DRIVING THE DIGITAL TRANSFORMATION OF TRANSPORTATION IN LATIN AMERICA AND THE CARIBBEAN

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IN COLLABORATION WITH:

AAPA LATINO · ALTA · IRU · WORLD ECONOMIC FORUM

WITH THE CONTRIBUTION OF:

Microsoft · intel

Cataloging-in-Publication data provided by the
Inter-American Development Bank
Felipe Herrera Library
Calatayud, Agustina.
Driving the digital transformation of transportation in Latin America and the Caribbean / Agustina Calatayud, Raúl Katz, Alex Riobó.
p. cm. — (IDB Monograph ; 1011)
Includes bibliographic references.
1. Transportation-Technological innovations-Latin America. 2. Road Safety-Technological innovations-Latin America. 3. Traffic safety-Technological innovations-Latin America. 4. Road inspection-Technological innovations-Latin America. I. Katz, Raúl. II. Riobó, Alex. III. Inter-American Development Bank. Transport Division. IV. Title. V. Series.
IDB-MG-1011

Keywords: Digital transformation, air transportation, maritime transportation, urban transportation, land transportation, technology, public policy.

JEL Codes: O38, L91, R58

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ABBREVIATIONS

AAPA	American Association of Port Authorities
ADAS	Advanced Driver-Assistance System
ALTA	Latin American & Caribbean Air Transport Association
API	Application Programming Interface
ASCT	Adaptive Signal Control Technology
ATMS	Advanced Traffic Management System
AV	Autonomous Vehicles
CIO	Chief Information Officer
CV2X	Cellular Vehicle-to-Everything
DOT	Department of Transportation
ETC	Electronic Toll Collection
ETSI	European Telecommunications Standards Institute
FAA	Federal Aviation Administration
FHWA	Federal Highway Administration
FMS	Freight Management System
FTTx	Fiber To The x
GDPR	General Data Protection Regulation
GPS	Global Positioning System
IA	Inteligencia Artificial
IADB	Inter-American Development Bank
IATA	International Air Transport Association
IEEE	Institute of Electrical and Electronics Engineers
ICAO	International Civil Aviation Organization
ICT	Information and Communications Technology
IoT	Internet of Things
IRU	International Road Transport Union
ISO	International Organization for Standardization
ITF	International Transport Forum
KOTI	Korea Transport Institute
LACAC	Latin American Civil Aviation Commission

MaaS	Mobility as a Service
NextGen	Next Generation Air Transportation System
OECD	Organisation for Economic Co-operation and Development
PCS	Port Community System
QR	Quick Response
R+D	Research and Development
RFID	Radio Frequency Identification
RSS	Responsibility-Sensitive Safety
SME	Small and Medium Enterprise
TNC	Transportation Network Companies
UN/CEFACT	United Nations Centre for Trade Facilitation and Electronic Business
V2I	Vehicle to Infrastructure
V2V	Vehicle to Vehicle
V2X	Vehicle to Everything
WCO	World Customs Organization
WEF	World Economic Forum
WMS	Warehouse Management System

Acknowledgements

This study benefited from the valuable collaboration of the American Association of Port Authorities (AAPA - Latin American Delegation), the Latin American & Caribbean Air Transport Association (ALTA), the Latin American Civil Aviation Commission (LACAC), the International Road Transport Union (IRU), the World Economic Forum (WEF), Intel and Microsoft. The authors are grateful to participants in the survey and interviews; the roundtables with the U.S. Department of Transportation and the U.K. Government; and sub-sector focus groups, where study results were presented and validated. This work would not have been possible without the excellent research assistance of Felipe Bedoya, Adriana Calle, Rodrigo Cruvinel, Francisca Giraldez and Seonhwa Lee of the IDB Transport Division. The authors are grateful for the advice of IDB's Cristian Navas on urban mobility and Isabel Granada and Pier Paolo Saraceno on human capital and employment; as well as the valuable comments received from David Barahona, Ana María Pinto, Claudia Díaz, Richard Mix and Gonzalo Rodríguez (IDB); Jason Hill and Guadalupe Contreras (U.S. Department of Transportation); Jiten Vyakarnam and Margi Van Gogh (WEF); Carlos Rebellón and Martín Hain (Intel); Jeremy Goldberg and Pedro Uribe (Microsoft); and Luciana Pagani, who was the external reviewer for this report and for the support received from the Offices of the Executive Directors of the United States and United Kingdom at the IDB, Miguel Aldaz and Heleno Barbosa from the IDB, Zulma Dinelli from PR Ports, Martín Rojas from IRU and Juan Camilo Guerrero from ALTA. The graphic edition was in charge of Cleiman.

Foreword

The transport sector is going through a transformation not seen since the invention of the automobile or the airplane, with advances in automation, electrification, and digitalization of assets and operations. In the context of the Fourth Industrial Revolution, the adoption of technologies such as the Internet of Things, big data, artificial intelligence, and edge computing can bring unprecedented benefits to the sector in order to increase its efficiency, sustainability, and inclusion. The crisis of the COVID-19 pandemic gave concrete examples of these benefits allowing, among others, to continue with the distribution of products to isolated populations through e-commerce and reducing the risk of contagion in transport processes through the digitization of documents and payments.

Recognizing these benefits, the private, public, and academic sectors of the world's leading transportation countries are actively driving digital transformation, with positive results in terms of costs reductions and operating profits, decreasing the environmental impact of transportation, improving the competitiveness of economies and providing greater accessibility of citizens to employment, health and education opportunities. The situation in Latin America and the Caribbean (LAC), however, is far from this reality. This analysis, the first in the region on the subject, shows that the transformation is incipient and focused on certain sectors and countries. However, the COVID-19 pandemic and the increased awareness of the benefits of digital transformation are generating a change of perspective, increasing the attention of regional leaders and, consequently, the allocation of investment resources in this area.

To overcome the challenges of transportation in Latin America and the Caribbean, a big push of digital transformation is required.

In line with the pillars of the Inter-American Development Bank´s (IDB) Vision 2025, the main message of this study is that to overcome the challenges of transportation in LAC -increased urban congestion, loss of public transport ridership, high logistics costs and fight against climate change, among others- a big push of digital transformation is required. The private sector must lead the transformation, but it needs an enabling framework that incentivizes investment, enhances the benefits of such investment for economies and societies, and mitigates risks around, for example, privacy protection, cybersecurity, equity, and competition. The actions of the public sector are key in this regard. Thus, from the IDB, we are committed to assisting national, state, and municipal transportation agencies in the modernization of their processes, roles, and infrastructures, in order to encourage the digital transformation of transportation, in partnership with the private, academic, and civil society sectors.

The threat of climate change and the socio-economic crisis in the region as a result of the COVID-19 pandemic make it imperative to take measures that make transport a catalyst for sustainable and inclusive recovery. The time to take action is today, and digital transformation presents a once-in-a-generation opportunity for it.

Néstor Roa
Chief, Transport Division
Inter-American Development Bank

Executive summary

Latin America and the Caribbean (LAC) is dealing with the worst socioeconomic crisis since World War II. The COVID-19 pandemic and recent natural disasters have deepened the region's development gaps, rising inequality and vulnerability to climate change and reducing international competitiveness. **The transportation sector has been critical** to ensure the supply of staple goods, medical products, and vaccines during the pandemic **and will continue to play a significant role during recovery given its ability to provide access to markets and job, health, and education opportunities, generate employment, and contribute to tackling climate change, as long as the appropriate mitigation and adaptation measures are taken.**

However, the transportation sector in LAC currently faces numerous challenges to become a catalyst of recovery. The most important are:

- A higher motorization rate, lower quality and use of public transportation, and, consequently, higher levels of urban congestion.
- Elevated logistics costs throughout the region affect LAC company competitiveness and hinder their insertion in global value chains.
- Polluting emissions from the sector and their harmful effect on the environment.
- The financial impact of the COVID-19 pandemic on transportation companies, especially on air, public, and land freight transportation, jeopardizing their survival, with its subsequent economic and social consequences.

Amid this context, and in line with the **Inter-American Development Bank's (IDB) Vision 2025, digital transformation provides a unique opportunity to overcome the sector's challenges**, which could lead to:

- Unprecedented **efficiency** gains, as a result of increased visibility and the coordination or integration of processes that involve multiple players in the sector.
- Improved service **quality** that is more predictable, reliable, and focused on user needs.
- **Fewer harmful emissions** from the sector as a consequence of increased operational and energy efficiency.
- Diversified sources of income through the generation of **new services**.

To materialize these benefits, it is necessary to develop a deeper conception of digital transformation. Exceeding the mere adoption of technology to automate processes and reduce costs, it should be considered a true **technological disruption**

that, based on data generation and analyses in combination with the adoption of new technologies, leads to a fundamental shift in the sector's organization and roles, with new players, new services, and greater emphasis on users or clients.

Due to its application and impact on transportation, the main **technologies** considered in this study are:

- **Internet of Things (IoT):** the set of sensors, devices, and networks that connect objects with computing systems, allowing these objects to generate data about themselves and the surrounding environment.
- **Digitalization:** the conversion of documents and processes that have thus far been physical into digital data and processes.
- **Artificial intelligence (AI):** the digital execution of operations specific to human intelligence, relying on machine learning algorithms based on big data.
- **Edge Computing:** locating processes and data storage closer to their point of creation thanks to a distributed computing architecture.
- **5G:** a wireless technology to share data between devices, faster and with lower latency than 4G.
- **Automation:** machines or automatic procedures performing processes that used to be manual.
- **Electrification:** replacing internal combustion for electricity as an energy source.

As with every technological change, the digital transformation of transportation also involves challenges, like the eventual increase of motorization rates due to the comfort associated with automated vehicles, and a subsequent decline in public transportation use, leading to more traffic, and affecting the financial sustainability of services and urban quality of life; higher unemployment rates and social conflict as a result of automation; the exclusion of people with less access to and knowledge of digital technology, and smaller companies that face multiple barriers to transformation; the proliferation of standards that hinder information integration and interoperability; and uncertainty in regard to privacy protection and cybersecurity. Having an appropriate institutional and regulatory framework in place is essential to mitigate those risks and maximize the benefits of new technologies.

The private sector is driving the digital transformation of transportation worldwide through four key players: (I) large transportation corporations, which have areas specifically dedicated to research and development (R&D); (II) tech companies, which provide solutions for the sector; (III) the innovative ecosystem, which also works as a driver to generate solutions and innovative products; and (IV) the financial sector, which provides the resources for necessary investments to develop and scale up solutions.

In transportation, air transportation is leading the transformation, followed by urban mobility, and the maritime-port industry, while land transportation is lagging behind. This leadership is due to the higher concentration and globalization of air transportation, the automotive industry, and maritime transportation, where digital transformation constitutes a competitive advantage, and is facilitated by greater resource and innovative environment availability. In addition, it is also a response to more empowered users/clients, who demand more services further tailored to their preferences, and the pursuit of meeting environmental regulations.

The experience of leading countries worldwide shows that public policy actions are critical to accelerate the benefits of digital transformation and mitigate its risks. In these countries, the public sector takes on eight roles: (I) catalyzing change; (II) facilitating innovation; (III) developing skills; (IV) regulating; (V) establishing standards; (VI) providing fiscal and financial incentives; (VII) acting as a smart client; and (VIII) providing platforms to scale up technologies. To this end, they have taken steps in **five areas**:

1. **Priority in sectoral planning.** In their planning tools, leading countries place digital transformation among the sector's main goals, as a vector for higher efficiency, sustainability, and social inclusion. There are digital transformation plans at subsector level, as well as for the development of digital technologies. A large number of public agencies, private agencies, academia, and civil society participate in their creation. They include roadmaps to move forward in implementation, identifying the actions each player should carry out.

2. **Focus on risk mitigation advancement.** Leading countries rely on a series of regulatory and policy instruments, that while stimulating the digital transformation of transportation, mitigate its risks. This includes strategies regarding cybersecurity, consumer data protection, public data disclosure, the development of high-capacity communication networks, prospective studies, public consultations, and regulatory sandboxes. They work with the private sector and academia to test technologies that allow them to gain knowledge used to inform public policy decisions.

3. **Variety of instruments to promote digital transformation.** There are fiscal and financial incentives to make it easier for players facing the toughest barriers in the sector, especially small and medium enterprises (SMEs) and the entrepreneurial ecosystem, to adopt new technologies. There have also been tech centers created to test technologies and spread knowledge, technical assistance and mentorship programs from larger companies, and evaluation mechanisms and roadmaps to guide SMEs in their digital transformation. At the same time, human capital strategies have been generated to develop the skills that new technologies require, educating new professionals, and retraining those whose jobs may be altered due to technological change.

4. **Digital transformation of the public sector.** The public sector has made progress in reengineering and digitizing paperwork, promoting a digital culture, making data-based decisions, and the technological management of infrastructure assets and transportation services. To do so, it has developed internal digital transformation strategies and put together specialized teams endowed with budgets to carry out projects, incorporate tech-related profiles, and highly train staff in general.

5. **Building alliances.** To ensure the collaboration with other agencies of the public sector, on different territorial levels, and with the private sector, academia, and the general public, leading countries have relied upon different mechanisms like high level committees, summoned by top ranking officials at the Executive level; inter-institutional committees, ad hoc groups to work on technical issues; strengthening of local and sub-sectoral authorities; memorandums of understanding and advisory groups with the public sector; and cofinancing of centers and programs with leading companies to broaden the transformation of the less advanced, among others.

LAC is progressing in the digital transformation of transportation, although this process is taking place at different paces. For this assessment, a survey of 223 representatives at manager level of the private and public sector was conducted throughout the region, the first of its kind for the transportation sector in LAC. The survey's findings were debated and deepened in the 96 interviews to sector leaders from the region and around the world, and in four regional sub-sectoral workshops. The main conclusions were:

- **Two out of every three surveyed players said their companies had a digital transformation strategy**, which reflects progress from 2019, when a study conducted by the IDB[1] showed that there was hardly any knowledge of this topic.

- As on the international level, **the air sector is leading the transformation**, applying a deeper concept of it and pursuing true technological discontinuity to offer services specifically tailored to each client's needs. Other large firms in the **logistics** sector (especially maritime companies and global freight forwarders) and the **mobility** sector (tech giants and massive public transportation system operators) also display progress in digital transformation, focused on **providing clients/users better services and generating new business areas**.

- With the exception of these cases, **most of the companies and public agencies** have pointed out that they are aiming at reducing costs through automation and digitalization processes, reflecting they are at the **initial stages of digital transformation**, where players tend to focus on areas linked to administrative and financial management. Therefore, **one out of every two organizations considers that they are behind** or very behind their international peers.

- Two out of three interview respondents pointed to the **COVID-19 pandemic as an accelerating milestone of digital transformation**, followed by cultural change (51%), top management (50%), changes in the sector (45%), and changes in clients (35%).

- Data analytics and cloud computing are the technologies currently in the spotlight. Towards 2025, the focus is seen shifting to artificial intelligence and technologies to cut emissions, which suggests that although the region is undergoing the first phase of digital technology, **investments in more advanced technologies are already being considered**. There are also technologies promoting the sector's sustainability, signaling **more awareness and future actions to battle climate change**, an area that is a current driver of digital transformation in leading countries.
- **Smaller companies and those less involved in global value chains display less progress**. This is particularly clear in both road freight and urban passenger transportation SMEs.
- **Public agencies report to find themselves lagging behind their peers**. A total 43% perceive themselves to be behind or very behind the LAC average. This figure rises to 67% when compared to leading countries worldwide. Around 40% does not have a digital transformation strategy, a number that drops to 27% in the private sector.
- The **main barriers to digital transformation** are resistance to change, the absence of top management prioritization, costs of technology, and insufficient financial and human talent resources.

Compared to the information obtained in 2019, the public sector in LAC has recognized the importance of taking steps in the digital transformation of transportation. However, there is still a long way to go.

- It is very positive to see the degree of leadership senior authorities in the sector have assumed in some countries, which has an impact on regulatory aspects and public policies. Nevertheless, the **situation is not homogenous throughout the region**. Although the mention of technological aspects in **sectoral planning instruments** is encouraging, digital transformation does not have the same relevance than in advanced countries. The topic is addressed either tangentially or in connection to some of the sector's specific aspects.
- As a consequence, the region continues to lag **behind in establishing public policy**, making specific, discontinued efforts with unclear goals. The limited presence of regulatory sandboxes and test beds, little development of prospective studies, and absence of economic incentives to digital transformation are examples of this situation.
- **Institutional strengthening has clearly improved**, which suggests there will be progress in the middle term. This headway should lead to a concerted construction of talent in the public sector, improvement of inter-sectoral coordination and central governments' public policy tools, and consistent and continued coordination with subnational entities.
- A less developed aspect in the region are **public-private collaborations** in connection with the digital transformation of transportation, which tend to be

limited to communication spaces ex post policy actions, and meetings about specific issues, among others. Given the importance of the private sector as a driver of digital transformation of transportation, it is essential to strengthen collaboration mechanisms, both in terms of dialogue and public policy tools.

To overcome these challenges, LAC's public agencies can leverage good practices of leading countries to rely on an institutional and policy architecture that streamlines early adoption and leapfrogging of technologies applied to transportation, thus materializing the benefits of digital transformation. Policy recommendations can be grouped in five categories:

1. **Strategic vision.** This requires the introduction of changes in sectoral and sub-sectoral planning tools to place digital transformation among the sector's development priorities, and ensuring that innovation, competitiveness, cybersecurity and any other plans connected to digital transformation also focus on transportation.

2. **Policy instruments.** This involves having a variety of instruments to mitigate risks in the context of technological uncertainty, overcome digital transformation barriers, help solve coordination failures in the transportation ecosystem, and build job skills for the future.

3. **Institutions 4.0.** This area embodies encouraging culture change and public institution capacity enhancement as well as fostering alliances with national, regional, and local institutions that have jurisdiction outside sectoral or national powers.

4. **Enabling framework.** This requires the execution of actions that normally take place outside of the transportation sector, but that are essential to promote the sector's digital transformation, including public purchase processes, telecommunications infrastructure, a data sharing ecosystem, and the job market.

5. **Strategic alliances.** This entails involving the private sector in: (I) workgroups in charge of producing strategic plans to identify opportunities, challenges, and gaps to address together, as well as to coordinate public and private actions to foster digital transformation; (II) inter-sectoral committees focused on digitalizing transportation to achieve consensus agreements with actions for each party to implement; and (III) tech development projects fostered by the government by signing memorandums of understanding and cooperation. Regarding the latter, leading countries have created specialized centers for training and technology testing, and have determined geographic areas devoted to researching new technologies (e.g. smart cities, AVs, vertical urban mobility) sponsored by the public sector and private companies that contribute financial resources and, in exchange, gain access to the area to develop and test their technologies in near-real scenarios. Collaborations with academia are also essential to this point.

Introduction

Latin America and the Caribbean (LAC) is dealing with the worst socioeconomic crisis since World War II. The COVID-19 pandemic and recent natural disasters have deepened the region's development gaps, rising inequality and vulnerability to climate change and reducing international competitiveness. The transportation sector has been critical to ensure the supply of staple goods, medical products, and vaccines during the pandemic and will continue to play a significant role during recovery given its ability to provide access to markets and job, health, and education opportunities, generate employment, and contribute to tackling climate change.

However, the transportation sector in LAC currently faces numerous challenges to become a catalyst of recovery. The most important are:

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To materialize these benefits, it is necessary to develop a deeper conception of digital transformation. Exceeding the mere adoption of technology to automate processes and reduce costs, it should be considered a true technological disruption that, based on data generation and analyses in combination with the adoption of

new technologies (Internet of the Things, digitalization, artificial intelligence, edge computing, 5G, automation, and electrification) leads to a fundamental shift in the sector's organization and roles, with new players, new services, and greater emphasis on users or clients.

This report assesses the status of the digital transformation of transportation in LAC, identifies gaps vis-à-vis leading countries worldwide, and offers policy recommendations based on those countries' best practices to create an institutional and policy architecture that streamlines the early adoption and leapfrogging of technologies applied to transportation. To this end, during 2021 and 2022, over 300 policy, private sector, and academic documents were reviewed; a survey was conducted of 223 representatives at the managerial level of the private and public sector in the region –the first of its kind for the transportation sector in LAC- 96 interviews were conducted to sector leaders in the region and worldwide; and four sub-sectoral regional working groups were set up to validate the assessment's results.

This report involved the collaboration of the American Association of Port Authorities (AAPA Latino), the Latin American and Caribbean Air Transport Association (ALTA), the Latin-American Civil Aviation Commission (LACAC), the International Road Transport Union (IRU), the World Economic Forum (WEF), Intel, and Microsoft.

The results of the study are presented below, and organized as follows: **Chapter 1** introduces the relevance of digital transformation of transportation in general for countries in LAC, and establishes important definitions on the assessment's scope. **Chapter 2** summarizes the technologies and trends in the digital transformation of urban mobility, logistics, and air transportation. **Chapter 3** identifies the mechanisms behind the digital transformation of transportation; **Chapter 4** offers the best practices of analyzed leading countries (France, Germany, the Netherlands, South Korea, Spain, the United Kingdom, and the United States) in terms of public policies to promote digital transformation. **Chapters 5** and **6** evaluate the reality of the sector's digital transformation in LAC and the policies adopted to encourage it, respectively. **Chapter 7** concludes with a series of policy recommendations based on leading countries' good practices to provide the big push needed to stimulate LAC's digital transformation.

1

What do we mean by digital transformation and why it is important?

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1.1 Definitions

The **transportation sector** involves a number of modes and procedures that allow people and products to move between geographical points. This study analyzes the sector's digital transformation in three main areas:

(I) **Urban mobility:** the transportation of people in an urban context, including private transportation –i. e., cars–, public transportation –such as buses, subways, and city trains– and active transportation, like walking and cycling.

(II) **Logistics:** focused on the storage and transportation of goods through both land and sea, which are the predominant means of transportation in the region, representing as much as 98% of domestic and international commerce (Calatayud & Montes, 2021).[2]

(III) **Air transport:** including both the transportation of passengers as well as goods.

A **myriad of actors** participate in these three spheres. Among them are construction companies and infrastructure operating companies, companies that provide transportation services –both for passengers and goods–, users –i. e., passengers–, clients –those purchasing the goods–, and local and national authorities involved in planning, regulating, and supervising the sector (IDB, 2020b).

In the context of the **Fourth Industrial Revolution**, transportation is undergoing a deep transformative process, comparable to those of the inventions of cars or airplanes (Calatayud & Muñoz, 2020). We call this process **digital transformation**, which encompasses more than the mere adoption of technologies for process automation and cost reduction. This process is a true **technological discontinuity** leading to a fundamental shift in the sector's organization and business models. The first impact of this discontinuity is the generation of a **shift in the value proposition** that stems from, among other things, further understanding of users' behaviors

[2] Railway transportation of goods is beyond the scope of this report. Short-distance passenger travel by railroad is part of the urban mobiliy subsector.

and needs thanks to *data science* tools. The second disruptive effect of digital transformation is that it facilitates the disintermediation between transportation service providers and their clients. Digitalization can eliminate steps by making them available online, fostering more efficient operations integration and harboring better service quality. Lastly, the third effect stemming from digital transformation is the **development of new goods and services**: digital technologies allow companies to develop new business models, extending their scope in traditional markets (Calatayud et al., 2022).

Therefore, in this report the term **digital transformation of the transportation sector** refers to:

The process of incorporating digital technologies in each of the sector's value chain components, including not just technological changes but operational, organizational, cultural, and of the value proposed to society as well.

For their application and impact on the sector, the main **technologies** contemplated in this report are (Calatayud & Katz, 2019; Calatayud & Montes, 2021)[3]:

- **The Internet of Things (IoT):** a set of sensors, devices and networks connecting objects to computer systems to generate information about themselves and their environment.
- **Digitalization:** the conversion of documents and processes from their original physical state into computerized information and processes.
- **Artificial Intelligence (AI):** operations native to human intelligence carried out by computer systems based on algorithms that include machine learning based on big data.
- **Edge Computing:** locating and storing data closer to its source, relying on an architecture of distributed computing.
- **5G:** a wireless technology to transfer data between devices at a higher speed and with lower latency than the current 4G.
- **Automation:** the application of machines or automated procedures to carry out previously manually performed processes.
- **Electrification:** replacing internal combustion for electricity as an energy *source.*

[3] These are the main technologies currently transforming the sector. Chapter 2 provides a detailed analysis of these and other technologies and trends, based on an extensive review of literature and consultations with world and regional leaders.

1.2 The importance of digital transformation for transportation

Recent IDB reports have pointed out that when it comes to providing infrastructure services, including transportation, digital transformation plays a disruptive role on three levels: (I) boosting the efficiency of productive units: (II) reconfiguring value chains; and (III) creating new markets by rolling out bilateral platforms or marketplaces (Calatayud et al., 2022).

- Higher **productive unit efficiency** crystallizes in two ways. First, any component in the value chain can increase its performance simply by becoming more efficient through automation, cost reduction, and time saved in each task. For example, within the transportation sector, artificial intelligence solutions help foresee shifts in service demand and adapt passenger and goods fleet positioning and frequency in accordance to expected volumes. These gains in efficiency also translate into lower emissions, contributing to the sector's climate change mitigation efforts. Secondly, digital transformation may **optimize interactions between value chain players to provide infrastructure services**. For example, implementing the use of sensors on containers may increase their traceability and visualization of their state and location, making it easier to plan the use of cranes and other port assets, as well as facilitating the entrance of trucks to the port, improving energy efficiency as well as operational efficiency.

The digital transformation boosts the efficiency of productive units, enhances the coordination of value chains, and create new business opportunities.

- **Reconfiguring industries and value chains through** digital transformation refers to the possibility that certain players in the chain may assume new roles, with no need for the intermediation of traditional players. Similarly, chain participants may leverage digital technologies to position themselves as specialists in certain parts of the chain becoming key players based on economies of scale and access to information assets. The transportation sector provides a good example with the surge of tech companies specialized in e-commerce, now capable of land, air, and sea transportation.

- Digital transformation contributes to the **development of bilateral markets based on platforms that link supply and demand** efficiently. In this case, the platform operator allows multiple suppliers of goods and services to gain access to a market of numerous purchasing companies. The benefit for the latter is the chance to connect with a variety of offers and make purchases at a more competitive price than in the case of a retail operator. Land transportation services hiring platforms are a good example, where one company expresses their interest in hiring a service and the transportation companies that partake in the platform offer quotations according to the specifications of the required service. In this sense, digitalization also facilitates the disintermediation of traditional operators.

Digitalization also **improves the business environment in which transportation services take place**. In this sense, **the digital transformation of the public sector is essential**, given that this sector not only lays out the institutional and regulatory frameworks for the sector, but also provides some of the services itself. For example, the public sector is in charge of managing the traffic in urban networks to maximize their capacity. The public sector also carries out customs controls, directly affecting the efficiency of international transportation (Calatayud & Katz, 2019).

Finally, **more empowered clients/users of transportation services** are also worth mentioning. More and more, operation management within the sector is focused on meeting the demands of a user with increasingly differentiated purchase needs. In this sense, digitalization allows users and clients to influence service provision within the sector. In fact, digital technologies let the user personalize the service according to their preferences (like meal selection during flights or in-flight entertainment), adapt their consumption based on environmental considerations (e.g., selecting the least polluting form of transportation to commute around the city), and even become service providers themselves (by participating in collaborative transportation platforms, for example). They also contribute to more effective participation on behalf of service users by, among others, evaluating the quality of services (e.g., rating the cleanliness of public transportation) on digital applications.

In short, **the digital transformation of the transportation sector entails five benefits**: (I) improving the efficiency of companies involved in service provision, (II) curtailing coordination costs between chain links and sector players, (III) enhancing the public sector's task performance, (III) increasing the competitiveness of exporting companies, and (V) empowering clients and users. Apart from individual benefits, the digital transformation of different players involved in the sector –construction companies, infrastructure operators, transportation service providers, public agencies, and users- may lead to a radical change in productivity, bringing about both economic benefits as well as a better quality of life for citizens using these services. When aggregated, recent IDB calculations suggest that reducing infrastructure costs by 15% by embracing digital technologies could increase Latin America and the Caribbean's GDP by 6% in 10 years (IDB, 2020a).

5 “benefits of the digital transformation: improving the efficiency of companies, curtailing coordination costs between chain links and sector players, enhancing the public sector’s task performance, increasing competitiveness, and empowering clients and users.”

IDB

1.3 Importance for the region

First and foremost, it is important to highlight that transportation is a key component for **growth, inclusion, quality of life, and sustainable development**. Transportation allows people, goods, and services to move and constitutes a means for market access and opportunities for jobs, health, and education. For example, in an urban context, access to high-quality public transportation can make cities more inclusive by increasing residents' mobility and opportunities, particularly among low-income and disadvantaged groups. In the economic realm, reducing transportation costs could contribute, among other things, to a higher productive and territorial integration. At the same time, being one of the leading emitters of polluting gases worldwide, it is a key factor in tackling climate change (IDB, 2020b).

The **COVID-19 pandemic** has underscored the importance of the sector for economies and societies. For example, the continuity of the transportation of goods at both national and international levels allowed people confined to their homes to have continued access to basic goods, despite quarantine policies in place to contain virus transmission. Similarly, economic recovery measures implemented by a myriad of countries around the world included investments in infrastructure and transportation services as a mechanism to: (I) create jobs; (II) reduce logistics costs for higher international insertion; (III) combat climate change; and (IV) foster social inclusion.

At the same time, the COVID-19 pandemic has highlighted the need to take steps towards the digital transformation of the transportation sector so it may contribute as much as possible to economic recovery, inclusion, and sustainability. Although countries in LAC have made significant progress in terms of infrastructure for public and active transport, maritime connectivity, and public policies regarding logistics, among others, transportation in the region continues to face significant **challenges**, including (IDB, 2020b):

- Rising motorization rates, low quality and use of public transportation, and therefore, top levels of urban traffic congestion.
- Elevated logistics costs throughout the region affecting the competitiveness of LAC companies and hindering their insertion in global value chains.
- Pollutant emissions from the sector, and their harmful effect on the environment.
- The financial impacts of the COVID-19 pandemic on transportation companies, especially air transport, public transportation, and land transportation of goods, which could threaten those firms survival and pose significant economic and social challenges.

In this context, and in line with the **IDB's Vision 2025**, **digital transformation constitutes a unique opportunity to increase the sector's efficiency, inclusion, resilience, and sustainability**. **Chapter 2** analyzes the trends and expected benefits of digital transformation for urban mobility, logistics, and air transport, considering different technologies. The main expected benefits for the sector can be summarized as follows:

- Unprecedented **efficiency** thanks to more visibility, and coordinated or integrated process management involving multiple players in the sector.
- Improved service **quality**, making services more predictable, reliable, and adapted to users' needs.
- **Reduced pollutant emissions f**rom the sector due to higher operational and energy efficiency.
- Diversified sources of income due to the creation of **new services**.

The digital transformation constitutes a unique opportunity to increase the efficiency, inclusion, resilience, and sustainability of transportation, enhancing its role as a pillar for the post-pandemic recovery.

Meanwhile, during the post-pandemic recovery, the adoption and use of digital technologies will be key to **multiplying the economic impact of investments** on transportation services and infrastructure, aiming at rebuilding or **building back better** by focusing on investment and public expenditure efficiency, resilience to climate change, and higher socio-economic sustainability (IDB, 2020a).

In order to promote the transformation of the transportation sector in LAC, it would be essential to strengthen **public-private collaborations**. In effect, the private sector drives digital transformation through four main players: (i) large transportation companies that have their own research and development (R&D) departments; (ii) tech companies that provide solutions for the sector; (iii) an entrepreneurial and innovative ecosystem that fosters the generation of solutions and innovative products; and (iv) the financial sector, which provides resources that facilitate investments needed to develop and scale-up solutions (see **Chapter 3**). For its part, the public sector also plays a meaningful role in guiding transformation in the transportation sector to pursue goals regarding efficiency, sustainability, and inclusion. That's why public-private collaborations are among the main promotion strategies for the digital transformation of transport systems in leading countries worldwide (see **Chapter 4**).

2 Main global trends

Main global trends

This chapter introduces the main digital transformation for the transportation sector worldwide, organized in three large **subsectors: (i) urban mobility; (ii) logistics; and (iii) air transport**. Over 300 articles of academic and applied literature were used to identify these trends, as well as 96 interviews to sector players, following the methodology described in **Chapter 5**. In general, the goals of investing in these technologies focus on **increasing operational efficiency**, through digitalization, automation, and operations integration, **provide higher safety and sustainability rates**, and **generate new value propositions** and sources of business. Examples applied in leading countries will illustrate its progress in **Chapter 5** to compare the situation of advanced economies with the current state of digital transformation of transportation in LAC.

Together with the technologies mentioned in **Chapter 1**, which set the ground for the sector's digital transformation, a number of technologies can be applied to urban mobility, logistics, and air transport. They have been summarized in **Chart 2.1** and grouped according to the use given by the sector, as shall be later detailed. While technologies may belong in more than one group –e.g. IoT is present in operations digitalization, although it is also used as a source of data to reduce emissions-, the following table presents them in their most common use according to consulted literature.

Chart 2.1. ▶ **MAIN TECHNOLOGIES FOR DIGITAL TRANSFORMATION IN THE TRANSPORTATION SECTOR**

	MAIN TECHNOLOGY	TRANSPORTATION SUBSECTOR				
		Air	LOGISTICS			Urban Mobility
			Maritime	Road	Urban Logistics	
Operations digitalization	5G	✓	✓	✓	✓	✓
	Big Data	✓	✓	✓	✓	✓
	Blockchain		✓	✓	✓	
	Edge Computing	✓	✓	✓	✓	✓
	Digital Twins	✓	✓			
	Artificial Intelligence (AI)	✓	✓	✓	✓	✓
	Internet of Things (IoT)	✓	✓	✓	✓	✓
	Digital platforms	✓	✓	✓	✓	✓
	Fleet Management Systems (FMS)			✓	✓	✓
	Global Positioning System (GPS)	✓	✓	✓	✓	✓
	Telematics		✓	✓	✓	✓
	V2X, V2I, V2V			✓	✓	✓
Operations automation	Electronic toll collection			✓	✓	✓
	Digital identity	✓	✓			✓
	Remote control towers	✓	✓		✓	
	Unmanned Aerial Vehicles (UAV)	✓	✓	✓	✓	
	Autonomous vehicles (AV)	✓	✓	✓	✓	✓
Security and sustainability	Biometrics	✓	✓			
	Encryption	✓	✓	✓	✓	✓
	Encryption standards	✓	✓	✓	✓	✓
	Alternative energy sources	✓	✓	✓	✓	✓
	Electric vehicles	✓	✓	✓	✓	✓

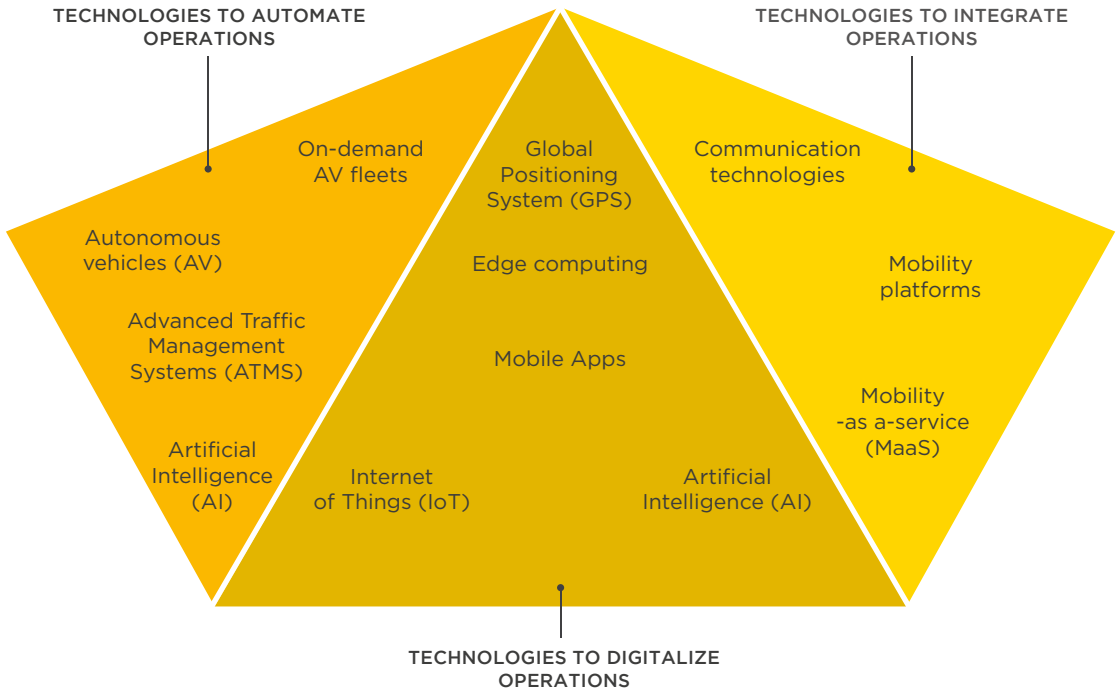
Source: Authors.

Although digital transformation is linked **to a great number of benefits**, it also poses some **challenges**, which will be further analyzed in this chapter's last section.

2.1 Digital transformation of urban mobility

Traditionally, urban mobility –meaning people's ability to move—has encompassed public, private and active –cycling and walking—transportation. In recent years, the surge of digital technologies has given birth to new forms of transportation, such as micromobility and transportation network platforms. The main technologies transforming the subsector have been grouped as follows for their analysis: **(i) technologies to digitalize operations; (ii) technologies to automate operations; and (iii) technologies to integrate operations**.

Figure 2.1. ▶ **MAIN TECHNOLOGIES FOR URBAN MOBILITY**



Source: Authors.

2.1.1 Technologies to digitalize operations

GPS, smart phones, IoT, AI, edge computing, and digital platforms are at the core of these technologies. A vast number of vehicles and buses already have a **GPS** system to share real-time information about their location. This can be used by public transport operators and taxi fleets to plan routes and better respond to the network's conditions (Gutiérrez et al., 2020). In addition, users can access this information through the operators or mobile apps (Google Maps, Moovit, etc.) making it easier for them to select the most convenient mode or route for their commutes (Chan et al., 2020). This also helps authorities supervise that the fleet follows the pre-established routes, as well as to identify odd fleet or driver behavior (OECD/ITF, 2016; Zhou et al., 2016).

> Since 2020 and due to the need for social distancing brought about by the pandemic, bus passengers in New York can access real-time information about the service through the MYmta app. This app provides users with service status (location and available capacity) and notifies them if there are any changes in usual routes. The system collects data in real-time through three sources: (I) sensors that count passengers as they get on and off of the bus; (II) 3D image pattern technologies; and (III) a GPS system linking passenger data to vehicle location (Mass Transit, 2020). Just like New York, many other cities already have apps where users can check service status in real time: Barcelona (TMB App), Paris (Bonjour Paris), London (TfL go), Berlin (BVG Fahrinfo), and Singapore (MyTransport.SG), among others (see OECD/ITF, 2020).

Increased **smartphone** penetration is radically changing urban mobility. Especially, since the development of **mobile apps** such as Waze or Moovit, which help users plan their routes depending on traffic conditions. They can also report incidents and the level of service they are experiencing. This allows other users to access this information about the transportation network in real-time to optimize their commutes and routes. This type of app also generates **big data**, which can be used to analyze accident rates, traffic jams, and other metrics, as well as estimate public transport efficiency.

> Transport for London relies on big data for a number of processes. For example, combining bus localization with information from the tickets, they can guesstimate riders' routes and use that data to review their itinerary plans. Additionally, traffic accidents could be analyzed by seeking patterns in serious and deadly accidents to develop an interactive map that stores information on accidents in the previous 10 years at each location. This map is used for interventions that boost traffic safety. Big data was also used to improve road system management by predicting critical traffic congestion points (Intelligent Transport, 2016).

Mobile apps have also led to new businesses such as **shared mobility platforms**. These apps have embraced the expansion of **micromobility**, lightweight vehicles like electric scooters and bicycles that can circulate as fast as 25 km/h, and are usually used for up to 10-km commutes (Vadillo et al., 2021).

> Regarding micromobility, its use in the United States grew from 35 million in 2017 to 135 million commutes in 2019, which can be mainly explained by the widespread use of electric scooters in 2019 (NACTO, 2020). Data collected in 2019 from major cities in Europe and the United States shows that the introduction of electric scooters led to a migration to this mode of transportation, 36% of which was previously done in private vehicles, 37% on foot, 13% on public transport, and 9% by bicycle (London Cycling Campaign, 2020).

These new businesses go hand in hand with the increasing digitalization of payment methods or **electronic payment methods**. In public transportation, the first step was payment through a transport card so that users could pay once and make connections among different forms of transport. The most current technology is electronic payment, which validates transactions through some personal device (smartwatch, cellphone, tablet, banking card, among others) (Hollnagel & Fook, 2019). According to recent studies, electronic payments can lower management costs by around 70% by replacing physical tickets with digital tickets (Visa, 2020). An additional benefit of electronic payments paired with digital platforms is the integration of transportation services, further covered in point 2.1.3. in the current section.

The efficiency in process management of urban mobility is getting better significantly thanks to GPS, smart phones, IoT, AI, edge computing, and digital platforms.

Another significant source of data for transportation planning and urban mobility service quality improvement is the large amount of **sensors and video cameras** placed on streets, vehicles, and transportation assets. The data is then transmitted to storage centers and later processed by **AI systems** to provide information for decision-making by transportation operators, authorities and users. As vehicle-to-vehicle (**V2V**) communications grow stronger, relying on vehicle to infrastructure (**V2I**) and the adoption of the **5G network**, the ability to receive, process and make decisions in real-time radically increases, for example, in regards to assigning parking spaces, route planning, and traffic accident prevention. **Edge computing** technology allows complex analysis, such as video analysis, in places where there is not enough connectivity and real-time decisions are required. When it comes to road safety, the increased use of sensors in transportation units allows drivers to maneuver more safely, by warning them when pedestrians or cyclists are in their blind spots (Intelligent Transport, 2018). At the same time, there are public transportation systems that have a direct line of communication with the police. In case of theft on the unit, since the police receive real-time information about its location, they are able to arrive there within minutes.

The new payment or collection technologies also make it possible to apply new fare policies, such as fare capping or fare limitation. This consists of those travelers who want to pay for individual tickets (or who, for economic reasons, cannot buy monthly or weekly

subscriptions) using recurring passes based on the number of rides/spends over time without the need to purchase in advance. Many agencies see this as an equity advantage in promoting public transport services. These can be complemented by other options for specific populations who want to receive benefits or discounts in the payment of urban mobility services.

> The ADAS system (Advanced Power Steering System) is defined as the collection of environmental data from the interior and exterior of the vehicle where, through integrated sensors, the presence of static and mobile objects near the vehicle is detected. It considers a wide range of technologies such as forward collision warning systems (FCW), lane keeping (LKCA), automatic emergency brakes (AEB) and driver support systems (parking assist, adaptive cruise speed) (SAE, 2021). There are currently a number of private companies that provide the installation of cameras with 360 degree view or sensors to detect obstacles near the bus, so the driver can keep an eye on the vehicle's blind spots (Viatech, 2019). In 2018, the European Union established a norm making these systems mandatory as of 2022.
>
> An example of safety within the vehicles is the system implemented in Boston. Every public transportation bus (MBTA) has security cameras and a GPS system that reports the unit's location in real time. Through Omnicast, MBTA also has access to a storage center where all recorded videos are kept, as well as coordinated procedures with the police should a criminal act occur.

As vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) grow stronger, the ability to make decisions in real-time regarding urban mobility management radically increases, reducing congestion and road accidents.

Another benefit related to these technologies is the possibility to shift from reactive maintenance in case of malfunction or damage to transportation assets and infrastructure, to precautionary and more frequent maintenance. Thanks to sensors in the units and the ability to visualize roads through cameras or satellite imagery, road and vehicle conditions can be monitored periodically. This precautionary maintenance reduces operational malfunctions during operations, improves unit availability and system reliability, and simplifies vehicle performance monitoring and maintenance operations over time. In a further step, maintenance teams will be able to analyze historical information to predict breakdowns before they occur.

The data generated by mobile phones, digital platforms, social media, electronic payments and IoT devices possess high levels of temporal and spatial granularity. They are being systematized and analyzed by **artificial intelligence models** to improve operators and authorities' decision-making regarding fleet management, traffic, transportation management, and land use. Among others, they are being used to complement origin-destination surveys (Rendón et al., 2020), analyze and quantify urban traffic (Agustina Calatayud et al., 2021), improve road safety (Sánchez González et al., 2021), estimate the impact of infrastructure works and public policies (Bedoya-Maya & Calatayud, 2022), or define new public transportation routes that better adjust to the demand (Sala et al., 2021).

2.1.2. Technologies to automate operations

In the field of urban mobility, automation takes various forms, among which are **advanced traffic management systems** (ATMS), which process and analyze data collected by video cameras and sensors on the roads to improve traffic flow, as well as the automation of data collection and processing processes using IoT and AI. In urban mobility, automation adopts different forms. **Driverless or autonomous vehicle** (AV) stand out. The Society of Automotive Engineers (SAE) classifies vehicle automation in six levels, from 0 to 5. At level 0, all driving features require human intervention; at levels 4 and 5, the vehicle can respond autonomously to every driving situation. At level 3, drivers don't need to monitor the system constantly, but they must be ready to assume control. Some vehicles in industrialized countries have already reached this level. At the same time, level 4 tests are in progress on the roads, but there is still no clear prediction as to when they will be available in the market, which will depend on a combination of technological advances, operational reliability, public policies, regulatory framework, infrastructure, and costs. Optimistic estimates suggest AV's levels 4 and 5 will represent 50% of sales towards 2035. More conservative predications think this threshold won't be reached before 2050 (Calatayud & Muñoz, 2020).

Many leading countries in transportation digital transformation have carried out AV tests, including (Rodríguez et al., 2021):

- In 2018, Waymo was the first company to be granted a license for the circulation of fully autonomous vehicles in California. They have carried out tests in the states of Washington, Texas, Michigan, and Georgia. In 2019, Los Angeles approved the circulation of three vans downtown and in the Miracle View neighborhood, which generated 3D maps of the busiest sections.
- In 2014, the company Uber ATG launched its first AV service in Pittsburgh, where they released a fleet of Ford Fusion vehicles that made 3D maps. In 2016, they began testing SUVs in San Francisco, but the tests had to be suspended because they had no license to operate. In 2017, they began operating in Arizona collecting passengers through the app.
- In 2016, Olli began tests on the freeway in Washington DC, at a maximum speed of 20 km/h. In 2017, they began additional tests in Las Vegas and Miami. In 2019, there were two 6-month tests in Australia, covering 1.4 km.
- The company Navya began testing autonomous minibuses in Greenwich (UK), and Saône and Civaux (France). A Swiss company was their first client, commissioning two minibuses for the Swiss city of Sion. In 2016, they began operating in Lyon (France), where two minibuses covered 1.3 km. In 2017, they collaborated with the University of Michigan where they ran tests of two buses on the university campus. Tests were also carried out in Japan, the United States, France, Australia, New Zealand, and South-Eastern Asia.

- Easymile currently has over 200 projects in place in over 20 countries. Their vehicles have covered more than 600,000 km and transported over 3,800 passengers. Their most prominent projects are: (I) the first minibus EZ10 public transportation line in Bad Birnbach (Germany) in 2017; (II) the first shared transportation service in the TLD Group's factory in Sorigny (France) since 2018; and (III) autonomous tow tractor TractEasy tests at the TLD Group's industrial plant and the airport in Narita (Japan) 2019.

As Calatayud & Muñoz (2020) have pointed out, integrating levels 4 and 5 of AV is expected to have positive impacts on urban mobility efficiency, inclusion, and sustainability. Regarding efficiency, this technology makes commutes more comfortable and productive for passengers, who could be free to perform other activities (such as sleeping or working). Urban traffic and planning could also be improved using big data collected by AV's. Yet another benefit is a reduction in mobility and logistics costs due to lower labor costs and better route mapping, made possible thanks to big data. When it comes to inclusion, and with the appropriate policies, higher mobility rates are expected for senior citizens, non-drivers, and people with disabilities. Lastly, in terms of sustainability, this technology should bring about increased road safety due to a reduced dependence on human factors –responsible for 90% of the accidents–, fuel savings of up to 20% as a result of more efficient driving, and increased urban space available for sustainable developments because of a reduced need for parking spaces (Calatayud & Muñoz, 2020).

An additional use of autonomous vehicles will be in **AV fleets available on-demand**, through digital platforms, which will compete with the need for a private vehicle in the household. Among expected benefits is an increase in public transportation accessibility –covering the first and last miles, as well as low-density urban areas–, a reduced number of vehicles overall, and less urban traffic when these vehicles are shared.

2.1.3. Technologies to integrate operations

Optimistic estimates suggest AV's levels 4 and 5 will represent 50% of sales towards 2035. More conservative predications suggest this threshold won't be reached before 2050.

The use of **digital platforms** allows for the integration of different modes of transportation, as cycling, micromobility, public transportation, and shared vehicles, so that users can choose to do a part of their commute using one mode and then change to another further down their routes. Some benefits of these apps are increased user access to the public transportation network, reduced traffic by increasing vehicle occupancy, and improved environmental quality in the city (Bedoya-Maya et al., 2021; Kim et al., 2021; Oviedo et al., 2021). The evolution of these platforms is called **Mobility-as-a-Service** (MaaS), defined as the integration of existing (and new) mobility services into a single digital platform where users can combine alternative modes of transportation to arrive to their final destinations. In other words, instead of relying on a single transport or combining different types as they commute, users would purchase a transportation service pack adapted to their needs (Zijlstra et al., 2020). Payment digitalization and integration is key for MaaS to succeed (Gordillo et al., 2019; Rodriguez & Gordillo, 2018).

36%

“of trips previously done in private vehicles in European and North American cities migrated to micromobility services, contributing to reducing road congestion (London Cycling Campaign, 2020).”

Users can choose between two forms of payment: (I) a monthly subscription, granting them unlimited access to the public transportation network, limited mileage in shared mobility or taxis, and a maximum number of hours to rent a car, or (II) pay as they go.

According to EVA (2020), there are three integration models between MaaS players, which differ in their efforts on mobility, transport quality, energy use, and number of users:

Chart 2.2. ▶ TYPES OF MaaS MODELS

MaaS 1 Model — **COMERCIAL INTEGRATION**	• Market with agreement between MaaS supplier and transportation operators. • Unregulated free and competitive markets. • Data is likely not shared with public authorities, which would prevent improving public management. • Unclear if it fosters social inclusion.
MaaS 2 Model — **OPEN PLATFORM**	• Established by a public entity, with regulations determined by a public authority. • Serves as public infrastructure. All mobility suppliers must provide access to their data and open their application programming interfaces (API). • Local mobility suppliers are more likely to integrate. • Need to define open platform funding.
MaaS 3 Model — **TRANSPORTATION AS INTEGRATOR**	• Executes public transport with selected mobility services. Regulations established by public transportation. • Other mobility service providers may offer the API. • Perceived as the one who achieves the most sustainable mobility, being socially inclusive, and most aligned with public policies (data would be shared with authorities).

Source: Authors based on EVA (2020).

The Whim app in Helsinki offers access to public transportation, the possibility to rent a car, get a cab, and unlock a public electric bicycle or scooter. The app locates stations and vehicles, and revises public transportation itineraries and their occupancy. To begin their commute, users must indicate their destination and the app will offer them a number of routes and forms of transportation. Then, they just need to validate the trip, and a QR code is generated for this purpose. The app offers different packages for each user profile. The subscription costs 499€/month for unlimited access to all modes of transportation (Cerema, 2019; Velco, 2018).

Vienna's Wien Mobil app has an annual cost of 365€/year. This app grants users access to a number of urban mobility services such as public transportation, public bicycles, shared cars, taxis, scooters, and available parking spaces. The app reduces the difficulties of multimodal commutes, granting access to operator platforms, connecting taxis, and purchasing tickets through the app itself. One third of the population is using this app (Cerema, 2019; Velco, 2018).

Lastly, generating **big data** through GPS, IoT, video cameras, and other technologies, together with the **digitalization of operations** of the various players involved in urban mobility is simplifying sharing information and operator integration, for example, between the management of the transportation fleet and traffic light programming, and more generally, urban traffic management. Integrated intermodal transportation systems provide more information on the exact location of transportation units, identify road obstructions, and redirect units to prevent delays. At the same time, traffic lights may be programmed so that their cycles are adapted to the traffic (Jeon et al., 2018).

2.2 Digital transformation of logistics

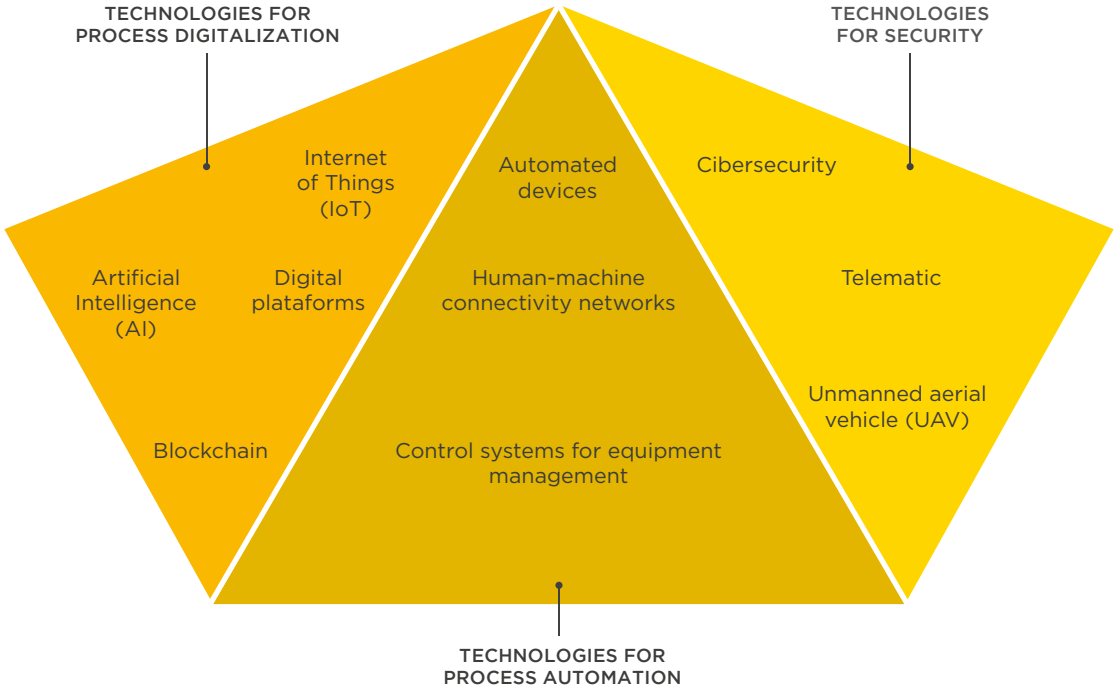
The transportation and distribution of goods can take place through different channels. In this report, we will focus on the most commonly used in LAC: maritime (for example, 95% of international regional trade in volume) and road (30% of intraregional trade in South America, and practically all in Central America) (Calatayud & Montes, 2021). Road transportation may be divided into long distance transportation and urban distribution of goods. Air transport of goods will be covered in section 2.3.

Next, we will introduce the technologies that are being adopted in logistics according to their use in each mode.

2.2.1 Maritime transport

During the last decade, leading companies in the international maritime sector have invested significantly in digital transportation to increase efficiency, collaboration, sustainability, and the reliability of maritime and port operations (Manners-Bell, 2019). **Figure 2.2** summarizes the main technologies in the spotlight divided into three categories: **(i) technologies to digitalize operations; (ii) technologies to automate operations; and (iii) technologies for security**.

Figure 2.2. ▶ MAIN TECHNOLOGIES IN MARITIME TRANSPORTATION



Source: Authors.

2.2.1.1 Technologies to digitalize operations

These technologies make possible the conversion into digital format of processes that previously required analogic elements. This includes, for example, converting documents and physical assets into computerized data that can be digitally managed. The most commonly used technologies in the maritime sector to this effect are **IoT**, **AI**, **digital platforms**, and **blockchain**.

The adoption of **IoT** is leading to the appearance of **smart ports**, where all the agents linked to maritime activities are connected 24/7, exchanging information about port processes. This requires the collection of large amounts of data through sensors installed in containers, machinery, and infrastructure, its transmission to a system usually installed in the cloud, and its processing with AI techniques. This facilitates, for example, real-time monitoring of the state of vessels, tow trucks, warehouses, and other assets, producing information to organize port operations and optimize the use of such assets. An important aspect that the adoption of this technology is leading to is the reduction of the carbon footprint of maritime and port operations, by helping identify energy and efficiency losses, and simplifying and integrating processes.

The port of Hamburg, the third largest port in Europe, was one of the first in the world to deploy IoT technology in 2014, with sensors to coordinate traffic between vessels and roads, and monitor infrastructure performance (DHL, 2015). The information collected by the sensors is used in several ways. One of them is that it sends notifications to truck drivers about available parking spaces and bridge closings due to vessels passing through the city's canals. This allows the drivers to plan routes and cut travel time (Calatayud, 2017). The best coordination brought about benefits in container and truck rotations at terminals, reducing port asset downtime (Frost & Sullivan, 2021).

In a smart port, all the agents related to maritime activity are permanently connected, exchanging information about port processes and allowing actions to be coordinated, the use of assets to be optimized and polluting emissions to be reduced.

Big data generated by the adoption of IoT, together with the use of **AI models**, not only leads to a better understanding of how maritime and port processes are working –for example, regarding their energy efficiency– but also to make predictive assessments that inform decision-making. In more advanced harbors, planning vessel load and unload is already done based on data provided by sensors and other digital tools, which is analyzed by AI models that predict different scenarios. Planning is adjusted to the results of these scenarios, so as to meet certain performance indicators laid out in the plan. The most advanced way to use these technologies is to build a **digital twin** of the port terminal, a virtual representation of the physical world on which to generate simulations about endogenous and exogenous changes to maritime and port operations and develop scenarios that help improve the speed and effectiveness of decisions.

Digital twins are not solely used in large harbors worldwide, but also in middle-sized ones. Livorno is an important regional port in the northeastern coast of Italy, with an annual capacity of about 30 million tons of load and 600,000 thousand TEUs. Since 2016, the port has invested in improving its tech infrastructure, adopting 5G communications, AI, and a digital twin. The port has been virtually modeled to replicate physical elements such as containers, forklifts, and a general cargo storage area. To improve storage capacity efficiency, for example, the digital twin traces loads transported on forklifts and their subsequent locations. This information, together with AI models, is used to develop different scenarios to test the layout of cargo and storage operation management practices before executing them at the real port to identify which practice would produce better results (SINAY, 2021). 5G technology has had a significant role in implementing the digital twin, making possible the collection and transmission of large amounts of data from different sources, such as video cameras, sensors, radars, and mobile devices. Benefits obtained since the deployment of this technology include CO_2 emissions reduced by around 8.2% as a result of higher operational efficiency at the terminal (Ericsson, 2021). Another medium-sized port where digital twin technology is being used is Belfast, in the United Kingdom. Given the port's geographical size, assets may be far from where they are needed. The digital model is making it possible to sequence processes in such a way as to reduce time and distance to both use and conduct predictive maintenance of assets (CTAC, 2021).

PCS are points of central information that optimize data management between players in the community.

Regarding **digital platforms**, Port Community System (PCS) are noted in the sector. These are points of central information that optimize data management between players in the community. These players include importers and exporters, shipping agents, freight forwarders, storage centers, and port, customs, and sanitation authorities (Van Baalen et al., 2008). The main goal of PCS is to digitalize and automate information flows linked to port operations, redirect them to relevant parties, and reduce processing time, errors, and costs of exchanging information associated to these operations (Tsiulin et al., 2020). In some cases, PCS has evolved from a Single Window for Foreign Trade. In others, it has been independent, later integrating into the systems to avoid duplicate procedures.

> International experience has shown a wide range of benefits derived from PCS. With this technology, the Port of Los Angeles went from having information 2 days to 14 days ahead of vessel arrival, with a corresponding boost in productivity of between 8% and 12% (Port of Los Angeles, 2020). In Barcelona, PCS was used to develop an automatic customs control for ship departure, saving customs clearance 50,000 hours in 2019 (Port of Barcelona, 2020). At the Port of Shanghai, the electronic exchange of 75% of the documents through PCS has reduced diesel consumption by 40,000 tons, and generated yearly savings of $60 million in port operational costs (World Bank Group, 2020).

Blockchain technology is one of the trends that players in the sector identified as having a significant potential to alter traditional operations, mainly in regards to the speed and security of information exchange (UNCTAD, 2018). In the case of maritime transportation, the documentation is usually manually created by a multiplicity of players, travelling long distances (OPENSEA, 2017). Blockchain aims at securely digitalizing, transmitting, and conferring traceability to documents such as the Bill of Lading (BL), Letters of Credit (LC), Certificates of Origin, commercial invoices, and cargo boarding lists (Rushton et al., 2010).

> An example in the sector is the TradeLens initiative developed collaboratively by Maersk and IBM. The platform promotes the efficient, transparent, and secure exchange of information to promote further collaboration and trust throughout the global supply chain (OECD/ITF, 2018). In December 2018, over 100 organizations partook in the early adoption program of TradeLens (Tradelens, 2018). Other initiatives are BLOCK and ShipChain; the first specializes in combating the false declaration of hazardous goods and the second in transaction information management between players in the chain including inland carriers.

8 to 12%

“boost in the productivity of the port of Los Angeles through the implementation of a Port Community System, also reducing the volume of polluting emissions.”

2.2.1.2. Technologies to automate operations

Nowadays, many maritime and port operations include repetitive manual activities, subject to the probability of errors and damages. As automation advances in assets such as tow trucks, forklifts, and other vehicles, the performance of specific tasks through standardized and consistent operations 24/7 will improve while reducing the risk of errors, accidents, injuries, and delays. This is an important factor if we take into consideration that ship size will continue to rise, leading to significant operational challenges in dock loading and unloading maneuvers as well as container yard management (Calatayud & Montes, 2021). According to the *Global Infrastructure Hub* (2020), port automation requires three elements: **(i) automated equipment**, including accesses, vehicles, and tow trucks; **(ii) control systems** to manage this equipment, such as AI models to guarantee that the operations are continuously improved through automatic learning; and **(iii) human-machine interactions**, operating machines remotely, supervising operations, and intervening when necessary.

> One of the most advanced ports in process automation is Rotterdam, which inaugurated the first fully automated terminal in the world in 2015. In 2019, the port began to develop a digital twin relying on data from sensors, aiming at preparing their communication systems for interactions with autonomous ships towards 2030 (MACH, 2019). Meanwhile, current investments in Singapore aim at transforming it into the port with the largest autonomous terminal in the world by 2040, capable of moving up to 65 million TEUs per year. The project includes the automation of operations at the port and container yard, and the use of fully electric autonomous-guided vehicles (MPA Singapore, 2019). Smaller ports have also advanced in terminal automation. This is the case of the Port of Newcastle in Australia, where the container yard has the capacity to handle 2 million TEUs per year, and vessels up to 10,000 TEUs (Port of Newcastle, 2020).

2.2.1.3. Technologies for safety

Maritime and port operations' safety includes the safety of goods, assets, people, and data. There has been significant progress in the development of **technologies for good and asset control**, including IoT and telematics. In this aspect, **IoT** apps aim at avoiding alterations, damages, or theft of goods and assets, as well as smuggling and other illegal activities. **Telematics technology** makes it possible to track and monitor information on secured vessel activity in real time (Allied Market Research, 2021a).

The impact of the COVID-19 pandemic has underlined the need to improve **people's safety** at ports and vessels. Some of the technologies that have been used for this purpose are **mobile apps** to track infections, **video detection** for the maintenance of physical distancing, and **thermal cameras** to check the temperature of both workers and passengers. **Automation** is another technology that boosts worker safety in maritime and port contexts. The use of tow trucks, vehicles, vessels and automated aircraft can also lead to creating less stressful, more comfortable, and safer work environments for workers that are now carrying out inspections and supervising operations from surveillance posts.

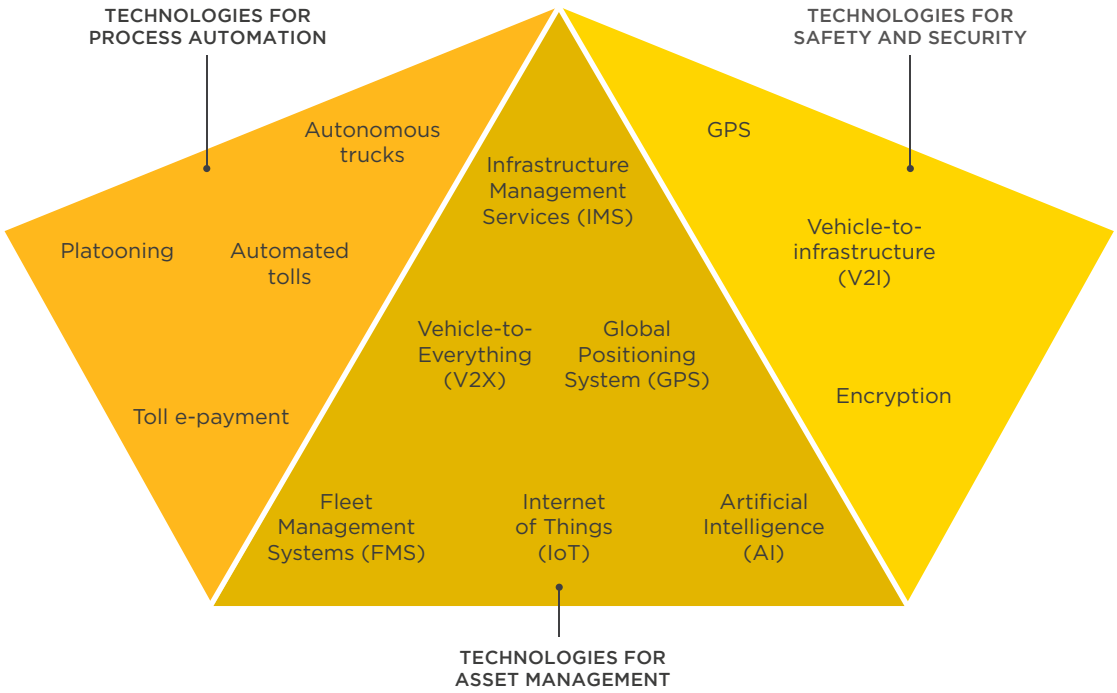
> Since 2017, the Police Department at the Port of Los Angeles has been using drones to inspect and help vessels in areas that are hard to navigate, and detect the illicit transport of goods. Regarding the latter, towards 2020, the drone called ScanEagle had already dismantled around 1,700 kilograms of smuggled goods valued at $55 million. Meanwhile, the Port of Singapore uses drones to deliver light goods to nearby ships at six times the speed of normal delivery for this type of goods, alleviating ship-to-shore operations, reducing costs up to 90%, and eliminating the risks for human personnel during operations (FreightWaves, 2020).

Concerning security, it is worth noting that the sector's growing digitalization leads to an increased **risk of cyberattacks**. According to a maritime cybersecurity poll carried out in 2020, 77% of the companies were at a mid to high risk of cyberattack. Despite this, only 42% of respondents claimed to be implementing solutions to help protect operational vessel infrastructure (Forbes, 2021). An emblematic case in the industry was the cyberattack against the shipping company Maersk in 2020, which brought delivery orders processing to a standstill and froze several of the company's lines of income for weeks. As a result, the company reported losses to the tune of $300 million. To mitigate this risk, tech solutions focus on using high **encryption standards to protect data and biometric systems in real time**, blocking unauthorized access, as well as developing **algorithms and resilient mechanisms** to restore systems needed for maritime operations in case of cyberattack (IMO, 2017).

2.2.2 Road transportation

The digitalization of the road transportation of goods plays a key role in cutting logistics processes' operational costs, boosting efficiency, improving road security, and reducing the environmental impact of transport. The following are the three main categories used in this sector: **(i) technologies to digitalize operations; (ii) technologies to automate operations; and (iii) technologies for security**.

Figure 2.3. ▶ MAIN TECHNOLOGIES IN ROAD TRANSPORTATION



Source: Authors.

2.2.2.1. Technologies to digitalize operations

This category encompasses all technologies that simplify **transportation fleets and infrastructure management** through digital platforms. **Fleet management systems** (FMS) are platforms that rely on data from different sources –such as mobile devices with GPS or Bluetooth, cameras, and sensors placed on goods, vehicles, and infrastructure– to plan and manage the transportation of goods. These technologies are used for a number of purposes, including designing routes, optimizing fleet quality, calculating fuel costs, load traceability, and accounting. Incorporating AI models into the systems to help foresee the demand more reliably has significantly increased fleet management efficiency (McKinsey, 2018). At the same time, detecting energy losses in processes and seeking to boost their efficiency is leading to significant gains in emissions reduction. That's why, according to recent studies, one out of every three companies worldwide is considering implementing these types of platforms to manage their transportation network (Allied Market Research, 2021b).

Among these systems are **tracking technologies** that employ sensors –such as sticker tags with QR (Quick Response) codes on them and RFID (Radio Frequency Identification) tags– located on products, containers, and vehicles to gather information on their location and state. More and more, carrier information is shared with cargo owners, and inspection, port, and airport authorities to, among other things, simplify administrative procedures, control the cargo, and synchronize processes among players.

Infrastructure management systems receive and process data from multiple sources, generating information to improve vehicle flow and road safety.

For their part, **infrastructure management systems** are platforms that also receive and process data from multiple sources, including sensors and cameras located on both vehicles and roads, mobile devices, radars, and weather stations, among others, generating information to improve vehicle flow and road safety by adapting to changing conditions (Poveda et al., 2019). This information can be used, for example, in **Adaptive Signal Control Technology** (ASCT), which optimizes traffic light scheduling. By coordinating adaptive signals, ASCT cuts commute waiting times, improves traffic flow, alleviates traffic congestions, and enhances emergency response time (Intel, 2020).

In the United States, the Department of Transportation reports that the ASCT app has cut travel time by over 10%. Pennsylvania constitutes a case study, having reported reductions of about 20% after ASCT was installed on Highway 22. In turn, the implementation on ASCT in Iowa has reduced crashes by 38% on roads where it was installed. In areas where times were particularly outdated, improvements can exceed 50% (FHWA, 2017a).

The UK has implemented an infrastructure management system on highway M42, one of its main roads, used by 120,000 vehicles a day. The system manages traffic flows and the use of lanes through variable message signs. Thanks to the improvements in speed and lower fuel consumption due to better speed consistency, the system has led to vehicle emissions dropping by 10% (WEF, 2014). An additional aspect worth noting is that the cost of implementing the system was five times lower than conventional road widening.

Due to the installation of sensors in roads and vehicles, and improved connectivity through the use of 4G and 5G networks, today **information can be exchanged** not just **between vehicles** (V2V) but also between vehicles and **infrastructure** (V2I), and **vehicles and everything** (V2X). Shared information includes but is not restricted to position, vehicle characteristics, and speed, which is used by computer algorithms to alert about dangerous situations, delays, alternative routes, and decisions that can improve road safety and traffic flow. Previously mentioned adaptive traffic signal management can also be used through V2I communications.

According to a series of V2I implementation programs by the Department of Transportation of the United States –V2I Safety, Dynamic Mobility Applications (DMA), Real-Time Information Synthesis (AERIS), and Road-Weather Management–, the main calculated benefits of combining these apps with signaling networks include up to a 27% reduction in overall traffic congestion, and 11% less CO_2 emissions. In particular, intersection safety apps have the potential to avoid 575,000 crashes and 5,100 deaths per year. Additionally, V2I in traffic monitoring systems in freeways can reduce fuel consumption by as much as 4.5% and traffic congestions by 14%. On these roads, speed alert systems can potentially prevent up to 169,000 crashes and 5,000 deaths per year (DOT, 2015).

2.2.2.2. Technologies to automate operations

The first technology within this category is truck **platooning**, defined as the linking of two or more trucks in a convoy, using automated driver-assistance systems and connectivity solutions between vehicles. Platooning reduces aerodynamic resistance by grouping vehicles together and safely reducing the distance between them through electronic coupling. This allows several vehicles to accelerate and break simultaneously, improving energy use and space on the roads.

In the United States, tests of different platooning pilots have calculated the potential savings for platoons of two and three trucks. The results have revealed a wide range of fuel savings: the leading vehicle saved up to 10% in closer separation distances, the vehicle in the middle up to 17%, and the towing vehicle saved up to 13%. These are significant figures considering that up to 65% of the distance currently covered in the United States could be travelled while platooning (NREL, 2021).

The second technology is the **autonomous truck** or commercial vehicle. In many countries, around 45% of the total cost for road freight operators is related to drivers (McKinsey, 2018). In addition, the lack of drivers is a growing concern in advanced countries (WSJ, 2018b). Given this context, the development of autonomous trucks has made significant progress both in public and private roads, with tests being carried out in Europe, North America, and Asia.

In Europe, for example, several platoons of semi-automated trucks drove to Rotterdam from Sweden, Denmark, Germany, Belgium, and the Netherlands, as part of a challenge coordinated by DAF, Daimler, Iveco, MAN, Scania, and

Volvo. Meanwhile, PSA Corporation and Singapore's Ministry of Transport have signed agreements with Scania and Toyota Tsusho to design, develop, and test an autonomous truck platooning system to use in public roads throughout the country. In the United States, automated trucks are operating on the Interstate-10 highway, between Texas and California, in a collaboration between Ryder, technology solutions provider Embark, and appliance maker Frigidaire. In China, a firm called TuSimple is testing operations in 10 harbors.

Another technology for process automation is **Electronic Toll Collection** (ETC), which automatically collects road usage fees without any human interaction and with no need to stop the vehicle. ETCs are possible through a variety of technologies, including adhesive barcodes glued to the car, proximity cards, transponders, license plate recognition cameras, and GPS. These systems allow traffic to maintain higher speeds and efficiency, saving drivers' time.

The implementation of the ETC system in New Jersey, USA has resulted in a nearly 85% reduction in delays at tolls for all vehicles, with total saving of about 2.1 million vehicle hours per year (Texas A&M Transportation Institute, 2022). Florida saw a 57% speed increase on fast lanes (DOT, 2007).

85% reduced delay in toll stations in the state of New Jersey (United States) due to the installation of Electronic Toll Collection.

At the same time, **Weigh in Motion** (WIM) systems are eliminating the need to stop vehicles on the road to be inspected in person, speeding up control procedures and, consequently, traffic flow. This is made possible by the installation of sensors in vehicles and/or roads that calculate characteristics and weight, and send the information to control systems that alert authorities when current regulations are being broken. This information can be used to feed the aforementioned road asset management systems.

In the United States, thanks to a program developed in collaboration with the University of Maryland, the Maryland State Highway Administration (MSHA) is using weigh in motion technology in ten virtual stations to support regulations compliance and generate traffic data for future road planning and traffic congestion reduction. Meanwhile, The New York City Department of Transportation (NYCDOT), in cooperation with the New York State Department of Transportation (NYSDOT) and the Port Authority of New York and New Jersey, is using three weigh in motion stations to collect and analyze trucks' weight. NYCDOT is also relying on data collected by these stations to make decisions regarding truck route management. According to the MSHA, a two-lane weighing station costs roughly $600,000 and a single-lane station $400,000. This compares with $2-3 million for a traditional fixed weighing station (FHWA, 2017b).

2.2.2.3. Technologies for safety

Fleet and cargo tracking through platforms that rely on GPS and other sensors is essential for land transportation companies to monitor vehicles and drivers. Among other safety benefits obtained by these platforms is the capability to track hours and driving practices, improving vehicle maintenance management, cargo remote surveillance, driver physical safety, and quick response to road contingencies.

This category includes **electronic registration devices**, which use data from the vehicle's engine to determine how long the driver has been at the wheel. This information makes it possible to monitor not just the number of truck drivers' working hours, but also their fatigue levels and associated risks.

> The United States Department of Transportation's Federal Motor Carrier Safety Administration (FMCSA) requires truck and bus drivers to electronically trace their working hours, particularly driving hours. This regulation applies to commercial vehicles used for interstate trade that weigh 10,001 pounds or more, transport certain hazardous materials, or fit the description of commercial vehicles for passenger transportation. According to estimates, this mandate has prevented 1,844 accidents, 562 injuries, and 26 deaths per year (FMCSA, 2015).

V2I connectivity can improve road safety by alerting drivers on the state of roads, reducing distractions while driving and eliminate the effects of weather and visibility on road sign visibility.

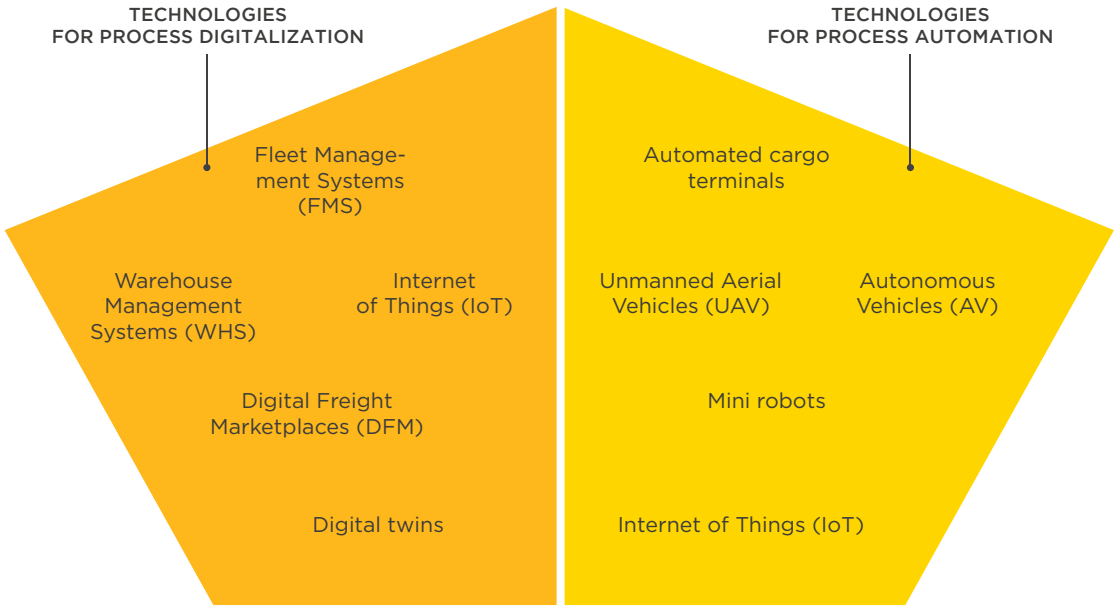
V2I connectivity can improve road safety by alerting drivers on the state of roads, with no need for them to read road signs themselves. This would reduce distractions while driving and eliminate the effects of weather and visibility on road sign visibility. In addition, digitalizing signs would reduce road maintenance requirements, making them reprogrammable with varying weather and road conditions.

As with maritime transportation, this sector's digital transformation comes with an increased risk of harmful attacks, unauthorized accesses, damages, and any number of things that could interfere with safety regulations of the vehicle and driver. That's why it is necessary to implement information **encryption technologies** adapted to trucks and road operations, as well as best practices, to minimize the risk of attacks at each stage of the journey. As we will discuss in the public policy section, there are good public-private collaboration practices worldwide regarding the development of strategies and technologies to build integral cybersecurity environments, all the way from early warning systems to mandatory periodic audits.

2.2.3 Urban logistics

E-commerce expansion is leading companies and governments to pay more attention to urban logistics. Different technologies are being implemented to improve the efficiency in a segment with a hard balance between cost reduction and delivery speed. These may be classified into two categories: **(i) technologies to digitalize operations; and (ii) technologies to automate operations.**

Figure 2.4. ▶ MAIN TECHNOLOGIES IN URBAN LOGISTICS



Source: Authors.

2.2.3.1. Technologies to digitalize operations

These technologies consist of software that recognizes data from different sources, including sensors and video cameras, and applies models following certain predefined parameters to optimize the use of logistics assets such as transportation warehouses and fleets, increase process visibility and traceability, and reduce product delivery time, boosting customer satisfaction. **Warehouse Management Systems** (WMS) include technologies such as pick-to-light, put-to-light, and voice picking to reduce traveling time within warehouses and order preparation, which in turn leads to a higher number of orders processed in a given period of time. Meanwhile, transport fleet management systems are increasingly relying on big data and AI algorithms to optimize delivery routes, which have always been a challenge in urban logistics.

Another technology that aims at optimizing the available transportation fleet is that of **digital freight marketplaces (DFM)**, digital platforms connecting companies shipping products on transportation companies. This type of platform allows companies to select the best available option among a list of available drivers and transportation companies, vehicle sizes, and other required features. The company can also schedule cargo shipments in advance and establish a delivery date. All the communication and documentation is conducted virtually on the platform. Among other benefits, this reduces the time spent searching for available carriers, improves cargo traceability, and increases the transparency of market conditions, especially pricing.

Digital twins are also being implemented for sensitive and high-value products, such as pharmaceutical goods, through sensors that monitor their temperature, package orientation, vibration levels, and other characteristics. Digital twins rely on huge volumes of data provided by sensors during the various stages of transport to improve, among other factors, thermal insulation and suspension conditions. At the same time, there are developments to use digital twins in storage centers to optimize final shipping processes, which could enhance their efficiency by between 20% and 25%, according to recent studies (McKinsey, 2020a).

2.2.3.2 Technologies to automate operations

Mobility restrictions resulting from the COVID-19 pandemic have boost the use of AVs in urban logistics, including distributing medicine in confined areas and transporting lab tests between health centers.

Goods storage and shipping processes are at the forefront of technologies to be automated to increase their efficiency and safety while reducing operational costs. In **warehouses**, the adoption of robots and AI for inventory movement and management, picking, and order fulfillment has been very swift, especially since the COVID-19 pandemic. This can be explained by the speed of the sector's tech development, lower tech purchase costs (as compared to other segments), the clear return of investment (significant savings in labor, faster processes with less errors, 24/7 uninterrupted operations, higher storage density, and lower spending on public services due to robots, among other things, operating in the dark), and the ability to satisfy demand peaks in light of a growing business volume led by the expansion of e-commerce. One of the most emblematic examples in this sense is *Amazon's* warehouse located in Baltimore, USA. In its 93,000 sq. m, different kinds of robots and automated machinery prepare 1 million orders per day while managing an inventory of 10 million products (WSJ, 2018a).

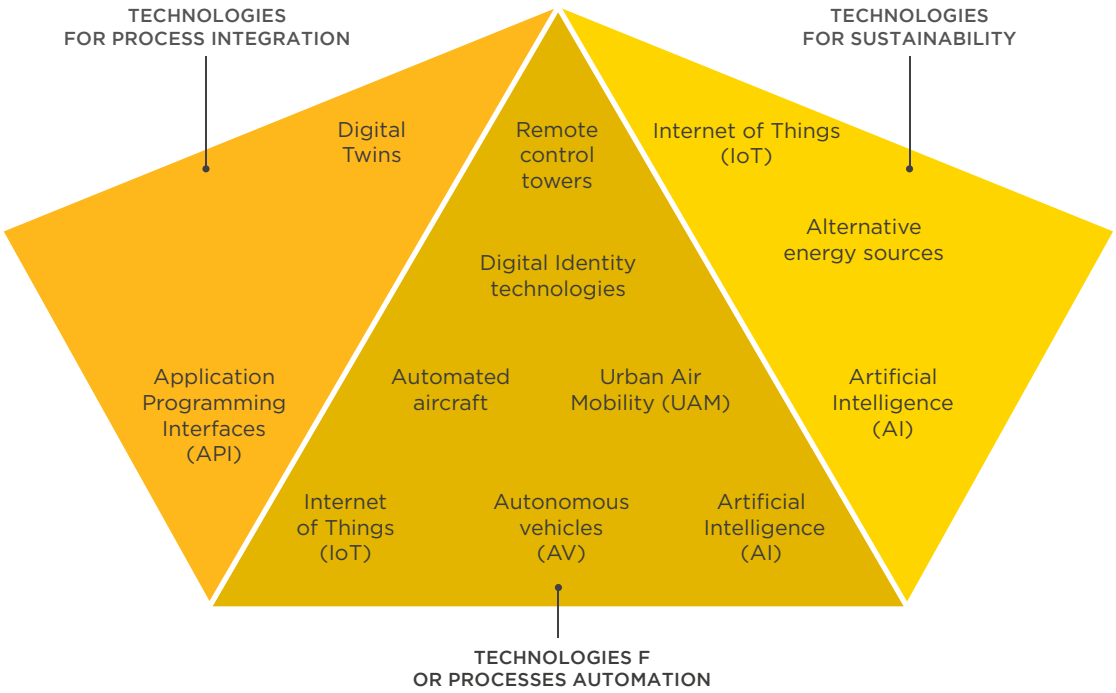
For their part, **Unmanned Aerial Vehicles (UAV)** –aka "drones"– have received a lot of attention from the tech and logistics industries, having been tested in a wide range of operations such as delivering online-purchased lightweight items, transporting medications to remote areas, and carrying emergency medical equipment to low-connectivity or high-congestion areas. Other uses include surveillance during cargo shipment, managing warehouse inventory, and collecting images to plan transportation. While experts in the logistics industry point out that using drones in urban areas is not highly feasible in the near future due to potential risks to passersby and insufficient landing and take-off points, **mini robots** have emerged as a fast, less vulnerable to traffic congestion alternative for last-mile deliveries. Available tests have been run on robots that can transport up to 10 kg, and that travel on sidewalks and special lanes (such as bicycle paths) (WSJ, 2020). When they reach their destination, buyers are notified and get a code to open the robot's container and access their purchase. Some companies have suggested using these robots as temporary storage space for orders to reduce the cost of unsuccessful deliveries. They are also employing **autonomous vehicles**. Mobility restrictions resulting from the COVID-19 pandemic have put these technologies through the ulterior test, including distributing medicine in confined areas and transporting lab tests between health centers (UNIDO, 2020).

Regarding deliveries, **Terminal-to-Terminal facilities**, independent units in busy spaces near residential areas, have become significantly more popular. These terminals are open 24/7 and allow final users to pick up their packages whenever they find convenient. They possess a variety of units depending on size, controlled by a computerized center. Consumers are notified that their package is ready to be picked up via SMS or e-mail. When a person arrives at a terminal, they must enter the code they got in the message. The same procedure works for returns.

2.3 Digital transformation of air transport

Historically, the aviation sector has been at the forefront of technology, and digital transformation is no exception. Nowadays, the most relevant technologies for airlines, airport operators, and intervening public agencies can be grouped into three categories: **(i) technologies to automate operations; (ii) technologies to integrate operations; and (iii) technologies for further sustainability**.

Figure 2.5. ▶ **MAIN TECHNOLOGIES FOR AIR TRANSPORT**



Source: Authors.

38%

“reduction in road crashes in the United Stated (Iowa) due to the implementation of Adaptive Signal Control Technology.”

2.3.1 Technologies to automate operations

The **tools for digital identity** are at the core of the automation processes in air travel. Through a unique and biometric registry of passengers and collaborators in the aviation sector, there will no longer be a need for personal interactions to identify and screen people. This would boost the efficiency of check-in processes, access control to restricted areas, airplane boarding, border control, and passenger health certificate inspection, among others, reducing time and costs for all players. At the same time, it would increase screening security, simplifying automated screenings to be more data intensive and reducing human errors.

> In the United States, an association between Delta Airlines, U.S. Customs and Border Protection (EBP), and Hartsfield-Jackson Atlanta, Minneapolis-Saint Paul, and Salt Lake City international airports, has implemented automated boarding for international flights since 2019. Relying on facial recognition technology, passengers no longer need to scan their boarding passes (Delta Airlines, 2019).
>
> Automated border patrol processes are already popular worldwide through biometric recognition systems –be it face recognition and/or fingerprint scanning— to identify passengers. Some of these systems, with different degrees of implementation, can be found at airports in countries like Australia, Brazil, Canada, Colombia, France, Germany, Japan, Mexico, Peru, Turkey, the United Kingdom, the United States, Uruguay, and others.
>
> Biometric baggage handling is also in place in airports including Auckland and Dublin, cutting check-in time by approximately 60%, as well as the need for airline and airport staff (Future Travel Experience, 2016; Rockwell Collins, 2017).

It is worth mentioning that automation technologies in baggage drop-off and tracking, which aim to boost efficiency throughout the entire handling processes, reduce odds of loss and delay and increase customer satisfaction by simplifying and speeding up luggage tracking. These technologies have led to the creation and/or expansion of baggage drop-off points outside of airports, curtailing the need for staff and infrastructure within the airport –both on behalf of airlines as well as airport operators and other players involved- to help passengers with boarding and landing processes. They are also making it simpler to offer passengers and clients new services, like dropping off or picking up luggage in different points outside the airport.

Lufthansa Group, in collaboration with Rimowa, offers a service called "Smart Bags", where the paper tag is replaced by an electronic one in Rimowa suitcases fitted with an e-tag option (Lufthansa, 2021; Swiss, 2021). Since 2016, Delta Airlines relies on RFID systems to track luggage to boost the process' precision and automation, which speeds up luggage identification in case of change of destination as a result of modified and/or cancelled flights, and allows passengers to track their baggage in real-time through a mobile app (Delta Airlines, 2016).

Progress in AI is taking place in the aviation sector to expand the **automation of aircraft and airport operations**. There already is technology in place for landing and take-off with no human intervention, whether from the pilot or air traffic control. The next step is automating air traffic control so airplanes can control themselves through the uninterrupted and automated exchange of flight data, with or without interaction with ground personnel. The automation of air control services will be particularly significant for operations involving *Urban Air Mobility* (UAM or *Electric Vertical Takeoff and Landing* [EVTOL]), which are expected to lead to a significant increase in the number of vehicles in air space, particularly in urban areas. Coordinating operations between different users of such space is essential to carry out operations safely and efficiently.

Remote control towers are also connected to this. They are expected to simplify the shared use of resources, infrastructure, and systems. This would cut operational costs by reducing idle or underutilized capacity, and boost the safety of airstrips that lack or have insufficient assistance from control towers, usually located in remote areas.

Digital identity tools are key to automating processes such as check-in, access control to restricted areas, aircraft boarding and border control, reducing time and costs for all agents, and providing greater security at controls.

In Europe, this technology is already being implemented. In Sweden, the Örnsköldsvik and Scandinavian Mountain airports are remotely operated by control towers located at Sundsvall Timrå airport (LFV, 2019; Simple Flying, 2019). In the UK, the London City airport is operated by a remote control tower located at Swanwick (Reuters, 2021).

Urban Air Mobility (UAM) is a technology with a huge potential to transform the air sector in which both well-established players and tech companies are investing (Airport Technology, 2021). UAM comprises the use of vertical takeoff and landing aircraft, high levels of automation –including autonomous operation–, the use of sustainable fuel, reduced noise emissions, and condensed physical space for their operation due to vertical takeoff and landing. Proposed uses focus on frequent and short-distance flights, with variable scopes of up to 300 km depending on manufacturer specifications. This technology is expected to allow air operations in highly populated areas or places that are difficult to access overland, and attend to mobility needs quicker and more comfortably.

Currently, over 150 different companies are developing versions of UAM all over the world, from startups to large, well-established aeronautical products manufacturers like Airbus, Bell, and Embraer (through its subsidiary EVE Air Mobility) (Airport Technology, 2021). Plus, many air companies and leasing firms from countries worldwide –including Australia, Brazil, Japan, the United Kingdom, and the United States– have already expressed interest in buying UAM to begin operations in 5 to 10 years (American Airlines, 2021; Avolon, 2021a, 2021b; CNN, 2021; EVE Air Mobility, 2021c, 2021b, 2021a; Lilium, 2021; United Airlines, 2021b).

Robots and autonomous vehicles are being used in different aviation sector areas as well. For example, they are employed for baggage transportation and management, passenger services, and cleaning and disinfecting aircraft and areas with high flow rates of people, among others. They are also used to screen infrastructure and deliver small parcels.

In the Netherlands, Schipol airport (Amsterdam) has begun running tests with automated vehicles for luggage transport between aircraft and terminals (Schipol, 2021). Dallas Fort Worth, Rotterdam, and Lelystad airports have carried out pilots of automated systems to manage and transport baggage from drop-off to arrival on planes (Airside International, 2019).

UPS Flight Forward has been certified by the US Federal Aviation Administration (FAA) to operate air drones to transport up to 7,500 lbs. (3,400 kg) of cargo, either with a human operator or autonomously (UPS, 2021a). The company has used drones to carry COVID-19 vaccines, with special packaging for refrigerated goods, to the Atrium Health Wake Forest Baptist, in Winston-Salem, North Carolina (UPS, 2021b).

2.3.2 Technologies to integrate operations

The aviation ecosystem involves various players including airlines, airport managers, passengers, government entities, passenger service providers (e.g. airport restaurants, shops, and parking valets), and handling and catering providers, among others. IoT, AI models, cloud computing, and **application programming interfaces** (API) allow the generation and exchange of huge amounts of data about flights and passengers between these actors, particularly airlines, government agencies, and airport managers, improving airport operational management and boosting the efficiency of departure and arrival, boarding and landing, cargo, and baggage processes. An additional benefit of the integration of big data generated by digital technologies is the increased security of airport operations through early warning systems in case of delays, malfunctions, or other contingencies, passenger and cargo control processes,

and aircraft maintenance, due to early collection and processing of data from multiple sources to detect potential risks.

Meanwhile, passengers highly benefit from this integration. Processes, from the arrival at the airport to leaving the terminal at destination point, become simpler and quicker. Data about individual users' behaviors collected through mobile devices and biometric controls, among others, can be used to create services and processes catered to each person's needs and profile (IATA & ACI, 2020; NEC, 2018; SITA, 2019, 2020; WEF, 2017).

> The International Air Transport Association (IATA) is developing a program called One Record to standardize data exchange processes and develop a single registry of air freight, fostering the interaction, transparency, visibility, and security of processes between players in the air transport chain (IATA, 2022).
>
> Predictive maintenance is already a reality, where platforms that analyze big data, like Airbus' Skywise, and Embraer's IKON, allow airlines to analyze and process operational data sent in by aircraft and use it to boost airplane efficiency (Airbus, 2022a; AWS Amazon, 2022).

As already mentioned, combining IoT with AI models is leading to the development of **digital twins**, which help decision-making in the air sector's operation management to improve asset use, response to emergency situations, and service provision to passengers and aircraft (ACI, 2021).

Applying new technologies and integrating processes will make the trip more comfortable for passengers due to more straightforward and faster processes from arrival at the departure airport to the final destination.

> The European Union Aviation Safety Agency (EASA) has approved the first Flight Simulation Training Device (FSTD) Qualification for helicopter pilots, allowing them to train for risky maneuvers in a virtual space. This boost training safety in the helicopter subsector, where statistics point out that around 20% of all accidents occur during training flights (EASA, 2021).
>
> Singapore Changi Airport relies on augmented reality technology for land equipment to provide airplane cargo loading and unloading instructions. This lets the staff visualize information by scanning QR codes, gaining access to data such as weight, freight organization, and destination, while also allowing the process to be monitored in real time by a control center. Adopting this technology has reduced loading and unloading time by 25% (Reader's Digest, 2017).

2.3.3 Technologies for further sustainability

Data generated by **IoT and AI models** is being used to reduce the carbon footprint of airport operations by identifying energy and efficiency leaks, streamlining and integrating processes, and transforming airport assets into "smart" ones.

The airport in Dallas Fort Worth (USA) was the first airport in the world to be certified as Category 4+, carbon-neutral, by the Airport Council International's (ACI) global Airport Carbon Accreditation program (ACI, 2020). To earn it, the airport implemented, among other measures, project Morpheus, which included adopting the digital twin analysis model to simulate operative scenarios in line with current and future energy demands through 2050.

Another area that is making progress linked to **energy sources** –not directly related to digital aspects– is the promotion of hydrogen, biofuel, electricity, and hybrid models, not only in aircraft but also in all airport operations and infrastructure.

Copenhagen Airport, A.P. Moller-Maersk, DSV Panalpina, DFDS, SAS, and Ørsted have joined forces to develop a hydrogen and biofuel production plant for their use in buses, trucks, ships, and airplanes. It has been estimated that by 2030 the plant will be capable of producing 250,000 tons of sustainable fuels, reducing annual carbon emissions by 850,000 tons. When it comes to the aviation sector specifically, the project is believed to have the potential to cut fossil fuels by 5% through 2027, and by 30% through 2030 (CPH, 2020).

Airbus is developing a program called ZEROe of hydrogen-powered commercial airplanes (Airbus, 2022b). United Airlines has partnered with ZeroAvia to develop zero-emission hydrogen-electric engines to equip aircraft for regional flights (United Airlines, 2021a).

2.4 Challenges for digital transformation of the transportation sector

Despite the benefits that new digital technologies offer transportation, the **challenges** they pose should not be ignored. These include:

- Uncertainty during the period in which AVs and conventional vehicles coexist, which could affect road safety.
- Challenges to adapt the infrastructure and regulatory frameworks to the emergence of new modes of transport.
- Higher motorization rates which, in turn, would lead to more traffic in cities due to the convenience of AV and increasing e-commerce.

- Less use of public transportation, with its consequent impact on traffic, financial service sustainability, and quality of urban life.
- Higher unemployment rates and social conflict.
- Exclusion of people with less access to and/or knowledge of digital technology.
- New risk scenarios in air transport as a result of autonomous mobility.
- Exclusion of smaller enterprises that face multiple obstacles to embrace this transformation.
- Less competition within transportation markets, affecting social welfare.
- Proliferation of standards that hinder the integration of information.
- Individual identity and privacy vulnerability.
- Increased exposure to cyberattacks.

As we will discuss in **Chapter 4**, **appropriate public policies** are key to mitigating risks and boosting the benefits of these new technologies to attain higher efficiency, sustainability, and social inclusion through transportation.

3 Private sector: driver of the digital transformation of transportation

Private sector: driver of the digital transformation of transportation

As is the case in other sectors, the private sector is the driver of digital transformation in transportation. This chapter analyzes the reasons this study has found behind the investment and implementation of digital technology in this sector, as well as the mechanisms through which it is put into action. Lastly, there will be a comparison between many transportation subsectors. The goal is to identify the main aspects that are incentivizing transformation in leading countries and, based on these aspects, analyze the role of the public sector in these geographies in **Chapter 4**, and compare the situation in LAC in **Chapter 5**.

3.1 The role of the private sector

Within the private sector there are **four players incentivizing the digital transformation** of transportation: (I) big transport companies, which have areas devoted to research and development (R&D); (II) tech companies providing solutions to the sector; (III) the innovation ecosystem, which also drives the development of solutions and innovative products; and (IV) the financial sector by providing resources that streamline the necessary investment to develop and scale scale-up solutions.

Although R&D has always been a crucial feature in **large transportation manufacturing companies**, especially aircraft and automakers, significant headway was made in the past decade as a result of the enhanced computational capacity of IT systems, faster communication networks, and the spillover of progress made in technology and telecommunications, especially in regard to AI models and IoT deployment. Many of these companies have gone from having R&D areas to having innovation areas that integrate open innovation, virtual innovation, and corporate venturing programs, applying agile and iterative organization models and innovation processes. From these spaces, automotive companies are promoting the innovation ecosystem through acceleration programs, “startup garages”, crowd innovation and technology scouting. In this regard, recent data shows that the application for patents in the automotive industry has increased by 40% between 2010 and 2020. For example, recent data shows that patent applications in the automotive industry has shot up by 40% between 2010 and 2020 (LexisNexis PatentSight, 2020).

Meanwhile, **tech companies** have developed business areas specifically for the transportation industry, which they use for a variety of purposes –from providing data

and tailor-made solutions to a specific subsector, to digital infrastructures and cloud services–. A very common modality adopted by tech firms is collaboration with large companies in the transportation sector to test new technologies and generate use cases.[4] Besides service provision, some companies are dabbling into transportation hardware, deploying autonomous vehicle projects by capitalizing on gained big data and artificial intelligence resources and knowledge. Among these companies, Alphabet, Apple, and Amazon are most actively investing in tech development for the sector. For example, Alphabet is focusing their strategy on three areas: technology for automated vehicles, operating systems for vehicles, and alternative mobility. At the same time, Amazon is working on positioning itself as the leader on improving the in-vehicle experience through voice-command (Business Insider, 2019).

The **innovation ecosystem** is also key to boosting the sector's digital transformation. Startups are present in every transportation subsector, providing a large array of products, from autonomous vehicles for urban logistics to digital platforms for the integration of mobility services. Sectoral leadership is one of the factors that incentivize startup creation in a specific area. For example, startups appear around the most important ports in the world, partly financed by the harbors themselves that aim at responding to operational maritime and port problems with new technologies. One example of this is the Advanced Technology Program developed by the ports of Los Angeles and Long Beach in California, which goal is to promote the deployment of innovative solutions to reduce CO_2 emissions in the port area. In many cases, these innovations are introduced and implemented by startups located in the Los Angeles area, which focus on developing green technologies for logistics. Industrial clusters and technological poles such as those located in Tel Aviv and the San Francisco Bay Area are other preferred locations for innovative companies in the sector.

A particularity in these geographies is the great **availability of seed accelerators and venture capital funds** to finance innovative ideas. In recent years, the transportation sector has attracted significant venture capital, placing itself among the top ten resource recipients worldwide (Statista, 2021). For example, total global startup funding in the logistics sector was around $26.2 billion between 2010 and 2019, out of which the largest contribution was by novel last-mile delivery models with $9.9 billion (37.8%), followed by the road freight transportation market ($6 billion, or 22.9%), and storage ($3.3 billion, or 12.6%) (McKinsey, 2020).

3.2 How does the digital transformation of the transportation sector begin?

To answer this question, it is necessary to analyze the large transportation companies' strategies. In different subsectors, the reasons tend to match up, being the most relevant:

[4] See for example the cases of USPS (2017), ZPMC (2018), Hitachi Vantara (2018), and ITF (2018).

- **Increasing efficiency** and reducing costs in segments with low profit margins;
- **Improving customer/user satisfaction, offering products and/or services** best tailored to their individual needs;
- **Strengthening the resilience of infrastructure and transportation services**, which is particularly important due to the impact of COVID-19 and increasing extreme weather phenomena;
- **Pushing for higher sustainability within the sector**, identifying, redesigning, and monitoring processes to cut emissions; and
- **Boosting occupational and user safety**.

In the sectors where transformation is most advanced –air, private mobility, and maritime–, digital transformation comes as a response to the **competitive pressure** that these companies face worldwide. This pressure comes not only from traditional players, but also from the disruptive threat posed by new technologies and new entrants. For example, consolidated multinational logistics companies are challenged by newcomers such as e-commerce enterprises, which are investing large sums in developing their transport operations to gain more control over the last mile, cut costs, and boost the general efficiency of logistics operations. The technological foundation of new business entrants allows them to make decisions based on large amounts of data, reducing costs and offering more personalized services, with more visibility for clients, putting them at an advantage to increase their market share. That is why over the past five years, a large portion of traditional logistics companies' investments has focused on data collection, analysis, and provision for their decision-makers and clients (Calatayud & Katz, 2019).

Collected data also indicates that **the transformation pace of large manufacturing companies** –to whom sector players provide services– transform is a key incentive. In this context, the risk of not transforming is loss of business. That's why global logistics leaders are already involved in a process of technological innovation similar to that of big manufacturing companies. In these cases, the four most popular strategies are: (I) internal R&D investment; (II) tech capability building –for example, buying startups– directly related to their core business; (III) vertical integration of processes throughout the supply chain, with clients and suppliers; and (IV) associating with tech companies to implement solutions that improve operational performance.

In the search for greater efficiency, customer satisfaction, resilience, and sustainability, the private sector is the catalyst for the digital transformation of transportation.

After understanding the challenge posed by competitiveness and the possibility to solve it through digital transformation, the next step is **redefining the business model and operating model**, and **assigning the necessary resources** (human capital, technology, etc.) to implement them. As we will see, large companies possess certain enabling factors for innovation processes, including internal capacity (e.g. high quality, competitive human resources), organizational support (in terms of incentives and resources allocated to innovation), and company magnitude (which determines the volume of resources available for this transformation).

Apart from the competitive pressure, companies' strategic digital transformation goals increasingly include **boosting sustainability and resilience**. Sustainability is reflected in efforts to reduce greenhouse gas emissions, to which transport is the third largest contributor worldwide. In this regard, transportation is currently the second sector with the highest number of "green" patents (Sagacious IP, 2021), even surpassing renewable energies. Meanwhile, resilience aims at avoiding supply chain disruptions, like the ones caused by natural disasters, preventing their increase in coming years, or those resulting from the COVID-19 pandemic. Regarding the latter, worldwide leading logistics companies consider visibility technologies their top investment priority since the pandemic (Kenco Logistics, 2021).

Despite progress in the sector, it is worth noting that **even in leading countries, digital transformation is not homogenous**. Previous IDB reports combined with interviews conducted for this report show that digitalization is mostly restricted to large operators and a handful of subsectors (Calatayud & Katz, 2019). As will be further examined below, there are structural and cyclical reasons behind these differences. In this context, given the key role that transportation plays for the economy and society, the governments of leading countries are adopting different initiatives to close gaps and promote the sector's full digitalization (see **Chapter 4**).

3.3 A digital transformation at various paces

The interviews conducted for this report suggest that within the transportation sector, digital transformation is not homogenous. A comparative evaluation shows that there are **different levels of progress** between subsectors. In general, air transport leads digital transformation, followed by urban mobility, the maritime and port industry, and overland freight transport. **Industrial organization** greatly explains this difference: the air, maritime, and private mobility (mainly the automotive industry) subsectors comprise a **few large, global companies** competing between them for market share, having identified digital transformation as a crucial element, not only for its **competitive advantage**, but also for their survival in the market. This is connected to a new concept of transportation as a tech business, where generating data for **service customization** to clients' specific needs is as important as transporting a product or a person from point A to point B.

In this sense, each of the major companies in these subsectors has a **digital transformation strategy**; a R&D department; programs that are progressively promoting a culture of innovation; and an active collaboration with their suppliers, clients, and academia. Their **financial capacity** allows them to actively monitor the global and sectoral technological landscape; attract digital talent; invest in their own R&D projects; fund projects of clients, suppliers, startups, universities, and the public sector; and acquire innovative startups to streamline developed solutions into their business. The magnitude of these companies also makes R&D investment more profitable, due to the **effects of economies of scale**, which reduces the cost of implementing technology while magnifying its benefits for the company.

$ 26.2 billion

"total global startup funding in the logistics sector between 2010 and 2019, placing itself among the top ten resource recipients worldwide."

IDB

Another aspect that stems from industrial organization is **growing vertical integration**, which favors the implementation of digital transformation projects involving numerous players and processes. Large port and airport infrastructure is usually operated by maritime and air holding companies, respectively. Meanwhile, companies in both subsectors are advancing in the provision of land services. In their pursuit of integral efficiency of their businesses and increased process visibility, these companies are more prone to adopting digital platforms that favor integrated management, reduce system interoperability barriers, and incentivize the exchange of information. At the same time, digital transformation gains traction from large economies of scale that make adopting technology more profitable.

As Calatayud & Katz (2019) have pointed out, companies that participate in **global value chains** tend to be more advanced in terms of their digital transformation, as compared to those focused on local markets. For example, in the port industry, harbors that are under large port and maritime holding concessions tend to benefit from tech development fostered by their parent companies, where these technologies are developed and tested. Similarly, logistics service providers to multinational manufacturing companies reveal a higher degree of technological adoption, due to the latter's demands for visibility, process coordination, and high quality standards.

The structure of the industrial organization, economies of scale, vertical integration and global value chains, financial capacity, and more empowered customers determine the leadership of large companies in the digital transformation of transport.

We have previously mentioned the focus on clients' needs. In the aviation and private mobility subsectors **there are more empowered clients**, with differentiated demands and higher interest in obtaining information in real time. This is linked to *digital natives* beginning to represent a significant part of the market to be attracted by these transportation segments. For example, in the air travel industry it is now possible to check the amount of emissions generated by a flight, or whether the luggage is on the right airplane. When it comes to mobility, on-board computers in vehicles permit many tasks, from generating early alerts of potential failure to semi-autonomous driving. In addition, the COVID-19 pandemic has strengthened the tendency toward digitalization of maritime transportation and last-mile logistics, increasing the amount of data shared regarding location, status, and scheduled deliveries of goods in order to reduce the risk of disruptions in transport and ensure higher fidelity to clients wishing to know the status of their consignments at all times.

Generating and analyzing data is essential not just to improve operation efficiency and provide clients and users with more information, but also to **identify their profiles and needs** in order to customize the service rendered. Once again, the air and private mobility subsectors have achieved the most progress, combining analysis of their own data with social media and other sources to send promotional messages, adapt offers, and improve customer support, among other things. There is also significant advance in urban logistics, with companies relying on this type of information to for example predict customer purchase habits, bring products to their locations, and provide faster delivery.

The presence of an **innovative landscape** and availability of **venture capital** are also important to boost digital transformation. In recent years, a large number of technology-based startups have emerged, providing solutions to increase efficiency,

sustainability, and quality, especially for urban mobility and logistics. Because they are more atomized and companies within them are smaller, these subsectors face larger information barriers and efficiency losses; this is why startups have found significant opportunities to promote their solutions through platforms and new digital businesses. TNCs and data aggregation platforms about urban mobility, covered in **Chapter 2**, constitute examples of these solutions.

The experience of leading companies suggests that **reduced labor costs** coupled with a **shortage of workers** incentivize the sector's digitalization. The experiences in the aviation subsector regarding check-in and baggage handling automation, and in logistics with the development of autonomous trucks, respond to these needs. They also foster investment in R&D, which promises to save companies money, increase their productivity, or perform tasks for which today's labor is unable to supply sufficient workers.

Smaller companies are in the very early stages of their digital transformation due to a lack of human and financial resources, resistance to change, and ignorance of the benefits of technology for their activity.

Regarding human capital, leading companies have modified their human resources strategies to attract **personnel versed in the new digital technologie**s. Thus, proficiency in system engineering, statistics, and physics is being more and more sought by large companies in the air, maritime, and private mobility subsectors, which are the ones with sufficient resources to compete with tech companies for skilled workers. Another strategy is to go into deals with universities and professional training centers to integrate computer skills and big data analysis into their curricula, in the case of more traditional careers linked to these sectors, and sectoral knowledge in the case of technology or related studies. The third strategy is to hire external services from tech companies, either for specific projects or to have access to infrastructure and cloud services without the need to make internal investments. This variant is the most employed by smaller companies.

In contrast to the progress made by leading companies, there is a **large number of smaller firms that remain at incipient stages of digital transformation**. According to collected information, the digitalization of these organizations faces three main barriers: (I) lack of resources; (II) managerial resistance, based on the complexity of justifying the return of investment in technology; and (III) low core business profitability, which limits investment capacity. So, **not only do different transportation subsectors advance at different paces, but there are also significant variations within each of them**. An emblematic case is road cargo transportation. Respondents have mentioned that transportation companies, particularly small and medium sized ones, constitute a bottleneck in terms of the digitalization of logistics processes and of the supply chain overall. This limits the entire logistics system's efficiency, because large logistics operators depend on small and medium shipping companies for first and last mile operations. Among other things, this backlog leads to reduced visibility and transparency regarding the status of goods in transit. To overcome this barrier, some global logistics enterprises tend to limit their providers to those that can ensure the complete traceability of goods in transit. Additionally, these companies, or the manufacturing companies themselves, install devices on containers to guarantee the flow of information. In other cases, large logistics

companies and manufacturers resort to providing training and signing co-investment agreements to stimulate the digitalization of logistics service providers. Finally, in the case of agro-bulks, for example, digital platforms have emerged that integrate the entire chain, providing services to the different stockpiling players, carriers, drivers, transport companies, and ports, improving the transparency and overall efficiency of the logistics process. (Calatayud & Katz, 2019).

Despite these obstacles, surveyed experts agree that the big question is not whether transportation companies will embrace digital transformation, but when and how they will do it, and who will be forced out of the market for failing to follow suit. The transition towards digital transformation and pursuit of higher sustainability of advanced economies will end up fostering this process across all transportation subsectors. Given the key role that transportation plays in society and the market failures that hinder the development of a more efficient, sustainable, and inclusive sector as a result of digital transformation, the governments of leading countries are implementing multiple public policy programs. The next chapter examines best practices.

4 Participation of leading countries public sectors in the digital transformation of transportation

Participation of leading countries public sectors in the digital transformation of transportation

As previous chapters have shown, new digital technologies can lead to significant benefits for the transportation sector in terms of efficiency, sustainability, and safety. Given the role of transportation for the economy and society, boosting its performance through digital transformation can lead to substantial impacts in economic competitiveness, social inclusion, and battling climate change (see **Chapter 1**). Therefore, in leading countries the public sector is actively involved in putting together plans and implementing policies to promote the digital transformation of the transportation industry. While there are wide variations among different countries and modalities, the general tendency is to focus on prospective analysis, planning, designing or updating the regulatory framework, and making financial instruments available for the sector's digitalization. In addition, the importance the transportation sector has gained in the context of the pandemic has led governments in all leading countries to implement new public initiatives to move forward and speed up digitalization.

The goal in this chapter is to identify best practices and lessons learned from countries who are leading the way in terms of formulating and implementing public policies that can boost the digital transformation of the transportation sector. To this end, the cases of France, Germany, the Netherlands, South Korea, Spain, the United Kingdom, and the United States will be analyzed. Their experiences will be used as a reference to assess the situation in Latin America and the Caribbean (**Chapter 6**) and formulate policy recommendations (**Chapter 7**).

4.1 The role of the public sector in promoting the digital transformation of transportation

The UK's Government Office for Science identifies **eight actions through which governments play an active role in digital transformation**: (i) catalyzing change; (ii) facilitating innovation; (iii) developing skills; (iv) regulate when needed; (v) establishing standards; (vi) providing fiscal and financial incentives; (vii) acting as a smart client; and (viii) promoting platforms (Government Office for Science & United Kingdom, 2019). An analysis of international experiences reveals that these actions are also present in the transportation sector, as will be further described below.

Through planning exercises, governments identify sectoral goals. Doing so, they act as **catalysts of digital transformation**. More and more, these goals include the digital transformation of the transportation sector, or some of its subsectors, as a pillar to achieve efficiency, sustainability, and social inclusion. As is detailed in **Section 4.2**, in certain cases governments even issue recommendations on what technologies should be used in line with their national development strategies.

The early stages of tech development require testing in spaces that simulate real-life environments in order to adjust the technology and prepare sectoral regulations to boost the benefits and mitigate the risks of scaling up, and to help the industry and the public at large familiarize themselves with these new technologies. To this end and as will be further analyzed in subsequent sections, every leading country is fostering regulatory sandboxes and test benches, thus becoming **innovation facilitators**.

Catalyzing change, building skills, providing incentives, setting standards, and acting as a smart customer are key roles governments must play in the digital transformation of transport.

The third role refers to **planning the abilities needed by new technologies**. In the previous chapter we mentioned the difficulty of attracting digital talent to the sector, even for large companies. Given that education and future workforce training are essential to a country's development, most of the countries analyzed have already identified the demand of skills, quantified the existing gap between needs and talent production, and determined what actions the public sector needs to take to help bridge it. As **Section 4.2** will show, this also includes transforming the current workforce due to advances in automation.

One of the public sector's main roles is to **regulate intelligently**, to guide technologies to generate benefits for the whole society, mitigating economic, environmental, and social risks. Best practices identified by our analysis of new technology regulations, taking into consideration the uncertainty of technological progress, indicate that regulations should be flexible and speedy enough to facilitate testing and technological advances, while establishing criteria to mitigate potential risks for the society (see **Section 4.3**).

In terms of technology, **developing standards** is vital to facilitate the transmission of data, favoring the interoperability between platforms and tech systems, and protecting the consumer. Although governments have different approaches to promoting and adopting standards, as will be exposed in **Section 4.3**, one common feature among them is that they have defined the establishment of standards as a fundamental public policy issue, whether accompanied by the private sector, or participating with an outstanding role in the agenda and in international agencies working in these fields.

Incentivizing digitalization through fiscal and financial mechanisms is another key action that leading countries have adopted. Designing and implementing technologies poses risks that discourage investments from the financial sector. Meanwhile, as discussed in the previous chapter, smaller companies tend to face numerous hurdles for their digital transformation, especially due to a lack of internal resources and access to credit. In this context, by granting low-interest loans or tax deductions, governments act as transformation agents (see **Section 4.3**).

The public sector provides infrastructure and transportation services and also participates in related activities. For example, it manages traffic in urban networks to maximize their capacity. It also carries out customs controls, which affects the performance of international transport. In this sense, the digitalization of processes within the public sector also turns it into a **smart client**, which acts as an incentive to develop solutions for the sector and encourages the digitalization of companies that rely on public services. This technological change in the public sector significantly **improves the business environment in which transportation takes place** (see **Section 4.3**).

Lastly, and in connection with the aforementioned developments, the public sector can promote the scaling up of technologies, given its ability to implement them in its own processes and infrastructures. This way, it acts as a **provider of platforms for the dissemination and adoption of technologies**.

In exercising these roles, leading countries have generated **best practices and lessons** learned that can be of great value to countries in LAC seeking to put digital transformation on a fast track. These practices will be analyzed in the following sections.

4.2 Identifying the digital transformation as a priority in sectoral planning

One of the most important roles of governments is sectoral planning, which means setting goals, investment priorities, and work agendas for the different public agencies involved. One point in common among analyzed countries is that they have all clearly **identified that digital transformation is a key goal to achieve**. There are five reasons to move forward in this direction:

- The importance of digitalization to boost the economic contribution of logistics to post-pandemic recovery.
- Provide logistics support to a transition towards new productive models centered around the concept of Industry 4.0 (smart logistics).
- The need to promote decarbonization to mitigate the effects of climate change.
- The pressing need to develop sustainable urban mobility.
- Improving air transport security.

Although there already is a relatively high level of agreement on why to develop public policies for the sector's digital transformation, this can lead to different lines of action. Countries like the UK have worked hard on prospective research and

In their sectoral plans, the leading countries identify digital transformation as an important mechanism to achieve the objectives of efficiency, inclusion, and sustainability of transport.

prospective development, focused on analyzing the impact of advanced digital technologies on transportation (for example, studying consumer behavior vis-à-vis mobility as a service.) Other nations, like South Korea, have emphasized long-term planning, setting industrial policy goals (such as development of the autonomous ship industry.) Lastly, other countries have prioritized developing regulatory frameworks to establish the direction of technological diffusion (such as the protection of data sharing privacy in urban transportation in Spain.) Simply put, although all leading countries agree on the strategic importance of the sector's digital transformation, they are not necessarily addressing it similarly.

The intervention of the public sector in digitalization begins with the formulation of **three kinds of planning tools**: (I) general transportation plans, including digital transformation as one of their goals; (II) specific plans for the digital transformation of the sector or one of their subsectors (maritime, air, urban mobility, etc.); and (III) plans that don't necessarily aim at transportation although, given their focus on digital technologies (e.g. AI), can have an implicit impact of its digitalization (see **Chart 4.1**).

Chart 4.1. ▶ PLANS THAT IMPACT THE TRANSPORTATION SECTOR'S DIGITAL TRANSFORMATION

		URBAN MOBILITY	LOGISTICS	AIR TRANSPORT
GERMANY	National transportation plans	• The 2030 Federal Transport Infrastructure Plan • National Intelligent Transport Systems (ITS) Action Plan		
	Plans for specific areas of transportation	• Action Plan for Digitalization and Artificial Intelligence in Mobility • Initiative on Digital Connectivity in Public Transport	• Maritime Agenda 2025 • Logistics 2030 Innovation Program	• Aviation Strategy of the Federal German Government • Digital Platform for Unmanned Aviation • Unmanned Aircraft Systems and Innovative Aviation Strategies Action Plan
	Cross-sectional plans that have an impact on transportation	• Charting the Course for Digitalization • High-Tech Strategy 2025 • Industry 4.0 Platform • National Strategy for Artificial Intelligence • The Federal Ministry for Economic Affairs and Energy's Strategy on Regulatory Sandboxes		

		URBAN MOBILITY	LOGISTICS	AIR TRANSPORT
SOUTH KOREA	National transportation plans	• Fifth Comprehensive National Territorial Plan		
	Plans for specific areas of transportation	• The 3rd Smart City Master Plan 2019-2023 • Green Digital Roads Plan	• National Logistics Plan 2021-2030 • Smart Transport and Logistics Expansion Strategy • Smart Ports Strategies and Policies 2030 • Smart Railroad Safety Management System Basic Plan (2018-2027)	• Third Air Policies Plan (2020-2024) • Korean Urban Air Traffic Road Map
	Cross-sectional plans that have an impact on transportation	• Korean New Deal 2.0 • Plan for the Fourth Industrial Revolution • Sixth Basic National Plan for Computerization • National Cybersecurity Strategy • National Cybersecurity Basic Plan • National Strategy for Artificial Intelligence		
SPAIN	National transportation plans	• Innovation Plan for Transport and Infrastructures • Transport Mobility and Financing Law		
	Plans for specific areas of transportation	• Strategy for Safe, Sustainable and Connected Mobility 2030 • Spanish Urban Agenda (AUE) • Road Safety Policy • Electric and Connected Vehicle PERTE program • DGT 3.0 project		• Strategic Plan for the Development of the Civilian Drone Sector 2018-2021
	Cross-sectional plans that have an impact on transportation	• Spain 2050 • Recovery, Transformation and Resilience Plan (PRTR) • Spanish Science, Technology and Innovation Strategy • Spain Digital 2025 • The Plan for Connectivity and Digital Infrastructure • National Artificial Intelligence Strategy • Digitalization Plan for Small and Medium-Sized Enterprises • Plan for the Digitalization of Spain's Public Administration • National Plan for Digital Skills • Strategy to Promote 5G Technology • National Cybersecurity Strategy		

		MOVILIDAD URBANA	LOGÍSTICA (*)	TRANSPORTE AÉREO
UNITED STATES	National transportation plans	• Department of Transportation's Strategic Plan for FY 2018-2022 • U.S. Department of Transportation's (DOT) Research, Development, and Technology (RD&T) Strategic Plan 2022-2026 • Strategic Plan for Intelligent Transportation Systems (2020-2025)		
	Plans for specific areas of transportation	• Automated Vehicles Comprehensive Plan	• National Freight Strategic Plan	• Latest Generation Air Transport System
	Cross-sectional plans that have an impact on transportation	• Public Law 117-58 • H.R.3684 – Infrastructure Investment and Jobs Act ("Build back better") • National Cyber Strategy (2018) • National security memo: Developing Cybersecurity Performance Goals for Critical Infrastructure Control Systems • Strategy for American Innovation • Federal Data Strategy (FDS) • Transportation Systems Sector-Specific Plan (SSP)		
FRANCE	National transportation plans	• Innovation in Transport: Investments for the Future - PIA 4		
	Plans for specific areas of transportation	• French National Strategy for the Development of Automated Road Mobility 2020-2022 • Strategy for Accelerating the Digitalization and Decarbonisation of Transport • Mobility Orientation Law • Strategic Contract with Automotive Sector 2018-2022	• National Port Strategy • Port Cybersecurity: Good Practices for Cybersecurity in the Maritime Sector • National strategy "France Logistique 2025"	• National Strategy 2025 for Air Transport • Strategic Safety Enhancement Plan "Horizon 2023"
	Cross-sectional plans that have an impact on transportation	• National Recovery and Resilience Plan • National AI Strategy • Strategy for Cybersecurity Acceleration • National Strategy for Cloud Technology		

		MOVILIDAD URBANA	LOGÍSTICA (*)	TRANSPORTE AÉREO
NETHERLANDS	National transportation plans	• The Dutch Multi-Year Program for Infrastructure, Spatial Planning and Transport • Digital Transport Strategy		
	Plans for specific areas of transportation	• Public Transport in 2040 • Smart Mobility Strategy • Roadmap for Improving Traffic Information • Development Agenda for the Future of Public Transport 2040	• The Dutch Maritime Strategy 2015-2025 • Port Memorandum 2020-2030 • Dutch Maritime Industry and Ports 2018-2021	• Aviation Policy Memorandum 2020-2050
	Plans that impact transportation	• Action Plan for the Optimization of Infrastructure Use • Dutch Digitalization Strategy • Smart City strategy		
UNITED KINGDOM	Planes Nacionales de Transporte	• National Infrastructure Delivery Plan		
	Planes para áreas específicas del transporte	• The Future of Mobility: urban strategy • The Future of Transport Regulatory Review "Bus Back Better" • Regulations for Electric Scooters Tests and Traffic Signals • Automotive Sector Deal • Smart Motorway Evidence Stocktake and Action Plan (England)	• Maritime 2050 – Navigating the Future • Clean Maritime Plan • "Technology and innovation in the British maritime sector" roadmap • Great British Railways: William-Shapps plan for rail	• Future Flight Vision and Roadmap • Aerospace Sector Deal • Airspace Modernization Strategy
	Planes transversales con impacto en el transporte	• Innovate UK – UK Transport Vision 2050 • Industrial Strategy: "building a Britain fit for the future" • AI Sector Deal • Transport Decarbonisation Plan		

Source: Compilation by the authors.

(*) Includes maritime, land, and last-mile.

As a centralized sectoral planning tool, among the essential topics they cover, **national transportation plans** address intermodality, energy transformation, and rolling out physical infrastructure (road networks, logistic nodes, etc.). Therefore, although they don't focus exclusively on the sector's digitalization, they tend to consider it one of the key issues for a long-term infrastructure strategy. The concept of digital transformation outlined in national transportation plans acknowledges its crucial importance for the sector's development. For example, Spain's Innovation Plan for Transport and Infrastructures 2018-2022 is a cross-sectional plan structured around themes like smart platforms, smart roads, and energy efficiency. Hence, leading countries' national transportation plans are based on **recognizing that digital transformation is a key component and lever for the sector's development**. In this sense, national transportation plans are useful to create a **conceptual framework in which plans for specific sector segments, like urban mobility and logistics, are developed, and articulated**.

A recent innovation in the national transportation planning processes of leading countries is the recognition that these tools should be based on input provided by the public, private, and academic sectors, and by civil society. For example, Germany's 2030 *Federal Transport Infrastructure Plan* was developed based on a process of citizen participation in which 40,000 contributions were received from citizens and consulted unions. The same happened with Spain's *Innovation Plan for Transport and Infrastructures 2018-2020*, developed in collaboration with private sector companies. In the case of France's *Innovation in Transport: Investments for the Future - PIA 4*, its development involved consultations with academia, different economic players, local authorities, and associations, which helped identify and prioritize key subjects for sectoral innovation. In general, consultation processes include setting up *ad hoc* roundtables on specific issues (e.g., roads, urban mobility) calling for the presentation of citizen proposals, focus groups, and surveys.

The plans by mode and the roadmaps for the implementation of the digital transformation make it possible to establish clear objectives and coordinate actions with public and private actors.

Apart from the national plans, considering the complexity of each of the transportation segments' transformation processes, advanced countries have addressed urban mobility, logistics, and air transportation through **specific plans**. Analyzing these segment-specific plans, it is worth noting the number of tools linked to the logistics sector, especially maritime, that acknowledge the importance of technology as a factor for competitiveness and increased sector sustainability in the context of post-pandemic recovery, as each of the maritime plans of studied countries has shown. In this sense, the Netherlands is implementing its Maritime Agenda 2025, with detailed plans for digitalization and innovation based on its Port Memorandum 2020-2030. Following a participative process involving players from the maritime and logistics sectors, France passed its new National Port Strategy, underlining the digitalization of logistic chains, deploying a maritime single-window, and supporting the development and improvement of new professional careers related to port innovation. Germany's Maritime Agenda 2025 highlights the importance of digitalization for the maritime sector in the next five years and defines the government's role in each area of action.

Leading countries have developed specific plans for the digital transformation of maritime transport, logistics, urban mobility and air transport.

Another field of special interest for specific segment planning is urban mobility, where the role of digital transformation is underscored to boost the efficient use of limited urban space, inclusion, and sustainability. For example, South Korea's 3rd Smart City Master Plan 2019-2023 features autonomous, inclusive, and sustainable mobility as one of its key components, given that in the Korean development vision, new technologies are one of the main drivers of wellbeing and allow solving problems such as traffic congestion and public transport sustainability (IDB Invest & Korean Development Institute, 2021). The Plan includes actions on several fronts –personal mobility, group mobility, smart parking, smart roads, and logistics– proving its comprehensiveness. In general, national mobility plans tend to encompass a variety of technologies applied to the urban context. An example of this is Germany's Action Plan for Digitalization and Artificial Intelligence in Mobility, which deals with areas such as connected and autonomous vehicles, 5G communication systems, and automatic control of traffic flow. They can also focus on specific modes of urban transportation, like the UK's new national policy for public transport "Bus Back Better," which offers a long-term vision of the future of buses, relying on digital transformation to improve the quality of the service and increase its accessibility, including the development of new bus lines on demand. A good practice worth highlighting in specific transportation subsector plans is the **inclusion of roadmaps to move forward in their implementation,** identifying actions to be taken by the public sector, the private sector, or both.

In addition to plans focused on a specific transportation subsector, leading countries develop **plans focused on promoting a distinct type of technology**. Analyzed countries paid special attention to encouraging electric and connected mobility, with plans that include not only components related to mobility, but other themes such as industrial development, AI solution integration, and the deployment of recharging infrastructure. In many cases, this is linked to the importance of the automotive industry in the country's productivity matrix, and their need to enhance efficiency and sustainability. Examples of this are the actions to promote the electric vehicle industry as part of the United States' new infrastructure act Build Back Better, which includes an Electric Vehicle (EV) Charging Action Plan and $17 billion to support the nationwide battery supply chain under the Advanced Technology Vehicles Manufacturing Loan Program. Other examples include the Strategic Project for Economic Recovery and Transformation (PERTE) aimed at Spain's Electric and Connected Vehicle development, and the U.S. Department of Transportation's Connected Vehicle Pilot Deployment Program. In both cases, "plans" refers to a wide range of public policy tools to foster transformation, including R&D stimuli and incentives for direct investment by different government agencies.

The deployment of unmanned air vehicles has also been in the spotlight in sectoral planning. The U.S. Federal Aviation Administration's (FAA) BEYOND[5] program addresses the issue of drone deployment, focusing on aspects such as better quantifying the social and economic benefits of operations, dialogue with communities, and use of beyond line-of-sight drones, emphasizing on infrastructure examination, public operations, and small-package delivery. In Spain, the Strategic Plan for the

[5] BEYOND Program (Federal Aviation Administration, 2017).

Development of the Civilian Drone Sector 2018-2021 was structured on three pillars: (I) the regulatory field; (II) Spain's integration in U-Space's[6] drone component of the European initiative for a unified airspace; and (III) strengthening the private sector by fostering R&D. In the United Kingdom, the research and innovation agency UKRI's Future of Flight program has also prioritized research and the deployment of these vehicles. The program covers the general future of aviation, and specifically, the use of drones for both urban passenger transport as well as last-mile logistics. A roadmap was established together with private players, academia, and consumer associations as part of this program. It has been complemented with a socio-economic report, a safety framework, open consultations on legislative reform, and pilot programs and concept tests, using drones to reinforce health services.

The advantage of having specific plans in place is that they generate a series of more focalized interventions than those included in sectoral plans. In terms of best practices, leading countries indicate that the development of specific plans requires the participation of professionals with expertise in the particular areas under consideration in the plans. In addition, the experience of the United States, the UK, and South Korea shows that specific plans require collaboration between the public and private sectors, as the latter have more experience in the technologies to be deployed. Therefore, the public sector should have a permanent participation in consultation mechanisms established for the plan's development rather than just being consulted at the end of its formulation. This is particularly relevant when there are roadmaps for the plan's execution, given that many of these actions need to be implemented in tandem with the private sector.

Complementing the transportation sector's specific plans, analyzed leading countries also develop **cross-sectional plans** that impact the sector. Although not all cross-sectional plans specifically mention transportation, they will likely have a spillover effect on the sector. There are three kinds of cross-sectional programs that affect the digitalization of transportation: (I) national digitalization strategies; (II) specific tech strategies; and (III) plans that impact the management of digital technologies (e.g., cybersecurity and data protection).

National digitalization strategies are based on acknowledging that the future of the productive matrix's transformation is linked to digital transformation. Although in some cases transportation is not analyzed in depth, the plan's effects on the sector (e.g., regarding R&D investment) are implicit. In other cases, the digital transformation of transportation is one of the main pillars of the national digitalization strategy. For example, Germany's High-Tech Strategy 2025 is a compilation of government initiatives and programs touching on every aspect of R&D in advanced technologies and affecting many transportations digitalization programs. Three of the strategy's themes directly impact transportation: economy and sustainable energy, smart mobility, and civil security. At the same time, the strategy sets the basis for an action plan for digitalization and the use of AI in mobility. Similarly, South Korea's Plan for the Fourth Industrial Revolution includes the vision of the Presidential Committee on

[6] U-Space is a set of new services that rely on a high level of digitalization and automation to support safe and efficient access to airspace for many drones. It is the drone component of SESAR, the technological pillar of the European Union's Single European Sky policy. SESAR defines, develops and deploys technologies to transform air traffic management in Europe. (SESAR 3 Joint Undertaking, 2017).

Transport is included as a sector of attention in the national digitalization and cybersecurity strategies.

the 4th Industrial Revolution, identifying strategies to develop new industries through smart technological innovation. The goals relevant to the digital transformation of transportation and logistics in this plan are: (I) turning South Korea into a leader in autonomous vehicles, autonomous ships, and drones; (II) accelerating innovation in smart logistics; (III) accelerating the deployment of smart cities; (IV) turning the traffic management system into a smart system; and (V) creating jobs in the sector to boost economic growth. One of the most significant contributions of national digitalization strategies is that, by making digital transformation their main goal, they can better steer it. By addressing the challenge digital transformation poses to the economy and society, national digitalization strategies are very effective at putting together action plans focused on their implications for transportation.

Specific technology strategies respond to cross-cutting digital development goals, like Spain's National Artificial Intelligence Strategy, developed as part of the Spain Digital 2025 strategy. Its value lies in reinforcing development plans, especially in regard to R&D&I.

Lastly, it is important to underscore those cross-sectoral plans that, due to their regulatory importance, constitute a benchmark for the use of digital technologies in transportation, namely **user data protection and cybersecurity**. The largest cross-cutting impact has been the General Data Protection Regulation (GDPR),[7] which extends to all Europe, and regulates the treatment of people, company, and organization's personal data. This directive has influenced shared mobility platforms' business models. Other examples of cross-cutting framework affecting the sector are the UK's National Cyber Strategy 2022, which repeatedly mentions the cyber-risks of new technologies for transportation,[8] and the Netherland's National Cybersecurity Agenda, which also underscores the importance of security in increasingly digitized processes regarding mobility. The perspective of security in transportation may stem from a general perspective of security in infrastructure like in the United States, where the National Infrastructure Protection Plan contains a Transportation Systems Sector-Specific Plan. Besides this plan, the U.S. Department of Transportation's Intelligent Transportation Systems Joint Program operates a series of research subprograms destined to guarantee a securely connected transportation environment, covering issues such as vehicle cybersecurity, connected infrastructure cybersecurity, and secure communications between vehicle and infrastructure.

Another key dimension of planning that impacts on the transportation sector's digital transformation is the **development of high-capacity communication** networks. This dimension's public policies include managing the radio spectrum for its use in wireless communications, as well as the plans and incentives that aim at deploying fixed broadband network infrastructure. In the case of radio spectrum management, all leading countries analyzed have defined frequency allocation frameworks to deploy 5G networks and have designated the range of the spectrum bands for unlicensed uses (e.g., essential Wi-Fi apps for storage management, and logistic nodes), and for inter-vehicular communications. When it comes to assigning band spectrum for

[7] What is GDPR, the EU's new data protection law? (Wolford, 2022).

[8] National Cyber Strategy 2022 (Cabinet Office & United Kingdom, 2022).

5G deployment, they have all auctioned 700 MHz, 3.6 GHz, and 28 GHz spectrum licenses. By end 2021, 49% of the European Union population was already receiving services based on 5G infrastructure.[9] Regarding Wi-Fi, the U.S. and South Korea have set aside all the 6 GHz spectrum band for free use, while European countries included in our study have assigned 500 MHz, at the lower end of the spectrum. In the case of inter-vehicular communications, the U.S. has assigned 30MHz in the 5.9 GHz band for Cellular Vehicle-to-Everything (CV2X) communications.[10] In Europe, the entire 5.9 GHz band has been allotted to Intelligent Transportation Systems (ITS).

In addition, most leading countries have implemented broadband network development plans focused on the deployment of advanced technologies, such as FTTx and 5G. For example, a universal deployment of fiber optic networks to homes and 5G mobile networks were included as part of Germany's Coalition Agreement, focusing on covering unserved areas.[11] Similarly, the Spain Digital 2025 agenda establishes digital connectivity and the deployment of 5G networks among its top priorities. The results thus far in terms of network deployment in advanced countries are significant (see **Chart 4.2**).

Chart 4.2. ▶ DEPLOYMENT OF TELECOMMUNICATION NETWORKS (2021

Countries	Fiber optics coverage	5G networks coverage
Germany	59.4 %	27.0 %
South Korea	81.6 %	97.0 %
Spain	62.6 %	64.0 %
United States	56.1 %	86.0 %
France	35.0 %	19.9 %
Netherlands	83.8 %	63.9 %
United Kingdom	59.1 %	45.9 %

Sources: AIDATE; GSMA Intelligence.

In short, **leading countries' experience with plans impacting the transportation sector reveals that digital transformation cannot be addressed by a single instrument, but that each plan contributes to a certain area**: national transportation plans acknowledge that digitalization is a key element for infrastructure development that has significant socioeconomic impacts; subsector-specific plans can address challenges and action plans with the level of detail required for their implementation. Lastly, cross-sectoral plans in specific technologies contribute to generate interventions in critical areas to advance the sector's transformation. In particular, leading countries' experience helps identify a series of best practices for planning the transportation sector's digital transformation, for LAC governments to take into consideration (see **Chart 4.3**).

[9] (European 5G Observatory, 2022).

[10] FCC modernizes 5.9 GHz band for Wi-Fi and auto safety. (Federal Communications Commission, 2020).

[11] (European Commission, 2021).

5G

"all leading countries have advanced in its deployment, have designated the range of the spectrum bands for unlicensed uses, and for inter-vehicular communications."

IDB

Chart 4.3. ▶ **BEST PRACTICES FOR PLANNING THE DIGITAL TRANSFORMATION OF TRANSPORTATION**

INSTRUMENTOS DE PLANIFICACIÓN	MEJORES PRÁCTICAS
National transport plans	• Including digital transformation as a core element for the sector's development • Developing a plan based on consultation processes with the public sector, private sector, academia, and civil society
Plans for specific areas of transportation	• High availability of specific plans for urban mobility, logistics, and air transport • Based on the concept of deep transformation that digitalization entails • Including roadmaps to implement actions, identifying those to be carried out by the public and private sectors • Plans to develop and implement sector-specific technologies, with private participation, including electric and autonomous mobility
Digitalization plans	• National digitalization strategies that help clearly define the main axis of intervention for the sector's digital transformation, particularly in regards to technological innovation
Cross-sectional plans that have an impact on transportation	• Digital agendas that identify transportation among priority sectors • Cybersecurity strategies that consider transportation a critical security element and lay out recommendations • Plans to develop high-capacity telecommunication networks

Source: Authors.

4.3
Use of public policy tools to foster the digital transformation of the transportation sector

A significant observation is that leading countries' embrace of digital transformation as a goal for transportation goes hand in hand with the **design of public policies that combine instruments to promote developing and adopting new technologies**. Public policy instruments that have been implemented so far aim at **solving challenges in four areas**:

- **Defining policies in the face of uncertainty:** policy decisions made today have long-term consequences. However, the future in which they will impact is uncertain, especially in regards to technological change and its effects.[12] In this context, governments have to adopt practices that help them define public policies with enough flexibility, anticipating possible or probable development and adoption scenarios.
- **Incentives to overcome digital transformation barriers:** Even after the appropriate policies are in place, the digitalization of transportation may face obstacles due to lack of human resources (i.e., insufficient professionals with the required knowledge in advanced digital technologies in the public sector, and not enough manpower to adopt these shifts in the private sector) or limited funding to acquire the technology. The goal in this area is to generate mechanisms to overcome these hindrances.
- **Incentives to solve potential lack of coordination between players in the transportation ecosystem:** the digital transformation of transportation requires aligning goals and plans among multiple players (private operators, central government public agencies, and local governments.) Lack of coordination can happen when actors disagree on what incentives to implement. For example, a critical area of digital transformation is the exchange on data on the urban transportation systems' monitoring and efficiency. This requires that all operators in the transportation ecosystem –service providers, news aggregators, collection agencies, regional transportation agencies, or local authorities— implement data collection and exchange systems, making sure that these systems are interoperable. Nevertheless, the difficulty lies in the fact that, for institutional or transportation market structure reasons, both public and private urban transport service providers have few incentives or the capacity to implement these systems. Similar barriers exist in the emerging logistics segment. The difficulties of implementing port community systems, where multiple players from various sectors intervene, each with different interests and incentives constitutes an example of this. Therefore, this area's goal is to define incentives, and provide the means so that every player in the ecosystem shares data.
- **Promoting and educating on the digitalization of transportation:** as with all technological dissemination processes, the digital transformation of transportation requires adapting technical knowledge to satisfy the demands of new profiles within the sector, and permanently carrying out educational campaigns so the general public can comprehend all the benefits and challenges of technologies and polies that are being or will be implemented.

4.3.1 Instruments to define policies in the face of uncertainty

Reducing uncertainty when defining public policies for the digital transformation of transportation in leading countries is attained by **three types of instruments**: (I) prospective studies combined with public consultations; (II) regulatory sandboxes; and (III) monitoring and exchanging good practices internationally.

[12] U-Space is a set of new services that rely on a high level of digitalization and automation to support safe and efficient access to airspace for many drones. It is the drone component of SESAR, the technological pillar of the European Union's Single European Sky policy. SESAR defines, develops and deploys technologies to transform air traffic management in Europe. (SESAR 3 Joint Undertaking, 2017).

3 instruments to reduce uncertainty: prospective studies and public consultations, regulatory sandbox, and exchange of good international practices.

Prospective studies and the development of scenarios help find strategic ways to think about the goals, opportunities, challenges, and long-term actions of digital transformation, considering priority public policy areas such as promoting decarbonization, egalitarian access to transportation, economic competitiveness, and security. In the case of the UK, for example, since 2018[13] the Department for Transport commissioned challenge reports for different sectors of the population in the face of tech shifts in mobility, in pursuit of defining accessibility and affordability strategies for vulnerable groups, mitigating risks of exclusion due to age, ethnic, gender, or disability barriers. At the same time, the reports connected to maritime transportation that derived in the strategy *Maritime 2050*, concluded that it was essential for the government to focus their digital transformation interventions on achieving the following goals: (I) promoting the use of clean energies; (II) strengthening security; (III) positioning the country as a sector leader to attract foreign investment. In the U.S., the FAA, under budgetary authorization from Congress, carries out research on topics considered key and innovative for the air sector, like the upgrading of the national air system (NextGen) and Advanced Air Mobility. Research programs are executed with private sector and academia participation, with discussion groups addressing different agendas. Therefore, completion of prospective studies is an interesting instrument to capitalize the present knowledge of the academic and private sectors and strengthen collaboration from an early stage of public policy design. The most common format is a call to present proposals for studies to be financed through sector agencies' budget.

Prospective studies must be complemented with **research on potential social impacts**. In all advanced countries, safety, especially in the field of vehicle autonomy, although also in MaaS and micromobility, is the main criterion in digitalization policy design and implementation. Beyond technical considerations, the concept of safety should be addressed considering the general public's admissibility of risks. Therefore, the future of transportation will depend upon a clear understanding of the population's adoption and use dynamics. A solid policy of **public consultations to learn about social behavior and the degree of admissibility** can help make pragmatic decisions that prevent adverse reactions which could dampen opportunities for progress or innovation.

Open consultations offer **transparency in the development of public policies**, especially in the case of a public service, like mobility. Consultations help understand each player's point of view, map the knowledge that the government may be lacking, and understand how to modify regulations when necessary, while avoiding overregulation that could hinder innovation or solutions that stem from the market. Among the usual mechanisms are focus groups, surveys, open consultations, and events with the general public. For example, the UK's Department for Transport has commissioned reports about the general knowledge and opinions of the public about current, emerging, and future transportation technologies. The goal is to support public dissemination strategies and understand the resistances or unawareness of future changes in the transportation system (see **Box 4.1**).

[13] Department for Transport et al. (2020).

Conducting reports and consultations requires having enough resources. The cases of the United States and the United Kingdom are paradigmatic in the sense that they have **budget provisions set aside for research and communication, with projects usually assigned through contests**.

Box 4.1. ▶ PUBLIC PERCEPTION AND DIGITALIZATION OF TRANSPORTATION

The government of the United Kingdom has commissioned four large studies on people's perception of new transportation technologies. The first, *Transport and Technology: Public Attitudes Tracker*,[14] consists of periodic surveys about the knowledge and perceptions of the general public when it comes to current, emerging, and future transportation technologies, including car ownership and connectivity, electric vehicles, autonomous vehicles (AV), and driver assistance features, drones, MaaS, shared rides, space tourism, and flying taxis. The second report, *Shared Mobility*,[15] relied on interviews to explore why current shared transportation users choose this method and how they weigh their decisions for different commutes. The third, *Future of Transport: User Study*,[16] analyzed consumer characteristics, obstacles, and motivations associated to the adoption of different new and emerging transportation technologies. Analyzed characteristics include the demographics, perspectives, and intentions of new modes of transportation, typical commute behavior, and location. The fourth study, *Future of transport: deliberative research*,[17] was carried out to explore the perception of connected vehicles and AV safety, and identify minimum safety requirements and guarantees needed to gain the general public's confidence. It also studied the role of MaaS in fostering more sustainable traveling behaviors and barriers and incentives to promote shared mobility in a post COVID-19 scenario.

Source: Authors..

The second instrument that leading countries use involves **regulatory sandboxes**. The traditional model of regulatory framework development is based on complex, institutionally fragmented regulations, and takes a long time to come to conclusions. All these features do not fit with the new, disruptive models characterizing the digital ecosystem, and therefore, the digitalization of transportation. This poses a true challenge for public policymakers (Rodríguez et al., 2021). To overcome these barriers, leading countries have implemented regulatory sandboxes. Sandboxes are technical, physical, and legal spaces for flexible experimentation, to promote innovation in a safe environment, with more flexible regulations, and minimizing the risks for end users and the rest of the ecosystem. This methodology makes it possible to carry out quasi-experimental innovation evaluations under the control of regulatory authorities, gauge socio-economic impacts, and monitor user and service provider responses while reducing test times and costs.

The use of regulatory sandboxes in leading countries is considerably widespread in the case of AV (Germany, Netherlands, the UK, the US, and South Korea.) The US Federal Transit Administration (FTA)'s Mobility on Demand (MOD) sandbox analyzes a series of mobility options, from shared bicycle and private cars systems to bus

[14] Department for Transport & United Kingdom (2018).

[15] Department for Transport & United Kingdom (2020b).

[16] Department for Transport & United Kingdom (2020b).

[17] Department for Transport & United Kingdom (2021b).

on demand services (Federal Transit Administration, 2021).[18] The program integrates payment systems as part of a series of concepts, technologies, and solutions that can potentially advance the vision of integral mobility, which is at the core of FTA's research efforts. Sandbox users are the providers of public transportation, including public transportation agencies, and the departments of transport of state and local governments. In Germany, sandboxes have been used in different sectors and have a federal integrated strategy developed by the Federal Ministry for Economic Affairs and Climate Action. In the case of transportation, HEAT (Hamburg Electric Autonomous Transportation) uses a regulatory sandbox to research the impact of electric autonomous minibuses for passenger transportation on urban roads.[19] In South Korea, a regulatory sandbox mechanism was integrated into Smart City Korea, where specific projects can get tax exemptions for solutions linked to AV or drones. Projects are evaluated by KAIA (Korea Agency for Infrastructure Technology Advancement) following security criteria and contributions to Smart City Korea goals. If they are approved, they are granted an initial four-year period for their study, as well as a series of fiscal and financial incentives, including access to an innovation fund and preferential rates for loans (KAIA, 2019). In the United Kingdom, the Civil Aviation Authority (CAA)'s Innovation Hub is operating a regulatory sandbox for Future Air Mobility, with cases that include urban and interurban air mobility (Civil Aviation Authority & United Kingdom, 2021). This sandbox has published the results of its first phase, including a map of regulations that need to be modified to enable a larger deployment of technology.

Lastly, it is common for leading countries to promote or participate in **formal association programs or in informal cooperation exchanges** to benefit from other nations' experience, coordinate policies and regulatory modifications, and solve cross-border interoperability issues, as in the case of standards. This is done bilaterally or with the support of international organizations. For example, these countries' civil aviation agencies actively participate in the discussion and design of recommendations for drones and the interoperability of aeronautical systems, among other topics, that take place in the International Civil Aviation Organization (ICAO). Similarly, the UN Economic Commission for Europe (UNECE) has coordinated the work of several countries in the continent in the field of data standardization.[20]

An important aspect related to the context of uncertainty in which public policies are developing refers to the fact that **independently of adjustment needs that are likely to emerge during program planning and management, there must be principles and regulations that guide digital transformation**. These guidelines are included in the sectoral plans and are related to the sector's general goals of efficiency, sustainability, and inclusion. In a practical sense, this translates into, for example, if regulations need to be adjusted as technologies evolve and there is better knowledge of them due to regulatory sandboxes, those changes need to follow the general principles espoused. In this sense, in the case of urban mobility, the strategic framework developed by the United Kingdom[21] follows the following guidelines:

[18] FTA's on-demand mobility efforts continued under the Integrated Mobility program in March 2020, and, more recently, with the Enhancing Mobility Innovation initiative.

[19] Erneubar Mobil (2018).

[20] Standards and metadata (UNECE, n.d.).

[21] Future of mobility: urban strategy (Department for Transport & United Kingdom, 2019d).

- New modes of transport and new mobility services must be safe and secure by design.
- The benefits of innovation in mobility must be available to all parts of the UK and all segments of society.
- Walking, cycling and active travel must remain the best options for short urban journeys.
- Mass transit must remain fundamental to an efficient transport system.
- New mobility services must lead the transition to zero emissions.
- Mobility innovation must help to reduce congestion through more efficient use of limited road space, for example through sharing rides, increasing occupancy or consolidating freight.
- The marketplace for mobility must be open to stimulate innovation and give the best deal to consumers.
- New mobility services must be designed to operate as part of an integrated transport system combining public, private and multiple modes for transport users.
- Data from new mobility services must be shared where appropriate to improve choice and the operation of the transport system.

Regardless of the specific actions, there must be principles and guidelines to guide public policy on digital transformation.

Similarly, the US Federal Highway Administration (FHWA) mentions the following elements as guidelines to design shared-mobility policies: (I) including shared mobility as a component of transport planning and regulation; (II) promoting physical and fare integration of shared mobility services among public transportation systems; (III) determining shared mobility standards and definitions; (IV) implementing regulations to ensure transportation user access and equality; (V) obtaining data for transportation planning and assessing the operational, economic, and social impacts of these services; and (vi) protecting the physical security and privacy of users (FHWA & USA, 2016). In regard to air transport, a meaningful aspect of the experience of – among others – the United States and European countries that can be extrapolated to other transportation segments is the **shift of prescriptive regulations towards regulations based on performance with the purpose of guaranteeing that transportation systems meet minimum security levels for operation**.

4.3.2 Incentives to overcome digital transformation barriers

Chapter 3 covered the difficulties that smaller companies face on the road to digital transformation. However, these companies constitute significant players in the sector, both from the point of view of efficiency and integral sustainability of transportation systems, and from an economic and labor inclusion perspective. Data from 2021 for Germany and the United Kingdom, for example, suggest that SME participation in the transportation and storage sector reaches 99.9% (UK Department for Business, Energy and Industrial Strategy, 2021). This weight makes it necessary to boost their digital

transformation processes. The main barriers for the adoption of digital technologies include limited knowledge and capabilities, and insufficient resources. To tackle these obstacles, the governments of advanced countries have set in motion **sectoral and general programs for SMEs in the entire productive sector**, consolidated in **three lines of action**:

- Deploying **tech centers** to promote practices regarding the digitalization of industrial processes, digital technologies research, and pilot execution, including the transportation sector.
- **Spreading knowledge** to the private sector about the advantages associated with concepts of digital transformation, such as increased productivity, market expansion, and ways to introduce transformation.
- Incentives to digitalize processes by granting **loans with low interest rates or tax deductions**, for example, for the conversion of fleets.

In regard to the latter, many post-pandemic economic recovery programs include the sector among the beneficiaries of fiscal exemptions and loans with subsidized rates to take steps towards digital transformation, acknowledging the importance of this transformation for recovery. For example, the resources allocated to France's Mobility Orientation Law amount to EUR 13.4 million. These funds can be used to support restructuring projects and tech adoption programs that include converting fleets and equipment to more sustainable and modern standards.

Apart from post-pandemic recovery programs, most advanced countries provide funding schemes that can be used by transportation SMEs to implement digitalization initiatives. For example, in the United States, the *Research and Experimentation Tax Credit*[22] allows companies to deduct R&D spending, which represents an implicit subsidy to cost reductions associated with digital transformation. In Germany, the Federal Ministry for Economic Affairs and Energy's *Central Innovation Program for SMEs* (ZIM) offers non-reimbursable assistance to companies with under 500 employees. The program aims at improving products, processes, or technical services. In addition, the ERP *Innovation Program*[23] offers low interest loans of up to $7 million to private companies that have difficulties accessing loans for innovative initiatives.

Together with economic incentives, several of the analyzed countries have developed **roadmaps or guides to help SMEs in their digital transformation**. Although there are few cases specifically referred to transportation, those part of Industry 4.0 may constitute a good example, as the transformation guide developed by the United States' Digital Manufacturing and Design Innovation Institute (DMDII). A similar effort was conducted by the National Academy of Science and Engineering (Acatech) in Germany, which culminated by launching an *Industry 4.0 Maturity Index* that lays out a six-stage development path to lead a company from basic digitalization implementation capacity all the way up to the point where it can carry out production diagnostics in real time, and anticipate shifts in demand, optimizing its operations (Calatayud & Katz, 2019).

[22] What is the Research and Experimentation Tax Credit? (Akabas & Collins, 2014).

[23] Federal Ministry for Economic Affairs and Climate Action (n.d.).

99.9%

“of transport companies are SMEs and have a lower level of progress in digital transformation, which is why the leading countries are focusing actions on this segment.”

4.3.3 Incentives to solve potential coordination failures between players in the transportation ecosystem

There are coordination failures between players in the private sector that hinder progress towards the digital transformation of transportation. These especially refer to a reluctance to share information and the difficulty of coordinating the pace of digital transformation between sectoral players. The reasons hampering information sharing include advantages over competitors, lack of transparency to avoid public audits or having to comply with private contracts, and the cost of processes to generate and share data. In these cases, the most common incentives governments have relied on have been creating **policies and regulations that foster open data**, as a source to boost efficiency, transparency, and inclusion in the sector. This requires the early **adoption of standards or codes**. The United Kingdom's experience in urban mobility is paradigmatic in terms of the incentives the country has instituted to share public transportation data in a context in which service providers are private. The Eighth Report of the House of Commons' Transport Committee on Mobility as a Service introduces the concept "*no data, no service*", which forces all public transportation operators to share data if they want to offer a service in a given area (Transport Committee, 2018). This principle was picked up by the Joint Rail Data Action Plan and the Public Service Vehicle (PSV) regulations.

Open data policies and regulations are key to resolving coordination failures and facilitating information sharing.

Another area where governments contribute to solving coordination deficiencies is in **developing standards for data communication**, which simplifies the interoperability between platforms and technological systems. This is crucial, for example, to make data transmission possible between players in a logistics chain that may be using different systems by different technology providers. Although it is common for private-sector industrial consortia to begin developing their own standards, governments play an important role in defining regulations. In general, the goal is not only to simplify devices and platform connectivity, but also to favor the adoption of open standards to avoid excluding medium and small players, and reduce the cost of adopting technologies by integrating broad solution provider ecosystems.

The approach that governments are taking to promote the adoption of standards is varied. Some countries address the development of data standards in a centralized, vertical way, under a process led by the government. In others, like the United States, the private sector assumes a leading role and the government supports the process and establishes the legal framework once regulations have been defined. In the latter, the United States' *Internet Industrial Consortium* (IIC) defines data standards for industries including energy, healthcare, manufacturing, and transportation. This task includes developing benchmark architectures, theoretical frameworks, and open standards to facilitate the interoperability between industrial systems. Somewhere in between these two models, some governments bring in the private sector from the beginning of the program to define standards, developing a collaborative framework based on a close relationship between the public and private sectors. For example, based on the authority of the Korean Agency for Technology and Standards (KATS), the Korean government has defined a structured program with each of the industrial sectors, involving the private sector in the definition phase. In the case of Germany,

setting up standards for Industry 4.0 is led by The Federal Ministry for Economic Affairs and Energy, and the Federal Ministry of Education and Research, while representatives from the private sector, universities, and unions participate in workshops.

Regarding the need to **stimulate the pace of digital transformation at the sector and subsector levels**, national and sectoral plans, tax break and subsidy funding programs, non-reimbursable aid, the deployment of tech centers and the awareness of the benefits of digital transformation are the most commonly used tools by advanced countries. Many of them aim at logistics and public transportation, where the multiplicity of players in these subsectors and the different sizes of companies involved make digital transformation to advance at different paces.

4.3.4 Promoting and educating about the digitalization of transportation

Do not forget the people: education and awareness campaigns on new technologies and their impacts on transport are required.

A more complicated problem is **talent recruitment** for the development of technologies and the digital transformation of service providers. The **lack of human capital in digital transformation** of productive processes has been widely documented in both developing and advanced countries.[24] The aforementioned development plans for specific technologies are essential in this area. For example, France's National Strategy for Artificial Intelligence led to the creation of the French National Institute for Research in Digital Science and Technology (INRIA).[25] INRIA comprises new university research centers, including the University of Bordeaux, the University of Grenoble, Sorbonne, the University of Sophia Antipolis, and the University of Paris-Saclay. The organization connects 3,000 researchers grouped into 200 work teams, and has incubated 200 startups since 1984. The research areas include the digital transformation of government organizations, SME digitalization through the provision of open software, and web platform algorithms regulation. Alternatively, although there are no experiences of specific training programs in transportation digitalization areas, the German experience of learning 4.0 technologies has generated a spillover effect in the sector. With funds from the Federal Ministry of Education and Research, the German Research Center for Artificial Intelligence (DFKI) offers intensive training in digital technologies and mentorships to Masters and Doctorate students with high potential. The program allows them to work in private sector projects to develop high-level capabilities in the TIC sector. Meanwhile, the experience of leading countries in talent formation for the digitalization of transportation is beginning to show. The U.S. Federal Transit Administration provides financial support for the *Transit Workforce Center* (TWC) to directly support the development of the public transportation workforce. Their mission is to help transportation agencies recruit, hire, train, and retain the workforce in public transportation through technical assistance activities aimed at developing workers capabilities, including tech skills that prepare this workforce for the transportation of the future.

The key for the successful implementation of transportation digitalization processes lays in guaranteeing that the release dates of initiatives, projects, or technologies are in line with the public's knowledge or familiarization. Transportation's digital transformation

[24] One can consult the many studies of CEDEFOP or European Center for the Development of Vocational Training such as Empowering adults through upskilling and reskilling pathways (Vol. 1, Rep.) (CEDEFOP, 2020); or Germany: Adult population with upskilling and reskilling potential (CEDEFOP, 2019). As well as the new European digital skills agenda (European Commission, 2016).

[25] Inria (n.d.).

requires carrying out **permanent education campaigns** to raise awareness among the general public about new technologies and the impacts in the sector, and disseminate the programs for the digitalization of transportation that are being or will be implemented. An example of direct communication with the public was Spain's Ministry of Transport, Mobility and Urban Agenda's *Diálogo Abierto de Movilidad* (Open Dialogue about Mobility), encouraging debate among civil society on the transformations included in the Strategy for Safe, Sustainable and Connected Mobility 2030. The campaign was divided into thematic weeks, with multiple events and public participation tools such as surveys and idea labs. One of them was the Digitalization and Mobility as a Service Week, and there was another one on drones and connected and autonomous vehicles.

Another communication space for both industry and citizens is **government representation in sectoral conferences**. Innovation awards such as the *German Mobility Award* or the *Maria Bernaldo de Quiros* award to best female professional in the transport sector constitute a preferred indirect form of communication for governments, since they allow them to highlight strategic priorities and identify players who are thriving in the ecosystems of innovation in transportation.

In short, and as illustrated in **Chart 4.4**, **advanced countries' experience reveals the implementation of multiple public policy tools to promote the digitalization of transportation**.

Chart 4.4. ▶ BEST PRACTICES IN THE USE OF PUBLIC POLICY TOOLS FOR THE DIGITAL TRANSFORMATION OF TRANSPORTATION

CHALLENGES FOR PUBLIC POLICIES	BEST PRACTICES
Uncertainty in the definition of appropriate policies	• Prospective studies and transportation digitalization development scenarios, with inputs from the private sector, academia, and civil society • Social behavior impact studies on the adoption and use of digital platforms • Regulatory sandboxes • International cooperation to access experiences • Defining principles and guidelines for the digital transformation of transportation to put together a public policy framework that maintains flexibility and tech neutrality
Barriers to digital transformation	• Creating or supporting the development of tech centers for the sector or segments of the sector • Knowledge awareness campaigns for the private sector about the benefits of digital transformation • Tax breaks • Subsidized funding • Non-reimbursable aid

CHALLENGES FOR PUBLIC POLICIES	BEST PRACTICES
Lack of coordination between players in the transportation ecosystem	• Legal requirements for data sharing • Adopting standards and norms • Identifying segments that are lagging behind and combining instruments to promote the shift in technologies
Lack of talent and knowledge about digital transformation in the sector	• Programs and training centers about 4.0 technologies • Continuous education campaigns • Events focused on the sector or technology-oriented, with the participation of top government officials

Source: Authors.

4.4 Strengthening sectoral institutions and processes for digital transformation

Designing policies for transportation digitalization requires **updating decision-makers capabilities** in terms of planning, regulation, management, and supervision. A significant aspect strictly related to the public sector is that not only does it lay out an institutional and regulatory framework for transportation, but it also provides certain services itself. For example, the public sector is in charge of managing the traffic in urban networks to maximize its capacity. It is also in charge of cargo control activities, whose efficiency determines the performance level of international transportation. In this sense, every country analyzed is taking steps to **digitalize paperwork and enhance the technological management of infrastructure assets**. Some examples include port community systems, where documents needed by transportation authorities are already digitalized; or urban mobility control centers, where transportation service and infrastructure capacity can be dynamically adjusted according to demand.

To this purpose, leading countries have adopted at least four actions. The first is **incorporating profiles linked to technology, putting together specialized teams and allocating budgets to carry out projects, and training their general staff**. For example, the Departments of Transportation in U.S. states have appointed Chief Information Officers to lead the definition and execution of the institution's digital transformation strategies. Thus, a good practice in this case is that most Departments of Transportation already have an internal digital transformation strategy as well as staff and budget allocated to its execution (see **Box 4.2**). The same thing happens at a sectoral level around the world, as in the cases of the Port Authorities of Antwerp and

Hamburg and the Mobility Agencies of London and New York. An interesting aspect that stems from these experiences is the creation of increasingly interdisciplinary workgroups, with profiles specialized in computers, statistics, and physics, apart from engineering, which has been the most required in the sector traditionally.

Box 4.2. ▶ CDOS & CIOS IN U.S. TRANSPORTATION FEDERAL POLICY: DIGITALIZING FROM LEADERSHIP

In recent years, a growing number of federal agencies and state transportation departments in the United Stated have appointed a Chief Data Officer (CDO) to develop strategies to collect, manage, and share data, which is considered an asset. From this perspective, data is examined internally to obtain knowledge and boost efficiency, and is shared both with the general public and with companies and the entrepreneurial ecosystem. The Federal Data Strategy (FDS) of 2018 boosted the creation of this figure in organizations. CIOs and CDOs tend to have similar or overlapping roles, and they both partake in a national council that brings its members together. These councils act as forums where best practices can be shared between government agencies. They also monitor the progress of data and information management. The Federal CDO Council brings together the government's chiefs of data. This institution held its first formal meetings in 2020, while the CIO Council has existed since 2012. Both organizations have launched practical guides like the *CDO Playbook*, and *Chief Information Officers Council Handbook*, which can operate as the starting point to create similar positions in other governments given that they lay out these officials' responsibilities, opportunities, and legal framework for action.

In the context of these transformations, transportation governance federal agencies like the National Cooperative Highway Research Program, in cooperation with the American Association of State Highway and Transportation Officials, have created a program to support the digital transformation of employees in transportation departments: a joint workgroup to manage the impact of digitalization in DOT workforces. This project has led to data management recommendations such as:

- Keeping data governance groups small
- Allowing data governance to develop organically
- Organizations need a champion or leader to carry out data governance
- Transfer knowledge from retiring experts to the new generation
- CDO responsibilities cannot be carried out part-time
- Defining a clear role for information technology, and guaranteeing the alignment between organizational processes and technology
- Creating an executive commitment at every stage
- Internal advertising and marketing to change the culture, workforce, and procedures
- Defining the life-cycle of data

An example of these leadership actions based on technology is the Virginia Department of Transportation's 2020-2022 Information Technology (IT) Strategic Plan, which addresses technical concepts and concrete enhancements such as the transition to cloud services in the Department's IT programs. The Minnesota Department of Transportation has four

compulsory training programs in regard to data, including a full data management training program in phases with modules targeting specific audiences, like California DOT, which is building its own data training program led by its CDO.

Digitalization processes can also focus on specific aspects of transportation infrastructure management. For example, Pennsylvania DOT's Digital Delivery Directive 2025 involves digitalizing bidding processes and public work delivery using BIM. This initiative's strategic plan includes a roadmap, work plans, and the tools to fulfill them, with a diagnostic of training and knowledge elements both within the DOT and among its counterparts.

Source: Authors.

Another option is **creating research agencies with ministries or sector agencies**, which requires recruiting academic experts among the workforces. Spain's Centre for Public Works Studies and Experimentation (CEDEX) or the Korea Transport Institute (KOTI) are examples of these initiatives. KOTI is a national agency in charge of carrying out prospective policy, socioeconomic, and tech studies related to transportation. They investigate innovations and the transformation of the transportation system to contribute to the development of the future of mobility. The Institute is a key player in the Presidential Committee on the 4th Industrial Revolution, as well as in the transportation sector, as part of the Third Smart City Master Plan. This institute specifically includes a Department of Mobility Transformation, a Center for Smart City and Transport, a Center for Future Vehicles, and a Center for Connected and Automated Driving Research. Similarly, CEDEX is an autonomous agency affiliated with Spain's Ministry of Transport, Mobility and Urban Agenda. Its role is to advise and assist public institutions and administrations, as well as private enterprises, in civil engineering, construction, and environmental technologies. Since the new mobility strategy has been in place (Ministerio de Transportes & España, 2020), CEDEX has begun reorganizing activities in the fields of transportation and infrastructure, to shift towards the research, development, and innovation of integrated mobility solutions.

The third action is to **hire external advisory services for strategic developments and for projects that require specific profiles**, usually related to advanced knowledge in some form of 4.0 technology or skill outside the scope of the transportation sector. These services may also include **telecommunications infrastructure and software**. The digital transformation of agencies in the sector entails upgrading and adapting their technological infrastructure to, for example, be able to store and analyze large amounts of data. In many cases, public agencies choose to acquire storage capacity and cloud services through tech companies. For example, Vancouver's metropolitan transportation system, in collaboration with Microsoft, has developed AI models to reduce waiting time at public transportation stops.[26] Similarly, the Massachusetts Bay Transportation Authority, in a joint effort with Intel, has updated its infrastructure and bus management system, adopting a real-time video and GPS monitoring system and centralized cloud storage.[27] The goal in these cases is to make services safe, quick, reliable, and with open and transparent standards (Kenneally et al., 2014).

[26] Metro Vancouver improved bus departure estimates by 74% with Azure Machine Learning (Microsoft, 2020).

[27] The MBTA deploys Genetec Omnicast (Intel Solution and Partner Company) on its fleet of buses to monitor safety (Genetec, n.d.).

The fourth route to bridging the access gap to qualified human resources in digital transformation within the public sector is to **incorporate academic experts in advisory councils**. For example, Spain's Council of Transport, Mobility and Urban Agenda is an independent agency in charge of selecting and evaluating high-profile infrastructure investment projects. It is constituted by independent experts with a mission to contribute to better investment planning in transportation infrastructure. Current regulations require the council to evaluate public-private associations' infrastructure investment proposals. At the same time, before adopting any road or rail infrastructure plan, the council must present a report on the proposed project or review topics of special interest, such as applying European legislation in Spain, or transportation infrastructure security. The decisions made by the council are non-binding. Similarly, the United Kingdom's AI Council is a committee of independent experts that advise the government on AI-related issues, supporting its development in the country, and promoting its adoption and use by companies and society as a whole. The Regulatory Horizons Council (RHC), also in the UK, is another committee of independent experts that identifies the implications of tech innovation and advises the government on all regulatory reforms. The government's response can be regulation introduction, adaptation, or overturn (like voluntary standards), depending on the nature of the innovations.

4.5 Horizontal coordination within the national government

Because the plans and instruments described in the previous sections are developed and implemented by various institutions –even within the transportation sector itself– it is necessary to establish **coherent public policies** so the development agenda of each specific technology can be aligned with the goals of the sector as a whole. To respond to this need, when it comes to public policies, most advanced countries have developed **inter-institutional coordination mechanisms**.

Inter-institutional coordination is essential to ensure the alignment of multiple agencies' policies and actions with the transport sector's development objectives.

Although national transportation authorities are fundamentally in charge of long-term planning and policy implementation in the transportation sector, in the context of which they address digital transformation, it is common that given the multiple modes of transportation, there are multiple authorities with national prerogative. For example, France and South Korea have differentiated transportation ministries that possess jurisdictional authority on maritime transportation. In addition, there are central government agencies with authority on specific aspects of digitalized transportation (like the use of data by urban mobility apps). **Chart 4.5** summarizes the sector's central agencies, discerning between those with power over a specific transportation segment from those fully accountable.

Chart 4.5. ▶ NATIONAL AUTHORITIES IN CHARGE OF NATIONAL DEVELOPMENT PLANS THAT INCLUDE THE DIGITALIZATION OF TRANSPORTATION

		LOGISTICS (*)	AIR TRANSPORTATION	URBAN MOBILITY
GERMANY	Multimodal authority	• Federal Ministry of Transport and Digital Infrastructure • Federal Ministry for Economic Affairs and Climate Action • Federal Ministry of Education and Research		
	Specific authority	• Waterways and Shipping Administration (WSV) • Federal Trunk Road Authority (FBA) • Federal Office for Goods Transport (BAG)	• National Civil Aviation Authority Luftfahrt-Bundesamt (LBA)	
SOUTH KOREA	Multimodal authority	• Ministry of Land, Infrastructure and Transport (MOLIT) • Ministry of Science and ICT • Korea Agency for Infrastructure Technology Advancement (KAIA)		
	Specific authority	• Ministry of Oceans and Fisheries	• Korea Office of Civil Aviation (KOCA	• Korea Transport Institute (KOTI)
SPAIN	Multimodal authority	• Ministry of Transport, Mobility and Urban Agenda (MITMA)		
	Specific authority	• Ports of the State • Maritime Safety Agency (SASEMAR)	• Aviation Safety and Security Agency (AESA) • ENAIRE	• Directorate-General for Traffic
UNITED STATES[28]	Multimodal authority	• Department of Transportation (DOT)		
	Specific authority	• Maritime Administration • Federal Motor Carrier Safety Administration (FMCSA)	• Federal Aviation Administration (FAA)	• Federal Transit Administration (FTA) • Federal Highway Administration (FHWA) • National Highway Traffic Safety Administration (NHTSA

[28] Each of the agencies listed under "Specific Authority" in the United States reports to the multimodal authority (Department of Transportation).

		LOGISTICS (*)	AIR TRANSPORTATION	URBAN MOBILITY
FRANCIA	Multimodal authority	• Ministry of Transport • General Secretariat for Investment • Transport Innovation Agency		
	Specific authority	• Ministry of the Sea	• Directorate General for Civil Aviation (DGAC)	• French Agency for Ecological Transition • Regional Mobility Authorities
PAÍSES BAJOS	Multimodal authority	• Ministry of Infrastructure and Water Management • Directorate-General for Public Works and Water Management (Rijkswaterstaat)		
	Specific authority	• Directorate-General for Civil Aviation and Maritime Affairs	• Air Traffic Control the Netherlands – LVNL	• Directorate-General for Mobility and Transport • RDW (independent Vehicle Authority)
REINO UNIDO	Multimodal authority	• Department for Transport (DfT) • Department for Business, Energy & Industrial Strategy (BEIS) • Office for Low Emission Vehicles		
	Specific authority	• *Maritime and Coast Guard Agency*	• Civil Aviation Authority	• Centre for Connected and Autonomous Vehicles (part of BEIS and DfT)

Source: Authors compilation.

(*) Includes maritime, land, and last-mile transportation.

In addition to public policies in the transport sector, there are **ministries whose main activities affect the sector's digital transformation**. These are mainly related to the **deployment of infrastructure for telecommunications, R&D, and industrial policies**. For example, in Korea, the Ministry of Science and ICT is in charge of leading the Fourth Industrial Revolution, supporting the development and adoption of digital technologies. Therefore, this agency coordinates R&D policies that directly impact transportation, for example, in regard to the deployment and management of 5G technology. It also directly or indirectly funds R&D projects in transportation. In Spain, the Ministry of Science and Innovation is the main agency in charge of executing state policy in terms of scientific and technical research, tech development, and innovation. Regarding the future of transportation, it coordinates strategies and manages

The multiplicity of institutions related to transportation and digital transformation requires the implementation of inter-institutional coordination mechanisms.

both its own funds as well as those from the European Commission destined to innovation in mobility, transportation, and logistics. In France, the General Secretariat for Investment (SGPI), under the authority of the Prime Minister, is responsible for applying the Investments for the Future Program, a public investment program for outstanding research and innovation projects focused on sustainable growth. This program funds numerous logistic and mobility technologies pilot projects. In the United Kingdom, the Department for Business, Energy & Industrial Strategy (BEIS) is responsible for the industrial policy strategy and the research and innovation agenda. In this sense, their involvement with the transportation sector is translated into the aegis of UK's Research and Innovation agency, which leads R&D programs for the digital transformation of aviation and urban mobility.

The number of dimensions it impacts (e.g. tech development, industrial policies, consumer rights, and many others), its interrelationships, and the implicit interoperability of this multimodal system demand an enormous effort to achieve institutional and public policy alignment. This requires a **unified political commitment and leadership from the executive branch, highlighting the importance of digitalization of transportation as a mechanism to generate economic competitiveness and quality of life**. To simplify its **horizontal coordination**, analyzed countries have developed ***ad hoc instances***, usually under the form of inter-ministerial councils, that encompass various agencies depending on the specific mode, issue, or technology they address. These instances are used to establish priorities, devise joint efforts, and align interventions that are independently executed.

Horizontal coordination is achieved through **two kinds of inter-ministerial committees: (i) committees built around a specific mode of transportation**, where the digitalization of transportation is included, although many other elements linked to the sector are addressed; **and (ii) committees for the digital transformation of the economy, including transportation**. As an example of the former, France's Inter-Ministerial Logistics Committee (CILOG) was created in December 2020, driven by the "key role of logistics in the context of the pandemic," to develop a more competitive supply chain. At the same time, the country's Inter-Ministerial Committee on the Sea leads the development of the new port strategy, the post-Brexit support plan, and defines recovery policies in regard to the "maritime and port" chains.[29] Within the second category, South Korea's Presidential Committee on the 4th Industrial Revolution (PCFIR) was created to oversee and coordinate policies related to the Fourth Industrial Revolution. *Industrial Innovation*, one of the key pillars of the policy recommendations, includes strategies for the mobility, logistics, and smart cities sectors, with dimensions covering AI, cybersecurity, Blockchain, and stimulus for the startup ecosystem.

One of the main issues inter-ministerial committees deal with is the efficiency of their operations, in accordance to the goal for which they were assembled. In this sense, eight successful practices have been identified from the experiences of advanced countries:

[29] CIMer 2021 Press Release (Secretariat General of the Sea, 2021).

2 types of committees for inter-institutional coordination: committees formed around a mode of transport and committees for the digital transformation of the economy.

- **Leadership responsibility:** inter-ministerial committees are more successful than those convened by the executive branch's maximum authority (President or Prime Minister.) This confirms the political importance of establishing and executing the agenda to all members. For example, France's Inter-Ministerial Logistics Committee reports to the Prime Minister. Similarly, South Korea's Presidential Committee on the 4th Industrial Revolution is led by the Prime Minister.
- **Purpose of the committee:** the committee's role must be clearly established upon formation: (i) managing joint actions, or (ii) coordinating actions executed by each public agency. As an example of the former, South Korea's Mobility Innovation Committee is in charge of providing policy recommendations and developing strategies to improve the operations of mobility platforms so services can be more accessible, affordable, sustainable, and secure. In the same country, the National Smart City Committee aims at establishing a comprehensive smart city plan, and managing nationwide projects to build these cities. To this effect, the committee is in charge of coordinating with the central and local governments. As an example of the latter role, the country's Presidential Committee on the 4th Industrial Revolution (PCFIR) was created to review and coordinate cross-ministerial policies related to the Fourth Industrial Revolution. This committee serves as a policy control tower of national data, boosts digital economy based on data, and provides support to sectoral policies in regard to the use of data and artificial intelligence.
- **Committee structure:** will depend on the goal. If the committee has an executive role, it must be led by a representative of the executive branch and comprise high-level authorities from ministries and other national agencies. As an example, the Inter-ministerial Committee for Logistics in France combines the relevant ministries (Transport, Sea, Industry.) If the committee's role is inter-institutional coordination, its members must include representatives of local organizations. For example, the same country's Ministerial Council for Transport Development and Innovation founded in 2020 as a response to the crisis in the transportation sector during the pandemic, brings together the main federations and companies in the sector, transportation equipment manufacturers and operators, representatives of different regions in the country, and several members of the National Assembly.
- **Meeting frequency:** meeting regularity varies according to the role and composition of each committee. Even in cases where the committee did not meet frequently (e.g. France's Inter-Ministerial Logistics Committee holds an annual meeting to offer the government recommendations for logistics), there must be a technical support group in charge of advancing the defined agenda, monitoring goal fulfillment, and making decision-making recommendations on behalf of the committee.
- **Private sector involvement:** in recent years, the permanent formal participation of the private sector in inter-ministerial committees has become increasingly more common in leading countries. For example, private sector representatives participate in South Korea's Presidential Committee on the 4th Industrial Revolution. *France Logistique*, an association created to bring together and coordinate all players from the private sector and civil society in the logistic sector (i.e. professional organizations, unions,

and key businesspeople) is part of the Inter-ministerial Committee for Logistics. Among the members of the U.S. Advanced Aviation Advisory Committee (AAAC) are top-level executives in the aeronautics industry.

- **Measuring results:** evaluating results is yet another good practice by the committees in order to follow up on adopted decisions or actions. For example, France's Inter-Ministerial Committee of the Sea keeps track of the number of measures adopted since their first meeting, as well as their efficacy rate depending on whether they have been implemented, are ongoing, or have been disregarded.
- **Establishing committees with deadlines:** to avoid procrastination or obsolescence, depending on each case, there can also be committees or areas of cooperation within a specific timeline and with a practical issue to be tackled. Germany's National Platform Future of Mobility (NPM) was created with a determined mandate from 2018 to 2021, and a specific mission: to address digital mobility issues. After delivering its advice and reports, the platform considers that its goal has been met, its knowledge integrated into policy decisions and public policy, and its work completed.
- **Participation of academia:** the involvement of academic experts represents a good approach to acquiring technical talent. For example, representatives from academia participate in South Korea's Presidential Committee on the 4th Industrial Revolution, and in the Netherlands' Council for the Environment and Infrastructure, which acts as the government's and Parliament's main consultative body on infrastructure issues.

There are also **collaboration groups that**, although lacking the formality of committees, **are specifically established to tackle an issue that requires the participation of different institutions**. The experience of the United Kingdom in connection to the deployment of autonomous and connected vehicles is illustrative: when jurisdiction issues or affairs that fall under the expertise of another agency arise, a work team is put together for a limited time and with specific goals, usually related to technical aspects. These work teams also articulate collaborations with regional and local authorities if the topic requires their involvement.

4.6 Vertical coordination with regional and local authorities

Strengthening the capabilities of local authorities is key to advancing in the digital transformation.

While plans, policies, and coordination instruments are deployed at a national level, regional and local governments in leading countries are actively engaging in the sector. When it comes to urban mobility, these levels play a key role, given that regional and local authorities are in charge of planning, regulation and supervision. In this regard, analyzed experiences reveal that **metropolitan transportation authorities** that lump together the different political-administrative divisions comprising the urban environment, contribute to coordinating and scaling up digital transformation initiatives. In the United Kingdom,

for example, Transport for London (TfL) is in charge of planning and managing urban transportation and roads in the London metropolitan area. This requires promoting cooperation between the companies that operate transportation services, whether public or private, and local administrators that hold the rights to infrastructure and services that provide funding. Similarly, the New York Metropolitan Transportation Council (NYMTC) is the agency managing transportation planning and operations for the city of New York, Long Island, and the lower Hudson Valley, encompassing over 12 million inhabitants. The existence of these authorities has simplified things, from implementing e-payments to generating integrated apps for public transportation services, in line with MaaS goals, for services that operate in more than one administrative division.

France is another example of a practice focused on solving coordination needs at local level. Every region and department in the country has its own Mobility Organizing Authority (AOM) in charge of managing public transportation services, shared mobility, and urban logistics. To help multiple mobility players within the same region coordinate their actions, an operational mobility agreement is signed. This is a contractual document between the main players in mobility in the territory, namely AOM, parity coordination unions known as SRUs, and the departments and operators of passenger stations or multimodal stations (Ministry for the Ecological Transition, 2021). Depending on the characteristics of the territory at stake, the contract may also involve Public Inter-municipal Cooperation Establishments (EPCI), a neighboring region, or any other partner (transportation operator, municipality, etc.). The areas covered by the operational contract include the coordination to create and organize favorable conditions for the development of the future of mobility.

Meanwhile, South Korea has developed a central government-based mechanism to foster coordination, associated with the Ministry of Land, Infrastructure and Transport. The Metropolitan traffic Committee takes on the role of mediating between local authorities and promoting the creation of efficient governance mechanisms. The Committee is structured in five regional offices located in large metropolitan areas throughout the country (Seoul-Incheon-Gyeonggi, Busan, Daegu, Daejeon, and Gwangju.) In addition, there is an initiative called The Smart City Challenge[30], in which local governments play an active role in tackling urban problematics, including transportation, and private entities can participate in the innovative solutions and demonstration plans. Half of this initiative's financial support comes from the central government.

In terms of coordination between the central government and local authorities, analyzed experiences reveal different courses of action that have yielded positive results. In some cases, the mechanism applied consisted of **boosting the knowledge of local authorities** due to their expertise and competences in specific subsectors. This was the case of the Port Authorities of Antwerp[31], Hamburg[32], and Rotterdam[33], which have their own digital transformation strategies, teams, and resources. Another option is that the central government **formulates a regulatory framework or guidelines that local governments must follow as they establish their specific policies or regulations**. This occurs, for example, in France's micromobility services,

[30] The Korean "Smart City Challenge" is inspired by its U.S. counterpart launched in 2016. In the Korean version, launched in 2019, it incorporates transportation challenges like the original and additional dimensions such as energy, safety, or environment.

[31] Port of Antwerp (n.d.).

[32] Hamburg Port Authority (n.d.).

[33] Rotterdam Maritime Capital of Europe (n.d.).

where the national government has laid out guidelines by promoting a new national mobility law that guarantees things like public spaces occupation prevention, user data protection, and device batteries' compliance with environmental regulations. At the same time, it leaves in the hands of local authorities the issuance of permits to service operating companies and the management of the cash flow proceeding from public space use fees charged to operators.[34] On a broader scale, the plans for developing technological or productive clusters are used to identify the strategic areas to be developed in a given geographical area, which often include transportation as an aspect to be prioritized for their development, with some mentions of innovation in this sector. An example of this is the Mobility and Logistics Cluster of the Basque Country in Spain, in line with European and Spanish policies in this regard.

Lastly, an additional practice is that in which the central government promotes **capacity building at local government level** so that they can solve regulatory issues. One example of this is the recently established Buses Centre of Excellence in the UK, through which the central government has established a series of activities and programs aimed at improving transportation planning and bus driving, by training teams within municipal transportation agencies in topics that include new technologies (Department for Transport & United Kingdom, 2021a).

4.7 Active collaboration between the public and private sectors

As described in **Chapter 3**, large global companies are leading the digital transformation of transportation. However, the public sector plays a significant role in ensuring that the transformation leads to transportation systems' efficiency, sustainability, and inclusion. That is why each of the analyzed experiences of leading countries underscores **promoting public-private collaborations**. There are three main mechanisms used to this end: (I) institutional coordination; (II) coordination for tech development; and (III) consultations with the private sector for the development of the sector's strategic plans.

The **institutional public-private coordination model** involves the private sector's participation in inter-sectoral committees for the digitalization of transportation, organized by governments. France (Ministerial Council for Transport Development and Innovation, and Inter-Ministerial Logistics Committee), United Kingdom (Maritime 2050), Spain (Alliance for Electric and Connected Vehicles), and the United States (Advanced Aviation Advisory Committee) are good examples of this. The integration of the private sector into inter-sectoral committees (e.g. Ministerial Council for Transport Development and Innovation, and Inter-Ministerial Logistics Committee in France; Maritime 2050 in the UK) represents a good opportunity to transform a sectoral plan from a series of government commitments to a true agreement with consensual objectives between the state and the private sector.

[34] Accelerating the new mobility revolution (Ministry for the Ecological Transition & France, 2021).

8 areas to increase the effectiveness of inter-ministerial committees: responsibility, purpose, composition, duration, frequency of meetings, monitoring of progress, and participation of the private sector and academia.

3 mechanisms to promote public-private collaboration: institutional coordination, technological development coordination, and consultations to prepare strategic plans.

These committees can be organized ad hoc for a specific need. As has been previously stated, France's Inter-Ministerial Logistics Committee was created in December 2020 due to the key role logistics plays in the context of the pandemic, the evident shortfalls in the sector, and the opportunities for improvement, including digital transformation. A call was issued to relevant ministries (Transport, Sea, and Industry) and to *France Logistique*, an association created in January 2020 to gather and coordinate private players in the logistics sector. Meanwhile, the U.S. Advanced Aviation Advisory Committee is a federal-level committee that advises the FAA on key issues such as the development and integration of Urban Air Mobility Systems, helping identify challenges and prioritize improvements in the air sector as a result of technological progress. Its members include CEO/COO executives of stakeholders, which represent the development technology's wide range of interests, including industry (such as airlines, drone manufacturers, and logistics operators), research and academia, retail commerce, and technology.

The second public-private collaboration model involves **agreements to develop specific application technologies** for the transportation sector. South Korea is one of the most advanced countries with the broadest experience in public-private collaboration on specific projects. This country implements three models of public-private cooperation: (I) signing a Memorandum of Understanding between the government and a private company to carry out a specific project; (II) creating a consortium of private companies with unique specifications to undertake a joint project; and (III) creating a research area (e.g., smart cities) sponsored by the public sector and private enterprises that contribute financial resources and, in exchange, gain access to the area where they can develop their technology. For example, to develop smart ships, the South Korea's Marine Equipment Research Institute partnered with Samsung Heavy Industries to build capacities in the country's shipping industry and create the industrial capacity to build these ships. The United Kingdom is working with Intel to develop a map of all its infrastructure and road assets by implementing Mobileye technology.[35] The city of Antwerp and Be-Mobile developed a digital platform integrating multiple sources of information under Azure to suggest intermodal routes and reduce the use of private vehicles (Microsoft, 2019). In the Netherlands, SMASH! - the Netherlands Forum for Smart Shipping, was created bringing together the country's maritime public and private sector players to promote smart ship transportation and thus strengthen the sector's competitive position. This cooperative platform is used to share information, develop projects, and promote the country's maritime industry internationally.

[35] Since 2019 Ordnance Survey, Britain's national mapping agency, and Mobileye have been deploying solutions to map British road infrastructure (Ordnance Survey, 2019).

Box 4.3. ▶ USE CASE MODEL OF SPECIAL PURPOSE COMPANY (SPC) CONSORTIUM – SOUTH KOREA

The Smart Cities initiative is one South Korea's main strategies to reinforce the digital transformation of infrastructure and urban mobility. As part of this initiative, public-private cooperation plays a key role to promote tech innovation, guarantee financial sustainability and establish enabling conditions. To foster this cooperation, a public-private SPC was put together. It is first being implemented by the cities of Sejong and Busan to develop smart infrastructure and manage mobility services. The SPC structure was created with contributions from the Ministry of Land, Infrastructure and Transport (10% of funding and support with budget and legal, regulatory, and institutional transformation), each city's local government (10% of funding and support with administrative processes for project permits), other public agencies (20% of funding and support in terrain and real estate), and private companies (60% of funding and supply of tech and innovation services.)

The financial structure of SPC, with its public and private contributions, allows the public sector to monitor and guarantee the public interest in implementing smart cities, for example in sustainability and social inclusion, while the private sector has the flexibility and autonomy to test and prove the impact of the innovations. Public entities suggest a roadmap with the services that private firms should include in their proposals, and these firms can include additional services. In the case of Sejong, the consortium of firms must apply IoT, AI, digital twins, and cybersecurity tools, with a special focus on the mobility sector. The legal concept of consortium also allows for SME participation, reducing entry costs for tech pilots.[36]

Source: Authors.

A third public-private cooperation model, very popular among analyzed countries, involves innovation projects or policies based on **test labs or testbeds**. For example, Germany's Digital Test Field Air Cargo aims at increasing the efficiency, yield, and competitiveness of the country's airfreight (Fraunhofer Institute for Material Flow and Logistics IML, 2021). The active participation of key players from the logistics sector covering different air transport processes introduces and reveals different perspectives and development needs throughout the sector, tests technologies in real scenarios, and facilitates down-the-road scaling. In addition to the airports in Cologne, Frankfurt, Leipzig, and Munich, the consortium includes members like Lufthansa Cargo AG, DB Schenker, and Sovereign Speed as logistics service providers, as well as LUG and CHI Deutschland Cargo Handling. Meanwhile, the U.S. government provides funds to install centers that promote tech development and contribute to progressing in the sectoral regulation of transportation technologies like drones and AV. At these centers, private sector players can test their technologies in close-to real scenarios, while the sector's authorities monitor progress to determine risk levels and prepare themselves to take regulatory action in case these technologies scale up. This is the case at the five airports selected by the FAA to test drones and their relationship with airport operations under the Airport Unmanned Aircraft Systems Detection and Mitigation Research Program. The United Kingdom uses drone and AV testbeds as an additional way to leverage knowledge and private investment to the country.

[36] National Smart City Pilots (SMART CITY KOREA & Ministry of Land, 2020).

The fourth public-private coordination model is based on **consultations with the private sector** when governments develop strategic plans for transportation, including its digital transformation. The many examples in this field in industrialized countries analyzed reveal the importance of this practice. In the United States, the National Freight Strategic Plan was created through a multi-institutional effort that included ample consultations with stakeholders in the transportation of goods, both from the public and the private sectors. Also in the United States, the FAA has a public-private work team to foster the development of Advanced Air Mobility (AAM)[37] and design public plans for its promotion. The EASA (European regulatory agency) has already held public consultations about its proposal to regulate this issue. Similarly, France's new National Port Strategy was designed with inputs from leading companies in the maritime, fluvial, and logistic sectors.

In many cases, experts and academics also take part in consultation processes. A particularly relevant case is that of the United Kingdom where the Government Office for Science invites people with those profiles to participate in the prospective analysis of future scenarios. As has been previously mentioned, these reports help develop a series of tools to enable the government to implement more adaptive public policies with a greater capacity to adapt to multiple horizons or future scenarios. The entire strategy that addresses the future of transportation in the United Kingdom was built on the first prospective studies on the future of transportation and mobility, which were conceived by analyzing tendencies and possible scenarios for 2040 by the Office of Science, and its foresight team (Government Office for Science, 2017).

4.8 Síntesis de aspectos destacados de la experiencia internacional

To summarize the international experience, leading countries in digital transformation share five key aspects:

- **Prioritizing sectoral planning.** Leading countries consider digital transformation a key planning tool for the sector, as a vector of efficiency, sustainability, and social inclusion. In addition to general transportation plans, there are digital transformation plans at the subsector level, as well as plans focused on developing digital technologies (such as AI) that the sector can benefit from. Several agencies from the public and private sectors, academia, and the general public participate in planning processes. In most cases, these plans include roadmaps to move forward in their implementation, identifying the actions for the public sector, the private sector, or both of them combined.

[37] The Advanced Aviation Advisory Committee (AAAC) is a broad-based federal advisory committee that provides independent advice and recommendations to the FAA on key unmanned aircraft systems (UAS) and advanced air mobility (AAM) integration issues, interests and policies (FAA, 2018).

5 lessons from the international experience: prioritization in sectoral plans, risk mitigation, use of various instruments, digital transformation of the public sector, and intersectoral collaboration.

- **Focus on advancing risk mitigation.** Due to the uncertainty and new risks that the current technological revolution poses, leading countries have put together a series of regulatory and policy tools that, while stimulating the digital transformation of transportation, help mitigate its risks, and direct its benefits towards achieving goals regarding efficiency, sustainability, and inclusion. To this effect, they include policies concerning cybersecurity, user data protection, public open data, development of high-capacity communication networks, and implement prospective studies, public consultations, and regulatory sandboxes. They promote monitoring and sharing good practices internationally, and participate in the definition of standards, guaranteeing their flexibility and transparency. At the same time, close collaborations with the private sector and academia to evaluate technologies allows them to gain further knowledge, and make better decisions for public policies.

- **Variety of instruments to promote digital transformation.** Leading countries rely on fiscal and financial incentives to facilitate the adoption of new technologies by the players who face the toughest barriers in the sector, especially SMEs and startups. They have also developed tech centers to test technologies and promote knowledge, technical assistance and mentorship programs from more advanced companies, and evaluation mechanisms and roadmaps to guide SMEs in their digital transformation. Similarly, they have generated human capital strategies to develop the skills required by new technologies, training new professionals, and reeducating those whose jobs could be affected by the technological shift.

- **Public sector transformation.** As relevant players in the transportation sector, leading countries' public agencies have taken significant steps in reengineering and digitalizing paperwork, promoting a digital culture, and making data-based decisions, as well as in the technological management of transportation infrastructure and service assets. To this end, these agencies have developed internal digital transformation strategies and specialized teams with their own budgets to take on projects, incorporate profiles linked to technology, and strongly train their staff in general. Other implemented mechanisms include creating research agencies within ministries or agencies in the sector, and hiring external tech infrastructure and advisory services for strategic developments as well as for projects that require specific profiles.

- **Incentives for inter-sectoral collaborations.** Promoting the digital transformation of transportation requires working in areas that often belong to different sectoral ministries (e.g. cybersecurity, data protection, or reeducating the work force.) Similarly, it can involve agencies with different territorial scope (e.g., national, regional, or city level) and mode (e.g. air, maritime). Lastly, it involves collaborating closely with the private sector, the main driver of digital transformation (see **Chapter 3**). To guarantee this collaboration, leading countries resort to different mechanisms such as high-level committees –convened by the highest-level position in the Executive branch—; inter-institutional committees; ad hoc groups for technical issues; strengthening local and sub-sectoral authorities; memorandums of understanding and advisory groups with the private sector; and the co-funding of centers and programs with leading companies to extend the transformation to those less advanced, among others.

5

The state of digital transformation of transportation in Latin America and the Caribbean

The state of digital transformation of transportation in Latin America and the Caribbean

The goal of this chapter is to present the **current situation of digital transformation in LAC** in four transportation subsectors: maritime transportation, air transportation, land transportation, and urban mobility. The assessment is based on the results of a **survey of 223 managerial-level representatives from the private and public sectors in the region**, the first ever conducted in the transportation sector in LAC.[38] The questionnaire can be found in **Annex 1**. The survey's findings were debated and reinforced by **96 interviews to sector leaders in the region and at a global scale**. The list of respondents can be found in **Annex 2**. The survey and interviews were conducted between the months of November and December 2021, and January and February 2022. They included the participation and collaboration of the American Association of Port Authorities (AAPA – Latino), the Latin American Air Transport Association (ALTA), the Latin American Civil Aviation Commission (LACAC), the International Road Transport Union (IRU), the World Economic Forum, Microsoft, and Intel. Given the extensive heterogeneity of players participating in the urban mobility sector (e.g., transportation authorities, bus companies, TNC, micromobility firms, subways, technology, and navigation providers), interviews were conducted to obtain a more representative perspective of the sector's reality.

The results of the surveys and interviews were presented and validated in **regional working roundtables at a subsector level**, with representatives from public and private agencies, held during the month of March 2022. **Chart 5.1** displays the number of answers to the survey and the number of interviews.

Chart 5.1. ▶ **NUMBER OF SURVEYS AND INTERVIEWS CONDUCTED BY SUBSECTOR**

		Maritime transportation	Air transportation	Land transportation	Urban mobility	Total
Surveys	1-50 employees	57	2	18	- - -	77
	50-500 employees	45	5	16	- - -	66
	501-1,000 employees	18	5	7	- - -	30
	More than 1,000 employees	31	11	8	- - -	50
	Total	151	23	49	- - -	223
Interviews		25	19	21	31	96
Total		176	42	70	31	319

Source: Authors.

[38] The answers' statistical reliability margin of error is approximately 10%.

The chapter begins by presenting the compared results of the field research for each subsector. The assessment focuses on four aspects: (I) digital transformation strategies and goals; (II) main technologies and areas of transformation that the initiatives target; (III) state, incentives, and barriers of transformation; and (iv) perspectives of the public and private sectors. Once the state of digitalization was aggregated, the results were analyzed for each subsector.

5.1 Strategies and goals of the digital transformation in the transportation sector

The report conducted by the IDB in 2019 revealed that the state of productive process digitalization, especially in supply chains, in LAC was highly embryonic (Calatayud & Katz, 2019). As expected, multinational and large local companies were more advanced. In the former, digital transformation took place as a response to the competitive pressure these companies face at a global level. This pressure comes not only from traditional players but also from the disruptive threat generated by new technologies and new entrants. In the case of major local companies, the progress of digital transformation varied by industrial sector, conditioned by the level of insertion each sector had in global productive chains, the degree of vertical integration within each company, and the intensity of the competition. Therefore, the digital transformation of large companies, even within the same sector, was less than homogenous. This is due to the fact that certain firms faced barriers to advance in their transformation such as organizational inertia, difficulties adapting to rapid technological change, and the premature obsolescence of adopted technologies. This has led certain large companies to postpone their transformation until they eventually perceived stability in the digital ecosystem.

7 out of 10 organizations have a digital transformation strategy.

At the same time, while large companies were progressing towards the digital transformation of productive processes, the situation was different for SMEs. Although this group of enterprises was also affected by competitive pressure, other factors such as limited financial resources, low economies of scale, insufficient knowledge of new technologies, and other business priorities significantly reduced the incentive for digital transformation. In short, digital transformation was not a priority in SMEs' strategic agenda.

In the context of this report, the conducted field research revealed that, in the case of the transportation sector, the situation **has evolved positively over the past three years**. In effect, it is encouraging to observe that, when considered as a whole, seven out of ten companies manifested that their organization already had a digital transformation strategy (**Chart 5.2**).

Chart 5.2. "DOES YOUR ORGANIZATION HAVE A DIGITAL TRANSFORMATION STRATEGY?"

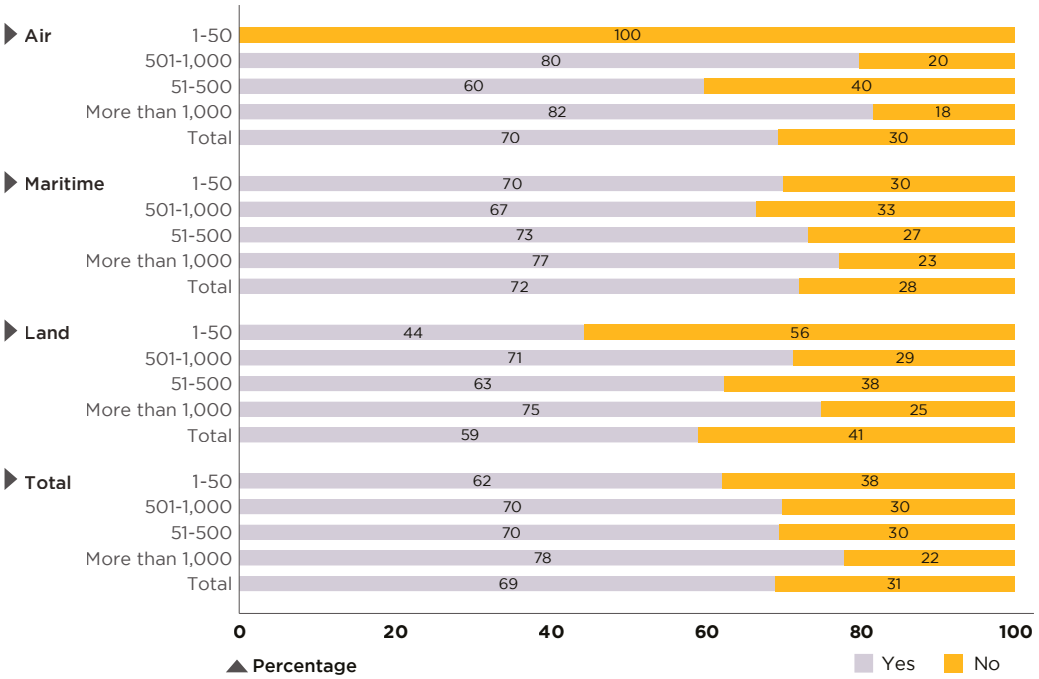
	Maritime transportation	Air transportation	Land transportation	Total
Yes	72%	730%	59%	69%
No	28%	30%	41%	31%
TOTAL	100%	100%	100%	100%

Source: Authors.

These values remain stable for the air and maritime subsectors, while land transportation is slightly lagging behind, with six out of every ten companies replying affirmatively. The difference between the air and maritime subsectors on the one hand, and land on the other, is one of the most significant results of this survey. The specific causes and aspects for this are analyzed further on in this chapter.

The survey's answers can also be broken down by company size to better understand the situation of SMEs (**Figure 5.1**) This shows that while 78% of companies with over 1,000 employees already have a digital transformation strategy in place, that number drops to 62% among small firms (1-50 employees.) The **difference between large and small companies** is due to the factors identified in **Chapter 3**. Nevertheless, the fact that 62% of companies with fewer than 50 employees claimed to have a digital transformation strategy represents progress when compared to evidence collected in 2019.

Figure 5.1. "DOES YOUR ORGANIZATION HAVE A DIGITAL TRANSFORMATION STRATEGY?"
(by company size and subsector)



Source: Authors.

The differences between companies that have a digital transformation strategy and those who don't are consistent in every subsector, although the **most pronounced is in land transportation**. In this case, the percentage of companies that declared to have a strategy is ten percentage points below the air and maritime subsectors.

Having a strategy in place is an important step vis-à-vis the 2019 study, when logistics and land transportation companies claimed that 4.0 technologies were not a priority for their organization. One way to validate the existence of a strategy is to ask companies what stage of implementation they are at. Grouping together those who answered, "advanced adoption" and "in the process of implementing an established plan" one out of every two answers was affirmative (**Chart 5.3**).

Chart 5.3. ▶ **"HOW MUCH PROGRESS DO YOU CONSIDER THAT YOUR ORGANIZATION HAS MADE IN DIGITAL TRANSFORMATION THUS FAR?"** (by subsector)

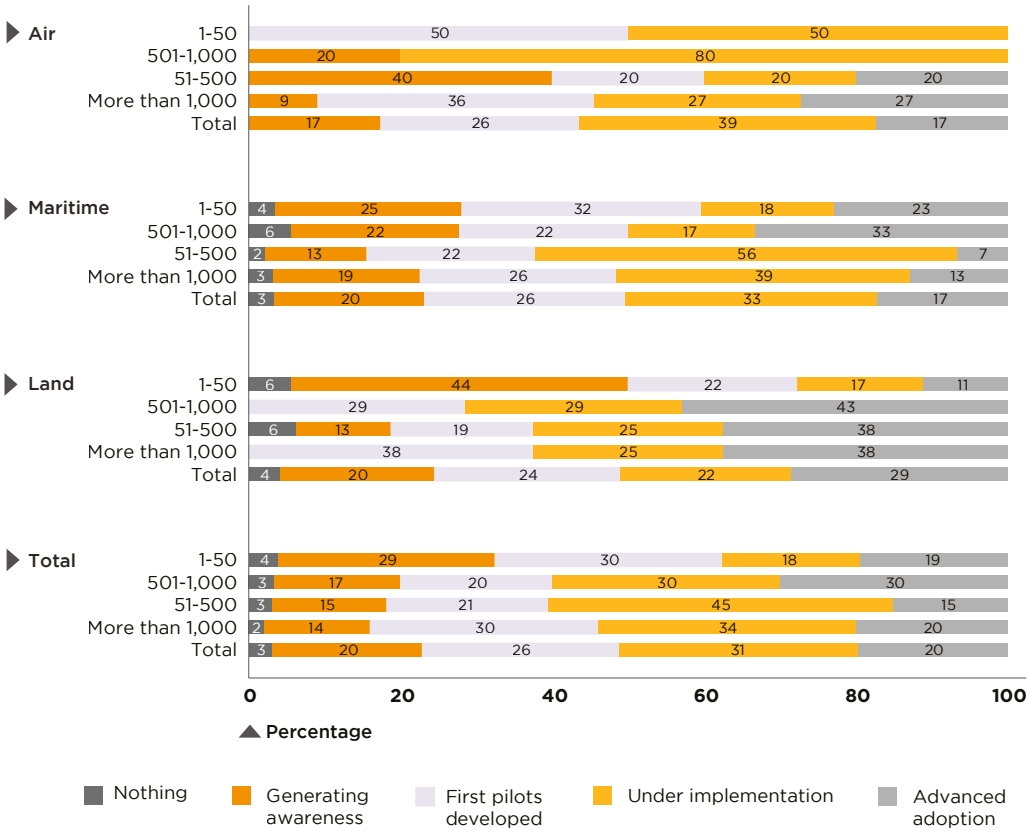
	Maritime transportation	Air transportation	Land transportation	Total
Advanced adoption	17%	17%	29%	20%
In the process of implementing an established plan	33%	39%	22%	31%
The first pilots have been conducted	26%	26%	24%	26%
Generating awareness	20%	17%	20%	20%
Nothing	3%	0%	4%	3%
Total	100%	100%	100%	100%

Source: Authors.

The percentage of companies that are implementing digital transformation rises to 56% for air transportation companies, and 50% and 51% respectively, for maritime and land transportation. Meanwhile, 23% of respondents stated that their organization is just now becoming aware of new technologies or has no knowledge whatsoever. In the air segment, this figure drops to 17%, which puts it at the forefront.

By breaking these figures down by company size, the difference between large, medium, and small companies becomes clear (**Figure 5.2**).

Figure 5.2. ▶ **"HOW MUCH PROGRESS DO YOU CONSIDER THAT YOUR ORGANIZATION HAS MADE IN DIGITAL TRANSFORMATION THUS FAR?"** (by company size and subsector)



Source: Authors.

While only 37% of companies with less than 50 employees are making progress in the implementation of a digital transformation strategy, this number grows to 54% for companies with over 1,000 employees, and 60% for companies with a workforce of between 500 and 1,000 people. These statistics are consistent with the information gathered from the 2019 report and the international situation, where SMEs tend to lag behind in digital transformation as compared to large companies, who have launched transformation processes to increase their competitiveness and have more resources to invest and to attract human capital (see **Chapter 3**).

Regarding the **goals behind the investment in digital technologies** in transportation, the results are similar across the three subsectors in terms of those that received the most responses: **automating processes and reducing costs** (**Chart 5.4**), which is consistent with the competitive pressures in a sector with low margins, as was explained in **Chapter 3**.

Chart 5.4. ▶ **"IN WHICH AREAS HAS YOUR ORGANIZATION BEEN IMPLEMENTING DIGITAL TRANSFORMATION?** (*)" (by subsector)

	Maritime transportation	Air transportation	Land transportation	Total
Automating processes	81%	91%	82%	82%
Reducing costs	70%	65%	76%	70%
Improving security	48%	74%	55%	52%
Increasing online presence	38%	65%	47%	43%
Contributing to environmental goals	43%	43%	35%	41%
Increasing brand power	30%	13%	45%	31%
Getting additional sources of income	19%	26%	35%	23%
Exploring other industries	7%	17%	18%	10%
Others	9%	13%	2%	8%

Source: Authors.

(*) Check all that apply.

Process automation confirms the information collected from interviews, where the main focus was to digitalize documents and automate business processes that previously required physical documents and the interaction of people, and that the COVID-19 pandemic transferred to the digital space. As subsector analyses reveal, air transport is leading automating with a higher performance and a true interaction between people and systems, for example for check-in and passenger screenings. In line with international trends, improving security (52%) and contributing to environmental goals (41%) are two other objectives boosting digital transformation. These goals are common among organizations of various sizes. However, when taking into consideration the information from the interviews, in practice, cost reduction and improving security are at a higher level of priority compared to environmental goals. This differs from what European countries leaders responded in interviews, giving equal priority to battling climate change.

5.2 Main technologies and areas of digital transformation

The process of digital transformation involves adopting digital technologies to increase the efficiency of internal productive processes in the company and disruptively reconfigure production chains. The most commonly adopted technologies can be divided into two groups:

- Mature technologies (management computing, mobile telecommunications, fixed broadband), typically adopted by companies to increase the efficiency of productive processes. The adoption of these technologies is being studied through industrial surveys regularly carried out by international agencies (e.g., UNCTAD[39]) and statistical agencies in each country in the region.[40]
- Advanced technologies (robotics, sensors, internet of things, artificial intelligence) adopted within the conceptual framework of Industry 4.0, which includes the collaborative development of products, configuration of production chains, flexibility of productive means, and optimization of logistic chains. Reports on the adoption of these types of technologies are not common in LAC, given that they are not integrated into the region's industrial census, so this document is one of the first to address the topic.[41]

The survey carried out for this study focuses on advanced digital technologies, aiming at verifying the degree of digital transformation among companies in the transportation sector (**Chart 5.5**).

Chart 5.5. ▶ **"WHICH OF THE FOLLOWING TECHNOLOGIES HAS YOUR ORGANIZATION ALREADY ADOPTED? (*)" (by subsector)**

	Total	>1,000 employees	501 - 1,000 employees	51 - 500 employees	<50 employees
Cloud computing	53%	56%	53%	55%	51%
Data analytics/Big data	52%	66%	63%	50%	40%
Internet of things/Sensors	35%	44%	57%	30%	23%
Omnichanneling	23%	26%	17%	18%	27%
Drones	18%	24%	20%	26%	8%
Machine learning	16%	22%	33%	12%	9%
Applied artificial intelligence	12%	14%	7%	12%	13%
Blockchain	12%	20%	10%	12%	8%
Building Information Modeling	10%	14%	3%	15%	6%
Robotic Process Automation (RPA)	8%	10%	17%	6%	4%
Electric vehicles	8%	20%	7%	6%	3%
Augmented reality/ virtual reality	7%	12%	3%	3%	9%
3D/4D printing	4%	6%	0%	2%	5%
Autonomous vehicles	2%	6%	0%	2%	0%

Source: Authors.

(*) Check all that apply.

[39] See UNCTAD (2009).

[40] See Government of Colombia. DANE. Indicadores Básicos de Tenencia y Uso de TIC en Empresas. *Módulo de Tecnologías de la Información y Comunicación - TIC en EAM, EAC y EAS. Bogota; Government of Peru. Instituto Nacional de Estadística e Informática. Peru: Tecnología de Información y Comunicación en las Empresas. Encuesta Económica Anual.* Lima; Government of Chile. Ministry of Economy, Development, and Tourism. *Informe de resultados: Tecnologías de la información y comunicación en las empresas.* Third Longitudinal Company Survey. Santiago: October.

[41] One of the few systematic surveys about the adoption of advanced technologies is included in (Katz et al., 2018).

In general, the importance of generating, transmitting and analyzing data as revealed by the survey is consistent with **organizations' initial stages of digital transformation**. Responses indicate that most organizations in the sector aim at implementing big data and data analytics (52% of respondents), along with cloud computing to store, analyze, and share data (53%). These technologies are the most attractive, followed by IoT (35%) and omnichanneling (23%). This is also true for organizations of all sizes, especially in regard to big data, data analytics and cloud computing. There is a slight decline in IoT, where 47% of companies with over 500 employees are already implementing it. Meanwhile, the least attractive technologies thus far among respondents are automated vehicles (2%), 3D/4D printing (4%), and augmented reality/ virtual reality (7%).

Conversely, technologies linked to more advanced stages of digitalization that are already broadly deployed in leading countries still get embryonic attention in LAC. In this sense, some figures seemed particularly low, such as applied AI (12%), robotics (8%), and autonomous vehicles (2%). On the other hand, and in connection to what was emphasized in **Section 5.1** about the low score obtained by electrification is striking, with only 8% positive responses, mostly from land transportation, whereas on the international stage it is one of the main technologies underscored by companies throughout the entire transportation sector.

Breaking these figures down by subsector reveals that **not all technologies are equally important** (**Chart 5.6**).

Chart 5.6. ▶ **"WHICH OF THE FOLLOWING TECHNOLOGIES HAS YOUR ORGANIZATION ALREADY ADOPTED?** (*)" (by subsector)

	Total	Maritime transportation	Air transportation	Land transportation
Cloud computing	53%	50%	70%	55%
Data analytics/Big data	52%	52%	65%	45%
Internet of things/Sensors	35%	32%	22%	47%
Omnichanneling	23%	19%	26%	33%
Drones	18%	22%	9%	12%
Machine learning	16%	16%	30%	10%
Applied artificial intelligence	12%	12%	22%	8%
Blockchain	12%	14%	9%	8%
Building Information Modeling	10%	13%	9%	4%
Robotic Process Automation (RPA)	8%	9%	4%	4%
Electric vehicles	8%	7%	9%	12%
Augmented reality/ virtual reality	7%	7%	13%	6%
3D/4D printing	4%	4%	0%	4%
Autonomous vehicles	2%	3%	0%	0%

Source: Authors.

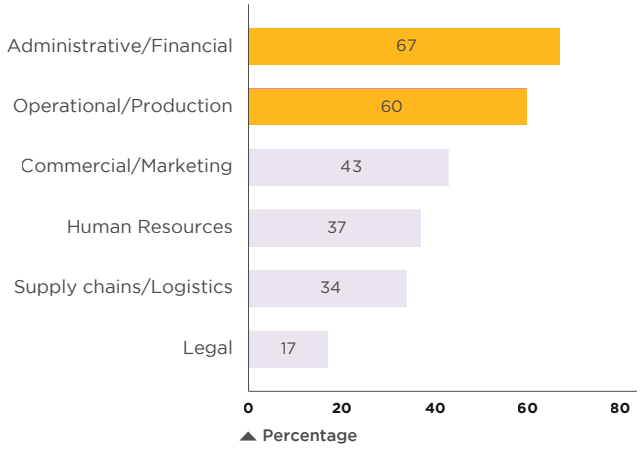
(*) Check all that apply.

Cloud computing is particularly relevant to air transportation organizations, concentrating 70% of positive responses vis-à-vis 50% in maritime transportation, and 55% in land transportation. The same is the case with big data and data analytics, where air transportation gave a 65% affirmative response, compared to 52% in maritime transportation, and 45% in land transportation. This is because air transportation has already migrated a large part of their processes to the virtual realm, which requires high-caliber computing infrastructure in the cloud to function, and manage and analyze data. Coherently with the subsectors' greater progress in digital transformation, machine learning gets a great deal of attention, with a 30% positive response rate, vs. 16% in maritime transportation, and only 10% in land.

The results reveal that IoT technology has the most traction among land transportation subsectors (47%), followed by the maritime sector (32%). This is similar to what happens on the international scenario, where the use of sensors to manage transportation assets has increased significantly (see **Chapter 2**). In either case, it is interesting to note the levels of drone use: 22% for maritime, and 12% for land, especially for vehicle infrastructure control.

In regard to the areas of the organization where these technologies are applied, two out of every three respondents reported it was administration and financial management. This is unsurprising, given that these procedures, internal to the organization, have solutions widely available in the market – both in terms of software as well as tech infrastructure—and are mostly standardized, which makes them more prone to be digitalized in the early stages of transformation. Managing operations is another very relevant area, with a 60% affirmative response rate, in the pursuit of cost reduction and increasing security. Therefore, big data, data analytics, and cloud computing have grown in importance among available technologies, by being absolutely necessary to digitalize, automate, and optimize processes. Additional areas of interest mentioned in the cases of maritime and land transportation are marketing and customer care, to increase market presence.

Figure 5.3. ▶ "IN WHICH AREAS HAS YOUR ORGANIZATION BEEN IMPLEMENTING DIGITAL TRANSFORMATION? (*)"



Source: Authors.

(*) Check all that apply.

The answers to which will be the main areas of tech investment in the middle term suggest that the **sector is already aiming at progressing in its digital transformation**. In a three-year perspective (2025), 72% said the organization will continue digitalizing their internal processes, 69% will include digital processes in their relationships with clients, and 53% will apply security technologies. In this sense, investments in digital solutions will continue to be directed towards big data and data analytics (58%), and IoT (45%), AI (43%), and electric vehicles (24%, particularly in the road segment where this technology is expected to develop) will increase as well. The mention of electric vehicles reveals that, in the middle term, **the priority level of environmental aspects will increase** for the sector's organizations, possibly guided by more strict regulations for emissions.

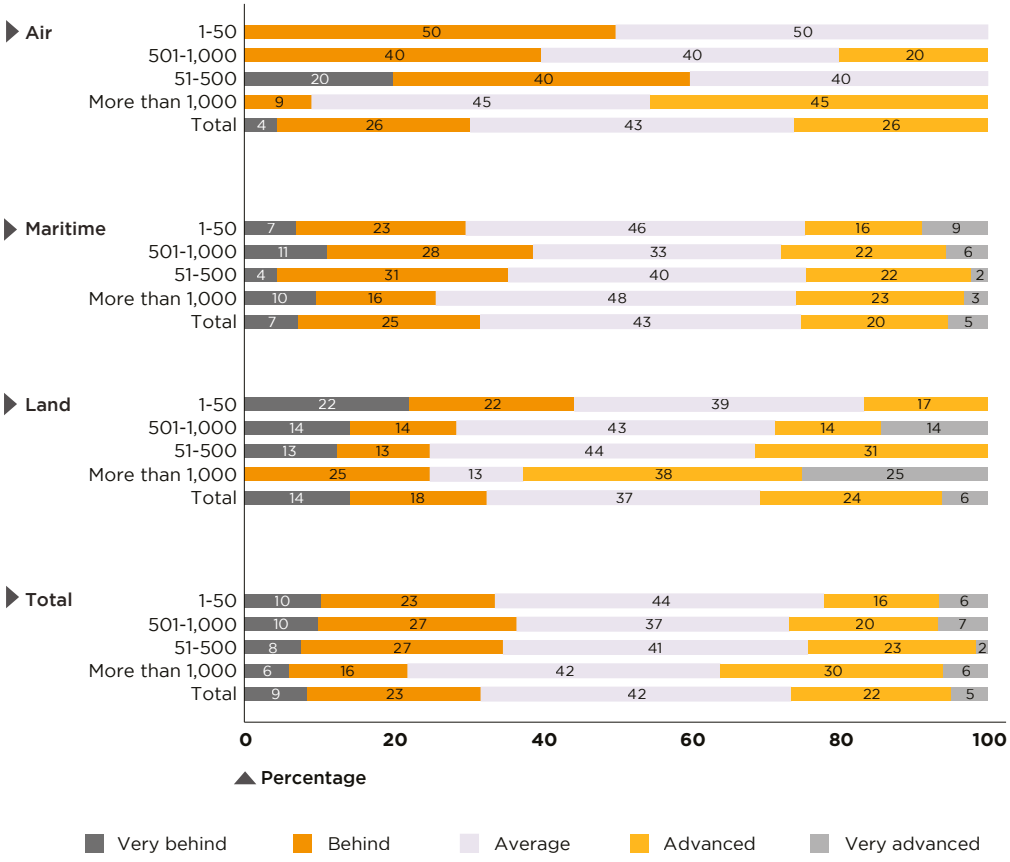
Towards 2025, environmental aspects and the generation of new business models will drive digital transformation.

A focus area that appears in three years is the innovation in products and services, with 54% of affirmative responses, connected to the **generation of new business models and revenue streams**. This is related to the **deeper concept of digital transformation**, beyond the mere adoption of technologies to automate processes and reduce costs, leading to a **true technological discontinuity, and transforming the organization** to provide a service according to each client's specific needs. The progress of generating and analyzing data, cloud computing, and AI implementation will be essential to achieving these innovations.

5.3 State, incentives, and barriers for digital transformation

It is worth noting that four out of every ten players perceive that their progress in digital transformation issues is at par with the sector's progress in LAC. Players who expressed being lagging or very behind represent around 30% of the air subsector, and slightly higher in the case of maritime and land transportation (32%). Analyzing the answers by organization size, those that are largest are perceived to be more advanced among their sector in the region (30% for companies with over 1,000 employees compared to 16% for those with less than 50) (**Figure 5.4**).

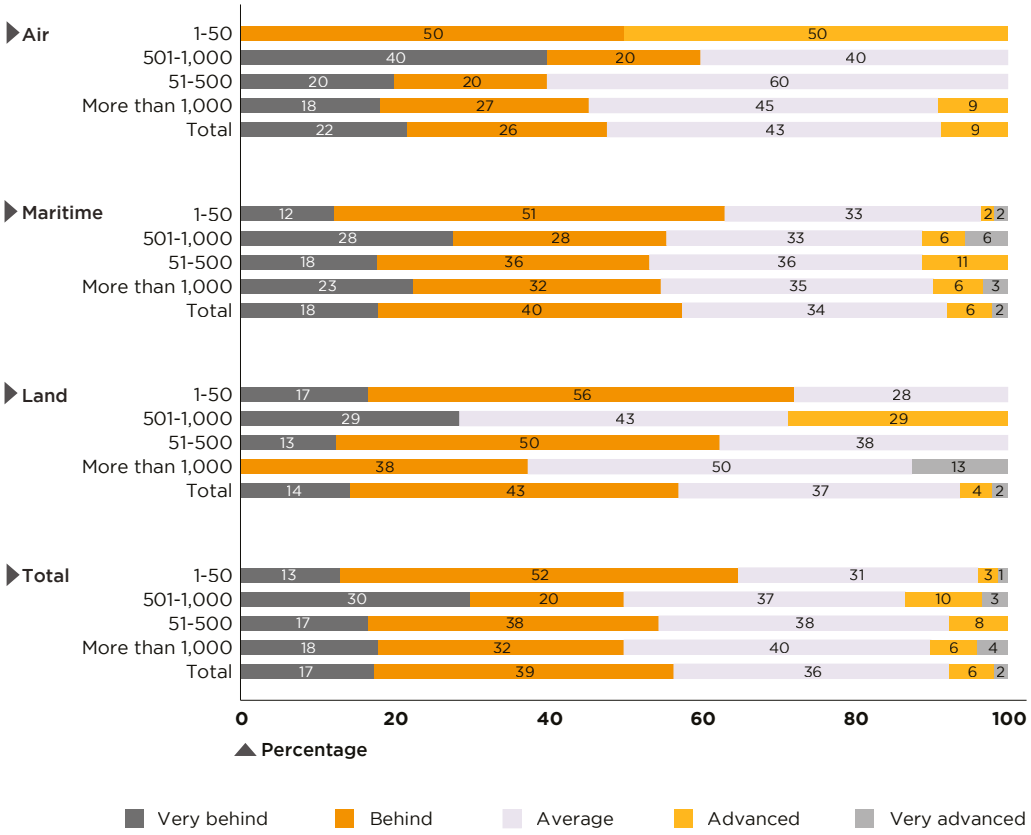
Figure 5.4. ▶ **"HOW DO YOU PERCEIVE YOUR ORGANIZATION'S PROGRESS IN DIGITAL TRANSFORMATION COMPARED TO THE SECTOR AVERAGE IN LATIN AMERICA AND THE CARIBBEAN?"**



Source: Authors.

However, when compared with the sector in leading countries worldwide, 56% of respondents perceive that **their organization is behind or very behind**. The exception is the air sector, where one out of every two players answered that they are at the world average, compared to 48% who perceive themselves to be lagging or very behind. **Smaller organizations (under 50 employees) declared being** the most behind, with 65% considering themselves behind or very behind, compared to 50% of the organizations with over 1,000 employees (**Figure 5.5**).

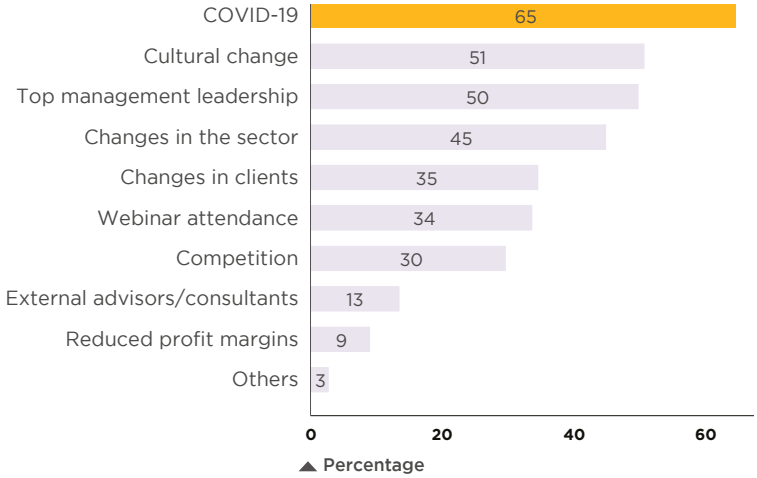
Figure 5.5. **"HOW DO YOU PERCEIVE THE PROGRESS OF YOUR ORGANIZATION IN TERMS OF DIGITAL TRANSFORMATION COMPARED TO LEADING COUNTRIES WORLDWIDE?"** (by company size and subsector)



Source: Authors.

Two out of every three respondents indicated that the **COVID-19 pandemic was an accelerating milestone for digital transformation**, by having to quickly digitize processes and documents to continue operating (**Figure 5.6**). At the subsector level, the results remain high: 70% for air transportation, 66% for maritime, and 60% for land. **Cultural change and top management** are two important factors that also rate high among the responses, at 51% and 50%, respectively, followed by **sectoral changes** (45%) **and with clients** (35%). Meanwhile, competition within the subsector and reduced profit margins are much more significant for land transportation (45% and 18%, respectively) than for air transportation (4% and 9%, respectively).

Figure 5.6. ▶ "WHICH ASPECTS HAVE CONTRIBUTED THE MOST TO THE PROGRESS OF DIGITAL TRANSFORMATION IN YOUR ORGANIZATION? (*)"



Source: Authors.

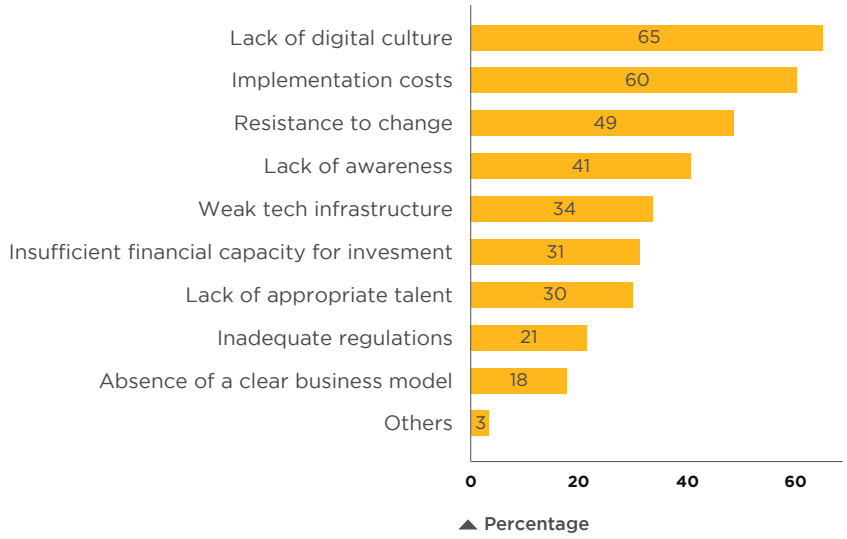
(*) Check all that apply.

By segmenting by organization size, there is clearly a stronger influence from top management leadership in large companies (56% in organizations with over 1,000 employees vis-à-vis 37% in those with less than 50 employees), and the competitive pressures due to changes in the sector (58% vs. 42%). The latter is consistent with the process which sets off digital transformation, detailed in **Chapter 3**, where business competition fosters progress in this transformation. In fact, competitive pressure was considered an incentive to innovation by 38% of the large organizations surveyed, as compared to 23% of smaller organizations.

65% point to the lack of digital culture as the great barrier to the transformation of their organization.

In regard to the barriers for digital transformation, along with **implementation costs** (60%), respondents underlined three key aspects internal to organizations: **lack of digital culture** (65%), **resistance to change** (49%) and **lack of awareness** (41%). The latter was more frequently mentioned by smaller organizations (42% of companies with under 50 employees vs. 33% of those with over 1,000 employees). Other aspects that score highly are the tech infrastructure gap (34%) and lack of talent with appropriate training (30%) (**Figure 5.7**). The relevance of these factors remains constant between subsector levels.

Figure 5.7. ▶ "WHAT RESTRICTIONS HAVE YOU FOUND TO MOVING FORWARD TOWARDS THE DIGITAL TRANSFORMATION OF YOUR ORGANIZATION? (*)"

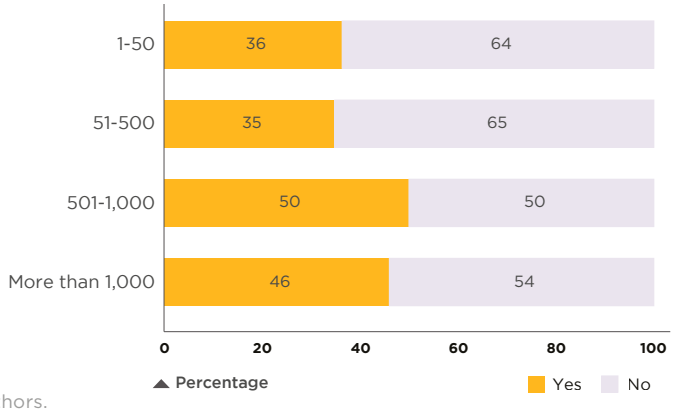


Source: Authors.

(*) Check all that apply.

An interesting feature arising from the survey's answers is a lack of awareness not only about digital transformation and its overarching benefits, but also of the benefits stemming from processes already launched by organizations. Six out of every ten respondents said their organizations did not measure the impact of investments in digital transformation vis-à-vis the goals that motivate them. The most significant case is maritime transportation, where 64% of respondents said they did not quantify it. When broken down by size, 36% of small enterprises indicated they measured the impacts, as did 46% of larger companies (**Figure 5.8**). This leads to a lack of a business case to stimulate digital transformation. Among companies that did measure these impacts, 27% did so in process efficiency, 21% in income and costs, and 18% in customer satisfaction.

Figure 5.8. ▶ "HAVE YOU QUANTIFIED THE IMPACT OF YOUR ORGANIZATION'S INVESTMENTS IN DIGITAL TRANSFORMATION?"



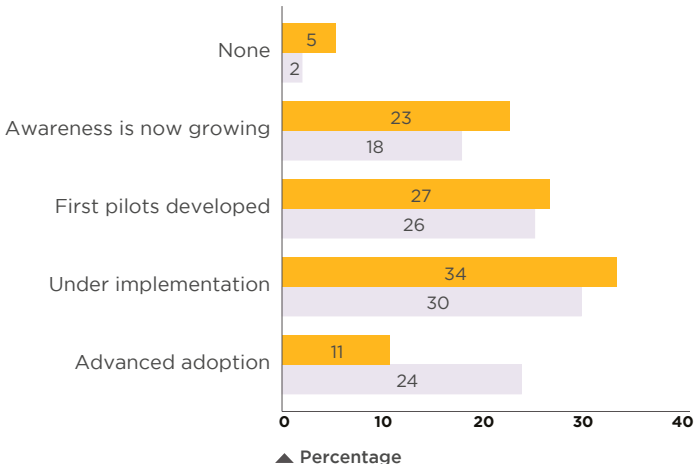
Source: Authors.

(*) Marcar todos los considerados.

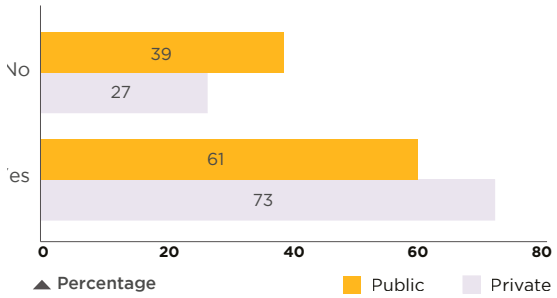
5.4
Public and private sectors perspectives

According to survey results, **private sector organizations are more advanced in their digital transformation processes**: nearly 30% of respondents from the public sector declared they are just becoming aware, or haven't yet made progress in this sense, compared to 20% in the private sector (**Figure 5.9**). Similarly, about 40% of the organizations in the public sector lack a digital transformation strategy, vs. 27% in the private sector.

Figura 5.9. ▶ **PROGRESS IN DIGITAL TRANSFORMATION**



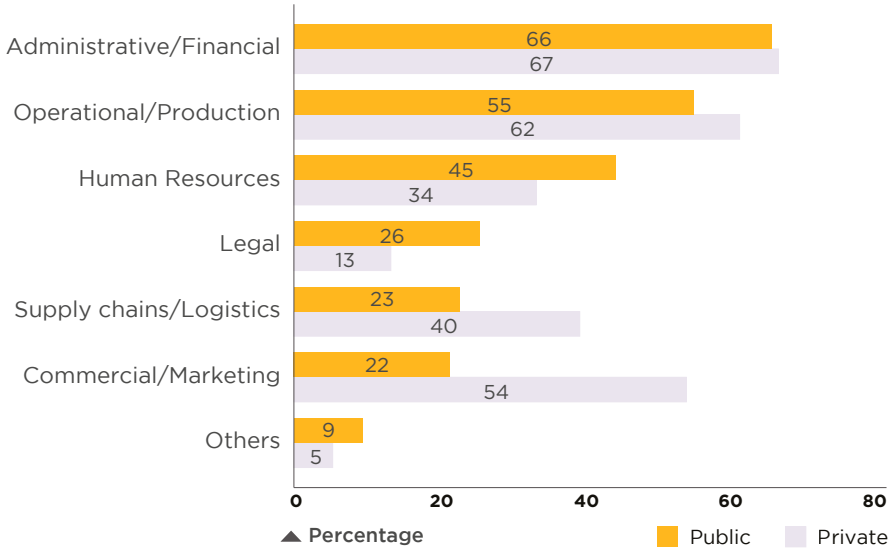
▶ **DOES YOUR ORGANIZATION HAVE A DIGITAL TRANSFORMATION STRATEGY?**



Source: Authors.

Among organizations that have embraced transformation, there is consensus between the sectors in focusing on **administrative and financial processes** (around 67% for each sector) and operative (60% on average). Beyond this, each sector is focusing their efforts on the most relevant aspects for their operations: the private sector mentioned **commercial/marketing areas** (54%) and the supply/logistics chain (40%) as the main targets of their digital transformation, while the public sector focused on human resources (45%) and legal (26%) (**Figure 5.10**).

Figure 5.10. ▶ "IN WHICH AREAS HAS YOUR ORGANIZATION BEEN IMPLEMENTING DIGITAL TRANSFORMATION? (*)"

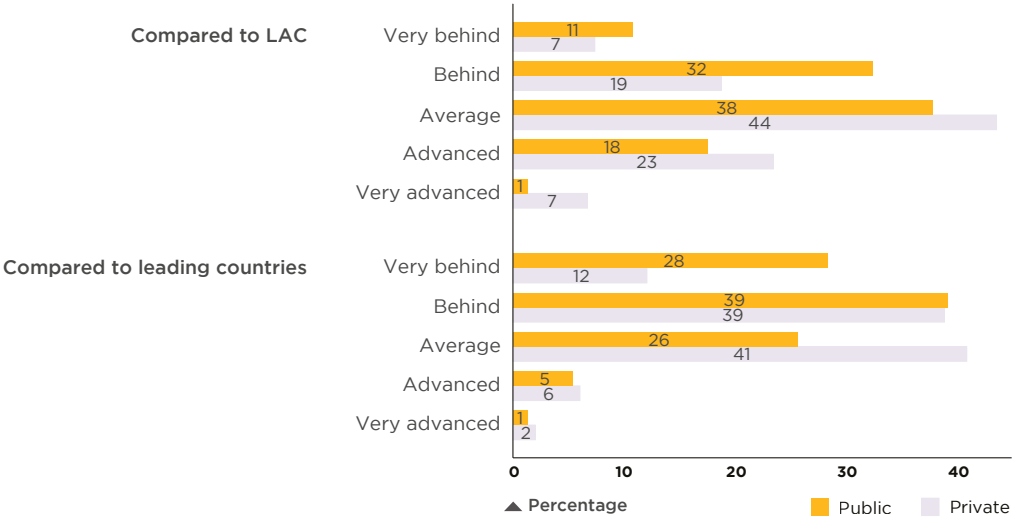


Source: Authors.

(*) Check all that apply.

It is worth noting that 43% of the **surveyed organizations in the public sector perceive themselves as behind or very behind** as compared to the LAC average. This figure rises to 67% when compared to leading countries worldwide. In the case of the private sector, 44% perceive themselves to be at the sector average for LAC, and 23% even report to be ahead. Compared to the private sector of leading countries, there are significantly more private sector organizations that consider themselves to be at an average level (41%) than in the public sector (26%) (**Figure 5.11**).

Figura 5.11. ▶ "HOW DO YOU PERCEIVE YOUR ORGANIZATION'S PROGRESS IN DIGITAL TRANSFORMATION?"



Fuente: Autores.

When asked about the investment goals for their organization's digital transformation, 89% of public sector respondents specified process automation, which is consistent with the goals of digitalization and streamlining of administrative procedures, especially since the advent of the COVID-19 pandemic. In regard to the concept of digital transformation described in **Chapter 1**, these goals are more related to the **initial stages of transformation**, compared to those more advanced, where there is a true technological discontinuity and a deep organization transformation. The interviews suggest that, in many cases, instead of rethinking processes to improve operations and customer service, less efficient processes are automated or digitalized. Improving security (61%), cutting costs (60%), and contributing to environmental goals (47%) are other important goals that foster investments.

In the case of the private sector, although they also point out these topics, others emerge, such as increasing online presence (46%), and gaining more market share (39%), in line with the competitive pressures that encourage digital transformation. To achieve these goals, both sectors mention big data and data analytics, along with cloud computing, as the most implemented technologies in their organizations. In contrast, AI, IoT, robotics, and omnichanneling are more present in private companies. Investing in these technologies reveals a more advanced conception of digital transformation among the private sectors. There, transformation exceeds the mere adoption of technologies to automate processes

and cut costs, producing **true technological discontinuity** and an organizational transformation to offer a service adapted to each client's specific needs. This conception is **particularly rooted in air companies**, in line with what takes place on the global landscape (see **Chapter 2**). Here, the goal of implementing this technology is not the technology per se, but improving the client's journey from beginning to end, with the least possible contacts and conducting interactions through mobile devices.

The COVID-19 pandemic is the milestone that has most driven the digital transformation of transport in LAC.

The COVID-19 pandemic has been signaled by respondents as the milestone that has most boosted digital transformation, especially in the public sector (72% vis-à-vis 62% of affirmative responses from the private sector.) Other aspects that scored high among public organizations were the changes that the transportation sector is going through, the development of new skills, and external consultations. In the case of private organizations, the focus was placed on changes in clients' and competitors' behavior.

Considering the middle term (2025), enhancing internal processes, product innovation, and developing new business models and revenue streams, are the areas where respondents from both sectors believe progressing in digital transformation will be essential. Meanwhile, results suggest the public sector is focusing more on client relations, collaboration with third parties, and security, which is promising to consider the need to take steps towards more streamlining, visibility, and collaborations along transportation processes, as has been exhibited by leading countries. In regard to technology, there was a higher degree of response diversification, especially in the public sector, which mentioned technologies such as AI, IoT, robotics, drones, and electric vehicles to big data and cloud computing, which are already priorities. Thus, there appears to be a middle-term tendency to pursue more advanced stages of digital transformation, and to adopt a deeper conception about it, following in the steps of airlines in LAC.

In terms of barriers to digital transformation, lack of a digital culture and resistance to change have been pointed out by both sectors. For their part, public organizations have more frequently reported financial resource constraints (46% as compared to 24% in the private sector), as well as human limitations (35% vs. 27%), implementation costs of technologies (69% vs. 56%), and the lack of appropriate tech infrastructure (52% vs. 24%). Not measuring the impact of investing in technology does not help counter the internal resistance nor improve the priority level of these investments. These measurements are carried out by only 32% of the public sector, and 44% of the private sector.

43%

“of the public entities surveyed are perceived as lagging behind or very lagging behind in terms of digital transformation compared to the regional average.”

5.5 The state of maritime transportation's digital transformation

Digital transformation is **high on LAC's maritime sector's agenda**, with 72% of respondents reporting that their organization had a digital transformation strategy. In addition, its implementation is already in operation, with 27% developing their first pilots, and 17% reporting advanced adoption. This data reveals significant progress compared to the IDB 2019 report, where respondents mentioned that digitalization was not a priority for the sector in LAC but rather an aspect to take into consideration in the long term (Calatayud & Katz, 2019).

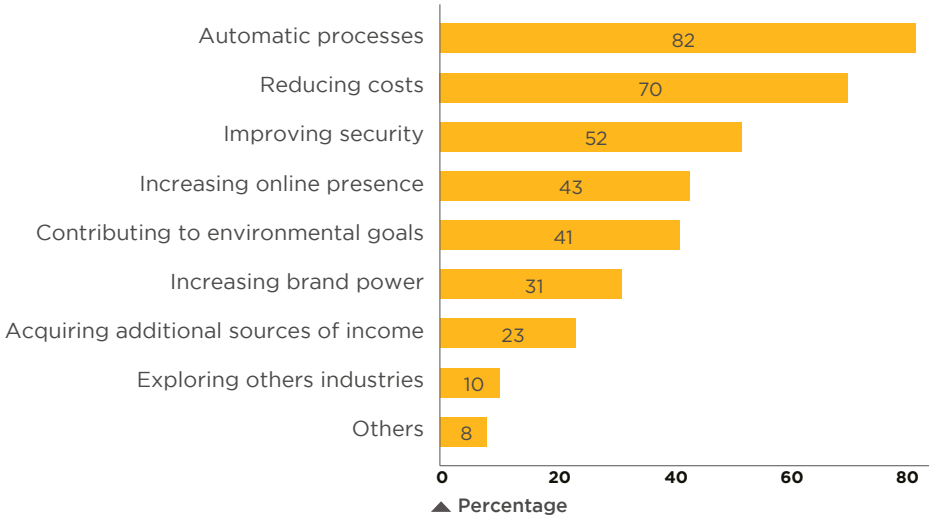
There are multiple examples of progress in the sector's digitalization in LAC, of which only a few have been mentioned. SPA, the Brazilian state agency that operates the port in Santos, launched in 2021 a public tender for the deployment of IoT in the entire port. Puerto Bahia, the terminal in Cartagena, is implementing the DigiPort project, aimed at creating Colombia's main smart port. The initiative focuses on four aspects: business models, internal processes, client experience, and organizational culture. In 2019, Barranquilla implemented a Terminal Operating System (TOS), which allowed automated and safe operational continuity during the COVID-19 pandemic. The harbors of Kingston, in Jamaica, and Valparaiso, in Chile, have already implemented Port Community Systems, which they are currently extending to include AI analysis modules. In Paraguay, some inland ports have increased container monitoring and tracking thanks to GPS and RFID (radio frequency identification). Similarly, some of the most advanced terminals in Argentina are introducing IoT-based solutions to check grain conditions in silos, drones for inventory management, and systems based on AI to respond to customer queries. Several ports in LAC have implemented appointment systems that assign a specific day and time for trucks to load and unload at those ports.

72% of maritime industry respondents say their organization has a digital transformation strategy.

Economic arguments such as process automation (82%) and cost reduction (70%), along with increased security (52%), gaining more online presence (43%), and contributing to environmental objectives (41%) are the **main goals** behind investment (**Figure 5.12**). Additional factors that appeared by analyzing the responses of private organizations are generating new sources of income (19%) and exploring new industries (9%), in line with global tendencies in the sector in terms of searching for a more vertical integration, and turning their data and platforms into a significant business area (see **Chapter 2**). In effect, there are already platforms operating in the region offered by large shipping companies to make reservations, monitor the state of shipments in transit,

and meet administrative requirements, which is an additional business to traditional maritime transportation. Just like important airlines in LAC, shipping companies are progressing towards the implementation of a **deeper concept of digital transformation**, which implies a true technological discontinuity and organizational shift.

Figure 5.12. ▶ "WHAT ARE THE INVESTMENT GOALS OF DIGITAL TRANSFORMATION IN YOUR ORGANIZATION? (*)"



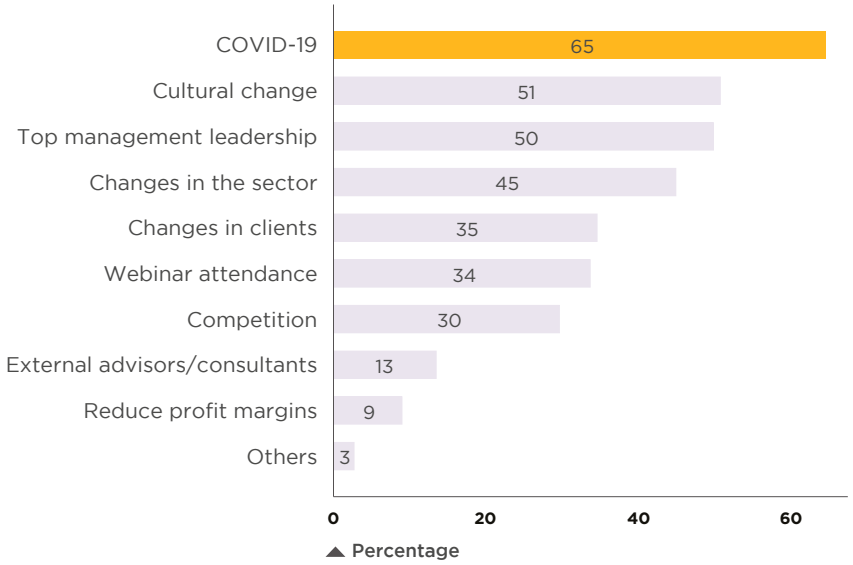
Source: Authors.

(*) Check all that apply.

In the interviews conducted for this report, **three key factors explain progress from 2019**: (i) the push large shipping companies and terminal operators internationally gave to digital transformation, which has set off a cascade effect into LAC through the international maritime transportation network and the concession of port terminals in the region (see **Chapter 3**); (ii) reduced cost of technology, significantly improving the ROI time[42]; and (iii) the COVID-19 pandemic, which has required quick digitalization of paperwork and procedures so that they could be carried out with minimal human intervention, avoiding new infections. In particular, six out of every ten organizations reported in the survey that the pandemic has had a catalyzing effect on digital transformation in the sector. Meanwhile, 50% identified top management leadership, 45% changes in the sector, and 35% clients' requirements as reasons for progress, in line with the first factor mentioned in interviews (**Figure 5.13**). An aspect worth noting is that while the environmental emergency is one of the main drivers of digital transformation in leading countries, which also appears in the regional survey, interviews suggest that in LAC it plays a much lesser role than economic factors.

[42] One respondent mentioned that in 2013 the ROI period for an ORC system was six years, while in 2019, it had been reduced to one year.

Figure 5.13. ▶ "WHICH ASPECTS HAVE CONTRIBUTED THE MOST TO THE PROGRESS OF DIGITAL TRANSFORMATION IN YOUR ORGANIZATION? (*)"



Source: Authors.

(*) Check all that apply.

Breaking down the answers between those from **the public and the private sector** revealed that despite all the progress that has been made, there still are disparities in LAC in the level of awareness of digital transformation and even more so of its implementation. Three out of every ten public organizations are only just becoming aware or haven't made any progress in digitalization (18% in the private sector), and 41% does not have a strategy for it (22% in the private sector). As a consequence, 39% declared to be behind or very behind as compared to others in the sector in LAC (24% in the private sector). In leading countries, this number rises to 74%. In this case, the figure is also high for private organizations: one out of every two companies considers their organization to be behind compared to world leaders.

The information gathered from the interviews of sector leaders indicates that harbors that operate as global or regional hubs, and where there are terminal operators belonging to multinational holdings, like Balboa, Colon, and Cartagena are the most developed organizations. In addition, in some cases fostering digital transformation has been defined as a sectoral priority. This is the case of Chile, where the Ministry of Transportation and Communications is promoting digitalization to strengthen the logistics sector. A study of the eleven busiest ports in the region in terms of container traffic reveals nearly a full adoption of IoT technology and significant progress in robotic systems. However, private 5G telecommunication networks, a key component of smart port infrastructure that leading ports are embracing around the world, is not yet a short-term goal (see **Chart 5.7**).

Chart 5.7. ▶ **ADOPTION OF ADVANCED TECHNOLOGIES IN MAIN PORTS (BY TEUS, 2021)**

Port	TEU (millions) (2019)	Automation and robotic systems	Internet of Things	Artificial Intelligence	Virtual Reality/ Augmented Reality	Blockchain	Data analytics	Drones	Private 5G networks
Balboa (Panama)	2.90	No	Yes	Yes	Yes	No	IMP	No	No
Buenos Aires (Argentina)	1.49	IMP	No	No	No	No	No	No	No
Callao (Peru)	2.31	Yes	Yes	IMP	No	IMP	IMP	No	No
Cartagena (Colombia)	2.93	IMP	Yes	No	Yes	IMP	No	No	No
Colon (Panama)	4.38	Yes	Yes	Yes	- - -	- - -	- - -	- - -	- - -
Guayaquil (Ecuador)	1.94	No	Yes	No	Yes	Yes	No	No	No
Kingston (Jamaica)	1.65	- - -	- - -	- - -	- - -	Yes	- - -	Yes	- - -
Manzanillo (Mexico)	3.07	Yes	Yes	Yes	Yes	No	No	IMP	No
San Antonio (Chile)	1.71	Yes	Yes	No	No	IMP	No	No	No
San Juan (Puerto Rico)	1.51	- - -	Yes	- - -	- - -	- - -	- - -	- - -	- - -
Santos (Brazil)	3.90	- - -	IMP	- - -	- - -	- - -	- - -	- - -	IMP

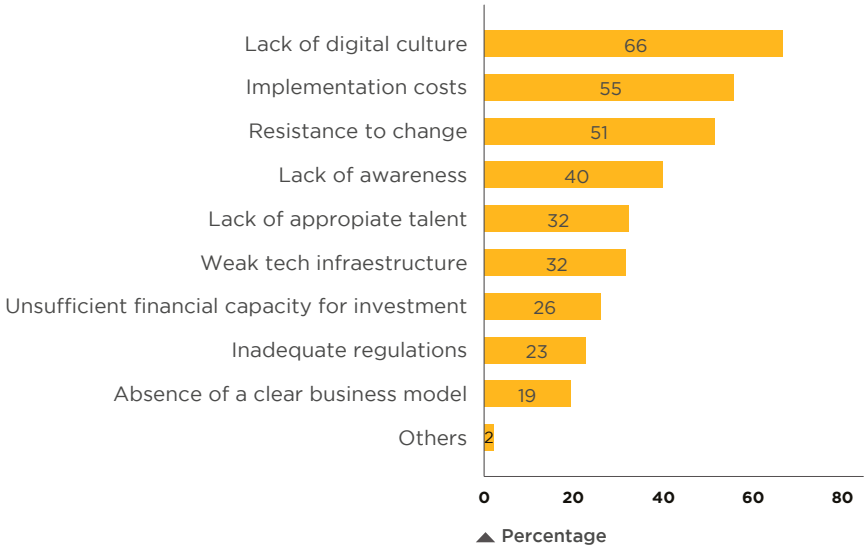
Notas: TEU (Twenty-Foot Equivalent): Container volume equivalent to twenty Feet.
IMP: Under implementation.

Source: Authors Compilation based on Placek (2021), STC International (2020), Bnamericas (2021), and Jamaica Customs Agency (2020).

Public and private organizations in the maritime transportation subsector tend to agree that the main **barriers to progress in digital transformation** are: (i) lack of a digital culture, whether out of unawareness (40%) or resistance to change (51%), among others; (ii) costs (55%), and lack of financial (26%) and human resources (32%); (iii) weak tech infrastructure (31%, and 51% for the public sector); and (iv) absence of a clear business model (19%), especially in the public sector (27%) (**Figure 5.14**). With regard to the cultural barrier, respondents mentioned that there is a strong attachment to manual procedures, which vary in every port, shipping company, and government agency, as well as to written documents. Many regulations still require physical documents, even when there is already a digital equivalent. There are local, national, and international legislative barriers that lead to 99% of waybills still being on paper. Although there has been progress in the context of the work of UN/CEFACT, lack of international agreements on data collection, classification,

and sharing has hindered the digitalization of these and other documents involved in maritime-port operations.

Figure 5.14. ▶ "WHAT RESTRICTIONS HAVE YOU FOUND TO MOVING FORWARD TOWARDS THE DIGITAL TRANSFORMATION OF YOUR ORGANIZATION? (*)"



Source: Authors.

(*) Check all that apply.

Meanwhile, **lack of awareness of the benefits technologies can bring about** feeds back into the cultural barrier. In the case of port terminals, for example, their managers have traditionally been experts in harbor operation, not in information or communication technologies, making it harder to identify solutions in a region with less technological maturity and to convince decision makers of the benefits they can provide. In fact, when investments occur, 73% don't measure their impacts, making it difficult for decision makers to see the benefits and justify further resource allocation. Despite these limitations, respondents mentioned that progress in the sector at global level, competitive pressure, increased visibility requirements posed by clients, and the exchange of experiences with ports outside the region (e.g., Antwerp, Rotterdam, and Hamburg) and within the region (namely, San Antonio and Cartagena) are leading organizations to make internal shifts and promote digital culture. In this sense, top management in LAC is convinced that soon they will have to choose between "transforming or quitting the market" in the case of the private sector, and "transforming or losing competitiveness on a country level" in the case of the public sector.

41% of the LAC Port Authorities surveyed do not yet have a digital transformation strategy.

The second barrier is **lack of financial resources**, which is specifically **critical in the public sector**. While large companies in the sector are allocating part of their budgets to improve infrastructure, tools, and tech knowledge, public sector agencies typically lack specific organizational structures in the form of units with clear mandates endowed with a budget and staff, whereas leading agencies in Antwerp, Rotterdam, and Hamburg do have them (see **Chapter 4** and **Chapter 6**). In fact, European Union's post-pandemic recovery plans have assigned more resources to public initiatives to promote the use of technologies in transportation as a way to increase the sector's sustainability and resilience. This is in line with Europe's agenda for digital transformation by 2030, which lays out a strategic horizon and regulatory framework, making digital transformation a priority in every sector, including transportation. In LAC, there are different degrees of progress in the elaboration and implementation of a macro digital strategy. However, as the survey shows, sectoral digital transformation strategies are unpopular, with 41% of public agencies stating they still don't have one. Many agencies continue to focus their strategies on physical infrastructure, when digitalization is essential to make a more efficient use of available infrastructure and reduce investment needs.

The lack of financial resources can also affect **staff size**. While Port Authorities in leading countries already have their own digital transformation teams led by Chief Information Officers, LAC still suffers from a lack of professionals familiar with new technologies and their use in the sector and in public entity processes; high staff turnover; and little access to training for experts. In this sense, respondents mentioned that in many cases, the private sector assumes the role of educating public employees.

The **need for tech infrastructure** emerging from the survey not only refers to devices, which usually reach the region a bit later than in advanced countries, but also specifically to telecommunications infrastructure. Digital transformation is not possible without a telecommunications infrastructure with enough coverage and speed to generate and share data, and data analytics when cloud services are involved. That is why, on a global level, leading players in the sector are already employing 5G networks. This is the case seen in **Chapter 2** on different size harbors having deployed 5G to move forward with automated vehicle and digital twin testing. Meanwhile, the ports that have their own private network in the region are scarce, and when they do, they rely on 4G technology or older. In this respect, respondents reported that poor **coordination between public transportation and telecommunications agencies** does not contribute to close the sector's connectivity gap. In addition, there is also a lack of awareness and of attention to **cybersecurity risks** that new technologies may pose. Lastly, as is the case in other transportation sectors, there are **governance and data management** challenges.

Just like they did in the 2019 survey, LAC's sector leaders interviewed mentioned the persistent **absence of system integration between players in the maritime-port ecosystem** as a key obstacle. This shortcoming is also seen applying to players in different terminals within a single port. Limited system integration and data sharing with agencies in the public sector and road transportation companies were emphasized the most in the interviews, with the exception of those that have a Port Community System. The progress some of the region's ports have made by implementing truck shift systems but, in general and just like in 2019, trucks continue to be perceived as the weakest link in the digitalization of transportation. Also mentioned was the insufficient coordination and coherence between ports and even port terminals within the same port, which multiplies the number of systems in use and makes processes more complex.

Certainly, these shortcomings may be put down to the slow adoption of technological solutions, but there are also components linked to **lack of trust and of coordination between actors**.[43] Major companies in the sector are reluctant to share data with competitors, be it large transportation companies or port terminals, because they see it as a loss of a competitive edge. So while alternative platforms have been created for process and system integration by a number of transportation companies, they have run into competitors' unwillingness to participate.

This is an area where **Port Authorities of leading countries** worldwide are playing a major role in facilitating collaboration between private sector players at ports. To this end, they have built cooperative relationships called *coalitions of the willing*, usually around a certain type of shipment in the beginning, and later on brought over to the table of public sector agencies that also intervene in maritime-port processes. Respondents pointed out that in leading countries, Port Authorities have played a key role helping build a model of data governance that provides clarity on what and how to share data about, who should gain access to it, and what it should be used for. Comparing these experiences with those of LAC, respondents reported that a significant difference with the region stems from the fact that Barcelona, Rotterdam, Hamburg, and others have undergone a deep shift in the conception of their ports, from mere transportation infrastructure facilities to being considered a supply chain node. As a consequence, the goal has been to reinforce collaboration and integration of information, processes, and even strategies with port users (shipping companies, freight forwarders, land transportation firms, importers, and exporters) to reduce times and costs. By contrast, respondents said that dialogue between public agencies and clients is rare, fragmented, and problem-specific. There are no roundtables within the port community, which in leading countries have eventually evolved into a (digital) Port Community System.

[43] These shortcomings have eluded private property ports of large commodity and agro-industrial product exporters, where lack of coordination between players, especially in regard to computer systems' transmission and integration, is compensated by the fact that they belong to the same company.

In the world's leading ports, another form of connectivity, the digital, is beginning to be seen as an essential attribute for competitiveness, as important as maritime connectivity.

In particular, respondents underscored that **leading ports focus on the client**. This client is no longer the shipping company or freight forwarder, but the importer-exporter, which requires increasing speediness, efficiency, and visibility in transportation processes, especially since the disruptions caused by the COVID-19 pandemic. In the case of these ports, agents can take their cargo to other harbors, making competitive pressure a driver for digital transformation due to the need to preserve and even gain new clients. Therefore, **another kind of connectivity, namely digital, is starting to be conceived as a special attribute for port competitiveness, as relevant as maritime connectivity**. That is why leading ports are aiming at a deep digital transformation process, with a true process and business discontinuity, focused on the client. However, interviews reveal that, with the exception of the Caribbean, LAC is different in that the drive felt by competitive pressure in Europe, for example, is typically diluted by the fact that there is a single port for all national shipments.

An additional aspect worth noticing from the international experience is that leading ports have promoted **collaborations with the urban landscape** in which port activities are carried out. For example, in its strategic planning exercise, Barcelona included over 200 participants to define the vision of the port by 2040. Closer relationship between leading ports and communities has led to important benefits for both parties. For example, sharing port operation data has been used to improve urban traffic management and the smoothness of port entry and exit. In addition, the relationship between the port and the entrepreneurial and academic environment has fostered the creation of innovation ecosystems, a major element to boost digital transformation by providing solutions to specific local problems. Conversely, these experiences are just emerging in LAC to the detriment of large companies that are more advanced in terms of digital transformation, given that they lack the innovative environment present in other ports, where they could have access to solutions adapted to their specific context.

> Since 2004, Grupo Puerto de Cartagena organizes a contest called "Port-ideas: irradiando ideas" aimed at encouraging innovation in port operations and opening the port to new proposals by external entities. There are three categories: (i) Nova Estelar, for ideas that can materialize physically; (ii) Nova Cósmica, for ideas related to procedures, software design, internal organization programs, etc.; and (iii) Supernova, for ideas that respond to a specific topic, which changes yearly according to the organization's needs and opportunities for improvement. Due to the success of these initiatives, in 2019 the Group's startup accelerator DeltaX Ventures was launched, the first in its kind in Colombia to foster solutions for the digital transformation of the logistics chain and bring the port and the entrepreneurial communities together.

59% of land transport companies have a digital transformation strategy.

Lastly, there is significant concern in the sector in regard to the **future of the workforce**, which generates resistance to change. Although automation will get rid of certain manual labor, it will also create new jobs in tasks with greater added value and, therefore, better pay. In this sense, and as leading cases worldwide have shown, progressing towards the adoption of digital technologies requires new employee profiles like data scientists, programmers, and electricians. Given the speed of change –consider for example the progress between 2019-2022– it is essential to reeducate the workforce and train upcoming generations in, among other things, managing operations remotely and repairing electric equipment. That is why collaboration with academia and the entrepreneurial sector is vital. This is still lacking in LAC as compared to Antwerp, Rotterdam, or Hamburg, where there exist knowledge and training hubs focusing on the needs of ports of the future.

5.6 The state of digital transformation of land freight transportation

As the IDB's 2019 report has pointed out, **land transportation of goods is the most lagging subsector** in terms of the digital transformation of transportation and main supply chains in LAC. According to that survey, this subsector's digitalization was restricted to large companies, while SMEs faced three main barriers to further adopt technology: (I) lack of resources; (II) management resistance based on the difficulty to justify the return of investment in technology; and (III) low profitability of the core business, limiting their capacity for investment (Calatayud & Katz, 2019). Academic literature documents the reality of SME management, which traditionally lacks the human and financial resources that are necessary to assign to innovation related activities (De Massis et al., 2018).

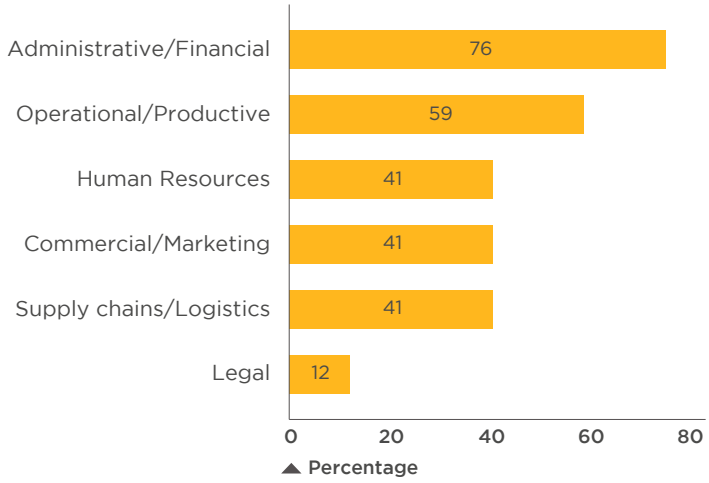
These aspects have been reconfirmed by this report. According to the interview conducted as part of this study, 14% of respondents from the land transportation subsector believe their organization is very behind in terms of transformation as compared to the digital average in LAC. This figure is much higher than in other subsectors (7% in maritime and 4% in air transportation).

As prior reports have shown, the most important variable behind this lag is the great **fragmentation of the land transportation industry**, an aspect also present in industrialized countries. For example, in 2020, there were 184,774 land freight transportation companies in Mexico, 1,181 of which operated over 100 trucks, 3,753 operated 31 to 100 units, 29,328 between 6 and 30, and 150,512 represented individuals who owned trucks (Government of Mexico, 2020). Colombia registered approximately 3,500 carriers in the formal sector, 61% of whom owned a single truck, and 23% more than three. Overall, most land shipping agents, especially in small companies in the

region, displayed a high level of technological obsolescence, managing services still on paper or through systems that can't connect to those of other players in the supply chain (Barbero & Guerrero, 2017; Calatayud & Montes, 2021).

A positive result compared to 2019 is that, according to the survey conducted for this report, 59% of the managers claimed that their companies already **have a digital transformation strategy**. This reflects the fact that the topic has gained traction in the sector and that many companies have evolved from the awareness stage to developing an action plan. Among the main focus areas for transformation, 76% of respondents mentioned administrative/financial, followed by commercial (**Figure 5.15**).

Figure 5.15. ▶ **"IN WHICH AREAS HAS YOUR ORGANIZATION BEEN IMPLEMENTING DIGITAL TRANSFORMATION?** (*)" (land freight transportation)



Souce: Authors.

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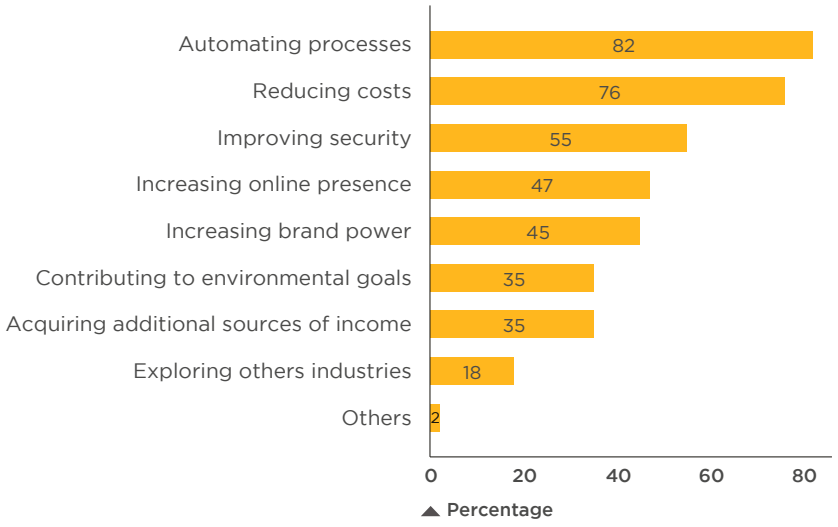
Although managers also mentioned other focus areas such as operations or logistics, the prevalence of administrative digitalization suggests that the subsector's digital transformation process is currently in its **initial stage of development**, where technological discontinuities and radical shifts in activities are not yet considered – whereas air transportation companies are– but instead they are undergoing process digitalization and automation. This was validated by the response given in the survey to companies' goals for digital transformation. In 82% of the cases, the main goal was process automation, while 76% of respondents made references to cost reductions.

It is also worth mentioning that, when broken down by company size, there is a **more advanced state of digitalization in larger companies**, which are aiming at modifying processes to improve the response to client demands, which was confirmed in the interviews. Therefore, they are focusing on certain disruptive areas of digital transformation, such as exploring other industries or acquiring new sources of income (18% and 35% respectively) (**Figure 5.16**).

Figure 5.16. ▶ **"WHAT ARE THE INVESTMENT GOALS OF DIGITAL TRANSFORMATION IN YOUR ORGANIZATION?** (*)" (land freight transportation)



Source: Authors.

(*) Check all that apply.

When asked about the ROI assessment for investments in digital transformation, only 40% of respondents reported that their organizations perform some kind of economic evaluation. Companies that do mainly focus on cost reduction or process efficiency, as opposed to more advanced metrics like business generation or internal rate of return.

Regarding the use of advanced digital technologies, there is a difference between those being currently implemented and those considered for future adoption (**Chart 5.8**).

Chart 5.8. ▶ **"WHICH TECHNOLOGIES HAS YOUR ORGANIZATION IMPLEMENTED AND WHICH WILL BE IMPLEMENTED OVER THE NEXT THREE YEARS?** (*)" (land freight transportation)

	Today	Next three years
Cloud computing	55.10%	34.69%
Data analytics/Big data	44.90%	55.10%
Machine learning	10.20%	24.49%
Internet of things/Sensors	46.94%	36.73%
Applied artificial intelligence	8.16%	38.78%
Robotic Process Automation (RPA)	4.08%	10.20%
Drones	12.24%	16.33%
Building Information Modeling	4.08%	18.37%
Augmented reality/Virtual reality	6.12%	12.24%
Blockchain	8.16%	22.45%
3D/4D printing	4.08%	2.04%
Autonomous vehicles	0.00%	18.37%
Electric vehicles	12.24%	36.73%

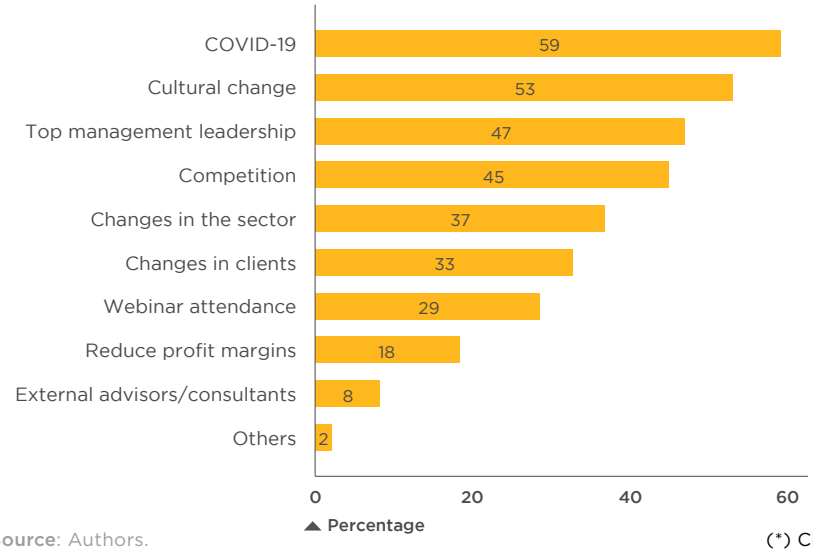
Source: Authors.

(*) Check all that apply.

Today, the two most relevant technologies are cloud computing (55%) and sensors in IoT systems (47%), which are significant in terms of cost reduction (data processing in the former, and maintenance and cargo traceability in the latter). However, over the next three years, the two technologies that will be most widely adopted will be data analytics (55%) and applied artificial intelligence (39%). This confirms that, independently of the state of digital transformation that the subsector is currently in, the future perspective of its development indicates the **evolution towards a more advanced stage of digitalization**.

As in other subsectors, **the pandemic has been an accelerating milestone** of the digital transformation of land transportation of goods. 59% of respondents mentioned COVID-19 as the most important driver in the digital transformation process (**Figure 5.17**). This figure is consistent with that observed in the digitalization cycle of productive processes that have taken place worldwide over the past two years.

Figure 5.17. ▶ **"WHICH ASPECTS HAVE CONTRIBUTED THE MOST TO THE PROGRESS OF DIGITAL TRANSFORMATION IN YOUR ORGANIZATION? (*)"**
(land freight transportation)



Source: Authors.

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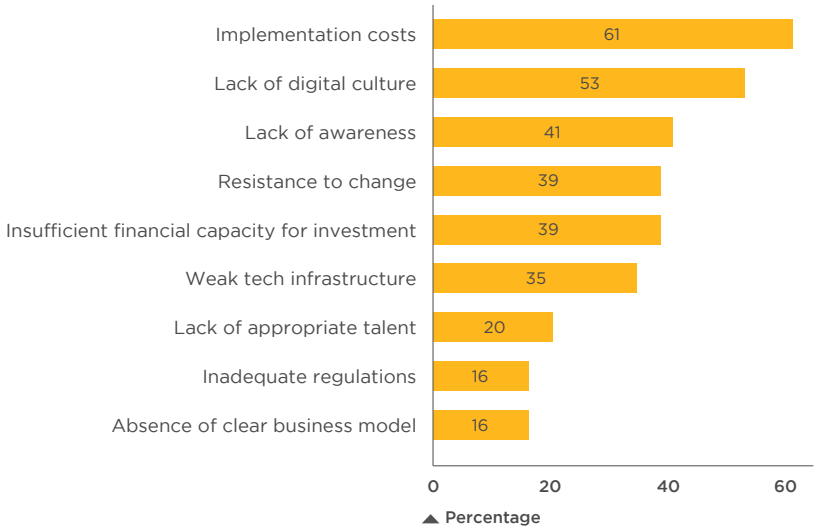
From the perspective of **barriers**, implementation costs and lack of a digital culture were the most commonly mentioned factors (**Figure 5.18**). The second factor is linked to the obstacles associated with SME management characteristics that literature points out. These companies are usually family businesses, making generational change slow and therefore less prone to innovation (Chrisman et al., 2012). This was confirmed in the interviews and subsector focus group conducted for this report.

Figure 5.18. ▶ **"WHAT RESTRICTIONS HAVE YOU FOUND TO MOVING FORWARD TOWARDS THE DIGITAL TRANSFORMATION OF YOUR ORGANIZATION? (*)"**
(land freight transportation)



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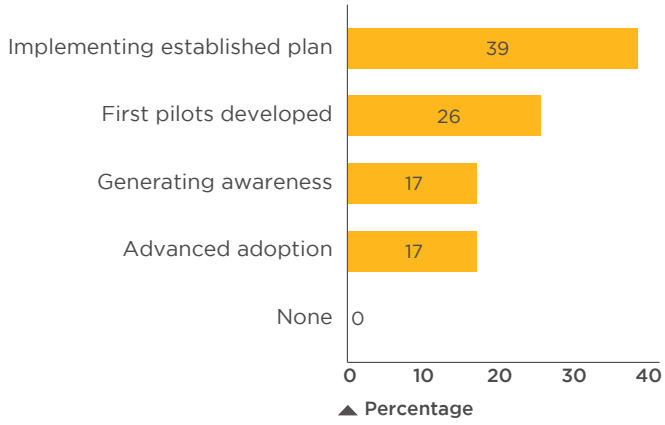
As in the 2019 report, an aspect commonly mentioned in the interviews and focus group of land freight transportation was the **lack of mobile broadband connectivity in logistics corridors**. The need to improve connectivity and implement telecommunications supporting infrastructure at industrial hubs and logistics corridors was specifically pointed out. In most countries in the region, the deployment of 4G networks only prevails in metropolitan areas, with a near complete absence of mobile coverage on highways. There are also primary and secondary sections with considerable distances lacking 2G/3G technology coverage to deploy transportation geolocation solutions and cargo routing in real time.

5.7 The state of the air sector's digital transformation

The air sector has made the **largest progress** globally in terms of digital transformation. The information obtained by our research shows that this is also the case in LAC, with 83% of respondents saying their institutions have already made some progress in this field (**Figure 5.19**). In particular, all private sector organizations declared to be implementing their digital transformation strategies, with one out of every four at an advanced stage of implementation. Similarly, most (70%) perceive themselves to be at or above average in LAC.

Figure 5.19. ▶ **"HOW MUCH PROGRESS DO YOU CONSIDER THAT YOUR ORGANIZATION HAS MADE IN DIGITAL TRANSFORMATION THUS FAR?"** (air transportation)



Source: Authors.

The information gathered from interviews to sector leaders reveals that the most developed organizations are in the countries with the highest volumes of air traffic like Brazil, Chile, Colombia, and Mexico, and in those that have prioritized fostering digital transformation, such as Uruguay's Carrasco Airport. Below are some examples from these countries. Overall, public airports and those located in the Caribbean continue to run less technologically sophisticated operations.

All private companies in the airline sector have a digital transformation strategy.

The National Civil Aviation Agency of Brazil (ANAC) already has a work group to identify potential regulatory interventions linked to airport infrastructure needed for the secure operation of eVTOL aircraft (electric vertical take-off and landing) in urban area mobility (ANAC & Brasil, 2021), and has begun the process of certifying the first electric horizontal take-off and landing vehicle in the country (ANAC & Brazil, 2022).

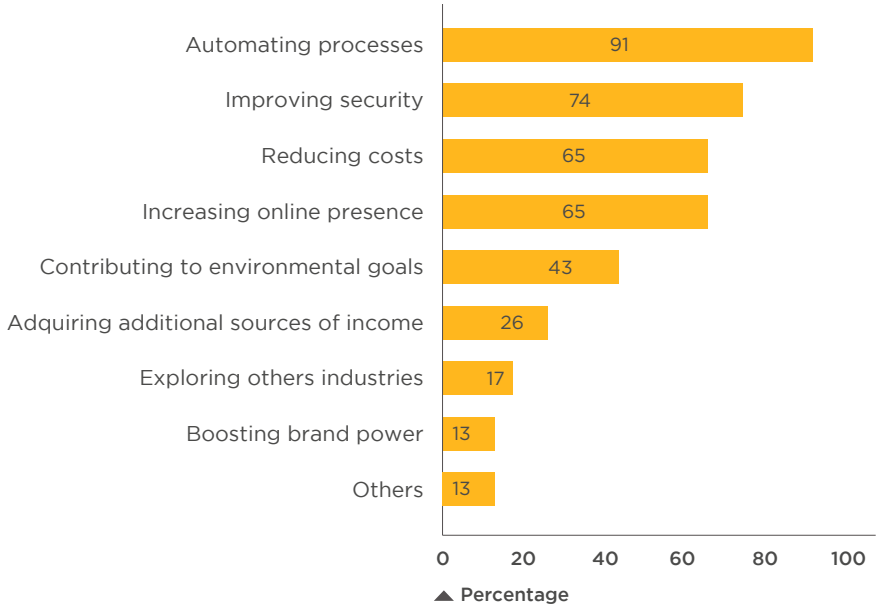
Airbus, through its subsidiary VOOM, has offered travel services by helicopters on demand in São Paulo (Airbus, 2017) and Mexico City (Airbus, 2018), and the operational knowledge obtained is supporting the development of AAM vehicles. Embraer-EVE has carried out simulated operations with helicopters in Rio de Janeiro (2022), aiming at better understanding the operational processes and needs of the players involved in the air operation of these services (CNN, 2021b).

Through its National Green Hydrogen Strategy, the government of Chile is developing a plan for the airport of Santiago to be the first in Latin America capable of receiving and supplying green hydrogen-fueled airplanes by 2030 (Ministry of Energy, Chile, 2021). Similarly, the government of Colombia has put together a "Hydrogen Roadmap" that identifies air transportation as one of the focus areas (Ministry of Energy, Colombia, 2021).

Uruguay stands out as an example among regional leaders in terms of public-private coordination to encourage digital transformation. The national government, the airport operator Portal del Sur (concessionaire of the Corporación América Group) and airlines work together to implement tech solutions to airport terminal operations, like biometric immigration control to automate processes and make passenger experience at the airport more comfortable. This has contributed to accelerating passenger flow, optimizing the need for staff and infrastructure.

In terms of technologies employed, most respondents identified process automation (91%), increased security in activities (74%), and cost reduction and increased online presence (65%) as their main **goals** (**Figure 5.20**). This is in line with global trends (see **Chapter 2**) on seeking to cut costs through automation and increase market share by providing more online services and improving client experience, while always ensuring sector's security.

Figure 5.20. ▶ **"WHAT ARE THE INVESTMENT GOALS OF DIGITAL TRANSFORMATION IN YOUR ORGANIZATION?** (*)" (air transportation)

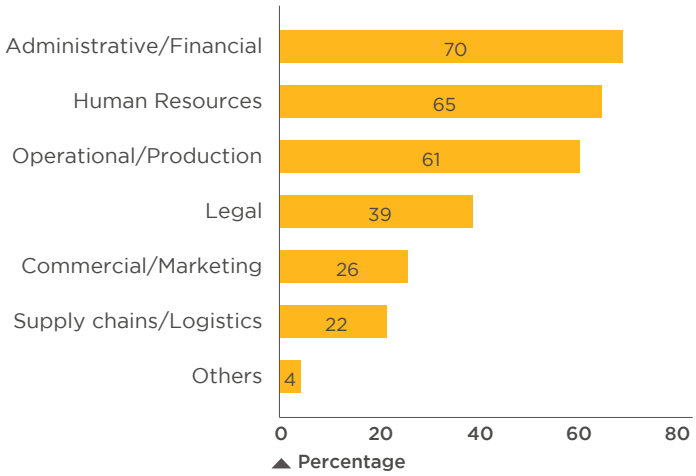


Source: Authors.

(*) Check all that apply.

With these goals, current **priority areas** for tech implementation, considering the air subsector as a whole, are administrative/financial (70%), human resources (65%), and operations' management (61%) (**Figure 5.21**). To this end, and in line with what has been observed in other transportation sectors, the **most commonly employed technologies** are data analytics and cloud computing (65% and 70%, respectively). When asked about the middle-term (2025), respondents pointed to the need to advance in areas related to clients (76%), which is consistent with the sector's tendency to be more customer-centric; operations management (71%); security and protection (67%); and product and service innovation (52%). In this sense, further use of AI is expected (78%), together with data analytics (65%) and cloud computing for AI feasibility (56%) (**Chart 5.9**).

Figure 5.21. ▶ **"IN WHICH AREAS HAS YOUR ORGANIZATION BEEN IMPLEMENTING DIGITAL TRANSFORMATION? (*)"** (air transportation)



Source: Authors.

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Chart 5.9. ▶ **"WHICH TECHNOLOGIES HAS YOUR ORGANIZATION IMPLEMENTED AND WHICH WILL BE IMPLEMENTED OVER THE NEXT THREE YEARS? (*)"** (air transportation)

	Today	Next three years
Omnichanneling	26.09%	30.43%
Cloud computing	69.57%	52.17%
Data analytics/Big data	65.22%	65.22%
Machine learning	30.43%	78.26%
Internet of things/Sensors	21.74%	56.52%
Applied artificial intelligence	21.74%	65.22%
Robotic Process Automation (RPA)	4.35%	30.43%
Drones	8.70%	34.78%
Building Information Modeling (BIM)	8.70%	26.09%
Augmented reality/Virtual reality	13.04%	21.74%
Blockchain	8.70%	17.39%
3D/4D printing	0.00%	8.70%
Autonomous vehicles	0.00%	4.35%
Electric vehicles	8.70%	13.04%

Source: Authors.

(*) Check all that apply.

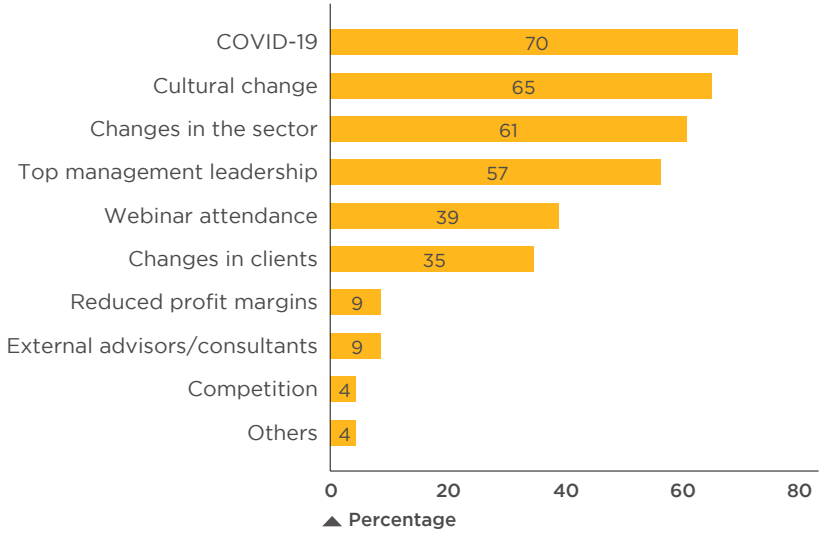
Despite progress in the sector, the results show a **technology adoption gap in the region as compared to leading countries around the world**, with 48% of respondents declaring that their organization is behind or very behind leading counterparts. They also say that the region is a **late follower**, with innovation only arriving after it is first adopted by large international aviation, airport, and tech industry firms. The mode of transmission is through multinational companies that operate in LAC, for example, in airport terminal management, and large airlines and aviation firms in LAC that, due to competitive pressure and the requirement to be part of international alliances, see digital transformation as a way to cut costs and secure client loyalty. In effect, **changes in the sector** have been acknowledged by 75% of private companies as one of the main factors contributing to accelerating transformation.

70% of respondents mention the COVID-19 pandemic as an incentive for digital transformation.

Modernizing air traffic control systems is an example of the long time it takes in the region to adopt technologies. As **Chapter 2** has shown, huge efforts are being made worldwide to promote upgrading the system, so as to increase the operational capacity to manage a larger amount and types of equipment in air space, enhance integration and management of traffic within and outside the region, and automate operations. There are technologies already available in the market and extensively used in different latitudes. However, in the case of LAC, their adoption is lagging behind significantly. Brazil has been making powerful investments to modernize the control system of their air space. Other countries like Argentina, Colombia, and Mexico, are also investing, but with more specific goals.

The **COVID-19 pandemic** has also had a catalyzing effect on the digital transformation of air transportation, as expressed by 70% of respondents (**Figure 5.22**). In particular, measures taken to contain the spread of the virus have encouraged higher process digitalization and automation to reduce human contact. The adoption of tools such as data analytics, AI, and omnichaneling was crucial to rapidly respond to challenges that included virtual communication with clients, building trust on the bio-sanitary safety of the means of transportation, promoting new businesses at airports, cost management, and interactions between public and private entities, among others.

Figure 5.22. ▶ **"WHICH ASPECTS HAVE CONTRIBUTED THE MOST TO THE PROGRESS OF DIGITAL TRANSFORMATION IN YOUR ORGANIZATION?** (*)" (air transportation)



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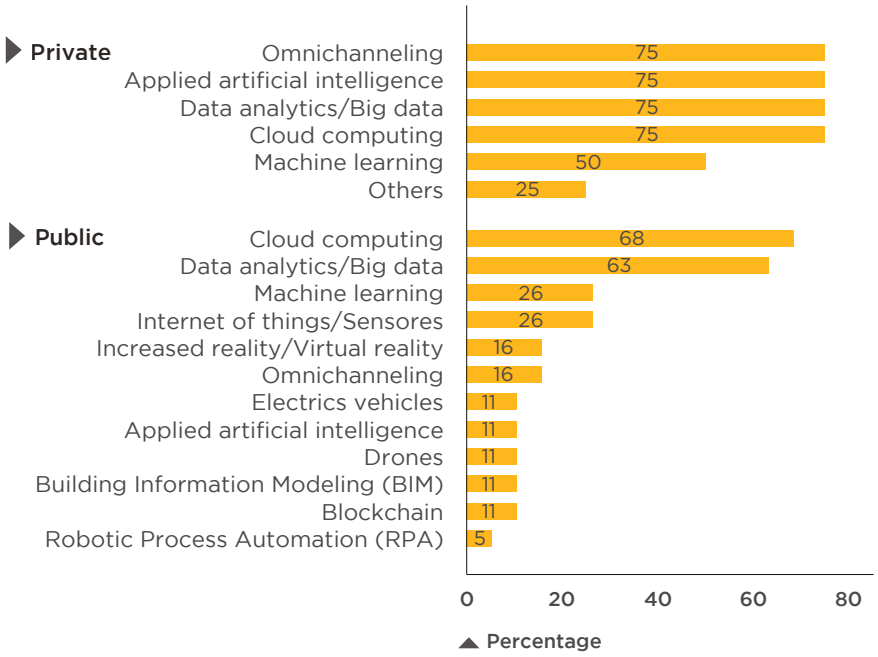
This impact has been particularly meaningful for public organizations, where 84% of respondents said the pandemic was the main factor behind the acceleration of digital transformation, followed by changes in the organizational culture (66%) and in the sector (58%). Nevertheless, there is an important **gap between these organizations and those in the private sector**. In the region, players involved most directly with the operational part of the sector (e.g., manufacturers, airlines, airport terminal concessionaires) have adopted more technology in their activities, while public sector players (e.g., air sector authorities, regulating agencies) are generally lagging despite recent progress in their adoption of technological/digital solutions. A demonstrative example of the survey is the employment of AI tools: 75% of respondents from the private sector are already applying them in their processes, compared to 11% in the public sector (**Figure 5.23**). In this scenario, it comes as no surprise that 32% of public entities are perceived to be behind or very behind the sector in LAC, a figure that rises to 53% when compared to leading countries around the world.

Figure 5.23. ▶ **"WHICH TECHNOLOGIES HAS YOUR ORGANIZATION IMPLEMENTED** (*)**"**
(air transportation)



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In the region, Brazil stands out as the country where the private and public sectors are making the biggest strides towards digital transformation of the air sector. Features like digital logbooks, airworthiness certificates, emission control and flight authorization control systems, and the regulating agency's citizen care system through digital channels are already in place in the country. Another ongoing initiative is a digital aircraft registry.

There are a number of factors considered barriers for the public sector's digital transformation: cost of technology (88%); limited financial resources for investment (53%); lack of a digital culture (88%); resistance to change (59%); and obsolete or insufficient tech infrastructure (41%). In contrast, private organizations have identified three main barriers: cost of technology (75%), lack of digital talent (50%), and weak tech infrastructure available in the region (50%). A fourth challenge mentioned by the private sector is precisely the public sector's regulations and procedures. In this sense, sector leaders have pointed out that many efforts fostered by public entities throughout the region have implied digitalization processes which were already required by authorities, rather than actual progress towards true digital transformation, including reassessing needs and required steps to enhance the performance of public activities.

Therefore, there is a significant **dichotomy in the notions that the public and private sectors have of digital transformation**. For the former, it is in its initial stages and the goal is to digitalize and automate processes, whereas the private sector visualizes a deeper and more advanced form of digital transformation that includes process reengineering, a new value proposition for clients, and upgrading companies' internal procedures. As the interviewees stated, the goal is to improve clients' travel experience, making it as dynamic and comfortable as possible. By breaking down the answers to the survey between the public and private sector, these two conceptions emerge, with the public sector aiming at digitalizing and automating administrative and legal procedures, and the private sector focusing on new customer services by implementing data analytics and artificial intelligence (See **Figure 5.23**).

Private companies in the airline sector have a more advanced and profound conception of digital transformation than the public sector.

It is worth noting that due to safety concerns, the aviation sector is highly regulated. Having operational safety at the core of any technological development and implementation typically slows down innovation by sectoral players. Thus, not only in LAC but worldwide, civil aviation authorities and regulating agencies tend to behave conservatively in regard to adopting new technologies, because this often requires changing established procedures, and implementing new procedures to ensure that the new technologies won't have a negative impact on operational security. This affects the legal and regulatory frameworks, which seldom match the digital world's speed of generating quick innovation and significant changes in short periods of time. Additionally, much of the sector's legislation and regulations are prescriptive, detailing extensively how the service or activity must be developed or provided, which does not leave space for variations due to technological upgrades.

There are additional **institutional capacity** factors, like unawareness of the benefits of adopting new technologies in operations (pointed out by 47% of respondents); the rigidity of bureaucratic requirements –often established on a legal level–; insufficient professionals familiar with the new technologies and their use in the sector and in institutional processes; high personnel turnover, making it difficult to preserve the memory, and institutional and operative capacities; lack of access to training on technological tools by professionals; and the absence of clear rules to store, handle, or share data.

Regarding the last of these points, and as is the case with other transportation sectors, there are challenges related to **managing and sharing data** between both public and private players. The interviews to regional leaders revealed challenges linked to process and procedure standardization; types of information and required technical standards; data sharing and system interoperability procedures; security and cybersecurity for data sharing and management; possible data apps and uses; and rights and responsibilities regarding data access and use, among others.

Compared to others in the sector, in air transportation, the process of certifying technologies by government agencies is crucial to guarantee the sector's operations safety. This certification usually requires specific technical knowledge to prove that

the product or process meets the preconditions established by the corresponding authority. However, the lack of professionals with specific technical knowledge, and the public agencies' difficulty to attract and hire them, together with insufficient retraining of professionals already in the public sector, leads to postponing tech certifications and their implementation. The same is true for the development of norms to test technologies in controlled and real scenarios to later establish the legal requirements for their scaling.

The provision of **financial resources** is another barrier emphasized not only by the public sector, but by the private sector as well. Overall, larger entities –which tend to be private, like airports with high passenger flow or major airlines— invest more in adopting technologies for their operations. In contrast, smaller companies and infrastructure managers that have less passenger and cargo traffic (e.g., secondary airports or countries with little air market development) limit themselves to investments required by law to operate. In the middle-term, this will place them at an ever-greater disadvantage, because it will potentially impact the degree of service sophistication and efficiency, raising costs, and hindering or impeding the operations of some companies linked to the air segment (e.g., airlines and logistics operators that require certain minimum standards to operate). In this sense, respondents agree that this is a challenge throughout LAC, but especially in the Caribbean.

Institutional capacity, technological infrastructure, and availability of human and financial resources are the main barriers mentioned by the public sector.

Lastly, the **communications infrastructure** in place in each country is a challenge that directly impacts technological adoption. Many of the technologies being developed require telecommunications infrastructure to share and process data, including 4G/5G telecommunications systems, radiofrequency management and availability, and fiber optic cables with bandwidth available for high data traffic, among others. The lack of coverage and quality of telecommunications infrastructure, especially outside of the main urban centers, acts as a constraint to digital transformation in certain subsectors, for example, the use of remote air control towers.

5.8 The state of the digital transformation of urban mobility

As was mentioned at the beginning of this chapter, given the vast heterogeneity of players involved in urban mobility (e.g., transportation authorities, bus companies, TNCs, micromobility firms, subways, navigation technology service providers), interviews were conducted to assess the status of digital transformation in order to obtain a more representative perspective of this sector's reality. The results were validated in a round table with representatives of the public and private sectors of the region.

Boosted by environmental sustainability agendas in the context of the region's increasing urbanization, urban mobility has assumed a very relevant role in public policy. National governments and especially local governments **acknowledge that digitalizing urban mobility management is a key element** to developing a sustainable environment that contributes to the appeal of metropolitan centers as innovation poles and economic development hubs. The progress of this subsector's digitalization will be evaluated in three areas: (i) progress in the private sector; (ii) the digital transformation of public transportation services; and (iii) the digitalization of urban mobility management systems.

Starting with the private sector, one of the key elements to develop urban mobility digitalization and innovation has been the arrival in the region of international operators of **shared mobility platforms**. Given some of these platforms' relatively low entry barriers, this has driven local competition, through the appearance of Latin American firms. The progress of smart phone adoption in urban areas in LAC has spurred rapid development of this business. For example, with Uber arriving in Argentina in 2016, currently four out of every ten cell phone users have this app on their phones. Encouraged by the adoption of cell phone communications, bilateral shared mobility platforms have developed from the crossed network effects between users and car drivers.

Shared mobility platforms, urban mobility data platforms, and the automotive industry are fueling digital transformation in this subsector.

Parallel to introducing the product, these apps have grown by widening their offer, for example adding information about public transportation or providing shared bicycle and scooter services. Meanwhile, among their goals, some already include the electrification of their entire fleet, with objectives set for 2040. There are even examples of information-sharing deals with local authorities to improve urban traffic management. It is worth underscoring that future progress of shared mobility largely depends on the creation of specific public policies for the segment, and the coordination between local and national governments, covered in **Chapter 6** of this report. Introducing these platforms in cities has met resistance from taxi drivers, and has also increased the distance traveled by cars in urban areas, affecting the demand for public transportation (Sabogal-Cardona et al., 2021; Scholl et al., 2021). The regulatory vacuum that persists in many countries in LAC leads to uncertainty about the presence of these services and how to integrate them into a sustainable urban mobility scheme (Oviedo et al., 2021). At the same time, it hinders the exchange of information between providers and the public sector.

> There are several public bicycle systems in LAC. Some companies have extended their services to numerous cities in the region. For example, Tembici is the public bicycle system operator in São Paulo, Rio de Janeiro, Salvador (Brazil), Pernambuco (Brazil), Porto Alegre, Santiago (Chile), Buenos Aires, Brasilia, Vila Velha, and Riviera de São Lourenço (Tembici, 2021). In the case of electric scooters, this form of transportation became increasingly popular in LAC since 2019 with regional and external players. However, the COVID-19 pandemic has severely impacted these companies' operations. Extraregional companies have focused on winning back users in other areas, withdrawing a large portion of their operations in LAC (Contexto, 2020).

1,107 km

"toured the first autonomous bus tested in LAC in a public space, whose operation took place between 2019 and 2020 in Santiago, Chile."

The arrival of international firms has also extended to **shared data platforms linked to mobility**, such as Moovit and Waze, which operate in many LAC cities. These platforms have established collaboration agreements with multiple municipalities to share real time data on the current state of traffic or urban transportation (Gutiérrez et al., 2019; Rendón et al., 2020), and some are also offering shared mobility services, like Waze Carpool.

Following their parent companies' R&D guidelines, firms in the **automotive industry** have increased the availability of models with driver assistance, road safety, communication, and entertainment technologies. LAC's sector leaders agree that safety and electric mobility will become priority technology areas in the short to middle term. This requires taking steps towards more sensors and vehicle connectivity, V2X interactions, analysis of big data with AI models, and significantly developing supply chains and reconverting facilities to produce electric vehicles. Development of the recharging network will be essential in determining electric vehicle penetration in LAC towards 2025 (Gómez Gélvez et al., 2016; Voege, 2019).

Like their leading countries' counterparts, private companies are developing **alliances with national or local governments to test new technologies** in real urban environments. Such is the case with autonomous vehicles in Santiago, Chile, where the government carried out a pilot project with the IDB and Transdev, consisting on the circulation of a minibus in a city park (Rodríguez et al., 2021). Perhaps the most significant progress is currently visible in the electric vehicle industry, where manufacturers, energy companies, and the public sector have hammered out deals aimed at generating information about the operational characteristics and investment needs for the large scale deployment of these systems (Beltran Real & Lefevre, 2021; Isla et al., 2019; Navas et al., 2021; Pérez et al., 2019; Sosa et al., 2020). In Costa Rica, for example, the ministries dealing with transportation and environmental issues, a power utility, and a group of public transportation service firms carried out, with international assistance, a pilot between 2019 and 2020 to evaluate the operating conditions of electric buses in the country with a view of moving towards a higher degree of electrification of the bus fleet. Meanwhile, the Environment and Energy Ministry supported a pilot of the *Tecnologico de Costa Rica*, GIZ, and freight transportation companies to test the performance of light duty vehicles. Although numerous advances in electric mobility are evident, this is not the case with connected and autonomous mobility, such as MaaS. Within the barriers cited in this regard, there are gaps or regulatory impediments; lack of initiative from government agencies; data governance, standardization, privacy and security challenges; and supplier lock-in.

Regarding autonomous technology, there are two metro systems in LAC that operate vehicles without drivers. In 2010, Line 4 (the yellow line) of the subway in Sao Paulo, was the first driverless underground line in the region.[44] Currently, the Metro in Santiago operates two automatic lines, namely lines 6 and 3, which started operating in 2017 and 2019, respectively. Several automatic lines are being planned in LAC: Lima (Line 2), Santiago (Lines 7, 8, and 9), and Bogota (Line 1).

[44] Read more about the potentiality and risks of autonomous mobility for the region in Gutierrez et al. (2019), Navas & Mix (2021a) and Calatayud et al. (2020).

The first pilot test of an autonomous vehicle in LAC was conducted in Santiago. It took place in a downtown park during three months between 2019 and 2020. The vehicle was operative for 179 hours and 1,107 kilometers in total, having transported 6,685 passengers over 2,649 round trips (Navas & Mix, 2021b).

The **digital transformation of public transportation operators** has initially focused on implementing fee collection systems with different levels of functionality, although there is a tendency to introduce technologies that increase the value and quality of essential public services. The second dimension of digital transformation consists in supplying users with information on waiting times, available spaces, route changes, and journey planning, including other modes of transportation, among others. To make this possible, it is crucial to promote the implementation of electronic collection systems and their integration. For example, cities like Buenos Aires, Santiago, and Sao Paulo use information from their systems to identify occupation rates in transportation units, changes in demand, and subsidy targeting, among others. At the same time, this information is essential to ensure that concessionaires offer the service quality assumed in their contracts.

E-payment for public transportation through magnetic cards has been implemented in several cities throughout the region: Asuncion (Jaha and Más), Buenos Aires (Sube), Mexico City (Movilidad Integrada), Montevideo (STM), Sao Paulo (Bilhete Unico), and Santiago (bip!). Other cities, including Lima and San Jose, are working on pilots or beginning to implement these systems.

In addition, Mexico City and Santiago are starting to implement payments to public transportation via QR codes, bank cards, or mobile phone payments (Crotte Alvarado et al., 2018; Diario Financiero, 2022; Forbes, 2022).

Digital transformation is considered a key tool to generate new business models and new sources of income for public transport.

The next step is to collect information about operations, like emissions generated, passenger count, user characteristics and preferences, and safety levels to continue improving public transportation service quality. One obstacle cities and operators continue to face is a **lack of data capture and exchange standards and interoperability** between various sources of information (e.g., GPS, in-vehicle measuring devices, video cameras) to develop an efficient data analytics feature. In addition to low interoperability, there are also **contractual barriers** to acquire data, like the creation of an internal capacity for data analytics. Lack of interoperability also affects the possibility of introducing a single collection system in metropolitan areas feeding back into a loop (See **Chapter 6**). Lastly, respondents mentioned **regulatory vacuums regarding data privacy and property** as a limitation to consider the integration of biometric and image recognition tools, which, as air transportation has proven, can improve planning and reduce operational delays. The

following should also not be ignored: (i) the presence of **informality** in the provision of transportation services; (ii) the **reluctance** of mobility actors to **share data** and be audited in a transparent manner; and (iii) **the lack of banking and financial inclusion** of the lowest strata of the population, which makes it difficult to implement digital payments in urban mobility and, at the same time, can generate risks of exclusion of this population.

One aspect that concerns players in the sector is that the **public transportation systems' financial crisis** caused by lower demand during the COVID-19 pandemic may hinder further investments in technology, which would also degrade service quality. Nevertheless, it is encouraging to see that decision makers in large public transportation operating systems and in Secretariats of Mobility **are already considering digital transformation as a key tool to reduce operational costs and generate a higher value proposition to service users and have strategies to guide this transformation**. This generates more traction, even in the face of current difficulties. When consulted on their perspectives for urban mobility in the middle term (2025), **everyone agreed in considering digital transformation as a pillar for system competitiveness against other modes and in creating new sources of income by generating new business lines**. Many aim at embracing the concept of **Mobility-as-a-Service** to achieve an integrated supply of mobility services based on the specific needs of each citizen so as to cover a larger share of the market, especially in the face of increasing private car and motorcycle rates. In this sense, they claim to be focusing investments on generating big data and applying AI models to better understand the mobility needs of citizens and tailor services to their needs.

The advancement of Mobility-as-a-Service, with an integrated offer of mobility services based on the specific needs of each citizen, can increase the market share of public transport compared to the increase in car and motorcycle use.

Relying on digital transformation strategies, municipalities throughout the region are also advancing in the development of **higher internal capacity for traffic management** based on the integration of information flows from multiple sources, such as transportation units and traffic monitoring systems. The number of Secretariats of Mobility with control centers that integrate this information and rely on data analytics to make mobility management decisions in real time is on the rise. For example, Montevideo has deployed a network of technological equipment comprised of centralized traffic light controllers, cameras for transit monitoring and for closed TV circuits, and variable messaging panels providing big data that can be analyzed in real time by models that include AI to handle, manage, and control urban traffic and transportation. With the support of South Korea, Medellin has created its Integrated Traffic Information Center, which gathers information about traffic, traffic lights, buses, subways, and road safety, among others, allowing them to offer citizens more information through a website, consolidated reports, mobile apps, and social networks. The creation of specific units in local agencies, the recruitment of computer and data science experts, and the migration of service infrastructure to the cloud are critical factors driving progress. Medium-sized cities are also taking steps. For example, an integrated smart traffic light system was installed in Maringa, Brazil, to improve traffic management. Among the **challenges** ahead, several respondents mentioned interoperability and inter-institutional agreements to collect and use data; setting out data sharing standards for the private sector; lack of resources to conduct tests, hire, or retrain staff and increase the availability of cloud infrastructure; and high employee turnover (See **Chapter 6**).

As in other transportation subsectors, there is great **heterogeneity among cities throughout the region**. There is evidence of significant progress in a small group of large cities such as Bogota, Buenos Aires, Medellin, Mexico City, Montevideo, Rio de Janeiro, Sao Paulo, and Santiago given the interest of the private sector, larger institutional capacity, and resource availability of the Secretariats of Mobility, while the improvement in small and medium cities remains incipient. These differences **are also present among service providers** that range from large tech firms to a multiplicity of startups that are already digitally based, and even large bus companies operating both formally and informally. The latter is similar to the situation of land freight transportation, where the main barriers to innovation stem from management, cultural factors, and the limited financial capabilities of these companies.

5.9 Summary of the state of digital transformation of transportation in LAC

As a summary of the assessment laid out in this chapter, the following items regarding the digital transformation of the transportation in LAC are worth highlighting:

- **The region is moving towards the digital transformation of transportation**: most players reported having a digital transformation strategy. This is an improvement from 2019, when there was barely any awareness of the topic.
- As is the case in the international arena, **the air sector is leading the transformation**, with some companies progressing on a deeper level of digital transformation, beyond the mere adoption of process automation technologies and cost reduction, producing true technological disruption and transformation of the organization to offer a service tailored to each client's specific needs.
- **Other large firms in the logistics** (especially maritime companies and global freight forwarders) **and mobility sectors** (tech giants and massive public transportation system operators) are also making significant progress in the region around this deeper concept of digital transformation, focused on providing a better service to clients and users.
- With the exception of these cases, most companies and public agencies report that they are aiming at automating and digitalizing processes, and investing in technologies in line with that. This correlates with the **early stages of digital transformation**, where players tend to focus on areas related to administrative and financial management, like the ones most frequently mentioned by respondents.

- The process of digital transformation transmission on a global and sector level is verified in the case of transportation in LAC. As a consequence, large companies and those less involved in global value chains show less progress. This is particularly clear in **land freight transportation and urban passenger transportation SME**s.
- The **industrial organization** of each subsector has a major impact on the level of progress. Subsectors concentrated in larger global companies, like air and maritime, are more developed than land subsectors. The atomization of urban public transportation is seen as a significant barrier hindering progress towards the transformation of all urban mobility.
- In most sectors, **public agencies are going through the phases of awareness, experimenting, and process automation**. This is more extensively analyzed in the next chapter. However, there is consensus among the maritime, air, and land subsectors that the slower pace of public players constitutes a **meaningful challenge for the digital transformation of transportation**.
- Resistance to change, lack of priority by management, technology costs, and insufficient financial and human resources are the **main barriers** for digital transformation.
- The technologies that are currently gaining the most traction are data analytics and cloud computing. Facing 2025, there is deeper emphasis on artificial intelligence and technologies to cut emissions. This suggests that, although the region is in the initial stages of digital transformation, **investments in technologies typically associated with more advanced stages and in technologies that promote the sector's sustainability are already being considered**.

6 Public sector involvement in Latin America and the Caribbean's digital transformation of transportation

Public sector involvement in Latin America and the Caribbean's digital transformation of transportation

Governments in LAC have begun considering the digital transformation of transportation as a strategic need. Before the pandemic, a small group of countries in the region began to include in their agendas the digitalization of the manufacturing sector to spur economic growth in the context of the Fourth Industrial Revolution. In certain cases, the various programs implemented to this purpose indirectly reached transportation and logistics. However, they rarely included a specific incentive towards the digitalization of transportation (Calatayud & Katz, 2019).

Over the past two years, this situation has started to change. The disruptions to essential goods' supply chains during the pandemic have shown the importance of logistics to safeguard the normal functioning of the economy and modern society. At the same time, transportation's rising costs due to disturbances to maritime and air networks have affected economic recovery perspectives. Lastly, the need to reduce pollutant gas emissions has positioned freight transportation as a key sector to promote the battle against climate change. All this has led the digitalization of transportation to gain increasing traction in the public policy agendas of countries throughout the region.

Meanwhile, driven by the environmental sustainability and social inclusion agendas and in the context of growing urbanization in the region, exacerbated poverty and inequality during the pandemic, and the effects of climate change, urban mobility has also gained considerable prominence in government agendas. In this context, public authorities, especially local public authorities, have acknowledged that the digital transformation of urban mobility is crucial to create a sustainable environment with better quality of life, contributing to the appeal of metropolitan centers as innovation hubs.

Similarly, the acceleration of technological changes in air transportation, especially since the pandemic, together with the need to reduce its environmental impact is encouraging an update to the agendas and shedding light on the need to improve public institutional capacity in this subsector.

As a result, **public policies are showing greater interest in the digital transformation of transportation** as compared to the gathered from the IDB report of 2019. At that point, digital transformation was considered a subsequent stage after closing the infrastructure gap and service quality throughout the sector. Instead, the triple combination of: (I) the effects of the pandemic, (II) the urgency to battle climate change, and (III) the progress made by leading countries and companies in the sector are incentivizing the governments in LAC to boost the amount of attention paid to digital transformation.

As we shall see in this chapter, rather than blindly copying the transformation models and practices of leading countries analyzed in **Chapter 4**, public policy makers in LAC are following **paths specifically adapted to reflect conditions in the region**, marked by a limited availability of technical capacities and financial resources, as well as by an idiosyncratic institutional tradition. Below, we will analyze the governments' participation in the digitalization process of transportation, starting by identifying plans and programs in place, reviewing the instruments employed to implement them, studying how governments build the necessary technical capacity to lead these processes, and evaluating the level of collaboration with the private sector and other relevant players. In each case, the situation in Latin America is compared with best practices identified in leading countries in **Chapter 4**.

6.1 Identifying digital transformation as a sectoral planning priority

As has been mentioned in **Chapter 4**, public sector participation in transportation digitalization begins by establishing **three types of planning tools**: (I) general transportation plans, including digital transformation as one of their goals; (II) specific plans for the digital transformation of the sector or one of its modes (e.g. maritime transportation, air transportation, urban mobility); and (III) plans not necessarily aimed at transportation although, given their approach to digital technologies (e.g. AI, IoT) they implicitly have an effect on it. In general, LAC countries also rely on the following instruments (see **Chart 6.1**).

Chart 6.1. ▶ **PLANS, PROGRAMS, AND INITIATIVES THAT AFFECT THE DIGITAL TRANSFORMATION OF TRANSPORTATION IN LAC** (selected countries)

		URBAN MOBILITY	LOGISTICS (*)	AIR TRANSPORTATION
ARGENTINA	National transportation plans	• National Action Plan for Transportation and Climate Change • Federal Strategic Plan for Mobility and Transportation		
	Plans/programs for specific areas of transportation	• National Urban Policy Argentina	• Port Modernization Plan	• Modernization Plan for Air Traffic • Action Plan of the Argentine State for the Reduction of CO_2 Emissions in Aviation
	Cross-sectional plans that have an impact on transportation	• AI National Plan • Argentine Cybersecurity Strategy • Productive Development Plan Argentina 4.0 • Data Opening Package of the Argentine Republic • Guide for the identification and use of interoperable entities • Strategic Federal Plan for Mobility and Transport		
BRAZIL	National transportation plans	• National Transportation Policy • Long Term Integrated Plan for Infrastructure 2021-2050		
	Plans/programs for specific areas of transportation	• National Urban Mobility Policy	• National Logistics Plan 2035 • Master Plan for Information and Communication Technologies, and Telecommunication 2021-2024 • National Land Transport Agency 2020-2030 Strategic Planning	• National Aviation Plan 2018-2038 • National Air Transport Facilitation Program • Sirius Program
	Cross-sectional plans that have an impact on transportation	• Artificial Intelligence Strategy • Digital Governance Strategy • Brazilian Digital Transformation Strategy • IoT National Plan • National Cybersecurity Strategy • Science, Technology and Innovation Policy for Advanced Materials (in public consultations to begin its preparation) • National Innovation Strategy • STI Action Plan for Convergent and Enabling Technologies for Advanced Manufacturing • National Science, Technology, and Innovation (STI) Strategy 2016-2022 • Rota Program 2030 of the Federal Government – Mobility and Logistics		

		URBAN MOBILITY	LOGISTICS (*)	AIR TRANSPORTATION
CHILE	National transportation plans	• Transport Digitalization Plan • Gender Equality in Transport Policy • National Transportation Policy		
	Plans/programs for specific areas of transportation	• National Strategy for Sustainable Mobility • National Electromobility Strategy 2021	• Collaborative Logistics Plan • National Plan for Land Accessibility to Ports 2021 • Ports Policy Review of Chile • Port Modernization Fund	• Strategic Plan to Support Air Transport • International Air Transport Facilitation Program • 2019-2030 DGAC Strategic Plan
	Cross-sectional plans that have an impact on transportation	• National Artificial Intelligence Policy and Action Plan • Digital Agenda • National Policy on Science, Technology, Knowledge and Innovation • Digital Transformation of the State Law • National Cybersecurity Policy • Digital Transformation of the State Strategy • Chile Smart Territory National Plan		
COLOMBIA	National transportation plans	• Transportation Master Plan • Intermodal Transportation Master Plan • Institutional Training Plans • Data Privacy & Security Plan • Ministry of Transportation's Open Data Plan		
	Plans/programs for specific areas of transportation	• National Master Plan for Smart Systems for Infrastructure, Transit and Transportation	• National Logistics Policy • Pact for Transport and Logistics for competitiveness and regional integration 2030 • River Master Plan of Colombia • National Road Plan for Regional Integration • Colombian Regional Road Plan • National Road Safety Plan 2011-2021 • Strategic Plan for Intermodal Transport Infrastructure	• Air Navigation Plan for Colombia • 2030 Strategic Aviation Plan

		URBAN MOBILITY	LOGISTICS (*)	AIR TRANSPORTATION
COLOMBIA	Cross-sectional plans that have an impact on transportation	• National Development Plan 2018-2022 • Strategic Information Technology Plan 2020-2023 • National Cybersecurity Policy • National Policy for Digital Transformation and Artificial Intelligence (CONPES 3975) • ICT Plan 2018-2022 "The Digital Future is for All" • 5G Plan • Single ICT Fund		
COSTA RICA	National transportation plans	• National Transport Plan 2011-2035 • Sectoral Strategic Plan 2019-2024 Infrastructure and Transport		
	Plans/programs for specific areas of transportation	• National Urban Development Policy 2018-2030 and Action Plan 2018-2022	• National Freight Logistics Plan 2014-2024 • Master Plan for Pacific Coastline Ports	• Facilitation National Plan
	Cross-sectional plans that have an impact on transportation	• Decarbonized and Inclusive Territorial Economic Strategy for Costa Rica 2020-2050 • Costa Rica post 2030: main challenges by 2050 • National Telecommunications Development Plan • National Cybersecurity Strategy • 2019-2022 Bicentennial National Development Plan and Public Investment Plan • The Road to 5G Networks – the path of Costa Rica towards IMT networks		
JAMAICA	National transportation plans	• Vision 2030 Jamaica – National Development. Transport Sector Plan 2009-2030 • National Transport Policy		
	Plans for specific areas of transportation		• Jamaica PCS and its Implementation Project	• The air sector is integrated in the plan Vision 2030
	Cross-sectional plans that have an impact on transportation	• Vision 2030 Jamaica – National Development Plan • Information and Communications Technology - Sector Plan • National Cybersecurity Strategy • Jamaica Eye National CCTV Initiative		
PANAMA	National transportation plans	• 2019-2024 Strategic Government Plan		
	Plans/programs for specific areas of transportation	• Integrated Plan for Sustainable Urban Mobility for the Metropolitan area of Panama 2016	• National Logistics Strategy 2030 • Five-year Strategic Plan of Panama's Maritime Authority	• Air Cargo Security National Program • National Civil Aviation Security Program

		URBAN MOBILITY	LOGISTICS (*)	AIR TRANSPORTATION
PANAMA	Cross-sectional plans that have an impact on transportation	• National Digital Agenda • "Panama Hub Digital" Strategy to Develop the ICT Sector • Cybersecurity Strategy • Open Government Data Action Plan of Panama		
DOMINICAN REPUBLIC	National transportation plans	• 2020-2030 Dominican Republic's National Infrastructure Plan		
	Plans/programs for specific areas of transportation	• Sustainable Urban Mobility Plan for Greater Santo Domingo	• National Plan for Cargo Logistics 2020-2032 • 2021-2024 Institutional Strategic Plan of the Dominican Republic's Port Authority	• Institutional Strategic Plan of the Dominican Republic Civil Aviation Institute 2021-2024
	Cross-sectional plans that have an impact on transportation	• Public Sector 's National Pluriannual Plan 2021-2024 • National Cybersecurity Strategy 2018-2021 • National Development Strategy • 2021-2024 Action Plan of the Digital Agenda 2030 • Digital Agenda 2030		

Source: Compilation by the authors.

(*) Includes maritime, land, and last mile.

Digital transformation is not usually a priority in LAC sector plans.

As **Chart 6.1** shows, most of the assessed regional countries have developed **national transportation plans**. Some plans point at the need to advance in adopting technologies in different modes of transportation. For example, Brazil's National Transportation Policy presents goals for air transportation (fostering investments in technology and incorporating facilitation procedures of civil aviation, crew, passengers, and cargo transportation); land transportation (incentivizing the use of technologies aimed at identifying vehicles to subsidize transportation planning); and maritime transportation (improving the port system's productivity in the freight transportation). Chile's National Transportation Policy presents urban mobility initiatives (information systems to support route and journey decisions, automatic traffic and user data collection mechanisms, exchange infrastructure payment method, strengthening information to users), ports (space reservation program to build roads, port terminals, support areas, truck valets), and land transportation (information systems about transportation costs and travel times). Argentina's National Action Plan for Transportation and Climate Change mentions three measures in connection to digitalization: adopting buses with alternative energies, implementing smart transportation systems, and promoting improvements in air navigation.

However, although references to technology in LAC's plans may sound promising, **digital transformation is not nearly as relevant** as in leading countries. The latter focus on new technologies generating a deep shift in the sector and, subsequently, acknowledge that digital transformation is an essential component to develop transportation. Not assigning this level of priority in national plans **affects the inclusion of this topic in public policy agendas and its relevance for investments**.

To complement national plans, many countries in LAC have **plans for specific modes or subsectors**. Although the situation is heterogeneous, there is a closer link between technology and transportation at public policy level in those documents. In terms of urban mobility, for example, Argentina's National Urban Policy, enacted in 2018, clearly states that there is a need to invest in digital technologies to improve planning and management of urban mobility processes. Similarly, Chile's National Strategy for Sustainable Mobility sets among its priorities the enhancement of mechanisms to collect, process, and analyze mobility data, digital transformation for integrated traffic management, and the strengthening of information services to citizens.

Regarding logistics, most national plans and agendas include initiatives and axes of intervention connected to digital transformation. For example, Costa Rica's National Plan for Cargo Logistics 2014-2024 favors using ICT to achieve full digitalization of foreign trade processes and of logistics communities and chains operations, simplifying paperwork and institutional interoperability. Panama's 2030 National Logistics Strategy, conceived as a "strategy of strategies", includes among its areas of intervention the development of a system to exchange data between port terminals in real time that captures the capacity and short-term predictions, the creation of a Cargo Community System for air transportation, and the implementation of an integrated management system of logistics data.

In the air transportation sector, the plans reviewed mention the need to forecast what will be the impact of new technologies it develops. The most advanced case is Brazil, where the National Aviation Plan 2018-2038 considers promoting measures to foster the adoption of emerging technologies and innovation like automated border controls, biometrics and system optimization in air space control, as well as identifying work areas for new air technologies (e.g. vertical take-off and landing aircraft). Other countries mention technologies in their plans but less specifically than Brazil. In Argentina, the 2021 update of the Action Plan of the Argentine State for the Reduction of CO_2 Emissions in Aviation contemplates the need to modernize air navigation systems, promote sustainable energy sources, and implement Electronic Flight Bags (EFB). Chile's Strategic Plan to Support Air Transport makes an overarching mention of technological transformation as an element to be considered when planning infrastructure and air operations. In Colombia, the 2030 Strategic Aviation Plan discusses the challenges that new technologies bring about, including training administrative professionals.

The mention of technology in sub-sector plans is very incipient, and there are no roadmaps for digital transformation either.

That said, progress is not the same in every country or even subsectors within a single country. Compared to the international experience, **references to technology in sub-sectoral plans is limited**. In addition, the notion in plans tends to be more focused on using technology for efficiency gains than for a digital transformation of transportation altogether and its impacts on the economy and society. However, the results of interviewed decision-makers in the region suggest a **growing awareness on the relevance of this issue** and its inclusion is being considered for future plan updates. Therefore, the **number of references in documents is expected to grow** and with it, the priority of digital transformation among sectoral priorities. It will be essential that these plans include a **roadmap** to advance in implementation, identifying the actions to be taken by the public sector, private sector, or both.

Another planning area among leading countries' subsectors is the **promotion of certain technologies**, such as electric vehicles, autonomous vehicles, and drones. As has been detailed in the United Nations Environment Programme (2021), LAC countries are advancing in their electromobility plans, including roadmaps and instruments for their promotion and materialization, although heterogeneously. However, there are no specific plans for other technologies such as autonomous vehicles and AI, which have caught the attention of leading countries.

Combined with plans for specific modes of transportation, many countries have developed **cross-sectoral digital agendas**. Nevertheless, transportation is seldom a priority sector, although there are actions that touch on it tangentially or for a specific project. For example, Chile's Digital Agenda focuses on issues like connectivity, digital government, digital economy, and digital competences, and mentions the need to boost the development of smart cities pilots. Panama's National Digital Agenda includes modernizing the Integrated Customs Management System and discusses calling a tender for an Automated Collection System for urban transportation in Panama City.

Another crosscutting planning issue is **cybersecurity**. Every analyzed country has already developed national strategies in this field. In general, the development of cybersecurity strategies and/or plans has evolved simultaneously with broadband connectivity and the deployment of fiber optics backbone networks in the region. National strategies tend to mention the critical importance of transportation infrastructure and their vulnerability to cyberattacks. For example, Argentina's National Program for Critical Infrastructure Information and Cyber Security, based on the National Cybersecurity strategy, defines the regulatory framework to protect essential components of the public and private sectors, including transportation. In Brazil, every public sector player involved in critical infrastructure (including transportation) must coordinate cybersecurity agreements with the Ministry of Defense. Chile's National Cybersecurity Policy and Jamaica's National Cybersecurity Strategy identify the transportation sector as critical infrastructure that must be protected in case of a cybersecurity attack. Comparing leading countries' strategies with those in the region, it is noticeable how beyond the mention of transportation in the latter's strategies, there are no subsequent specific actions for the sector.

Cybersecurity strategies do not present specific actions for transport.

Lastly, consistently with advanced economies, some countries in LAC have established **national plans of specific technologies** with a potentially crosscutting impact on the transportation sector. For example, Argentina developed an AI National Plan, which, although mainly focused on human resources training and R&D promotion, may have a spillover effect on specific economic sectors. Chile's National Artificial Intelligence Policy takes the same approach.

Chart 6.2 summarizes the region's situation in connection with planning instruments and best practices covered in **Chapter 2**. The main message is that **there is certain progress in including technology as an impact factor in the sector, although it is still at an embryonic stage compared to advanced countries, which have identified digital transformation as a priority for the sector's development and have strategies and roadmaps in place**.[45]

Chart 6.2. ▶ COMPARISON BETWEEN THE SITUATION IN LAC AND BEST PRACTICES IN DIGITAL TRANSFORMATION OF TRANSPORTATION PLANNING

PLANNING INSTRUMENTS	BEST PRACTICES	SITUATION IN LAC
National transportation plans	• Including digital transformation as a key element for the sector's development	• Some countries point out the need to advance in the adoption of technologies in different modes of transportation, but digital transformation is not mentioned as a priority for the sector
Plans for specific areas of transportation	• Ample availability of specific plans for urban mobility, logistics, and air transportation • Based on the notion of deep transformation that digitalization brings about • Include roadmaps to implement actions, identifying those to be carried out by the public and private sector	• More references to the relationship between technology and transportation than in national transportation plans • Concept limited to the adoption of technologies rather than digital transformation • Increased awareness on the need to be included in future sub-sectoral plans
	• National digitalization strategies help clearly define the pillars of intervention for sectoral digital transformation, in particular, in connection with technological innovation	• The concept of the digital transformation of transportation in digitalization strategies is approached either tangentially or in connection to specific projects • Although some countries have developed specific plans to digitalize transportation, only in Brazil does it propose actions for each mode

[45] This conclusion is consistent with that articulated by Calatayud & Katz (2019) in their assessment of the digital transformation of supply chains in the region.

PLANNING INSTRUMENTS	BEST PRACTICES	SITUATION IN LAC
Plans for specific areas of transportation	• Plans to develop and implement specific technologies in the sector, with private participation, including electric and autonomous vehicles	• Progress in terms of planning, roadmaps, and instruments for electric mobility exclusively
Cross-sectional plans that have an impact on transportation	• Digital agendas include transportation among priority sectors • Cybersecurity strategies that consider transportation as a key element for security, and make recommendations	• Digital agendas do not see the sector as a priority • Cybersecurity strategies mention the sector but offer no guidelines

Source: Authors.

6.2 Use of public policy instruments to encourage the digital transformation of transportation

The assessment of leading countries experiences presented in **Chapter 4** indicated that promoting the digital transformation of transportation requires **devising public policies aimed at overcoming challenges in four areas**:

- Establishing public policies in a context of technological uncertainty.
- Developing incentives to overcome barriers to the adoption of technologies.
- Introducing stimulus to surmount coordination failures (data sharing, standards) between players in the transportation ecosystem.
- Promoting and educating about the digitalization of transportation.

Evaluating the experience in LAC has shown that: (I) countries in the region are facing the same obstacles than the leading countries, and (II) the tools deployed in Latin America to counter them are not the same than in those countries, revealing **adaptations tailored to the region's specific conditions**, such as limited human or financial resources.

6.2.1 Instruments to define public policies in a context of uncertainty

The governments of leading countries have employed three practices to control uncertainty in order to define public policies for the digitalization of transportation:

- Prospective studies and development scenarios for the digitalization of transportation, combined with public consultations.
- Regulatory sandboxes.
- International cooperation to gain access to other countries' experiences.

The use of these instruments in Latin America and the Caribbean is still limited, partially due to the **region's position on the periphery of the global cycle of technological innovation**. In this sense, regional countries benefit from being late adopters in terms of technological dissemination, given that they have the opportunity to learn from more advanced players and leapfrog in adopting technology.[46] That is why, out of the three previously adopted practices, **international cooperation to access leading countries' experiences** is probably the most applied instrument among Latin American governments. This cooperation stems from multiple channels.

In the first place, **international organizations** constitute a vehicle to socialize knowledge with governments in the region. In the field of logistics, for example, United Nations agencies like the World Customs Organization and UN/CEFACT (United Nations Centre for Trade Facilitation and Electronic Business) play a significant role in promoting standards and developing single foreign trade windows. In air transportation, the International Civil Aviation Organization (ICAO) is participating in the encouragement of biometric technologies, regulating air space and security management. Through its investment programs and technical assistance, **Development Banks** are playing a key role in the promotion and adoption of technologies. In effect, the **IDB's Vision 2025** for recovery and economic growth in LAC places digital transformation among its five pillars, underscoring its importance for efficiency, sustainability, and inclusion in countries throughout the region. Therefore, the IDB is fostering progress in planning and sectoral regulations, development investments, and testing of technologies[47] strengthening transportation institutions, and collaborating with the private sector, which also simplifies the region's access to best international practices (See Calatayud *et al.*, 2022 for examples in this sector).

In addition, **international private sector organizations** act as innovation promoters and facilitators. For example, the International Air Transport Association is cooperating with Latin American nations through their *One Record* program to digitize documentation, systematize data and share end-to-end information between parties involved in air freight operations. Similarly, the International Port Community Systems Association (IPCSA) acts as a coordination point to share experiences on the implementation of these systems.

The channels to share experiences extend to **collaborative relationships between governments**. For example, Brazil's National Civil Aviation Agency (ANAC) has deployed intense communication channels with similar organizations in the United States, Canada, Europe, and China. At the same time, ANAC has established dialogues with agencies from several LAC countries, including Argentina, Chile, and Colombia, concerning security and small aircraft certifications.

[46] The concept of *late adopters* was originally coined by Everett Rogers in his study *Diffusion of Innovations* (Rogers, 1995).

[47] For example, tools like Pavimenta2 and VíaSegura use video detection and artificial intelligence to detect pavement and road marking failures, respectively, being both open-access tools for the technical strengthening of the sector in the region.

3

“planning instruments to promote the digital transformation of transport: general plans for the sector that include transformation among their objectives, plans focused on digital transformation, and plans for the development of specific technologies.”

Regulatory sandboxes and testbeds are beginning to spread in some countries, although examples are still very limited.

The governments of leading countries also contribute to disseminating knowledge and experiences. For example, the Netherlands' Business Promotion Agency, under the Ministry of Foreign Affairs, conducts periodic studies of port digitalization assessments in the region to promote knowledge and experience developed in the country.[48] In another case, the US Federal Aviation Administration has been working with ICAO and a group of LAC countries to provide training and technical assistance in cybersecurity issues in the air sector. South Korea has numerous collaboration projects with civil aviation authorities in the region to transmit technologies.

Another way for LAC governments to integrate technologies has been through **physical or technological infrastructure projects**. This way, multinational companies with activities in the region act as natural transmission vehicles to spread innovation. The **public procurement process** is crucial in this sense. That's why some governments are modifying their procurement policies to offer more flexibility, for example, concerning purchasable products. Countries like Brazil, Chile, Colombia, Ecuador, Mexico, and Peru, among others, have incorporated the concept of public purchase of innovation, allowing them to acquire R&D services that may result in prototypes of first products or services in the form of series of tests that are technologically innovative and satisfy user needs.

Concerning **prospective studies** of developing technologies or adoption scenarios, these are typically part of national plans or strategies referred to specific technologies, sectoral plans focused on technology, or certain specific projects. Therefore, these types of tools are much more limited than the research activity of leading countries like the UK or those supported by the U.S. Department of Transportation, and are normally not available to the public or subject to public consultation. Similarly, once the plan has been carried out, it is hard for the organizing agency to continue conducting follow-up studies or update them, as well as to delve into areas of impact or specific adoption, which does happen in countries like the United Kingdom and the United States.

Regulatory sandboxes and test beds are starting to gain traction in some countries although they are still few in number. For example, the government of Chile, together with Transdev and the IDB conducted pilots of autonomous minibuses between 2019 and 2020 to assess the technology on three levels: regulatory, technological, and cultural.[49] Airbus, through its subsidiary VOOM, offered an air taxi and helicopter initiative in Sao Paulo between 2017 and 2020, and in Mexico City between 2018 and 2020.[50] The purpose of this service was to better understand users' needs, interactions with air space control systems, and available infrastructure. Embraer, through its subsidiary EVE, conducted concept flights in Rio de Janeiro using an adapted helicopter to better understand the operational processes and needs of players involved in an air operation of this sort.[51] The test involved 12 organizations, including regulating agencies. However, these examples are isolated and do not yet reflect the adoption of principles or strategies guiding the progress of these technologies, starting with frameworks that allow and encourage testing in real environments. International cooperation can contribute to this given that, because LAC is a late adopter, the region can adapt standards and guidelines from leading countries to their unique reality.

[48] Ministry of Foreign Affairs (STC International, 2020). *Study on digitalization in ports in the Latin American region* (November).

[49] Navas & Mix (2021). *Primer piloto de vehículo autónomo en Latinoamérica.* Inter-American Development Bank Technical Note (November).

[50] Airbus (2017). Rethinking Urban Air Mobility. https://www.airbus.com/en/newsroom/stories/2017-06-rethinking-urban-air-mobility

[51] EVE (2021). Eve's Urban Air Mobility simulation in Rio de Janeiro starts in November. https://eveairmobility.com/eves-urban-air-mobility-simulation-in-rio-de-janeiro-starts-in-november/

Overall, sector agencies have **very limited financial resources available for research and investment in tech projects**, which hampers efforts to develop test beds and conduct prospective studies and research on potential social impacts in areas like urban mobility. This marks a major difference with leading countries, where sector agencies have budget lines clearly established for R&D projects. In addition, they benefit from funds from other government areas, like science and technology, security, or the environment.

6.2.2 Incentives to overcome digital transformation barriers

One of the main challenges for the digital transformation of transportation in leading countries are the **difficulties that smaller companies face for innovation**, considering both their human capital and financial resources limitations. Although this barrier also exists in LAC, it extends to larger transportation companies.

In the interviews conducted, this came up mostly in land transportation and public transportation of passengers. In this case, companies agreed that there are **six barriers for the digital transformation of their operations**:

- Limited local availability of technology, which has to be sourced overseas, with its subsequent impact on costs.
- Low human capital qualification levels.
- Limited managerial capacity to lead the design and implementation of digital transformation. Many managers are from an older generation and therefore, have certain difficulties visualizing a transformation strategy.
- High capital costs.
- Low internet connectivity, especially in the hinterlands.
- A certain degree of resistance among the workforce.

Compared to the instruments applied by leading countries to overpower these challenges –which include deploying tech centers and promoting knowledge and technology modernization programs–, the region has placed **more attention to regulatory and public procurement aspects**. This is connected to less available resources to establish fiscal incentive and financial programs, such as those found in leading countries. In any case, progress has been made in terms of programs designed to renovate public and cargo transportation fleets to promote reliance on and a more efficient use of clean energies. Examples of this are the programs to promote electric fleets for public transportation that Colombia, Ecuador, and Peru established with IDB support.

A favorable feature seen throughout the region is that **public procurement programs** are being increasingly used to stimulate the adoption of technologies for both infrastructure and transportation services development and operations. The subway in Buenos Aires is a good example. The tender held in 2020 included commitments to generate real time data that could only be attained through process digitalization. In parallel, the scoring system

used to award the contract includes metrics linked to technological aspects such as the degree of process digitalization. This incentive is currently being evaluated to extend it through a socialization and integration process with the suburban railroad system. Colombia held a tender in 2021 for the collection process of the network's main road corridors, making it electric, which is expected to expand to other roads in the network.

Regulatory measures are also used to promote the digitalization of transportation. In the case of public transport, many LAC cities have begun implementing electronic payment systems and bringing the different payment schemes of public transportation on a single platform. This has favored the generation of a large amount of data about service use that has helped manage transportation fleets, provide users with information, and monitor performance objective compliance as per public transportation operators' contracts. In land transportation, the government of Brazil, for example, established in 2021 that every road transportation company had to share information in digital format, eliminating paper. In Mexico, the fiscal authority ordered in May 2021 that every import or export operation had to be accompanied by the corresponding electronic invoice (fiscal document) with a Waybill Complement establishing a transition period for companies to adjust to these new requirements.[52]

As mentioned at the beginning of this section, a great difference with leading countries is the **scant availability of fiscal and technical assistance to companies in the sector** –especially for smaller firms– to encourage technological upgrading or even adjust to new digital requirements established by regulations. This leads to resistance to change in the face of norms that seek to push the sector forward in terms of efficiency and transparency, and a faster communication with public agencies in regard to compliance of administrative requirements.

6.2.3 Incentives to solve potential coordination failures between players in the transportation ecosystem

Uncertainty about data governance and privacy protection makes it difficult to share transport information.

Assessing the experience of leading countries has shown that the digital transformation of transportation faces coordination failures between players in the sector's ecosystem in connection with the exchange of information and development of standards for data communication. LAC is no exception in this matter.

The mechanisms to try to solve these failures in the region are many, normally applied to specific experiences and solutions. For example, in the case of urban mobility –where the construction of integrated management systems requires data obtained from multiple sources, including some *ad hoc* of private nature– data collection responds more to an **ad hoc negotiation process** than to regulatory measures. **Institutional barriers to exchange information**, especially concerning security, where there is a large amount of information gathered from video surveillance systems installed throughout cities, is a major limitation mentioned by respondents. In this case, the main difficulty has been the **absence of clear regulations on privacy protection**

[52] http://omawww.sat.gob.mx/cartaporte/Paginas/documentos/PreguntasFrecuentes_Autotransporte.pdf

and data governance mechanisms, which have been defined one at a time for each signed inter-institutional agreement. An additional aspect that has been underscored is the little access and/or lack of standardization of information from surrounding municipalities that are part of the metropolitan areas, which in leading countries has been overcome thanks to Metropolitan Transportation Authorities or inter-regional collaboration agreements.

The **fragmentation** and obstacles for institutional collaboration, whether within or between territories, has made it hard to progress in implementing technologies such as electronic collection for public transportation. Lack of an institutional mandate and human and technological resources are other significant challenges brought up by players in the sector.

All of these aspects are much more challenging than the limitations of systems interoperability. One respondent stated something that illustrates this point very clearly: of the time needed to structure the coordination between agencies or with the private sector –which can exceed one year–, 90% is used to define and sign agreements, while solving technical problems takes up the remaining 10%.

One positive note is the presence of **initiatives that foster data sharing**, such as those implemented by the cities of Buenos Aires and Bogota, and the Observatories that have been created for different transportation subsectors, like Colombia's National Logistics Observatory. One aspect mentioned by respondents in terms of data sharing is the need to **take steps towards the adoption of standards or norms to share and communicate data, with a proactive role from competent sectoral agencies**. This is crucial for cities, where clear guidelines are needed to establish the information that the private sector must provide them with, including public transportation operators, TNCs, mobility technology companies, micromobility firms, logistics companies, etc. An important aspect is aiming at adopting open standards to avoid a suppliers and systems lock-in. Once again, the fact that the region is a latecomer to the digital transformation cycle makes it easier for countries to learn and choose the international experiences that better adjust to their realities.

It is key to point towards adopting open standards to avoid the lock-in of providers and systems.

6.2.4 Promoting and educating for the digitalization of transportation

Although leading countries are implementing different programs to promote new digital technologies and communicate with civil society about innovations in the digitalization of transportation, this is not taking place systemically throughout the region. Experiences reveal that there are certain plans and programs for segments like SMEs or the manufacturing industry, and also specific technologies like AI, in which transportation could be included. However, **the region still lacks professional and educational systemic efforts for the sector**.

Training courses and seminars offered to employees by private companies in sector associations and universities are a good starting point towards more ambitious schemes that prepare the future workforce of transportation. Online knowledge and training is becoming an ally to improve awareness and digital skills through participation in webinars, massive online courses, or specialized courses for people working in the sector. Nevertheless, the lack of human capital with digital abilities is one of the private sector's main concerns and, as discussed in **Chapter 5**, constitutes one of the main barriers for public sector agencies.

Regarding **communication campaigns**, governments have made great efforts to promote digital payment systems and electronic transactions, and to boost road safety linked to increased micromobility. There have also been campaigns specifically aimed at raising awareness about future technologies. An example of this took place in Chile with a pilot for autonomous vehicles, and in Brazil, with drone pilots for passenger transportation. At the same time, it is very positive to note the number of **participating high-ranking authorities** from agencies in the sector **in national and international events where the future of transportation is discussed** with counterparts from regional and world leading nations.

To summarize this section, although LAC has made some headway in the use of public policy instruments to promote the digital transformation of transportation, **it continues to lag behind other leading countries**. Due to the absence of strategies to promote digital transformation, **efforts are isolated**, **discontinued**, and **lacking clear goals**. As **Chart 6.3** shows, this **differs greatly in terms of the variety and depth of instruments employed by leading countries** to pursue the strategies designed for the sector.

Chart 6.3. ▶ SITUATION OF LAC REGARDING BEST PRACTICES IDENTIFIED IN THE USE OF INSTRUMENTS FOR THE DIGITAL TRANSFORMATION OF TRANSPORTATION
(selected countries)

CHALLENGE	BEST PRACTICES	SITUATION IN LAC
Uncertainty in defining appropriate policies	• Prospective studies and development scenarios of the digitalization of transportation, with inputs from the private sector, academia, and civil society	• Specific studies to develop plans • Limited participation of players outside the sector, usually at final stages • Limited resources available for research activities on the topic
	• Impact studies of social behavior about the adoption and use of digital platforms	• Little attention. Normally, specific studies are carried out in the context of developing plans • Lack of depth in specific areas
	• Regulatory sandboxes	• Very limited presence throughout the region, restricted to few cases linked to urban mobility and air transportation

CHALLENGE	BEST PRACTICES	SITUATION IN LAC
Uncertainty in defining appropriate policies	• International cooperation to access experiences	• Countries in the region are members of international organizations (WCO, ICAO, UN/CEFACT) that foster the adoption of standards • Cooperation with international associations from the private sector • Cooperation with leading countries • Limited exchange of experiences between LAC countries
	• Defining principles and guidelines to orient the digital transformation of transportation in order to establish a framework in which to develop public policies, preserving flexibility and technological neutrality	• No examples have been detected in this area
Barriers for digital transformation	• Creating or supporting the development of tech centers for the sector or segments of the sector	• Existing tech centers aim at promoting the Industry 4.0, with little participation of transportation
	• Awareness campaigns about the benefits of digital transformation	• Very limited presence linked to specific projects
	• Tax breaks	• Specific programs to renew bus fleets to adopt clean energy sources that include new technologies such as GPS
	• Subsidized interest rate funds	• Specific programs to renew bus fleets to adopt clean energy sources that include new technologies such as GPS
	• Non-reimbursable aid	• Within the context of programs for Industry 4.0, but with limited participation from the sector
	• Other	• Incorporating technological requirements in public procurements

CHALLENGE	BEST PRACTICES	SITUATION IN LAC
Failures in coordination between players in the transportation ecosystem	• Legal requirement to share data	• Bilateral ad hoc negotiations with data providers
	• Adopting standards and norms	• Lack of formalized data sharing standards and norms
	• Identifying lagging segments and combining instruments to encourage a technological shift	• No experiences have been observed in the region
Lack of talent and knowledge about the sector's digital transformation	• Programas y centros de formación sobre tecnologías 4.0	• Occasional development of Industry 4.0 tech centers, but less focused on use cases of transportation
	• Campañas de educación permanente	• Further progress in urban mobility, including, for example, electronic collection systems and communications about online procedures
	• Eventos dedicados al sector o de corte tecnológico con participación de altos responsables gubernamentales	• Mentioned in national and international forums by representatives of ministries and government agencies

Source: Authors.

6.3 Strengthening sectoral institutions and processes for digital transformation

The big challenge in terms of governments' capacity to support and lead the digital transformation of transportation is the lack of human resources knowledgeable of the subject. Although the level of readiness varies between countries, survey results and interviewees testimony suggest that **institutional capacity shortcomings prevent governments from supporting fast-speed digital transformation**. Independently of whether the country includes digitalization among its sectoral strategies, there are few institutions that have specialized resources for the sector's technological upgrade.

This is reflected in the fact that regulations and the elaboration of sectoral plans is lagging vis-à-vis the technological shift, which is more evident in subsectors with an accelerated rate of innovation, like air transportation. In general, the concept of digital transformation of governments tends to be perceived in terms of **process**

automation rather process reengineering aimed at improving their performance. On the other hand, as expressed in **Chapter 4**, the agencies of leading countries act as inducers, or at least, partners of change, laying out the rules and business environment that allow the private sector to pursue digital transformation. Some even promote actions to generate data exchange platforms and streamline processes, such as MaaS and PCS. Study respondents pointed out the absence of such orchestrators in LAC and stressed the need for the public sector to assume this role.

Chapter 5 analyzed the causes behind this limited capacity of public agencies, which included the absence of a mandate, low budget and resource allocation in this field, insufficient access to training programs for sector officials, resistance to change, and high staff turnover. All of this reflects the **low priority that the public sector is giving digital transformation from a strategic and transportation planning perspective**. The **notion that the deficit of infrastructure must be solved first** is still largely present throughout the region, with no consideration –or knowledge- of the benefits that new technologies imply, for example, in terms of better use and preservation of existing and future infrastructure, reducing the enormous investment needs throughout the region.

However, some **recent experiences show progress** in institutional strengthening and promise even further headway in the short term. For example, Brazil's Information Technology and Communications Master Plan 2021-2024, jointly developed by the Information Technology Superintendence and the National Land Transport Agency, sets out goals for updating the information architecture of transportation services, the adoption of predictive analytics based on AI, and progress in cybersecurity for land transportation.[53] Meanwhile, Colombia's Ministry of Transportation Information and Communications Technology Strategic Plan 2020-2023 emphasizes building tech capacities in the ministry. Chile's Ministry of Transportation has signed agreements with private institutions to obtain data, and strengthened its units to build internal analytic capacity. A challenge that public agencies in LAC are overcoming in this process is adapting their procurement policies, usually designed to purchase physical infrastructure, which need to be adjusted to be able to hire cloud technology services regularly.

At local level, there is also a group of cities where there are transportation control centers with advanced tech support and high-level staff for traffic planning and management purposes. Aiming at improving response capacity, local authorities are installing street devices to generate data (e.g. CCTV video cameras, Wi-Fi and Bluetooth sensors, and traffic counters to monitor vehicles' volume), using AI algorithms, and expanding their tech infrastructure through the use of storage platforms and cloud computing.

Concerning talent recruitment and retention, and staff requalification, some internationally renowned and advanced agencies in the region **collaborate with**

[53] All federal public agencies are required to produce such a plan to meet the criteria of Decree No. 10322/2020 setting out the Digital Government Strategy (https://www.in.gov.br/en/web/dou/-/decreto-n-10.332-de-28-de-abril-de-2020-254430358).

universities that educate their students according to the requirements of those agencies. Others grant scholarships to trained personnel to study in national and foreign institutions in areas of interest for the public administration. Some institutions have chosen to outsource roles, such as data analytics for urban mobility management, or operating electronic collection systems. In this regard, some governments are considering the configuration of an entity in charge of collecting, analyzing, and prescribing transportation management solutions –like urban and interurban traffic management– through a concession contract to a private firm.

6.4 Horizontal coordination in the national government

Promoting the digital transformation of transportation requires **close coordination between agencies both within and beyond the sector**. **Chart 6.4** shows the group of public agencies responsible for establishing public policies affecting the digitalization of transportation for a selection of LAC countries.

Chart 6.4. PUBLIC AGENCIES IN CHARGE OF DEVELOPING PLANS THAT AFFECT THE DIGITALIZATION OF TRANSPORTATION (selected countries in LAC)

		URBAN MOBILITY	LOGISTICS (*)	AIR TRANSPORTATION
ARGENTINA	Multimodal authority	• Ministry of Transport • Ministry of Public Works • National Commission for Transport Regulation • Transport Safety Board		
	Specific authority		• National Commission for Transport Regulation • National Road Safety Agency • Port authorities	• National Civil Aviation Administration • National Airports System Regulatory Body • Argentine Air Navigation Company
	Other authorities	• Ministry of Science, Technology and Innovation • National Open Government Directorate • National Communications Entity • General Customs Bureau		

		URBAN MOBILITY	LOGISTICS (*)	AIR TRANSPORTATION
BRAZIL	Multimodal authority	• Ministry of Infrastructure • National Department of Transport Infrastructure		
	Specific authority	• Ministry of Regional Development – Secretariat of Mobility and Urban Services	• National Land Transportation Agency • National Land Transportation Authorities Commission • National Secretariat of Ports and Waterway Transport (SNPTA) • Port authorities	• Brazilian Space Agency • National Civil Aviation Agency • Department of Airspace Control
	Other authorities	• Ministry of Science, Technology and Innovation • National Data Protection Authority • National Telecommunications Agency • Internet of the Things Council • Federal Ministry of Finance		
CHILE	Multimodal authority	• Ministry of Transportation and Telecommunications • Ministry of Public Works		
	Specific authority	• Under Secretariat of Transport • Regional Public Transportation Division • Transport, Roadways and Urban Transport Program (SECTRA) • Civil Society Council • Intelligent Transportation Systems (ITS) • National Oversight Program	• Fluvial, Maritime, and Lake Transportation Department • Road authorities • Logistics Development Program • Port authorities • System of Public Companies (SEP)	• MOP's Airport Directorate • Civil Aviation Council • Directorate-General of Civil Aviation
	Other authorities	• Chilean National Agency for Research and Development • Ministry of Science, Technology, Knowledge and Innovation • Production Development Corporation (CORFO) • National Customs Service		

		URBAN MOBILITY	LOGISTICS (*)	AIR TRANSPORTATION
COLOMBIA	Multimodal authority	• Ministry of Transport • National Planning Department • Superintendence of Transport		
	Specific authority	• Sustainable Urban Mobility Unit	• Logistics Committee • National Roads Institute • General Maritime Directorate • National Road Safety Agency	• Civil Aviation Authority of Colombia
	Other authorities	• National Council on Economic and Social Policy • Ministry of Science, Technology and Innovation • Ministry of Information and Communication Technologies • National Directorate of Taxes and Customs		
COSTA RICA	Multimodal authority	• Ministry of Public Works and Transportation • Administrative Court of Transportation		
	Specific authority	• Council of Public Transportation	• National Council of Roads • Road Safety Council • Board of Port Administration and Economic Development of the Atlantic Coast • National Port Council • Costa Rican Pacific Ports Institute	• Directorate-General of Civil Aviation • Technical Council of Civil Aviation
	Other authorities	• National Council of Urban Planning • Ministry of Science, Innovation, Technology and Telecommunications • National Customs Service		
JAMAICA	Multimodal authority	• Ministry of Transport and Mining • Ministry of Science, Energy & Technology • Ministry of Economic Growth and Job Creation (MEGJC)		

		URBAN MOBILITY	LOGISTICS (*)	AIR TRANSPORTATION
JAMAICA	Specific authority	• Jamaica Urban Transit Company • Transport Authority of Jamaica	• Port Authority of Jamaica • Maritime Authority of Jamaica • Caribbean Maritime Institute • National Works Agency • Island Traffic Authority	• Jamaica Civil Aviation Authority • Airports Authority of Jamaica
	Other authorities	• National Spatial Data Management Division • Jamaica Customs Agency		
PANAMÁ	Multimodal authority	• Ministry of Public Works		
	Specific authority		• Consultative Committee of the Logistics Cabinet • Land Transit and Transportation Authority • Maritime Authority • Panama Canal Authority	• Civil Aviation Authority
	Other authorities	• National Authority for Government Innovation • National Secretariat of Science, Technology and Innovation • National Public Services Authority • National Customs Authority		
DOMINICAN REPUBLIC	Multimodal authority	• Ministry of Public Works and Communications		
	Specific authority		• National Institute of Transit and Land Transportation • Dominican Port Authority • National Maritime Authority	• Civil Aviation Board • Airport Department
	Other authorities	• National Council of Competitiveness • National Cybersecurity Center • Ministry of Higher Education, Science and Technology • Directorate-General of Customs		

Source: Compilation by the authors.

(*) Includes maritime, land, and last-mile.

In the region, the **ministries of transportation** typically assume the role of long-term planning and implementing the policies of the transportation sector. This is the context in which the digital transformation of the sector is normally approached, although it can also be touched on cross-cuttingly by ministries in charge of technological management (see **Chart 6.5**). At a sub-sectoral level, **national agencies have specific responsibilities**, such as Brazil's National Land Transportation Agency or National Civil Aviation Agency, Panama's Land Transit and Transportation Authority and Maritime Authority, and the Dominican Republic's Port Authority.

Complementing this institutional architecture, there are multiple **agencies with technological or economic development responsibilities** whose activities affect the digital transformation of transportation (e.g. Brazil's Ministry of Science, Technology and Innovation; Chile's Ministry of Science, Technology, Knowledge and Innovation; Colombia's Ministry of Information and Communication Technologies), as well as agencies with more limited responsibilities (e.g., Argentina's National Agency for the Promotion of Research, Technological Development and Innovation, and Brazil's National Data Protection Authority).

In this context of multiple ministries and agencies, it is necessary to guarantee public policy coherence through inter-institutional coordination mechanisms. The main problem is that, unlike leading countries, inter-institutional coordination in LAC is not always guaranteed. Some countries have begun to deploy horizontal coordination mechanisms based on **national councils**, like Colombia's National Council on Economic and Social Policy, Costa Rica's National Council of Urban Planning, and the Dominican Republic's National Council of Competitiveness. There are also **sub-sectoral committees**, like Logistics, where even the private sector can be involved. It is within these committees, where amongst other things, debates about digital transformation and actions for its implementation take place.

Chart 6.5 compares the observed state of LAC with leading countries' best practices to promote inter-institutional collaboration, as defined in **Chapter 4**.

Chart 6.5. ▶ **LAC COMPARED TO BEST PRACTICES IDENTIFIED FOR THE CREATION AND MANAGEMENT OF MULTISECTOR COMMITTEES** (selected countries)

MAIN ASPECTS	BEST PRACTICES	SITUATION IN LATIN AMERICA AND THE CARIBBEAN
Leadership responsibility	• Committees assembled by the Executive branch's top official (President or Prime Minister)	• Presence of some committees linked to the sector convened by high-ranking officials. For example: - The Brazilian Chamber of Industry 4.0 is led by the ministries of Economy, and of Science, Technology and Innovation. - The Dominican Republic's National Council of Competitiveness is a joint government agency led by the president of the country.

MAIN ASPECTS	BEST PRACTICES	SITUATION IN LATIN AMERICA AND THE CARIBBEAN
Purpose of the committee	• Clearly defined purpose: (i) managing joint actions, or (ii) coordinating actions executed by each public agency. This is why it is crucial to grant it legal powers.	• The presence of committees with roles defined around best practices was observed. For example: - The scope of Costa Rica's Council of Public Transportation areas of responsibilities and attributions is well defined, completely involving all actions regarding planning, hiring, following up, and evaluating public transportation services provided in the country. - Colombia's Logistics and Foreign Trade Committee aims at inter-institutional coordination, public-private integration, and logistics decision-making. - Panama's Consultative Committee of the Logistics Cabinet offers recommendations to the group of ministers to take actions and create laws that are necessary for the logistics flow to be expedited, without obstacles or barriers. - Argentina's Advisory Council for the National Plan of Science, Technology and Innovation is in charge of defining and monitoring compliance with that Plan. - The Brazilian Chamber of Industry 4.0 is responsible for formulating and executing initiatives aimed at the industry adopting 4.0 technologies. - The Dominican Republic's National Council of Competitiveness is in charge of implementing the National Logistics Plan.
Committee structure	• If it plays an executive role, it must be led by a representative of the executive power and composed by high-level authorities in the board and national agencies • If its role is of inter-institutional coordination, among its members are representatives of local organizations.	• Presence of national authorities and private participation. For example: - In Colombia's Logistics and Foreign Trade Committee there are representatives from the President's Office, the ministries of Commerce, Transportation, Energy, Agriculture, and the National Planning Department, as well as a number of private players - Panama's Consultative Committee of the Logistics Cabinet is formed by four representatives of the Logistics Business Council and three government officials - Argentina's Advisory Council for the National Plan of Science, Technology and Innovation has private participation - In the Dominican Republic's National Council of Competitiveness there are 40 members representing the public and private sectors • Less representation of academia and local organizations.

MAIN ASPECTS	BEST PRACTICES	SITUATION IN LATIN AMERICA AND THE CARIBBEAN
Frequency of meetings	• Frequency varies with different committee roles and compositions • Even in those cases in which the committee doesn't meet frequently, there needs to be a technical support group in charge of advancing the defined agenda, monitoring goal completion, and making recommendations to inform committee decisions	• The situation in LAC is heterogeneous in terms of frequency and presence of technical support groups. In general, there have been fewer mentions to meeting frequency compared to advanced countries.
Private sector participation	• Permanent formal participation of the private sector	• Participation of the private sector in many committees. For example: - Colombia's Logistics and Foreign Trade Committee includes several representatives from the private sector (e.g. the National Council of Competitiveness, the Colombian Chamber of Infrastructure, the National Business Association of Colombia, and the National Trade Union Council.) - Panama's Consultative Committee of the Logistics Cabinet is formed by four representatives of the Business Logistics Council (private sector.) - The Dominican Republic's National Council of Competitiveness has nine representatives from the private sector, appointed by the Presidency.
Performance measurement	• Measure results to monitor the consequences of decisions or measures	• In general, the practice of introducing mechanisms to measure results and progress is not deep-seated, leading to a lower presence of technical support groups for committees.
Committee composition including deadlines	• Present composition within a specific timeframe and with defined problems to be addressed	• No deadline for role completion has been identified in analyzed committees.
Participation of academia	• Participation of experts from academia represents a good approach to seek technical talent	• In general, representatives from academia are less present among committees compared to good practices. Some examples of committees that do include members from academia are Colombia's Logistics and Foreign Trade Committee and the Brazilian Chamber of Industry 4.0.

Source: Authors.

6.5 Vertical coordination between central government and regional and local authorities

As **Chapter 4** has shown, leading countries are relying on different practices to ensure the coordination of public policies between central and local governments. Among them, four stand out: (I) the creation of an authority in the central government to mediate between different local authorities and boost the creation of efficient governance mechanisms; (II) developing a regulatory framework or guidelines to help local governments produce specific policies or regulations; (III) empowering local authorities; and (IV) training local authorities on issues related to new technologies.

Respondents agreed that this kind of collaboration is very limited in the region. In connection to the central agencies favoring collaboration at territorial level, there are examples like Costa Rica's Council of Public Transportation, in charge of coordinating adequate implementation of public transportation policies, their planning, technical reviews, granting and managing concessions, and regulating permits. The Council establishes and recommends regulations, procedures, and actions to improve policies and guidelines concerning public transportation. Some countries have developed regulatory frameworks for digital technologies applied to the sector, offering guidance to local authorities, such as the legislation regulating Chile's TNCs. Other countries are seeking to improve nation-municipality interactions concerning specific projects, like data sharing about ship departure and arrival to manage urban traffic. In any case, **vertical collaboration is where the region is lagging the most** vis-à-vis the great number of initiatives developed by leading countries on this matter.

6.6 Active collaboration between the public and private sectors

Among leading countries, active public-private collaboration takes place on three levels: (I) institutional coordination; (II) coordination for tech development; and (III) consultations with the private sector to develop strategic plans for the sector.

Previous paragraphs have described how many **committees in LAC include private sector participation**. This paves the way for progress in the third level of transportation company involvement –national committees help include the private sector in national transportation plans–. LAC's experience shows a strong tendency towards participatory planning although, unlike in leading countries, their intervention tends to be limited to consultation stages prior to public policymaking, or ex post stages concerning promotion. Much remains to be done **for increased private sector participation in policymaking**.

When it comes to coordinating technological developments, **pilots to test new technologies** have been carried out throughout the region – for example, autonomous vehicles in Chile and Brazil, and urban mobility areas in Mexico City, Rio de Janeiro, and Sao Paulo. However, unlike testing centers in leading countries, these are isolated cases that are not part of tech development programs for transportation. **Public procurement** mechanisms are also encouraging collaboration. This is the case, for example, of the implementation of biometric authentication systems in passenger air transportation, or port community systems in maritime transportation.

A particular area of collaboration in digital transformation programs is the **development of observatories** that concentrate useful data to plan and manage the digital transformation. For example, the Digital Economy Observatory in Colombia was cofinanced by Bogota's Chamber of Commerce and the federal ICT Ministry to generate information and assessments about the state of digital transformation in each of the country's productive sectors. Chile's Data Observatory is a tripartite collaboration between public sector, private sector, and academia, led by the Ministry of Science, Technology, Knowledge and Innovation, the Ministry of Economy, Development, and Tourism, together with Amazon Web Services (AWS), and the Adolfo Ibañez University (UAI). This observatory has been created with the goal of acquiring, storing, processing, analyzing, and spreading information to contribute to the development of knowledge in the fields of astronomy, climate change, seismic activity, hydric resource availability, and other relevant activities. Although not focused on transportation, it does provide data that is useful to the sector. The model of collaboration for observatories is also applied in logistics to provide companies and government agencies with updated information concerning logistics costs and technological assimilation.

Another area of collaboration concerns **promoting digital abilities** which, although they may not be specifically focused on transportation as occurs in leading countries, can benefit the sector indirectly. For example, to generate knowledge on big data and other data analytics technologies, Colombia's Ministry of ICT has supported the development of centers of excellence, in cooperation with companies in the financial, technological, and agro-industrial sectors, as well as universities throughout the country. Similarly, in an agreement between Brazil's Ministry of Science, Technology and Innovation and the Brazilian Internet Steering Committee, six Research Centers for Applied Artificial Intelligence were created to work with the private sector to identify research challenges, and with universities to tackle them.

As with vertical coordination, although the region shows clear examples of progress in generating alliances between the public and private sectors, the conclusions drawn from interviews and focus groups conducted for this report reveal that there is still a **significant gap with leading countries**. Collaboration in the region is less deep, systematic, and strategic, and tends to be more oriented at meetings, roundtables, or specific projects. Nevertheless, it is promising to see that representatives from both sectors suggest that this is where there is more space for progress in LAC, and that this will define the speed at which the region will reap benefits and mitigate risks from the sector's transformation.

6.7
Summary of lac public sector's participation in the digital transformation of transportation

As a summary, regarding the little progress made since the observations of the IDB report from 2019, the public sector in LAC **has now more awareness of the importance of taking steps towards the digital transformation** of transportation. It is highly encouraging to see the leadership that top officials have assumed in some countries, affecting regulatory and public policy aspects.

However, **the situation is not consistent throughout the region**. Therefore, in line with the perspectives of government officials and companies in the region, it can be argued that **public policies are at a very incipient stage vis-à-vis the active role they should have** in terms of: (I) catalyzing change; (II) facilitating innovation; (III) developing skills; (IV) regulations; (V) establishing standards; (VI) providing fiscal and financial incentives; (VII) acting as a smart client; and (VIII) platform provision. The next chapter will explore policy recommendations for LAC governments to play a more dominant role in the digital transformation of transportation, based on international best practices and collaboration with the private sector, academia, and civil society.

7

Boosting the digital transformation of transportation in Latin America and the Caribbean

Boosting the digital transformation of transportation in Latin America and the Caribbean

As the previous Chapter has illustrated, public policy is in its very early stages compared to the active role it plays in leading countries concerning the digital transformation of transportation. Given the importance of transportation to reach post-pandemic recovery goals, battle climate change, and foster social inclusion (see **Chapter 1**), it is essential to adopt measures for the public sector in LAC to be able to: (I) catalyze the shift; (II) facilitate innovation; (III) develop skills; (IV) regulate; (V) set standards; (VI) provide fiscal and financial incentives; (VII) act as a smart client; and (VIII) offer platforms for the transformation (see **Chapter 4**). Next, we will analyze a series of **policy recommendations** to this end, based on leading countries' best practices and lessons learned throughout the region. Although LAC countries currently are not part of the sector's global innovation hubs, the goal is for them to develop an **institutional and policy architecture** that fosters the conditions for early adoption and leapfrogging technologies applied to transportation to reap the benefits of digital transformation. These recommendations are grouped into five categories:

Figure 7.1. ▶ RECOMMENDATION CATEGORIES

STRATEGIC VISION	POLICY INSTRUMENTS	INSTITUTIONS 4.0	ENABLING FRAMEWORK	STRATEGIC ALLIANCES

The main message is that steps need to be taken in every field to give the digital transformation of transportation a big push in LAC. To this end, governments ought to:

(I) **Develop a strategic vision** for the transportation sector and its subsectors

(II) **Seek early gains** through policy instruments and associations with other government agencies, the private sector, and academia

(III) **Advance towards establishing frameworks**, both regulatory and institutional, as well as an enabling framework that encourages the sector's digital transformation

(IV) **Generate flexibility** to accommodate changes in a context of constant uncertainty and upgrading, preserving the principles of security and social welfare.

7.1 Mainstream digital transformation into the sector's strategic vision, and define the corresponding roadmaps

This requires introducing changes in **planning tools** to identify digital transformation as one of the priorities for the sector's development, including the following actions:

Chart 7.1. ▶ PLANNING RECOMMENDATIONS FOR THE DIGITAL TRANSFORMATION OF TRANSPORTATION

PLANS THAT HAVE AN IMPACT ON TRANSPORTATION	RECOMMENDATIONS
National Transportation Plans	• Include digital transformation as a **central element in the sector's development plans**, acknowledging its importance for the future development of transportation and all its modes, and establishing the way in which it contributes to reaching the sector's goals of efficiency, competitiveness, sustainability, and inclusion. Mention a more advanced vision of digital transformation, linked to a true technological discontinuity to achieve sectoral objectives. The plan must establish a vision on which to subsequently generate specific plans and instruments, as presented below. • Produce **prospective documents and technical studies** on the impact of new technologies in the sector (IoT, digitalization, AI, edge computing, 5G, automation, and electrification) to identify scenarios, opportunities, obstacles, and lines of action for public policy, serving as an input for sectoral plans. • Carry out a **consultation process** in advance, during, and after putting together the plan. Include the private sector, civil society, academia, and other public agencies with power over aspects linked to digital transformation. This can include ad hoc roundtables on specific topics, calls to present citizen proposals, focus groups, and surveys. Consider establishing a **top-level advisory committee** to develop the plan, including the participation of national and international experts on the topic. • Promote regulatory changes that foster **the plan's funding and sustainability**.[54]

[54] A good example of this is the U.S. Infrastructure Law: https://www.whitehouse.gov/bipartisan-infrastructure-law/

PLANS THAT HAVE AN IMPACT ON TRANSPORTATION	RECOMMENDATIONS
Sub-sectoral transportation plans (urban mobility, logistics, and air transportation)	• Introduce the digital transformation framework in **sub-sectoral plans** and develop **specific strategies** for the digital transformation of subsectors, identifying opportunities, challenges, and roadmaps with concrete actions for the public and private sectors. It is therefore necessary to carry out the extensive consultation process described in the previous point. • The strategies must define the roles of government agencies in implementing roadmaps, establishing coordination mechanisms between them and external players, identifying goals and progress monitoring mechanisms, and defining funding sources for their implementation.
	• Define plans to develop and implement **specific technologies** in the sector, with the participation of the private sector and academia, in line with the goals established in national and sub-sectoral plans. For example, private participation and academia can promote artificial intelligence, the use of cloud computing, and edge computing, developing strategies with clear objectives, fixed-term goals, stakeholder commitment, roadmaps, and coordination and monitoring mechanisms. • Develop action plans concerning **cybersecurity**, with the participation of government agencies involved in this field and private sector, and defining actions for each stakeholder to carry out, as well as the mechanisms to coordinate them (see **Section 7.4**). Encourage the inter-regional and international coordination of these activities. • Use these **international cooperation mechanisms to access knowledge** gained by leading countries and peers in the region concerning best practices and lessons learned for the design and implementation of national, sub-sectoral, and technology-specific plans.
Cross-sectional plans that have an impact on transportation	• Promote the inclusion of transportation as a prioritized sector among national digital agendas, national digitalization strategies, national data strategies, national smart city strategies, and development plans for technological or industrial clusters, which requires coordinating with the corresponding public agencies, proving the social value of promoting the digital transformation of transportation. The contribution of transportation to goals linked to environmental sustainability, economic competitiveness, and higher social inclusion is crucial in this sense. • Incorporate transportation as a key security element in **national cybersecurity strategies** and lay out specific recommendations for the sector that can be detailed in the aforementioned sectoral action plans (see **Section 7.4**). Seek to be included in Cybersecurity Committees that operate on a national level.

Source: Authors.

7.2 Diversify public policy instruments to encourage digital transformation

In order to adopt an active role in the previously mentioned areas, sectoral authorities need to have in place a **variety of instruments** to mitigate risks in the context of constant uncertainty and technological change, overcome digital transformation barriers, contribute to solving coordinate failures in the transportation ecosystem, and build the required job skills to lead and implement continuous transformation. The fact that the region is a late adopter of digital transformation allows it to learn and choose the international experiences that better adapt to its reality, including:

Chart 7.2. ▶ DIVERSIFY PUBLIC POLICY INSTRUMENTS TO ENCOURAGE DIGITAL TRANSFORMATION

POLICY CHALLENGES	RECOMMENDATIONS
Uncertainty in defining the appropriate policies	• Encourage production of **prospective studies** and development of scenarios for the sector and its modes, with contributions from the private sector, academia and civil society, as inputs for the aforementioned planning instruments, identifying opportunities and challenges, and proposing focus areas. Encourage transparency in the process of defining regulations by publishing these studies. • Conduct studies to learn about **social behavior and acceptability** concerning the adoption and use of digital technologies and platforms, and use academic and civil society organizations' input to produce planning and regulatory tools. • To this effect, seek for **specific resources** to be allocated to R&D within agency budgets, and leverage resources from other public and international cooperation agencies, strengthening their coordination, and showing the social value of promoting the digital transformation of transportation. • Cooperate with other agencies to **educate citizens** on the benefits brought about by the responsible adoption of multiple technologies to collect and analyze information, such as IP cameras, motion sensors, and location information devices, among others.

POLICY CHALLENGES	RECOMMENDATIONS
Uncertainty in defining the appropriate policies	• Identify opportunities and goals of establishing **regulatory sandboxes**, **testbeds**, and **concept tests**, for example, to promote the development of technologies, attract investments, raise awareness, etc. • Foster the development of regulatory sandboxes and testbeds, and provide relevant authorities with training, implementation guides, and specialized legal and technical advisory on their use (see an example applied to AV in Rodríguez et al. (2021)). • Promote **sharing experiences** with other public agencies that have implemented this tool (commonly used in finances) and with other countries through international cooperation, seizing on the progress made by leading countries and peers throughout the region, as well as on the knowledge gained from their experiences. • Strengthen **collaboration with the private sector** to identify opportunities to use this instrument and promote tech development, defining courses of action for each party. • Seek to allocate specific funds to R&D within agency budgets and **leverage resources** from other public and international cooperation agencies. • Involve **academia** to conduct studies about the impact of technologies and the civil society, to learn their perspectives and raise awareness. • **Publish** the results obtained to boost knowledge and transparency.
	• Participate in **international cooperation** programs and activities (WCO, ICAO, UN/CEFACT, IATA, ISO, IEEE, ETSI) and international agencies to gain access to lessons learned and best practices, as well as to contribute to defining international standards.
	• Lay out **principles and guidelines** to orient public policies in a context of uncertainty and technological progress, preserving flexibility and technological neutrality. This should be conducted both at sector and sub-sectoral levels, and be included in each of the corresponding strategic documents. • Update sectoral regulations to mainstream technological shifts and verify compliance with established principles. To this effect, promote the development of **regulatory frameworks based on performance** that guarantee meeting principles and minimum security, inclusion, and sustainability standards, among others, while preserving flexibility on the type of technology to be adopted. An example of this is the adoption of AV standards in terms of their autonomy (ADAS[55]) and security (RSS). Upgrading regulations is essential to encourage public-private partnerships, for example, on data exchange. • To adapt to technological changes, promote the development of regulatory frameworks based on performance, on the basis of guaranteeing the fulfillment of principles and minimum required levels of security, inclusion, sustainability, etc.

[55] https://ec.europa.eu/growth/sectors/automotive-industry/safety-automotive-sector_en

POLICY CHALLENGES	RECOMMENDATIONS
Barriers to digital transformation	• Extend the approach of Industry 4.0 **tech centers** to the digital transformation of transportation, incorporating leading companies in the sector, the entrepreneurial ecosystem, and SMEs. These centers can be used as **geographical regulatory sandbox** and **testbed locations**. They can encompass several technologies or focus on just one or a few of them (e.g. AV, AI, IoT). • Adapt **Industry 4.0 promotion experiences** to the transportation sector, for example, in producing digital maturity self-diagnostic systems for SMEs, manuals, technology catalogues, and roadmaps, as well as in conducting knowledge information campaigns for SMEs about the benefits of digital transformation and its tools (for more information, see Calatayud & Katz, (2019). **Coordinating with sectoral and sub-sectoral organizations** is important to reach out to a larger number of companies. • Foster **new digital technology pilots** (IoT, digitalization, AI, edge computing, 5G, automation, and electrification), encouraging participation of SMEs and the entrepreneurial ecosystem through technical and financial assistance, and alliances with companies and tech centers. • Create experience **socialization networks** where staff from those SMEs further advanced in transformation can share experiences with their peers. • Use 4.0 tech centers to connect SMEs with hardware, tech, and software suppliers to favor **training and development of use cases**. • Link these centers to **leading companies in the sector** in terms of digital transformation to leverage the demonstration and spillover effects of these companies. • Promote **knowledge exchange with other countries** through international cooperation.
	• Provide **fiscal and financial incentives** to reconvert the sector's technology, following the principles of efficiency and sustainability. This can include expanding government programs already in place for industrial production to the transportation sector, as well as designing specific programs tailored to transportation, such as bus and truck fleet renovation programs towards clean energy sources, which include new technologies.
	• Extend the incorporation of technological requirements (e.g. use cases of digitalization) among **public procurement conditions** (see **Section 7.4**). • Rely on the public procurement process to encourage the adoption of technologies by project beneficiaries during the phases of building infrastructure and operating both infrastructure and transportation services.

POLICY CHALLENGES	RECOMMENDATIONS
Coordination failures between players in the transportation ecosystem	• Establish regulatory and contractual obligations to share data based on the ***no data, no service*** **principle**, safeguarding simultaneously people's privacy and data security (see **Chart 7.3**). For services that are already operating, set up a transition period to adapt to new regulations. During design, transition, and implementation phases, establish mechanisms with stakeholders to align actions and simplify compliance with regulations' objectives. • Reinforce the sector's transparency by creating **open data portals** and observatories, without jeopardizing people's privacy and data security. • In this regard, work with the private sector to **open models and data** that expedite standardization, as with corresponding government agencies to set up **privacy protection** (e.g. by adopting new models like confidential computing) and **data security mechanisms** to reduce obstacles for data sharing between agencies and with the private sector.
	• Adopt programs focused on developing and adopting standards and rules to collect, manage, and share data, which integrate best practices and lessons learned from leading countries, available thanks to international cooperation. • Encourage the adoption of **open standards**, disclosing models and data for standardization, mitigating vendor lock-in risks and the exclusion of smaller players, and reducing technology adoption costs by integrating wide solution-provider ecosystems.
Lack of talent and knowledge about the sector's digital transformation	• Identify the **need for skills** related to the digital transformation of transportation and the current gap (see **Section 7.4**). • Promote **online programs** to increase the impact of their scope, as well as educational centers about 4.0 technologies focused on transportation's digitalization. This requires coordination with public education and professional career training agencies, and academia, educational centers, and the private sector. These programs can take place at various educational levels, starting at primary schools to foster interest in the sector, all the way through tertiary level, to train the future workforce in skills needed in the sector, to the professional level, reeducating current employees. • Collaborate with sectoral associations to design and implement **programs to reeducate the workforce** to foster the involvement of players from the sector. • Include sector companies and agencies when defining skills and programs, and design internships as well as training programs for the current staff.

POLICY CHALLENGES	RECOMMENDATIONS
Lack of talent and knowledge about the sector's digital transformation	• Strengthen communications with civil society through **Campaigns to raise awareness** of new technologies and their impact on the sector, and inform people about the transportation digitalization programs that are being or will be implemented.
	• Encourage the participation **of top government officials'** in events dedicated to the sector or to technologies, as an indirect form of government communication to present digital transformation as a strategic priority in public policies, and identify thriving players within innovation ecosystems.

Source: Authors.

7.3 Build institutions 4.0 and inter-sectoral alliances for the digital transformation of transportation

The big push of the digital transformation of transportation requires a **cultural shift and change in public institution capacities, as well as alliances** with national, regional, and local institutions with jurisdictions beyond sectoral or national competencies:

Chart 7.3. ▶ **RECOMMENDATIONS TO STRENGTHEN INSTITUTIONAL CAPACITY AND INTER-SECTORAL COORDINATION**

INSTITUTIONAL ASPECTS	RECOMMENDATIONS
Capacity of public institutions with responsibilities in the transportation sector	• Make sure public agencies have a special unit in charge of acquiring and managing information, and designing and implementing TIC-related measures, under the figure of ***Chief Information Officer*** or similar. The existence of national data strategies reinforces the need to have these capacities within public agencies. • Endow these units with **human resources capable of handling new technologies** and with adequate funding to implement a digital transformation strategy within the agency. • Establish **digital transformation strategies for the agency** with clear objectives and short-term goals; tasks and responsibilities description; internal monitoring and coordination mechanisms inside the government as well as external; well-defined governance and risk management models; and staff and financial resource allocation for implementation. • Digital transformation per se should not be made a strategic goal, but rather a **tool to improve services** provided by the agency and the sector's overall performance. In this sense, process reengineering could be required prior to digitalization. • As part of the strategy, establish needs and actions to update the **data infrastructure and architecture** of the sector's agencies, **data governance** mechanisms, and the **risk management** plan for cybersecurity and other areas. • Promote the development of **platforms** that aggregate and disclose data at a sub-sectoral level (e.g., urban mobility), as well as platforms that integrate processes and foster coordination (e.g., PCS). To this end, establish data governance mechanisms and develop alliances with relevant public and private players to attain standardized reliable data periodically. These platforms can leverage existent solutions from the private sector, which requires open standards and preventing provider lock-ins. • Promote conducing **pilots** to test new technologies to manage infrastructure, transportation services, and related processes. In this context, seek **alliances with the private sector and academia** to gain access to technologies to evaluate their benefits and challenges. • Adapt **procurement policies**, usually designed for the acquisition of physical infrastructure, enabling it to hire regular tech cloud services that help reinforce data collection and analysis, and adopt solutions that require great storage and computational capacity, such as AI-based predictive analyses.

INSTITUTIONAL ASPECTS	RECOMMENDATIONS
Capacity of public institutions with responsibilities in the transportation sector	• Develop a **cybersecurity plan** for the agency, in collaboration with agencies in charge of national cybersecurity, identifying risk points, monitoring and response mechanisms, and a roadmap for implementation. Design training programs for the public and private transportation sectors. • Strengthening these capacities at the **sub-sectoral**, **regional**, and **local levels**, following international good practices, such as those pointed out in **Chapter 4**, for example, in terms of generating practical guidelines like the CDO Playbook and Chief Information Officers Council Handbook, which outline the responsibilities, opportunities, and legal framework of these officials and their units. • Set up **CIO coordination** mechanisms between public agencies linked to transportation, engaging the sub-sectoral and sub-national levels, and invite representatives from the private sector to take part in them to identify opportunities, challenges, and joint action lines, among other things, concerning interoperability, cybersecurity, and governance. • Encourage the **ongoing training of public officials** by participating in seminars and programs offered by other public institutions, international agencies, universities, training centers, etc. as an additional way to retain talent. As part of this effort, promote the **creation of a center or program** to train public officials on technologies and trends in the digital transformation of transportation, its consequences for the sector's regulations and institutions, share international and national experiences, and move forward in the implementation of sectoral and sub-sectoral roadmaps.
Horizontal coordination between government agencies	• Extend the competences of existing transportation **inter-sectoral committees** –or similar– to encompass digital transformation. In the absence of inter-sectoral committees, create them at modal or sub-sectoral level (e.g., air, maritime, logistics), led by the highest authority in the subsector's executive branch, and including digital transformation in their agendas. • Encourage the participation of top authorities from the cabinet and national agencies, as well as representatives from subnational agencies, the private sector, and academia. • Implement the **Eight best practices** mentioned in **Chapter 4** on how committees work should, including clear goals, deadlines, frequent meetings, presence of a technical support group, results monitoring, and compliance with recommendations.

INSTITUTIONAL ASPECTS	RECOMMENDATIONS
Horizontal coordination between government agencies	• Establish ***ad hoc* work groups** for specific matters in case of jurisdictional issues or third-party agency expertise issues (e.g., designing regulations or conducting pilots and regulatory sandboxes, spectrum allocation for autonomous conducted connectivity, or regulating mobility platforms) for a set timeframe and with clearly stated objectives. • Seek **inclusion in committees** related to data protection, cybersecurity, standards, digital infrastructure and platforms, band spectrum, work relations, and other topics which usually escape the sector's dominion, but which have a meaningful impact on the progress of its digital transformation.
Coordination between national and local governments	• Promote the development of **smart cities programs** or similar programs conducted by the central government and participation in tech and productive cluster initiatives, which requires reinforcing collaboration with public agencies in charge of these areas, and help pushing transportation issues higher up in these programs' agendas. • Encourage the creation of **geographical areas** designated for research and validating new technologies (see **Chart 7.4**) with the participation of the private sector, integrating local governments in these programs' management. • Spur national programs that help local authorities, especially in medium-sized and smaller cities, **modernize their transportation management**, including technical assistance for digital transformation, equipment upgrade, updating roles and responsibilities of local authorities, and designing data governance systems, among others. • Strengthen local authorities' knowledge via the ongoing **training** of public officials, for example, through their participation in seminars and programs offered by public institutions, international agencies, universities, and training centers.
	• Examine the creation of **unifying agencies** such as metropolitan transportation authorities, port communities, and other inter-territorial committees, aimed at coordinating the initiatives of different authorities, and boosting the creation of efficient governance mechanisms, including aspects such as standards, management, data sharing, and cybersecurity.
	• Develop a **legislative framework or guidelines** to assist local governments in the elaboration of specific policies or regulations in terms of new technologies and transportation.

Source: Authors.

7.4 Develop enabling framework

This refers to actions that are normally beyond the transportation sector's scope, but that are essential to promoting the sector's digital transformation, including:

- **Public procurement processes.** Traditionally, these processes do not favor the introduction of new technologies, partially due to their evaluation mechanisms, or because infrastructure's service life is not in line with the pace of technological innovation. An initial recommendation in these cases is to change the evaluation standards of the winning proposal, adapting it to criterion associated with digital transformation. For example, to foster the deployment of an enabling technology like 5G (see below), the government can determine that the selected bidder to obtain the license for a certain radio frequency bandwidth shall not be the highest-paying telecommunications operator but the one offering the best plan to deploy networks at industrial hubs and logistics corridors (this method is known as "beauty contest" to differentiate it from highest bidder.) This way, by modifying the conditions to award the license, the regulator can foster the deployment of a technology critical to the sector's digital transformation. Other practices require that proposal evaluation criteria incorporate factors such as innovative or alternative technologies for a single service through different technological profiles, economic consequences, and risks.

- **Telecommunications infrastructure.** Critical network coverage gaps must be taken into consideration in national telecommunications plans and digital agendas to be included among the goals of deployment plans. A consequence of this could be including coverage goals for logistics corridors as part of license awarding, and changes in spectrum allocation processes. The lag in assigning an unlicensed spectrum (Wi-Fi) and vehicular communication must be addressed urgently in national frequency plans, which fall under the responsibility of regulatory authorities.

- **Data sharing ecosystem.** Pushing the digital transformation agenda forward requires legal and regulatory frameworks aimed at guaranteeing privacy and data protection. Key issues to take into consideration are: (i) transparency (have users been informed of the use of the data they generate? Have they agreed to its use?); (ii) security (has only strictly necessary data been shared? How are data protection and appropriate data use being guaranteed?); and (iii) governance (who controls data? Are there auditing mechanisms?). The development and implementation of these points require expanding the knowledge and capacity of transportation's regulatory agencies. To generate trust among the general public, it is important for representatives to be involved in framework revision and compliance. In addition, governments should create the necessary incentives to share data by developing interoperability standards, and digital security control measures and systems,

The digital transformation requires inter-institutional collaboration to advance in aspects outside the transport authorities' jurisdiction.

which includes considering the consequences of operations and their control over data stored in the cloud. Cybersecurity controls must include private network use and traffic routing mechanisms.

- **Job market.** The first step to develop the talent needed for the digital transformation of transportation is to evaluate demand and define the number of employees required and their profiles. The second task is to assess the quality of students graduating from the education system. It is equally important to conduct studies to quantify the number of positions that could disappear as a result of digital transformation and automation to define reskilling programs. Meanwhile, a digital jobs catalogue could be developed to generate a scheme of certifications and training programs, in response to the sector's needs. Lastly, the coordination between the education system, private sector, and government needs to be promoted on the basis of: (i) public-private alliances to better understand the needs of digital training for the transportation sector; (ii) offering short training courses to employees and public officials; and (iii) the education sector supporting companies to reduce friction costs in the transition between education and production. Training processes can be sped up by relying on technologies such as virtual/augmented reality platforms and MOOCs. Creating physical or virtual education centers, or including the topic in existing centers, both private and public, is a key aspect in which leading countries in the digital transformation of transportation are already taking steps.

7.5 Set up strategic alliances with the private sector and academia

Given the key role that the private sector plays in the digital transformation of transportation (see **Chapter 3**), it is crucial to move towards developing further organic collaboration with this sector:

Chart 7.4. ▶ RECOMMENDATIONS TO ADVANCE IN PUBLIC-PRIVATE COLLABORATIONS

INSTITUTIONAL CAPACITY	RECOMMENDATIONS
Institutional coordination	• Formally involve the private sector in **inter-sectoral committees** focused on the digitalization of transportation to reach consensus agreements with actions for each party to implement. These committees may be permanent or ad hoc for a specific need. • Consider setting up **advisory committees** with representatives from the private sector and academia that contribute to identify challenges and prioritize enhancements in transportation systems as a result of technological progress. • In order to boost representativeness, make sure that private sector participation is based on **business organizations** representing the sector in areas relevant to the digitalization of transportation.
Collaboration for tech development	• Include the private sector in **tech development projects** fostered by the government by signing memorandums of understanding or cooperation. These can aim not just at the progress of a technology, but also at increasing the technological skills of the current and future workforces, for example, by creating training programs and centers.
	• Create specific private company **consortiums** to carry out joint projects in areas of interest such as autonomous vehicles, electric vehicles, vertical urban mobility, and port community systems, among others.
	• Create/identify **geographic areas aimed at researching** new technologies (e.g. smart cities, AV, vertical urban mobility) sponsored by the public sector, and with private companies that contribute financial resources in exchange for access to areas where they can develop their technology and test it in quasi-real scenarios. For their part, authorities can monitor progress to assess risk levels and get ready to make regulatory adjustments in case these technologies scale up. These areas can also be used to attract investments and gain regional and international traction by, for example, creating tech clusters or hubs. To this end, it is important to coordinate with technological, industrial, and territorial policies promoted within the content of implementing the national development strategy.

INSTITUTIONAL CAPACITY	RECOMMENDATIONS
Consultations to develop the sector's strategic plans	• Include the private sector in the **work groups** in charge of elaborating the sector's strategic plans in order to identify opportunities, challenges, and gaps to work on jointly, as well as to coordinate public and private actions required to advance in digital transformation. • Invite the private sector to participate in roadmap implementation **management and monitoring** teams to ensure their collaboration in implementation phases and propose actions for both sectors to accomplish strategic goals.

Source: Authors.

In addition, it is of the essence to **bring the academia into this process**, both for the elaboration of prospective studies and sectoral/sub-sectoral plans, and for tech development and testing, the education of the future workforce, and reskilling current employees. Participation in advisory committees and technical development projects, generation/reform of academic programs in line with the transportation sector within the technological revolution, and the constitution of research and training centers have proven highly successful in leading countries, and could be replicated in the region.

5 lines of public policies to advance the digital transformation of transport: strategic vision, variety of instruments, institutions 4.0, enabling framework, and strategic alliances.

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Annex

Annex A. Survey to leaders of transportation sector

BACKGROUND

- The Inter-American Development Bank (IDB) is conducting a study on the state of the digital transformation of transportation in Latin America and the Caribbean (LAC), which will contain chapters dedicated to air, sea, and land (road) transportation modes.
- In this context, it is key to have the perspective of the main players in the various subsectors, including representatives of airlines, infrastructure managers, manufacturers, port operators, transport companies, and the public sector.
- The survey results will be presented in a focus group with sector actors to identify the status, barriers, opportunities, and guidelines that promote the digital transformation in the LAC transport sector through public-private cooperation. Completing this survey will take no more than 10 minutes.
- The concept of digital transformation considered refers to the change of institutional culture, organizational model, methods, and processes, which takes advantage of information and communication technologies (ICT) so that organizations improve their operations and the value proposition offered to their clients or users.

SURVEY

Objective:

- Analyze the situation of digital transformation in the LAC's air, maritime, and land transportation subsectors and identify the main areas of public-private collaboration to promote this transformation.

Respondents:

- Senior management, preferably linked to information technologies (IT) and innovation, of public and private organizations that carry out LAC's air, sea, and land transport activities.

Survey
Digital transformation in the transport sector in Latin America and the Caribbean

1 Which type is your organization?

( ) Publico
( ) Private

2 In which transportation subsector is your organization primarily active?

( ) Air
( ) Sea
( ) Land

3 How many employees does your organization have?

( ) 1-50
( ) 51-500
( ) 501-1,000
( ) Over 1,000

4 What is your role in the organization?

( ) President
( ) Vice-President
( ) Chief Information Officer (CIO) / Chief Technology Officer (CTO)
( ) Manager
( ) Division chief
( ) Other. Which one?

5 To date, how much do you think your organization has made progress in digital transformation?

( ) Nothing
( ) Awareness is being raised
( ) The first pilots have already been developed
( ) We are in the process of implementation with an established plan
( ) It has an advanced adoption

6 Does your organization have a digital transformation strategy?

( ) Yes
( ) No

7 **In what areas has your organization been applying digital transformation? Check all that apply.**

( ) Administrative/Finance
( ) Comercial/Marketing
( ) Legal
( ) Operational/Production
( ) Human resources
( ) Supply chain/Logistics
( ) Other. Which one?

8 **How do you perceive your organization's progress in digital transformation issues compared to the average for your sector in Latin America and the Caribbean?**

( ) Far behind
( ) Behind
( ) In the average
( ) Ahead
( ) Way ahead

9 **How do you perceive your organization's progress in digital transformation issues with respect to leading countries worldwide?**

(( ) Far behind
( ) Behind
( ) In the average
( ) Ahead
( ) Way ahead

10 **What are the investment objectives for digital transformation in your organization? Check all that you consider.**

( ) Automate processes
( ) Reduce costs
( ) Increase online presence
( ) Get into other industries
( ) Achieve additional sources of income
( ) Increase brand power
( ) Contribute to environmental goals
( ) Improve security/safety
( ) Other. Which one?

11 **Which of the following technologies have you been using in your organization? Check all that you consider.**

( ) Omnichannel
( ) Cloud computing
( ) Data analytics/Big data
( ) Machine learning
( ) Internet of things/Sensors
( ) Applied artificial intelligence
( ) Robotic Process Automation (RPA)
( ) Drone
( ) Building Information Modeling (BIM)
( ) Augmented reality / Virtual reality
( ) Blockchain
( ) 3D / 4D printing
( ) Autonomous vehicles
( ) Electric vehicles
( ) Other. Which one?

12 **Considering a horizon of up to three (3) years, the digital transformation should be implemented mainly in which areas of your organization? Check all that you consider.**

(( ) Internal processes of the organization
( ) Innovation in products and services
( ) Relationships with customers
( ) New business models and revenue stream
( ) New distribution channels
( ) Talent management and human resources
( ) Collaboration between companies/third parties
( ) Protection and security/safety
( ) All of the above
( ) Other. Which one?

13 **Considering a horizon of up to three (3) years, which of the following technologies do you believe should be implemented in your organization? Check all that you consider.**

( ) Omnichannel
( ) Cloud computing
( ) Data analytics/Big data
( ) Machine learning
( ) Internet of things/Sensors
( ) Applied artificial intelligence
( ) Robotic Process Automation (RPA)

( ) Drone
( ) Building Information Modeling (BIM)
( ) Augmented reality / Virtual reality
( ) Blockchain
( ) 3D / 4D printing
( ) Autonomous vehicles
( ) Electric vehicles
( ) Other. Which one?

14 What have been the aspects that have most positively contributed to your organization's advancement in digital transformation? Check all that you consider.

( ) COVID-19
( ) Top management leadership
( ) Cultural change
( ) Changes in customers
( ) Changes in the sector
( ) The competition
( ) Attendance at webinars
( ) Margin reduction
( ) External advisors / consultants
( ) Other. Which one?

15 Have you quantified the impact of the investments your organization has made in digital transformation?

( ) Yes
( ) No

16 If yes, what indicators have you used to measure the impact of these investments? Check all that you consider.

( ) Increase or decrease in income and costs
( ) Process efficiency
( ) ROI (Return on Investment)
( ) Project projections
( ) Online sales volume
( ) Number of transactions and / or digital processes
( ) CAPEX, OPEX or EBITDA
( ) Measurement of customer satisfaction
( ) Contribution margin
( ) Business value
( ) IRR (Internal Rate of Return)
( ) Market penetration
( ) Other. Which one?

17 **What restrictions/limitations have you encountered to advance the digital transformation of your organization? Check all that you consider.**

( ) Implementation costs
( ) Lack of digital culture
( ) Unawareness
( ) Lack of financial capacity for investment
( ) Lack of a clear business model
( ) Lack of talent with adequate training
( ) Inadequate regulation
( ) Resistance to change
( ) Weak technological infrastructure
( ) Other. Which one?

18 **Please, indicate any observations you think are necessary for the technological development in your area or sector (optional).**

Annex B.
List of interviewees and panelists

B1. INTERVIEWEES

ORGANIZATION	INTERVIEWEE
A.P. Moller - Maersk	Julian Thomas
ACI	Francisco Medela
ACI	Rafael Echevarne
Aeropuerto El Dorado	Luis Soto
Aeropuertos Argentina 2000	Federico Buzzoni
Aeropuertos Argentina 2000	Gustavo Sábato
Airbus	François Le Maréchal
Airbus	Zsolt Lattmann
Airbus	Balkiz Sarihan
Airbus America	Catherine Sadler
Airbus America	Eugene Chang
Airbus America	Arturo Barreira
Airbus America	Guillaume Gressin
Airbus America	Amanda Simpson
Airbus America	Emily Wilson
ANAC	Roberto Honorato
Buenos Aires City Government	Alan Balfour
Buenos Aires City Government	Martín Viale
Caribetrans	Héctor Mieses
CEL	Ramón García
Citiway	Chloe Spano
Commercial Drones Alliance	Lisa Ellman
DNP Colombia	Jonathan Bernal

ORGANIZATION	INTERVIEWEE
DP World	Alberto Róbinson
DR Trade LCS	Francisco Domínguez
Ericsson	Fernán Izquierdo
FAA	Krista Berquist
FAA	Michelle Westover
FAA	Bonnie Ahumada
FAA	Lorrie Fussel
FAA	Adrienne Vanek
FAA	Thomas Naskoviak
FAA	Biruk Abraham
FHWA	Ryan Endorf
FHWA	Caitlin Hughes
FHWA	Stephen Kern
FHWA	Chandra Bondzie
FHWA	Lateefah Burgess
FHWA	Ken Leonard
FHWA	Egan Smith
FHWA	Kelsey Owens
FrioExpress	José Ramón Medrano
Hogan Lovells	Emily Kimball
IATA	Oracio Márquez
IATA	Felipe Coutinho
IATA	Carlos Cirilo
ICAO South American Office	Fabio Rabbani
ICAO South American Office	Oscar Quesada
ICAO South American Office	Pablo Lampariello
ICAO South American Office	Leonardo Boszczcowski

ORGANIZATION	INTERVIEWEE
IDB	Manuel Rodríguez
Independent Consultant	Wolfgang Lehmacher
Indra	Lidia Muñoz Pérez
Intel	Carlos Rebellón
Intel	Martín Hain
Intel	Sahid Khan
IRF	Gonzalo Alcaraz
JAC	Martin Mackenna
McKinsey	Stephanie Haag
McKinsey	Anja Huber
Metron Aviation	Chris Jordan
Microsoft	Pedro Uribe
Microsoft	Doug Priest
Microsoft	Jeremy Goldberg
Ministry of Transportation and Communications, Chile	Pedro Vidal
Ministry of Transportation of El Salvador	Saúl Castelar
MIT	Andrew Salzberg
Moovit	Juan Palacio
NAVBLUE	Luis Gáfaro
Panama Canal Authority	Oscar Bazán
Panama Metro	Ana Laura Morais
Panama Metro	Luis Carlos Díaz
Port of Antwerp-Bruges	Erwin Verstraelen
Port of Barcelona	Jordi Torrent
Port of Rotterdam	Govert Geerlings
Port Society of Cartagena	Giovanni Benedetti

ORGANIZATION	INTERVIEWEE
PSA International	Eddy Ng
SAAB Group	Sergio Martins
Secretariat of Mobility of Bogota	Germán Escovar
Secretariat of Mobility of Bogota	Lina Quiñones
Secretariat of Mobility of Bogota	Jady Pérez
Sparx Logistics	Boris Franchomme
Subterráneos de Buenos Aires Sociedad del Estado	Manuela López
Transmilenio	Felipe Ramírez
Uber	Florencia Nigro
UN CEFACT	Sue Probert
UNSAM	Fernando Dobrusky
Volaris	Ronny Rodríguez
Wilson Sons	André Porto
World Economic Forum	Margi Van Gogh

B2. PANELISTS (Subsector Focus Groups)

ORGANIZATION	PANELIST
A.P. Moller - Maersk	Santiago Larzábal
ABC Cargas	Danilo Guedes
Aeroméxico	Fernando Rocha
Aeroméxico	Guillermo Rosales
Avianca	Fernando Lara
Buenos Aires City Government	Alan Balfour
Buenos Aires Subway State-Owned Company (SBASE)	José Luis Lodeiro

ORGANIZATION	PANELIST
Copa Airlines	Julio Toro
Didi	Salvador Maturana
Dufelook	Mauro Borzacconi
Fadeeac	Guillermo Werner
Fadeeac	Cecilia Anán
FrioExpress	Jose Ramón Medrano
Gol Linhas Aéreas Inteligentes	Luiz Borrego
Jet Smart	Fernando Santos
Latam Airlines	Francisco García
Marva	Miguel Ángel Martínez
Metbus	Andrés Vilches
Moovit	Juan Palacio
National Secretariat of Ports and Waterway Transport (SNPTA) Brazil; AAPA	Rita de Cássia Vandanezi Munck
Port Society of Barranquilla	René Puche Restrepo
Secretariat of Mobility of Bogota	Germán Escovar
Sky Airlines	Felipe Andrés Izquierdo
Sky Airlines	David Gálvez
STI	Angel Hernandez
Tradelog	Diego Sánchez
TransApp	Jacqueline Arriagada
Viva Air	Hugo Pando
Viva Air	David Ramos
Viva Air	Guillermo Herrera
Viva Air	Francisco Lalinde


IDB