficiaries are other road users, such as pedestrians and cyclists, who can enjoy better road space and increased safety through better management of traffic flows.

TIMELINE

A brief timeline that led to the introduction of the Seoul TOPIS is summarized in Table 1:

Table 1: A timeline of the Seoul TOPIS introduction and evolution

1995	Established the first ITS to detect the violations on exclusive bus lanes
1997	Introduced the freeway traffic management system (FTMS) on urban expressways at the Olympic Expressway
2004	Started the public bus system reformation
2004	Integrated with the smart transportation card system, making it an official launch for the efficient operation of total traffic management systems
2005	Launched the Seoul TOPIS 1.0 to connect the traffic information control centre to manage the general traffic situation
2006	Expanded the TOPIS 2.0 for strategic decision-making and combination with the public transportation services
2008	Enhanced the TOPIS 3.0 to be a smart metropolitan management hub including disasters and security incidences
2013	Commenced the Seoul Integrated Safety Centre to manage transport and disaster control

2014	Commercialized the Seoul TOPIS solutions and established the business model by applying a trademark registration of TOPIS. It also formed an expert cooperation body.
2018	Moved the computerized equipment to the Sangam Cloud Centre
2019	Upgraded the traffic control platform to include the Green Transport Zone and redesigned the TOPIS website
2019	Announced the Information Strategy Plan (2019)
2020	Provided MyData service that recommends a customized transport service based on individual travel behaviour in real-time
November 2021	Plans to launch the Seoul TOPIS Portal project

IMPACTS

CARBON REDUCTION

Based on the FTMS Phase 1 implementation between 2003 and 2007, the social benefits were obvious: 176,189 million KRW saved from reduction in travel time; 38.383 million KRW reduction of energy consumption from operational costs; and 3,829 million KRW of air quality improvement were seen as a result of the drop in vehicle-kilometres travelled (VKT) by private vehicles.

While it may be difficult to attribute the introduction of Seoul TOPIS directly to reduced carbon emissions from transport, the Seoul TOPIS system enhanced the public transportation system. Therefore, it is a means to reduce the VKT by private vehicles and the energy consumption and carbon emissions, as presented in the modal split over the years in Figure 4.

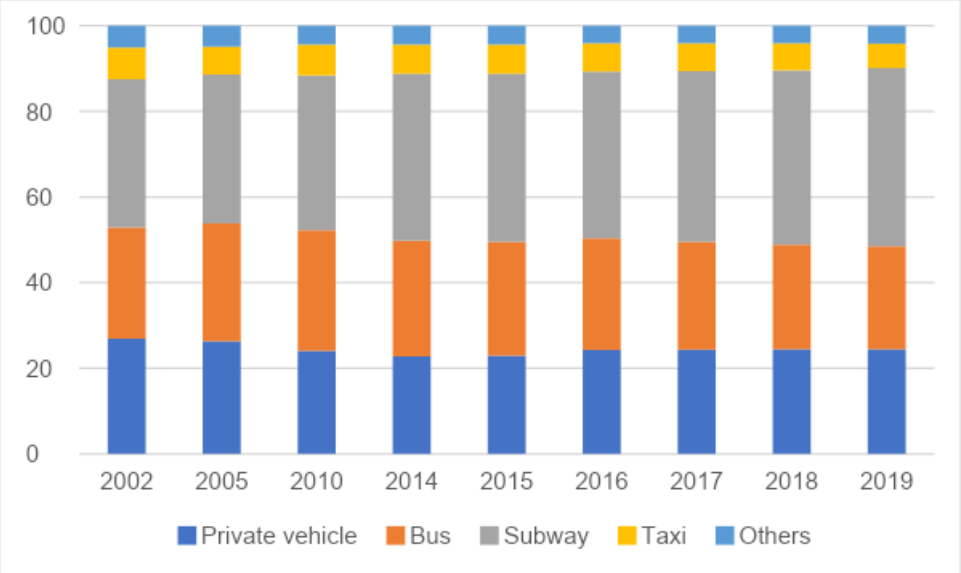

Figure 5: Modal split of Seoul

RESILIENCE

While urban resilience cannot be directly measured in this case, the Seoul TOPIS allows live meteorological assessments in the event of flooding, heavy snow and redirecting local traffic to enhance safety.

CO-BENEFITS (e.g., JOB CREATION, AIR POLLUTION REDUCTION ETC.)

Introducing the Seoul TOPIS is not just about an ITS system, it also catalysed innovation in line with the digital revolution, in connection with autonomous driving, connected vehicles, 5G-infrastructure, and digitalization. This positions Seoul as the world forerunner in advanced technology and attracts various start-ups and funding in new mobility ecosystems, spurring innovation, employment, and high-end specialized industries.

The increase in public transport usage and reduction in private transport usage can be observed over the years

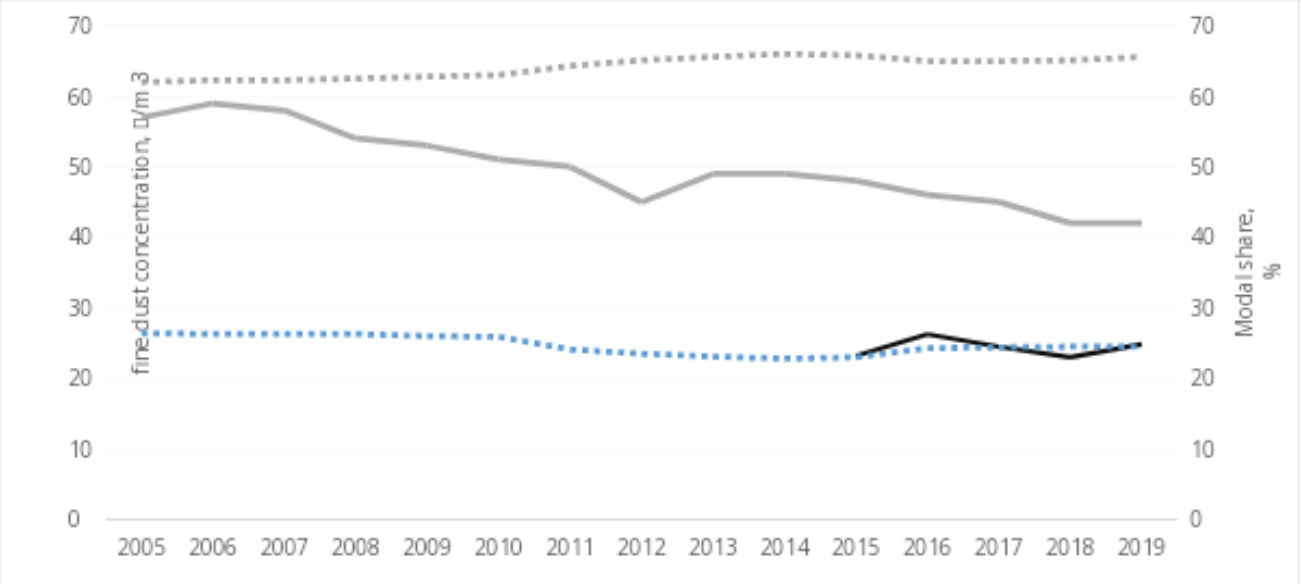

Figure 6: Trend in fine dust concentration and public-private transportation modal share (ICLEI, 2021)

FACTORS FOR SUCCESS

The factors for success are:

- The determination of SMG in reforming the urban mobility system and consistent strategies and interventions allowed the Seoul TOPIS to function well and meet the intended goals
- The phased approach to progressively introduce and upgrade the software and hardware of the Seoul TOPIS over the years
- The sustainable financing and innovative investment from the municipal budget and support from the national government
- Strategically leveraged on the public bus reform to maximize its impacts by complementing the software with effective institutional setup, bus-route negotiations with the private bus operators, and other municipal departments and agencies
- All transport policies and strategies are well aligned and led by the SMG Transportation Bureau, enabling a unified approach in fare collection, data collection, information processing and policymaking

- Korea has a vibrant and advanced technology, including ITS, IoT, ICT, with active participation and investment into innovation and research and development (R&D) by private companies
- A series of negotiations and collaboration with the taxi companies, bus operators, and multi-stakeholders, including the police authorities, fire stations, and others, to reach a consensus to set up a central transportation management system and the response structure. This may be the most difficult as negotiations the institutional setup is a core component to ensure its success.

LESSONS LEARNED

OPPORTUNITIES, CHALLENGES, AND SCALING UP

While the software system can be easily replicated, the core of the successful implementation is the institutional setup, consistent transport strategy that prioritizes public transport over private vehicles, and financial resources for public transportation. Some of the short-term opportunities for cities are:

- Begin with a pilot to collect data, preferably public transportation data, through a smart card system
- Agree with an institutional setup involving the relevant stakeholders for data-sharing
- Adjust the traffic signal system also to ensure that the time priority is given to public buses or pedestrians
- Identify opportunities to enhance the public bus system and services by working on the Bus Management System or Bus Information System, which are essential to an ITS that favours public transportation
- Leverage on existing public transportation improvement or reform efforts to use technology as a means to support the reform goals
- Work with the existing data and resources, whether it is a formal or informal transportation services

In the medium-to-long term, a sustainable financing model is necessary to ensure continuation. This can also be complemented by better public transport infrastructure, e.g., building exclusive bus-only lanes, upgrading public bus stops, creating a Mobility-as-a-Service application, expanding public transportation, and sharing mobility services to enable multimodal transportation.

SUSTAINABILITY

In the long-term, SMG plans to tap upon the digital revolution in transportation by connecting with the automated driving industry and 5G-based connected cars. It is envisaged that by upgrading the system to high-tech road infrastructure, such as blind-spot and accident hotspot surveillance, traffic accidents can be reduced by over 30%.

TRANSFERABILITY

The Seoul TOPIS is a trademark and can be easily transferred. SMG provided training and assistance to other developing countries from Azerbaijan to implement the system. About 2,062 foreign officials visited the Seoul TOPIS annually, a testament to its success and recognition.

Cities interested in replicating the system must first begin with a clear Sustainable Urban Mobility Plan or similar mobility policy that is people-oriented and mobility-focuses, instead of a car-oriented transport engineering masterplan. This will be able to guide the ITS system

implementation to ensure that it does not only favour car speed but a more holistic approach in ensuring that while road traffic is improved, it also meets the overall sustainable mobility vision that is low-emission and people-oriented.

Furthermore, while the technology can be replicated and reengineered easily, the core basis is also the governance framework and structure that supports the implementation and response management. Therefore, cities need to begin by strengthening horizontal and vertical integration and collaboration to build an institutional framework that allows for data sharing and collaboration.

EFFICIENCY/EFFECTIVENESS

The Seoul TOPIS collects data from about 70,000 taxis and 1,955 video detectors in real-time to effectively provide immediate response and policymaking due to the amount of big data available. As a result, the bus arrival information and bus service operations boast an accuracy of 99% and 96% satisfaction rate, respectively.

The continuous upgrading of the system reflects the interests and demand from the users, the commuters themselves. Since December 2020, the Seoul TOPIS has also provided the MyData service, a customized travel service that analyses individual travel behaviour through AI technology. Once the user agrees to collect personal information, the AI analyses the commuter's travel patterns across the public and shared transportation services (e.g., bus, shared bikes) paid by a credit card. This will customize and recommend the best route in real-time based on transport forecasting, e.g., traffic, weather situations, demonstration activities, and others. During the COVID-19 pandemic, MyData also shows travel routes of confirmed COVID-19 patients to avoid travel overlap with any patients. In the future, it is expected that the role of big data will be more prominent in customizing the travel of each individual and for policy making.

INSTITUTIONAL CONSTRAINTS/SUPPORTS

One of the core elements of this system is data collection, which is evolving to be more customized and individualized. Users or commuters need to agree that such personal data collection, cyber security risks, and confidentiality are essential considerations for the city and the users. Currently, the regulations for cyber security are relatively weak in many countries and cities. At the same time, many daily users may not be skilled to understand the intricacies of the data exposure, technological systems, and regulations, making them vulnerable to such risks. Therefore, the regulatory systems need to also be more progressive in line with the rapid pace of technological development.

FURTHER INFORMATION / CONTACT

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