Block 4 Reading

Management of Urban Transportation Systems

Authors: IGLUS, EPFL

This reading is the fourth block on management of urban infrastructures and focuses on the management of urban transportation systems, mainly in the context of efficiency. In it we first present the basic features of an urban transportation system and then discuss its management dimensions. Then, we look at the typical operation and the future challenges for urban transportation managers. Finally, we present the case study of Seoul's transportation system.

The basic features of an urban transportation system

Before addressing the management aspects of urban transportation, it is essential to gain insight into an urban transportation system's basic features, particularly on how the system relates with the structure of the city, the basic physical infrastructures present in it, the main transportation modes, as well as the main interfaces.

Relationship between transport and the city structure. Transport is clearly the most interrelated infrastructure of a city. First, transport is closely related to housing and the built environment. The structure of the built environment conditions the transport infrastructure and more generally the mobility of a city (for example, aging cities even today only allow for the use of reduced-size public buses, given the narrowness of their streets). But, inversely, the transport offerings also condition urban housing and industrial and commercial development (in other words, stores will locate near metro stations, and cheap cars and fuel favor the development of low-density suburbs outside city centers). Transport is also a significant driver of urban energy consumption, as well as pollution, using around 25 percent of the energy that goes into a city (for example, 28% in 2011 for the city of Copenhagen (Mathiesen et al. 2015)). Hence, the structure of the city is influenced by the need to provide the energy required for the transportation system.

Basic physical infrastructures. The main physical infrastructures that make up an urban transportation system in a city are as follows:

- *Underground infrastructures.* These include such structures as metro tracks or underground train tracks.

- *Surface infrastructures.* The majority of the transport infrastructures are, in fact, above ground. We find surface metro or train tracks, but the main part of surface infrastructure are roads. Yet on these roads we can find several other transport infrastructures, such as tram and light metro tracks, dedicated bus lanes, sidewalks, and dedicated bicycle lanes.

Main transportation modes. Different transport means are available to the user of the urban transportation system, such as these:

- The most important transport mode in cities today is still by far the *car* for which most of the urban roads have been constructed and used. Similarly, *taxis* are a commercial use of the car. Both are private transport modes.

- Increasingly, public transport modes are used by the inhabitants of a city – namely, public *buses*, *trams,* and *metros*, which may use dedicated surface tracks on the roads as well as underground metro tracks. Similarly, suburban *trains* and *mass transit* are also increasingly used as cities expand outward.

- A newly emerging mode of transport are called *soft mobility* means, which include public and private bicycles, along with walking.

Main interface. These serve as intermediaries between the physical infrastructure and the means of transport for the users. Yet, they are physical infrastructures taking up space and must therefore be considered as being as equally important as all other urban transport infrastructures, because they are essential for the transportation system's functioning. The most important such interfaces are as follows:

- Everybody is familiar with *railway stations*, which are often hallmarks of a city, at least in Europe. To a certain extent, *airports* have become the modern version of such an interface, even though they are generally located at the periphery of a city. In this context, one can also mention major *bus and metro stations*.

- Equally important but taking up less public space are *bus and tram stops*, along with *taxi stands* and *bicycle stands*.

- *Parking lots* and parking spaces, more generally, take up a significant portion of urban space, yet have an essential exchange function for the users.

Figure 1 summarizes this urban transportation infrastructure.

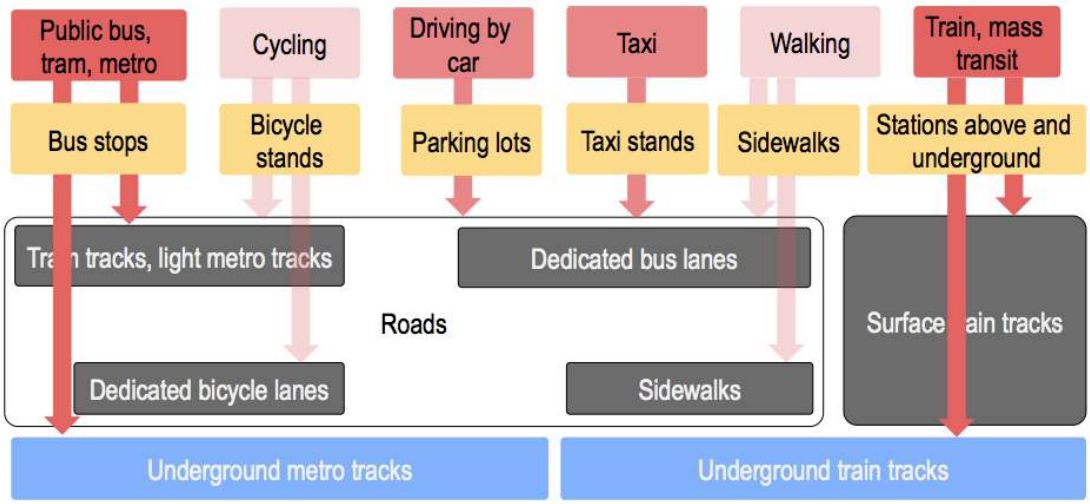

Figure 1: Schematic representation of the main physical infrastructure elements, means of transport, and interfaces of the urban transportation infrastructure system.

Managing the urban transportation system

In this section, we will now address the three main aspects that pertain to the management of an urban transportation system – namely, the question of the performance of the system, the management of different transport modes and infrastructures, along with the corresponding responsibilities.

The main performance dimensions

In our view, performance of the urban transportation system has to be looked at as a whole – looking at the performance of the entire system, as opposed to just examining the performance of each of the transport modes or of each of the operators. When doing so, two key dimensions appear to be important, and we discuss them first separately: efficiency and attractiveness.

Efficiency refers to how efficient the overall transportation system is. To that effect, we distinguish between time spent in urban transport and energy used and cost efficiency.

- *Time efficiency* of the system is measured by the time it takes to move from one point to another within the urban transportation system. This, in turn, is related to two key factors: congestion and reliability. Congested systems are not capable of responding to the transportation needs or demands. Congestion often happens during peak hours (typically, in the morning, before the beginning of the work hours, or in the afternoon, when most workers leave their workplaces). Additionally, reliability refers not only to the time it takes to reach one's destination, but to the certainty of arriving there in the foreseen time (both by public transport and by car). Consequently, in a less reliable system, the users have to plan for buffer time, which considerably reduces the overall time efficiency of a public transport system.

- *Energy efficiency* refers to the performance of an urban transportation system in terms of energy usage per mobility service. To recap, an average of 30 percent of global energy is consumed by transport out of which a big portion takes place in cities. Furthermore, 25 percent of urban CO_2 emissions stem from urban transport. How much energy is consumed in the system and whether it is possible to reduce this energy while maintaining the same or even an increased transportation output are the key questions of urban transportation energy efficiency.

- Finally, *cost efficiency* is of course a crucial indicator when assessing the overall efficiency of an urban transportation system. For example, would it be possible to provide the same output in terms of passengers transported at a lower cost? Or could passengers get more mobility services at a lower price? The same consideration applies to the subsidies paid by the public authorities to the urban bus system, for example.

Attractiveness generally refers to the comparative performance of the public transportation system compared to the private one. Questions here are whether the public transportation system is more accessible, more affordable, and more convenient (allowing, for example, for intermodality). It is understood that the public transportation system in a city must become equally desirable, if not more attractive, than the private car.

- *Accessibility* of urban public transport refers to how easy it is for users to reach it. For example, how far in terms of distance and walking time are the main interfaces from a user's home and workplace?

- *Affordability* refers to how expensive it is to use public transport. Affordability is not an absolute value. Rather, it is related to the economic situation of a user. Therefore, public transport prices could be affordable for the wealthy, but completely unaffordable for lower-income citizens. Aligned with the goal of achieving the largest use of public transport possible (replacing private cars), the objective should be to make public transport generally affordable.

- *Convenience* refers to the user's experience in the public transportation system, for example, in terms of cleanliness, sense of security, and ease of use.

- *Intermodality* is just one aspect of ease of use, but a particularly crucial one. Here, integrated timetables, integrated ticketing, and easy-to-use interfaces are key. Indeed, making the transition from one mode of (public, but even from private to public and vice versa) transport to another as smooth as it could be is key for the overall attractiveness of urban transportation systems.

How efficient and attractive the public transport system is can be a direct result of the urban transportation infrastructure system's management, as management of the entire system ultimately determines how efficient the system ultimately is. Let us therefore look, in the next section, at the main management functions.

Main management functions

Urban transportation system managers aim, or at least should aim, at maintaining and improving the performance of the system, both in terms of efficiency and attractiveness. In this context, the three main tasks they have to attend to are operations, maintenance, and planning.

- *Operations* refers to the different infrastructures, vehicles, and interfaces that need to be operated daily by fulfilling tasks such as technical operations, scheduling, or human resources management. Additionally, the customer relations function needs to be managed as well, with tasks such as fare collection and attending the needs of the users (in other words, customer support). Each transport mode has of course its own operations, and no management function for the operations of the overall system exists (for example, public buses are operated independently from the metro, not to mention the car), which significantly complicates the achievement of overall system efficiency and attractiveness.

- *Maintenance* of infrastructure, vehicles, and interfaces obviously needs to be addressed (individually), where the challenge is to coordinate the maintenance of all these infrastructures and vehicles in order to cause minimum disturbance to the system, for example, in terms of delays or service interruptions.

- *Planning* covers both the building of the physical layer (such as infrastructures and interfaces) and the purchase of the different vehicles employed in the different transport modes. As this is done separately by the different owners and operators,

there are huge coordination needs to be able to ultimately offer an efficient, attractive urban transportation service and system.

Transportation modes and their management

As we have just seen, operations, maintenance, and planning are generally done separately by the different operators and owners of the various transport modes, vehicles, infrastructures, and others. Let us therefore look in more detail at exactly how this is accomplished.

- The *roads* are the biggest portion of the urban transportation infrastructure. Roads are generally planned, operated, and maintained by a city road department. It is a separate department in each city of an agglomeration, which can create jurisdictional challenges when urban areas under different local authorities connect.

- *Taxis*, which are basically private operators making use of the city roads, are generally licensed by a public authority – in general, a local public authority. In big urban areas with several different municipal authorities (recall the Mexico City case study from our first reading with several dozens of municipalities within an urban region), there will likely be several different taxi municipal authorities, which remain often uncoordinated.

- *Buses* – ranging from minibuses to public and private bus companies – are usually the most coordinated transport mode in a city. Generally, we can find a local transport authority that licenses or controls the different bus-operating companies and coordinates, to an extent, among them (for example, with schedules and ticketing).

  [It is important to highlight that the city road department, the local taxi licensing authority, and the local transport authority are more often than not independent institutions within a local government. The effort to coordinate their actions is further complicated in the case of large urban areas containing numerous municipalities.]

- Regarding other transport modes, *trams* are often independently managed. The local tram operator is generally the owner of the tram tracks and is responsible for the operations, maintenance, and planning of the tram services. Rarely, the management of trams is coordinated with other transport authorities, thus negatively affecting the intermodality of the urban transportation system.

- Similarly, the *metro* is usually managed by an agglomeration metro operator who also owns the metro tracks and takes charge of operating, maintaining, and planning the metro system. The main difference with the tram system is that, due to its wider geographical scope spanning different jurisdictions, the metro operator may work under the supervision of a regional transport authority, instead of under the local one.

- Broadening the scope even more, the *train* that crosses and has stations in the city is usually operated by a national train operator, that sometimes owns the train tracks and operates, maintains, and plans the rail network. Given the much larger geographical scope of this transportation mode, it does not operate under the supervision of local transport authorities, but typically of national ones.

All these operators (tram, metro, and train, but also the modes related to the road infrastructure) are very likely to manage their systems independently of each other – a practice that typically hampers the performance of the overall urban transportation system. In other words, the challenge of providing an efficient and attractive urban transportation system results basically from its fragmentation, as can be seen in Figure 2.

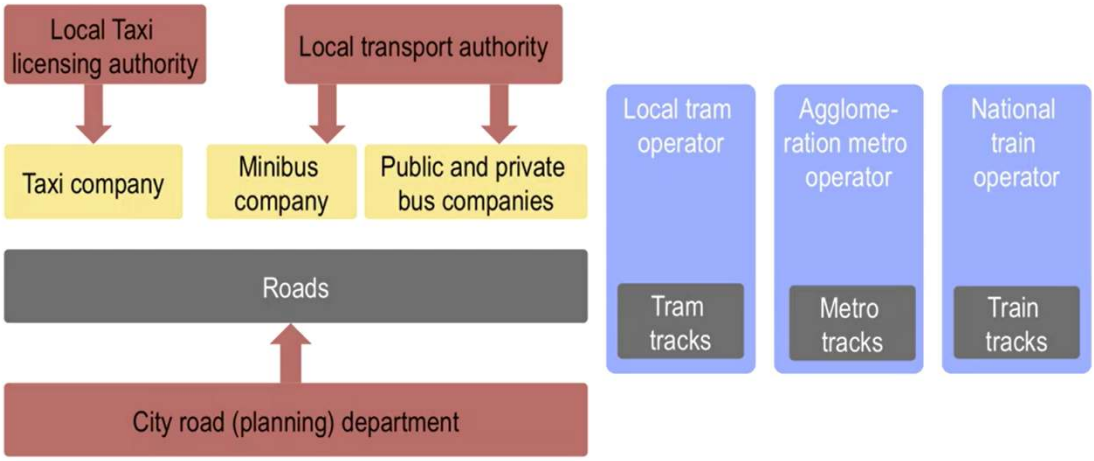

Figure 2: Main modes of transport in the city and their management.

Who is in charge?

As a consequence of this fragmentation of responsibilities in matters of operations, maintenance, and planning, the central question is this: "Who is really in charge?" Trying to answer this seemingly trivial question, we review in this section the different modes of transportation present in the city and the various means of coordinating them – namely, monopoly, tendering of monopolies, and real competition. This section is then summarized in Figure 3

- *Bicycles*. In a city, we may find a public bike provider, which may or may not offer its services for free (being subsidized by the municipality), but could simultaneously (or not) face competition from private bike-sharing companies. Private companies are likely to be allowed to operate in the city through a licensing process (that is, by way of tendering of licenses).

- *Cars*. Besides private cars, which are still the dominant mode of transportation, we find different types of car operators, not to mention, at this stage, the presence of rapidly emerging sharing platforms such as Uber. There could be private car-sharing companies competing against each other, generally unregulated. Similarly, there will be private car-rental companies competing for market share, again in an unregulated manner. And of course there are taxi operators, whose licenses are typically tendered by the local taxi licensing authority.

- *Buses*. We find private minibus companies, private bus firms, and public bus companies, typically coordinated by a local transport authority. Private firms get their licenses through tendering processes, while public entities receive them by virtue of the monopolistic status of the local transport authority.

- *Tram*. The tram is generally operated on a monopolistic basis by a public tram company owned by the municipality. It can (or might not) operate under the supervision of the local transport authority.

- *Metro (subway)*. Similar to the tram, the metro is usually operated by a monopolistic public metro company, although it becomes less rare to find private metro operators who obtain their licenses by way of a tendering process. At least the private metro does not necessarily operate under the control of a local authority.

  [Linking the public bus company, the public tram company, and the public metro company, we may find a public transport company operating all of them.]

- *Train*. In most cases we only have public train companies, which are generally owned and operated at the national level.

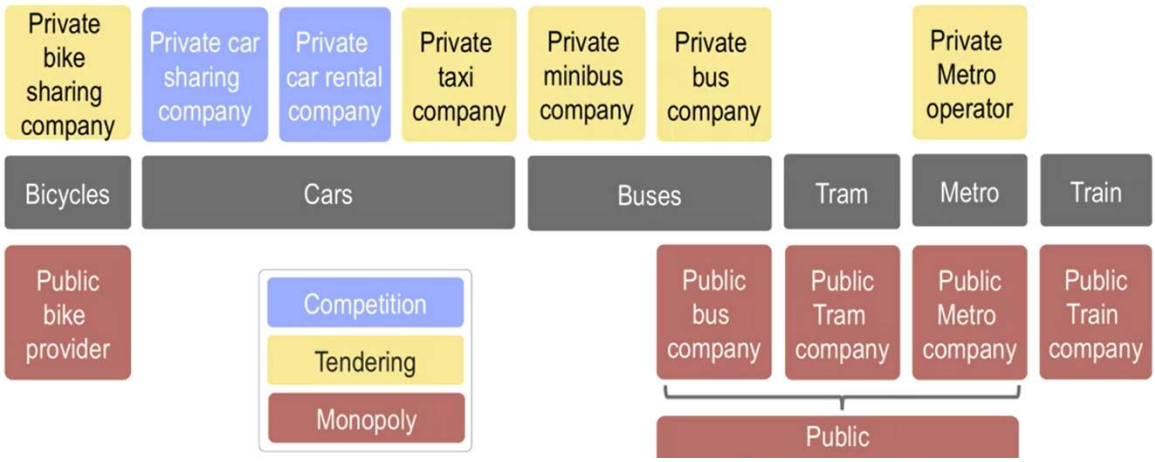

Figure 3: Infrastructure operators in each transport mode and coordination means in urban transport systems.

Analyzing the management of urban transportation, we thus find a fragmented and uncoordinated urban transportation system. This is in stark contrast with the previously observed urban electricity system, which is generally owned and operated by one single local public authority, and where even jurisdictional problems certainly also apply. The question of who then can make the urban transport more efficient and more attractive remains open. The city is not necessarily a coherently operating entity that can address this task. Therefore, at times, we now see the emergence of agglomeration transport authorities whose aim it is to coordinate at least the public transport modes. However, these authorities rarely cover all the transport modes.

Typical challenges for urban transportation managers

In order to properly identify the typical challenges for urban transportation managers, one has to start out with demand, more precisely the demand for transport or rather mobility services by a city's (or agglomeration's) inhabitants. The main challenge for the urban transportation manager is therefore to provide transportation services. Generally, meeting these needs amounts to operating the public transportation system by providing vehicles, schedules, trips, and other amenities. The number of trips people take daily, the kinds of transport modes they prefer, the economic status of the majority of the users, and the types of trips they make (work-related versus leisure-related) constitute the main features of transportation demand

and will determine how the public transport system has to be configured: how many lines shall exist, what frequency, what price level, and so on.

Once demand is well understood, operations, maintenance, and planning of the system can be defined. The manager will also be able to determine its budget needs and try to find the funds for the sustainable operation of the system, its maintenance, and development. From a broader perspective, knowing the demand will allow the transportation manager to design the organization required to carry out all the required tasks for meeting the service needs (for example, define the bus drivers needed, the bus maintainers, and others).

In different countries and regions, different answers have emerged as to how to organize for providing public transportation services. In the case of the United States, for example, the most prevalent ownership model is to have a public authority supervising or controlling a publicly owned company. The public authority generally sets the conditions under which the public company operates, hires the general manager for the entity (in case he/she is not elected), and monitors its performance.

In the European Union, a similar approach exists. A local authority monitors the management of the public transportation operator, which increasingly turns out to be a private operator having a contract with the municipality (see reading in block 2). The contracting process is often a bidding process where private firms, but also other entities such as cooperatives, can compete for a contract, which itself is limited in time (generally five to 10 years maximum).

One challenging aspect of public transport management is accountability: how to make sure the entity operating the public transportation system is responding to the demand and the needs of the users and citizens, and not using its (monopoly, exclusivity) position for its own advantage. In other words, what's the best way to measure the performance of the transportation operator and hold this entity accountable? This is particularly relevant in countries such as the United States, where it is common practice to outsource services to private (for-profit) firms whose main objective is profits. More broadly, the question is how to align the private and the public interests. Another challenge pertains to the social tariffs already mentioned in the case of electricity (discussed in block 3), which, in the case of public transport, pertain to running nonprofit lines and providing access to handicapped people and seniors.

Who pays for the cost of meeting service demands is not a simple question, and the answer varies depending on the socioeconomic and political contexts in which public transportation systems operate. Although public transportation is generally considered a public good, the amount of subsidies very much depends upon the political culture. In the European Union, the general feeling is that public authorities should pay a significant portion of the operating costs of the services, while in the United States, the politically acceptable level of public finance is only around 30 percent of the costs. On the other hand, capital costs in the United States come from three sources – namely, grants from the federal government, subsidies or grants from the state, along with debt. This turns public transport management into a political issue, where managers need to convince public authorities that the system is well managed so they can obtain the funds necessary for its operations and development.

Finally, the recent emergence of alternative transportation services based on the massive diffusion of the information and communication technologies (ICT) (Uber is one example) has exacerbated the challenges for urban public transport managers, but also created new opportunities (and threats). Indeed, the growing implementation of the ICTs is transforming

not only the use and management of urban public transport but also the way by which demand is met. Let us turn to this now.

Future challenges and opportunities

In this section we discuss the big challenges and opportunities to managing urban transportation systems. These mainly arise from three different angles: (1) urban sprawl and corresponding mobility needs; (2) environmental challenges, especially climate change; and (3) the rapid spread of information and communication technologies, as presented in Figure 4.

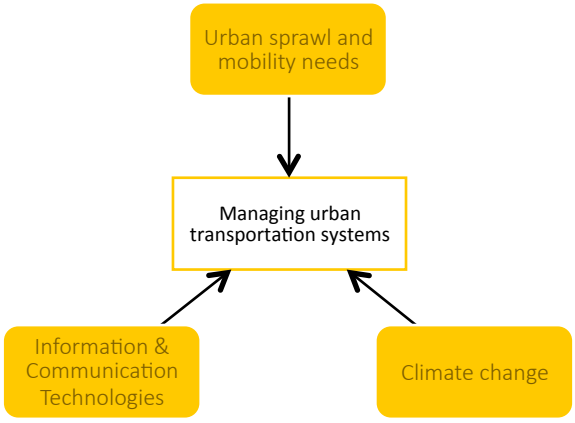

Figure 4: Principal trends creating challenges and opportunities for urban transportation systems managers.

Urban sprawl and corresponding mobility needs. As already mentioned, transportation infrastructures are a key driver of urban sprawl. The ease by which one can move around has indeed significantly determined the development modes of cities. For example, the typical configuration of American cities with extensive suburbs with low-density housing, often kilometers away from the city center, and basic services (such as supermarkets) outside of the residential areas, can only be explained thanks to the readily available car and corresponding road infrastructures.

Inversely, urban sprawl has also triggered mobility needs: the location of households outside of the city requires means to get to the workplace every morning, but also to reach the shopping centers, the hospital, the schools, and elsewhere. This in turn creates all kinds of mobility challenges for urban transportation managers, such as traffic congestion.

Taking India as another example, we see that the number of motorized vehicles on city streets is growing at an annual rate of more than 20 percent (Pan 2011; Tiwari 2011). Or the case of Mexico, where two new cars enter into circulation for each child born (Jirón 2011). As these figures suggest, urban sprawl and the related growing mobility needs already are and increasingly will be the main challenge for urban transportation managers in the years to come.

In order to address this challenge, urban transportation managers need to resist investing in urban road infrastructures, which inevitably will put more cars onto the streets and ultimately lead to traffic gridlock. Instead, managers should better integrate transport and housing planning and increase the share of public transport by, on the one hand, incentivizing its use and, on the other, discouraging the use of private cars (for example, by reducing parking

space and introducing dedicated bus and bicycle lanes). It is important to keep in mind that discouraging the use of cars must go hand-in-hand with the development of new urban transportation alternatives; otherwise, this will only make transportation more difficult, creating unnecessary problems for citizens.

Environmental challenges, especially climate change. Growing environmental problems – namely, emissions and overall pollution – will only exacerbate the pressure on urban transportation managers to develop public transport and to make it more attractive over the use of cars. Additionally, urban transportation managers need to develop new or improved public transport modes that are less polluting and more efficient (that is, replacing diesel buses with electric vehicles). They also need to encourage soft mobility (creating dedicated bicycle lanes, public bicycle offerings, dedicated pedestrian ways, and so forth) so that citizens can reach their destinations without making use of private cars, but also without needing to use public transport. It is important to recall here that soft mobility is not a substitute but only a complement to public transport, which can help alleviate the "last-mile problem" (that is, making it easier to get from one's house or workplace to the closest metro station or bus stop, thus producing an integrated yet intermodal mobility chain).

Information and communication technologies. The ICTs represent a challenge but also an opportunity for urban transportation managers. Indeed, the ICTs have the potential to discourage private car use by creating mobility-pricing schemes that better incentivize mobility behavior. For example, raising the prices during peak hours can lead to reducing congestion and shaving peaks to reduce investment needs. Such mobility schemes can also generate the investment needed to develop and subsidize public transport. Overall, the ICTs have the potential to make public transportation more attractive: they can do more than just improve the intermodality of the system by more integrated planning and more integrated ticketing. They can also help travelers with more integrated planning of their trips, as they can help infrastructure managers to better plan their development. Finally, the ICTs can create new transportation services, such as car, bike, and ride sharing or lead to what is now being called "mobility-as-a-service."

Case study: Seoul's urban transportation system

"But you have to decide, are the organizations going to serve the people, or the people the organizations?" (Marshall 2012). This is the question, according to Dr. Kim Gyeng Chul, former head of the Seoul Metropolitan Government (SMG) and former president of Korea Transport Institute, which guided Seoul's reform of its urban transportation system in the mid-2000s. Thanks to a profound reorganization of its urban transportation infrastructure and the introduction of ICTs, the city managed to greatly increase its transportation system efficiency and attractiveness.

A decade after the beginning of its transformation, Seoul's public transport system continues to improve, and it is often listed as one of the best urban transportation systems in the world (Flint 2013; Falzon & CNN Travel Staff 2013; Marshall 2012). In this case study, we briefly review the key features of Seoul's metropolitan area and its world-class urban transportation system; we study the transformation of its urban bus system; and then we look at the challenges and opportunities facing Seoul's urban transportation system.

Seoul, a world-class urban transportation system

The first human settlements on the Han River, where modern Seoul is today, were established more than six thousand years ago (Lee 2015). However, the long history of the city has never been a burden for developing a leading role in public governance innovation, because Seoul was among the first Asian cities in introducing electricity and electric streetlights in the very first years of the twentieth century (Hwang 2010). After the Korean War (1950–1953), a shattered Seoul concentrated its efforts on reconstruction. A large population flow moved in, and the economy flourished during the next decade, inaugurating an explosive growth, shaping today's Seoul (Hamnett & Forbes 2012).

The Seoul metropolitan area population and geographical scope exploded from less than 2 million inhabitants and around 270 km^2 until 1960, to nearly 11 million people and over 600 km^2 by 1990 (see Figure 5) (Seoul Metropolitan Government 2015c). Including the Greater Seoul area, Seoul is home to 25 million people with a population density surpassing 17,000 persons per km^2 (Seoul Metropolitan Government 2015c; Allen 2011).

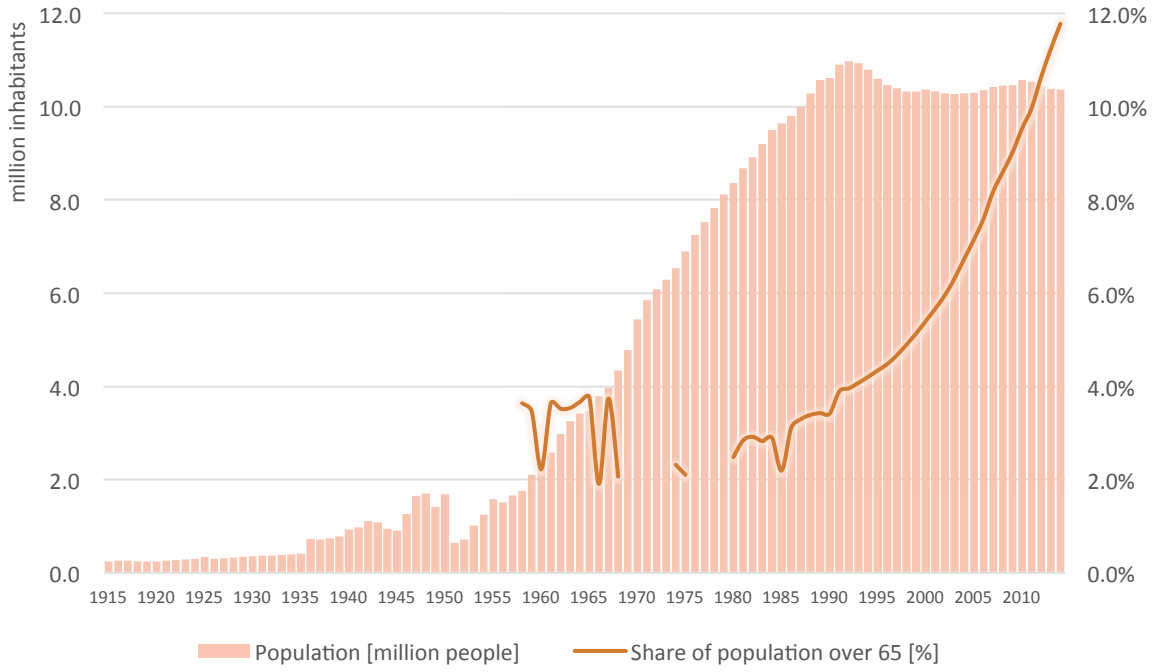

Figure 5: Seoul metropolitan area population and share of senior population evolution 1915–2014. Author's elaboration, data from Seoul Metropolitan Government 2015c.

The rapid demographic growth was accompanied by strong economic progress. Regional gross domestic product per capita was above US$30,000 in 2014, and most people work in the services sector (83.4%) (Seoul Metropolitan Government 2015a, 2015b). The demographic and economic progress contributed to a sharp increase in the demand for transportation. The urban transportation system became gradually obsolete, requiring a complete update in the mid-2000s.

Today, the urban transportation infrastructure system in Seoul has modernized itself to provide its citizens with high-quality service, adequate to the city's needs. In 2011, 32 million trips per day occurred in Seoul's transport system, modally divided into its subway (37.1%), buses (28%), cars (23.5%), taxis (7%), and bicycles and others (4.4%) (Seoul Metropolitan Government 2014b).

Underground infrastructures. Seoul's subway is the principal and most used urban transport mode. From its unique line, with 7.8 km and nine stations, in 1974, it has grown to nine lines with around 330 km and 292 stations giving service to 7.29 million passengers daily (more than 2.66 billion passengers in 2014) (Seoul TOPIS 2015; Seoul Metropolitan Government 2015d, 2014a). Similar to the bus system, Seoul's subway is a particularly successful example of how a management scheme composed of for-profit private firms and government-owned companies can run a seamless urban transportation network.

Seoul's subway has taken significant actions in recent years to improve its efficiency and attractiveness, while addressing the challenging demographic demand, the imperative of improving the system sustainability, and greatly expanding the use of ICTs. Platform screen doors were installed in all stations to prevent accidents, but also to improve air quality and reduce noise, making the metro more convenient (Seoul TOPIS 2015). Accessibility improved by the expansion of metro lines and stations, and greater expansion of the service is under way, with eight new lines in the pipeline, as well as several line extensions (Seoul TOPIS 2015). Intermodality and affordability were boosted by the coordination of the fare system across different transport modes and the use of smart cards (Audouin 2015; Song et al. 2015; Kim 2007). Single ticket prices vary between less than US$ .50 to around US$1.20, making it widely affordable for residents and tourists (Korea Tourism Organization 2015).

Surface infrastructures. Seoul's 8,096 km of roads are traversed by more than 3 million cars (from less than half a million in 1985 (Kim 2007, p. 156)) and more than 72,000 taxis (Seoul Topis 2015). A national train system connects the city with others through more than 100 km of rails across Seoul, and more than 7,500 buses handle the 361 routes running across Seoul's metropolitan area (Seoul Topis 2015).

Previous to its urban transportation system update, Seoul's surface transportation infrastructure was focused on car traffic, which was reflected in declining bus ridership. The number of bus passengers was following a decline from nearly 3 billion passengers per year in 1985 to little more than 1.5 billion passengers by 2004, the year when the public transportation reform started being implemented (Seoul Metropolitan Government 2014b, p. 14). The physical infrastructure reflected this car-oriented approach to urban mobility, which changed in the mid-2000s.

The case of the Cheonggyecheon Expressway, which was removed and replaced by a green, public space that has become one of the most visited places by Seoul citizens to walk and relax, symbolizes the mind-change of city planners and infrastructure managers (see Figure 6) (IAU îdF 2013; GIZ & KOTI 2011). It also exemplifies the impact of road infrastructures in the city, and vice versa.

Figure 6. Cheonggyecheon Expressway (left) in the early 2000s, and currently in 2013 (right).
Right image ©Seoul Metropolitan Government. Left image © P. Lecroart, IAU îdF. Adapted from IAU îdF 2013.

The city's approach to its surface urban transportation infrastructures management has moved toward sustainability and quality of living. Pedestrians have become a priority over motor traffic, with actions such as car-free day, car-free streets, widening sidewalks, or creating child safety areas where traffic restrictions (on such things as speed and volume) are imposed (Seoul Topis 2015). Simultaneously, bicycle riding is encouraged. Some 303 bicycle lanes have been developed (spanning 674 km), often linked with the expansion of green corridors (such as the Cheonggyecheon transformed corridor). A public bicycle rental service started in October 2010 with 43 bicycle stations and facilities to encourage their use (along with bicycle-only parking centers) are spreading across the city (Seoul Topis 2015).

Urban infrastructure management has also been updated in Seoul. Recalling the difficulty in answering the question, "Who is in charge?" from section 3 of this reading, the SMG has tried to provide an innovative answer with the establishment of the Seoul Transport Operations & Information Service (TOPIS, see figure 7).[1] Information and communication technologies and a cooperative mindset are the foundations upon which the Seoul TOPIS manages the operations of the urban transportation system of Seoul, while coordinating actions on the system (such as development and maintenance) with other organizations involved in the system (Seoul's Road Authority, for example) (Seoul Metropolitan Government 2014b).

The main tasks of Seoul TOPIS are related to managing the urban transportation system, such as managing real-time traffic flow and bus operations and operating vehicle enforcement systems, but also related to infrastructure development (which provides improved data for surface transport planning) (Seoul Metropolitan Government 2014b). This innovative approach helps coordinate the numerous actors, private and public, in the urban transportation system, as well as smooth jurisdictional problems while making extensive use of the ICTs. However, not all actors fall inside the scope of TOPIS, and the subway system (and the companies operating in it), or the taxi licensing authority, remain independent.

Bus system transformation[2]

Before 1980, when the first subway line started operating, Seoul public transport system basically consisted of its bus transport system. The demographic and geographical expansion contributed to longer trip distances and higher passenger volumes, while the economic development fueled the rising traffic congestion levels. Bus transport attractiveness thus suffered. A vicious cycle was created: more congestion, slower bus trips, less convenient

[1] Further information on Seoul TOPIS can be found on its official website: http://TOPIS.seoul.go.kr/english.jsp .
[2] This section has been written following the case study for the UN-Habitat Globe Report on Human Settlements 2013 (Allen 2011).

buses encouraged citizens to use their cars instead, more cars on the roads pushed traffic congestion up and thus restarting the cycle. The introduction of the subway worsened the situation for the bus system. Besides, the increasing use of cars started elevating pollution to dangerously high levels, as well as creating noise and traffic accidents.

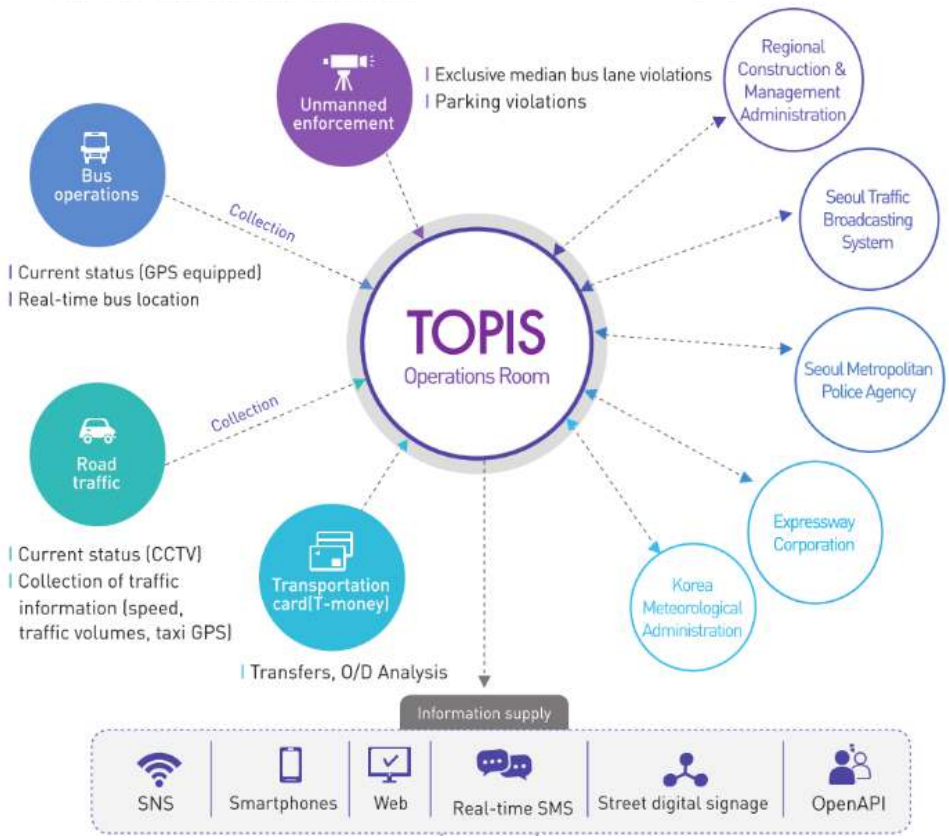

Figure 7. Seoul TOPIS schematic tasks and information flows representation.
Adapted from Seoul Metropolitan Government 2014b.

The fragmentation in the management of bus lines was a key factor contributing to the degradation of its attractiveness. Around 90 private companies operated buses in Seoul in the 1980s, and because they were not coordinated, they competed against each other for the most lucrative routes while not serving less-profitable ones (Seoul Development Institute 2003). The city had little control over the private operators, except in determining the tariff levels. Different drivers provoked an unsustainable situation that led the city to act and implement a bus transport system reform:

- *No public authority supervision* took place on routes, schedules, or other service aspects.
  - *High levels of competition* on most profitable routes led to duplication of services, while *not serving socially relevant, but less-profitable routes*.
  - *Uncoordinated fare system*. Trips usually involved combining bus lines or bus and subway, and passengers were forced to pay for each trip leg, with different tariffs and paying systems.

- *Increasing modal competition.* Some 30 percent of passengers chose the bus in 1996 (29% took the metro), only 26 percent in 2002 (35% for the subway) (Seoul Metropolitan Government 2014b; Pucher et al. 2005).

- *Private operators' revenues shrinkage led to escalating operating deficits*. This triggered a drop in its number from 89 by 1995 to 58 in 2002 (due to bankruptcies and consolidation) (Seoul Development Institute 2003).
- *Growing public subsidies to private operators gradually decreased their service level*. SMG's subsidies to keep private bus services operating jumped from around US$9 million in 1999 to US$110 million in 2002[3] (Allen 2011).

- *Unprofessional behavior of bus drivers* was pushed by overheated competition.
  - *Unreliable service*, with routes being modified or deleted without previous warning, took place.
  - *Normal traffic disruptions and accidents* occurred.

The combination of these factors "prompted a complete re-examination of ways to improve service quality while keeping costs and subsidies affordable" in 2002, led by the "visionary and ambitious Mayor Myung-Bak Lee" (Allen 2011, p. 5). The reform was approached as an integrative effort to radically improve Seoul's urban transportation infrastructure management, pursuing

- an environmentally sustainable model with a low carbon transport system;
- a socially inclusive and human-oriented transportation system; and
- economic growth through strengthened demand management.

Despite the two years of preparation, an intensive media campaign, and the general public acceptance that serious actions needed to be taken, a major challenge was managing the numerous stakeholders opposed or reactive to any changes (namely, the bus drivers and the private operators), where agreeing on an integrated fare policy became a major challenge. An institutional and organizational reform started then, transferring responsibilities from different agencies and private operators to the SMG (leading to the establishment of the Seoul TOPIS, see the previous discussion). Bus companies remained in charge of operational maintenance of the buses and labor relations, while functions regarding strategic planning, infrastructure construction and maintenance, service and quality levels, and public transport operational management were gained by the SMG.

In July 2004, the change became reality. SMG took effective control over the bus system operations, completely reorganizing all bus services, introducing the first Bus Rapid Transit (BRT) lines, and substantially increasing the integration among bus, metro, and taxi services (thereby improving the intermodality of the system). A fully integrated fare system coupled with electronic ticketing contributed to the cause, as well as the extensive use of ICTs to provide the operations manager with all information needed.

A "semipublic operation system" was implemented where private firms stayed as operators, leaving routing, scheduling, and fare decisions to the SMG. The emphasis was put on passenger convenience, resulting in improved accessibility and reliability of the service. A keystone of the new business model was the payment to bus operators per kilometer of service instead of passenger trip, and pooling all the fares collected. It provided guaranteed service and helped achieve high performance levels.

Further changes were introduced such as renumbering routes, establishing a four-color bus services code to enhance rapid identification by users, expanding dedicated bus lanes, with the introduction of exclusive median bus roads for BRT services (more than 215 km currently) (Allen 2011). In addition, multilateral stakeholder participation (including citizens)

[3] This burden was especially heavy for Seoul Metropolitan Government due to the financial effort being made in the development of the subway network across the city.

was formally organized through the establishment of the Bus Reform Citizens Committee, including civil society representatives, the government, the bus firms, and other professionals.

To date, the reform is considered a success and studied as a model for integral urban public transportation systems updates. The results are these: an increase in the average speed of buses, a change in the declining trend of passengers using the bus system (Seoul Metropolitan Government 2014b), five times more reliable service (Allen 2011), a decline in bus-related accidents, improvements in quality and attractiveness, and a new management structure.

Challenges and opportunities

Despite the outcomes of the bus reform, Seoul's urban transportation system still faces significant challenges. Here are some of the most prominent ones:

Urban sprawl and mobility needs. Seoul experienced an extremely high and continuous population growth, accompanied by a geographical expansion, from the end of the Korean War to the early 1990s (see Figure 5). Since then, the total population has remained approximately stable between 10 and 11 million people, although two effects are changing the mobility needs in the city and posing challenges to the urban transportation system managers.

- *Seoul's population is aging.* The share of senior citizens over 65 years or older has grown exponentially since the mid-1980s (from around 3% to around 12% in 2014) (see Figure 5). This population sector requires special measures so that transportation deficiencies won't diminish their quality of life. Some actions recommended to face this challenge are improving the pedestrian environment, simplifying information desks (particularly for buses), and increasing the accessibility to public transport (such as reducing walking distance to subway stations) (Kim et al. 2014).
- *Traffic congestion continues.* Seoul's economic progress brought with it the "my car" era in the 2000s (Seoul Metropolitan Government 2014b). It contributed to reinforcing the trend of rising traffic congestion costs, which were seven times higher in the late 2000s than in the early 1990s (Seoul Topis 2015). The public transit system reform effectively managed to stop the growth of congestion costs, although the challenge is not completely solved. The SMG promotes car-free days weekly and has invested in an impressive network of cameras and sensors across the urban road infrastructure to manage the traffic congestion in real time (see Figure 7).

Environmental challenges and climate change. Seoul is no stranger to environmental challenges. The city got firsthand experience with the rising pollution levels caused by the increased use of cars in the 2000s, which also pushed the city toward its public transport system reform. As one of the reform pillars, SMG is carrying out several actions to improve the overall sustainability of urban transportation in the city:

- *Natural gas fueled buses used.* After the bus system reform, all buses were gradually replaced by NG-fueled vehicles, which reduced particle and air pollution (Allen 2011).
- *Electric vehicles promoted*. The SMG has established a network of small electrical vehicles across the city, and it encourages the use of hybrid vehicles in taxis and fully electrical taxis (differentiated by a distinctive color pattern), as well as buses (Seoul Topis 2015; Seoul Metropolitan Government 2014b).

The city has set itself goals to deepen its commitment to a sustainable urban transport system. Seoul aims to reach a modal share of 80 percent green transportation by 2030 (which includes walking and cycling), and reducing greenhouse gas emissions to two thirds that of 2010 (Seoul Metropolitan Government 2014b).

Information and communication technologies. Seoul excels at making use of ICTs for improving the user experience enhancing the system management. Seoul Metropolitan Government pursued an integrated operation management of the system, as well as integrated the fare system to make intermodality traveling as easy as possible for passengers.

The integrated fare system has benefited from the inclusion of electronic payment means, which have been extended with the use of a smart card system (Audouin 2015). The system also allows users to pay with a mobile phone or contact-less credit card, improving the convenience of public transport. Additionally, it provides 4G and Wi-Fi services in all lines and stations, and full-color LCD monitors inform passengers of real-time subway arrival times, if they do not want to check them out through the application on their smartphones.

But the use of ICTs goes well beyond improving the user interface. The Seoul TOPIS is a world-class example of implementing ICTs for urban transportation management. GPS-located buses are monitored to check any problems or delays; a dense web of cameras registers the traffic activity across the city; the electronic payment methods provide information about the level of usage of public transport, and adds to other sensors' information (for example, speed sensors) (see Figure 7). These services allow for real-time management of the system, but also for improved planning and maintenance by uncovering the patterns of Seoul's urban transportation system.

Conclusions

Seoul has become a major global population center that has successfully addressed its urban transportation flaws. The integrated public transport system reform has changed the way Seoul citizens perceive mobility in the city and raised their satisfaction levels from less than 5 out of 10 before 2004 to between 7.5 and 8 currently (Seoul Metropolitan Government 2014b). Seoul Metropolitan Government addressed the challenge to make its system more efficient and attractive and continues to face its challenges by taking advantage of the opportunities presented by communication technologies. Seoul has positioned itself as an example for integrated public transportation systems reform.

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