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Abbreviations

AI	Artificial Intelligence
API	Application Programming Interface
CCTV	Closed-Circuit Television
GBA+	Gender-based Analysis Plus
GIS	Geographic Information System
G2G	Government-to-Government
G2C	Government-to-Citizen
G2B	Government-to-Business
GPS	Global Positioning System
H2020	Horizon 2020 European Program
HTTP	Hypertext Transfer Protocol
ICT	Information and Communication Technologies
IoT	Internet of Things
ISO	International Organization for Standardization
IT	Information Technology
JSON	JavaScript Object Notation
KPI	Key Performance Indicator
MQTT	Message Queuing Telemetry Transport
OGC	Open Geospatial Consortium
SMS	Short Message Service
UI	User Interface
UX	User Experience
WFS	Web Feature Service
WMS	Web Map Service
XML	Extensible Markup Language

Foreword

Since late 2019 governments, businesses, and communities around the world have suffered severe disruption as a result of the ongoing COVID-19 pandemic. As vaccination programs have started in many countries, cities slowly have begun the long way to recovery from what many consider the biggest challenge of modern times. The pandemic has left a trail of economic, social, and human damage that only adds further pressure to cities already dealing with many other problems (such as climate change, natural disasters, inequality, etc.). These challenges are as complex as they are interrelated. Hence, the idea of “Smart Cities” arises as a promising approach for cities wishing to find sustainable solutions, that capitalize on data and technology for advancing urban development. Utilizing the right data can be a game-changer for cities that wish to, for example, radically improve their public transport, reduce greenhouse emissions, tackle epidemics, and deliver evidence-based policies. To this end, data needs to be connected, interoperable, and translated into knowledge. This requires innovative technical solutions and thus, financial, economic, and intellectual resources.

The COVID-19 crisis has given a boost to digitalization and prompted cities from both developed and developing countries to reach out for data, technological tools, and data-based interventions. Seoul has used its data infrastructure to implement contact tracing, Melbourne has used its pedestrian counting system to monitor activity in the city and inform recovery initiatives, Jakarta has implemented a mobile application to coordinate its vaccination activities, the Municipality of Miraflores in Peru has used digital portals for providing services to its citizens and reduce risks associated with direct contact. These examples, among others, show the many ways in which cities can use data to save lives, reactivate the economy, exercise better decision making, and improve the provision of city services. However, this deployment of technological interventions has placed more attention on challenges around data, and highlighted questions on the risks arising from the dependence of smart city approaches on data and technology: how do we secure data? How do we protect people’s privacy? How are we ensuring inclusion and minimizing the digital divide? How can we share and make data interoperable? Furthermore, questions about the new possibilities for control and misuse of information opened by the use of data, as well as concerns around the reconciliation of economic interests and the public good also need to be considered.

Post-COVID19, cities across the globe will never be the same again. Although the specific focus is public health related, cities are beginning to take tangible steps to move beyond the idea of smart cities to their actual implementation. The differentiating factors between success and failure will be the willingness to anticipate global trends and plan accordingly through the use of data for common good. Ultimately, the goal is to build a city that continuously improves, is more efficient, more sustainable, and more inclusive -a city that builds on the interactions between its people, technologies, data, and the processes in place to manage the governance of this complex ecosystem.

This is a study conducted for the International Smart Cities Network (ISCN)¹. The ISCN supports the international exchange and knowledge transfer in the field of smart cities. Through international dialogue, the network promotes the shaping of digital change in the city in the sense of integrated urban development oriented towards the common good. For the ISCN, the current situation means a rapid rethink to find answers to urban challenges and to ensure intensive dialogue and constant learning from each other despite travel restrictions. As a vehicle for even closer and networked cooperation worldwide, the ISCN secretariat has organized this study of “Data Strategies for a Common Good-Oriented Urban Development – International”, in close coordination with the ISCN team.

This study provides international technical know-how, best practices, lessons learned and recommendations from the data approaches followed by cities around the world. It does so by first providing a short analysis and summary of the current international debates on data strategies, highlighting the many opportunities that arise when working with data. Second, an overview of international best practices shows how different cities are implementing data strategies and data-based interventions to ensure the sustainable provision of common goods. Lastly, this paper provides an overview of the main challenges and corresponding recommendations identified by this team during the research process.

This study is possible thanks to the contributions of a number of experts in charge of data strategies, smart city programs, and sustainable urban development. We asked these experts to reflect on their experiences in the design and implementation of data strategies and data interventions in their cities, and to share the lessons they learned and the main challenges they encountered. The hope is that the sharing of experiences, the different examples on how cities make the most out of urban data, and the formulation of recommendations to tackle common challenges will serve as inspiration to other cities in their efforts to orchestrate their data ecosystem and develop their own solutions. We hope we can foster a data culture and approach that is viable, scalable and inclusive, and that allows data to pave the way to a future in which the human factor defines our city experience.

¹ Further information on the ISCN can be found at: <https://www.smart-city-dialog.de/en/icsd>

Executive summary

A growing number of today's societal challenges, including climate change, urban development, and natural disasters, are highly complex and equally interconnected. The COVID-19 pandemic has given a boost to digitalization and prompted cities from both developed and developing countries to reach out for data, technological tools and data-based interventions. At the heart of this digital expansion, lies data as the key raw material that can be used by both the public and the private sector to support decision making processes and provide better services. Overall, data plays a huge role in the ability of cities to reach their long-term sustainability and post-COVID recovery goals.

However, designing and orchestrating a data ecosystem, and creating the right conditions for collecting, sharing, and using data is no easy task. A data strategy represents an important departure point that provides the orientation for the data governance arrangements that will guide the entire data ecosystem in a way that reflects societal values and serves the common good. Furthermore, as cities pilot smart city technologies, attention has to be given to ethical issues and fundamental questions around data sovereignty and the risks associated with citizens' privacy, as well as their role in the management and access to the data collected.

This is a study conducted for the International Smart Cities Network (ISCN). It looks at international best practices for data Strategies for common good-oriented urban development and provides insights on the approaches of cities worldwide for the set-up of data governance arrangements and the implementation of data-based solutions adapted to their particular local realities. For the making of this study, 13 interviews with experts and representatives of the cities under analysis were undertaken and over 50 documents (strategies, strategic plans, project reports, analyses etc.) were analyzed and compared.

Overview of selected best practices

The study focuses on two different levels: data strategies and data interventions. **Data strategies** refer to the holistic approaches followed by cities to govern their data ecosystems and orchestrate data management across various organizations. **Data interventions** refer to specific data-based initiatives and projects which the selected cities have implemented around different urban domains. At the intersection of both levels lies the use of data and technologies to advance different urban development goals and to ensure the provision of common goods.

Data Strategy Level:

Hamburg, Germany: The comprehensive "Digital Strategy for Hamburg" establishes the adoption of technologies as means to improve life quality in the city. It does so by implementing innovative data-

based pilot projects. The Urban Data Platform Hamburg is the central “data hub” that serves the entire city and standardizes the technical linking of the city’s systems and databases.

Melbourne, Australia: Melbourne has set a Smart City Strategy where data, technology and innovation are set to make a better city and play a key role in the economic recovery in the aftermath of COVID-19.

Montreal, Canada: The data strategy- Montréal Numérique – is oriented towards the provision of better citizen services, amplifying participation, ensuring the responsible use of data, creating an evidence-based decision-making environment, and increasing its innovation capacity.

Seoul, Korea: Anchored in a robust data ecosystem and cutting-edge digital infrastructure, the city envisions the co-creation of data-based solutions together with citizens and the private sector, aligned with social and environmental values.

India: The national “DataSmart Cities Strategy” aims to institutionalize a culture of data across the 100 cities of India’s “Smart City Mission”. This strategy document lays down the basic premise, foundational pillars and a suggested roadmap for cities to improve their readiness for intelligent use of data.

Data Intervention Level

Jakarta, Indonesia: The Smart City Framework 4.0 envisions the use of technology and data to advance urban development and citizen’s happiness. The city is collaborating with Berlin, Germany for strengthening its smart city capacities, good governance, and to foster an entrepreneurial ecosystem.

Municipality of Miraflores, Lima, Peru: The Municipality has already implemented a series of digital tools for improving its planning, decision making, and services. It recently launched an ambitious Smart City Project for improving traffic and public safety.

São Paulo, Brazil: The São Paulo City Laboratory for Mobility Innovation (MobiLab) introduces innovation for the creation of data-based mobility solutions, together with local start-ups.

Seoul, Korea: The Digital Mayor’s Office is an integrated smart city data platform that comprises all available urban data and allows decision makers and citizens to intuitively navigate and understand it.

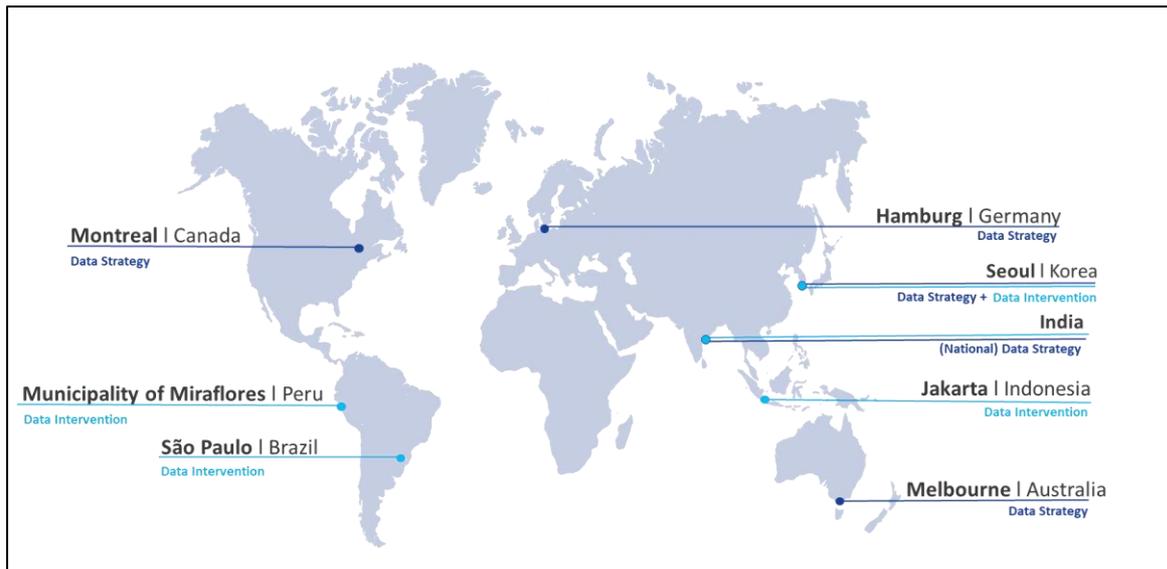


Image 1- Overview of best practices included in the study

Common Challenges:

This study finds a range of challenges which present themselves for most cities, irrespective of their location on the map. These challenges are grouped under the following categories:

- A) **Preparing and implementing a data strategy and a smart city framework:** The task of setting the vision, strategies and policies for a smart city is complex and sometimes, overwhelming. Not only do cities often lack the foundational policies for sound deployment of technologies and for protecting data and citizen’s privacy, but they also lack the ability to influence these regulations, as they can fall out of the local scope. Additionally, communicating the advantages of having a data vision, urban data platforms, and data-based solutions can get lost in the midst of complicated technical details and processes. When transferring practices from one city to the next, municipalities might encounter barriers related to different cultures, values, and approaches to working with technology. Lastly, changes in political agendas might hamper the continuity of long-term data strategies and data initiatives.

- B) **Setting the data governance and interoperability principles:** Cities aiming to become smarter are challenged with making use of data collected from many different organizations and places. This might compromise their interoperability and prevent data sets from “communicating”. When it comes to data management and operation of big-data analytics, cities can find themselves bound to large corporations and fall into a long-term vendor lock-in. In addition, accessing data from third-parties and citizens might be challenging.

- C) **Finding the resources and capacities:** Smart city strategies rely on infrastructure that is often costly. Investments are often expected to come from the digital unit of a city (which frequently have little to no budget), but the benefits materialize in other domains. This has wider

implications for the overall organization of municipal responsibilities and budgets. Also, the digital competencies of municipal staff need to be brought up-to-speed.

- D) **Orchestrating innovation:** Adopting innovation and implementing disruptive new solutions is a difficult task that sometimes requires risk taking. This is often not well received by city administrators or policy makers.

Recommendations and the way forward:

Smart city projects are transformational initiatives and evolve hand-in-hand with the dynamics of their implementation. Cities can start their projects by first identifying compelling areas of action and focusing on small digital interventions or pilot projects, that can be further developed and scaled up later. Nevertheless, it is important to see each intervention, as small as it might be, as part of a coherent long-term strategy built around interoperability and open standards principles. Overall, there is no “one size fits all” solution. Policy frameworks in areas such as ICT accessibility, privacy, data protection, and open data need to be mainstreamed and adopted at national and city levels. To ensure continuity, rooting a smart city strategy within a multi-stakeholder external advisory board can help gain independence from political cycles and build trust, co-innovation and ownership.

To achieve interoperability, cities need to refer to common reference architectures as underlying design principles for urban data platforms, even when specifying data requirements towards municipal organizations and third-party suppliers of data. Reference architectures function as open standards and make sure that all platforms and components used can communicate with each other. In addition, cities should refer to established standard for metadata. To avoid vendor lock-in, cities are advised to diversify their tech-and-infrastructure basis and gradually build on Open-Source technology. Cities can convince third parties to share their data by providing incentives. Data provisions should be included as conditions for awarding city contracts. The lack of trust of citizens in the ability of their governments to keep their information safe can be counteracted by providing accessible, easy-to-understand information on what the governments do with data, and how they ensure their protection. More advanced cities enable their citizens to decide, which data they want to share with whom.

Municipal authorities can accelerate the adoption of infrastructure and their investment capacity. Local governments can develop partnerships with industry to support established information and communication infrastructure plans. This can be further supported by the development of policies and regulations that enable and incentivize industry to invest in digital city infrastructure.

Lastly, not all innovative changes can be successful, and failures are an important element of the process. Communicating successful examples is as important as recognizing failed programs and stopping them before more resources are invested. It is advisable to start purchasing from smaller and innovative companies when it comes to services and solutions that can be operated separately from large infrastructures. When it comes to smart cities, this is often the case; thus, data-driven interventions usually provide a great opportunity to bring new and innovative players on board.

Introduction: the different aspects of the data puzzle

Background and Smart City introduction

Today, cities are home to more than half of the world's population. At the same time, it is in cities where the highest rate of resources is being consumed (UNFPA, 2021). Developing countries experience rapid and uncontrolled urbanization where the population growth far outpaces the availability of sufficient city infrastructure and services (Gurara et al., 2018). On the other hand, many industrial regions have stagnating populations and are challenged with aging population and infrastructure. As urbanization and greenhouse gas emissions are correlated, cities have not only caused but also suffered significant environmental and climate impacts. These have in turn affected citizens' lives within and beyond the city borders.

As cities are centers of life and human activity, they also bundle a huge amount of resources and potential for innovation. Yet, globally, the essential question remains: how can cities exploit this potential in order to successfully adapt to rising pressures on infrastructure and city services in ways that are sustainable and inclusive? This question is the very foundation from which buzzwords such as "sustainable, future and smart city" are derived. The term "Smart City" carries different meanings and implications. It generally refers to cities that rely on interconnected technologies and data-based instruments to improve the life quality of their citizens, generate smart responses to their main challenges, and ensure their efficiency on a sustainable basis. This is done through the deployment of various technologies and digital interventions for the improvement of urban management across the different domains of urban life: environmental sanitation, mobility, usage and management of public health and space etc. However, designing and orchestrating a smart city and its data ecosystem is no easy task. Creating the right conditions and frameworks for collecting, sharing, and using data comes with a series of challenges. Regardless of that, the planning and management of the 21st century cities cannot be done without the incorporation and usage of data for city planning and management.

A strategic approach to data

Digital tools and digital cities should be the means to an end: to create value for society and opportunities for prosperity. In the urban context, strategic thinking looks past the technology, data, and processes, and focuses on the ultimate value for society and opportunities for prosperity. Lessons learned from the architects of smart cities, show how important strategic thinking and preparatory work are. That means, before designing a platform, coding algorithms, acquiring and deploying smart technologies, digital cities need to focus on the value creation and broader outcomes that would later guide implementation of solutions to the unique city context, tailored to their specific cultural and social characteristics. A data strategy represents an important departure point for smart cities that provides

the orientation for the data governance arrangements that will guide the entire data ecosystem, so that they reflect societal values and serve the common good. To do so effectively, such arrangements should be reflective of the various stakeholder groups, in ways that are inclusive of all demography.

Data governance and interoperability

At the root of data strategies is the objective of unlocking the data's potential for public and private sector stakeholders. However, dealing with data owners, using the required technical infrastructures, promoting open data, and developing institutional mechanisms and cultures for data sharing represent profound challenges. The opening of data sets can often be hampered by organizational culture, lack of data quality and accuracy, funding deficits, and legal obligations. Furthermore, as data strategies need to bundle a wide variety and large amount of data and data owners, audits to understand the datasets pool, identify gaps, and prioritize the data are needed. As data silos are broken and more and more data is shared, the interoperability and the ability of the systems in place to process and exchange the information provided by this data are central issues. Municipal authorities that want to enhance interoperability need to pay special attention to their ICT architecture, open systems and open data standards, as well as provide support to help organizations open their data. Avoiding vendor lock-in is of special importance for preventing dependence on providers, enable stakeholder participation, and to enable an open-data ecosystem. It is also important to refer to the concept of open urban platforms, which constitute the foundation of interoperability in urban ICT. Such platforms utilize software systems that are based on Open Standards and allow cities to manage the often overwhelming amounts of city data.

Infrastructure and financial considerations

Cities need to pay close attention to key issues concerning the configuration, and operation of the urban infrastructure needed for their transformation. For example, the harvesting of data for traffic management and monitoring air quality usually relies on sensory data. However, questions might arise such as: how will the infrastructure be powered? Will it require hard-wiring, battery or solar panel operations? In case of an emergency, what kind of response should be triggered? The answers to these questions are embedded in the type of technology deployed and the data strategy of each city. Additionally, the implementation of data strategies often requires either the improvement of the already existing urban infrastructure, or entirely new infrastructure. The existence, for example, of sensor networks, fiber optic cables, IoT technologies, and data analytic tools can decide the level of digital transformation possible in a city. Cities must prioritize the particular needs of their citizens and gradually implement the technology that is relevant to the solution needed. Financing mechanisms for technology and innovation need to be established to support this process. However, the financing of smart city projects and the high-risk nature of innovation can be challenging. Financing options for smart city projects include government-based financing schemes, development extractions, public-private

partnerships, mechanisms to leverage private sector (e.g. loans, taxes), and new funding alternatives like crowdsourcing, microlending, venture capital and philanthropic funding (Von Radecki et al., 2020).

Ethical implications

The deployment of smart city technologies is beginning to highlight a lot of technical and ethical issues. In the time of open data and big data analytics, fundamental questions are arising concerning data sovereignty and the risks associated with citizens' privacy, management of the data collected by public and private institutions, and who has access to and control over the data. By establishing the processes and the key issues to be considered when handling data, cities can address citizens' privacy concerns in a manner consistent with public interest. Another important ethical concern is how local governments can address and guarantee transparency in algorithms that support or perform decision-making tasks. In this sense, public servants need to not only understand the impacts and implications of such tools, but the principles and rules to guarantee ethical standards are followed beginning in the data procurement processes.

Digital skills and the digital divide

Another fundamental issue that needs to be accounted for as cities navigate the digitalization waters is the need to define and develop new roles and responsibilities. In this sense, cities are tasked with the development of digital skills and capabilities of their personnel. Furthermore, the increasing polarization between those with access to and understanding of technology and those with fewer skills can further drive inequality in the labor market and the overall society. Smart cities could unintentionally exacerbate the marginalization of certain groups through what has been called the digital divide. Thus, the digital skills of the population need to be further developed, particularly for groups that are at risk of marginalization.

The importance of data for improving cities

Despite its challenges, data represents an invaluable resource for cities. When used correctly, data can be a key enabler of better cities and societies at large. Its potential for creating more efficient city services, enabling scientific knowledge, informing policy making and decision-making processes, and opening new forms of participation is unmeasurable. Not only that, the vast amounts of data produced every day can be a window that allows us to explore and better understand the human activities that take place within and beyond the borders of our urban spaces. These insights can ultimately be the decisive factor for arriving at better decisions that serve common interests. Even more, data-driven innovation and the linking of data can be used to improve, among other things, transportation flows, energy and water usage, and energy systems, all of which will make cities more resilient and efficient. For example, smart parking and dynamic parking fees have the potential to drastically change how cities manage their space, while considerably reducing noise and air pollution. Early warning systems for floods, natural disasters, and extreme weather events can dramatically impact preparedness,

response and recovery. City governance can also be promoted with technology through e-government services for facilitating access to information, exchange of experiences, and opening communication channels between government and citizens. New forms of participations like participatory budgeting can give citizens the possibility to voice their opinions on public spending. The potential applications of data are as big and numerous as the challenges that our cities face.

Data is in its nature unlike any other resource: it is non-rivalrous and non-excludable, meaning that many actors can use it and reuse as many times as they want, and for different purposes, without impacting its quantity or quality. As data needs to be collected just once, society can save costs and develop more than one output from the same data set. Furthermore, data sets can be even more valuable when they are used in combination with other datasets, a process that is further leveraged by technological developments like big data analytics and AI. The combination of different data sets can provide a more complete, accurate, and less-biased picture (Von Radecki et al., 2018).

Data and the city domains

As cities set their goals and establish their smart city vision and strategies, data- based interventions can profoundly impact different interconnected domains of the city, including:

- Smart economy: To exploit the large innovative potential of cities and cope with economic challenges, data can aid the strengthening of existing industries and promote the development of new ones (like digital services).
- Smart living: The integration of ICT-based applications can improve the quality of life of citizens, for example, through better household appliances, technologies to help citizens monitor their health, and more efficient home energy use.
- Smart governance: Processes and interactions can be improved within governments, and between governments and their citizens.
- Smart environment: Intelligent solutions can lower the resources needed for cities and foster sustainable growth. Sensor technology, behavioral economics, and gamification can influence and improve decision making on infrastructure and resource use.
- Smart mobility: The energy consumption, emissions, noise and air pollution caused by the transportation sector can be lowered through the development of ICT solutions. Furthermore, the mobility demands of city inhabitants can be better met using, for example, sensor-driven dynamic pricing and shared mobility schemes.
- Smart people and smart education: “Smart people” refers to citizens whose digital skills are developed in a way that enables them to actively participate and create innovation in their city. Education enabled by virtual learning is opening new opportunities for teachers who can leverage data and analytics to maximize students' success. More opportunities triggered by COVID-19 have normalized remote learning and working,

- Smart security: Cities can use data and technologies like drones, facial recognition and video-based predictive analysis to improve public safety. Different streams of data can be used to prevent and fight crime.

Data for the common good

To make sure data is being utilized with a strong focus on the common good, it is of vital importance that local policy makers and city administrations play an active role in the governance of their local data ecosystem. Developments like the Toronto Waterfront project – a private development project by Alphabet affiliate Sidewalk Labs – have put the conflict around citizen data right into the center of the public debate on smart cities. Is it the big corporations that will run our data-driven urban infrastructures and services, or are the cities themselves in the driver's seat? If big tech is being handed over control over citizen data, smart city algorithms are likely to reflect ever increasing profit margins and not what is best for the common good. To illustrate this point: a data-driven ride hailing application can be programmed to increase revenues for the platform operator or it can be designed to reduce traffic. An algorithm that channels more customers to drivers who share a high percentage of ride fares with the platform provider will automatically increase traffic, since it will not book the vehicle closest to the customer, but rather the vehicle that is most profitable for the platform. On the other hand, an algorithm that increases revenues for drivers and lowers costs for customers based on proximity and sharing is likely to optimize urban mobility, but will not produce maximum returns for the platform operator. So, how can cities assure that data is being used in a way that strengthens the common good and does not gradually transform citizens into customers of their city? The key lies in data governance. Cities need to come to grips with the complex nature of data, making clear rules for data-driven services and digital service providers. The trick is to find a balance that helps cities harness the innovative power and digital skills of private companies, while favoring the common good of citizens.

Data Strategies and data-based interventions

This report will look at international best practices for data strategies for a common good oriented urban development. It provides insights on the approaches of different cities for the set-up of data governance arrangements and the implementation of data-based solutions adapted to their particular local realities.

It focuses on two different levels: data strategies and data interventions. Data strategies are holistic approaches followed by cities to set their data ecosystem and data management. Data interventions are specific data-based initiatives and projects that the selected cities have implemented across different urban domains. At the intersection of both levels lies the use of data and technologies to advance different urban development goals. The selected best practices at the data strategy level include the cities of Montreal, Hamburg, Melbourne, and Seoul, while the cities selected for data-interventions are São Paulo, the Municipality of Miraflores (Lima), Seoul and Jakarta.

Best Practices: Data Strategies

Hamburg: Sharing, using, and protecting data

Keywords: •urban data platform •interoperability •innovation

Lessons learned:

- When communicating the insights of an urban data platform, cities should highlight implemented interfaces and standards to enable interoperability, provide manuals and name frameworks instead of software products to enable re-use, and develop narratives that build around the uses and added values created by the platform.
- A precise legal framework for data use can be key for enabling and encourage innovation.
- The entire process of setting and implementing a city-wide digital strategy should be built on the basis of early participation of all relevant stakeholders.
- Joint Mechanisms for decision making, definition of common terms, training programs, and co-working are key for bringing stakeholders closer and engaging them in the digitalization process.

With 1.84 million inhabitants, Hamburg is the second largest city in Germany and the seventh largest in the EU. In the past two decades, it has developed a strong digital and innovative culture, which can be observed in the many digital interventions across the city, the proliferation of local start-ups, and the increasing incorporation of digital services. These developments have led Hamburg to be considered a digital pioneer and front-runner in Europe, with studies on the extent of digitalization placing the city on the first place for mobility, society, digital infrastructure and digital strategy in Germany (Bitkom, 2021; Haselhorst Associates, 2021; Rotterdam School of Management, 2021).

Since the 2000s, city leaders have held a vision of transforming Hamburg into a modern digital metropolis. The comprehensive “Digital Strategy for Hamburg” (City of Hamburg, 2018) was published in 2020 and is strongly oriented towards the goals of the Smart City Charter for Germany. It establishes the adoption of technology as a means of improving residents’ quality of life and make Hamburg prosperous and economically attractive. It does so through the implementation of different innovative pilot projects across the many domains of city life, all while promoting the development of sustainable climate and energy transformations.

The strategy focuses on all aspects of life and digital spaces, and establishes the following strategic development areas: digital infrastructures and platforms, data, digital administration, transformation and cultural change, and innovation. From the user’s point of view, it calls for the development and introduction of products and services that reflect the realities of the city, and through which all parts of

society can participate and benefit. It names a series of people-centered programmatic guidelines where digitalization is not seen as a final goal, but rather as the means to progress on behalf of citizens. Taking a holistic approach, the strategy has been formulated with the aim of opening perspectives for stakeholders in the city beyond the city administration, including citizens, companies, scientific and educational institutions, and even tourists.

The Urban Data Platform Hamburg (UDP_HH)

The main supporting factors of the transformation process in the city of Hamburg are: sustainable and efficient technology, an urban data platform, a standardized, decentralized data exchange ecosystem, and an urban data consulting unit (the Urban Data Hub). The digital strategy promotes the expansion of data networks and scaling up new and existing IT systems using standardized APIs. In this context, the Urban Data Platform Hamburg (UDP_HH) is recognized as the central “data hub” that serves the entire city. The UDP_HH was founded in 2017 using the standardized spatial data infrastructure of the Agency for Geoinformation and Surveying (LGV), an agency which has been in operation since 2005. Since then, the well-established and standardized spatial data infrastructure became a multi-use data infrastructure handling spatial and non-spatial data. Its interoperability and quality had been ensured through the application of the INSPIRE Directive (European Commission, 2007) and the worldwide well-known and steadily refined OGC-Standards² (amongst other measures). This data was used as the central component of the data platform. In 2019, a fully operational IoT data infrastructure, based on freely available Open-Source technology³ was implemented to provide real-time data with very low latency (Fischer et al., 2021). The central goal of the UDP_HH is to standardize the technical linking of the numerous cities systems and databases to ease data provision through standardized APIs of the urban data platform IT infrastructure. Hence, each specialized IT system focuses on its specific purpose while forwarding standardized data into the UDP_HH to be made accessible for third-party applications via openly standardized modern APIs such as OGC API⁴ or SensorThings API⁵. The data can be configured individually, accessed in real time and be quickly analyzed. These features can in turn be used to aid decision making processes, facilitate the identification of synergies between data sets and create added value for the city.

The UDP_HH is the result of an ongoing co-creation process between the city and a wide range of data users and data providers including stakeholders from the public administration, civil society, science, and economy. These actors were involved from the beginning of the process to ensure that the resulting product would be a simple, well documented, and easy-to-use platform that could easily adapt to a wide range of needs. Following a demand-based approach, these stakeholders were not only invited to use the data already available, but also share their own data in their digital spaces and fields of action and,

² Information of the OGC Standards and Resources can be found at <https://www.ogc.org/standards/>

³ The implementation manual can be found at <https://bitbucket.org/geowerkstatt-hamburg/hh-udp-iot>

⁴ More information on OGC API can be found at: <https://ogcapi.ogc.org/> and <https://api.hamburg.de/datasets/v1>

⁵ More information on SensorThings API can be found at <https://www.ogc.org/standards/sensorthings> and <https://iot.hamburg.de/>

thus, leverage its potential uses. The quality and interoperability of this data is ensured by open standards and APIs such as OGC Web Feature Services, OGC SensorThings API or OGC API.

The Urban Data Hub is responsible for the further development of the platform, the expansion of its data sets, and the coordination of the urban data ecosystem. Here, the technical data and process interfaces are organized, applied open standards are selected, and the integration of the data in the UDP_HH IT system is enabled. The Urban Data Hub also carries initiatives and projects to further break data silos inside and outside of the administration. They set the requirements for data standardization based on available, open and well-known standards. They also provide advice to actors inside and outside the administration on questions regarding the connection of IT processes to the municipal network, and on the development and implementation of data-based projects.

With more than 500 data sets available, the UDP_HH platform constitutes the basis for the development of digital services across the different city domains, and a variety of practical applications are already running. Some examples include a school routing tool to facilitate the work of administrators when allocating school placements, as well as a digital participation system (DIPAS)⁶. Through DIPAS, citizens can access digital maps, aerial photos, 3D models and geodata from their own devices or at events, as well as provide localized feedback on planning projects. Other applications include tools for mobility and navigation, management of city services, and an Urban Data Platform cockpit⁷ with an overview of the most used data sets and their applications. The UDP_HH also provides real-time data streams of city-wide automatic traffic counts to improve traffic planning and traffic lights signaling to be used in routing and driving assistance systems such as PrioBike-HH⁸.

Additional cockpits and dashboards have been developed as tools using UDP_HH to visualize and analyze data, assess technical processes in a clear and condensed form, and facilitate the evaluation and implementation of projects. For example, a Cockpit for Social Infrastructure (CoSI) grounded in regularly updated statistical and spatial data was created by networking participants from district offices, public authorities and neighborhoods. It consists of a GIS-based planning support system that serves as an easy-access interface between the UDP_HH and the municipal planners for different topics of city infrastructure, including planning of green infrastructure, schools and day care centers, among others. This tool is being used for sustainable neighborhood and infrastructure development, facilitating communication and decision-making with evidence-based planning. Another example is a cockpit used for Digital Urban Land Planning (DiPlanung) which is a system that integrates tools for control of legislative procedures and urban land use planning. The cockpit includes a web interface for information overview of ongoing procedures, reporting functions, and task planning and control. Furthermore, it allows for scheduling and forecasting procedures, facilitating their control and verification.

⁶ A full project description is available at <https://www.hamburg.de/dipas/>

⁷ The Urban Data Platform Cockpit can be accessed at <https://geoport-hamburg.de/udp-cockpit/>

⁸ A more detailed description can be seen at <https://www.hamburg.de/bvm/priobike/>

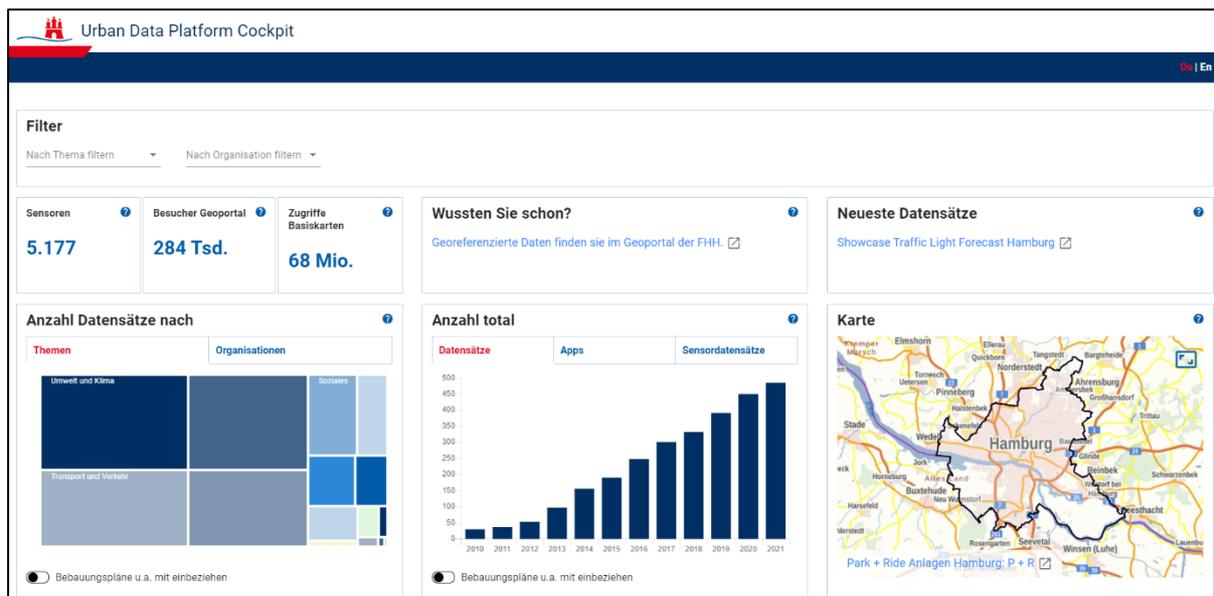


Image 2-The Urban Data Cockpit of the City of Hamburg

The potential of the available data sets is also being used to help gradually establish a Digital Urban Twin, which will be accessible to experts and citizens. The project is funded by the German Federal Ministry of the Interior (BMI) and is a joint project of the German cities of Hamburg, Leipzig and Munich⁹. The project will create multiple digital twins, capturing a specific version of the city that will emerge and open a wide range of new possibilities for data-based visualizations, forecasting and simulations, in particular with urban development planning purposes. The LGV maintains a basic version of a Digital Urban Twin to ease data integration for specific digital urban twins helping to solve challenges such as assessment of interactions in urban life like traffic optimization, efficient construction, precise weather forecasts, events planning, etc. In turn, this can be integrated with other data sources for an enormous range of potential uses. The UDP_HH works as an operating system for a holistic Digital Twin of the city of Hamburg.

Share, use, and protect data: A data governance approach

To utilize the full potential of data, the principles of “share, use, protect” have been established as a key rule for the entire data ecosystem. In this sense, the data governance within and outside of the city administration is guided by the principles of self-determined data usage, data privacy and information security. This is seen as a gradual process for which the city needs to progressively formulate binding guidelines and standards for data privacy, freedom of information, data quality standards, and clear rules for the use, access, and sharing of data. This data governance is also seen as a task that needs to harmonize with the regional, national and international data ecosystems, in order to ensure the uniformity and compatibility beyond the city borders.

⁹ More information on the Digital Twin project can be found at <https://hamburg-news.hamburg/en/location/smart-city-german-government-funding-digital-twins-project>

For processes concerning the digital administration of the city, data privacy is seen as the basic prerequisite. The Digital Strategy determines that all citizens have the right to have their data processed in compliance with data privacy regulations and safe from unauthorized access. To this end, participants of the urban data ecosystem need to give information about their data and categorize it in an open metadata catalogue. This process contributes to transparency, traceability and improves usability. Furthermore, all actors need to be clear about what their responsibilities are in terms of the quality of the data, what access rights they have, and the technical formats the exchange of specific data is available in. With this in mind, the city has carried initiatives to train employees on the requirements of data privacy law and information security in order to ensure the appropriate processing of data. Furthermore, the UDP_HH provides easy to use data via open and standardized APIs in commonly known formats such as the OGC standards WFS, WMS, API-Features and SensorThings API using XML or JSON Objects and protocols such as HTTP and MQTT.

On the matter of information security, the city follows a careful approach in which its digital citizen and business services are designed in a way that does not create new points of attack and risks. This is done with Dataport, the IT service provider for public administration, with which the existing security procedures and organizational rules are developed on a long-term basis. In addition, the city uses a computer center at Dataport certified by the Federal Office for Information Technology Security (BSI) to process the data used and ensure the security of information against loss and unauthorized access. In addition to data protection and freedom of information considerations, the city is also committed to the openness of administrative data. This open data spirit is the cornerstone of the Hamburg Transparency Act of 2012 (City of Hamburg, 2012), which establishes the rules for open data, while addressing important questions on transparency and data sovereignty. The Transparency Act is implemented through the Hamburg Transparency Portal¹⁰, which was established in 2014 and represents the central access point to current data and information from the Hamburg administration. It includes, among others, data on official statistics, expert opinions and studies, geodata, real-time data streams, contracts of public interest, urban land use and landscape plans and subsidies. This data is available in a wide variety of file formats, free of charge, and are connected through so-called delivery systems, which are queried via technical interfaces. The UDP_HH is the biggest delivery system for datasets of the Transparency Portal¹¹. With this culture of openness, Hamburg seeks to further ensure its relationship with citizens and other actors in society.

A data strategy for innovation and cultural change

The Digital transformation of the city is a holistic process between technology, organization and human resources that continuously calls for creativity, flexibility, and adaptation. The data strategy of the city of Hamburg aims to be a 'catalyst of change', centered on the recognition that digitalization and the

¹⁰ The Transparency Portal of Hamburg can be accessed at <https://transparenz.hamburg.de/>

¹¹ The GovData open Data Portal can be accessed at <https://www.govdata.de/>

creation of an innovation-friendly environment cannot be achieved without overcoming rigid organizational mindsets and structures.

The city administration sees the framework provided by the digital strategy as an orientation that can be used for aligning the objectives of already existing strategies, and for the development of new objectives that might be needed as the process of digitalization unfolds. This streamlining of goals across the different domains of the city is seen as the basis for remaining resilient and achieving digitalization. The need to align the functions and responsibilities within the city administration and the new opportunities offered by digitalization are also key components of the city's digital strategy. These new roles are to be defined in consensual processes including the different city departments. To cope with these changes, the personnel and legislative framework need to be adapted for supporting the digitalization goals of the city. Additionally, new e-government formats and IT strategies are also key factors to be integrated as part of the digital strategy.

Outlook for the UDP_HH

As the city recognizes that data analysis and data-based solutions will be increasingly important in the future, it also plans to examine the integration of new technologies (like machine learning and AI) to address specific challenges through the UDP_HH. Furthermore, IoT and Big Data will likely play increasingly important roles in Hamburg's digital transformation, resulting in more attention being given to the currently operational IoT data infrastructure. The domain of mobility is currently receiving special attention, as the city is looking into further developing their traffic light management into full real-time city-wide models, as a means of optimizing routing and planning activities.

Lastly, flexibility and being able to rapidly react to and adapt with the ever-changing demands and developments of society are key features of a successful data approach. In light of this, pressing current issues, like those arising from the COVID-19 pandemic, the increasing occurrence of extreme weather events (e.g. heavy rainfall, extreme temperatures), and the need for successful refugee integration, are some of the topics that are currently being addressed through data driven approaches and implementations that rely on the data provided by the UDP_HH.

Melbourne: Using data for recovering and reactivating the city

Keywords: •data privacy •best practice scaling •data uses •economic recovery

Lessons learned:

- Cities can leverage data to provide insights and solutions, as well as facilitating decision making to address the problems posed by the COVID-19 pandemic, and to support the city's post-Covid recovery.
- Cities can incorporate privacy and security principles in their data strategies (for example, privacy by design principles)
- When scaling practices from other cities, local governments need to consider their own characteristics and the challenges of their communities. Cultural differences might affect how cities look at their data governance and data privacy and should be reflected in the local vision and implementation of smart city projects.
- When designing and implementing city initiatives that incorporate data, thinking ahead about the information that is most valuable to the challenge being addressed can be key for the evaluation, design, and further development of the initiative.

The City of Melbourne is the capital and most populated city of the Australian state of Victoria. It is a dynamic city that comprises 31 municipalities, each one with its unique characteristics and needs, ranging from densely populated urban centers to more residential areas. Melbourne has a population of over 5 million, representing 19% of the Australia population in 2020. In 2021, the city occupied the 20th position of the Smart City Ranking by the Eden Institute, the 27th in the Easy Park Group ranking (EasyPark, 2021; Eden Strategy Institute, 2018), and is among the ten most livable cities in the world according to the Global Livability Index (The Economist Intelligence Unit, 2021).

Until early 2020, Melbourne was the fastest growing city in Australia. However, Melbourne's economy was badly hit by the COVID-19 pandemic, leading to shutdowns, increased unemployment, and a population migration away from the city in search of better prospects and looking to avoid the risk of infection. The pandemic has not only impacted the economy, but it has also transformed the local landscape and highlighted social and environmental vulnerabilities. Before COVID-19, the biggest challenge in the city was to successfully manage its economic growth. Now, the attention has been diverted to stimulating and reactivating the city. Modelling undertaken by PwC Australia projects that the municipal economy would lose around 79,000 jobs and up to \$110 billion in output over the next five years.

The city has developed a comprehensive strategy for recovery with over \$50 million¹² investments made in rapid response initiatives since March 2020. While the city emerges from the effects of the pandemic, a number of key plans and strategies guide the city's response to the immediate challenges and establish goals to ensure long-term economic growth, social cohesion, and environmental resistance. The *Future Melbourne 2026* plan sets a series of key smart city goals including innovation, knowledge, and technological advancements. Taking a citizen-centered approach, it envisions the use of data and technology to make a better city. It sets long-term infrastructure planning goals that consider the integration of new and emerging urban system technologies to citizens lives. Opening government data is included as a pillar for transparency and for enabling co-creation processes of urban solutions. Not only that, but the plan specifies that the open data should be provided in formats that allow its innovative use. Melbourne is envisaged as an "online city" where a high percentage of people have access to the internet and to public Wi-fi networks. To ensure inclusion and minimize the digital divide, training, education and resources are destined to enable people to acquire digital skills and make use of new technologies (City of Melbourne, 2016).

Melbourne's Smart City goals are further cemented by additional strategic documents. The Council Plan 2021-2025 aligns its recovery vision with the Smart City goals and strives to make Melbourne "one of the most connected cities in the world", with thriving collaboration and an innovative ecosystem made up of start-ups, businesses and the education sector (City of Melbourne, 2021a). Additionally, an Economic Strategy was launched in 2021 as a roadmap for activating the hard-hit economy of the city. This city's recovery and long-term visions include making Melbourne a knowledge-enabled city where innovation serves as a source for creating high-value jobs. This innovation environment is to be supported by technologies and data, in collaboration with businesses, researchers, universities, and the community (City of Melbourne, 2021b).

Digitally connected city and data uses

There are a number of branches dedicated to data and smart city within the city of Melbourne. The Technology and Digital Innovation (TDI) branch supports the city in realizing the full value of its technology, developing and delivering innovative tools for internal and external use, and providing support to evidence-based decisions. The Smart City Incubator sits within the TDI branch. It defines and drives the adoption and use of new digital and data-based solutions. It also applies experimental innovative standards, fosters rapid innovation, and tests new ideas. More recently, a new City Data branch was created to focus on data competencies. With a team of about 35 people, this branch looks at reactivating the city and providing insights to decisions makers.

Melbourne has established an open data platform with almost 100 unique data sets that are available for all citizens¹³. This data includes, among other things, a 24-hours pedestrian counting system

¹² Australian dollars (AUD)

¹³ The open data platform of Melbourne can be accessed at <https://data.melbourne.vic.gov.au/>

collected by an automated network of sensors. This system shows pedestrian activity in the city's busiest locations and provides insights on how people use locations at different times of the day. The data is available in an online visualization tool and also as downloadable raw data¹⁴. This information has been used for many purposes, such as assessing optimal foot-traffic locations when leasing spaces. In addition, a number of mobile applications have been developed based of this data, including a hot-spot mapping and a safety app.

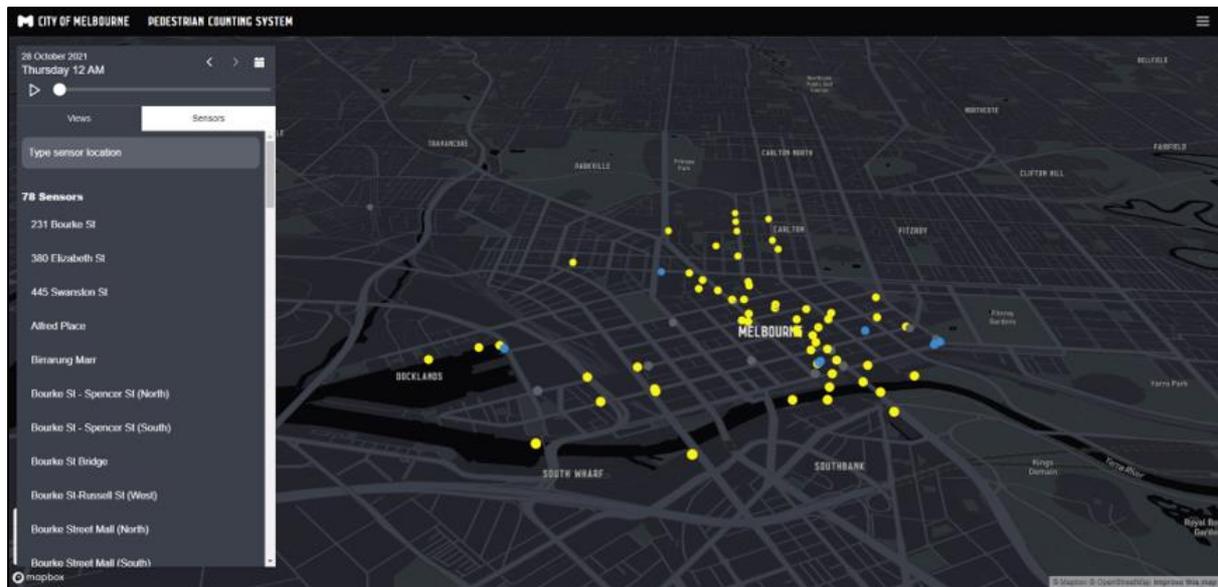


Image 3-The 24-hours pedestrian counting of Melbourne

On-Street parking data collected by 4300 in-ground sensors is also available in the city's Open Data Portal. Sensors collect vehicle movement in and out of individual parking spots and the data can be used to check on their availability, the amount of time allowed for parking in each spot, and whether or not it is restricted to disabled people. Similar to the information provided by pedestrian sensors, this data can also be used to create apps, products or services that further detail parking information, and ultimately make parking more efficient. The city has developed a parking map for citizens to access the information¹⁵.

In order to collaboratively explore the functions and impacts of new technologies on the city's residents and communities, testbeds involving a variety of challenges, pilots and trials have been implemented for emerging technologies, such as 5G and IoT. Challenges are launched by the city and innovative solutions that build on data and technology are called upon from start-ups, students, and community members. Collaborative data-based projects are established, and trials for specific technologies occur through industry collaboration. For example, data collected using sensors at a city square is being used to explore how to design and maintain city parks. The sensors include bin sensors, micro-climate sensors, and pedestrian sensors. Citizens can access real-time data and visualizations of the data

¹⁴ More information available at: <http://www.pedestrian.melbourne.vic.gov.au/>

¹⁵ More information available at <https://www.melbourne.vic.gov.au/about-council/governance-transparency/open-data/Pages/on-street-parking-data.aspx>

collected on an online dashboard¹⁶. Residents are also able to scan QR codes that explain each technology and its data collection approach and allow them to provide feedback.

Melbourne has also introduced smart, innovative solutions to manage waste and recycling, including solar smart bins that issue alerts once the bin is full. Recently, the city has conducted a trial using AI technology to gain a deeper understanding of waste disposal behavior. The aim is to allow the city to be more efficient on the issue of waste dumping and to keep streets and pedestrian areas clean. The trial used Nokia Scene Analytics, CCTV Cameras, a video Analytics platform, data visualization, Python dashboards and SMS notifications to monitor waste compactors. It employed AI-powered algorithms to filter and collate data from the cameras, while also combining other data sources like operational data on the compactor itself. This was done to produce real-time changes for the people who service the bins, support the identification of waste needs of different areas, and better understand waste disposal events. Following privacy considerations, the video stream collected by the CCTV cameras is processed by blurring faces and number plaques and converted into numerical information that appears in real-time dashboards. This video stream is sent to a secure server room in Sydney.

Data has already informed decision-making during the COVID-19 pandemic and provided important insights for policy and strategies for recovery. Using pedestrian sensors, data on foot traffic was used as a proxy to inform activity in the city. This data was also used as evidence of the low-levels of pedestrian activity, to leverage narratives calling for an increase in funding and grants for the recovery of local city businesses, ultimately leading to policy changes to support the local economy.

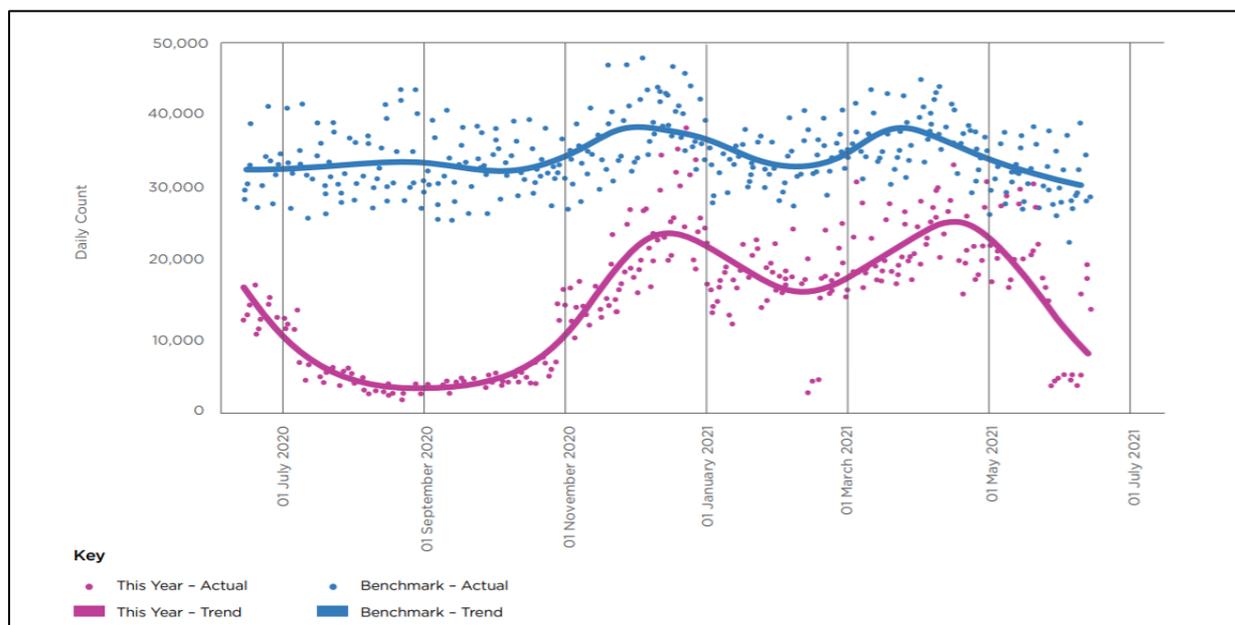


Image 4-Pedestrian Movements for Town Hall West- June 2020-June 2021 with data originated from the Melbourne Pedestrian Counting System

¹⁶ More information available at <https://melbournetestbed.opendatasoft.com/pages/argyle/>

Another way in which data is informing the city recovery is by guiding the planning and implementation of initiatives to reactivate the city's economy. Launched in mid-2020, Melbourne Money was a \$8.4 million joint initiative between the Victoria state government and the Melbourne city council. By giving citizens the option to claim a 20% rebate on their food and drinks purchases, the initiative aimed to bring people back into the city and provide support to the city's hospitality sector. Citizens were asked to fill in a survey at the moment of filing for their rebate. This survey collected information on demography, frequency of visits, and reasons for going out. The data team used this information to perform target analytics and to see movement patterns according to destination, places of origin, and the money spent. This information is providing important insights for targeting marketing approaches, and for the design and investment of the next phases of the initiative, which will now target specific times of the week.

Protecting individual privacy and data security

Protection of individual's privacy, data security and data integrity are part of the City of Melbourne's smart city vision. There is an array of legislation, standards and policies that ensure the data collection and sharing across government is done in a safe and a secure way. The Victorian Data Sharing Act of 2017 enables data to be shared across government agencies while providing safeguards, oversight and privacy rules. The Privacy and Data Protection Act of 2014 sets the policy for the management of personal information. Additional frameworks and standards for data sharing and use are set in the Victorian Protective Data Security Framework and Standards¹⁷.

The future Melbourne 2026 plan holds privacy of individuals and businesses highly, and stresses that management of data should always be done in a secure way that guarantees its use in the long-term benefit of the people. To ensure privacy, the city's operating model, project model and technological platforms are based on principles of "privacy by design" and "defense in depth". Privacy by design ensures that appropriate privacy protections are embedded into the overall design decisions. Defense in depth ensures a series of layered defensive mechanisms to protect data and information, including physical, technical, and human security. The testbeds are another way in which the city of Melbourne is designing new governance models and establishing protocols for its data management, privacy, sharing, and security. This can be seen in the case of video analytics being used to monitor waste bins in the city. After the footage is collected and before it is sent to be processed, an algorithm deletes all recognizable traits and ensures that only the data of the bins is transferred to the cloud. Another approach is the one used by the pedestrian sensors: by registering only group movements, the data collected cannot be used to track a specific individual.

To underpin this careful approach to data privacy, Melbourne has rooted the oversight of compliance with the data regulation in a new organizational element: The Information Governance Management

¹⁷ The landscape of legislation, standards and policies for data security, privacy, and integrity can be seen here <https://www.vic.gov.au/navigating-legislation-sharing-safely>

Forum. This organization is tasked with monitoring compliance and making decisions on collecting, sharing, and using data. The Forum has members of the city's legal, data and privacy teams that meet periodically and, among other functions, serves to verify that appropriate privacy impact assessments are done before introducing new technological interventions. In addition, it checks on implications of software that interact with citizens and oversees data that is being collected across governmental institutions.

Facial recognition is only used in the city for public safety purposes. For all other cases, the city has actively decided against implementing and using facial recognition technology to uphold privacy and protection of personal data. There is currently a CCTV network in the city that collects data and images that can be requested by the police to serve public safety purposes. Nevertheless, a systematic security divide between the police infrastructure and that of the City of Melbourne was established to enhance trust between the city and the community. Additionally, the city actively asked citizens if they felt comfortable with the introduction of these cameras and the decision was approved with the citizens' consent. Still, policy and processes have been written to ensure that CCTV footage is only used in cases of citizen attacks and not for identifying and finding minor offenders.

Montreal Smart City: more human than digital

Keywords: •open data •innovation •capacity building

Lessons learned:

- A culture of data sharing, along with supported experimentation on specific urban challenges can build the foundations of a an open and interconnected data ecosystem.
- An urban innovation lab can leverage data as an input to address community needs by bringing together urban stakeholders and working through methods of collective intelligence, design and experimentation.
- Researchers, businesses, citizens and cities need to work together in order to have a strong innovation ecosystem and develop more uses of data for urban development.

With a population of 1.7 million inhabitants, Montreal is the largest city in the province of Quebec, Canada. Having built its smart city foundations in recent years, the city is now considered one of the smartest, most innovative cities in the world, even occupying high positions in different rankings for smart cities in 2020 and 2021 (EasyPark, 2021). More recently, the city won Infrastructure Canada's Smart Cities Challenge, a pan-Canadian competition open to all municipalities¹⁸. Montreal has established processes for public consultation, in which citizens are given the opportunity to provide input for city strategies at the ideation phase. The city also makes use of its digital platforms to interact with citizens for specific projects in many areas, such as urban planning. An instance of this can be seen in the recent participatory budgeting for ecological transition initiatives, where more than 600 ideas were received, and 7 winning projects were chosen¹⁹.

Urban development in the city has taken a human scale, where working at the neighbourhood level for the creation of accessible, livable, and inclusive spaces is key. Throughout its transformation process, Montreal has developed a culture of openness and transparency and set strategies orientated towards a number of defined goals, namely:

- providing services adapted to citizen's needs
- amplifying democracy and participation
- ensuring responsible use of data and transparency
- establishing evidence-based decision-making processes
- increasing innovation capacity
- aligning the city actions with the ecological transition

¹⁸ More information at <https://www.infrastructure.gc.ca/cities-villes/index-eng.html>

¹⁹ The winning projects at <https://www.realisonsmtl.ca/budgetparticipatifmtl>

At the same time, the city has implemented initiatives to provide citizens with tools for accessing city services, data, and ensuring fundamental rights, like privacy. This has been done through projects such as the implementation of a large scale free public Wi-Fi network, the signing of the Cities Coalition for Digital Rights declaration, the creation of a Montréal's Digital Data Charter, the adoption of an open data policy and the implementation of an open data portal.

Montreal is a city made up of boroughs that vary in their history, population, territory and infrastructure. Similar to other urban centres, the city faces a wide range of challenges like the aging of city infrastructure and traffic congestion. The current climate crisis has also exacerbated the area's vulnerability in an environment characterized by challenging weather conditions. Furthermore, the city is dealing with the consequences of the unprecedented crisis brought by the COVID-19 pandemic.

To guide the municipal administration towards boosting the economic, social, and ecological resilience of the city, the Montreal 2030 plan provides a framework for guiding the city's recovery in the COVID-19 aftermath, whilst further improving the quality of life of residents and increasing the quality of the city services (City of Montreal, 2020). The creation of Montreal 2030 began before the outbreak of the pandemic, with a public consultation process that engaged with over 12,500 people. In this process, a series of challenges including climate change, inclusion, and diversity were pointed out as key issues for the city. As the pandemic unfolded, these became even more pressing and have been put at the heart of the plan. Building on a vision where technology and digital services are developed around human experiences, Montreal 2030 calls for the adoption of emerging technologies and the development of data-based tools, with an emphasis on open data, to shape a greener, fairer, and more inclusive city.

Montreal's data governance framework

To strengthen the position of Montreal as an innovative center and to serve the vision described in Montreal 2030, a new digital strategy called Montréal Numérique was launched in 2021. The strategy puts people at its center by setting the approach for using data and technologies for the common good and digital commons. This is envisioned by the creation and support of common projects, co-created with citizens and organizations that make data and technology available (City of Montreal, 2021). Digitalization and data are means of improving service-provision, organizational performance, and the experiences of city employees and citizens. Data is seen as a lever for economic development and social inclusion, and an asset for improving decision making processes. The latter is key, as better decision making and the creation of an evidence-based environment can translate into quality public policies, which in turn can increase confidence between citizens and government. The strategy supports the framing and governing of data with responsible management that minimizes the potentially harmful impacts to individuals and society, such as data breaches, imbalances in the concentration of power, surveillance risks.

Under Montréal Numérique, digitalization and use of data are also aligned with the long-term ecological transition of the city, and its goal of reducing greenhouse gas emissions. The digital and ecological transitions are seen as two converging pillars, where data and digitalization fuel potential solutions for reducing the ecological footprint of the city. This is particularly true for emissions reductions in traffic by improving availability of alternative mobility solutions – but also for the increase of energy efficiency in buildings. To this end, the principle of digital ecological responsibility has been established, and tools have been established for assessing the ecological risks arising from digital interventions. Montreal has adopted a climate test to ensure that decisions concerning all actions and operations in the city, including data-based initiatives, serve the ultimate purpose of achieving municipal carbon neutrality by 2040. Furthermore, the digital strategy emphasizes opportunities to support shared mobility solutions, the circular economy and the mutualization of resources.

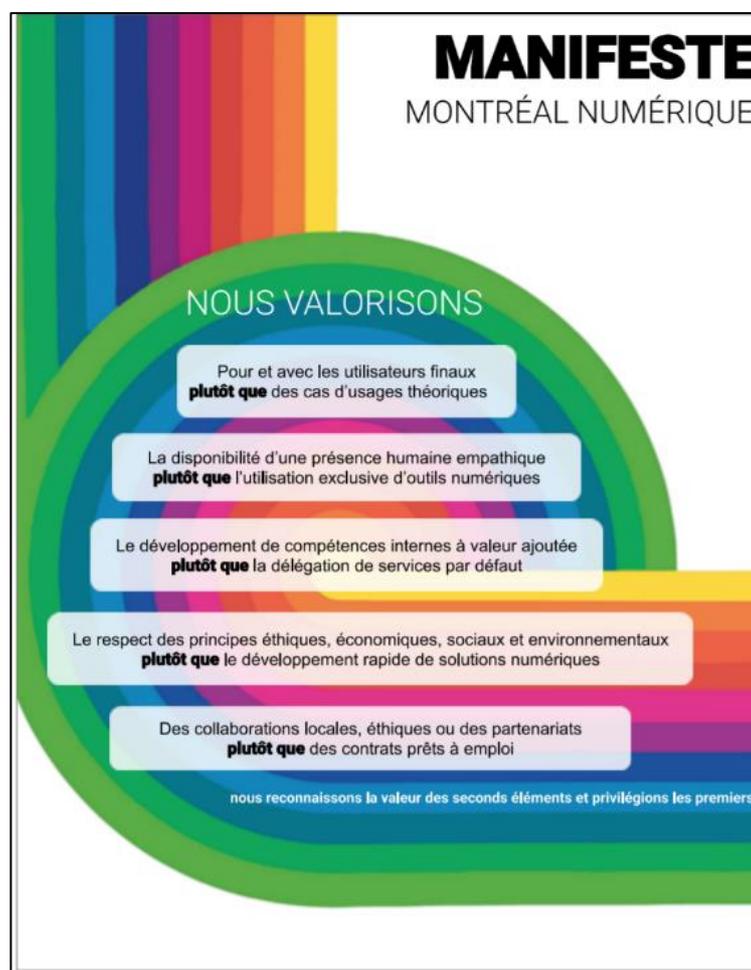


Image 5- The Montréal Numérique Manifeste

Capitalizing on data for aiding decision making, operational efficiency, and ultimately, urban development goals, calls for a robust data management and governance framework. Montreal was one of the first cities in Canada to adopt an Open Data policy in 2015. This initiative has catalysed other programs and strategies that today shape the data policy landscape of Montreal, and set the criteria for the management, collection, and use of data by the city's departments and boroughs. These include

the Digital Data Charter, the GBA+ approach, the City of Montreal's signature to the Montreal Declaration for Responsible AI, and open-source policy. Furthermore, the city is part of the Coalition of Cities for Digital Rights that sets principles and values for protecting human rights on the internet at local and global scales.

The Montréal Digital Data Charter lays out the core principles of the city's data governance framework. It is the result of a collaboration and consultation process between the Montreal Urban Innovation Lab, the Information Technology Department, numerous collaborators from various city departments, partners from the digital and academic worlds, and civil society. The Montreal Digital Charter sets the ethical principles that guide the way in which data is collected, managed, and governed not only by the city but also by the different actors in its territory. The Charter is governed by 13 principles that are expressed in the form of three commitments, namely: 1. To guarantee human rights in the digital age. 2. To ensure the primacy of the general interest and the common good. 3. To build a brighter future through data (City of Montreal, 2020).

As part of its commitment to protecting individuals in digital spaces, the Digital Data Charter establishes the principle of preserving privacy and preventing individual and collective surveillance. For the latter, the city safeguards against general and individual surveillance, and gives citizens the ability to control the personal data the city collects in the course of delivering public services. The charter supervises technologies (like sensors) that might allow the personal identification, and bans the collection of biometric data, including facial recognition data without consent, by entities under the responsibility of the city council. In this manner, it determines that sensor data should be used to strengthen democracy rather than to further commercial interest or strictly public safety purposes. The city also applies principles of inclusive public participation in analyses and use of these technologies. To ensure its digital sobriety, the city has established a rule that states that all collection of personal information is limited to what is strictly necessary to provide a service and fulfil the city's public service mission. This principle also includes the consideration of the end of the data's lifecycle and limiting the data's storage time. In turn, data security and protection of personal confidential information is ensured by the adherence to high system standards. In this matter, Montreal favours the hosting of data within the Canadian national territory.

The Charter establishes mechanisms to assess risks and opportunities of new technologies, including their environmental impact, along with approaches for ensuring the control of digital assets, like infrastructure, software, hardware and data. These approaches include the encouragement of adopting environmentally-friendly solutions and ensuring that the city controls the data that relates to its territorial jurisdiction. These approaches are based on responsible procurement processes and clear frameworks for dialogue and application with stakeholders. Furthermore, as the possibilities for data sharing and use rely on the requirements of interoperability (through adherence to recognized standards), the city of Montreal is committed to promoting procurement for systems that allow data

portability and transfer. This is further advanced by the systematic consideration of Open-Source solutions and adequate procurement frameworks to ensure the city owns and controls the data²⁰ .

Avoiding vendor lock-in particularly in the light of dominant players, is also set as a key consideration for promoting interoperability and potential dependencies. The Digital Data Charter places digital sovereignty as a core principle and establishes that the city can declare data from certain actors, public or private to be of “territorial interest” and thus, have access to it. The application of this principle must not interfere with fundamental rights of privacy, confidentiality, intellectual property and the protection of industrial secrets.

“Open by default” data policy and Open Data team

The data strategy of Montreal is built around democratic principles that translate into promoting the use and value of data through transparent and accessible data sharing, accompanied by measures to protect privacy and public security. To do this, the data approach follows principles of universality of access, interoperability, and portability, and is anchored in the creation of collaborative spaces that seek to engage with individuals and stakeholders in the use of data.

The city of Montreal follows an “open by default” data policy. The ultimate goal is to share data so that it can serve the community and contribute to the development of the metropolis. In this sense, the data opened by the city can allow companies to develop services and products, serve the business ecosystem and economic development of the city and region, and provide evidence on which development measures can be planned. An open data team was established in 2015 when the city adopted its open data policy. The team manages an inventory of all the data produced by or held by the boroughs and municipal services, in addition to coordinating the publishing of that data on the open data portal. Some private actors have also agreed to share their data. This is the case with Bixi, which shares its bike sharing data.

The open data team performs tasks that include maintaining the data inventory, coordinating technical tasks to extract data from databases and systems, working on city-wide data governance and strategy, and applying the principles of the Digital Data Charter. These include principles that translate into mechanisms addressing confidentiality, public security and intellectual property, among others. Data sets that cannot be published are also documented, along with the grounds for their non-disclosure²¹ . Through the Data Governance Directive, this team also assigns and enforces responsibilities and roles related to data, such as who is responsible for maintaining, updating, and ensuring quality of databases. Furthermore, the open data team works with and supports the Data Governance Committee, a group

²⁰ The policy on open source solutions and procurement of Montreal can be found at https://portail-m4s.s3.montreal.ca/pdf/politique_sur_lutilisation_et_le_developpement_des_logiciels_et_du_materiel_libres.pdf

²¹ The list of available datasets and the different levels of openness can be found at <https://donnees.montreal.ca/ville-de-montreal/inventaire-donnees-ouvertes>

that tackles issues surrounding data governance when needed. This Committee includes representatives from IT services, business intelligence units, the access to information bureau, and the geomatics unit .

The Montreal Urban Innovation Lab, which houses the open data team, constitutes the collaborative space in which the municipal staff, citizens, businesses, and researchers are invited to innovate through experimentation. In this setting, data sharing and the use of data will be promoted, enabling the emergence of new services and projects which advance the city’s vision in service of the population. Here, the use and development of disruptive technologies is embedded in an experimentation framework anchored in responsible principles for data use and technology deployment.

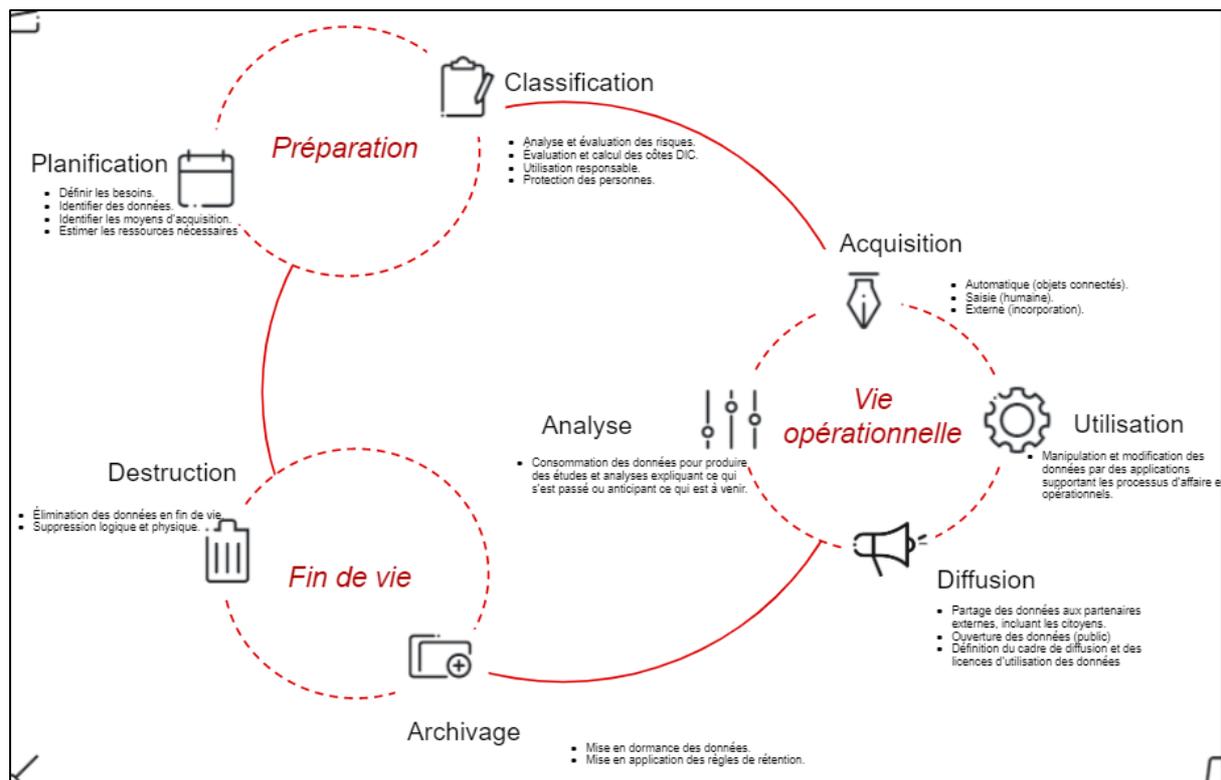


Image 6- The data approach of Montreal

To translate data into concrete opportunities, the Lab designs ideation activities and facilitates workshops. This is done through Montréal en Commun (City of Montreal, 2021), a program funded through the national Smart City Challenge (a competition in which Montreal won the grand prize), as well as other activities such as hackathons. Montréal en Commun is a community of 13 different innovation projects where community partners are at the center of the process. The program supports partners as they conceive and implement the projects, while the city acts as a facilitator. Montréal en Commun projects include a mobility hub, a social data hub, and an indigenous data hub, where data and technology can be tested with the ultimate goal of improving the lives of citizens. This is just one example in which the Lab acts as a facilitator, bringing knowledge on the city’s data, existing services, and current needs, while also providing the criteria that is used to direct the innovation efforts and the

technological components of each initiative. The Lab supports a number of projects focusing on digital commons, which enable collaboration between academia, civil society, and businesses around specific urban challenges. Data is used as an input in activities such as hackathons, co-creation activities, and urban pilot projects. Currently, the main data-based solutions which use advance analytics include intelligent traffic light systems, data-based optimization of snow removal operations, and the optimization of firefighter responses.

Addressing the digital divide and developing digital skills

Inclusion is a fundamental value in the city of Montreal that also applies to the digital domain. In order to guarantee inclusion of all citizens in its digital approach, the data strategy recognizes the need to address the digital divide. This is not only understood as access to technology and an internet connection, but also the competencies required to use digital tools. In order to achieve a true digital transformation, developing data literacy will be an important area of intervention for both the general public and city staff. The deployment of public wi-fi networks in areas with low rates of access to internet, the creation of affordable alternatives for accessing digital services and the replacement of obsolete equipment, are some of the city interventions to address the digital divide. Education and capacity development programs play a key role in the digital capacities in the city. In these efforts, businesses, non-profit organizations, universities, and other public and private organizations make ongoing contributions to strengthening data literacy in the population. For the city staff, an online training portal has been created where aspects of data privacy and data security are included as part of the onboarding process of new city personnel. A network of open data leaders also promote knowledge sharing among staff, which serves to build the data culture across all boroughs and services.

Finally, gender-based analysis which embodies an intersectional perspective is also an integral component of the Data Charter that reduces biases and the exclusion of vulnerable groups. In this sense, the city looks to apply GBA+ principles in the collection, processing, analysis, and dissemination of data. These principles apply not only to data, but also to algorithms, to ensure that ostensibly neutral software does not lead to the exclusion or stigmatization of a part of the population.

Seoul: a mix of tradition and modernity

Keywords: •smart infrastructure •big data •smart investment

Lessons learned:

- Smart city agendas and priorities evolve with the different stages of digitalization. However, it is important to incorporate long-term planning at all stages.
- Smart infrastructure is not only vital for advancing the data strategies of cities, but also for bridging the digital divide and ensuring access to data to all citizens.
- Multistakeholder Committees and Advisory Boards can be set in order to provide advice on smart city topics and data strategies.
- The essence of a smart city is the linking and combination of resources across the many domains of urban life. Incorporating big data and data from the private sector can enable a wide variety of city services.
- Institutional arrangements that support investment in smart city projects need to be established.

Seoul, a global mega city, is the capital of the Republic of Korea and an important center for the administration, economy and culture of the country. A flourishing economic center, Seoul accounts for 23% of Korea's GDP. The city has a size of 605 square kilometers and a population of about 10 million people, with more than 12 million people being active in the city every day for business and tourism. This accounts for a population density twice as much as that of New York City. With the city's population having more than doubled over the past 50 years, Seoul faces a number of challenges: housing shortages, traffic congestion, environmental pollution, an elderly population living alone more frequently, and increasing rates of violent crimes. Furthermore, the outbreak of COVID-19 has placed additional pressures on the city's infrastructure and services. In this context, the South Korean government unveiled the Korean New Deal in 2020, a 76-trillion won (\$62 billion U.S. dollars) spending plan that focuses on expanding the country's digital infrastructure and services, in areas such as data management, AI, and cybersecurity, in addition to promoting the green economy.

In recent years, Seoul has received international attention as a notable smart city, particularly for its e-government and citizen-centered smart city governance. In 2021, Seoul ranked second (after Singapore) in the Smart City Ranking by Eden Strategy Institute (Eden Strategy Institute, 2021), and 8th in the Easy Park Smart City Index (EasyPark, 2021) . Seoul has an extensively connected urban landscape, and an impressive technological infrastructure. Today, more than 93% of its citizens have a smartphone, and the city has installed sensors to collect data on a total of 17 urban phenomenon (such as fine dust, temperature, noise). There are about 2,883km of high-speed communication connections, vast public Wi-Fi coverage, and about 80,503 intelligent CCTV cameras deployed all over the city.

Seoul has a long-standing smart city tradition that dates back to the first computerization of public administrative data in 1990. Since then, the city has undergone different stages in its digitalization and smart city agenda, namely: digitalization (1990), Intelligent City Seoul (2003), U-Seoul (2006), Smart Seoul (2011), and more recently, Global Digital Seoul 2020 (2016) (Joo, 2019). Since the mid-2000s, the city has experienced a smart-city paradigm change, from a top-down supply-based approach focused on the integration of IT solutions into urban infrastructure, to a new concept where citizen's needs, and ecological considerations are the main drivers for ICT integration. This shift can be seen in its latest plan - Global Digital Seoul 2020 - which highlights social values, as well as environmental and development goals. The Seoul of today is a mixture of tradition and modernity, where ICT is integrated into virtually all aspects of public services and data is actively used to improve citizen's experience and life quality.

A global citizen-centered digital capital

Having pushed different stages of digitalization over the years, Seoul's latest plan is the Global Digital Seoul 2020 which was announced in 2016. The plan has the goal of positioning Seoul as a front-runner in digitalization. Co-creation of data-based solutions together with citizens and the private sector lay at the core of this strategy. It also places great importance on the promotion of small and medium local enterprises for the innovation ecosystem of the city and stresses the role of Seoul in the global context, as an international reference for digitalization.

There are four pillars in the digital transformation of the city:

- "Social city" refers to enhancing digital governance, with citizens leading the process, in a process that further strengthens communication channels with citizens and cooperation with the private sector for data-based social innovation.
- "Diginomics" aims at developing a digital economy platform, further expanding the city's economy into digital technologies and data ecosystems, and infusing the existing industry with digital technologies.
- "Digital Social Innovation" centers on using technology and data to find solutions to urban problems and ultimately improving life quality.
- "Global Digital Leader" aims at developing Seoul as a global leader in digitalization and sharing its experiences internationally, showcasing its innovative technology, cutting-edge digital infrastructure, and robust data ecosystem. Within this pillar, lies the ambitious goal of establishing Seoul as the city with the world's best IT infrastructure.

Smart infrastructure is a central element of the city's strategy. Seoul has implemented a vast high-speed communication network. The latest is considered to be of key importance in bridging the digital divide and ensuring access to internet to all citizens. Free Wi-Fi is provided in public places with high accessibility, and the ultimate goal is to have public Wi-Fi implemented in all public spaces of the city. A vast IoT data collection network collects real-time data, including sensors, CCTV cameras, and smart poles.



Image 7 7-The Vision of Global Digital Seoul 2020

The notion of smart citizens, a vision in which citizens proactively participate in solving urban problems, is also a central feature Seoul's strategy. There is a wide portfolio of initiatives and interventions that have been implemented with this purpose and that actively build on data and digitalization. These include, among others:

- An online policy suggestion platform called Democracy Seoul that citizens can use to discuss and provide suggestions to decision makers.
- The Smart Complaint Reporting System for on-site reporting of inconveniences by residents receives about 1,627 petitions each day.
- The Open Data Plaza²² facilitates the development of services using public data, had more than 5,400 opened data sets as of 2019.
- The M-Voting Initiative, through which citizens can post and vote on policy agendas on urban life issues had more than 6,159 voting agendas that had been generated as of 2019. (Joo, 2019).

Ensuring data privacy and transparency

The data strategy of Seoul is built upon the principles of privacy, transparency, openness, and sharing. Privacy considerations are fundamental to the city and the country, and there is a robust legal framework related to data protection. An important regulation in this matter is the Personal Information Protection Act of 2011 (amended in 2020) and its implementation regulations, which control the collection, usage, disclosure, and other processing of personal information. In Korea, the data protection laws provide prescriptive requirements that cover the entire lifecycle of personal data.

²² The Open Data Plaza can be accessed at <http://data.seoul.go.kr>

Consent from the data subject is almost always required under the law in order to process personal data. The requirement of prior notification and opt-in consent and the relatively strong sanctions to offenders, have led the data protection laws in South Korea to be considered among the strictest in the world. Other important regulations include the Act on Promotion of the Provision and Use of Public Data and the Act on Disclosure of the Public Data that lay the policy foundations upon which the data ecosystem of the city is built. Transparency, sharing, and data openness are advanced through a number of initiatives. Several portals have been launched including the Seoul Information Communication Plaza, which shared about 17 million policy and administrative documents between 2013 and 2020, and the Seoul Open Plaza. This openness is particularly relevant for the “people-centered” city that the Global Digital Plan aims to build, and for enabling citizen-led governance.

A Smart City Committee has been created in Seoul, consisting mainly of external experts. The Committee introduces new agendas and develops policies for data and ICT utilization. A Smart City Policy Bureau sets the direction of Smart City Seoul and establishes action plans. Lastly, the Seoul Digital Foundation, the Seoul Institute, and the Technology Institute contribute through research on smart city topics.

Big data-based smart services

Seoul utilizes data for improving decision making processes and developing innovative solutions for the city. The development of solutions is based on citizen-centered demand and on a technologically advanced data ecosystem. Public services incorporating big data and data from the private sector are implemented across nearly all city domains (including traffic, safety, environment, welfare, economic management, and administrative services). Although there are many data-based public services in Seoul, several stand out. One of them is the Seoul’s Transport Operation and Information Service (TOPIS). It is an integrated data hub that serves as a control tower to monitor , collect and analyze overall traffic data, share information, and manage responses to ensure the city’s transportation runs smoothly. For this, TOPIS builds on real-time data collected via surveillance cameras, card transactions records and usage patterns, GPS systems, radio frequencies, sensors, and over 10 years of accumulated historical data.

TOPIS represents a city-wide platform that centralizes an enormous array of data and information from multiple departments within the Seoul Metropolitan Government and external institutions and provides a standardized, robust data management framework. There are several practical examples of big data analytics in action to plan and coordinate public transportation. For example, the city used anonymous mobile communication data provided by a private telecommunication company in the routing of city night buses. Mobile call logs and data on the journeys of taxis, collected through the T-Money card system, were used for the planning of the most efficient night bus routes. The night bus service has reduced the use of passengers cars by more than 2 million trips per year (Development Asia, 2019). Analyzing movement patterns has also been used, for example, to attend to the needs of the elderly population, and for planning the installation of escalators and elevators in the stations most heavily used by vulnerable groups.

Another prominent instance of the use of data is improving public safety, with the safety of women as a particular focus. The Ansimi service enables the use of mobile phones to automatically send location information to the user's family and the control centers of the city, when triggered in a case of emergency. Once the alert reaches the control center, around 40,000 CCTV cameras can be used to monitor the location and coordinate the appropriate responses. Other examples for urban safety include children's safety tracking, the city's intelligent fire prevention system, and the elderly home care service.

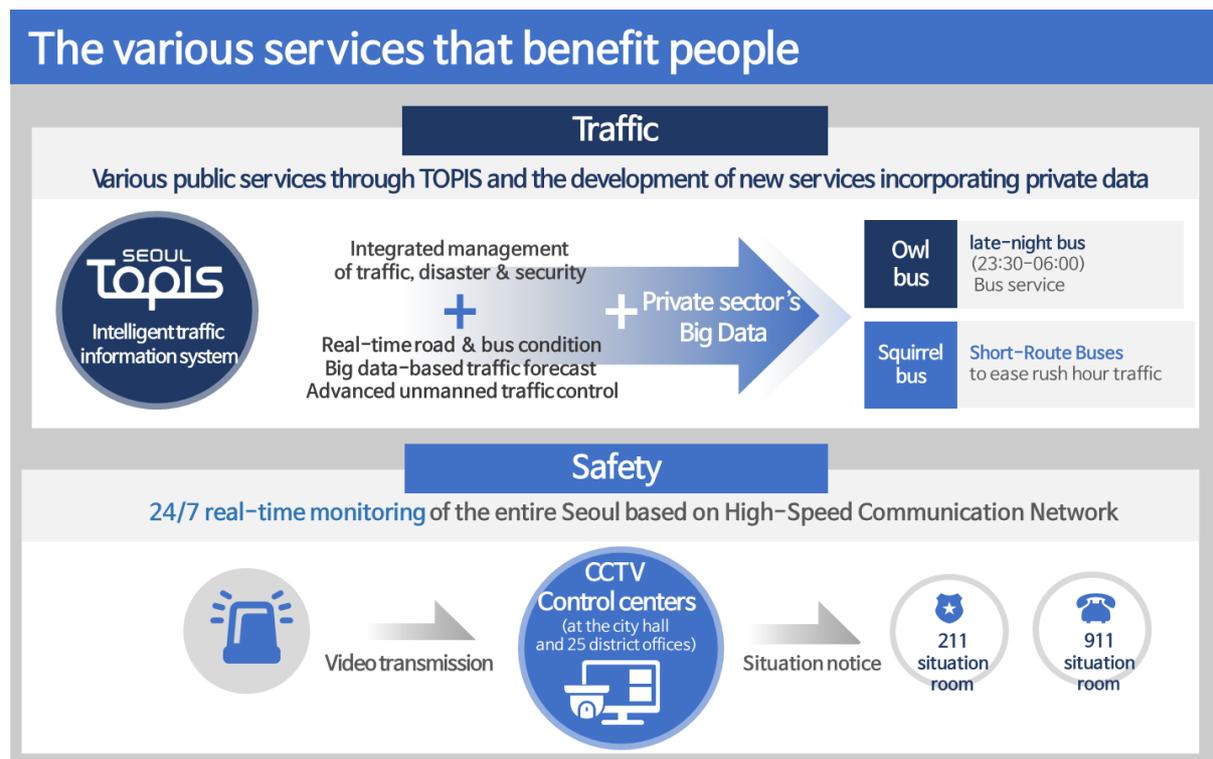


Image 8 8-Data-based services provided by the Seoul Metropolitan Government

Big data is also used for supporting small and medium size businesses in Seoul. A Big Data Business Environment Analysis Services makes use of big data collected by different departments and public agencies, as well as the private sector including telecommunication providers and credit card companies. The data gathered includes, for instance, credit card transactions, rent prices, transportation cards, traffic data, business statistics, income, building information, bus stops and subway stations, population, etc. With 210 billion data points, the system provides market insights into local business and policy making by providing data on consumption patterns, floating population, social media trends, purchasing power, commercial establishment etc. It also maps a range of market index figures, that are used for small business statistics, including risk, business activity, growth potential, stability, among others. To enhance the information provided, the Seoul Metropolitan Government offers additional support in the form of business consulting and supporting packages.

Smart Seoul policy investments

As big data-based solutions are implemented across the different city domains (traffic management, public safety, environmental protection, welfare services, and administration, among others), a budget of \$242 million U.S. dollars has been assigned for smart traffic technologies for the period of 2018-2022. Seoul aims to advance transportation innovation based on autonomous driving, smart parking management, and smart public transportation with a series of projects and test-beds, leveraged with big data platforms. Public safety policy is also being further developed on the basis of data and digitalization. CCTV systems are being expanded, smart crosswalks implemented and smart security lamps installed. Fire prevention and smart infrastructure management are also included under the safety strategy. \$155 million U.S. dollars have been destined to finance smart safety in the period of 2018-2022.

Under the umbrella of smart environment initiatives, a smart-city monitoring system has been established, including a 3D virtual model of Seoul to be used for planning urban spaces and IoT monitoring of air, fine dust and water quality. There is a city budget of \$621 million U.S. dollars dedicated to smart environment projects to be used between 2018 and 2022. For the same period, a budget of \$30 million U.S. dollars has been assigned to smart welfare interventions, with particular focus on the socially marginalized, including an IoT-based management and care system for the elderly and digital health care systems. To support economic development, smart city enterprises, and a smart city business ecosystem, initiatives like public testbeds and innovation challenges have been put in place. Furthermore, the city offers special support to big-data-based start-ups. There are \$344 million U.S. dollars earmarked for smart economy interventions in 2018-2022. Finally, a city data management system based on IoT networks (with about 50,000 sensors across the city), an integrated public big data storage, and a joint public-private big data platform are pillars of the smart administration of the city. The public-private big data platform aims to combine available public big data with private data, particularly telecommunication and financial data, to find synergies and create new data value. In addition, Intelligent e-government innovation platforms and systems are also in place. For its smart administration policy, Seoul assigned \$78 million U.S. dollars for the period of 2018 to 2022.

India: DataSmart Cities Strategy

Keywords: • data governance • stakeholder participation • data culture • data policy

Lessons learned:

- Cities that are open about how they function are constantly trying to build trust with their citizens and engender a collective conscience amongst their communities around important issues facing their present and future.
- Bringing data into the conversation ensures a development towards result-oriented planning guided by data-informed decisions for sustainable urban development. This will lead to greater efficiency in service delivery and resource allocation.
- To unleash the power of urban data for transformation it is crucial to make it available and use it as a common language for collaboration in the urban ecosystem.
- To create, nurture and further the spirit of data-driven empowerment, collaboration and governance in cities “DataSmart Cities Strategy” needs to be an evolving policy framework on data. This can catalyze the adoption of data-centric governance and foster a data culture in the urban ecosystem.

India is urbanizing faster than ever before. By 2030 the urban Indian population is expected to grow to 600 million people contributing to upwards of 70% of the country’s GDP. These challenges come along with resource constraints regarding capacity development and skill sets as well as financial and technological resources. This results in the need to have an innovative approach regarding common public goods and data strategies so that citizens can leverage these common public goods. Urban India needs transformation at scale and speed and to achieve that it is important to foster innovation and data-driven governance.

The “DataSmart Cities Strategy”, launched in 2019, aims to institutionalize a culture of data across the 100 cities of India’s “Smart City Mission” (Ministry of Housing and Urban Affairs, 2019). These 100 smart cities will serve as examples and create a scalability-effect that will spread to the more than 4,700 Indian local bodies. It is essential to build an enabling ecosystem supported by a robust system of data acting as a backbone. Therefore, making cities “DataSmart” is key in realizing the full potential of technological interventions and innovation ecosystems in cities. This strategy document aims to lay down the basic premise, foundational pillars and a suggested roadmap for cities to improve their readiness for intelligent use of data in addressing complex urban challenges.

The strategy focuses on three key pillars which are required to institutionalize a culture of data:

- **People:** How to get the right people? A couple meaningful steps are appointing a City Data Officer to create Data Champions in different departments and Data Coordinators. Both of these positions will help data flows avoid silos and create value, alliances, and partnerships.

- Processes: How does data flow? How do we make sense of this data? How do we ensure that this data is secure and addresses issues of privacy? It is necessary to build processes around data in order to use this valuable asset best.
- Platforms: Having common enabling platforms is a good way to address the challenges and to do more with less, so that these platforms can be used by the different stakeholders from the Government, citizens, academia, and industry. It is necessary to create common public goods as basic digital infrastructure to be used by all.

This warrants a focused effort on institutionalizing data-driven governance..

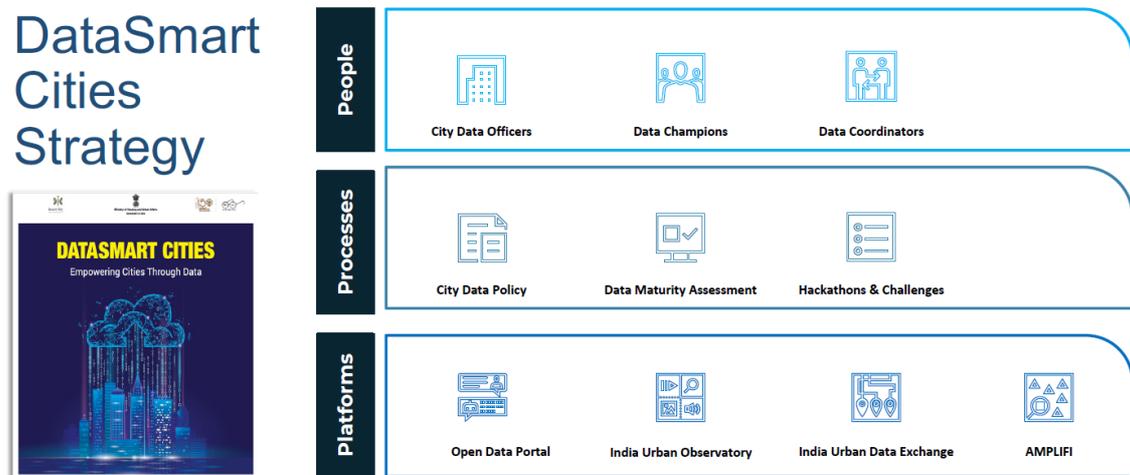


Image 9-The three foundational pillars of India's DataSmart Cities Strategy

The objectives of the DataSmart Cities are to:

- Institutionalize a “Culture of data”: The trend to draw insights and create actionable intelligence for city governance is already on the rise. However, formal mechanisms for data collection, management and use needs to be put in place. Also, there is a need to create awareness, dialogue and collaboration among different stakeholders to harness the power of data as a potential economic resource.
- Drive Data Governance: To propose a data governance framework that facilitates the implementation of key processes within the data life cycle and builds capacity in all stakeholders on data-informed decision-making. The data strategy should foster public accountability and transparency.
- Enable the framing of a City Data Policy: To unlock the power of data in the context of privacy, security and ownership in the context of the city, it is critical that cities create data policies that balance considerations for privacy, legality and public benefit. At the same time it must define the contours of collaboration between various Governmental/non-Governmental entities on data sharing and access.

- Facilitate City Data Alliance: It is important to assess the data available in all Government and non-Government entities that generate and store data crucial to better planning and functioning of the city and to engage with them on the understanding, creation and promotion of data-driven solutions for the city. The 'quadruple helix', comprised of communities, industry, academia and the Government, will be a constituent of the City Data Alliance.
- Adopt appropriate data platforms: With a clear strategy, cities can adopt and deploy robust, secure and intuitive data exchange platforms, which will lead to the effective sharing and management of city data. Such platforms allow common programming interfaces, data representation formats and data models that are interoperable.

The perceivable benefits of the "DataSmart Cities Strategy" are:

- Empowerment of citizens: When cities are open about how they function, connect with their communities through various platforms during the development lifecycle of projects, put out information about their tax collections, their financial and environmental health and are open to informed debates, they become true proponents of 'Open Government'. Such cities constantly try to build trust with their citizens and engender a collective conscience amongst their communities around important issues facing their present and future. Citizens can collaborate with government easily and with increased frequency; both within their community and beyond, forming stronger groups and exchanging ideas and building new collaborations.
- Data-driven governance and policy formulation: Data will help administrators in making better policies and decisions for the city. Data empowers city officials, citizens, and communities and helps promote evidence-based decision making. This will lead to greater efficiency in service delivery and resource allocation.
- Promotion of data sharing and exchange: Efficient governance requires relevant, readily availability data. Unfortunately, data is locked up in various systems with different data owners. Open Data initiatives, data sharing, and data exchange platforms will assist in facilitating G2G, G2C and G2B data sharing and exchange of data for effective decision making in real time.
- Promotion of multidisciplinary research on civic issues: Local data could unlock research on civic issues like transportation, traffic and solid waste. Multidisciplinary researchers may provide different perspectives on or solutions for civic issues.
- Co-creation , open innovation and civic engagement: City Governments will be able to work with entrepreneurs, industry, and academia to promote participation in governance, co-creation and open innovation. This will enable greater civic engagement through directed partnerships and collaborations with external and parastatal government agencies, communities, academic institutions and policy and civil society organizations.
- The emergence of innovative technologies: Data is fuel for the development of solutions based on emerging technologies like IoT, AI, Machine Learning, Blockchain, etc. Data platforms will help cities become ready to kick-start innovation in emerging technologies.
- Enhancement of transparency and accountability: Smart cities intend to deliver reliable services to their citizens through various smart solutions. Implementation of the "DataSmart Cities

Strategy” will lead to enhanced transparency and accountability among its citizens and communities by making reliable data available through data platforms. It will help build trust between the city Government and citizens.

In order to create the right kind of incentives for cities to adopt DataSmart Strategies, the Ministry of Housing and Urban Affairs (MoHUA) institutionalized a “Data Maturity Assessment Framework” (DMAF) as annual effort to measure data maturity in cities and boost competition among cities. The intent of the DMAF is to provide a comprehensive yet pragmatic set of indicators to help cities assess their preparedness in both these aspects. The DMAF based assessments focus on a “people, process and platform approach” in all Smart Cities as outlined in the “DataSmart Cities Strategy”²³.

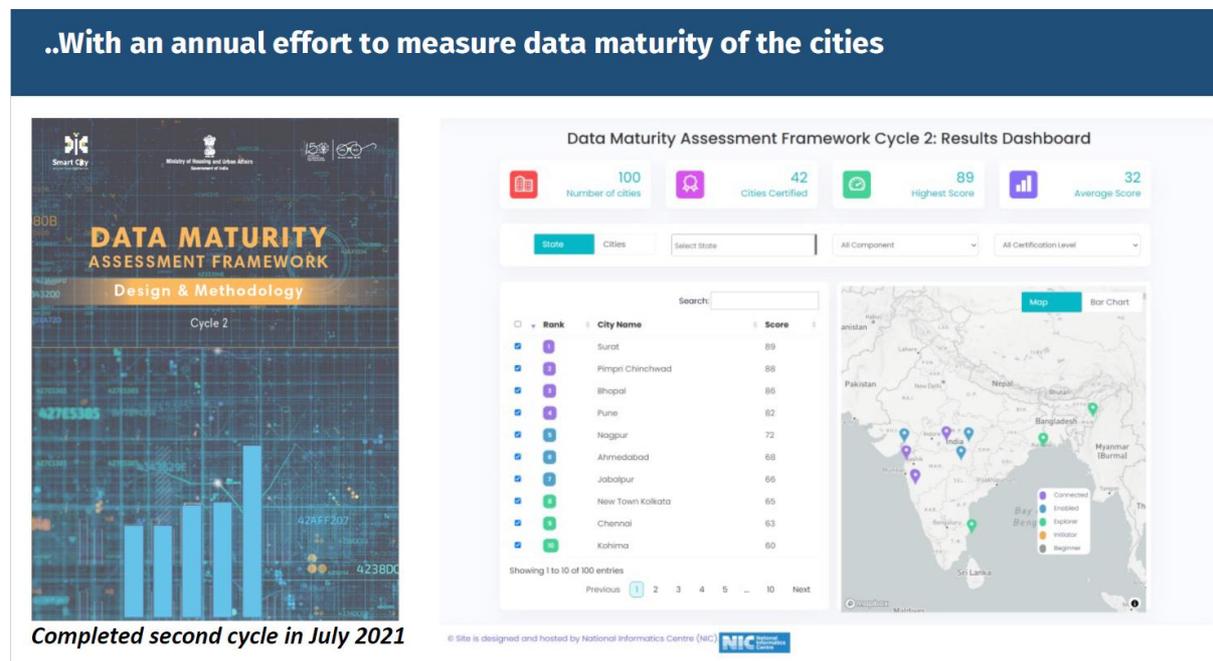


Image 10-Data Maturity Assessment Framework

Investing in common digital public goods for the cities and the ecosystem has been very important. For instance, the “National Urban Learning Platform” (NULP) was created as a common public good for seamless capacity development from supply-driven approaches (seminars for dissemination, etc.) to demand-driven approaches where cities could demand what they want and need. Additionally, the “India Urban Data Exchange” (IUDX) on how to exchange data securely, and Data Banks like the portal AMPLIFI which tries to capture 700 data points for every city from different sectors and where Government, citizens, academia, and industry can help to create use cases and gain insights about how the city really works with a data-informed base. An “Open Data Portal” (ODP) was also created so that cities are encouraged to share data as well as domain wide standards.

²³ The Data Maturity Assessment Framework is available at <https://smartnet.niua.org/dsc/dmaf-document.php>

We have also invested in common digital public goods for cities & the ecosystem

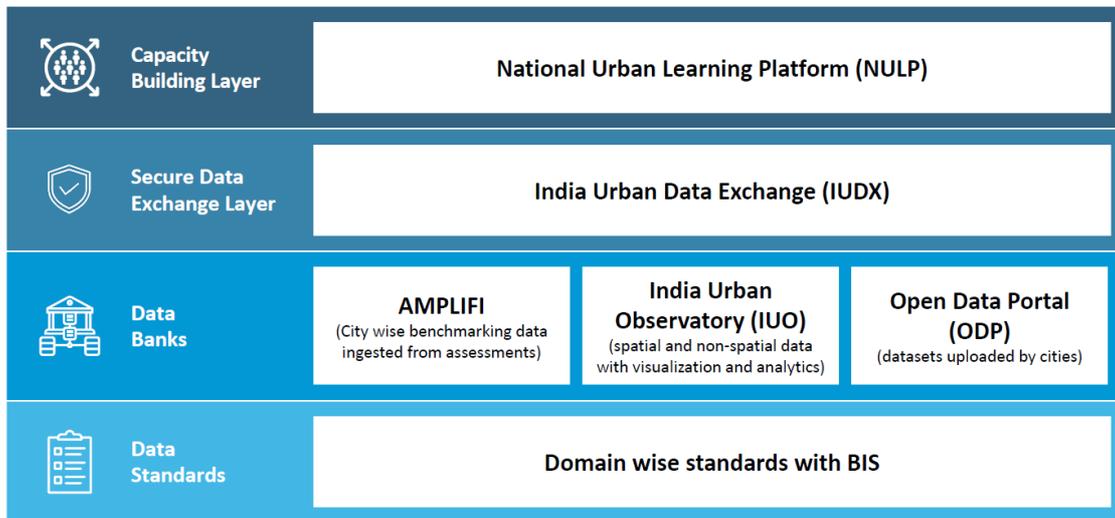


Image 11-Overview of common digital public goods for cities and the ecosystem

The “National Urban Digital Mission” (NUDM) is then a systemic approach which not only promotes data-driven decision making from the “DataSmart Cities Strategy”, but also digitalizes city planning and operations from the integrated Command and Control Centers and the urban data platforms of Indian cities. The NUDM is also creating a common platform for citizen-centric smart governance and building an innovation ecosystem to promote start-ups for city innovation exchange. The “Smart Code Platform” also gathers open source code for cities to use to foster collaboration and co-creation.

We are taking a systems approach to digitally transform urban India



Image 12-National Urban Digital Mission

Best Practices: Data Interventions

Jakarta: combining local and international expertise for a Smart City

Keywords: •international collaboration •co-creation •innovation

Lessons learned:

- International collaboration and exchange between cities on smart city topics can foster the learning of skills and the transfer of experiences for advancing digitalization for municipal service delivery.
- Incorporating different multi-stakeholder formats for co-working and co-creation (e.g. dialog workshops, online exchange platform), and providing physical spaces for bringing together urban innovators can close the gap between government and the city ecosystem.
- There are resources available for international city-to-city collaborations and networks. For example, innovation funding programs like HORIZON Europe help cities outside of Europe to leverage funding for their own data strategies and smart city innovations.

With a population of approximately 260 million, Indonesia is the fourth most populated country in the world. More than half of Indonesia's population lives in urban areas, and a process of rapid urbanization has taken place. Having grown by almost 9 million since 1950, the capital city of Jakarta has seen a dramatic increase in its population and is currently home to about 10 million people. The size of the city however, has stayed almost the same, making it one of the most densely populated cities in Asia, with around 14,000 people per square kilometer. This rapid growth has brought a series of urban challenges with it: congested roads and traffic, overcrowded streets, complex waste management systems, air and water pollution and a decrease in citizen safety (among others). The current COVID-19 pandemic has added even more pressure to the city and its services, while further highlighting the problems posed by inequality. To address these challenges, Jakarta has adopted a smart city strategy and an ambitious plan for improving the life quality of its citizens, boost economic and urban recovery efforts, and develop a flourishing innovation ecosystem.

Indonesia has had a smart city plan in place since 2017. The implementation of smart city projects at the local level, however, is up to each city. This way, local governments can adjust concepts and goals to their own local needs. In Jakarta, the Smart City Framework 4.0 defines the use of technology and data to advance urban development towards citizen happiness. In this process, the city envisions the role of citizens as co-creators of joint solutions to common problems.

Jakarta has recognized the potential of international cooperation to advance its 4.0 framework through experience and knowledge sharing. An instance of this is its collaboration with the city of Berlin, Germany. This sister city partnership was established in 1994 and has served to foster cooperation

between both municipalities in different fields. The topic of digitalization and good governance was included in the partnership in 2019, an effort which is supported by German Development Cooperation through the program “Experts for municipal partnerships worldwide”. The collaboration between both cities is currently done through the EU-financed Smart Change project²⁴, which also includes Bangkok as a regional partner for south-south triangular cooperation. This way, the city aims to strengthen its smart city capacities and good governance and to foster an urban entrepreneurial ecosystem. This is done through different initiatives including, among others, an Innovation Hub, a Future City Accelerator, and Multi Stakeholder Policy Dialogue Workshops. Overall, this is a model of how exchange between cities can foster the learning of skills and the development of solutions, particularly regarding the digitalization of municipal service delivery.

Data vision and data use

Jakarta Smart City was founded in 2014. By then, the governor of Jakarta promoted the project based on narratives around mobility, governance, environmental protection and community services. The most recent initiative is the Smart City 4.0 Framework which has two main goals: to make Jakarta an innovative city by using the appropriate technologies to foster digital growth; and to improve the quality of life of its residents. It incorporates the use of data, cloud computing, AI, IoT, and cutting-edge technologies. There are four principles within the framework: system and data drivers, mobile first design, the digital experience, and smart collaboration.

To advance its digitalization process and orchestrating the data ecosystem, the city has created a unit dedicated to the topic of the smart city. Founded by the provincial government, this unit has is based in the Department of Information, Communication and Statistics. It has the mission of realizing a data-driven city and using technology for better public service. It is also responsible for the internal and external digitalization on smart city topics. As part of its collaboration with Berlin, Jakarta can receive advising in digitalization from an integrated expert appointed to work with the Smart City Unit.

Jakarta recognizes data as a significant asset for the deployment of new and better services in various inter-disciplinary domains. To support data-based policies and services, the city uses various types of sensors that collect real-time data on many factors, such as bus movement, air quality, water levels, ambulance movement and garbage truck movements. There are at least 73 public services provided by municipal governments and 35 agencies that produce data in Jakarta. Given the number of public services and information, the city focused on building and operating a big data platform for handling data collection, management and analytics, as well as integrating the information about government services, citizens’ electronic feedback, and social networks. This information is fed into dashboards that can then be accessed by governmental units for monitoring and decision-making purposes. The provision of data-based services is provided by secure, reliable, and integrated systems based on APIs, and all data sets are integrated within a range of Big Data applications created by IBM (IBM, 2020).

²⁴ More information on the Smart Change Project can be found here <https://www.bgz-berlin.de/en/projects-and-products/project-overview/smart-change/>

An example of integration of data arising from different services is the city’s recently launched “super app” Jaki. This application condenses information and data from 28 service apps from different government services in a central place. With more than 15 features, it includes functionalities like digital wallets, on-street parking points, public transportation schedules and routes, and the online submission of complaints and feedback. The app is also being used during the vaccination process in Jakarta for vaccine registration. Furthermore, the government has used it as a communication channel to inform citizens about COVID-19 hot spots, confirmed cases and city responses. During the pandemic, Jakarta developed corona.jakarta.go.id as a center of information and data. This center is also accessible through JAKI.

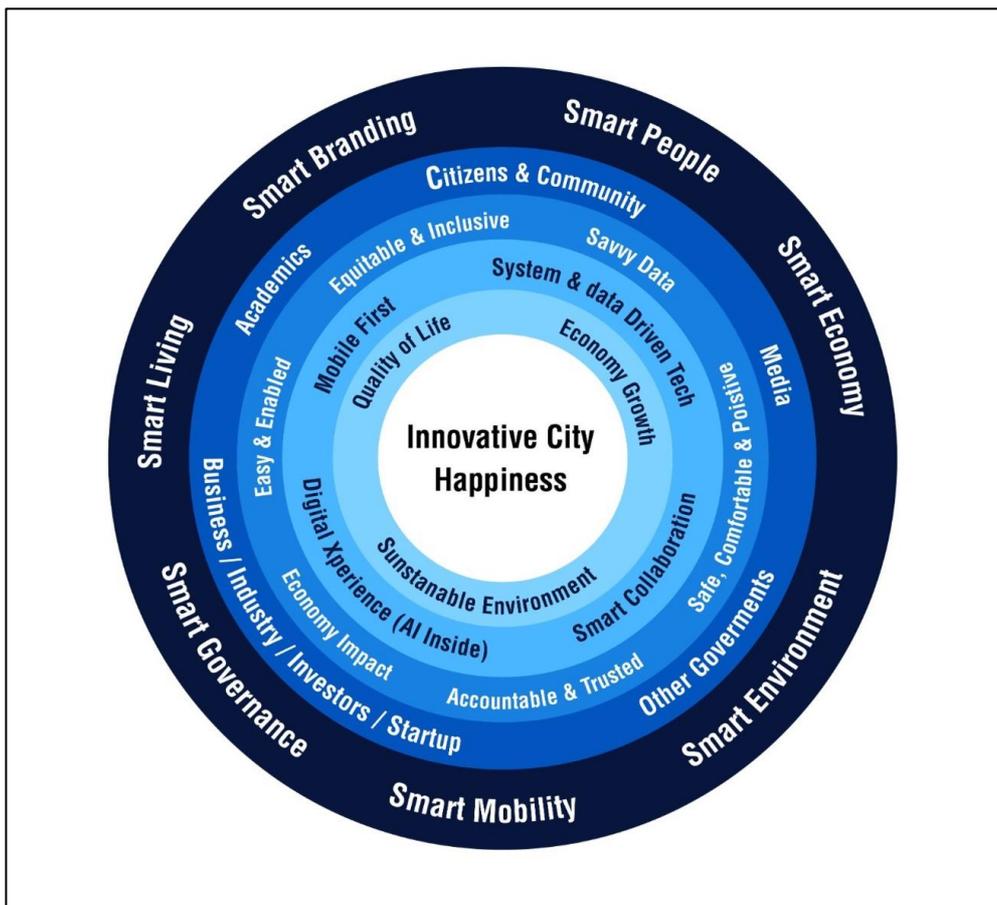


Image 13- The Jakarta 4.0 Framework

Working with data has allowed the city to establish analytics and visualizations to address pressing urban issues like traffic, pollution, or flooding. It helps to inform policy and decision making, for instance, by providing insights for the creation of policies dealing with the number of vehicles allowed to drive in the city each day, for real-time monitoring of rivers and sea levels and the issuing of flood alerts and response coordination. As resident feedback is also collected by the city, big data has provided insights into some relevant topics and allowed more efficient management. For example, by analyzing and identifying patterns on resident feedback, it was possible to identify problematic areas and common problems related to waste collection and improve the routing and scheduling of garbage trucks.

Building on its data culture, analytics have also been used to understand and manage risks associated with the COVID-19 pandemic in the city. Tableau visualizations have been developed to show pattern of cases in the different regions so that the government can gain an understanding of the situation and plan its responses accordingly – for example, identifying areas to be prioritized when medical staff and social assistance is distributed. Furthermore, an open public dashboard has been created and provides citizens with an overview of COVID-19 cases. This is used by the population to gain a better understanding of the risks and take the appropriate precautions.

Open data initiatives and citizen interactions

To increase transparency, the city has important initiatives in place to open data and create new opportunities for interactions with citizens. Indonesia started its open government transformation in 2011 when it initiated the Open Government Partnership (Open Government Partnership, 2021) with seven other countries. After launching a global declaration, Indonesia established Open Government Indonesia (OGI) in 2012, as well as an open government reform, including the opening up of governmental data. This is supported by the Law on Freedom of Information (N. 14/2008) and the Regulation on Personal Data Protection in Electronic Systems (N. 20 of 2016 , MCI 20/2016). These regulations also cover the general provisions on personal data processing requirements on digital systems.

The smart government strategic dimension of Smart city Jakarta builds on the open data platform for public information and as fuel for innovation. It aims at data standardization and protection, as well as data monitoring and e-government systems for all public services. Data from all agencies of the Jakarta Provincial Government is collected and opened to citizens, free of cost, in an Integrated Data Portal²⁵, established in accordance with a mandate from the Governor in 2014 (Jakarta Province Regulation N. 181). This provides an accurate and centralized database for all agencies of the Jakarta Provincial Government. In accordance with the Regulatory Framework of Indonesia, the data presented is not allowed to contain personal information, state secrets, or other matters that are regulated by the law. There are currently over 40 open data-based visualizations and 1,904 data sets in the portal.

Smart Collaboration, stakeholder workshops, and co-creation of solutions

Smart collaboration is another pillar of the smart city concept of Jakarta, and a cornerstone of the international collaboration initiatives that take place in the city. To implement the city's 4.0 plan, collaboration with co-creators, especially start-ups, for the ideation of data-based solutions is key. Therefore, different initiatives are being carried out, such as the installation of multi-stakeholder workshops, the creation of an online dialogue and exchange platform, hackathons, and the creation of

²⁵ The Open Data Portal of Jakarta can be accessed at <https://data.jakarta.go.id/>

an innovation hub called the Future City Hub. As of November 2021, the city has collaborated with more than 20 start-ups and innovators to solve pressing challenges in urban areas.

Local, multistakeholder policy dialog workshops serve as platforms where experts discuss city challenges based on indicators and data, according to the smart city pillars. It includes members from the Provincial Government of Jakarta, private sector, NGOs, research institutions and civil society. In these workshops, the Smart City Unit presents data on specific selected challenges. This data serves as the basis for discussion and ideation of solutions, designing of pilot initiatives, and connecting of policy measures. For example, in a recent challenge dealing with environmental challenges, data revealed that air quality in the city had not significantly improved during the COVID-19 pandemic, despite the decreased circulation of vehicles and people. This provided insights to the workshop attendants for the design of new initiatives to improve air quality. Other workshops have led to the development of joint concepts for smart traffic solutions and matching innovative international initiatives.

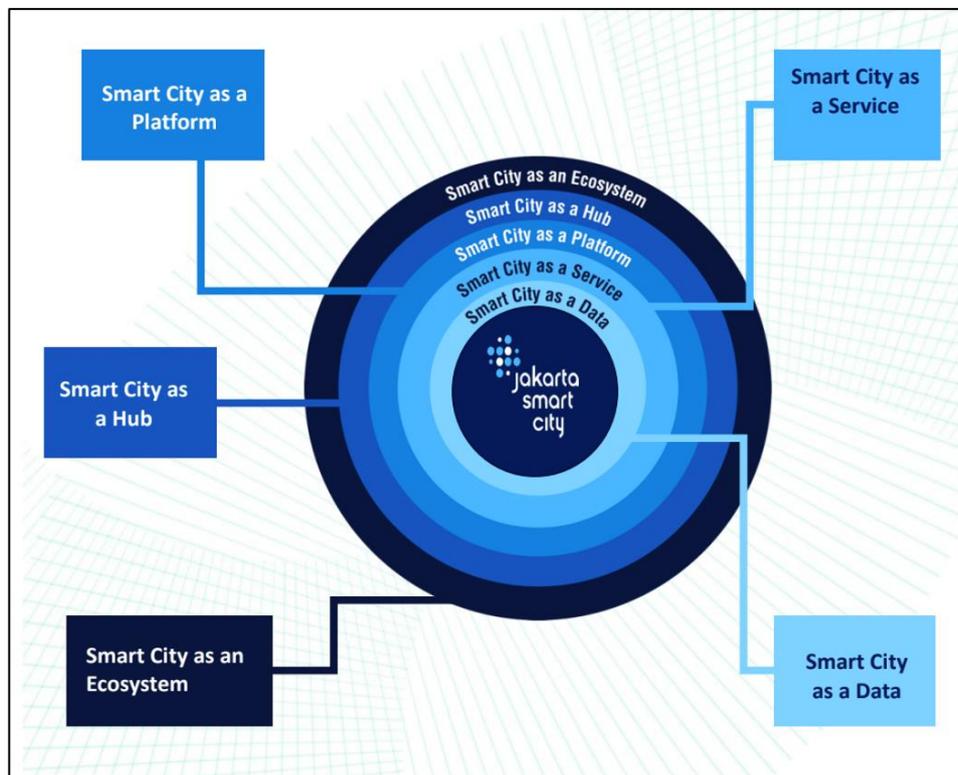


Image 14- The dimensions of Jakarta Smart City

A hackathon and an Accelerator Program have also been organized and implemented as means for bringing the city closer to innovation actors. Challenges are set in these events and data is provided to start-ups as basis for building their business cases. Particularly important is the brainstorming of solutions aiming to support the city recovery in a post-COVID time. Some of the recent challenges have also included problems around mobility (with data from the traffic department) and contactless mobility.

Furthermore, an Online Dialog and Exchange Platform is also envisioned as a connector for urban innovation and smart city experts for exchanging best practices and consulting about good governance and innovation. This initiative is further advanced by the Future City Hub which is currently being

planned and will constitute a place for physically uniting start-ups and other urban innovators for the co-creation of solutions. It is expected that the private sector will support the initiative and also engage in the creation and implementation of data-based solutions.

The Municipality of Miraflores in Lima and its data-based approach

Keywords: •urban data platform •public safety •smart traffic management

Lessons learned:

- In the making and implementation of a smart city project, thinking small and implementing targeted and prioritized digital interventions first, can be the best base for a more ambitious project in the future. Nevertheless, it is important to keep the big picture in mind from the beginning, to ensure that the data ecosystem develops toward pre-established goals.
- Highlighting impacts and letting results speak for themselves is often the best way to overcome residents' distrust of sharing their data with government entities. Transparency and clearly communicating the purposes for which data will be used are also key.
- Municipalities can establish formal cooperation agreements to access information relevant to their goals.
- When dealing with technologies that allow for individual surveillance and traceability, cities can work with teams or advisory boards to set parameters for data collection, use, and sharing, to address privacy considerations.

The Municipality of Miraflores is one of the 43 districts within the Lima Province in Peru. It is an emblematic district with an important historical legacy from pre-Columbian times and a vibrant cultural and financial life. Thanks to this, and due to its proximity to the Pacific Ocean, it is considered the main tourist district of the Province, attracting local and foreign visitors alike. Having political, economic, and administrative autonomy, Miraflores is home to a population of more than 100.000 inhabitants and receives about 500.000 visitors per day. It occupies the sixth place in the human development index of Peruvian districts and is one of the top districts for quality of life in Lima.

At its core, the Municipality has established an institutional vision where it aims to become a model for community, efficiency, transparency, sustainability, and quality of life. Furthermore, it intends to be the first smart city in Peru and build on digitalization as a means furthering advance its urban development goals. In 2011, the Municipality had already defined its vision of creating an information society where knowledge and information constitute the basis of well-being and progress (Municipalidad de Miraflores, 2011). As part of this, the creation, spread, use and integration of information and data is seen as a pillar of economic and social development. Furthermore, inclusiveness, development-orientation, and people-centered approaches were set at the core of the municipality's values when it comes to working with data. Since 2019, the Municipality has been running an innovation workshop to improve the data

management skills of the city's staff. Additionally, it has been active in regional cooperation on big data and urban data projects.

The Municipality of Miraflores has a well-defined, holistic approach to open government. Its goals and guidelines have a strong focus on transparency, participation, and collaboration (Municipalidad de Miraflores, 2015). Increasing access to public information through open data and a transparency portal are all parts of this approach, as well as the base of Peru's overarching National Strategy for Open Government Data (Presidencia del Consejo de Ministros, 2017). In this context, Miraflores has been recognized in the country as a front-runner in transparency and information access (Municipalidad de Miraflores, 2021) .

Besides this institutional vision and guiding values, the Municipality of Miraflores stands in a privileged position within the country that provides a favorable environment for piloting innovative digital interventions. Miraflores is characterized by high literacy levels, high use of technologies among its population, existing broadband infrastructure, widespread access to internet, and an ecosystem of companies and businesses that already have a strong internet presence. This context, along with a strong institutional drive towards innovation for the common-good, has led the Municipality to implement a number of data-based initiatives over the last few years, including an open data portal²⁶ and digital platforms for city administration and fiscal management²⁷. It has also paved the way for the recently launched Smart City Project, which aims to capitalize on digitalization and innovative technologies to provide solutions to some of the top challenges of the Municipality: mobility and public safety.

Data-based tools to enable municipal development

Data and digitalization can aid cities and municipalities in their efforts to improve decision making, optimize internal and external processes, and overall, provide better citizen-services. For these reasons, the Municipalities of Miraflores has deployed a series of data-based tools and initiatives.

First, a digital system of images and geographical data that catalogues land parcels and real estate, also known as a cadastre system, was implemented, allowing the real-time visualization of the information on each property that was recorded. This initiative resulted in Miraflores being the first municipality in Peru to systematize the cadastral registry. To this end, an Office of Cadastre was created within the Urban Development Division of the city in 2014 and the city personnel involved in the project were trained in data collection, data use and maintenance of the system. Furthermore, a strategy was designed for the dissemination of the project among citizens, with the aim of generating transparency in the processes and trust in the administration. The cadastre system is used as a tool for land-use strategic management, to improve administrative and fiscal processes, and to support participative practices in the community. It has enabled the municipality to offer better services to its citizens, increase its efficiency during tax collection processes, and quickly provide up-to-date information for

²⁶ The Open Data Portal can be accessed at <https://www.miraflores.gob.pe/datos-abiertos/>

²⁷ The platform for administrative procedures can be accessed at <https://www.miraflores.gob.pe/plataforma-digital/#/>

management and planning. The data in the system is not only used for fiscal purposes, but also for the establishing of participative budgets (where neighbors collectively make decisions about municipal spending), as well as improving waste collection systems and public safety in the neighborhoods (SEDI and OEA, 2005).

Besides the digital cadastre system, the Digital Platform for Business Intelligence was also implemented for the internal integration of municipal administrative data and the facilitation of decision-making processes among city personnel. Using this digital platform, municipal data can be accessed, extracted, and visualized in dashboards that allow real-time monitoring and review of administrative procedures. It is also used for fiscal purposes, with city administrators being able to provide on-the-go information on the ground.

In addition to this, and as a response to the new challenges arising from the COVID-19 pandemic, the municipality implemented a digital platform and a mobile application for citizen procedures. This platform not only positively impacted the quality of municipal services by speeding up and simplifying bureaucratic processes, but it also allowed the municipality to significantly reduce the space otherwise needed for paper-based materials and documents. It is important to point out that this initiative was first met with resistance by some citizens who showed distrust in sharing their data and engaging in new digital processes. However, the municipality emphasized the advantages of the platform and made transparent the intended use of data collected, which in turn increased public acceptance and ultimately led to the success of the initiative.

Lastly, the Municipality of Miraflores is about to launch a new mobile application that will allow citizens and visitors of the municipality to access information about events, special offers, businesses, and services. This initiative aims to further add to the already existing range of digital interventions across the municipality and contribute to its economic development.

Miraflores Smart City: A project to address municipal priorities

Despite occupying sixth place in the human development index of Peruvian municipalities and being placed at the top in Lima for life quality, the Municipality of Miraflores still faces important challenges. The topics of public safety and traffic congestion are perhaps the two most important problems in the municipality, as pointed out by its citizens in a survey in 2019 (Lima cómo vamos, 2019). There are around 7,000 buses circulating in the municipality. Moreover, it is a popular tourist destination that receives a large amount of visitors every day. This has led to an increase in traffic, which in turn has impacted the travel times of both private vehicles and public transport. As for public safety, it was already high on the municipal agenda, with initiatives to reduce crime being implemented in the past year.

Keeping these pressing challenges in mind, the Municipality of Miraflores launched the Smart City Project in 2020. Taking a problem-centered approach, the project aims to provide solutions to the challenges concerning public safety and traffic management by procuring a digital platform in order to connect, manage, and visualize data on transit and illegal behaviors in the municipality, allowing for the

improvement of various areas, optimizing activities and reducing manual errors. This will increase the understanding of municipality dynamics among staff and decision makers and facilitate decision making processes. With this project, Miraflores intends to become the first smart city of Peru and one of the most advanced municipalities in the region.

To enable the collection of data and its connection to the digital platform, the project includes the acquisition and deployment of IoT technologies, such as sensors and cameras for face and license plate recognition. As part of its smart mobility approach, the municipality will leverage AI and big data analytics for the control and monitoring of traffic. Additionally, a smart traffic light and parking system will be implemented, building on data collected by sensors, and supported by smart traffic signaling. During the procurement phase of the project, the municipality decided to opt for open source software for the platform. This would allow the municipality to perform maintenance on the digital platform, as well as incorporate new technologies at a later stage. All of this would be done in an effort to guarantee the independence of the municipality from any individual service provider and avoid licensing fees and other potential future costs.

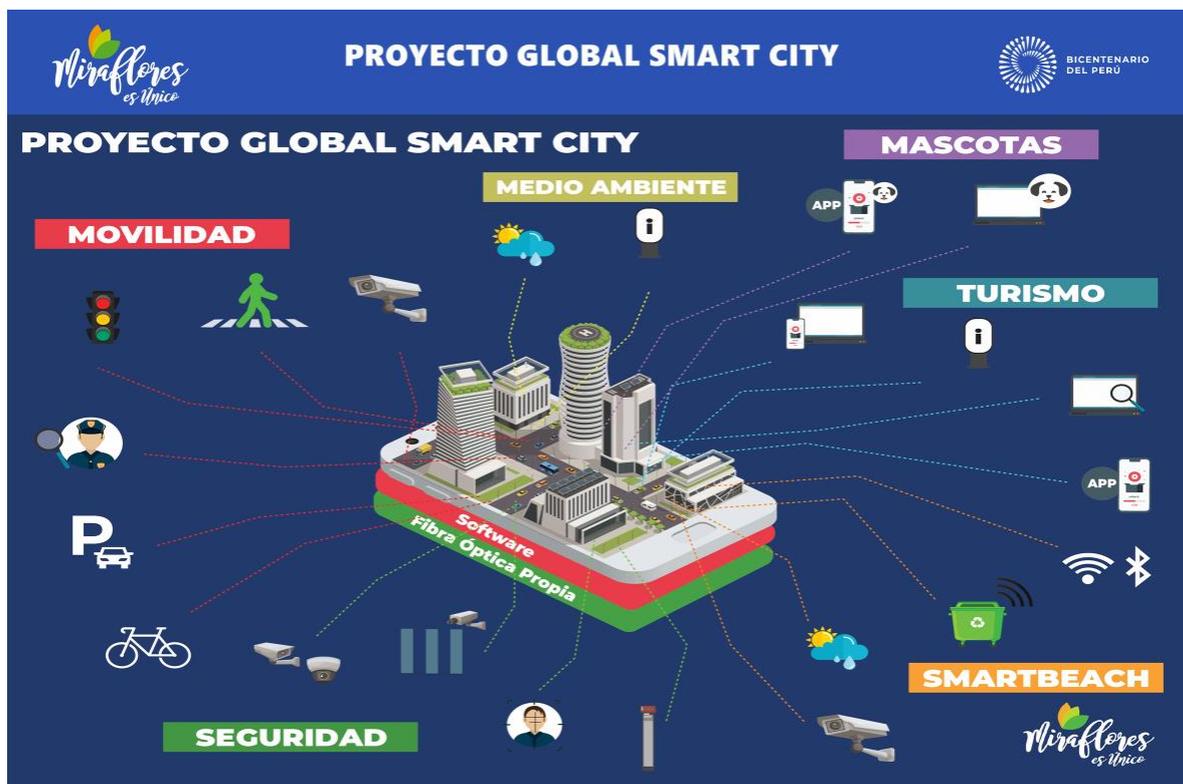


Image 15- The Smart City Project of the Municipalidad de Miraflores

Additionally, the Smart City Project includes the replacing of old technologies that are already deployed with new technologies that not only collect data, but also allow for their transmission to the digital platform. Overall, the ambitious goals and features of the Smart City Project have been described as follows:

- Integration of traffic light intersections with micro-regulated and adaptive equipment within the municipality to enable a traffic light grid for adequate traffic management.
- Inclusion of video analytics to allow for better decision making and identification of illegal behaviors in the municipality.
- Acquisition of impact signaling mobile devices for road safety, in order to provide timely and vital information to drivers.
- Increasing the efficiency of the use of public space by 60% by acquiring vehicle occupancy sensors in the areas where rotating parking lots are located and loading and unloading zones.
- Increasing road safety by 40% with the implementation of traffic lights and streetlights at pedestrian crosswalks, which will reduce the occurrence of accidents.
- Renewal of vehicular and pedestrian traffic lights at 34 intersections, providing greater safety for pedestrians and alerting vehicles with new equipment.
- Carrying out implementations to reduce speeding by installing radar speed signs. These visual reminders of a driver's speed will raise awareness among drivers, increase compliance with traffic regulations and reduce the number of traffic accidents.
- Implementation of infrared sensors to detect infractions such as running red lights, improper turns and stopping in crosswalks.
- Implementation of air quality measurement devices to measure toxic emissions and adopt district-wide measures to reduce environmental pollution and improve the quality of life of residents and visitors.
- Installation of mobility information points that will inform users about roads, routes, tourism and weather. It will also provide the municipality with information about the number, type, and circulation of micro mobility vehicles (among other metrics).

In addition to these goals, and in order to address the challenge of improving public safety in the Municipality, the Smart City Project also stipulates the acquisition of access gates, equipped with face and license plate recognition cameras, an alarm system, and speed sensors. Building on synergies between the municipality and the institutions tasked with guaranteeing citizen safety, the data collected at these points will be transmitted in real-time to the platform and to monitoring systems and will also be cross referenced with the data bases of these institutions (e.g. police). To this end, the Municipality of Miraflores has implemented formal cooperation agreements, in order to gain access to information relevant for crime prevention (e.g. data on criminal convictions or criminal history) and guarantee collaboration by all stakeholders. Furthermore, as the installation of facial recognition cameras poses a series of challenges for dealing with sensitive data, the municipality has created a team to develop data use and protection strategies. The project not only includes the acquisition and implementation of the aforementioned components, but also the development of a modern control center where the monitoring team will make use of these technologies for their daily tasks.

Besides the acquisition of a digital platform for traffic management and public safety, the Smart City Project builds on a second important pillar: the acquisition and implementation of a network of more than 50 kilometers of municipal fiber optic cable throughout the entire Municipality. With this measure,

the municipality will save the resources allocated to renting the fiber optic cables currently in use. It will also further cement the digital infrastructure required for its transformative journey. Additionally, this implementation, jointly with the development of the intelligent platform, will achieve the centralization of information collected from the different projects' components.

With an investment of \$10 million (U.S. dollars), the project is currently in its initial phase, with a number of offers already received as a response to the invitation to submit tenders launched by the Municipality in 2021.

The São Paulo City Laboratory for Mobility Innovation (MobiLab)

Keywords: •mobility •innovation •start-ups

Lessons learned:

- When striving to make data open, cities can develop small pilot projects, mock-ups, and prototypes in cooperation with private actors and researchers, that serve to demonstrate and make the potential outcomes of data-based innovation concrete.
- Support for data-based innovation requires the aligning of existing regulatory frameworks and power structures. One way to accomplish this is by changing regulations governing how the city contracts innovative solutions
- The belief that costly solutions provided by large established companies are always the best fit for cities can work against a healthy innovation ecosystem. A culture of trust in responsible innovation, regardless of the size and price, needs to be created.
- To ensure that innovative solutions address high-relevance problems, cities can collect information on, for example, the main challenges affecting the staff of public agencies.

With a population of more than 12 million, the city of São Paulo is the most populated city in Brazil and South America. It is a flourishing metropolis known for its financial sector, dynamic business ecosystem, and artistic scene. At the same time, and like many other mega-cities around the world, São Paulo faces complex environmental, technological, economic, political, and social challenges. In the last few years, the city has seen increasing demands from citizens calling for more civil participation, transparency, less bureaucracy, and improvement of public services.

With around 6 million private vehicles and approximately 15,000 buses, São Paulo has long been known for its traffic congestion and urban mobility problems. This is illustrated by the fact that São Paulo has the second largest fleet of helicopters and the second highest number of heliports in the world, which are often used as means to escape the heavy traffic jams. Public mobility policy in the city is managed by the Municipal Department of Transportation, which in turn operates two public agencies: one engineering traffic company and one company that contracts bus services out to private providers. Together, these companies manage the São Paulo transport system which generates 30 million data points every day and transports around 6.5 million passengers a day (Biderman and Swiatek, 2020). To explore the potential of this and other data for addressing the city's many mobility challenges, the São Paulo City Laboratory for Mobility Innovation (MobiLab), was launched in 2013. MobiLab aims to open relevant data up and develop an innovation ecosystem, with strong involvement from local start-ups, and to create new data-based solutions for the urban mobility of the city.

Paving the way for innovation: an open data story

In 2013, several factors converged to lead to the creation of MobiLab and the opening of important datasets that would later serve as the basis for start-up driven innovation to improve mobility in the city. An important early factor was the introduction of the Federal Transparency Law²⁸ in Brazil. The Law was introduced in 2010 as a result of the country's decision to join the Open Government Partnership, which called for open government, open data, and transparency interventions. The Federal Transparency Law stated that data which was not harmful for the privacy of citizens or businesses should be disclosed.

Additionally, data on buses and subways has been collected since the introduction of a tapping card scheme for the public transportation of São Paulo in 2003. This scheme had been seen as an innovative approach for the city as it enabled the integration of different forms of public transportation with a single card. The system was praised for its efficiency and impacts on poverty, as it allowed passengers to save money and time when using the card. Simultaneously, the system collected data on the locations and times of use of the cards which was stored and concentrated in the hands of the city. Furthermore, the municipal fleet of buses was equipped with an advanced vehicle location system (AVL), that captured and transmitted location data in intervals of about 45 seconds. This concentration of data in public hands was quite unique for São Paulo, where the contracts had been designed in a form that allowed the government to have wide access to data. At the same time, the 10-years concession period of the public transport contracts of the city with private operators expired in 2013, meaning a new bid would need to be elaborated. This opened an opportunity to establish new rules for the new contracts and leverage the possibilities offered by digitalization and the data collected by the transportation sector over the past 10 years.

The urban mobility topic gained further momentum in the political agenda of Brazil in 2013, when the streets of São Paulo were shaken by mass protests. After the bus fares were increased, more than a hundred thousand people turned to the streets to call attention to political and social issues, including the city's urban mobility services and traffic management. These protests included many calls for a more accessible and socially just public transport system with lower fares and higher service quality. These developments opened new opportunities to get public and political support for the development of new mobility approaches and for introducing the central role technology could play in meeting citizens' demands.

This favorable context was seen by a small team of practitioners within the Municipality of São Paulo, who started pushing for an open data initiative. After sorting out privacy requirements and developing an API, data on GPS dynamic data, bus lines, bus stops and programmed times was opened and made

²⁸ Federal Law number 12.527/2011, also referred to as Access Information Law or Lei de Acesso à Informação – LA in Portuguese

accessible to the public on the internet. Access to the data sets was made easy, with no documents or complex processes required.

The idea behind opening the data to citizens was to foster innovation and encourage the market to develop services for the citizens in the field of urban mobility. For this purpose, start-ups were seen as a potential means for saving cost and create quality solutions for the many mobility challenges of São Paulo. During this first experimental phase, a hackathon for start-ups was organized by the Municipality. Samples of the GPS data, and anonymized data collected from the tapping cards was provided to a number of start-ups who were asked to produce prototypes of data-driven mobility solutions. The hackathon served to portray and raise awareness to the public authorities and decision makers on the big potential on data-based solutions. It demonstrated how start-ups could be used to innovate and provide city personnel with small proofs of concepts, such as optimizing public bus operations.

Start-ups + Data = Solutions

The implementation of public innovation labs as platforms of communication between municipal administrations, the private sector, and civil society has been increasingly championed by governments around the world. Innovation labs can help to address complex issues through public engagement and innovative problem solving. The idea behind these labs is to create an ecosystem for innovation oriented towards the improvement of the design and implementation of municipal services that is less bureaucratic, more cost-efficient, and has bigger impacts. With this in mind, the São Paulo City Laboratory for Mobility Innovation (MobiLab) focused on changing the relationship of the city administration to technology by introducing innovation for the creation of data-based mobility solutions. MobiLab aims to enable innovation, transparency, start-ups and resident engagement, as well as to encourage intersectoral cooperation for the creation of innovative solutions for the city. This conceptualization also included the purpose of opening even more government data and creating participative solutions for mobility management (Smart Cities Dive, 2021). The Initiative is managed within São Paulo's administrative structure and financed by the municipal budget.

Working with partner institutions is also a key pillar for data analysis and the creation of a flourishing data ecosystem by the program. For example, a partnership with Bloomberg Philanthropies' Road Safety Program was established in 2015, and a partnership with the Municipal Secretary of Innovation and Technology and the Municipal Secretary of Mobility and Transport in 2017. MobiLab has also benefited from donations for some resources. For example, Bloomberg Philanthropies made a donation for all filming and sound equipment.

New ways of buying technology and solutions from start-ups had to be developed for the successful operation of MobiLab. Instead of focusing on public purchases based on large bids for already existing products (often with high costs), the idea was to focus on custom-made data-based products developed in a creative manner by start-ups. For this, a new bottom-up bid approach was created in the form of a tournament (with cash prizes) for small companies with projects in the topic of mobility. The solutions developed within these projects had the requirement of using open-source and free software.

Furthermore, MobiLab followed a strategy of “turning the procurement process upside down”, where the development of the technical terms of reference for public procurement were not developed based on the solutions that already existed in the market, but rather taking a problem-perspective approach. This meant calling for solutions as responses to identified problems and for the end user.



Image 16- MobiLab Participants

Another path of change for the public acquisition of innovation followed by MobiLab was concerning the pricing processes. In Brazilian procurement law, pricing was done by means of market research. This meant adjusting the expected pricing to the costs of pre-existing products and solutions in the market. As result, big suppliers influenced the expected price and the expectation of high costs was created at the stage of bid preparation. To change this mindset, MobiLab organized a tournament among graduate students who would have to develop data-based solutions and show their potential impacts and costs. As a direct outcome of this tournament, a number of solutions were developed for registration of penalties for bus operators and a ticketing system based on smartphones. These solutions were very well received by city officials and implemented at the city level. Their low cost and efficiency would serve as tangible proof of the potential cost-saving effects of innovation and challenge the belief that working with technologies and digitalization has inherent high-costs.

MobiLab would also later develop a tournament bid to purchase apps for urban mobility for governmental use from start-ups. It included specific open-source and modern technological requirements for the systems open to the tournament. It also required prototypes to be developed from the beginning. This was done to give the civil servants who would implement and maintain the solution the opportunity to provide direct feedback to the start-ups. Furthermore, the main problems affecting the technical staff in the public agencies for traffic and public transit were collected and listed to ensure the relevance of the solutions delivered. This exchange and involvement of the civil servants was key in achieving a sense of ownership, as well as for building knowledge inside the administration.

A start-up residence program was created as an initiative to further promote start-ups and advance the development of data-based solutions. The so-called “MobiLab Residence Program” was an initiative with the participation of the Department of Finance and Economic Development and included the provision of technical support and mentoring for start-ups, along with the provision of a co-working space. When possible, data sets were given and start-ups had the opportunity to develop and prototype their solutions, all whilst working in cooperation with city staff.

Data-based outcomes and innovation impacts

MobiLab is a pioneering initiative in Brazil for portraying the added value and potential of data for advancing citizens interests and advancing public interest in the topic of mobility. It did so by promoting and systematizing an innovative culture within the São Paulo public sector. It played a key role in introducing and showcasing the work of start-ups and their ability to innovate quickly and efficiently when supported by the right framework. In this regard, MobiLab played an important role changing the belief that big, established companies and their products are always the best option as providers of city solutions. By challenging the assumption that “cheaper equals low quality”, the program portrayed how the right use of technology, data, and problem-solved oriented innovation can often lead to the most efficient, cost-saving, outcomes.

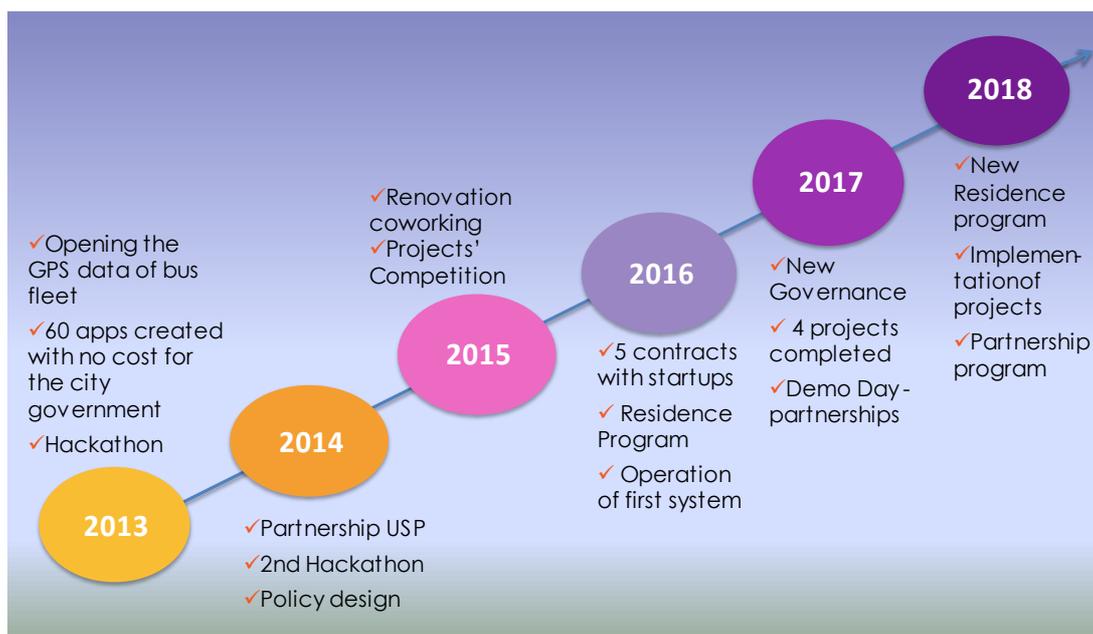


Image 17- The timeline of MobiLab

Furthermore, MobiLab supported the design, development and implementation of digital interventions for improving urban mobility in the city. For example, a system for the digitalization of manual processes for bus operation was developed and implemented to substitute the paper-based registration of penalties for the bus operating companies. The new system operated with smartphones and substantially reduced the number of staff involved in the process, thus eliminating a portion of the costs.

Furthermore, it facilitated the process of fining of bus operators for noncompliance, which in turn increased service quality (Biderman and Swiatek, 2020).

The program opened new paths for public purchases and working with innovation. An important outcome of MobiLab was showing how legislation can use a procurement model based on creativity and agile thinking to increase innovation. The bidding mechanisms developed allowed for a better prototyping, better identification of the most relevant problems faced by the city, and ultimately, more efficient, cost-saving outputs. More recently, the new legislation of the national government of Brazil for public contracts was relaunched after a creation process largely inspired by the formats created in MobiLab.

Lastly, by making data accessible and useable for creating common interest solutions, MobiLab fostered accountability and transparency of the city government to its citizens. It showed that opening up data sets does not necessarily have to be a complicated and expensive process. It also opened new paths and communication channels to increase participation of residents and city staff, with their involvement in different initiatives carried out by the program. Ultimately it has provided a space for dialogue between start-ups and city administrators.

Seoul Digital Mayor's Office: Citizens as Mayors

Keywords: • data visualization • participation • big data

Lessons Learned:

- Data has no added value if it's not analyzed and understood. The best way to represent data is through visualization methods that are usually offered by statistical and data analytics software.
- Initiatives that share information with citizens not only increase transparency but also fairness. To ensure the latter, giving information access to citizens in public spaces and free of cost is key for bridging the digital divide.
- A system should not only be monitored inside a situation room. Providing access to decision makers to the system through, for example, mobile devices can speed up response and increase overall efficiency.

Seoul is the capital of the Republic of Korea and home to about 10 million people. The smart city vision of the metropolis places citizens at the center stage, with technology and data serving the ultimate goal of improving quality of life for all. However, in such a megacity, the scale of planning and implementation of urban development can be extremely challenging. The Seoul Metropolitan Government is composed of hundreds of departments and more than 50,000 employees. It monitors and collect millions of information and data points each day. Nevertheless, the city government had no comprehensive integration protocol or institutional data coordination framework to manage these huge amounts of data. The different systems and their data sets were siloed and operated in isolation by individual departments and agencies. This lack of integration and coordination lead to inefficiencies, delays, and loss of information that could have otherwise been used to improve the city and advance its urban development goals.

To ensure its efficiency, Seoul is seeking to unlock the potential of data and technologies in a complex data strategy and data governance framework that is the result of decades of smart city initiatives and progressive stages of technological and infrastructure deployment. To streamline the use and management of data, the Seoul's Digital Mayor's Office was created and launched in 2017. At its beginning, the core function of the platform was to enable disaster response coordination, improve mobility management, and allow for decision makers' quick access to administrative information. Since then, it has been further developed and new features have been added. Today, it is an integrated smart city data platform that comprises all available data and information to produce comprehensive, real-time indicators. It makes use of previously isolated data sets to deliver information and real time monitoring of incidents and situations. It also allows decision makers to intuitively navigate and understand the integrated data. This way, the time and resources needed for administration and

bureaucratic processes for gathering information has been drastically reduced. Furthermore, the visualization of cross-sectoral data delivers new strategic insights for a robust evidence-based policy making environment.

An important aspect of the Digital Mayor’s Office is that granting access to citizens was planned from the beginning of the project. As such, a public access version of the Digital Mayor’s Office was launched in 2019. The public platform is available online²⁹ and is also showcased in screens placed in public areas and kiosks around the city. This public version of the platform advances transparency and openness in city operations, increases municipal accountability, and opens new data up for civic participation, as data is available for co-creation initiatives. The public version of the platform was designed to display information closely related to the everyday life of citizens, with five categories: Visiting Seoul, Enjoying Seoul, Working in Seoul, Handsome Seoul, and Walking Seoul. Among other things, citizens have immediate access to figures and visualizations, real-time data, status and information on key projects and policy indicators. Additionally, information on the relevant urban issues and emergencies can be provided in real time.



Image 18- The Digital Mayor's Office

The Digital Mayor’s Office incorporates video conference functionalities, voice and gesture recognition, and platform accessibility through smartphones, tablets, and other small devices. This enables quick responses to emergency situations without needing to be on-site. Currently, the platform integrates around 32 million data items from over 300 information systems and more than 2,800 real-time CCTV video feeds (“Digital Mayor’s Office,” 2021).

Operating the Platform

²⁹ The Platform can be accessed at <http://scpm.seoul.go.kr/> (Korean only)

Coordination across the different institutions that make up the Metropolitan Government of Seoul was vital to the platform's development and implementation. To ensure a unified approach for data management for the Digital Mayor's Office, specific departments were tasked with establishing and operationalizing a data integration framework, selecting relevant data and coordinating inputs from other departments.

The Big Data Division and the City Planning Division are the two entities involved. The Big Data Division acts as a control tower point that takes care of data integration and system development. It establishes data protocols to be applied to all relevant systems and databases. The City Planning Division manages the identification and the flow of datasets to the platform, while also coordinating inputs from other data management divisions. Lastly, the General Affairs Division manages the equipment needs of the platform and maintains the facilities in public spaces.

As these divisions work with the vast amount of data collected by Seoul, regulatory frameworks guiding the privacy principles and ethical use of data in Korea are necessary. These were established through a complex mix of laws and regulations, including the Personal Information Protection Act of 2011 (amended in 2020), the Act on Promotion of the Provision and Use of Public Data and the Act on Disclosure and Use of Public Data.

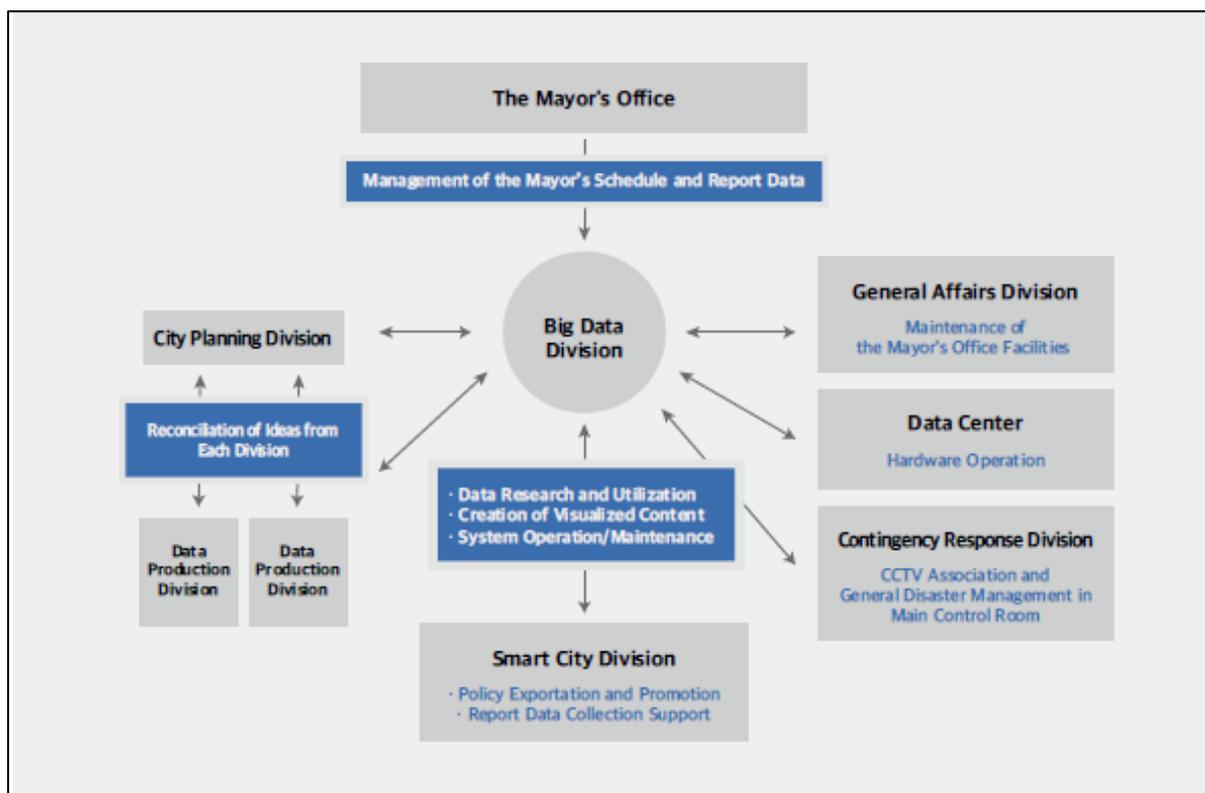


Image 19- - The institutional set up of the Mayor's Digital Platform

The entire process from basic planning of the Digital Mayor's Office, its comprehensive integration and its opening to the public took about 3 years, from mid-2016 until mid-2019. At that point, the cost for its implementation was \$430,000 for program development and \$80,000 for the Digital Mayor's Office installation. The initial construction cost of the Open Data Plaza was approximately \$850,000¹. The Digital Mayor's Office Platform is based on user-interface designs for easy-use and data visualization. UI and UX experts and business professors from different institutions provided advice for its development. (Seoul Metropolitan Government, 2019)

Data-Based solutions: a picture is better than words

The Seoul Metropolitan Government comprises hundreds of departments and oversees vast amounts of data. Real-time and static multi-sectoral data is aggregated and visualized in the platform. In turn, indicators and visualizations are created, including, but not limited to, real-time city status for traffic and environmental conditions, status of urban projects, administrative information, price information, water and construction works, financial status, living population.

The data flow is based on the Open Data Plaza, a system to disclose information and share administrative data with citizens on an open platform with over 16 million administrative big data sets. The data shared on the Open Data Plaza includes city data that has been collected since 2010. The Open Data Plaza provides the basis for directing and categorizing data from different databases and systems into one central database. Although the Major's Office was built on the pre-existing structure of the Open Data Plaza, it has expanded its data scope to integrate real-time data - for example, data from the Transport Operation and Information Service (TOPIS) (more than 300 million raw data sets) and from CCTV video (more than 1200 units in the city). Civil complaints, petitions, opinions on administrative authorities and trends are also collected as big data via social media. In addition, information provided by citizens on different public participation platforms that have been established in the city, including Seoul Online Civil Complains, Democracy Seoul and M-voting, is also collected.

The Digital Mayor's Office platform has been integrated into the daily operational routines of decision makers. The platform is used by the city Mayor to gain a quick and holistic report on the city and react to its developments. As both real time and historical data sets can be accessed and visualized, trends and special events can be identified and, even more importantly, understood by policy makers and citizens. These data insights have been used for different city interventions. Some insights have included the coordination of public transportation, planning bus route extensions, improving the efficiency of parking spot distribution, improving air quality, and planning locations for city bicycles.

Regarding the use of data to address the challenge of public parking in the city, Seoul has used mobility and transportation datasets, along with both real time and historical information on parking lot availability, to create a solution for its limited amount of parking spaces. Using an app, residents can register their parking space and the hours in which the space is free. When a space is free, other users can use it by paying an hourly fee. A part of the profit goes to the resident who is sharing their parking space. They also receive discounts for parking in other areas, and a better chance of being allocated a

more favorable parking space closer to their home once the parking spaces are reallocated. Data was also used to improve and better plan the city's bike rental service. As demand for bicycles increased, data was used to figure out the best place for placing new rental locations. Locations were identified by analyzing data on rental and return points, and by applying future modelling. This analysis also included data on other public transportation options in the surroundings. By doing this, the city could inform its decision on where to implement new rental points.

In Seoul, air pollution and fine dust are a significant problem. The city has been able to develop a wide range of services to overcome this challenge using data about environmental and atmospheric phenomenon. For example, data on air pollution in the metropolitan area, air pollution flow in Seoul and its neighboring countries was analyzed. Additionally, a time series analysis was used to identify peak air pollution times in the city. This combined analysis was used to gain a deep understanding of air pollution in the city and provided evidence for policy making. Furthermore, as old cars play a significant role in fine dust pollution, Seoul installed cameras with license plate recognition to identify and fine vehicles that are not allowed in the city.

Lastly, the Digital Mayor's Platform allows citizens to see data on 5 core municipal administrations and 62 municipal indicators. Besides this, they can see information related to disasters and receive instructions on how to react to emergencies. In those cases, on-site CCTV screens and related news can be viewed in real time, enabling citizens to respond quickly.

Challenges and Recommendations

This section highlights the key observations about the common challenges identified during our study. It also provides recommendation on how these can be met by local governments.

Challenges related to the implementation of data strategies

Challenge	Recommendation	Related best practice(s)
<p>Starting a Smart City project: There is tremendous hype in city halls and the media about making cities “digital” and “smarter”. However, there is no universal definition of what “smart city” means, let alone an established roadmap to becoming one. Topics around smart cities are complex and often focus on technology. This complexity might overwhelm decision makers tasked with setting the vision, strategies, and policies for smart city implementation.</p>	<p>Smart city projects do not come with a pre-establish size and set of ambitions. They are transformational initiatives and evolve hand-in-hand with the dynamics of their implementation. As such, planning for perfection and setting expectations too high can often lead to inaction. As seen in the case of the Municipality of Miraflores in Lima, cities can start their projects by first identifying compelling areas of action and focusing on small digital interventions or pilot projects that can be further developed and scaled up at a later date. Nevertheless, when starting small it is also important to think big. This means seeing each intervention, as small as it might be, as part of a coherent long-term strategy built around interoperability and open standards principles. In addition, national data strategies can be incredibly valuable for defining overarching priorities, roadmaps, and even tools for assessing data maturity in cities, as seen in the Data Maturity Assessment Framework provided in the India example.</p>	<p><i>Municipalidad de Miraflores (data intervention), Seoul (data strategy) , India (National Data Strategy)</i></p>
<p>Adjustments to local context: Transferring practices from one city to the next needs to incorporate considerations of local histories, politics, and cultures. The use of certain technologies might exceed the scope of particular data strategies or be incompatible with the city’s values. Cultural differences might also affect how cities look at their data governance and data privacy. For example, while some countries might ban the use of facial</p>	<p>Overall, there is no “one size fits all” solution. Practices which incorporate the local context and are subject to democratic oversight are most likely to be successful. In most cases, the process should integrate feedback from different stakeholders and citizens. For example, Melbourne asked its citizens whether or not they approved of the city using CCTV cameras for monitoring public safety. Choosing open vendor systems is also important for city councils that wish to be able to choose</p>	<p><i>Melbourne (data strategy), Jakarta (data intervention)</i></p>

<p>recognition, other countries might expand it.</p>	<p>vendors that best fit the city's vision. This consideration is also important for those cities engaging in city-to-city collaborations and networks.</p>	
<p>Internal resistance to open data: The process of sharing data and breaking data silos across governmental departments might encounter internal resistance of city staff. This can be due to fears of exposing mistakes and internal deficiencies in the data life cycle. Sometimes personnel might even resist the changes that open data brings to their daily routine.</p>	<p>Involvement of the different internal departments from the beginning of the process of opening data is key for achieving acceptance. Cities can portray the potential outcomes and advantages that open data could bring to citizens and highlight the advantages that it would bring to government employees (e.g. saving time, efficiency, insights). For many cities it is advised to take a stepwise approach in opening-up their data. Not all data needs to be disclosed to the public right away. However, providing access to datasets across city departments and service providers based on a sophisticated role and access scheme, enable city staff to improve service delivery and push for more innovative solutions.</p>	<p><i>Montreal (data strategy), Hamburg (data strategy), São Paulo (data intervention),</i></p>
<p>Communicating a data strategy: Communicating the technical aspects of urban data platforms and data-based solutions to citizens and municipal authorities that do not come in regular contact with data can be challenging. Innovation, the use of data and its potential to advance public interest can sometimes get lost in the midst of technical details and complex technological processes. Complicated narratives might be received with resistance and even fear, hindering the support needed for their success. The same accounts for abstract explanations about data architectures and digital solutions.</p>	<p>Cities need to exercise storytelling to show how data helps cities “do better”. Stories, as opposed to strategies, engage and motivate. Concrete examples of added value can be particularly helpful for communication purposes. For example, by highlighting actual instances where the Urban Data Platform Hamburg was been deployed, the city has built stories that focus on the product as a whole instead of on its technical architecture. Similarly, prototyping solutions and showcasing them to decision-makers, was the approach followed by MobiLab in São Paulo.</p>	<p><i>Hamburg (data strategy), Seoul (data intervention), São Paulo (data intervention)</i></p>
<p>Absence of a clear regulatory framework for Smart Cities: Cities and municipalities can sometimes lack foundational policies for sound deployment of technologies and data-based interventions. There</p>	<p>Policy frameworks in areas such as ICT accessibility, privacy, data protection, or open data need to be mainstreamed and adopted at national and local levels. Different governance environments will lead to different policy making</p>	<p><i>São Paolo (data intervention), Montreal (data strategy)</i></p>

<p>might be insufficient regulation in place to protect data. In some cases, cities lack the capacity and stakeholder coordination to coordinate the policies needed to fill these gaps. In other cases, cities implement cities implement sound policies, but fail to formally document them.</p>	<p>processes. City officials in charge of smart city initiatives should be conscious of the policy gaps exposed and be the ones to issue calls for action. In the absence of clear policies, creating new principles (and making them transparent) can be a helpful workaround³⁰.</p>	
<p>Political willingness and political resistance to policies for the common good: In the lifespan of a smart city project, political changes are bound to take place. Smart city projects are long-term and commitment beyond political cycles is essential for their success. However, political changes often imply alterations in the political agendas and priorities of the city, and can sometimes negatively impact the success and continuity of smart city projects</p>	<p>City data practices that have sustained implementation usually have a dedicated group of users that care about its continuity. Institutional set-ups can also support the continuity of smart city projects. Rooting a data or smart city strategy within an external advisory board consisting of representatives from civil society, higher education and local industry can foster independence from political cycles and build trust, co-innovation and ownership across several stakeholder groups. A range of cities, including Melbourne, Montreal, Hamburg, London, Amsterdam, and Barcelona have chosen this approach. Last, but not least, let facts speak for themselves: by tackling practical issues with data, cities can provide success stories and underpin them with numbers. There is no better argument than evidence. Thus, make sure to define clear sets of KPIs and monitor the success of your data-driven interventions in order to underpin your stories with compelling numbers. If you need inspiration for KPIs, there are great indicator frameworks.</p>	<p><i>Seoul (data strategy), São Paulo (data intervention)</i></p>
<p>Varying goals and regulations across levels of government: Municipalities might encounter issues where their goals and regulation for data usage and data protection might differ from those of other state regulated entities. For example, while municipalities might emphasize the need for personal data protection and privacy, police forces might</p>	<p>Data regulations and goals need to be integrated between the local and the state/provincial level. This integration should include considerations around the deployment of specific technologies, in the light of privacy considerations. For cities encountering this issue, the Melbourne approach of involving citizens in the decision of deploying (or not) facial recognition is exemplary.</p>	<p><i>Melbourne (data strategy), Municipalidad de Miraflores (data intervention, India (National data strategy)</i></p>

³⁰ Some best practices of cities that have set their own data principles include the Eindhoven smart society IoT charter (<https://data.eindhoven.nl/explore/dataset/eindhoven-smart-society-iot-charter/information/>), and the Montréal's Digital Data Charter (https://laburbain.montreal.ca/sites/villeintelligente.montreal.ca/files/25817charte_donnees_numeriques_ang.pdf)

claim the need for quick identification of criminal subjects through facial recognition.	However, continuous oversight and dialogue is needed to ensure a good integration across different levels in the long-run. In addition, data strategies at the national level can be powerful guiding forces to mainstream and define the fundamentals of the data approaches followed by cities	
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Challenges related to data governance and interoperability

Challenge	Recommendation	Related best practice(s)
Managing interoperability: Cities aiming to becoming smarter are challenged with making use of data collected from many different organizations and places. This data often comes in different formats that might compromise its interoperability and prevent data sets from “communicating”.	To achieve interoperability, cities need to refer to common reference architectures ³¹ as underlying design principles for urban data platforms, in addition to specifying data requirements for municipal organizations and third party suppliers of data. Reference architectures function as open standards and make sure that all platforms and components used can communicate with each other. In addition, cities should refer to established standards for metadata. There is a converging world of metadata standards that cities can refer to when describing datasets, such as DCAT-AP, INSPIRE (for geodata), or NGSI-LD ³² , (for real-time data and smart city data models). With both things in place – an urban data platform based on open standards and data-sets based on widely distributed metadata standards – interoperability will cease to be an issue in the long run.	<i>Hamburg (data strategy), Seoul (data Strategy)</i>
Ensuring data quality: As the city develops its data ecosystem and advances its vision for utilizing data, it is of great importance that datasets live-up to a high level of quality. Only	Beyond the things said about coherent meta-data standards, there are two key recommendations for data quality. 1) Make use of high-quality sensor data. A fast-growing number of data-driven	<i>Hamburg (data Strategy), Montreal (data Strategy),</i>

³¹ Compatible Common reference architectures include: ISO/IEC 30182:2017; DIN SPEC 91357; EIP SCC Reference Architecture; OUP+ Reference Architecture

³² The DCAT Application Profile for data portals in Europe provides a common specification for public sector data sets (https://ec.europa.eu/isa2/solutions/dcat-application-profile-data-portals-europe_en); the INSPIRE Directive addresses 34 spatial data themes needed for environmental applications (<https://inspire.ec.europa.eu/>); the NGSI-LD provides a standard interface for real-time data and smart-city data models (<https://rihab-feki.medium.com/all-you-need-to-know-to-create-your-own-ngsi-ld-data-model-e234b7ca3d22>).data models (<https://rihab-feki.medium.com/all-you-need-to-know-to-create-your-own-ngsi-ld-data-model-e234b7ca3d22>).

<p>then will real benefits emerge out of data-driven services. However, ensuring data quality is a challenging task since skills and resources are scarce and manual “data-plumbing” is a luxury most cities cannot afford.</p>	<p>applications are built on IoT and thus consume real-time data. Experience has shown that sensor quality differs a lot with regards to reliability and provision of accurate data. 2) Harness a use-case driven approach to data. Don’t spend time and money to collect and improve datasets if you do not know what to do with them. First, design the use case based on the challenges you need to solve. From there the necessary datasets can be defined and only then should time and resources be invested in achieving the highest data quality in a consistent way.</p>	<p><i>Seoul (data strategy)</i></p>
<p>Making open data useful: Open data platforms have been created in all of the cities included in the best practices in this study. Their provision is linked to a considerable amount of resources which are needed to provide high-quality data in a standardized, machine-readable and up-to-date way. The goal of these platforms is to increase transparency, and to drive innovation on the basis of the data provided. However, in many cities only a fraction of the data provided has been used to create city-related solutions. This can create imbalances between the costs for providing open data and the benefits it generates.</p>	<p>Only high-quality data (for example, machine readable, interoperable, clean, provided via an API) generates actual value for citizens and businesses. Taking into account the efforts and resources that assuring data quality implies, publishing a core set of data with good APIs might be a better approach than publishing high quantities of non-functioning data. Cities can provide request buttons on their open data portals and thus publish datasets that correspond to the demand. It might be an uncomfortable truth but one city by itself, even a large metropolis, is not a big enough market for new, data driven products and services. Only those datasets that are consistently available across multiple cities are interesting enough to become the basis of new, scalable data-driven products and services – and these datasets are usually produced by bigger companies and less by the cities themselves. The examples of Sao Paulo and Jakarta shows, however, that publishing high quality data as part of an integrative program (or hackatons) to drive innovative solutions together with start-ups, can be a great leverage to solve city challenges.</p>	<p><i>Hamburg (data Strategy), Seoul (data Strategy), Montreal (data Strategy), São Paulo (data intervention), Jakarta (data intervention)</i></p>
<p>Gaining access to third-party data: There are numerous sources of data in cities, and they do not all belong to</p>	<p>Cities can establish strategies to convince third parties to share their data. As a first step, cities should</p>	<p><i>São Paulo (data intervention),</i></p>

<p>city actors or city institutions. Nevertheless, municipal services can often be improved when municipal data sets are enriched by third-party data. Furthermore, this data often comes with data protection features that limit its use and sharing and can complicate the setup of bi-directional interfaces.</p>	<p>identify and map the third parties in order to recognize who can provide what kind of data. After that, it is necessary to understand how the city can provide a benefit and incentive to the data generating company (e.g. tax reductions or access to municipal data). In some cases, purchasing the data from the provider is also an option. Additionally, “Data partnership Agreements” are increasingly formed between cities, companies, and research institutions to ensure data exchange. Lastly, when working with city related contracts, data provisions (e.g. working with open source, when possible) should be included as conditions for awarding contracts. Cities should make sure, though, to not only include the provision of raw data, but also the provision of some basic analyses in the contracts with their service providers. In addition, promoting platforms for G2B data sharing, as seen in the DataSmart Cities Strategy of India is of high importance.</p>	<p><i>Montreal (data strategy), India (National data strategy)</i></p>
<p>Achieving a common understanding of data: Achieving an institutional data-sharing culture, a common understanding on what constitutes data and why and how it should (or not) be shared is a challenging task. Even well-established open-data initiatives can vanish if their value is not internalized, particularly by those who produce data as part of their daily workflow.</p>	<p>As the levels of data competencies greatly differ across the city staff that might be producing and collecting valuable data, focusing on language that is accessible (e.g. avoiding jargon) can prove useful when communicating the city’s data vision. Drafting user-friendly departmental guides to ensure staff understands the data approach and how performance and analytics can actually reduce workload should be considered. Cementing an organizational data culture requires investing in its development, appointing a data team, and understanding the internal landscape of data stakeholders.</p>	<p><i>Hamburg (data strategy), Melbourne (data strategy), Montreal (data strategy), Jakarta (data intervention), India (National data strategy)</i></p>
<p>Overcoming the deficit of citizens’ digital-trust: Although citizens often express their desire for more online services from governments, this is often accompanied by reluctance to share their personal information electronically. This paradox can pose a problem for initiatives that seek to</p>	<p>The lack of trust of citizens in the ability of their governments to keep their information safe can be counteracted by providing accessible, easy-to-understand information on what the governments do with data and how they ensure its protection. Additionally, citizens need to be convinced of the</p>	<p><i>Montreal (data strategy), Municipalidad de Miraflores (data intervention), Seoul (data intervention)</i></p>

<p>digitalize city services and offer digital alternative to otherwise long bureaucratic processes.</p>	<p>pay-off of sharing their data, which can be shown by highlighting the increase in efficiency and time-saving outcomes of digital interventions. More advanced cities enable their citizens to decide which data they want to share with whom. South Korea, for example, is working on a federated data ecosystem similar to the European GAIA-X initiative³³, which puts data sovereignty into the hands of the data-owner. By giving citizens an easy-to-use dashboard for activating and de-activating data-sharing with different applications and organizations, cities can build trust in their data-strategies and even apply incentive schemes: one example could be lowering ticket fares for public transport if citizens opt to share their movement data.</p>	
<p>Avoiding long-term vendor lock-in: When it comes to data management and operation of big-data analytics, cities can bind themselves to large corporations with long-term contracts and proprietary software. In the short term, this might provide the benefit of secure and stable big-data operations and the capacity of large corporations to run data-driven applications on a large scale. In the long term, cities might fall into a vendor lock-in that produces high costs and is less resilient.</p>	<p>Cities are advised to diversify their tech-and-infrastructure base and gradually build on open-source technology. Cities should, at a minimum, use open standards such as ISO/IEC 30141:2018 or DIN SPEC 91357 or quasi standards such as ETSI NGSI-LD to ensure interoperability and continued operation even if the service provider changes. This open-source approach can be seen in the specifications established for the procurement of the data platform in the Municipality of Miraflores. Common-good oriented data governance not only needs to make sure data is used as efficiently and all-encompassing as possible to deliver on well-being and sustainability, it also needs to weigh the advantages and disadvantages of various technology scenarios. Fortunately, open-source technologies for smart cities have now become widely available and increasingly match the robustness and scalability of proprietary solutions of large corporations.</p>	<p><i>Hamburg (data strategy), Montreal (data strategy), Municipalidad de Miraflores, Lima (data intervention)</i></p>

³³ The GAIA-X Initiative is working on the development of a federation of data infrastructure and service providers for Europe with stated aims of being efficient, competitive, secure and trustworthy (more information can be found at <https://www.gaia-x.eu/>)

Challenges related to resources and capacities

Challenge	Recommendation	Related best practice(s)
<p>Investing in digital infrastructure: Smart city strategies rely on infrastructure including hardware and software. The existence (or lack thereof) of sensor networks, fiber optic cables, IoT technologies, data analytic tools, data visualizations and data security systems often compromise the capacity of cities to implement their strategies. This task often implies not only incorporating new infrastructure in the city, but also updating old infrastructure to achieve interoperability. Furthermore, while investments are often expected to come from the digital unit of a city (which frequently have little to no budget), the benefits materialize in other domains (e.g. lower costs for departments of transportation or energy).</p>	<p>Municipal authorities have the power to accelerate the adoption of infrastructure and their capacity to invest in software and hardware. Each city should identify the investments that have immediate priority and gradually implement technologies. Local governments can develop partnerships with industry to support established information and communication infrastructure plans. This can be further supported by the development of policies and regulations that enable and incentivize industry to invest in digital infrastructure. The key to unlocking funds might be establishing proofs of concept with small pilot projects that deliver the right outcomes and help make the case for more investment. Lastly, cities need to adapt an approach that allocates a certain budget to their digital unit and find ways to relate the benefits created in other domains back to data-infrastructure.</p>	<p><i>Seoul (data strategy)</i></p>
<p>Developing technological competencies within the municipality: As cities and municipalities embark on the digitalization journey, the challenge of bringing municipal staff up-to-speed and ensure that the necessary digital competencies are acquired by all personnel in charge of working with new technologies can be very demanding.</p>	<p>The digitalization and incorporation of new technologies should always be accompanied by plans and strategies for training and knowledge transfer. Cities should identify the skill-gaps and develop training programs about digital tools for its staff. IT departments play a crucial role and, thus, should be included from the beginning of the process. It is also important to train staff in charge of handling data on privacy and data security matters. Many cities will find that it is hard to employ experts with the right set of skills and education – such as programmers, data architects or data analysts - since these are highly sought-after experts on the global job market and most cities do not stand a chance of competing for professionals with large corporations. It is therefore advised to build-up a trustworthy working-relationship with a set of service providers and expert companies who</p>	<p><i>Hamburg (data strategy), Melbourne (data strategy), Montreal (data strategy), Seoul (data strategy), Jakarta (data intervention)</i></p>

	are able to fill-in the gaps whenever needed.	
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Challenges related to orchestrating innovation

Challenge	Recommendation	Related best practice(s)
<p>Disrupting solutions and risk aversion: Adopting innovation and implementing disruptive new solutions is a difficult task that occasionally requires taking risks. This is often not well received by city administrators or policy makers.</p>	<p>Not all innovative changes can be successful and failures are an important part of the process. Communicating success examples is as important as recognizing failed programs and stopping them before more resources are invested. Creating test beds for disruptive technologies, with collaboration from government, industry and academia, might be an option for cities.</p>	<p><i>São Paulo (data intervention), Melbourne (data strategy)</i></p>
<p>Trusting innovation and small start-ups: There can be a tendency to associate big established companies with better solutions. For example, this mindset represented a key difficulty for MobiLab in Sao Paulo as the system tended to prefer expensive products from big companies. This belief of “expensive equals good” hindered the willingness to trust and embrace the (often much cheaper) solutions developed by small start-ups.</p>	<p>Education and capacity building of city staff in charge of engaging in procurement processes and operating and maintaining digital solutions is key to overcoming prejudices. Smaller companies are not only more flexible and creative when it comes to problem solving, they are often locally rooted, which means contracting them keeps the value of the public investment in local circulation. The incumbent procurement framework needs to be challenged to extend the portfolio of companies involved, and not limit it to only large companies. It is advised to start purchasing from smaller and innovative companies when it comes to services and solutions that can be operated separately from large infrastructure. When it comes to smart cities, this is often the case. Thus, data-driven interventions usually provide a great opportunity to bring new and innovative players on board.</p>	<p><i>São Paulo (data intervention)</i></p>

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Annex 1- Maturity Framework and Readiness Check for Urban Data

Data Readiness is a term used when speaking about the reliability, relevance and security of data. It is influenced by guidelines, processes, and organizational structures to support data management in companies and administrations. This Checklist was developed to help your city evaluate your data readiness, as well as uncover potential strengths and weaknesses regarding data readiness.

Answers to the following questions are to be given on a **scale of 1 (not existent) to 5 (fully deployed)**.

Governing data		1	2	3	4	5
1	A current data strategy exists.	<input type="checkbox"/>				
2	The data strategy is aligned with public bodies and recommendations from centers of excellence.	<input type="checkbox"/>				
3	Responsibilities for data handling are clearly allocated and separated from each other.	<input type="checkbox"/>				
4	Someone has been designated to be accountable for the collection, protection, and quality of data (data owner) and their responsibilities and rights are clearly defined.	<input type="checkbox"/>				
5	The duties and rights of staff who work directly with data are clearly defined and communicated.	<input type="checkbox"/>				
6	There are rules and guidelines that guarantee data protection.	<input type="checkbox"/>				
7	There are clear rules for embedding data provisioning and data ownership in municipal service contracts with 3 rd parties.	<input type="checkbox"/>				
8	The collection of data is transparent. Citizens can decide which data they want to make available.	<input type="checkbox"/>				
9	There is a unit that facilitates an improvement of municipal services (or the provision of new services) based on data (e.g., data intelligence unit).	<input type="checkbox"/>				
10	Policies, responsibilities, and accountabilities around the use and management of data are openly communicated to the outside world.	<input type="checkbox"/>				

Managing Data		1	2	3	4	5
1	There is an up-to-date inventory of data-sets available within the municipal organization.	<input type="checkbox"/>				
2	There is an up-to-date inventory of technical equipment and software in use.	<input type="checkbox"/>				
3	The city has agreed on an overarching architecture for the components of its digital system. It refers to open standards like ISO/IEC 30141:2018 or ISO/IEC 20547-3:2020.	<input type="checkbox"/>				
4	Both access to sensitive data and its location are defined and recorded.	<input type="checkbox"/>				

5	Open-Source applications and open standards are used where possible.	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>
	Value-added	1 2 3 4 5
1	Data is made available to other municipalities and to the public to promote public good.	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>
2	Guidelines are in place for the publication of data which consider data protection, the usefulness of the data and the availability of interfaces.	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>
3	Citizens and businesses are involved in decisions regarding data, in particular the use of data.	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>
4	Algorithms that refer to city data or have an impact on public spaces or public infrastructures need to be made made accessible to the public or open to verification from the municipality.	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>

Based on:
 - KGST Report 05/2021
 - Data Governance Checklist of the Privacy Technical Assistance Center, available at https://nces.ed.gov/Forum/pdf/data_governance_checklist.pdf

Annex 2- Taxonomy for Data Classification

Access	Collection	Personalization	Authorship	Format	Refinement Level	Dimension	Statistical Classification	Dynamic
Governance Relevance					Analytical Relevance			
Closed	Manual	Personal	Private	Open	Raw	Temporal	Quantitative	Static
Shared	Machine	Pseudo-anonymized	Companies	Proprietary	Processed	Spatial (2D)	Qualitative	Dynamic
Open	Crowd Sourced	Anonymized	Organizations	Standardized	Synthetic	Spatial (3D)		Real-time
		Not Personal	Research					
			<i>Official Entities</i>					

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