SMART MOBILITY FOR MEXICO CITY

BENEFITS OF AN INFORMATION MANAGEMENT STRATEGY
SMART MOBILITY FOR MEXICO CITY

BENEFITS OF AN INFORMATION MANAGEMENT STRATEGY
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# ACRONYMS AND ABBREVIATIONS

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<thead>
<tr>
<th>AEP</th>
<th>Public Space Authority of Mexico City.</th>
</tr>
</thead>
<tbody>
<tr>
<td>AGU</td>
<td>Urban Management Agency of Mexico City.</td>
</tr>
<tr>
<td>ALCDMX</td>
<td>Mexico City’s Legislative Assembly.</td>
</tr>
<tr>
<td>CDMX</td>
<td>Mexico City.</td>
</tr>
<tr>
<td>CGM</td>
<td>Mobility Management Center.</td>
</tr>
<tr>
<td>CIC</td>
<td>Computer Research Center of the National Polytechnic Institute.</td>
</tr>
<tr>
<td>CMM</td>
<td>Mario Molina Center for Strategic Studies on Energy and Environment.</td>
</tr>
<tr>
<td>COCETRAM</td>
<td>Coordination of Modal Transfer Centers.</td>
</tr>
<tr>
<td>CS</td>
<td>Command, Control, Computing, Communications, and Citizen Contact Center.</td>
</tr>
<tr>
<td>DCDIC</td>
<td>Directorate of Cyclist Culture, Design, and Infrastructure.</td>
</tr>
<tr>
<td>DGGTIC</td>
<td>General Directorate of ICT Management.</td>
</tr>
<tr>
<td>ESCOM</td>
<td>School of Computing of the National Polytechnic Institute.</td>
</tr>
<tr>
<td>GCDMX</td>
<td>Government of Mexico City.</td>
</tr>
<tr>
<td>GHG</td>
<td>Greenhouse Gases</td>
</tr>
<tr>
<td>GMC</td>
<td>Greater Mexico City.</td>
</tr>
<tr>
<td>GPS</td>
<td>Global Positioning System.</td>
</tr>
<tr>
<td>ICT</td>
<td>Information and communications technologies.</td>
</tr>
<tr>
<td>INEGI</td>
<td>National Institute of Geography and Statistics.</td>
</tr>
<tr>
<td>INFOCDMX</td>
<td>Institute of Transparency, Access to Information, Protection of Personal Data and Accountability of Mexico City.</td>
</tr>
<tr>
<td>ITDP</td>
<td>Institute for Transportation and Development Policy.</td>
</tr>
<tr>
<td>IPN</td>
<td>National Polytechnic Institute.</td>
</tr>
<tr>
<td>LABCDMX</td>
<td>Mexico City Lab.</td>
</tr>
<tr>
<td>M1</td>
<td>Mobility System 1 of Mexico City (formerly the Passenger Transport Network, RTP).</td>
</tr>
<tr>
<td>OBD</td>
<td>On Board Diagnostics.</td>
</tr>
<tr>
<td>OM</td>
<td>Mayor’s Office of Mexico City.</td>
</tr>
<tr>
<td>NGO</td>
<td>Non-Governmental Organization.</td>
</tr>
<tr>
<td>PPS</td>
<td>Provision of Services Projects.</td>
</tr>
<tr>
<td>RTP</td>
<td>Passenger Transport Network (now M1).</td>
</tr>
<tr>
<td>SAM</td>
<td>Mobility Analysis System.</td>
</tr>
<tr>
<td>SCT</td>
<td>Secretariat of Communications and Transportation.</td>
</tr>
<tr>
<td>SECITI</td>
<td>Science, Technology and Innovation Ministry of Mexico City.</td>
</tr>
<tr>
<td>Acronym</td>
<td>Description</td>
</tr>
<tr>
<td>---------</td>
<td>-------------</td>
</tr>
<tr>
<td>SEDEMA</td>
<td>Environment Ministry of Mexico City.</td>
</tr>
<tr>
<td>SEDUVI</td>
<td>Urban Development and Housing Ministry of Mexico City.</td>
</tr>
<tr>
<td>SEFIN</td>
<td>Finance Ministry of Mexico City.</td>
</tr>
<tr>
<td>SEMOVI</td>
<td>Mobility Ministry of Mexico City.</td>
</tr>
<tr>
<td>SISM</td>
<td>Mobility Information and Tracing System of Mexico City.</td>
</tr>
<tr>
<td>SLI</td>
<td>The Scientific Development, Technologic Development, and Innovation Local Information System of Mexico City.</td>
</tr>
<tr>
<td>SLT</td>
<td>Transparency, Public Information Access, Personal Data Protection, Open Government, and Accountability Local System of Mexico City.</td>
</tr>
<tr>
<td>SOBSE</td>
<td>Works and Services Ministry of Mexico City.</td>
</tr>
<tr>
<td>SSP</td>
<td>Public Security Ministry of Mexico City.</td>
</tr>
<tr>
<td>STC</td>
<td>Collective Transport System Metro.</td>
</tr>
<tr>
<td>STE</td>
<td>Electric Transport System.</td>
</tr>
<tr>
<td>TfL</td>
<td>Transport for London.</td>
</tr>
<tr>
<td>WRI</td>
<td>World Resources Institute.</td>
</tr>
</tbody>
</table>
The public mobility policies, adopted so far in Mexico City, have not been sufficient to counteract the economic, environmental, and social externalities that result from a lack of urban planning. It is urgent to consider in the planning process those elements that will allow to meet the mobility patterns of the population, considering essential aspects such as where people work, where people study, where people live, the mode and time of these trips, how many people travel on each route, how much does it costs to move from one point to another, among others.

By analyzing the interrelation between all these variables and their behavior over time, it is possible to make future estimates and thus to better plan the mobility of the city.

Smart mobility seeks to integrate these informative elements and to give them a purpose, a practical end, through the use of information and communications technologies (ICTs). An efficient data management facilitates the creation of descriptive and predictive analyzes, which have a direct impact on urban mobility solutions. This implies that the first step to generate them is to know the current state of mobility information in the city: who generates data, who consumes them, and what are the mechanisms used in each case to enable this communication. Starting from this knowledge, the information needs can be known and intelligence strategies based on standards to create, use and share data can be designed. It is precisely these information-based-strategies that give us the opportunity to plan truly smart cities.

In the case of Mexico City, the different actors that generate or use mobility data are extremely disconnected from one another, to the extent that in many cases they do not know what information others have or what part of the information they generate and it is not analyzed can greatly improve
the user experience and the transportation systems operation. This can be explained by the lack of clarity and specification of the norms and laws that govern interaction between actors; laws such as mobility, e-government or transparency have some general guidelines for information management but they still lack a set of procedures. Due to this lack of legal clarity it is also common for each unit to have a technical area that handles ICT per specific parameters that limit interoperability between dependencies or actors. All of this generates independent decision-making, even though by joining efforts the amount of work every actor does may be less and the benefits to the population more noticeable.

This situation also represents a large opportunity area to help solve at least three issues: the inefficient operation of public transport, bad user experience in transport systems and inefficient operation of the road network. To take advantage of these opportunity areas through smart mobility solutions, it is necessary to adopt three different strategies based on information management:

**Strategy 1.** Improve government information management capabilities.

**Strategy 2.** Create an integrated transport system.

**Strategy 3.** Create a mobility information management system.

In order for these strategies to be successful, they must be translated into four public policies or specific actions by Mexico City’s government.

- Standardization of payment methods and public transport tracking technologies in Mexico City, beginning with government-operated transport and continuing with contracted transport. This implies a change in the licence grant model.

- Implementation of the Mobility Information Management System already contemplated within the Mobility Law of Mexico City.
Establishment of protocols for the generation and exchange of information with contracted transport, non-traditional transport operators and other sources of mobility information.

Adoption of guidelines and complements for the use of open mobility data, which will allow the information exchange between the different actors involved in the city’s mobility and to encourage innovation.

A sample of the improvement opportunities in a public transport system, thanks to an efficient information management (collection, storage, and trip management) and open data policies is the SAM-Ecobici pilot project. This project takes advantage of the data generated by Mexico City’s public bicycle system to create a demand analysis and forecasting platform that can be used to rebalance the system using predictive analysis; which demonstrates tangible benefits to government, operators, and users. This example has the potential to be scaled to mass transit systems, maximizing the benefits for the entire city.

Given that Mexico City is promoting a new paradigm of mobility, focused on reducing the use of private cars, it is also time to take advantage of the use of information and communication technologies to generate smart mobility and thus obtain the greatest social benefits. Benefits that allow Mexico City to move towards a more sustainable development model with greater social equity.
INTRODUCTION

The Smart Mobility project in Mexico City seeks to facilitate the adoption of information management strategies and the implementation of new technologies to make the city’s transportation systems more secure, efficient, and sustainable, and to allow their integration.
In this way benefits for public and private operators can be generated, by reducing operating costs resulting from inefficient management; at the same time facilitating the governmental action of transport services rectory by simplifying the processes of monitoring, evaluation and therefore planning. However, the subsequent beneficiary are the transport systems users that can see transfer times being reduced or have accurate information in real time that allows them to make the best decisions regarding each trip they choose to take. The virtuous cycle is completed with generalized benefits that can be measured in emissions of pollutant gases reduction or in traffic incidents reductions.

Implementing such an ambitious agenda is not a simple task, or a quick one, there are too many dimensions in which the benefits of ICT in the mobility sector can be made tangible. This report focuses on what can be achieved with data analysis strategies (information management). For this, the following section presents the definition of smart mobility and the importance of adequate data management, its benefits, and best international practices. Then, the third section describes the institutional framework in the subject and the processes associated with it, and it also presents a diagnosis of Mexico City’s inventories and information needs, which includes the data that the government has and that can be used in an information management strategy.

The fourth section presents a road map that establishes a catalog of needs and a suggested order for the implementation of technologies that will allow the transition towards smart mobility in Mexico City. The fifth section describes a practical case or pilot project of an information management strategy that improves the efficiency of transport systems and allows data to be exploited for the user’s and city’s benefit. This project was developed concurrently with this research work and its progress allowed to put into practice some postulates that are shared in this document. The Computing Research Center (CIC) of the National Polytechnic Institute (IPN) is in charge of developing the pilot project and in its first stage the focus is to help to make the Ecobici operation more efficient and improve the Cyclist Culture, Design, and Infrastructure Directorate (DCDIC) of the Environment Ministry (SEDEMA) planning processes.

The sixth section focuses on the political and institutional transformations that must be carried out to push the smart mobility agenda, thus it incorporates a series of strategies and public policy recommendations that respond to the institutional framework that the Mexico City’s Government has. The seventh and last section gathers lessons learned throughout the project and invites to think about the use of ICT and information management strategies in mobility.
This investigation began on June 1, 2016 and will turn almost 9 months on the presentation day of this report. In addition to the cabinet work, the process included a workshop in which high level representatives of 17 government agencies from Mexico City participated; a series of semi-structured interviews with some of the main heads of local transport systems; continuous advice to the pilot project, SAM-Ecobici; workshops with international experts for public officials, social entrepreneurs, representatives of the private sector and academia; and the first steps to implement an information and task management system in the Ecobici control center that should be monitored to prove its effectiveness and generate new learning.

The improvement opportunities for transportation systems that are not being tackled due to the lack of high quality data or a government agenda specialized in the field are huge. Telemetry and data analysis technologies have come a long way and their costs have dropped significantly. The importance of this research lies in making these opportunities evident, promoting a strategy for their use and the development of a pilot test that can be replicated in any structured urban transport system and in the offices of the transport planners of this city and every other major city in Mexico.
SMART MOBILITY, LOCAL EXPERIENCES, AND BEST PRACTICES

Mexico City and its metropolitan area have undergone urban sprawl without adequate planning or sufficient investment in their transportation and mobility systems.
This has generated a fragmented public transport system and driven the growth of car use with negative consequences for society: death due to traffic accidents, air pollution (with deaths and related diseases), generation of greenhouse gases (GHG), road congestion, auditory contamination, loss of productivity, social fragmentation, and so on. (ITDP, 2012 & 2014).

This problem can be addressed through “smart mobility” strategies. In other words, with the adoption of technological systems, based on information and communications technologies (ICT), that allow the inhabitants of a city to have more control of their access to transport and a more efficient use of their time. ICT also allows city planning authorities to plan and control the various urban transport options more efficiently (ITDP, 2016).

To achieve a functional smart mobility frame, the coordination and exchange of information of the different modes of transport, including buses, metro, trains, public bike systems, among others is required. For this to happen, the generation, control, operation, and access to Big Data and Open Data, where necessary, is required. A network that collects and analyzes information from companies and institutions operating in the city and that provides each the layers that compose the mobility system, information that can be used to optimize the total system, is also required (see Figure 1).

**FIGURE 1.** The five layers of smart mobility functions

This goal of smart mobility is to facilitate the mobility of people and goods within a city, which generates six main benefits:

1. Traffic reduction
2. Travel time reduction
3. Travel costs reduction
4. Pollution reduction
5. Auditory pollution reduction
6. Trip safety increase

An illustrative example of smart mobility solutions is the integration and planning of London’s public transport system. The public transport has a unique payment card that can be used on buses, trains (both urban and suburban) and the cable car in the city and its surroundings (users can also use an “app” instead of a card). The underground is pricing is distance based, which requires users to scan their cards both when entering and leaving the system, and, as a fortuitous consequence, provides TfL with the origin and destination data of travelers using this system. However, London buses charge a flat fee per trip, users do not have to scan their cards on exit, causing the destination data of those users not to be captured. To provide a solution to this gap, Transport for London (TfL) has created a mass data analysis tool that combines location data and bus tickets to infer source-destination pairs, creating a set of multimodal travel data. The resulting information has been used to restructure transport routes in some areas of the city (Weinstein, 2016; Gordon, 2012), this without the need to resort to costly and time-consuming travel origin-destination surveys.
The transport smart card works for subway, buses, trains (urban and suburban) and cable car. An “app” can also be used to pay instead of a card.

The subway’s pricing is distance based, users scan the card when entering and leaving the system.

On the other hand, buses charge a flat fee per trip, users do not have to scan their cards when leaving the system.

For example, to infer origin-destination data instead of making a survey which is expensive and slow.

Transportation of London combines bus location and ticketing data to infer origin-destination data, creating a set of multimodal travel data.

Source: ITDP

In the same way, all the 700 bus routes of the city are operated by private companies under a Provision of Services Projects (PPS) model and, for public control and performance monitoring, each bus is equipped with a Global Positioning System (GPS), acquired, placed, and integrated by TfL. With this the massive data can be used to improve the system management. In the case of a road block or closure of a transport route, the data is used to predict the impacts of this on the network and to communicate the users the best routes to take in this new situation (the least busy, fastest, etc.). TfL also uses historical big data to calculate trends, enabling the prediction and prevention of traffic accidents (Wrinstein, 2016). Most data are available to the public, through an open data policy, to encourage the creation of new public solutions, foster innovation and create business opportunities (see Box 1).

This is an illustrative example of what an smart mobility strategy can do to improve public transport in Mexico City. It should be remembered that the later is highly fragmented, both within the administrative boundaries of the city and in its metropolitan area (see Ta 1). Only the subway, light rail, metrobus and public bicycle system use the same smart card; and metrobus is the only one that has a control center and real time geolocation. The rest of

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1 Information obtained from John Barry, TfL’s Head of Network Development for buses, in an interview on November 10, 2016 in Mexico City.
2 The subway has a control center, but it is based on other types of technologies and does not give the user a lot of information.
the transport systems, which cover most of the public transport trips, either do not use a smart card (minibuses, M1-RTP, trolleybuses and mexicable), or use their own card that is not compatible with the city’s card (suburban train and mexibus).

### TABLE 1. Public transport and public bike system in Greater Mexico City

<table>
<thead>
<tr>
<th>MEXICO CITY (DF)</th>
<th>METROPOLITAN AREA (State of Mexico, Hidalgo and federal areas)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Governmental Private</td>
<td>Governmental Private</td>
</tr>
<tr>
<td>Subway</td>
<td>Subway train</td>
</tr>
<tr>
<td>M1-RTP</td>
<td>Buses and contracted routes</td>
</tr>
<tr>
<td>Electric Transport System (Trolleybus and light rail)</td>
<td>Mexicable (Cable car)</td>
</tr>
<tr>
<td>Metrobus</td>
<td>Mexibus</td>
</tr>
<tr>
<td>Ecobici</td>
<td></td>
</tr>
</tbody>
</table>

Source: ITDP

Indeed, this public transport fragmentation and its associated problems can be solved through the implementation of smart mobility strategies; as well as helping solve many other mobility problems, regardless of the means of transport. In this context, the next section looks at the current situation regarding the use of mobility data in Mexico City, to establish strategies and recommendations that allow the adoption of smart mobility in this city.
TfL decided to implement an open data system that would allow technical, commercial and legal viability to third parties who are interested in the development and innovation of services related to London transport. The aim is to offer reliable and up-to-date data to all users who wish to know information concerning transfers in London in any means of transport and at any time. In addition, open data systems promote the technological development of small, medium, and large companies, which in turn benefits the country’s economy. In this way, the availability of TfL data serves as fuel for innovation.

**HOW DID IT COME ABOUT?**

The tax financed public data set generated questions in London citizenship, and requests were made to open the data to avoid subsequent payments. TfL, in conjunction with the government, recognized the potential benefit and innovation that could be generated with an open data system.

**HOW DOES IT WORK?**

Previously, the information provided by different transport means was gathered in different standards; making it difficult to apply this to multimodal services and applications. Now, with an API (Application Programming Interface), TfL processes, standardizes and unifies the information so that the result is easy to process, use and apply. Among the information available to developers exists data for travel planning, road blocks, schedules, routes, lines, topographic and geographic information, among others.

TfL, in order to encourage innovation that could not happen if the information is restricted or hidden, offers the following basic guidelines to provide data: information is provided free of charge, open government license, there is no supplier contract, does not require documents to accredit the developer’s extra official recognition, it is forbidden to act on behalf of TfL, it asks people to reference it correctly and it urges developers to use the color palette in the design of the applications and services created.
WHAT CAN THE RESULTS BE?

The free opening of data was done with the intention of promoting innovation, proposals that are not yet known and could not have been developed without the information that TfL is sharing. So far, the information has been used for different applications, such as multimodal travel planning, in private and academic research spaces, geo referencing and mapping, city traffic dashboards, associations (ex. Waze-TfL) and even artistic installations. Until now, these mediums have already delivered results concerning travel planning, air quality, stations location and services, subway information, parking lots, road and highway information, among others.

WHO BENEFITS?

The information allows the transport system daily users a more critical view of the service and the possibility to follow and even demand results based on the decisions that are made regarding the transport in London; competition is generated resulting in the application of the best solution; and transparency, that goes from the very operation of the transport to the proper application of the solutions generated from the open data; finally, users who use open information benefit from the data which is being provided by themselves.

On the other hand, the more than 8,500 developers who have registered for the use of open data have created research, applications and jobs that benefit the British economy. Being free, information has propitiated its use in small and medium enterprises that do not need to invest to start producing products and services. Information delivered in a standardized and “easy” format way has also been a manner to encourage developers to work with open data.

Overall, more than 42% of Londoners are already benefiting from more than 500 applications, getting information of transfers in the medium and at the moment they need it.

Source: Elaborated with information from Oliver O’Brien, Associate Researcher at University College of London (UCL)
CURRENT SITUATION IN MEXICO CITY: SMART MOBILITY AND INFORMATION MANAGEMENT

The analysis of the current situation is divided in two parts: The first one analyzes the institutional framework that governs transport systems and the information they generate to account for the rules and those responsible of implementing smart mobility policies. The second part presents a diagnosis of the data generated by transport services providers and local public administration agencies that can be used in an information management strategy, the actions that these agencies carry out to exploit their data and the capabilities of those to implement smart mobility strategies.
3.1 INSTITUTIONAL FRAMEWORK FOR DATA AND MOBILITY

The institutional framework of Mexico City, as the country’s capital, is governed by Article 122 of the Federal Constitution, which previews new actors with the creation of Mayorships and the Metropolitan Development Council starting in 2018. At the local level, CDMX has a variety of laws and regulations that have direct influence on any smart mobility policy being pursued. As shown in Figure 3, the current administrative structure in Mexico City provides similar, complementary and, in some cases, contradictory powers to different authorities.

Figure 3. Authorities responsible of data management in CDMX

Source: ITDP
An example of functions being duplicated is that both the Mayor’s Office⁴ and SECITI⁵ are empowered to develop new ICT that allow a more efficient administrative processes inside the agencies as well as to finance the acquisition of tools that allow the storage of large volumes of data. Another example is identified with INFOCDMX⁶, the Mayor’s Office and the Urban Management Agency, through LABCDMX⁷, since all are empowered to force the remaining dependencies to disclose public information in an open data format. Hence, to carry out an efficient data and information management a regulatory improvement that harmonizes the existing legal framework with federal policy, together with the publication of a unique regulation with specific action protocols between the different agencies, centralized or decentralized, of the local public administration will be necessary.

FIGURE 4. Agencies responsible of managing mobility in the CDMX

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⁴ See; Article 8 of the Electronic Government Law of the Federal District
⁵ See; Article 7 of the Law of Science, Technology and Innovation of the Federal District.
⁶ See; Article 111 OF THE Law on Transparency, Access to Public Information and Accountability of the CDMX.
⁷ See; Article 10 and 25 of the Law to make Mexico City a more open City.

Source: ITDP
To sum up, Figure 4 serves as an x-ray of the key centralized agencies during the proper management of smart travel. SPP, SEDEMA and SEDUVI have concurrent responsibilities in the planning, monitoring and evaluation of mobility policies, a scenario that allows them to individually manage the traffic light systems, parking meters and Ecobici, respectively. There are also several decentralized agencies such as the subway, metrobus and the Electrical Transmission System (STE) that act on their own for the operation and provision of the service, but they do directly respond to the policies dictated by SEMOVI as head of the sector.

It should be noted that the Mexico City’s Legislative Assembly (ALCDMX) proves to be a key actor, since it has the necessary powers to dictate normative instruments on urban transport, public roads, parking, science, innovation, technology, and transparency in city governance. It is important to highlight that the ALCDMX examines and, if appropriate, approves the budgetary impact on the organizational structure changes proposed by the Mayor, which is a determining factor for carrying out the institutional restructuring that implies a information and smart mobility management policy.

3.2 DIAGNOSIS OF THE USE OF DATA FOR THE MOBILITY MANAGEMENT IN MEXICO CITY

The diagnosis focuses on the understanding of the use of technology platforms currently used by the different actors involved in the generation and use of mobility information for its management and exploitation. To carry out this work, the Information Management Strategy methodology was used, Appendix 1 of this document describes in detail the process of this methodology. The results are presented per the five technical pillars that form the basis of any information technology platform: existing information sources, information architecture, maturity of information management capacities, exchange of information and other initiatives (See Appendix 1).

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8 See: Article 15, 24, 26, 31 and 40 of the Organic Law of the Public Administration of the Federal District.
9 See: Article 18 of the Budget and Efficient Expenditure Law of the Federal District.
10 This strategy is based on the methodology Information Management Strategy (IMS) developed by Intellego.
3.2.1 EXISTING INFORMATION SOURCES

It was analyzed whether the institutions and organisms that generate information on the public transport and road (traffic) operation have or do not have the information of the ideal data model. To this purpose, these institutions and transport organizations were classified in two: structured (routes and well-defined stations -subway, metrobus, light rail, trolleybus-) and non-structured (dynamic routes and stations –contracted transport and taxis-). In the case of instances involved with road information they were classified in two: road system and traffic/mobility.

TABLE 2. Source matrix of transport information generators

<table>
<thead>
<tr>
<th>Information component / Transportation mode</th>
<th>Structured Transport</th>
<th>Non-Structured Transport</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Subway</td>
<td>Metrobús</td>
</tr>
<tr>
<td>Ticketing Data</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Users entering and leaving the system information (time and location)</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>End user profile (sociodemographic)</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>Transport operation data</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Profile of drivers (sociodemographic and others)</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>Schedules planned by route</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>General information about transport stations</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>Sensor information at transport stations</td>
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<tr>
<td>Geolocation of transport units</td>
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<td>●</td>
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<tr>
<td>Data relating to transport units</td>
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<td>●</td>
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<tr>
<td>User payment data</td>
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<tr>
<td>Payment information (amount and time)</td>
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<tr>
<td>Payment information associated with end user</td>
<td>●</td>
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<tr>
<td>Integration of ticketing data with other means of transport</td>
<td>●</td>
<td>●</td>
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<tr>
<td>Unification of payment method in system</td>
<td>●</td>
<td>●</td>
</tr>
</tbody>
</table>

● Full information available  ○ Partial information available  ○ No information available

Source: ITDP
Table 2 shows the diagnosis performed\textsuperscript{11}, from which the following general conclusions can be made.

**Means of transport:**

- No means of transport exists that has all the information requirements that are needed to form a robust information management system. That is, no means of transport has complete information management system. That is, no means of transport has complete information on the users’ transactions, the operation of said transport system and the respective financial data.

- Structured transport presents more systematized information sources completeness than the not structured one (trips made, financial information, etc.). However, there are new non-structured transport systems, such as digital taxi platforms (Uber and others), which present more completeness in this respect (georeferenced data, distances, and travel times, etc.).

- Non-structured means of transport, such as traditional cabs, combis, or minibuses, have a practically null degree of systematization of information maturity. This means that they do not digitally systematize any data that account their operations.

- It should be clarified that any transport out contract forces the holder to present useful generated information to SEMOVI. Although this has not happened since the Regulation of the Law of Mobility has not yet been published.

**Road operation:**

- The only government agency that generates road data is the Public Safety Ministry of CDMX, however, not all traffic lights are integrated into a digitized data generation system.

- Although INEGI has generated origin-destination surveys, this information is only available for a sample of the population and the periodicity is very wide (10 years or more).

- Telecommunications companies and navigation platforms have very important mobility data. However, these are not shared with other actors like the government in its regulator role.

\textsuperscript{11} The table corresponding to the generators of road information can be consulted in the document “Technical Diagnosis of the State of Mobility in Mexico City”
Information components:

- The existing information regarding Mexico City’s road system is partial. This because the entirety of the traffic lights system is not digitized. Therefore, no information is generated regarding what happens at such crossings.

- Information related to general population mobility data could be very complete, but most of it is found in the information systems of private actors, which do not share them with the other entities involved (governmental agencies and means of transport).

- An important problem with transport data is the identification of the means of transport used by a citizen during a trip. While INEGI’s origin-destination surveys contain some of this information, telecommunication companies and navigation platforms have mobility data at citizen level (but it is still not easy to identify which means of transport is being used).

- There is information available from most modes of transport, such as information on user payments or operational information on their routes (drivers, routes, etc.) but in general there is a degree of completeness below most of the requirements and sources of an information management system.

- Transactional data that allow us to associate the use of a transport route to a particular user, practically do not exist. Similarly, having the profile of such user is not possible for almost every means of transport.

- Integration of information sources between different transport means and systems is practically non-existent. This is because there is no integrated entry, exit and collection systems between the different mobility options in the city. Not even among structured public transport systems. The only degree of integration in this sense is found in the subway, metrobus, light rail and Ecobici systems in which case it is possible for a user to use the same payment card indistinctly. However, in the first three systems, no output data is generated since it is not necessary to scan the card when leaving the system.
3.2.2 INFORMATION MANAGEMENT ARCHITECTURE

For each institution and organization related to the city’s mobility, the technical architecture they use to process information was analyzed by identifying the three main components of the information management architecture: database, business intelligence tools and mathematical and statistical tools or packages\(^{12}\). From this diagnosis, the following conclusions could be established:

**Databases**

Most public and private actors, whether information generators or consumers, have systematized databases, which represents a good practice in terms of information management. However, in most cases, such databases originate directly from the used systems and do not have data warehouse repositories that work to preprocess information and then exploit in an automated way. In most cases, there are no formal processes or robust quality and information standardization tools.

**Business Intelligence Tools**

Regarding this component, in almost all the institutions and organizations consulted Excel is used as their main information visualization tool. In almost all cases it is used to make periodic or on-demand reports that give account of generic indicators for different areas of the organization. There is no case of a robust internal practice dedicated to the automated and recurrent construction of indicators, reports or dashboards that account for the behavior of their particular context.

**Mathematical and statistical tools or packages**

In almost every instance interviewed, Excel is also used as the primary information analysis tool. It was not observed any case where it is used to make prediction or optimization models to exploit the data. Even those instances that have statistical analysis packages have a very low level of exploitation of these tools because they are used to make calculations of basic indicators, not predictive models. There are exceptions such as Sin Tráfico and Mario Molina Center, which have modeling capabilities, nevertheless, both are not public sector institutions.

\(^{12}\) The Table that explains the detail by instance can be consulted in the document “Technical Diagnosis of the State of MOBILITY IN Mexico City”
Although the agencies interviewed represent only a sample of the institutions that generate information that can be used in smart mobility strategies, there is not evidence to suggest that the situation is different in the agencies that were not considered in this sample.

3.2.3 MADURITY OF INFORMATION MANAGEMENT CAPABILITIES

The capacity of the different stakeholders in the process of generating and analyzing transport and road information was rated. The results are shown in Table 3 which shows a separate rating for each one of the five pillars of information management:

<table>
<thead>
<tr>
<th>Data platform: how complete is the information they have.</th>
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<tbody>
<tr>
<td>Technical architecture: what is the status on the technological tools that they have.</td>
</tr>
<tr>
<td>Analytical: do they have or not business intelligence and advanced analytics initiatives.</td>
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<tr>
<td>Management and Government: do they have an automated practice of quality and data governance.</td>
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<tr>
<td>Tangible Solutions: do they have tangible applications, in this case limited to end users.</td>
</tr>
</tbody>
</table>
### TABLE 3. Maturity of initiatives or information management capacities matrix

<table>
<thead>
<tr>
<th>Pilar</th>
<th>STRUCTURED TRANSPORT</th>
<th>NON-STRUCTURED TRANSPORT</th>
<th>TRAFFIC</th>
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<td>Subway</td>
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<td>Metrobus</td>
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<td>M1</td>
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<td>Ecobici</td>
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<td>Electric Transport</td>
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<td>Uber (others)</td>
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<td>Taxis</td>
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<td>Buses</td>
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<tr>
<td>Micro-buses</td>
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<td>Combis</td>
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<td>Road Network</td>
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<tr>
<td>Mobility</td>
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</table>

- 🟢 They have mature capacities for this pillar
- 🔴 They do not have capacities for this pillar and are unlikely to be implemented in the short term
- 🔵 They do not have capacities for this pillar but they are feasible to be implemented in the short term
- 🔴 🔵 They have partial capacities for this pillar but need to be improved

Source: ITDP

In most cases, there are no formal processes and robust quality and information standardization tools. In the same way, business intelligence efforts are carried out. However, these capabilities are very basic and there are no tools or methodologies that automate and strengthen this analytical component. Practically no advanced analytics tools are used to solve sophisticated prediction, segmentation, or optimization problems. Significant part of traditional informal transport has a null degree of maturity in terms of information management (all pillars).

On the other hand, the actors that provide services based on digital platforms present the greatest advances in technological capabilities: Uber (and similar businesses) and mobility platforms (Waze, Google, telecommunications companies).
3.2.4 INFORMATION EXCHANGE BETWEEN INSTANCES THAT OWN OR CONSUME MOBILITY DATA SOURCES

The degree of interaction between the different interviewed actors was identified, taking as a reference the exchange and integration of mobility information. It was concluded that the level of exchange is not so low if we observe the total number of instances that exchange information with each other. The problem is that the periodicity and formality in which such exchanges occur, as it does not necessarily point to an optimal information management system.\textsuperscript{13}

In general, there are no automatic information exchange mechanisms. Requests and extractions of specific information are performed. With some few exceptions, there is no integrated transport information management system, neither at the operational level nor at the transactional level, much less at the transport end users level (profile, destination, payments, etc.).

Similarly, the exchange of information between public and private actors is almost non-existent. There is no formal information exchange between organizations such as telecommunication companies or mobility platforms (Google or Waze) with Mexico City’s government. For example, INEGI continues to conduct origin-destination surveys, although private initiative actors could provide a very large part of that information, such as mobile phone companies or mobility applications that collect georeferenced data from their users. This could complement origin-destination surveys and could provide some of the information they generate in a timely and more frequently manner.

3.2.5 INICIATIVAS DE GESTIÓN DE INFORMACIÓN EXISTENTE

In addition, the special information management initiatives mentioned by the interviewees during the survey meeting were identified\textsuperscript{14}. On these, it is clear that structured public transport systems (subway, metrobus, STE and Ecobici) are looking for ways to digitize the payment method to have systematized transactional information. As well, there are many citizen efforts to build apps that improve the quality of transport. Despite this, the few projects involving advanced data analysis are led by ONGs or private corporations. Also, in general, there are very few projects aimed at strengthening the technological platforms of information management.

\textsuperscript{13} The matrix that accounts the exchange of information between instances that own or consume mobility data sources can be consulted in the document “Technical Diagnosis of the state of mobility in Mexico City”.

\textsuperscript{14} The table listing all the initiatives can be consulted in the document “Technical Diagnosis of the State of Mobility in Mexico City”.

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3.3 GENERAL CONCLUSIONS OF THE DIAGNOSIS

The general conclusion points to the little degree of development that exists in terms of information management capacities both for those involved with the generation and for the consumption of data on mobility, specifically on transport and road network.

Although there is a widespread tendency to have systems that count with digital databases, there are no robust tools to store, process, clean and analyze such information. Practically, there are no actors who possess optimal technological information management tools. About:

- Databases are stored in generic storage managers as they come from sources and there are no central data repositories that clean and order the information to be optimally exploited.

- With few exceptions, advanced visualization\textsuperscript{15}, and analysis tools concentrate, in the best of cases, on the use of Excel.

- There are virtually no actors with advanced components for information management, such as structured massive data storage (Big Data) or artificial intelligence analytical tools.

The few players who present some degree of sophistication in terms of information management tools are data consumers, licenced transport services and a few number of instances.

- Data consumers (NGOs or research organizations) who are not generators of mobility data and their work is not directly involved in the operation of mobility. Due to this, their contribution in this area does not necessarily directly affect improvements in the efficiency of the transport and the road or the experience of the end users.

\textsuperscript{15} The General Directorate of Urban Intelligence of the Urban Management Agency has SAS analytics and the General Directorate of Governance of Information and Communications Technologies of the Mayor’s Office has advanced software for the management of databases.
Licenced public transport operator (Uber and similar) which are not operated directly by the government. They are transport platforms of recent creation and are mounted in a completely digitized paradigm. The problem with these actors is that they do not share the mobility information they have with other actors, especially with government agencies for which such information would represent a very important benefit.

Instances that have mobility information because of their operation, but are not directly involved with their operation. For example, the Public Security Ministry, mobile phone companies or companies that provide mobile Waze-type traffic applications. In this case, the problem again is that these actors do not share the mobility information they have.

This generalized situation leads to a large area of opportunity to solve at least three problems:

**Operational inefficiency of public transport.** Many of the structured transport operators are ready to implement analytical solutions (business intelligence and advanced analytics) which could directly affect the efficiency of their operation. Likewise, these transports are prepared to move towards an integration at an operational level that will allow the collected data to have an even greater impact on the efficiency path of its operation. Finally, there is a large opportunity area for informal transport to start systematizing information in order to professionalize its operation.

**Poor user experience in transport.** Structured transport operators are also ready to implement solutions that provide end users with information that enhances their transportation user experience. In fact, most of them are even developing or going to develop mobile applications for their users.

**Inefficient operation of the road system.** The way in which many of the decisions to optimize the road network (traffic lights, road agents, etc.) are currently being managed does not always use analytical inputs. Here there is also a large opportunity area to integrate data from stakeholders such as mobile phone companies or companies that provide mobile traffic applications (Waze type) so that road operators have data on city traffic in a way that allows them to analyze it to optimize decisions. This information could complement and improve that generated by origin-destination surveys; as well as optimizing its development costs.

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16 Transport operators such as metrobuses or M1 have monitoring capabilities, creation and management of digital information, however, they do not have a digital information management platform on which to completely base their operation as is the case of Uber and similars.
Derived from the findings of the diagnosis, the following strategy divided into three consecutive levels of intervention is proposed for Mexico City.
It is important to point that this strategy requires the implementation of a series of components based on the five pillars of information management (see Appendix 1 for further information on these pillars) and should be adopted in the short, medium, and long term to establish a robust mobility information management system. In Figure 5 it is possible to schematically see this roadmap and a description for each recommendation classified per the five pillars of information management.
FIGURE 5. Implementation roadmap of the mobility information management strategy for CDMX

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<td>Final User Solutions</td>
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- **2017**: Construction of mobile app for users
- **2018**: Demand planning, segmentation of commercial strategies, Maintenance and creation of new user cases
- **2019**: Segmentation of commercial strategies, Integration with central data repositories, Maintenance and creation of new indicators, reports and dashboards, Creation of real-time reports integrating sensor data
- **2020**: Indicators, reports, and dashboards for the operating area, Integration of sensor information into transport units, Integration of sensor information into transport stations and units
- **2021**: Indicators, reports, and dashboards for the strategic planning area, Integration of sensor information into transport units, Integration of sensor information into transport stations and units
- **2022**: Creation of real-time reports integrating sensor data, Integration of sensor information into transport units, Integration of sensor information into transport stations and units
- **2023**: Indicators, reports, and dashboards for the finance area, Integration of sensor information into transport units, Integration of sensor information into transport stations and units
- **2024**: Indicators, reports, and dashboards for the marketing area, Integration of sensor information into transport units, Integration of sensor information into transport stations and units
- **2025**: Integration of new functionality

Source: ITDP
For public transport services operators:

1. **User identification at the entrance and exit of the transport system (with a payment method).** Placing a digitize payment system that tracks the beginning and ending of trips in a way that can such information be systematized.

2. **Placement of sensors in transport stations.** Placing motion, traffic, weather, etc. sensors in transport stations and systematize the storage of the captured data.

3. **Placement of sensors in transport units.** Placing sensors (GPS, OBD) on transport units that account for their movement and their efficiency indicators at a mechanical and electric component level and systematize the storage of the captured data.

For road operators:

4. **Placement of traffic sensors.** Placing motion sensors (cameras and others), and updating existing ones, at different points on the road infrastructure to measure flow and traffic.

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**DATA SOURCES**

For public transport services operators:

1. **User identification at the entrance and exit of the transport system (with a payment method).** Placing a digitize payment system that tracks the beginning and ending of trips in a way that can such information be systematized.

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For road operators:

4. **Placement of traffic sensors.** Placing motion sensors (cameras and others), and updating existing ones, at different points on the road infrastructure to measure flow and traffic.

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**TECHNICAL ARCHITECTURE**

5. **Creation of a data warehouse.** Construction of a data repository that allows the information to be cleaned, standardized, and centralized from different sources in a digital form so that it is possible to be consulted. In the medium and long term this repository must become a Data Lake that allows storing large volumes of unstructured information.

6. **Business intelligence tool.** Implementing technological tools that allow the visualization of data from graphs and tables in dashboards.

7. **Statistical tool.** Implementing a mathematical analysis tool that allows the analysis of the information to establish segmentation, prediction, or behavior patterns optimization scenarios.
Operations, finance, marketing, and strategy planning. Design, construction and implementation of indicators, reports, and dashboards for each of the operations, finance, marketing and strategy planning areas.

For road operators:

Road agents optimization. (Where, when, and how many road agents will be needed)

Traffic lights optimization.
**MANAGEMENT AND DATA GOVERNANCE**

19 **Data quality.** Implementation of data quality process so that they can be consumed reliably.

20 **Master catalogs.** Cleaning and optimizing master catalogs project to have standardized databases.

21 **Data Governance Center.** Implementation of an area responsible of information management.

**TANGIBLE SOLUTIONS**

22 **User app.** Transport user mobile application that includes at least: transportation schedules, transfers, estimated distances and times, estimated costs, transportation use, optimal routes, system map and complaints and alarms.

For each of the three levels of intervention, each of the proposals above were rated based on a periodization methodology that allows them to be ordered over time. This ranking was built using two periodization components: strategy impact and technical feasibility. In turn, each of these components contain several periodization subcomponents.\(^{17}\)

Once each subcomponent has been rated, a final ranking is generated that allows us to establish whether this particular initiative should be implemented in the short, medium or long term. This methodology allowed defining, for each intervention level, a final projects roadmap for the implementation of a robust information management platform\(^{18}\), which can be seen in Figure 5.

\(^{17}\)The detailed prioritization methodology and the ranking tables of initiatives for each level of intervention can be consulted in the document “Technical Diagnosis of the State of Mobility in Mexico City”.

\(^{18}\)The rest of the critical routes generated (one per level of intervention) can be consulted in the document “Technical Diagnosis of the State of Mobility in Mexico City”
As noted, in this case, the priority initiatives that should be part of the implementation in the short term are:

- Development of business intelligence and advanced analytics solutions.
- Implementation of specific business intelligence initiatives and specific uses for advanced analytics.
- Implementation of an area responsible for information management.

These are the initiatives that must be performed for those agencies that generate information on transport in the short term to begin to give results and strengthen their information management platform.\(^{19}\)

\(^{19}\) Once the general strategy for managing mobility information for the different levels of intervention in Mexico City was defined, a series of methodological recommendations were presented for the implementation of the initiatives on the five pillars of information management. The specific recommendations can be consulted in the document “Technical Diagnosis of the State of Mobility in Mexico City”.

Ecobici is the public bicycle system of Mexico City. It allows users to take a bicycle of any cycle station, make trips of up to 45 minutes (without any additional fee) and then return it to another cycle station; process that can be repeated as many times during the same day. To access the service, you need to have a subscription that can be up to one year or as short as one day.
The system started operating in 2010 with 84 cycle stations and 1200 bicycles and it now has 452 cycle stations and more than 6000 bicycles, representing an expansion of approximately 400%. This makes it the second largest system in Latin America with more that 35 thousand trips a day. The system has become so popular that, even with the continuous growth it has had, demand is such that users sometimes find gaps in the system, specifically the lack of bicycles in some popular cycle stations, close to mass transport systems or places of high work density, or lack of free anchorages in the cycle station to leave the bicycle.

Ecobici was chosen to generate a tangible example of the improvement potential in a transport system, using the information management strategy mentioned in the previous section. The main advantage of the public bicycle system compared to other options is that it has a solid base of technical and technological capabilities, especially data sources, technical architecture and analytics. The improvement in the operation of the Ecobici system through the pilot project focuses on automating processes, such as calculating the reorder point of each cycle station or choosing the routes used by bicycle loading trucks to rebalance the system. The ultimate intention is that the Ecobici service operator, Clear Channel, will use these new capabilities to provide customer service improvements in the form of fewer empty or full cycle stations, which, in turn, leads to more trips that start and end in places the user prefers and not in stations that divert from the ideal route. For the operator, it also brings benefits such as more efficient loading and unloading routes that imply fuel savings, and an increase in the levels of service and satisfaction.

Based on these objectives and capabilities, an advanced analytics web tool called the Mobility Analysis System or SAM was built. It is a digital tool created by the Computer Research Center (CIC) and the Computer Science School (ESCOM) of the National Polytechnic Institute (IPN), with support from ITDP, tailored to the needs of the Cyclist Culture, Design, and Infrastructure Directorate of SEDEMA. This tool uses the open data of the Ecobici public bicycle system to analyze it and express it visually, in order to facilitate their understanding for the decision-making process.

The data used by SAM are: date, time and cycle season when entering the system, date, time and cycle season when leaving the system, bicycle number, gender and age of the user. Data that is provided monthly on the Ecobici website and with which the following visualizations were developed:

- Graph of historical trips per station average.

- List of longest trips (in distance), with the total number of trips and their percentage of growth over time.

- Matrix of commuting trips (round trip between home and work or studies center) and the characteristics of users who perform them.
- List of most frequently used cycle stations (for rebalancing functions) and least used (for relocation).

- Bar chart showing total trips per year and month.

- Pie charts showing percentage of trips by gender and age range.

- Displays per station showing arrival and departure trips, gender and age of users.

- Graph showing connectivity between stations.

- Map with the location of stations.

- Heat map showing the weekly connection between stations.

**FIGURE 6.** Screenshot of the visualization per station

Source: IPN-CIC.
In addition to being an informative system, SAM includes advanced analytics capabilities to make it a smart system for the visualization and analysis of Ecobici, in order to optimize the allocation of reorder points of every system station. In other words, SAM’s objective is to be able to optimize the operation of the transport system by means of automating processes, such as calculating the reorder point of each cycle station, since the distribution process previously used as base a basic analysis of the quarterly behavior of the system but the deviations at any time from that base were corrected manually. SAM now delivers an hourly estimate of this reorder point using all the historical information available until that point in time.\textsuperscript{20} The demand \textbf{predictive model} is also adjusted to receive further variables in the future, such as weather conditions, road blockings, or traffic events, and in this way deliver even more accurate results.

The additional process that is optimized is the choice of routes used by bicycle loading trucks to rebalance the system. Initially this process was done manually, in other words, two operators used a table that reported the difference between the number of bicycles in each station and their optimal number and instructed the drivers to which station take the bicycles next. SAM performs this same process automatically and using more variables for this decision making, such as: straight line distance information between all the stations and, during peak hours, requests for information are made to Google to know the travel time between two stations that need a bicycle transfer.\textsuperscript{21}

\textsuperscript{20}The steps to achieve this were: 1) Create a data model. 2) Develop an automatic system. 3) Design and define indicators to exploit the information for the desired purpose. 4) Design and build a prediction model that allowed optimizing the bike’s rearrangement. 5) Integrate the model into the SAM web application.

\textsuperscript{21}The reason why information of travel times is only requested during peak hours is due to Google Maps policies that dedicate that a user is limited to 2500 system information requests per day.
The direct benefit of this solutions consists in reducing the use of resources to balance the Ecobici system. That is, operating expenses are reduced to know where to move bicycles according to travel needs and allows SEDEMA to have a better supervision of the operation of the system. This translates into more resources potentially aimed at solving problems that directly impact the user experience. Likewise, this is reflected in benefits for Ecobici users by reducing the times when stations are completely empty or full. This, in turn, brings further benefits to the operator and to the users, as would be:

- Reduce total travel times
- Reduce uncertainty
- Avoid users choosing to use another means of transport when they arrive at a cycle station without a bicycle or to a cycle station without free anchorages to perform the return.
These system operation improvements are reflected in the quality of the service, which also encourages more people to decide start using Ecobici as their main mean of transport or as a complement in some of their travel segments. Thus, creating intermodal travel and offering a mobility alternative that may be more convenient and attractive than the use of a private car.

**FIGURE 8.** Screenshot of the bicycle rebalancing table

Source: IPN-CIC.

The importance of the SAM tool lies in its ability to adapt, using the same data analysis and visualization methodology, to create solutions aimed at other transport systems, such as the metrobus or the subway, due to its ability to systematically collect operational data, or maybe, solutions to new problems of the Ecobici system and the intermodality with those transport systems.

By having a transport systems environment that use intelligence and analytics to make decisions two purposes will be served. The first concerns government, to optimize the operation of transport systems. This optimization has several aspects: to increase transport systems safety, to reduce fuel consumption and thus emitted pollutants, to improve transport times, to increase the availability of transport, to expand transport networks based on intelligence, to decrease operating costs, among others. As more and more transportation systems begin to use tools like SAM, more of these benefits will become a reality in Mexico City. The second is external to the government, SAM implementation could allow quality information to be within reach of the general population, which solves users’ doubts regarding the use of transport in its different forms in the GMC by creating dynamic queries open to the public.
The system for predicting demand and reordering of bicycles will be used by the Ecobici operator to help streamline the service and its functions. The pilot project will be operational until mid year and after this trial period culminates, the improvements and adaptations built to the operator and users needs will be made so that this tool will continue to be used for the benefit of Ecobici, and probably, in the future, of other public bicycle systems in Mexico.
RECOMMENDATIONS FOR THE ADOPTION OF A SMART MOBILITY SYSTEM

During the development of this research, a series of actions and processes were exposed that could exploit traffic and transport systems data and technological resources to make CDMX transport systems more efficient, secure, and sustainable, or, well, to facilitate their integration.
These actions and processes have been grouped into public policy recommendations that can be classified into two categories, technology adoption (recommendation 1) and process adoption (recommendations 2 to 4), according to each one’s approach.

These recommendations are presented in an optimal sequential order that will simplify their implementation. However, it is also possible to implement technology adoption and process adoption strategies in parallel.

Recommendation 1.

STANDARDIZATION OF PAYMENT METHODS AND PUBLIC TRANSPORT MONITORING TECHNOLOGIES IN MEXICO CITY

The first step towards smart mobility is for all means of transportation operated by Mexico City’s government to adopt the use of smart card payment. This would imply that such payment system would be installed in M1 public bus system and STE trolley buses. It would also require that in each of the city’s public transportation systems (where Ecobici may or may not be included) devices (GPS) will be installed to obtain their location in real time.

This first step will ensure the generation of information necessary to integrate the whole of the public transport system in charge of Mexico City’s government and to be offered to the public as open data in order to promote social innovation. The result would be to be able to improve the quality of service, to make a better planning and to be able to establish other policies in the future, like providing information of the service in real time, targeting subsidies to specific groups of users, fees per distance, among others. This requires a centralized information system and an operation control center, which is addressed in recommendation 2, and includes the contracted public transport, which is addressed in recommendation 3.

Finally, it is widely recommended that the Mexico City’s Government, through SEMOVI, realizes an agreement to coordinate actions with the Mobility Ministry of the State of Mexico to promote the standardization and the use of a single payment system with the GMC’s massive public transport systems, we are referring to mexibus, suburban train, mexicable and the future Mexico-Toluca\(^{22}\) train. This would allow extending the benefits of a smart mobility policy to the entire GMC.

\(^{22}\) Rail projects such as the Mexico-Toluca train are the exclusive responsibility of the federal authorities. As provided in articles 25 and 28 of the Federal Constitution, the SCT will be empowered to coordinate the single payment scheme in conjunction with the federative entities.
Recommendation 2.

IMPLEMENTATION OF THE MOBILITY INFORMATION AND MONITORING SYSTEM AND THE MOBILITY MANAGEMENT CENTER

The task of generating, storing, processing and analyzing quality data on mobility in Mexico City must have a strategy that unifies the efforts of the different actors involved to optimize resources and obtain the benefits from their exploitation. For this to happen, it is necessary to create an information management system within the city government that is the responsibility of a single institution.

In this sense, the Mexico City’s Mobility Law establishes the creation of a Mobility Information and Monitoring System (SISM) and a Mobility Management Center (CGM), operational center of the integrated transport system. In order for this to work in a central fashion, the necessary attributions must be granted to SEMOVI though the Mobility Law regulation. At the same time, the CGM should also have the authority to establish the content, format, and periodicity in which the rest of the authorities, institutions and agencies will transfer the transport and mobility data to the centralized model.

It is important to note that the SEMOVI must formalize a single protocol for extraction, transformation, channelling, and data loading with all the dependencies and competent bodies of the local administration. This unique protocol will serve as the institutional interoperability mechanism that validates the collection, storage, and processing of data.

It is highly recommended that the CGM takes advantage of the data center currently managed by the DGGTIC of the Mayor’s Office, which already has the installed capacity and data management tools needed not only to extract and store the Information on transport and mobility of the city, but to exploit it with business intelligence and advanced analytics solutions. This will allow the publication of data from applications aimed at different types of users.

The CGM should define use cases that directly impact on mobility processes within the city and then establish the characterization of the data needed, the sources from which they come. This definition must be supported by concrete benefits that can be reached from the use and exploitation of the information that is intended to be centralized, this is why the storage logic must be progressive In fact, this platform must be consistent with the e-government policy promoted by the Head of Government and thus tyo efficiently manage the data contained therein.

23 The Federal District’s Mobility Law in its article 47 states that SEMOVI will operate the SISM, but the regulation of the law has not yet been published.
24 As provided in Article 8 of the Electronic Government Law of the Federal District.
The process described above (use cases identification, information sources identification, loading, processing and analysis of information, and publication of results) must be continuous and the management platform must be scalable in the future to respond to a progressive logic of further incorporating information and use cases.

The CGM should continue to identify new use cases related to concrete benefits for the different actors involved with the city’s mobility, so that the SISM is constantly evolving in terms of new sources of information to be included and new ways of exploiting it to insert analytical inputs into processes that are optimized by their use. The infrastructure provided for this system by DGTTIC must respond to this model of scalability, so the paradigm of infrastructure and platform as a service in the cloud is highly recommended.  

Recomendación 3.

ESTABLISHMENT OF GENERATION AND EXCHANGE OF INFORMATION PROTOCOLS WITH CONTRACTED TRANSPORT, NON-TRADITIONAL TRANSPORT OPERATORS AND OTHER MOBILITY SOURCES OF INFORMATION.

Any technological effort to centralize information must be coupled by a series of mechanisms that guarantee that the information flows from its origin to this platform. In the field of transport and mobility there are some fundamental data sources which are not always available for public use and there should be some mechanisms that guarantee this.

CONTRACTED TRANSPORT

Any agreement to out contract a public means of transport must ensure that all generated information from providing such service is shared with the city government. Not only aggregated information that accounts for some processes, but all the generated information at the highest level of granularity (operational data, transactional data, sensor data, customer data, etc.). In this sense, in the case of contracted public transport (ex. Microbuses), technology (like GPS) should be installed to generate information on the trip and technology to integrate that will allow payment of them with the Mexico

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24 For the specific case of transport information of the city, the process described above should be anchored in a parallel process of transport system integration, so that the information management platform that is intended to be built, whether operated by the same SEMOVI from the CGT or the defined governing body of the integrated transport system, could take advantage of this effort.
City's smart card. The implementation model for such a policy could take many forms, either by the city government, where the government owns it and the concessionaires are obliged to install it; or the installation is the responsibility of the contracted company and agreements are established so that the generated information is shared with the government and its truthfulness is guaranteed.

**NON-TRADITIONAL TRANSPORT OPERATORS**

In the case of non-traditional transport operators, such as individual and collective transport services based on digital platforms, they must also share information of their operation. Although in this case, the information that is shared, as well as the level of granularity of the same, can be negotiated, due to matters regarding confidentiality and added value of the operators themselves, accountability mechanisms of important information that can be used to improve the mobility of the city must be required. An example is Sao Paulo, Brazil, where the prefecture created a regulation for companies that offer public passenger services with on demand platforms. Under this regulation, a tax was created based on the kilometers traveled through a credit system and forces the companies of this type of services to share some data such as the time, distance, maps and routes of each trip (origin-destination), the identifications of the drivers and the fees.

**OTHER SOURCES**

There are numerous information sources that can account for mobility within the city or that can help complement it, which come from actors outside the field of transport or road network. For example, information on urban mobility owned by telecommunication companies or information on health and safety in relation to transportation that different government agencies have. In this case, it is desirable for there to exist collaboration agreements and open exchange of information, so that the different stakeholders can contribute to the centralization of the mobility information.

It is important to point out that it is also necessary to create a normative and institutional framework that avoids the exclusive storage of information (by private service providers) and at the same time generates economic incentives for the collection, storage and use of information for public purposes.

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26 For more information on this regulation see City of SAO Paulo (2016)
Recommendation 4.
ADOPTION OF GUIDELINES AND SUPPLEMENTS FOR THE USE OF OPEN MOBILITY DATA

The implementation of the above recommendations implies the creation of mobility databases in Mexico City, which is why it is essential that it must be accompanied by an open data policy that allows innovation by both the public sector and private actors, including civil society (See SAM-Ecobici, Section 4).

This policy is already underway through Mexico City's open data portal, although it would be important to establish certain guidelines for its release (regardless of the institution in charge of publishing the data) in such a way that they are not used for purposes that could harm the public interest, as well as for their proper use. An example is the case of Transport for London (TfL), that releases open data free of charge, operate under the government license of open data, they must be assigned to TfL and it is recommended to use the official color palette. Although there are information restrictions, such as the stipulation that no personal data is released, nor is it possible to freely use typography, logos and created images (such as the subway map). This in order to avoid confusion or in the case that someone intends to release information as if it was official (TfL, 2016).

Likewise, it is required that the published data contains structures that are designed to support a logic of continuous and scalable consumption. It is important that before being published data structures are defined to ensure that the consumption of such source is optimal from an information management perspective. Such structures should be well documented (variables, catalogs, scale, etc.) and maintained over time so that their consumption can be periodic and scalable (periodic updates of new information). Mechanisms such as APIs or web services would be much more useful to publish this information and facilitate it being constantly updated for those who need to consume it.

27 In the United Kingdom, the Open Government License for Public Sector information is used and it that establishes that when using the open data of any public entity the conditions of this license are accepted. This includes the conditions of uses and restrictions of the information, as well as the legal definitions and implications of the use of UK Government Open Data. For more information, see The National archives (2016).
Intelligent mobility is an opportunity to generate the transformations in urban mobility that cities need to solve many of the challenges they face today that are directly related to the lack of adequate planning, such as pollution, traffic congestion or road safety, to mention a few.
For this to happen, it is required, among other measures of public policy, that the departments responsible of urban planning and mobility, which, on one hand, are generating information and at the same time lack information because they lack of coordination, adopt an efficient information management strategy. One of the main challenges to be resolved in this regard is the low degree of development and incentives to adopt it.

Although there is a widespread tendency to have systems with digital databases, there are no robust tools to store, process, clean and analyze the information generated. The few actors who present some degree of sophistication in terms of information management tools are data consumers (private enterprises), some taxi services (Uber, Lyft, Yaxi, Easy Taxi) and a few instances that have mobility information such as a result of their operation, but are no directly involved with their operation (such as SSP, mobile phone companies or providing mobile Waze type traffic applications).

This generalized situation leads to a large opportunity area to help solve at least three problems: the operational inefficiency of public transport; bad user experience in transport, as well as inefficient operation of the road system. To cover these areas of opportunity, it is necessary to adopt a comprehensive information management strategy for Mexico City’s mobility, along with complementary open data policies that allow the construction of smart mobility in the city.

This is possible to achieve as demonstrated by the SAM-Ecobici example. In which the use of an information management system improves the management of the public bike system, with benefits for both operators and users. Since this is a pilot project, it is clear that bringing it to the rest of public transport, contemplating intramodality, would generate much greater benefits.

Given that Mexico City is promoting a new paradigm of mobility, it is also time to take advantage of the use of information and communication technologies to generate smart mobility and in this way obtain the generated social benefits, which will generate a city with sustainability and social equity.
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OTHERS

Open Data CDMX http://www.gobiernoabierto.cdmx.gob.mx/sigdata/index.php/Publicacion/index

Open Data Ecobici https://www.ecobici.cdmx.gob.mx/es/informacion-del-servicio/open-data

Transport for London https://tfl.gov.uk/
The data-collection strategy, based on the information management strategy method, is based on **five technical pillars** that conform the base of any information management technologic platform:

**DATA PLATFORM**
Data is the base of any successful project. The data platform should consider the data sources and their integration structure.

**TECHNICAL ARCHITECTURE**
Hardware and software are comprehensive parts of any information management platform. The right tools must be chosen and an architecture, that warrants scalability, performance, integration and cost efficiency, needs to designed.

**ANALYTICS**
This component permits the extraction of information inputs from the data analysis, in a way that can be translated into decisions that directly impact the way organizations operate.

**DATA MANAGEMENT AND GOVERNANCE**
No information analysis effort is complete without the definition of an organizational structure behind it. It is necessary to define the necessary capacities to carry out the initiatives the organization requires.

**TANGIBLE SOLUTIONS**
The delivery of tangibles solutions should always be considered. This means that any information management method should start from the final user needs.
On the basis of such conceptual pillars, the method is constituted by six work stages, which have been implemented in the context of Mexico City’s mobility information.

1. **Initial preparation.** The instances that participated in the data-gathering: government, private enterprises, organized civil society, etc. Afterwards a detailed work and interview programme were created.

2. **Analysis context discovery.** Information gathering sessions with the responsible of data initiatives on each instance were performed.

3. **Information flux and existing initiatives evaluation.** A diagnosis of the way information is managed in every interviewed instance was made. For this purpose, the existing information sources and the way all this information is processed and analyzed, within the framework of the 5 method pillars, were identified.

4. **Information flux design.** The main components that should make up the data architecture that supports the needs were identified, following data management best practices.

5. **Initiative definition.** The new technological capacities to implement were selected using the prioritization criteria that the method defines: priority alignment and technical viability.

6. **Implementation and initiative integration plan.** An implementation strategy was designed based on the initiative prioritization in stages.
To perform the presented diagnosis and the strategy in this six stages a data model or structure was used, that included two main information components that account a city’s mobility:

**TRANSPORT:** information relative to the transport infrastructure, public and private transport in all its organization levels of a city: trips, users, operation, infrastructure, etc.

**TRAFFIC:** information relative to a city’s road network, or, in other words, the concrete use of the transport infrastructure: commute routes, user’s volume, use flows, etc.

For each case information subcomponents, that create the base of the diagnosis data model and the mobility information data management, were considered.
APPENDIX 2
GLOSSARY

ADVANCED ANALYTICS: Analytics focused in predicting future events based on historical data, allowing business and organizations to predict the effects of potential changes in their business strategies. Some examples of advanced analytics are: predictive analysis, data mining, big data, and location intelligence.

ANALYTICS: The discovery, interpretation and communication of substantial patterns in a data base or data series.

API: An application programming interface (API) is a set of subroutines, functions, and procedures (or methods) that offers a certain library to be used by another software as an abstraction layer.

ARTIFICIAL INTELLIGENCE: Multidisciplinary area that combines branches of science such as logic, computation, and philosophy that is in charge of designing and creating artificial entities that are able to resolve problems or creating tasks by themselves, using algorithms and paradigms of human behavior.

BIG DATA: Storage of large quantities of data and the procedures used to find patterns among these.

BUSINESS INTELLIGENCE: Group of strategies, applications, data, products, technologies and technical architectures, which are focused in the administration and creation of knowledge about the medium, through existing data analytics in an organization or company.

BUSINESS SOLUTIONS: Integration of database, data analysis, processes and programming languages tools to make actions and plans tailor made for the strategy of each organization.

DATA GOVERNANCE: Complete data management in every way, organizational, architectural and political of the company or organization.

DATA LAKE: Repositories where information in its original format and before being classified is stored.
**DATA MODEL:** Language that describes: 1) Database structures: the type of data that is located in the database and the way they relate to each other. 2) Security restrictions: a set of conditions that data must achieve to reflect the desired reality. 3) Data manipulation operations: typically, operations of addition, erasure, modification and recuperation of databases.

**GEOLOCATION:** Capacity to obtain and know the real geographical location of an object.

**HARDWARE:** Tangible physical parts of a computing system, its electric, electronic, electromechanic and mechanic components.

**INFORMATION MANAGEMENT:** Discipline in charge of everything related with obtaining adequate information, in the right way, for the right person, at the right cost, in the needed moment, in the appropriate place and articulating all these operations for the development of a correct action.

**INFORMATION MANAGEMENT ARCHITECTURE:** Study, analysis, organization, disposition and structure of information in information repositories, and the selection and presentation of data in interactive and no-interactive information systems.

**INTEGRATED TRANSPORT SYSTEM:** Articulated set of different means of passenger transport existing in a city, structured to provide a reliable, efficient, comfortable and safe service that allows to mobilize users with a high quality standard, access and coverage in all the city.

**MASTER DATA:** Represents the business objectives shared within an enterprise or organization. They can cover static reference data, payment data, unstructured data, analytical data, hierarchical data and meta data.

**METADATA:** Group of data that describe the informative content of an object which is called a resource.
ROADMAP: Diagram of steps with time periods and necessary resources to achieve an objective.

SCALABILITY: Desirable property of a system, network or process, which indicates its ability to react and adapt without losing quality, or to manage continuous work growth in a fluid manner, or to be prepared to grow without losing quality in the services offered.

SOFTWARE: Set of necessary logic components that make it possible to realize specific tasks.

TECHNICAL ARCHITECTURE: Formal description and representation of structures and behaviors of the technical organization of an information strategy or system.

TECHNICAL VIABILITY: Condition that makes it possible for the system, project or idea to functioning properly, attending its technological characteristics and the laws of nature involved.