THE DIGITALIZATION OF PUBLIC TRANSPORT IN MEXICAN CITIES

EXECUTIVE SUMMARY

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EXECUTIVE SUMMARY

The Importance of Digitalizing Public Transport in Mexico

The transport sector is the largest producer of greenhouse gas (GHG) emissions in Mexico, accounting for approximately 25% of total emissions. Additionally, transport emissions have a negative impact on people's health. A key factor is the low quality and inefficiency of public transport services, which has resulted in a high reliance on private vehicles. To contribute to the Sustainable Development Goals, it is crucial to implement public transport services that are high-quality, inclusive, safe, and environmentally sustainable, effectively competing with private cars. Digital technologies and smart mobility solutions are pivotal in modernizing Mexico's public transport infrastructure. The latest trends in digitalization, such as 5G networks, the Internet of Things (IoT), artificial intelligence (AI) and blockchain applications, are having a significant impact on various sectors of society and businesses, and the public transport sector is no exception. The impact of digitalization on public transport spans across multiple dimensions, both within organizations (e.g., efficiency improvements, need for new skills and competences) and in their relationship with users (e.g., improvements in service quality and reliability).

Key Digital Technologies for Public Transport

Digital Solutions for Transport Administrator: Digital Government

This category includes technologies whose main impact is in the government. Digital government solutions include digital communication and citizen participation tools, electronic tendering systems, and open data portals. The primary users are transport authorities and engaging stakeholders including transport operators, technology providers and public transport users.

Digital Solutions for Transport Planning

Technologies in this category aim to accurately match transport supply with expected mobility demand. These include big data analytics for studying mobility demand, transport modeling and simulation tools, geographic information systems (GIS), and data visualization tools. Transport authorities are the primary users of these technologies.

Digital Solutions for Transport Operations

This category includes all the technological solutions used in daily transport operations: operation man-

agement tools (e.g., operational support systems), vehicle technologies (e.g., occupancy measurement systems, driver assistance systems, road safety solutions, crime protection solutions, and emerging mobility services (e.g., shared mobility systems), among others. The primary users of these technologies are transport operators.

Digital Solutions for Public Transport Users

This group includes technologies aimed at public transport passengers, such as information services, digital payment methods, journey planners, mobility as a service and connected mobility solutions.

Assessing the Level of Digitalization of Public Transport: Evaluation Framework

To identify the digital technologies that best contribute to the mobility objectives of a city or region, **it is first necessary to assess the current level of digitalization of public transport.** This requires an evaluation framework that makes it possible to understand the baseline situation, assess the impact of future decisions, and determine to what extent the expected effects will be achieved. Based on an exhaustive literature review and extensive consultations with various public transport stakeholders in Mexico, this study proposes the use of **a set of qualitative indicators** that facilitates the application of the proposed framework and allows for comparison between cities.

The proposed indicators are grouped into five categories: (i) indicators related to the legal and institutional framework; (ii) indicators associated with digital governance; (iii) indi-

cators related to transport planning; (iv) indicators related to transport management and operations; and (v) indicators of service reliability, accessibility, and usability. For each indicator type, a set of potential values is proposed to enable comparisons across different contexts.

To summarize the different stages of digital transformation of public transport, a digitalization index is proposed, consisting of a weighted average of the various indicators that considers their relative importance. The following **levels of digitalization** have been identified to determine each evaluated city's status:

Initial Digitalization. The city is in the early stages of planning and implementation of digital solutions for public transport components and processes.

Intermediate Digitalization. The city has digitalized some components and processes, including aspects of operations and user interaction.

Advanced Digitalization. The city has digitalized most of its public transport components and processes, including administrative aspects.

Consolidated Digitalization. Nearly every component and process has been digitalized, and the city has been using these technologies for several years.

Family of Indicators	Weighting	Digitalization Level			
		Initial	Intermediate	Advanced	Consolidated
Legal and institutional framework	15%	0-2.49	2.5-4.99	5-7.49	7.5-10
Digital governance	15%				
Informed planning	20%				
Intelligent management	25%				
Service reliability, accessibility, and usability	25%				
Global index	100%	0-2.49	2.5-4.99	5-7.49	7.5-10

Digitalization of Public Transport in Mexico: Institutional Context

In Mexico, public transport responsibilities are largely decentralized, managed primarily by state and sometimes municipal governments, leading to a fragmented institutional landscape due to lack of strong federal coordination. Although there are ongoing efforts by the Ministry of Infrastructure, Communications, and Transport (SICT) to coordinate public transport management, their impact on legislation and regulation to standardize responsibilities and practices remains limited. Meanwhile, the Ministry of Agrarian, Territorial, and Urban Development (SEDATU) has advanced initiatives such as the General Law of Mobility and Road Safety (LGMSV), published in the Official Gazette of the Federation (DOF) and entered into force as from May 2022, as well as the development of the National Mobility and Road Safety Strategy (ENAMOV), approved by the National Mobility and Road Safety System on June 22 and published in the DOF on October 10, 2023.

The LGMSV (Articles 27-30) emphasizes the need for promoting technological progress and efficient data management. The ENAMOV, in its section 'Public Transport Services for People,' outlines various actions and instruments targeting digitalization, such as optimizing transport routes using demand data from monitoring systems and digitalizing the information generated by public transport services to support decision-making processes.

All Mexican states have their own transport laws. Regarding mobility laws, Jalisco and Mexico City were pioneers, implementing them in 2013 and 2014, respectively. Since then, another 27 states have adopted similar laws, most including clauses promoting technology use to improve road safety, transport management as well as data processing, storage and distribution. For instance, Mexico City's Mobility Law underscores the need to employ advanced technology for efficient transport management and automation, thereby reducing errors and mitigating the negative effects of travel.

Despite these advances, there is potential for further digitalizing public transport. In terms of technological equipment and infrastructure, there is a need to encourage the acquisition of hardware and software for public transport planning and operation, development of control centers, implementation of electronic fare collection systems, and establishment of data storage and processing infrastructure. In the legal and institutional realm, a federal strategy with clear goals is

needed to guide and measure progress toward a more digitalized public transport system. Additionally, standards and norms are required to harmonize the management, quality, format, and structure of information, facilitating information exchange between different systems and software tools. Strengthening the technical capacity of public transport personnel is also essential. Finally, although various national digitalization programs and initiatives, such as the Ideamos program, exist, they remain limited in scope, reach, and budget.

Digitalization of Public Transport in León, Oaxaca, Mérida, and Toluca

This study explores the progress, challenges, and strategies adopted in four cities with different levels of digitalization of its public transport system: León (Guanajuato), Oaxaca de Juárez (Oaxaca), Mérida (Yucatán), and Toluca (State of Mexico).
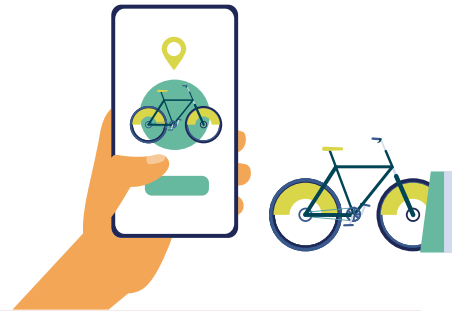
Global Index		León, Guanajuato	Mérida, Yucatan	Oaxaca, Oaxaca	Toluca, State of Mexico
		6.83	7.97	2.79	1.86
		Advanced	Consolidated	Intermediate	Initial
1	**Enabling framework**	**León, Guanajuato**	**Mérida, Yucatan**	**Oaxaca, Oaxaca**	**Toluca, State of Mexico**
1.1	Transport and mobility authority	Mobility department (municipal)	Mobility department (state)	Mobility department (state)	Mobility department (state)
1.2	Mobility law	Existent	Existent	Existent	Existent
1.3	Specific digitalization objectives in the regulatory framework	Partially addressed	Partially addressed	Partially addressed	Partially addressed
1.4	Digitalization budget	Non-existent	Existent	Non-existent	Non-existent
1.5	Connectivity	Basic	Basic	Basic	Basic
1.6	Integrated management of public transport	Partial implementation	Partial implementation	Partial implementation	Partial implementation
1.7	Data protection	Full Implementation	Full Implementation	Full Implementation	Full Implementation
Total Value		6.43	7.86	6.43	6.43

2	Digital Governance	León, Guanajuato	Mérida, Yucatan	Oaxaca, Oaxaca	Toluca, State of Mexico
2.1	Department responsible for information management	Mobility department	Technology department	Planning department	Public transport Registry Department
2.2	Specific department in charge of digital information management	Existent	Existent	Shared responsibility	Existent
2.3	Digital platforms	Partial implementation	Partial implementation	Non-existent	Non-existent
2.4	Disaster recovery plan	Existent	Existent	Existent	Existent
2.5	Intranet	Existent	Existent	Existent	Existent
	Total Value	9.00	9.00	7.00	6.00

3	Informed planning	León, Guanajuato	Mérida, Yucatan	Oaxaca, Oaxaca	Toluca, State of Mexico
3.1	Data collection systems	Full implementation	Partial implementation	Non-existent	Non-existent
3.2	Demand analysis	Non-existent	Existent	Non-existent	Non-existent
3.3	Transport modelling and simulation software	Non-existent	Existent	Non-existent	Non-existent
3.4	GIS	Existent	Existent	Existent	Non-existent
	Total Value	5.00	3.75	2.50	0.00

4	Intelligent Management	León, Guanajuato	Mérida, Yucatan	Oaxaca, Oaxaca	Toluca, State of Mexico
4.1	Control center	Existent	Existent	Non-existent	Non-existent
4.2	Operational support systems	Existent	Existent	Non-existent	Non-existent
4.3	Telematics	Existent	Existent	Non-existent	Non-existent
4.4	Advanced driver-assistance systems	Non-existent	Partial implementation	Non-existent	Non-existent
4.5	Passenger security and crime protection systems	Full implementation	Full implementation	Non-existent	Non-existent
4.6	Autonomous vehicle systems	Non-existent	Non-existent	Non-existent	Non-existent
4.7	Emergent mobility services	Non-existent	Existent	Non-existent	Non-existent
	Total Value	5.71	6.43	0.00	0.00

5	Service reliability, accessibility, and usability	León, Guanajuato	Mérida, Yucatan	Oaxaca, Oaxaca	Toluca, State of Mexico
5.1	Real-time information platform	Non-existent	Partial implementation	Non-existent	Non-existent
5.2	City mobility app	Existent	Existent	Non-existent	Non-existent
5.3	Agreements with commercial apps	Existent	Partial implementation	Non-existent	Non-existent
5.4	On-board passenger information systems	Full implementation	Full implementation	Non-existent	Non-existent
5.5	Passenger information systems at stations	Full implementation	Full implementation	Non-existent	Non-existent
5.6	GTFS	Full implementation	Full implementation	Existent	Non-existent
5.7	Digital fare collection systems	Full implementation	Full implementation	Non-existent	Non-existent
5.8	Trip planning platform	Full implementation	Existent	Non-existent	Non-existent
5.9	Internet connectivity in stations	Full implementation	Partial implementation	Non-existent	Non-existent
	Total Value	8.33	8.33	1.11	0.00

From this analysis, the following conclusions can be drawn:

⊙ **Diversity in the State of Digitalization.** The degree of technological maturity in the targeted Mexican cities varies widely. While León and Mérida have made significant progress in the implementation of digital technologies, Oaxaca and Toluca are comparatively lagging in the organization, management, and digitalization of public transport. For instance, Mérida already has an operations control center, fare integration, and electric buses, whereas Oaxaca still lacks a reliable database of transport concessions in the city.

⊙ **Importance of Legal Framework and Digital Governance.** The effectiveness of digitalization is fundamentally linked to an enabling legal framework and robust digital governance. Mobility laws and specific regulations are essential for driving and standardizing digitalization efforts. Although the new LGMSV is a significant step forward, not all federal entities have adopted it, nor have promoted the normative changes required to support transport digitalization.

⊙ **Gaps in Smart Planning and Operation.** Despite the efforts in certain areas, such as the fare collection and monitoring systems implemented in León and Mérida, there are still significant gaps regarding informed planning and smart transport management. The lack of travel demand analysis and transport modeling shows that digital

tools for strategic planning and operational management of public transport systems are largely underutilized in Mexico.

- **Implementation and Institutional Capacity Challenges.** State governments face significant challenges related to technology implementation, technical and financial capacity, and resistance to change from both operating companies and users. Interviews confirm that the institutional capacity to address the digitalization of the transport sector is still insufficient. In some cities, critical issues remain unresolved, such as the formalization of the transport sector and renewal of the fleets, which are often significantly outdated.

Towards an Intelligent, Accessible, Efficient, and Environmentally Sustainable Public Transport System

The future of transport in Mexico must involve **improving the efficiency, accessibility, and environmental sustainability of the public transport system while enhancing the user experience**. A key element of this vision is deploying digital solutions in the administration, planning, operation, and user interaction of public transport systems. Digitalization will:

- **Increase the efficiency of administrative processes** through digital government solutions such as citizen participation tools, electronic bidding systems, and open data portals.

- **Streamline the design of services that meet the population's mobility needs** using new sources of big mobility data providing better insights about travel behavior and adopting advanced transport modeling and planning tools.

- **Improve operational efficiency and reduce environmental impact** by incorporating fleet management systems, cleaner vehicle technologies such as electric buses, and new shared mobility services that will reduce private car use.

- **Develop more accessible public transport services** through the integration of comprehensive, transparent and non-discriminatory mobility platforms providing real-time information, contactless payments while integrating various modes of transportation.

To realize this vision, it is crucial to consider the following aspects:

- **Strengthening the legal and regulatory framework.** State governments must work on strengthening the legal and regulatory framework, including specific laws that promote digitalization and establish clear and uniform standards. The legal framework should also provide public entities with free access to information from all public transport operating companies.

- **Development of institutional capacity.** Public investment in the creation of institutional capacities for planning, implementation, and management of digitalization projects is imperative. This includes training specialized personnel and creating units or departments dedicated to the digital transformation of public transport.

- **Integration of public transport.** Integrated planning and operation of the different public transport services facilitate information exchange and well-coordinated actions amplifying digitalization benefits. Moving towards an integrated public transport system should be a priority for Mexican cities.

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- **Encouraging citizen participation and sectoral collaboration.** Promoting citizen participation in public transport planning helps encourage the use of digital systems to provide better services to users. It also fosters collaboration between government, the private sector, academia and non-governmental organizations for developing and implementing innovative technologies.

- **Commitment to informed planning and intelligent operations.** Public sector investment and/or public-private partnership projects are needed to facilitate advanced data collection and analysis systems that enable informed public transport planning and more efficient operations. Cities like Mérida and Mexico City that have invested in digital infrastructure (GPS devices, electronic fare collection systems, operations control centers, etc.) have made significant operational improvements, transforming the sector.

- **Enhancing accessibility and user experience.** Priority should be given to accessibility and user experience, developing user-friendly interfaces and real-time information platforms. To achieve an effective implementation of user information systems, it should be considered that there are already standards (such as GTFS), platforms (such as Google Transit) and tools (such as the CDMX app) that have been successfully tested in Mexico and other countries which can be replicated in the pilot cities.

- **Adoption of emerging technologies and SaaS solutions.** Encouraging the adoption of emerging technologies and Software as a Service (SaaS) solutions provides greater flexibility and can reduce implementation costs. Proven software facilitates the digitization of transport, from planning to operation and monitoring. While investing in new developments can be attractive, the use of SaaS solutions, cloud computing and storage services can save a lot of time and money.

- **Financing strategies and sustainable business models.** Innovative financing strategies and sustainable business models are necessary to accelerate public transport's digital transformation and enable the implementation as well as long-term maintenance of advanced technologies. Examples include public-private partnerships, concessions, specific funding instruments, digital advertising, dynamic fares and electronic payment systems.

THE COMPLETE REPORT IS AVAILABLE IN SPANISH