Block 2 Reading
Foundations of Managing Urban Infrastructure Systems

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This second reading introduces the main tasks and challenges of urban infrastructure managers. It is structured as follows:

- First, we present some basic definitions.
- Then we describe the three main tasks of urban infrastructure managers.
- We will discuss the management of the different stakeholders that infrastructure managers have to attend to in order to be successful in their jobs.
- We identify the five main dimensions of urban infrastructures and discuss in more detail what exactly the managers' key focus is or rather should be in each of these dimensions.
- We outline the three main approaches to managing urban infrastructure. This section will also include an excursion into public-private partnerships, which have emerged recently as a new form of managing urban infrastructures.
- Finally, we conclude with some considerations about the role of information and communication technologies and how they will affect the management of the urban infrastructures in the future.
- This reading will also discuss the case of Detroit's water and sewage management.

Definitions

Let us first define some of the basic concepts that will be used throughout this text:

- *Infrastructure services provider* is the organization (public or private) that delivers the service to the end user (for example, the bus operator or electricity retailer) and serves as the intermediary between this end user and the infrastructure operator. The infrastructure services provider does not need to be, but can be, the same organization as the infrastructure operator.

- *Infrastructure operator* refers to the organization (public or private) in charge of ensuring that the infrastructure (for example, the road, the rail track, the electricity grid) functions properly. Again, the operator of the infrastructure does not necessarily have to be the legal owner of this very infrastructure.

- *Infrastructure manager* is the broader concept that includes both the infrastructure services provider and the infrastructure operator. The infrastructure manager can be publicly or privately directed, just as the infrastructure services provider and the infrastructure manager may be.

- *Services provision* refers to the delivery of the services to the end users (customers) (with products such as electricity, gas, or water). Such services are typically provided by the service provider.

The three main tasks of urban infrastructure managers

Urban infrastructure managers' daily work consists of a wide variety of technical tasks, which can be subdivided into *operations, maintenance*, and *planning*.

- *Operations* (figure 1) is the most obvious and everyday task of infrastructure managers: the drinking and wastewater systems need to be operated. So does the electricity network, along with the trains and the buses. Operations is also what is most visible to the customers, as proper operations directly impact their daily lives. Consequently, operations pertain to the short term. One can distinguish between the operations of the physical infrastructure (for example, the wastewater treatment plant, the electricity grid) and the operations of the services layer (which might be the buses, the metro trains, the metering and billing of water). There is also a strong operational need to coordinate between the two layers, such as in the case of a damaged track impacting the train running on it, or a failure of an electricity transformer delaying the delivery of electricity services.

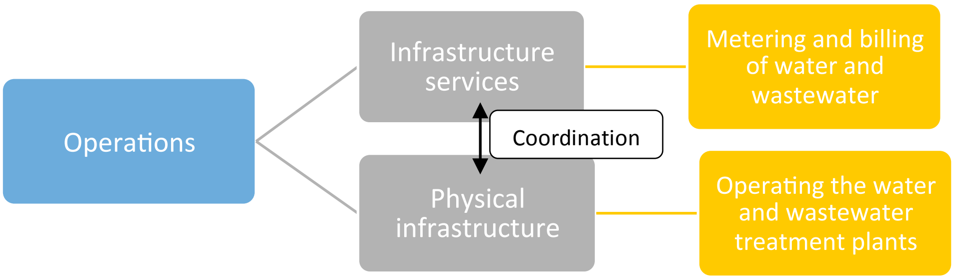

Figure 1: Operating tasks of urban infrastructure managers and examples.

- *Maintenance* (figure 2) is the second major task of urban infrastructure systems managers. Again, both the physical and the services layers need to be regularly maintained to keep them functional. Also, the maintenance of the physical infrastructure needs to be coordinated with the maintenance and especially the operations of the service layer (examples would be night shifts for road maintenance or programmed electricity cuts). Finally, the maintenance of one infrastructure needs to be coordinated with the maintenance of another (in other words, taking advantage of the road being opened to maintain both the gas and the water pipes) and especially with the operations of another (such as diverting the bus routes when there is a pipe being repaired in one street).

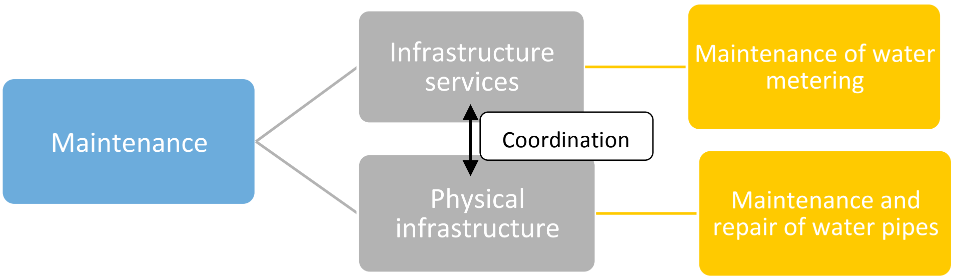

Figure 2: Maintenance tasks of urban infrastructure managers and examples.

- *Planning* of urban infrastructure systems is required mostly because of their long lifetime, but also because of their costliness and the corresponding negative impacts. One has to note that the lifetime of the physical infrastructure (for example, rail track or the electricity grid may have a 40- to 80-year lifespan) is different and longer than the lifetime of the service layer (the bus or the water or electricity meter may only have a five- to 15-year lifespan). This, in turn, triggers a particular need for adequate coordination between the two types of planning (in other words, adjusting the transportation infrastructure to the incorporation of electric vehicles).

Stakeholders such as citizens, owners, and authorities are always present while urban infrastructure managers carry out these three activities. Effective management of the infrastructures thus requires not only taking care of the planning, operations, and maintenance of the infrastructures, but also attending to and managing the demands of the major stakeholders, as explained later.

Managing stakeholders and related objectives

Users, citizens, owners, investors, and policy makers are the main stakeholders involved in urban infrastructure systems. They each have their own objectives and expectations, and urban infrastructure managers have to attend to them. Ultimately, successful management of urban infrastructures also means optimally balancing the responses to these different stakeholder demands and expectations. This is of course if one takes the perspective that infrastructure managers are the operators of either the physical infrastructures or the infrastructure services.

- *Users* are the ones who ultimately use or consume the infrastructure services provided. Usually, one distinguishes between individual or household users, on the one hand, and businesses or large users (such as factories), on the other. While individual users are rather concerned about traditional public services objectives – namely quality (for example, is water running and of drinkable quality?), accessibility (for example, how close is the nearest public transit station?), and affordability (for example, what portion of the disposable income goes to electricity?) – large users are generally primarily concerned with price and quality. For infrastructure managers, it is therefore not always easy to satisfy both objectives simultaneously, even though both types of users are connected to the same grid.

- *Citizens* are, of course, individual users, but these same people do not necessarily have the same demands regarding infrastructure services. While as users they are mainly concerned with the implications of infrastructure services on themselves personally (or on their households), as citizens, they are more concerned with the collective impact of infrastructure services, for example on equity (social dimension) or pollution (environmental dimension, see the next point). For example, an efficient, sustainable, and resilient public transportation system will cost less to the community, have a lower impact on air quality, and be better able to handle sudden increases in service demand.

- At the physical infrastructure layer, two key stakeholders enter into play: the physical infrastructure *owner* and, if applicable, the *investor* (into physical infrastructures). Such investors can be private, in which case they are most typically institutional investors (such as pension funds), or public, which is more typical and in which case they would also be called public owners (for example, municipalities but also regional and national governments). Private investors are particularly concerned about receiving a stable and predictable return on investments, while public owners are more concerned by public policy objectives, such as equity, affordability, and sustainability. For an infrastructure operator, it may be difficult to balance these objectives, especially when there are public and private investors, but also when the objectives of public owners are often contradictory.

- At the infrastructure services layer, the situation is identical, yet the possibility to have private investors (especially in the case of water, waste, and transport) is much higher. These private investors are then mainly concerned with questions of profitability and willingness to pay and, consequently of course, also by regulation that would particularly limit the pricing of the infrastructure services.

- For infrastructure and infrastructure services operators, other major stakeholders are the *policy makers*, mainly at the municipal level. While the municipality is often also the owner of the urban infrastructure (both physical and services), policy makers must be treated as a separate stakeholder, as they can affect urban infrastructures and their managers not only via ownership, but also via contract and more generally through legislation or regulation affecting the management of infrastructures, such as is the case in matters of water or transport tariffs, but also environmental legislation. Indeed, local policy makers will be extremely sensitive to citizen and especially interest group demands, which in turn may affect subsidies or financing. In some areas, particularly in large agglomerations, an additional layer of *policy makers* could exist in the form of an *agglomeration or metropolitan government*. Some contracts (for example for waste management services) may be with the agglomeration rather than with the municipal government. In addition, *regional* and *national government* may also come into play, as often legislation is emanating from nonmunicipal levels. Yet, these governments may be concerned by yet other objectives such as regional attractiveness or national competitiveness. All this of course constitutes a huge challenge for infrastructure managers, as many of these policy objectives are contradictory.

All these stakeholders, their concerns and expectations, require attention from the urban infrastructure managers who therefore cannot limit their attention only to operations, maintenance, and planning. Rather, they also have to give management attention to the major stakeholders, among which, in addition to the *users*, are the *citizens*, the *owners*, the *investors*, and the different types of *governments* and *policy makers*.

Main dimensions of urban infrastructure systems

In the first block of this course, we presented the main five characteristics of urban infrastructures – namely, the technical, the economic, the environmental, the social, and the jurisdictional characteristics – from a rather theoretical and conceptual point of view. Here we will now translate these characteristics into five dimensions that managers have to attend to. More precisely, we will identify, for each of these management dimensions, the main aspects that need particular management attention.

As for the *technical dimension*, managers need to pay specific attention to interconnection, interoperability, capacity management, system management, and interfaces among the different infrastructures:

- *Interconnection* and *interoperability* refer to the management of infrastructures across different jurisdictions that may not use the same standards. For example, water or wastewater pipes between two jurisdictions need to become interconnected at some point of urban development. Similarly, buses of one municipality serving customers in another jurisdiction need to be made interoperable – for example, the bus platforms need to all have the same heights.

- All infrastructures have limited capacities, leading to congestion. Urban infrastructure managers need therefore to pay particular attention to *capacity management*, which can be both an operational (how to manage particular peaks, such as during a sports event attracting a massive crowd) and a planning issue (where to invest in order to reduce chronic capacity problems, for example, when evacuating the water after a heavy rainfall).

- As said numerous times, urban infrastructures are systems and need to be managed as such. For example, an urban electricity system needs to be balanced at all times to avoid the risk of a blackout, which requires a *systems management* approach.

- Finally, managers can never consider only one urban infrastructure system at a time and need to be mindful that they are all *interrelated*, both in the short run and in the long run and therefore must again be managed as such. For example, digging up the street to repair a broken water pipe may be an excellent opportunity to simultaneously put in a fiber-optic cable (long-run management). Similarly, both transport and telecommunication systems critically depend upon electricity and a stable electricity system (short run).

As for the *economic dimension*, managers need to pay particular attention to efficiency and profitability but also subsidies:

- No matter which analytical perspective to managing urban infrastructure systems one adheres to – the public policy or the public economy perspectives (see block 1) – infrastructures always need to be managed in the most *efficient* way possible, so as not to waste natural and financial resources. A very good example here are the leaks found in drinking water pipes, which should be minimized as much as possible.

- Especially from the point of view of the public economy perspective, urban infrastructures also need to be managed *profitably*, meaning that the costs of providing them should be lower than the income generated from their services. To recall, profits are crucial for maintenance and new infrastructure development, as well as for investments into innovation.

- Generally, urban infrastructures that cannot be managed profitably (for example, because they are public goods or because they respond to politically defined public services obligations) should receive corresponding *subsidies*, yet subsidies make urban infrastructure managers automatically more dependent upon political priorities. Again, such subsidies must be used in the most efficient way possible (see previous discussion).

As for the *environmental dimension*, managers need to pay particular attention to pollution and ecological footprint:

- Just as for economic efficiency, infrastructure managers also need to strive for environmental efficiency such as minimizing *pollution* (examples would be noise, air pollution, water pollution, soil pollution) as much as possible given a certain state of infrastructure technology. This implies not only corresponding processes but also state-of-the-art technologies, which, in turn, are of course primarily a financial issue.

- But more generally, infrastructure managers need to be attentive to minimizing the overall *ecological footprint* of urban infrastructures, notably when it comes to land and land use, CO_2 and more generally greenhouse gas emissions, landfills, discharge of wastewater, and others. Of course, cities will always have an ecological footprint, but urban infrastructure managers must strive to reduce that footprint, not the least importance of which is because this has generally positive economic and financial implications.

As for the *social dimension*, managers need to pay particular attention to equity, nondiscrimination, and affordability:

- First, managers need to make sure that the users are treated *equitably*, meaning that different user groups have equitable access to urban infrastructure services (for example, clean drinking water may not be reserved for parts of a city only, or public transportation prices must remain identical across the entire city).

- If pushed further, this can also be an issue of *discrimination*, particularly of discrimination against poor social groups (with low influence on policy makers), such as in the case of locating landfills in areas populated by lower-income families.

- Finally, managers need to pay attention to the question of *affordability* of infrastructure services (and these would include affordable drinking water or electricity). Affordability should be looked at not in absolute terms but in relationship with the users' disposable incomes. For example, a metro ticket may be affordable for the occasional user, but will it present too high a cost for lower-income users who are obliged to take the metro daily to reach their workplaces?

The *jurisdictional dimension* relates to the challenges posed by the operations (and planning) of infrastructures across different jurisdictions. In particular, operations of urban infrastructures across different jurisdictions are fraught with political (different public authorities) and legal challenges (different legal regimes), both of which managers have to address. Additionally, *transparency* and *accountability* must always be a concern for urban infrastructure managers, but both are required when operating across jurisdictions.

All five management dimensions just presented, along with the different aspects requiring management attention, are of course generic. They apply no matter which of the following approaches one chooses for the management of urban infrastructure systems.

The main approaches to managing urban infrastructures

In this section, we review the three main approaches to managing urban infrastructure – namely, the public management, the new public management, and the market approach. At the end of this section, public-private partnerships are introduced as a particular and growing approach to managing urban infrastructures.

The *public management* approach is rooted in public administration, which itself is quite close to the public policy perspective presented in the previous block. Public management starts from the assumption that there is an integrated, municipality-owned infrastructure owner and service provider for each of the infrastructures (such as water, electricity, and public transit). It is also conceivable that some or all of these infrastructures are integrated within one single public infrastructure operator. This is the Stadtwerke model that can be found in Germany and Austria, and to a certain extent also in Switzerland, the Netherlands, Scandinavia, Italy, and others.

The primary focus of the urban infrastructure manager is to attend to the demands of the citizens. This integrated municipal infrastructure operator is owned and directly supervised by the municipal government, which in turn is elected by the citizens. Basically, the municipal government decides how the operator is to manage the infrastructure system. If the

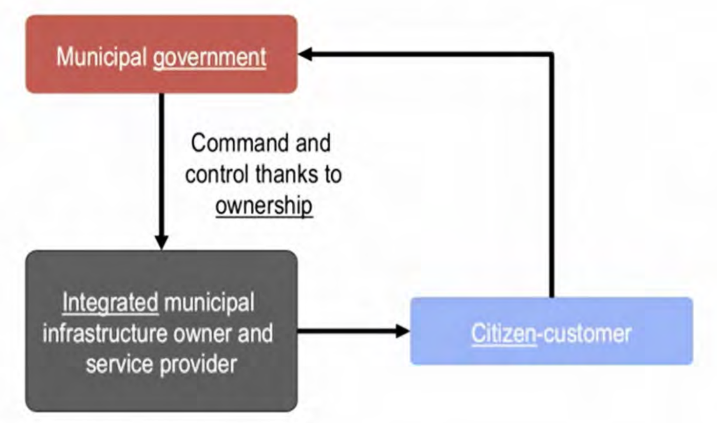

Figure 3: Public management framework schematic representation.

services provided are unsatisfactory, citizens will exert their influence over the municipal government (that is, expressed in the elections for the local government), and then the municipal government will intervene with the operator (by changing the management team). This approach is coherent in its own right and stems from a monopolistic view of urban infrastructure systems, where the political authorities are basically in charge. This is still the case in many countries and is prevalent in many sectors (public housing, for example). A schematic representation of this approach can be found in Figure .

The *new public management* approach became quite widespread in Europe after the 1990s. It is in fact a modification of the public management approach. Although it still contains an integrated entity owning the infrastructure and providing the service (that is, electricity operator, public transport operator), this operator now acquires a certain managerial autonomy from the municipal government. This leads to a shift in focus away from the citizen to the customer of the service. The key idea is that the operator acts like a private company, while remaining publicly owned. This also leads to a separation of the production from the responsibility of provision of the service: while the autonomous entity is responsible for producing the service, the political authorities remain responsible for the provision of the services.

Consequently, the management of the operator becomes more professional. The control over the urban infrastructure, however, remains unchanged, as citizens will continue to exert influence upon the municipal government, who will, in turn, act upon the professional management and thus modify the conditions under which the services are provided. The main differences with the public management approach are thus the professionalization of management, the focus on customers instead of citizens, and separation of responsibilities concerning service provision and production. Figure 4 summarizes this new public management approach.

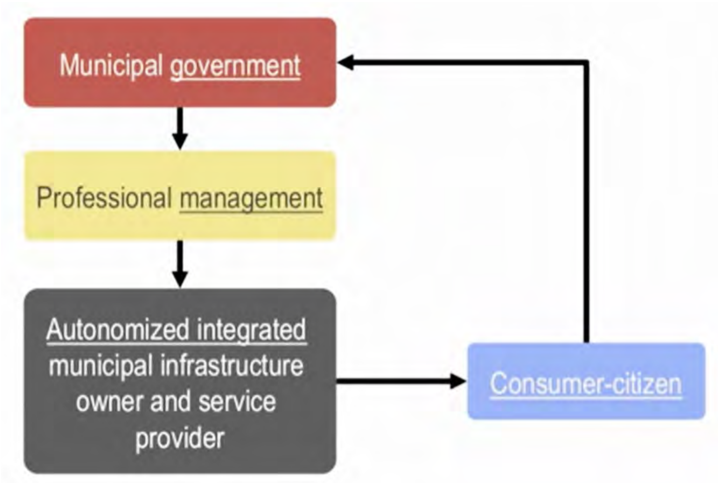

Figure 4: New public management framework schematic representation.

The *market* approach aligns with the *public economy* approach introduced in the first block. Here, the service producer is a privately owned (or a public yet corporatized) company operating, in principle, in competition with another operator. The operator could either be integrated (in which integrated operators are competing, as can be the case of waste management companies) or unbundled (where the physical infrastructure remains a generally public monopoly, and where operators are competing for the services). In both cases, the focus is on the services to the customers, which are, in principle, competitive. Sometimes, due to the economic characteristics of the service (that is, natural monopolies such as electricity transmission or water supply), a monopoly is the only economically viable way. In this case, competition is created for the market, namely by opening up service provision to competition.

This approach simultaneously requires regulation of the tendering process, as well as of services provision. Regulation then becomes the way by which municipal governments control the conditions under which the services are delivered to their citizens – and that would be by setting the conditions for obtaining the service operation's concession. The political control mechanism remains, however, unchanged: citizens (as customers) will exert pressure over the municipal government so that they modify the regulation and thus change the conditions under which the services are produced and delivered. Nevertheless, the link between consumers and citizen is less clear than in the previous perspectives, as often a new and direct link between the customer and the services provider is created, short-circuiting somewhat the traditional political control mechanism. Figure 5 summarizes this approach.

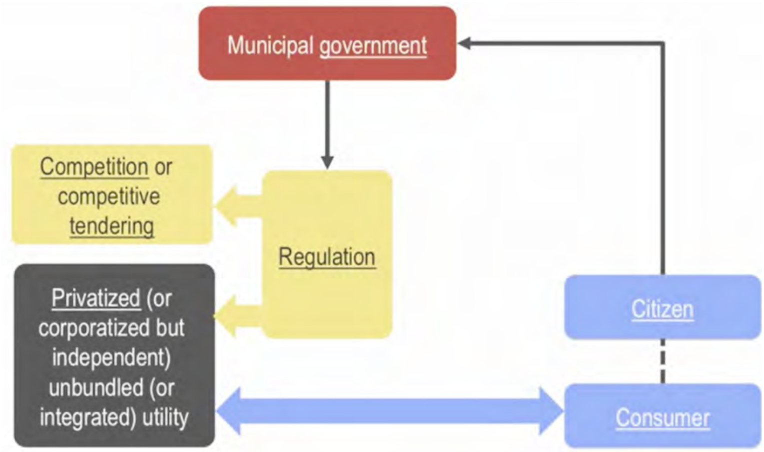

Figure 5: Market framework schematic representation.

A more developed version of the market approach is the increasingly widespread *Public-Private-Partnerships (PPP),* particularly in public transport and water and wastewater services. PPPs are also based upon private or corporatized service providers. Such operators are contracted by a municipal authority, generally after a tender, but sometimes also by what is known as a direct award. The conditions of the contract are dictated by the municipal government who decides the kinds of services, their quality, along with the price the operator can charge for the services. Control remains based upon the citizens' influence on the municipal government. Figure 6 summarizes this PPP approach.

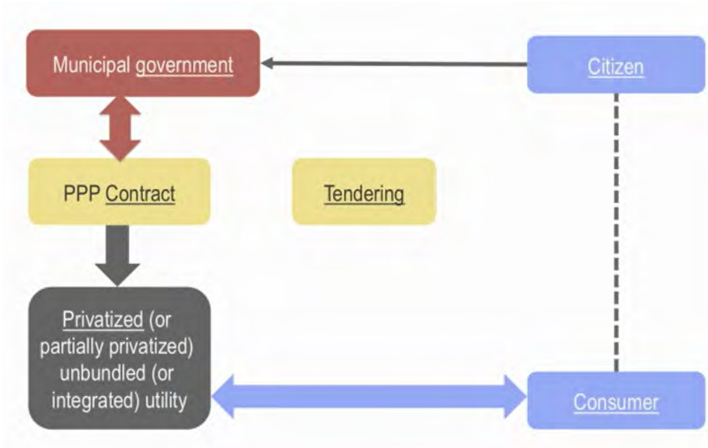

Figure 6: Public-Private-Partnership basic scheme.

More precisely, there are, in reality, two types of PPPs, management and financial PPPs:

- *Management PPPs* come into play when infrastructures are already in place (in other words, they do not need additional investments for rehabilitation or development). In a management PPP, the municipal government tenders a service contract, of which there exist basically three types: management contracts (one to four years), lease contracts (four to 15 years), and concession contracts (15 years and more). These durations basically relate to the economics of the service as well as to the political framework conditions: the shorter the contract, the more control the municipal government can exert over the company; the longer the contract, the more efficiency gains can be realized, thus lowering costs for the customer and/or the municipality, in turn. Additionally, the contract type also depends on the technology of the infrastructure (in other words, water supply contracts are in general longer than public transport contracts because of the so-called sunk costs).

- *Financial PPPs* come to play where infrastructures are deficient or do not exist to begin with, thus requiring extensive investment. In this case, the private operator, or rather a consortium also involving banks and construction companies, will finance the construction or the rehabilitation of the infrastructure and build it. Subsequently there are two options: Build/Rehabilitate-Operate-Transfer (B/ROT) or Build/Rehabilitate-Transfer-Operate (B/RTO). In the first case, the private operator owns the infrastructure and operates it for a certain time before transferring its ownership to the municipal authority. In the second case, which is the more widespread version, the ownership of the infrastructure is directly transferred to the municipal government after building is complete, after which it is operated for a certain period of time by the operator. This generally takes the form of either a lease or a concession contract, so that the operator can recover its investment. The increasingly widespread adoption of the B/RTO model is driven by the growing costs for developing infrastructures, combined with the lack of public funds.

The role of ICTs

The development and increasingly widespread use of the information and communication technologies (ICTs) and their pervasive impact upon every aspect of life has impacted the urban infrastructures and their management. The systematic application of these ICTs has had, so far, three main consequences – namely efficiency gains, empowerment of the customer, and the emergence of new, ICT-based services.

- The increased availability of information, originating in sensors, cameras, or tags (for example, radio-frequency identification or RFID), once collected and processed, allows managers to make more informed decisions. As the ICTs duplicate or mirror the physical infrastructure and the services provided thanks to them in what is known as a data layer, managers can make better decisions to operate these infrastructures, to maintain them, and even to plan them, thus ultimately operating infrastructures more *efficiently*.

- The *empowered role of the customer* results from the use of the data layer by the services users, such as in the case of real-time information about transportation or energy consumption.

- New *ICT-based services* also result from this new data layer, which is exploited by data intermediaries who are capable of turning their information into new services and especially into new business models (an example would be car or bike sharing).

During the study of the energy and transportation urban infrastructure systems, examples of these three roles of the ICTs are presented (for example, smart energy devices or smart mobility). Figure 7 summarizes the role of the ICTs in the urban infrastructures.

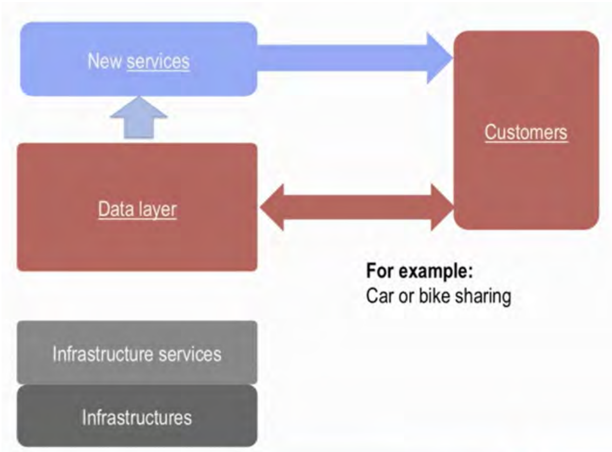

Figure 7: Data layer added by ICTs and relationship with new services and the customers.

Case study: water and sewage management in Detroit

The city of Detroit, Michigan, in the United States was once the embodiment of the American dream. It was a thriving city built by the car industry (Temple 2010). That is no longer the case. Following the automotive industry's decentralization, people started disappearing as jobs did the same (Caruso 2011). More than 60 percent of the people living in Detroit in the 1950s have left the city, whose population has dropped from about 1.8 million inhabitants to about 0.7 million (see Figure 8), and the trend has worsened in recent years.

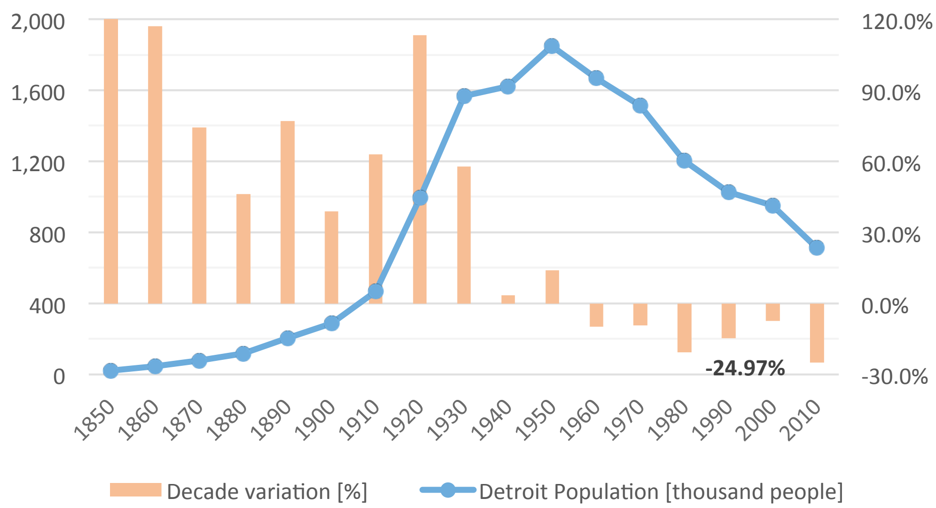

Figure 8: Detroit population historical evolution 1850–2010.
Author's elaboration, data from US Census Bureau 2015.

The demographic collapse has heavily impacted the urban infrastructure systems of the city, causing serious social problems due to the lack of access to basic services. The most basic of these services, drinking water, has become inaccessible for a large part of Detroit's population. In this case study, we focus on the water supply infrastructure system – the evolution of Detroit to understand what led to this state of affairs – and we explore the challenges for its management of each infrastructure dimension and how the urban infrastructure manager needs to confront them.

Detroit, story of the rise and fall of a major US city

The metropolitan area of Detroit is located on the US–Canadian border, in the Great Lakes region. It covers between six and nine counties,[1] according to different definitions, and is home to around five million people, being the second largest population center in the Midwest, only after Chicago (Bureau of Economic Analysis 2013). Although the car industry remains a top employer in the Detroit area, the economy of the city has now turned to the service sector (particularly, health services) (Detroit Regional Chamber 2014), and jobs have moved out from the city center, as well as most workers, in a long-term socioeconomic transformation started in the late 1940s.

Detroit was founded by French colonists in 1701 and quickly became a prominent settlement thanks to the fur trade (Woodford & Woodford 1967). The city's greatest boom times started in 1903, when Henry Ford founded the Ford Motor Company in Detroit, being followed by other car industry pioneers. The city grew explosively in the 1920s, causing the Great Migration of workers into it, and rivaling in importance with New York City, Chicago, and Philadelphia (Woodford 2001). A second Great Migration took place during World War II, thanks to the city's large manufacturing role.

During the 1950s, Detroit's demographics peaked, and the city's development model shifted. Inhabitants started moving out from the city center into the metropolitan areas. Manufacturing workers fled the urban areas, leaving behind sparsely inhabited neighborhoods, where 40 percent of households currently live under the poverty level (Mosley et al. 2015; Mitchell 2014). Low-density and car-oriented suburban regions prevailed, and the trend was reinforced by the oil crisis in the 1970s. Customer preferences moved away from highly gas-consuming American cars to the smaller and efficient imports. The car industry was badly hurt, and the former automotive capital speeded up its fall. The city touched bottom in July 2013, when it filed for the largest city bankruptcy in the United States, and the democratic rule was suspended by an emergency city manager (Davey & Walsh 2013).

The two Great Migrations required a fast development of large-scale urban infrastructure systems to fulfill the needs of the quickly growing population. The horizontal expansion of the urban area, mostly through low-density housing, called for the deployment of extensive transportation infrastructures (these were freeways and metro lines) and basic services networks (for water supply and sewage and electricity distribution). Years after the city's boom, the depopulation has led to problems in maintaining these infrastructures and financing its operation due to the shrinkage of the tax base. The most dramatic example, given its importance for ensuring the city's neighborhoods remain habitable, is the case of the drinking water system.

[1] A county is a jurisdictional subdivision of a state in the United States, acting as an intermediate political division between state level and cities, towns, and villages.

Detroit's water supply infrastructure challenges

Human rights compliance is no longer guaranteed in Detroit. The Universal Declaration of Human Rights proclaimed access to safe water to be a basic human right of all persons regardless of gender, race, or other status (that is, economic), as part of the right to adequate standards of living (Article 25)[2] (Mosley et al. 2015). Between 200,000 to 300,000 people have lost (or risk losing) access to drinking water in recent years due to the shutoffs carried out by the Detroit Water and Sewage Department (DWSD), causing a humanitarian emergency in the heart of the United States (Lukacs 2014). Urban infrastructure managers are not succeeding in delivering an affordable and equitable water supply because they failed to confront the paramount challenges of Detroit's infrastructure.

Detroit's water system was first developed in 1827 by a private company and bought by the city in 1836, where it has undergone numerous updates since (Fenkell 1921). Average consumption of water is around 177 gallons per person per day (644 liters), considering Detroit is located in a humid climate with regular rainfall (Thurm 2015).

The decline in water sales in recent years (according to the DWSD, from ~575 million gallons per day in 1999 to less than 400 million gallons per day by 2010, around a 30 percent drop (DWSD 2012)) has put at risk the current, oversized infrastructure, indefinitely postponing its update. In the Detroit area, many pipelines are lead lines that were installed in the 1960s and 1970s. Poor maintenance and aging causes important leakages and higher costs in pumping,[3] but the lead leaching into the water causes important environmental and health issues (Thurm 2015; Semuels 2015; DWSD 2009).

To the technical (and financial) challenge of replacing obsolete (and risky) lead, iron, and copper lines, add the imperative update of water metering. Minimizing operational costs and improving billing led the DWSD to adopt innovative IT technologies to replace old, manual meters. The technical challenge of modernizing water metering has been confronted by implementing an IT solution based on a fixed-network meter solution and a cloud-based solution, which avoids estimated bills (charging real consumption) and diminishes maintenance and reading costs (HP 2013; AT&T 2013).

Detroit's water infrastructure is bankrupt, drowned by debt. The debt related to the water department amounts to $5.7 billion (Hackman 2014), and the city has to allocate more than half of its decreasing revenues to repay it (DWSD 2012). This situation has created great difficulty in financing the much-needed updates to the network and has encouraged infrastructure managers to substantially increase the rates charged to customers. Charges for individual customers have climbed from ~$25 per month in 2010 (Circle of Blue 2010) to $139 per month by 2014 (Circle of Blue 2015) for an average household.

This means a staggering 450 percent increase that almost a third of households cannot afford, especially since real wages have gone down, particularly for automotive workers, by nearly 14 percent from 2003 to 2013 (Ruckelshaus & Leberstein 2014). "The flight of corporations toward cheaper, overseas labour" and "the movement of white, wealthier Detroiters to the suburbs" has drained the city's tax base (Lukacs 2014), eroding the financial sustainability of the DWSD. To counteract this trend and try to overcome the financial challenge, the

[2] This was reinforced in 2010 with the resolution 64/292 on "the human right to water and sanitation."

[3] In the Detroit urban region, it is not customary to use water wells due to the soil properties; hence, water is taken directly from the rivers and lakes in the region and pumped directly to customers (without reservoirs), making the system particularly expensive due to its spatial extension (Fenkell 1921).

infrastructure managers adopted an extremely aggressive collection policy, which has led to a dramatic social challenge.

Any household owing $150 or two months of bills to the DWSD can get their water supply shut off by armed officers, their water valves cemented (to avoid illegal connections), their house marked visibly with bright paint on the road, and/or their properties foreclosed (Lukacs 2014; Caruso 2011). This extremely harsh, discriminatory policy toward low-income families, which is starkly in opposition to the lenient approach to commercial or industrial consumers owing more than $30 million (more than half what is owed to the DWSD, see Figure 9), has led to more than 50,000 households losing access to safe water since 2013 (Mosley et al. 2015; Guillen 2014; Lukacs 2014).

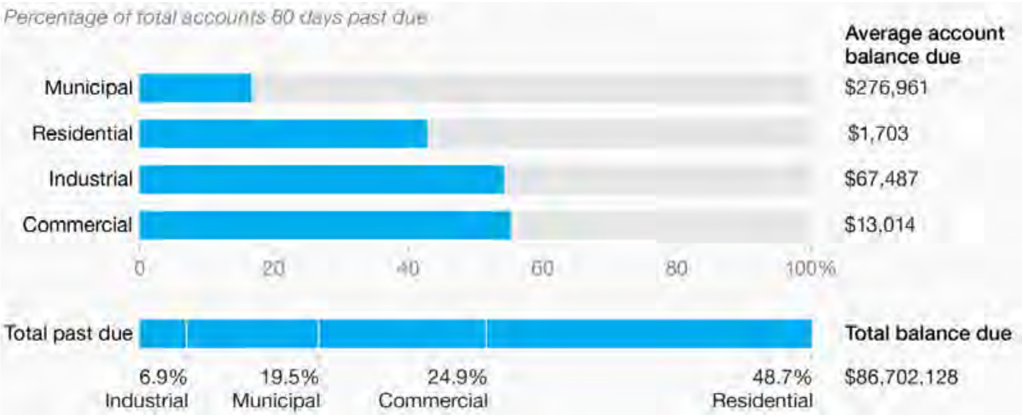

Figure 9: Detroit Water and Sewage Department past due accounts in July 2014.
Source: DWSD. Adapted from Mitchell 2014.

This tragic social situation reached the United Nations on a request raised by a local movement. The UN officials countered the urban infrastructure managers' attitude by stating that "disconnections due to non-payment are only permissible if it can be shown that the resident is able to pay but is not paying. In other words, when there is genuine inability to pay, human rights simply forbids disconnections" (Danny 2014). Despite the years since this situation started, little has changed, and many claim that the financial challenge is being used as a pretext to create a social catastrophe against legitimate privatization (Lukacs 2014; Caruso 2011). The social challenge remains and is aggravated by new problems.

An environmental challenge has recently emerged, partly derived from the technical, financial, and social challenges taking place in Detroit. Flint, a bankrupt Michigan town located in the metropolitan area of Detroit, depended on Detroit's water services until 2013. Unwilling to go on paying the high rates charged by the DWSD, which increased by 73 percent between 2004 and 2013, the city of Flint started building a new pipeline and taking water from the Flint River in the meantime (Semuels 2015).

Soon after Flint tapped into river water, several health problems emerged among Flint's population, particularly among children. After some months, the health issues were finally linked to the water supply because the presence of lead in the water exceeded safe concentrations. A state of emergency was declared, and citizens of Flint were asked not to drink the water coming from their homes' taps (*Huffington Post* 2015). The pollution of the river basins, but mainly the use of old lead pipelines, was found to be the origin of these problems, which are still ongoing (Davey 2015; *Huffington Post* 2015).

The US Environmental Protection Agency made public a report on the serious risks derived from the pollution of water by aging pipes. Not only does this finding add great pressure to Flint's and Detroit's urban managers, but it affects all municipalities countrywide, in an unprecedented challenge caused by water pollution potentially hurting millions of Americans (*Detroit Free Press* 2015).

Finally, a jurisdictional challenge arose from the spread of Detroit's water infrastructure across several counties (see Figure 0). As just discussed, municipalities other than Detroit's suburbs such as Flint are supplied water by the Detroit Water and Sewage Department. This requires joint planning of the infrastructure in order to develop the necessary network to reach distant locations (see Figure 10, where Flint is around seventy miles northwest of Detroit itself).

Lack of accountability and transparency in the operation of the infrastructure, as well as conflicts with the way Detroit was dealing with the emergency situation (instituting price hikes), have led to friction among adjacent jurisdictions and different approaches to the challenging situation. In the case of Flint, the town decided to become independent from DWSD due to the high costs of water, although it had to go back to using Detroit water, given the health issues uncovered (Davey 2015).

Highland Park, an independent urban area within Detroit itself (see Figure 10, the white space in the heart of Detroit's urban area), faced the same problems Detroit is facing now, but much earlier. In 2001, the Michigan governor sent in an administrator for the town short-cutting the democratic city council (Caruso 2011). The administrator imposed drastic austerity measures, raised the water rates steeply, shut off thousands of water connections (by using armed employees), and entered into secret conversations to privatize the water in Highland Park (Caruso 2011).

In 2004, the Highland Park city council voted against the privatization proposal. Despite that veto, the city administrator tried to formalize the contract by arguing that the city council was left with no decision power, and she did not cease in her efforts until the governor, attending to the mounting local pressure, decided to replace her with another administrator (Caruso 2011). This example illustrates not only the jurisdictional challenges that can emerge concerning the urban infrastructure management, but also how the different stakeholders may influence the outcome when dealing with the different challenges discussed here.

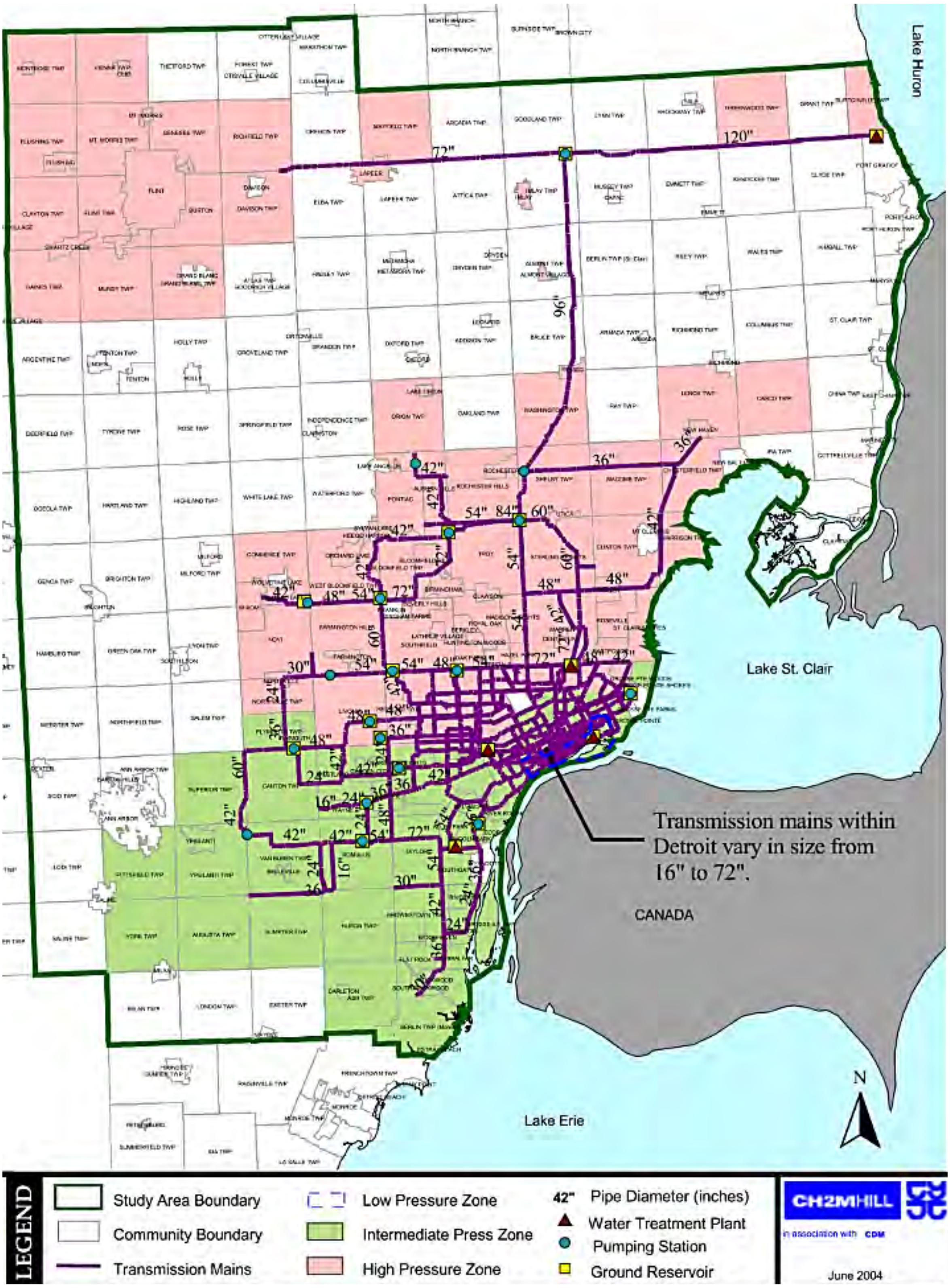

Figure 10: Detroit urban region water infrastructure managed by DWSD.
Adapted from CH2M Hill 2004.

The urban infrastructure manager's view and conclusions

Urban infrastructure managers in Detroit's water service need to confront the challenges through their main three tasks: planning, operating, and maintaining the infrastructure.

Detroit water infrastructure managers have to develop a comprehensive plan to renew the entire water network, with particular emphasis in those areas with the oldest pipes (some of them dating back to the 1940s) and zones with the most vacant buildings (where leakages and no maintenance can lead to inadvertent problems). Indeed, several efforts have been made in this respect in recent years aiming to improve the network and making it more sustainable, both financially and environmentally (Thurm 2015; CH2M Hill 2004). The implementation of IT-based solutions is already being explored in Detroit (HP 2013; AT&T 2013), evidencing the need to align the physical infrastructure planning with the service layer planning.

Operating the system does not seem to be a major issue in Detroit's urban area, where the system has been running uninterruptedly for centuries. However, certain activities not directly related to the infrastructure, but with the service (such as collection of delayed payments, administrative steps to (re)turn on the water supply), are in need of revision. These support tasks carried out by the service operator, often invisibly to most users, jump to the forefront because of the social challenge faced by the city. A proper collection policy and sensitive approach to individual cases can ease the situation in Detroit and smooth the infrastructure operation, although it remains a pending task for managers.

But renewing the network or adapting its operations will be enough to ensure a long-term, high-quality service to all Detroit metropolitan area inhabitants. Maintenance of the system needs to gain priority to avoid costs derived from leakages or poor knowledge of the condition of the pipelines (so recall Flint's health issues caused by old pipes) (DWSD 2012). Given the extension of the urban infrastructure, coordination with different communities and counties will be central for efficient maintenance, which may be enhanced by prospective changes.

Table 1: Summary of challenges faced by Detroit water infrastructure managers.

	Planning	***Operations***	***Maintenance***
Economic/ Financial	Reduce debt and financial costs	Ensure collection of delinquent accounts	Pursue sustainable financial model
Social	Space rate hikes, better allocate efforts (price discrimination)	Maximize served customers and affordability	Ensure service
Technical	Update the network (replace aging pipelines)	Integrate IT solutions	Avoid service disruptions and leakages
Environmental	Ensure river/lakes water quality through wastewater treatment	Monitor water quality to prevent health issues	Guarantee proper filter work
Jurisdictional	Joint development/ update of the network	Coordinate operations across counties and communities	Limit responsibilities and coordinate actions

During the bankruptcy crisis of summer 2014, a new water infrastructure authority emerged to coordinate efforts between Detroit and surrounding counties (dependent on the DWSD for their water services). On November 2014, the Great Lakes Water Authority was constituted as a new body that would take charge of the water infrastructure outside the city of Detroit by leasing it to the DWSD (GLWA 2015). This supposedly new approach to the challenges faced by urban managers that addresses the jurisdictional challenges gives more independence to local managers, but also eases the financial status of the DWSD (by regular payments for leasing its infrastructure) and allows for new, cheaper debt to finance the necessary network updates. However, it also poses some operations and maintenance challenges where coordination will play a crucial role (Cwiek 2015). Many are optimistic about the new regional water authority and the chances of losing the pressure on the distressed Detroit-area citizens, although the difficulties are high and results will not come easily (Cwiek 2015).

Detroit water services face important challenges in all the dimensions of urban infrastructure management related to all the tasks of infrastructure managers (see Table 1). It serves also as an exceptional example of how different stakeholders hold different roles in the system and of the mechanisms to pressure each other's actions (that is, replacing managers for emergency administrators, social movements pressing for management changes).

Finally, it also serves a more transcendental role: it is a reminder and a warning. Detroit's water problems remind us that urban infrastructure crises are not limited to developing economies. It is a warning to rich countries of the risks of deindustrialization without proper long-term vision of the impact on urban infrastructures.

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