Foresight and Scenario Planning for Smart Mobility in Latin America and the Caribbean
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**Abbreviations**

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<td>5G</td>
<td>fifth generation of mobile technologies</td>
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<tr>
<td>AI</td>
<td>artificial intelligence</td>
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<tr>
<td>CEO</td>
<td>chief executive officer</td>
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<td>GP</td>
<td>Global Practice</td>
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<td>IoT</td>
<td>internet of things</td>
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<td>ITSTI</td>
<td>Information and Technology Solutions Technology and Innovation Lab</td>
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<td>MaaS</td>
<td>mobility as a service</td>
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<td>WBG</td>
<td>World Bank Group</td>
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Acknowledgements

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Executive Summary

The World Bank Transport Global Practice (GP) promotes safe, clean, affordable transport that supports economic and social development. One of the focuses of the Transport GP’s portfolio is to support client countries’ and cities’ efforts to implement smart mobility. Smart mobility, in this report, refers to transport modes and services with efficient, convenient, safe, or sustainable features backed up by technological components. Examples of smart mobility include transport modes with digital ticketing, on-demand mobility, drones, and autonomous vehicles, although there is a wide variety of smart mobility options. World Bank Group (WBG) clients require expertise and strategies to be able to implement smart mobility applications and solutions.

The World Bank Information and Technology Solutions Technology and Innovation Lab (ITSTI) has expertise in use of disruptive technologies such as artificial intelligence, Internet of things, blockchain, and robotics and has developed policy recommendations using a policy development methodology called Foresight, which is a structured, systematic way of using ideas about the future to anticipate and prepare for change. Transport GP, Digital Development GP, and ITSTI used Foresight to develop this report to assist clients by providing insights into the Foresight methodology and how it can be leveraged to develop future-ready international development projects.

Smart Mobility Foresight

Section I describes the project background and approach and the Latin American and Caribbean context. Section II illustrates important aspects of Foresight techniques and research findings used to build the future state (scenarios) of smart mobility in Latin America and the Caribbean. The report then outlines what life would look like in 2030 under scenarios developed based on the current situation. Scenarios are illustrated with the personal perspectives (e.g., needs, concerns, experiences, interests) of people in those future situations to help readers understand the scenarios better.

The overall goal of this exercise is not to predict the future but to prepare for risks related to the future scenarios and maximize the potential benefits by considering current policy decisions. The Foresight exercise conducted for this report was not meant to develop an action roadmap for any specific country because action roadmaps depend on a country’s or city’s context, such as its political situation, available resources, and existing infrastructure. This report uses a high-level viewpoint to try to demonstrate and illustrate the process and outputs of Foresight. For those who would like to create concrete action plans, the report provides some inspiration and ideas to develop future action plans. In the meantime, Appendix A
lists emerging technology opportunities, Appendix B provides smart mobility examples, and Appendix C lists useful resources for reference.

After reading this report, readers will understand how to use Foresight to develop projects in any sector. Readers can also create variations of scenarios by extending scenario assumptions horizontally (modifying the time frame) and vertically (changing uncertainties, personas, and focuses on specific technologies) to gain further policy insights.

FUTURE SCENARIOS: TRANSPORT IN 2030

To analyze the future of smart mobility, four scenarios were created along two axes (technological adoption, pandemic frequency):

SCENARIO 1. Gap Between Haves and Have-Not's Widens
A low-tech future with frequent pandemics will lead to social division within and between countries. This scenario presents a more pessimistic view than the other scenarios, with frequent pandemics having weakened the customer base for transport services, hindering development of private companies that offer transport services. This scenario also illustrates the impact of lack of investment in technological development. In this future state, policy makers must respond to a regularly changing pandemic situation and will encounter difficulties in achieving a smart mobility vision.

SCENARIO 2. Hybrid Work Continues
In a high-tech future with frequent pandemics, technology will enable hybrid work styles and support mobility innovations. Frequent pandemics will keep many people working remotely, with those who must commute supported by safe transport systems. Governments will work to update the transport-related regulatory environment to accommodate new services that mitigate the challenges that arise with pandemics. A key takeaway from this scenario is the potential impact of pandemics on regulatory reform; frequent pandemics accelerate government responses to rising demand for individual-based mobility and highly efficient logistics systems.

SCENARIO 3. Return to Business as Usual
In a low-tech future without frequent pandemics, growing concern about climate change will drive investment in public transport and shared mobility services. Car ownership will become less popular, which will affect urban planning and government investment plans for transport. Future mobility will be, to some extent, a continuation of current conditions.

SCENARIO 4. Private Sector Blossoms
A high-tech future with no fear of frequent pandemics is the best scenario for most people. Stable use of mobility solutions will enable a healthy investment environment and predictability for the private sector to develop innovative solutions. Private sector actors will become major providers of transport services in some countries, although privacy concerns and cybersecurity risks will be more prominent as mobility data is continuously collected and reused to optimize services.
KEY TAKEAWAYS FROM THE FORESIGHT EXERCISE

The Foresight exercise and scenario planning provided some useful takeaways for the WBG and its clients. Investment in technology enables better transport systems regardless of the pandemic situation, but technological solutions develop in different ways depending on scenario assumptions. Technology will accelerate smart mobility implementation, along with risks such as misuse of sensitive data and cybercrime. Data collection, management, and cybersecurity are key components of high-technology scenarios. Frequent pandemics may widen economic gaps within and between countries and create an unpredictable customer base for transport services, although frequent pandemics can transform societies, creating momentum for policy change to update existing transport systems. In addition, mobility solutions will change as more-individual and -automated transport becomes the default. Climate change will be a key driver of policy consensus, requiring investments in mobility solutions for mass transport and environmentally sustainable mobility modes such as walking and cycling. Demographic characteristics will significantly influence the future of mobility. In Latin America and the Caribbean, the dependency rate\(^1\) has been low since the early 2000s, which enables vigorous economic growth through a large labor force and an increase in savings and investment in human and physical capital. The dependency rate is expected to increase during the 2030s,\(^2\) which will require governments to formulate long-term sustainable budgetary strategies and guarantee access to transport for vulnerable groups such as poor people and older adults. Because of constraints on public sector budgets, the private sector will be expected to play a larger role in offering transport services.

ROLE OF GOVERNMENTS

We have developed recommendations for government entities.\(^3\) It is critical that national governments develop strategies to foster smart mobility through strategic investment, consumer protection, and standard setting. In the meantime, national governments must bridge the gap between the haves and have-nots that the COVID-19 pandemic has widened. We suggest that they use the smart mobility scenarios in this report, adapting them to the local context to develop an action roadmap suitable for different situations.

Regional governments can pursue social innovations through partnerships with the private sector, local communities, and academia to encourage development and implementation of digital solutions. Risk mitigation measures such as ensuring data protection and cybersecurity should accompany the innovation effort. In addition, addressing exclusion is fundamentally important. Assisting with and ensuring access to transport services for vulnerable groups such as poor people, women, and digitally unconnected groups is an important role for government.

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1 The ratio of the population that is not in the labor force (the dependent part) to the population that is in the labor force (aged 15–64) in a society. Low dependency rates create positive conditions for economic growth.
3 The Foresight exercise conducted for this report was held at a high level and did not incorporate specific country contexts. The recommendations are not exhaustive.
ONE

Introduction
The World Bank is seeking to transition its portfolio to encompass the new generation of smart mobility applications; key knowledge and capacity gaps must be addressed to facilitate this transition. It is also necessary to review successful smart mobility case studies and international best practices in the evolution from cutting-edge technologies toward more-integrated, holistic, smart mobility solutions and to consider whether these experiences offer lessons for Bank operations in developing countries.

The World Bank Group (WBG) Information and Technology Solutions Technology and Innovation Lab (ITSTI) works as a collaboration platform, knowledge hub, and accelerator for experimenting with, prototyping, and mainstreaming cutting-edge technologies and innovative business models. ITSTI collaborates with stakeholders to explore and implement new capabilities to enable the WBG to achieve its mission of ending extreme poverty and promoting shared prosperity. ITSTI provides the knowledge, experimentation space, convening power, and guidance to deliver business solutions using new and emerging technologies such as artificial intelligence (AI), blockchain, the Internet of things (IoT), fifth-generation (5G) mobile telecommunications technology, robotics, drones, and other emerging technologies.

ITSTI collaborated with the World Bank Transport Global Practice (GP) to develop this report to supplement the Transport and Digital Development GPs’ effort to accelerate the WBG’s smart mobility projects. ITSTI used the Foresight methodology, which it has been using since 2019, to help Bank staff create policy projects with futuristic ideas to help cities transition toward smart mobility solutions. ITSTI illustrates the potential of disruptive technologies for smart mobility so that the Transport and Digital Development GPs can fully harness emerging technology—enabled solutions to assist client countries and cities.

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4 Blockchain is a type of digital ledger technology that consists of a growing list of records, called blocks, that are securely linked using cryptography. Each block contains a cryptographic hash of the previous block, a timestamp, and transaction data. The timestamp proves that the transaction data existed when the block was created. Because each block contains information about the block before it, they effectively form a chain. Blockchain transactions are irreversible in that, once they are recorded, the data in any given block cannot be altered retroactively without altering all subsequent blocks.

5 The IoT is a network of physical objects with sensors, processing ability, software, and other technologies that connect and exchange data with other devices and systems over the Internet or other communications networks.
The Latin American and the Caribbean Context

The mobility landscape of Latin America and the Caribbean is heterogenous, with various paradigms (colonialism, modernism, rapid urbanization, informality, suburban sprawl) shaping the urban landscape,\(^6\) resulting in a complex, variable ecosystem of transport modes and services, reflecting legacy forms of transport (e.g., gas-powered automobiles) and innovative approaches (e.g., cable cars).\(^7\) Traditional forms of mobility such as walking and bicycling are important transport modes for poor people, especially in urban areas.\(^8\) Although newer mobility options (e.g., ride sharing, electric bicycle rentals) have gained traction in the region, access is unequal.

The COVID-19 pandemic reduced ridership on public transportation. Geographic inequity is a key obstacle to mobility accessibility for poor people, with low-income housing frequently located far from employment opportunities.\(^9\) The pandemic also increased the number of people living in poverty by 22 million.\(^10\) Air quality remains a stubborn challenge, primarily driven by vehicle emissions.\(^11\)

The challenge of smart mobility includes providing policy makers and transport planners with options to reduce the burden of transport for disadvantaged groups, including elderly adults, low-income workers, women, and persons of Indigenous and African descent. Improving mobility requires making progress on a number of fronts, including non-technological (e.g., governance and infrastructure) and technological (e.g., taking advantage of the region’s growing technology startup sector).\(^12\)

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Approach

Challenges and potential solutions, disruptive technology opportunities, and their enabling architecture in the smart mobility space were researched in the literature. Then, drivers that will affect mobility solutions in the future in Latin America and the Caribbean were identified, as well as signals of changes such as small or local innovations with the potential to grow as globally accepted services. After that, drivers and signals of change were used as fundamental factors in developing future scenarios through a Foresight workshop with subject matter experts from the Transport GP, Digital Development GP, and IDOM, a global engineering and advisory firm. Section II provides a detailed explanation of the Foresight methodology used.

Four scenarios of the future of smart mobility were developed, shared with subject matter experts, and updated based on their feedback and the local context in Latin America and the Caribbean. Personas were developed to highlight the journey and pain points of various potential stakeholders in the smart mobility market: a commuter, an urban planner, the chief executive officer (CEO) of a mobility solutions firm, and a transport ministry official.

The project team then prepared this report and developed graphics to document and illustrate the results from this project with help from external designers. It is hoped that these graphics will make the Foresight methodology accessible to other transport projects and consolidate knowledge gained from this engagement. Figure 1 provides an overview of the approach used to develop this report.

**FIGURE 1.** Overview of the Approach Used
Description of Foresight

Foresight is a structured, systematic way of using ideas about the future to anticipate and prepare for change and often includes scenario planning. A growing number of regional Foresight activities are taking place in Asia and the Pacific, Europe, and Latin America and the Caribbean. Foresight is also gaining popularity in international organizations such as the United Nations, United Nations Development Program, and Organization for Economic Cooperation and Development. Figure 2 provides examples from international organizations.

Foresight helps international organizations and policy makers devise policy solutions based on continuously changing situations rather than static assumptions. This way, solutions address uncertainties and incorporate the potential influence of global trends and emerging inventions. The Foresight principles are listed in Figure 3.

**FIGURE 2. Foresight-Related Articles and Materials from International Organizations**

Multilateral institutions have used Foresight to support long-term planning for uncertain futures with respect to human capital, societal and political change, and development assistance.

- **The Converging Technology Revolution & Human Capital Potential—Implications for South Asia (2021)**
  World Bank. Sajitha Bashir, Carl J. Dahlman, Naoto Kanehira, and Klaus Tilmes

- **Latin America & the Caribbean 2030: Future Scenarios (2016)**
  Inter-American Development Bank. Jason Marczak, Peter Engelke, David Bohl, Andrea Saldarriaga Jiménez

- **Foresight Manual—Empowered Futures (2018)**
  United Nations Development Plan Global Centre for Public Service Excellence

  United Nations Sustainable Development Group

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As written in Foresight principle 1, the intention of Foresight is not to predict the future but to use a participatory approach to help stakeholders anticipate challenging futures. As the future cone diagram in Figure 4 shows, there may be many possible futures, and plausible and preferable futures are small subsets of possible futures. Scenarios are future representations based on current facts, trends, and signals of change. Some specific scenarios are seen as wild cards because they are so different from probable scenarios, whereas others are probable futures that are simply a continuation of the present. Somewhere in the possible future area, there is a preferable future that key stakeholders represented in the Foresight exercise believe is ideal. Foresight is fundamentally back casting: a planning method that starts with defining a desirable future and then works backward to identify policies and programs that will connect that future to the present. The vertical range of the future increases as the time range lengthens.

The Foresight methodology has four stages: preparation, Foresight creation, insight collection, and action planning (Figure 5). The Foresight process fosters a unified understanding of the actions to be taken through this collective, participatory process and hence works best when an intensive workshop takes place with stakeholders to devise scenarios and create action plans to maximize social benefits and mitigate risks. Foresight can be extremely beneficial in the initial stage of project development to imagine future possibilities and share a broad vision of the future that key stakeholders agree on. After conducting Foresight processes, several key outputs were developed: drivers, signals, scenarios, and key takeaways.

16 This report focuses on the preparation, Foresight creation, and insight collection stages. In the action planning stage, concrete action items are developed to maximize the possibility that the ideal future state happens. Because action plans depend greatly on a society of interest’s political situation, environmental situation, and infrastructure, this report does not explore them but instead focuses on methodologies and outputs from a future-centric perspective.

17 Project members have researched and studied Foresight methodologies from various sources, one of which was Institute for the Future, a well-known Foresight education organization in California.
FIGURE 4. The Futures Cone

The World Bank Transport Global Practice, together with client countries, promotes safe, clean, affordable transport systems that contribute to economic and social development. The Information and Technology Solutions Technology & Innovation Lab, Transport Global Practice, and Digital Development Global Practice have used the foresight and scenario planning methodology to explore smart mobility futures for the World Bank Smart Mobility Guideline for Latin America and the Caribbean.

Think systematically about possible futures by learning about the past and present, taking into account drivers, trends, signals, and emerging risks and opportunities that influence the future. During the Prepare stage, the systems in which society operates today is mapped out to make the complex ecosystem visible and reveal connections between systems.

Inform plausible, provocative, compelling views of the future by developing knowledge of the present. Creatively examining future options and analyzing patterns of change can reveal unexpected possibilities and alternative futures and help personalize how an organization might best serve current customers and new audiences.

Prioritize next steps and identify opportunities for change, innovation, and futuristic experiments. Design action roadmaps, test and adjust hypotheses, make better use of internal assets, and build appropriate strategic partnerships to overcome existing gaps based on the desired future.

Identify potential implications and choices for possible implementation. Revisit decisions about organizational, sectoral, and development transformation actions, incorporating insights about disruptive forces, systemic changes, opportunities, and risks.
Drivers and Signals of Change

When applying Foresight, project members researched the topic of interest—smart mobility—by studying news, academic papers, and case studies and interviewing subject matter experts. A typical first step of a Foresight exercise is to explore underlying drivers (also called trends or forces) that have been, are, and will be shaping the ecosystem. The next step is to scan the signals of change—small or local innovations with the potential to grow in size and geographic distribution—which can be a new product, service, technology, practice, market strategy, or policy and be a catalyst that can lead to larger changes in the market.18

Having a better understanding of and a consensus on drivers and signals is fundamental for scenario development because they will give breadth and depth to the representations of the future, which can help stakeholders prepare for surprising futures. The list of drivers and signals collected from the research and Foresight sessions are summarized in Figure 6. Tables 1 and 2 illustrate drivers and signals of change in detail.

### TABLE 1. Drivers of Change

<table>
<thead>
<tr>
<th>AREAS</th>
<th>KEY DRIVERS</th>
<th>INSIGHTS</th>
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<tbody>
<tr>
<td>Digital and technology</td>
<td>Robotics, autonomous vehicles, drones</td>
<td>Autonomous vehicles, also called driverless or self-driving cars, can navigate and overcome obstacles without a driver. Massive adoption of autonomous vehicles could transform all aspects of life because people could enjoy additional free time while using them. Drones offer a variety of services ranging from environmental monitoring to traffic management.</td>
</tr>
<tr>
<td>development</td>
<td>Rise of AI</td>
<td>AI has potential to change the smart mobility sector through various capabilities such as computer vision, voice recognition, and prediction. Those capabilities play fundamental technical roles in smart mobility solutions such as autonomous vehicles and drones. In the meantime, AI can be used for surveillance systems and traffic management.</td>
</tr>
<tr>
<td></td>
<td>Smart phones and mobility platforms</td>
<td>Smart phone–enabled apps have provided options for mobility and tracking of travel information. Mobility solutions such as on-demand transport and micro-mobility options such as bicycle and electric scooter rentals are often available via smart phone apps.</td>
</tr>
<tr>
<td></td>
<td>Financial technology</td>
<td>Payment for mobility is becoming more digitized and streamlined. Financial technology, such as mobile wallets and digital payment solutions, offers convenience and transparency.</td>
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<td></td>
<td>Mobility as a service</td>
<td>Mobility as a service is the integration of multimodal transport services into a single mobility service accessible on demand. It offers commuters added value through use of a single application to provide access to mobility services, with one payment channel.</td>
</tr>
<tr>
<td></td>
<td>Connectivity, Internet of things, transport data-gathering sensors</td>
<td>Connectivity is a fundamental factor for smart mobility, connecting vehicles, roads, and traffic lights, among other things, with Internet access. Communication between vehicles and road infrastructure is a critical enabler for autonomous vehicles. Connected sensors may also be employed to collect data to improve transport (e.g., preventive maintenance, intelligent conservation of roads).</td>
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<tr>
<th>AREAS</th>
<th>KEY DRIVERS</th>
<th>INSIGHTS</th>
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<tbody>
<tr>
<td><strong>COVID-19 and future pandemics</strong></td>
<td>Work from home, commuting at non-peak hours</td>
<td>Remote, hybrid, and flexible-schedule work have all become much more acceptable options in multiple sectors as a result of the COVID-19 pandemic and may become the new standard for many workers.</td>
</tr>
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<td></td>
<td>Demand for clean public transportation</td>
<td>Cleaner, safer public transport with good air circulation have become preferred.</td>
</tr>
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<td></td>
<td>E-commerce and food delivery</td>
<td>Demand for logistical services for e-commerce and delivery services have increased substantially.</td>
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<td></td>
<td>Reduction in tourism and business travel, vaccination passport</td>
<td>Reduction in overall travel has reduced use of transport. Countries with higher vaccination rates may recover more quickly.</td>
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<td></td>
<td>Broader economic opportunities</td>
<td>COVID-19 has exacerbated economic hardship. In addition to loss of employment, some people face challenges accessing services. Alternatively, fear of infection has increased demand for safer and individual travel modes.</td>
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<td></td>
<td>Lack of access to education</td>
<td>Access to online education varies depending on country, region, and family situation, which aggravates the existing human capital gap.</td>
</tr>
<tr>
<td><strong>Climate change</strong></td>
<td>National and international initiatives to address climate change</td>
<td>International, national, and local regulatory pressure to adopt sustainable solutions that can mitigate and adapt to climate change is increasing.</td>
</tr>
<tr>
<td></td>
<td>Green and smart mobility solutions</td>
<td>In Latin America and the Caribbean, 35 percent of greenhouse gas emissions are related to fuel combustion from the transport sector. Rising concerns about climate change are leading end users to prefer greener, smarter mobility solutions.</td>
</tr>
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<td></td>
<td>Electric vehicles</td>
<td>Electric vehicles have the potential to become the new standard of the automobile industry and will require new infrastructure such as power chargers, transformers, and power lines. More investment in electric vehicles may affect fossil fuel-related industries.</td>
</tr>
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<td></td>
<td>Consumer concern about transport emissions</td>
<td>Zero-emission transport will gain attention from consumers regarding prioritization of nonmotorized transport.</td>
</tr>
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<td></td>
<td>Rise of climate-neutral cities</td>
<td>Cities play significant roles in energy reduction, climate protection, and climate adaptation. Since the mid-2010s, an increasing number of countries, cities, organizations, and individuals have been focusing on climate-neutral cities.</td>
</tr>
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FIGURE 6: Drivers of Change and Signals That Will Influence the Future of Smart Mobility

This map represents research gathered through the Foresight process. To explore smart mobility futures, the project team considered key drivers of change and signals as strategic factors to develop possible scenarios.

DRIVERS OF CHANGE
The first step of the Foresight exercise is to scan and collect the underlying trends, forces, or drivers that have been, are and will be shaping the ecosystem.

SIGNALS
The next process of Foresight includes scanning the signals. Signals are small or local innovations with potential to grow in scale and geographic distribution.

TECHNOLOGY DEVELOPMENT
- Rise of AI, Robotics, Autonomous Car/Drones
- Smartphones and Mobile Platforms Expansion
- Fintech for Mobility for Convenience and Transparency
- Mobility-as-a-Service (MaaS)
- Connectivity, IoT, and Data Platforms

CLIMATE CHANGE
- Government/International Initiatives for Climate Change
- Prioritize Green and Smart Mobility Solutions
- Electric Vehicles Expansion
- Consumer Concern on Transportation Mode’s Emissions
- Rise of Climate Neutral Cities

DEMOGRAPHIC CHANGE
- Change in Demographics and People’s Behavior
- Increased Urbanization—Demand for Efficient and Safe Transport Mode
- Longevity Requiring Easy Access to Transportation for All
- Income Inequality—Uneven Access to Personalized Mobility
- Change in Political Priority

COVID-19 & FUTURE PANDEMICS
- Work from Home / Avoiding Peak Hours
- Demand for Clean Public Transportation
- Acceleration of E-commerce & Food Delivery
- Reduction in Trade, Tourism & Business Travel
- Widen Economic Opportunities / Lack of Access to Education

CRYPTOCITY
CityDAO makes city assets digitally legible to unlock accessibility, interoperability and opportunity.

METAVERSE
Hyundai Mobility Adventure chronicles future mobility lifestyle in the metaverse.

DLT BASED MOBILITY DATA ECOSYSTEM
Enables access to and benefits from vehicle-generated data.

AI MANAGED CITY
Solves problems of transportation, securing municipal construction, urban planning.

SYNCHRONICITY
Builds a marketplace for IoT and AI-enabled solutions to tackle challenges through innovation.

KULTUR TOKEN
Rewards climate-friendly citizens taking more sustainable mobility solutions.

ON-DEMAND RIDES
Individual transport available whenever you want, at a reasonable price.

CAR SHARING SERVICE
Peer-to-peer marketplace.

CBDC DIGITAL YUAN
Covers complete public transportation system, nudging people toward green travel.

ON-DEMAND MOBILITY ANALYTICS
Takes big data from mobile devices to fuel analyses.

SATELLITE IMAGERY
Makes it possible to analyze transportation situations and inform infrastructure investments.

EDGE COMPUTING
Data is processed and analyzed near its source, minimizing latency.

IOT
Network of objects through sensors that collect and transmit data, creating benefits for smart transport.

5G
The potential to empower connected and autonomous vehicles.
AREAS | KEY DRIVERS | INSIGHTS
--- | --- | ---
Demographic change and urban design | Change in demographic characteristics and people’s behavior | In Latin America and the Caribbean, the dependency rate has been low since the 2000s, which creates conditions conducive to economic growth through a large labor force and an increase in saving and investment in human and physical capital. In this favorable phase, a demographic “window” of opportunity is open that supports vigorous economic development.
Urbanization; demand for efficient, safe transport | People are moving to cities—increasing population density in city centers and creating demand for safe, accessible, cost-effective public transport.
Longevity, requiring easy access to transportation | Longer life expectancy requires elder-friendly design for transportation and cities, such as elevators in stations and good lighting. Driving a car can be difficult for some; autonomous vehicles could become an option.
Income inequality; uneven access to mobility | Access to affordable transportation remains a priority. Income inequality leads to uneven adoption of smart mobility solutions.
Change in political priorities | Political status affects development of transport. Long-term investment requires stability, geopolitical status often affects policy priority, and budget constraints require sound city planning strategies.

Note: Appendix A provides additional information about technology opportunities.
AI=artificial intelligence.


### TABLE 2. Signals of Change and Examples

<table>
<thead>
<tr>
<th>CATEGORY</th>
<th>SIGNAL</th>
<th>EXAMPLE</th>
<th>EXAMPLE DETAIL</th>
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<tbody>
<tr>
<td>Digital services</td>
<td>AI-managed city</td>
<td>Alibaba</td>
<td>City Brain is a new architecture of a smart city based on AI systems that help solve problems of transport, security, municipal construction, urban planning, and others. As of September 2019, City Brain had been implemented in 23 cities across Asia.</td>
</tr>
<tr>
<td></td>
<td>Metaverse</td>
<td>Hyundai Motor</td>
<td>Hyundai Mobility Adventure is the first virtual experience content on Roblox (a global gaming platform) developed by a global automotive brand to showcase future mobility lifestyles in the metaverse.</td>
</tr>
<tr>
<td></td>
<td>Token to reduce carbon dioxide emissions</td>
<td>Kultur</td>
<td>People can receive tokens for admission to cultural venues and events by taking part in a wide range of climate-friendly activities such as using public transport, biking, and walking in Vienna, Austria.</td>
</tr>
<tr>
<td></td>
<td>Central bank digital currency for sustainability</td>
<td>E-yuan</td>
<td>Chengdu is the first Chinese city to offer the Chinese central bank digital currency e-yuan across its public transport system, which includes metro, buses, and bicycles. It encourages people to use green travel, conserves energy, and reduces carbon emissions. Citizens can apply to win one of 100,00 digital yuan public transport packages that include coupons that can be stored in a digital yuan wallet and be redeemed for tickets via an app on their mobile phone.</td>
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Drivers and Signals of Change
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<thead>
<tr>
<th>CATEGORY</th>
<th>SIGNAL</th>
<th>EXAMPLE</th>
<th>EXAMPLE DETAIL</th>
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<tbody>
<tr>
<td>Digital services (Continued)</td>
<td>Blockchain for smart cities</td>
<td>City Dao</td>
<td>City Dao, a blockchain-based platform, is an experimental project into decentralized land ownership. The aim is to build a city with decentralized governance, where “citizens” purchase land in the form of nonfungible tokens. City Dao members make collective decisions about how to use land.</td>
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<tr>
<td>Data marketplace</td>
<td>On-demand mobility analytics</td>
<td>StreetLight Data</td>
<td>StreetLight uses data from mobile devices to conduct analyses. Volume of trips over different periods of time and differences according to type of day, time of day, data period, and vehicle type can be viewed via the platform, and trip time, length, speed, circuitry, and purpose can be identified.</td>
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<td>Mobility data ecosystem</td>
<td>Drive&amp;Stake</td>
<td>RIDDLE&amp;CODE</td>
<td>Drive&amp;Stake—a decentralized, end-to-end solution for the creation of automated mobility data marketplaces that enable all participants to access and benefit from vehicle-generated data.</td>
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<td>City data exchange</td>
<td>SynchroniCity</td>
<td>SynchroniCity</td>
<td>SynchroniCity has created a marketplace enabling a broad array of city-generated IoT data to be exchanged among a diverse group of stakeholders for deployment across multiple cities—now live in Santander, Spain; Manchester, England; Helsinki, Finland; Carouge, Switzerland; Porto, Portugal; and other cities.</td>
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<td>Mobility apps</td>
<td>On-demand rides</td>
<td>Uber, Lyft</td>
<td>With on-demand transport, one can request an immediate ride at any time. This is a rapidly growing service worldwide that often competes with a coexisting taxi industry.</td>
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<td></td>
<td>Car-sharing services</td>
<td>Turo</td>
<td>Turo is a community with more than 450,000 vehicles operating in a peer-to-peer car-sharing marketplace in which customers choose from nearby cars, and hosts earn cash to offset the costs of car ownership.</td>
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<td></td>
<td>Micro-mobility</td>
<td>Yulu</td>
<td>Micro-mobility services provide convenient methods of transport for short trips, increase access to public transport, reduce the number of cars on the road, and lower one's environmental footprint. Yulu is an Indian startup providing electric bicycles to reduce traffic in Indian cities.</td>
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<tr>
<td>Connectivity and data infrastructure</td>
<td>5G connectivity</td>
<td>Liberty Latin America</td>
<td>5G technology is a new standard in cellular networks that provides low latency (delay time) coverage for big data streams that power IoT devices, autonomous vehicles, augmented reality, and virtual reality. Liberty Latin America is a leading communications company operating in more than 20 countries across Latin America and the Caribbean that acquired AT&amp;T’s wireless and wireline operations in Puerto Rico in 2020 and offers 5G connectivity in the country.</td>
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<td></td>
<td>Edge computing</td>
<td>Red Hat</td>
<td>Edge computing is a distributed computation framework that brings data processing applications closer to data sources from centralized data centers. A network that includes edge computing tends to be more reliable and faster than one without and places less demand on network connectivity and Internet bandwidth use. Red Hat offers edge computing platforms on which edge-based applications for smart cities can be built and deployed.</td>
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<td></td>
<td>Industrial IoT</td>
<td>Honeywell Forge</td>
<td>Although consumers are the most frequent users of the IoT, it can also be used for industrial purposes such as manufacturing, supply chain monitoring, and management systems. Honeywell offers Honeywell Forge, a software solution that helps industry leaders see data coming from all parts of their operations so that they can transform their operations quickly and efficiently.</td>
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<td>CATEGORY</td>
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<tr>
<td>Connectivity and data infrastructure</td>
<td>Satellite imagery</td>
<td>EARTH-i</td>
<td>Satellite images are used to observe transport situations and help with infrastructure development decisions. EARTH-i helps companies and governments make better decisions by providing them with geospatial insight at a global scale. Some use cases that EARTH-i has introduced include preconstruction surveys and monitoring for maintenance.</td>
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<td>(Continued)</td>
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<tr>
<td>Ground mobility</td>
<td>Autonomous vehicles</td>
<td>Motional</td>
<td>Motional manufactures autonomous vehicles that will accelerate the transition from traditional to smart cities, with autonomous and electric shuttles replacing traditional public transport. With the decrease in use of privately owned cars and the increase in deployment of these shuttles, emissions and congestion from transport will decrease.</td>
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<td></td>
<td>Electric vehicles</td>
<td>Tesla</td>
<td>Tesla designs and manufactures electric vehicles that have environmental benefits over hybrid vehicles and internal combustion engine vehicles because they reduce noise and greenhouse gas emissions. Electric vehicles can actively promote development of the smart grid via two-way communications by deploying vehicle-to-grid and grid-to-vehicle communication.</td>
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<td>Hyperloop</td>
<td>Virgin Hyperloop</td>
<td>Hyperloop is a proposed high-speed transport system for passengers and freight. Virgin Hyperloop conducted the first human trial in November 2020 at its test site in Las Vegas, reaching a top speed of 172 km/h (107 mph).</td>
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<td>Three-dimensional printing</td>
<td>Run2Rail</td>
<td>A new European project is using carbon fiber and three-dimensional printing to design lighter, sturdier trains. If successful, the Run2Rail team could prove that three-dimensional printing methods and composite materials can be used to design trains that are more reliable, lighter, less damaging to tracks, more comfortable, and less noisy, all while reducing material waste.</td>
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<td>Three-dimensional network tunnel</td>
<td>Boring Company</td>
<td>Elon Musk’s Boring Company is developing a three-dimensional network tunnel consisting of a series of underground tunnels to serve electric vehicles and reduce traffic. Las Vegas has provided approval for the project to be built.</td>
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<td>Air travel</td>
<td>Flying cars</td>
<td>AeroMobil</td>
<td>The AeroMobil Company was established in 2010 to design, develop, and commercially introduce the world’s first flying car, which is scheduled for early 2023 and allows for traditional driving abilities on the ground coupled with the ability to fly in the air.</td>
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<td>Solar airplane</td>
<td>Solar Impulse</td>
<td>Solar Impulse is the first solar-powered airplane to fly around the world. After 14 months of travel and 550 hours in the air, it had traveled 25,000 miles around the world—two continents, two oceans, three seas—without any liquid fuel.</td>
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<td>Drones</td>
<td>DJI</td>
<td>DJI is one of the world’s leading drone manufacturers, with more than 50 percent of the global commercial drone market. DJI Drones can be used for everything from environmental monitoring to traffic management to provide cost-effective services to local governments.</td>
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<td></td>
<td>Gondola lift</td>
<td>TransMiCable</td>
<td>Bogota’s first urban gondola, TransMiCable, is a 3.34-km ropeway that is projected to benefit 700,000 residents living in some of the city’s most disadvantaged neighborhoods, making it the primary mobility option. The system is expected to reduce trips by up to 50 minutes, reducing a 1-hour bus trip to a 13-minute cable car journey.</td>
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Note: 5G=fifth generation; AI=artificial intelligence; IoT=Internet of things.


The next step in Foresight is scenario development, using drivers and signals as building elements. The market is complex, with many drivers operating in and affecting the transport sector simultaneously. With the trend toward automation and analytics in the transport sector to optimize operations, we chose technology development as a key driver of the future of mobility. Meanwhile, the COVID-19 pandemic has had downstream impacts in many areas, and we wanted to understand those impacts on transportation, so pandemic frequency was chosen as the other major driver. The team used those key trend areas of technology development and pandemic frequency as the critical axes and developed scenarios based on imaginable extreme situations for those two axes (Figure 7).

Because of the complexity of relationships between an infinite number of factors, future possibilities vary widely, so the process entails making additional assumptions based on many uncertainties and possibilities. For example, it was assumed that basic infrastructure such as roads existed in the regions of the scenarios. Even though reasonable attempts were made to guess the most common situations in Latin America and the Caribbean based on research, the assumptions do not necessarily hold true in some areas. With this in mind, when discussing scenarios in a specific region, uncertainties must be modified and updated through further analyses so that scenarios are relevant to the context. Figure 8 introduces major uncertainties that had to be considered when developing the scenarios for this report.

Personas are fictional characters created to illustrate the potential types of users involved with the topic of the exercise—the future of smart mobility—to capture their complexities and examine how they might behave in the future, given the different scenarios. Creating personas highlights users’ needs, experiences, behaviors, and goals while personalizing the underlying quantitative and qualitative data so that these scenarios can come to life. It also makes it easier to envision and interact with the various scenarios by capturing the texture and details. The four personas identified in this ecosystem were a commuter, an urban planner, the CEO of a mobility solutions firm, and a Transport Ministry official.
FIGURE 7. Scenarios According to Key Uncertainties: Technology Development and Future Pandemics

**The Widening 'Have' and 'Have Not' Gap**
A greater division of society, technology gaps from nation-to-nation are more pronounced.

**Impacts on Mobility in LAC**
1. Private sector offers innovative, cost-saving, & environmentally sound solutions, but unaffordable to some.
2. Increased public reliance on automobiles, sustainability effects suffer.
3. Public transport unsafe and unreliable.
4. Mobility managers forced to prioritize safety over game-changing investments.

**The Permanency of Hybrid Work**
Technology expansion. Telework has reduced CO₂ emissions, increased movement from cities. Concerns over privacy cyber security, gov't monitoring.

**Impacts on Mobility in LAC**
1. Public transport users expect bundled services during their commutes.
2. Private and public transport vendors struggle to balance consumer preferences with health and safety.
3. Public transport funding is lower while adaptation of safety measures and sustainability capabilities compete.

**The Return to Pre-Pandemic Life and Transportation Modes**
Emphasis on emission reductions and smarter urbanization. Transportation modes have advanced but not transformed.

**Impacts on Mobility in LAC**
1. Public investments in maintenance, safety measures, efficiency upgrades, but not real-time transport monitoring to improve consumer experience and reduce emissions.
2. Pressure for sustainability standards.
3. Private sector struggle to gain VC funding.

**The Emergence of a Digitized Data-Driven Society**
Cities and society transformed into interconnected transportation hubs. Transportation job market is booming.

**Impacts on Mobility in LAC**
1. Real-time data collection and monitoring enable safer and more efficient public transport.
2. Add-on services incorporated into public transit systems cater to commuters' needs.
3. Efficiency upgrades make transportation safer and more affordable.
4. Businesses are merging their services to support transit system growth.
FIGURE 8. Examples of Uncertainties with a Role in the Future of Smart Mobility in Latin America and the Caribbean

**CONNECTIVITY, E.G., 6G/5G/4G/3G/2G**
What will be the level of connectivity in urban and rural areas in 2030, and what role—if any—will satellite internet access have in improving accessibility?

**INFRASTRUCTURE, E.G., ROADS**
What will be the quality and availability of high-quality, safe infrastructure, especially given destabilizing phenomena such as climate change?

**POLITICAL STABILITY & TECHNOLOGY PRIORITIES**
Will COVID-19 and climate change affect political stability? Will the public sector adopt open source? Will cybersecurity capabilities support increasingly complex digitalization efforts?

**TECHNOLOGY DEVELOPMENT**
Will technological development be concentrated within private sector firms, or will governments be able to unlock technology for public smart mobility? What incentives and preconditions will need to be met?

**PANDEMIC FREQUENCY & AFFORDABLE ACCESS TO VACCINES**
Will governments be able to manage recurring pandemics with continued public health policy measures, and will they have access to effective, affordable vaccines as needed?

**HUMAN RESOURCES**
Will governments be able to attract and retain the type of digital skills they require to adopt smart mobility solutions and capabilities?

**BUDGET**
How will COVID-19 and climate change affect governments’ ability to fund innovative mobility projects? How will governments and communities sustain forward momentum in times of budgetary constraint?
Personas for Smart Mobility Foresight in Latin America and the Caribbean

45-year-old employee trying to get to work
» I depend on multimodal public transport (bus, train, walking) to get to work so that I can earn money for my family. I am unable to pay for higher-priced on-demand rides.
» My commuting experience is poor. There’s always lots of traffic, big crowds, bad air quality, interruptions for maintenance upgrades, and delays in each mode of transport. I have to leave the house very early to avoid delays and get to work on time.
» Safety concerns in public transport have been discussed in my city for a long time, but I don’t see great improvements.

32-year-old urban planner trying to fix and upgrade the city’s transit system
» I meet with multiple stakeholders such as public transport users, local government officials, and private companies to determine their priorities to make public transit efficient and safe.
» It’s hard to find consensus and coordinate stakeholder demands and funding priorities while trying to make our transport system smart, reliable, and accessible.
» I want to bring high-tech options into the service but don’t know how, and there are many legacy structures that are difficult to change.

52-year-old CEO leading an app-based rideshare service
» My service depends on technology and the underlying infrastructure to work with. It’s hard to avoid all the red tape of running a business while making a profit.
» I want to be innovative and improve the app by using the city’s big data, although it’s not always up to date and reliable.
» My business has suffered because of the pandemic, and people are not travelling as much as they used to. The pandemic and resulting policy changes make it difficult to predict the number of users. Also, pressure has increased to make sure it’s safe, reliable, and fast.

62-year-old Transport Ministry official
» I’m trying to catch up on new priorities of current ministers, but policy priorities change frequently as a result of elections. The least amount of change is most manageable, but I feel pressure to upgrade the transport infrastructure.
» There isn’t much money in the budget this year, so I need to prioritize policies while coordinating relationships with national and local politicians. Which investments do I support?
» My foremost priority is to make transport safe and reliable, which is a big challenge I deal with.
SCENARIO A
The Gap Between Haves and Have-Nots Widens
(Low Tech with Frequent Pandemics)

— In 2030, most people who need to commute to work are vaccinated because of the frequency of pandemics caused by COVID-19 variants, which results in greater division of society in terms of health conditions, educational opportunities, and professional status, and the world has yet to determine how to manage this.

— Frequent pandemics have created a world with less international trade, so the global technology gap has widened, and low-income countries have limited access to advanced technologies. Now the globe seems completely divided into two, and the lifestyle gap between them will increase for the foreseeable future.

— Countries with the capacity to invent and manufacture vaccines try to supply the world, and other countries rely completely on those countries and COVAX-type international pooled procurement mechanisms. The geopolitical influence from China is evident in terms of vaccine supply, and the United States invests more than any other country in Latin America and the Caribbean.

— In most economies, technology development is centered on concerns related to pandemics and includes some autonomous vehicles for safer, cleaner individual transport. Food and e-commerce delivery has increased over the past decade, resulting in development of autonomous delivery vehicles and drones. Legal and regulatory modifications support and accommodate these developments through an administrative process accelerated by general concerns related to frequent pandemics.

— Even within countries, the gap between rich and poor has widened. White collar employees maintain their lifestyle with remote work in less-dense areas, whereas employees in industries requiring their physical presence must choose whether to change jobs at the cost of temporary income loss or stay in their industry and face the risk of infection. Education suffers because of school closures, especially for poor people, because of lack of remote education access and the need to support their families.

— Fare collection on public transport remains largely a low-technology process, with fare cards that can be preloaded and refilled using cash or mobile money. Paper processes and cash transactions continue, especially in rural areas. Contact tracing of outbreaks linked to public transport remains a manual process, conducted via phone calls and in-person interviews.

— Governments often have a difficult time coordinating their policies and gaining national consensus, resulting in frequent political conflict.
» I feel unsafe taking public transport; it’s unreliable and not regularly maintained.
» I rely on public transport and cannot afford private sector solutions. Sometimes I’m unable to go to work when public transport is not available.
» Many of my colleagues who take public transport have been getting sick because of exposure to viruses in crowded spaces.

COMMUTER
Lucia

» It’s really frustrating to promote public transport when the pandemic and the economic situation are unpredictable.
» Spending money on reducing pandemic risk is the priority, and disinfection is done manually rather than investing in upgrades.
» To ensure that smart city initiatives succeed, I need to work with the private sector to offer innovative, cost-saving solutions.

URBAN PLANNER
Miguel

» It’s difficult to access the capital to provide highly innovative solutions that serve the public.
» I’m finding myself spending more money on making the transport service safer than on adding innovations and upgrades, requiring that I pivot in my business model.
» The customer base is unpredictable because of frequent lockdowns as a result of pandemics.

CEO OF MOBILITY SOLUTIONS
Maria

» I don’t have a budget to provide the public with innovations in transport while trying to respond to frequent pandemics.
» It’s difficult to promote public transport when people don’t feel safe taking it. There has been an increase in cars on the roads because of a preference for private ridership, and it’s affecting climate change commitments.
» I need to get creative to offer high-tech solutions, but the technology ecosystem is still immature, and it seems like there are not many good options.

TRANSPORT MINISTRY OFFICIAL
Ricardo
SCENARIO B
Hybrid Work Continues
(High Tech with Frequent Pandemics)

- In 2030, there are still frequent pandemics in various regions around the world, but society seems to have stabilized, supported by the evolutionary expansion of technologies in all areas of the economy. The pandemics have catalyzed societal transformation through pressure on governments and companies to minimize infection risks.

- Frequent pandemics have led to a global digital transformation. For example, fear of human interaction hastened the process of autonomous vehicle adaptation, with a preference for individual vehicles over mass transit, and the increase in demand for e-commerce and food delivery called for unprecedented investment and regulatory change in drones, which now can be seen everywhere.

- A remote-based work style has become the default because many people can work from anywhere. Many people have moved to the countryside, reducing the urban population and increasing the suburban population. Companies in Latin America and the Caribbean leverage technologically skilled professionals from around the world because workers’ locations are not important anymore. In the meantime, Latin America and the Caribbean attract remote workers; the two most popular destinations are Medellín, Colombia, and Buenos Aires, Argentina, for their rich culture and digital infrastructure.

- Some cities promote the “Crypto City” concept, whose aim is to build a city with a decentralized governance system. “Crypto City” minimizes the transaction costs of administrative processes by using distributed ledger technologies.

- After work, people tend to stay in the metaverse, where human interaction, shopping, asset exchange, and entertainment are available, backed up by nonfungible tokens, without leaving home. Drones or robot cars deliver objects that are bought in the metaverse and deliver them within 1 to 2 hours. All became possible because of technological development and regulatory reform, accelerated by frequent pandemics.

- Fare collection on public transport moves to mobile devices, with passengers able to pay using a digital wallet. Public health authorities use fare collection data to forecast pandemics using AI and machine learning.

- Privacy concerns and cybersecurity risks are not addressed, and the potential for government monitoring of everyone’s movements is a long-standing challenge, although most consumers have lost interest in this topic.
» I want to be productive while commuting to my job. This influences my transport decision making because many companies provide add-on services during my commute, such as entertainment, shopping, doing errands, paying bills.

» I do not have to use public transport alone because I can afford ridesharing and on-demand ride systems once in a while since the cost has decreased, although it is still expensive for me.

» As remote work becomes the default, we are considering removing noncritical transport infrastructure.

» I have needed to add ventilation and health compliance to make sure transport is safe during pandemics on all modes of transport.

» I can use data collected through the transport ecosystem to optimize the transport mode, but I must be diligent about protecting data privacy and ensuring cybersecurity.

» How do I handle the liability if someone gets sick on my ride? I must ensure that health and safety measures are monitored and enforced.

» I’m adding pandemic tracking as part of my service suite so my customers feel safer.

» I have heard that a major competitor of mine just terminated its service. The transport market size is unpredictable because of the pandemic.

» It’s difficult to determine the best investment for my budget. I’m choosing high tech and high safety, which requires pandemic monitoring technologies for public transport.

» I feel pressure to choose between strong sustainability standards and safety during pandemics.

» I’ve found myself working increasingly with city officials to make transport safe.
SCENARIO C
Return to Business as Usual (Low Tech without Pandemics)

– The years when the pandemic was widespread are treated as a unique period in history by 2030, and things are returning to normal, with social trends from before COVID-19, such as urbanization and mass transport, returning. Transportation modes are a continuation of current modes rather than a complete transformation.

– Investment in transport technology keeps growing because attention is being paid to greenhouse gas emissions and urbanization, although international bodies and governments are finding it difficult to develop a national strategy to set a clear direction for industry because of political disagreement.

– Pressure to boost climate adaptation encourages people to adopt nonmotorized transport modes such as walking and cycling, which requires modifications in rules and legislation to ensure safety.

– In response to climate change, people have begun to give up cars and use public transport, increasing the use of mass transit, car sharing, and on-demand ride services. When necessary, people rent cars or call an on-demand service, especially in urban areas. Three-dimensional printing and investment in new carbon materials has created more efficient, environmentally friendly, cheap rail service.

– The transport industry is still labor intensive in most cities, and advanced mobility solutions such as autonomous vehicles are available only in the largest cities (Mexico City, Sao Paulo, Buenos Aires, Bogota, Santiago), where technological capability and the necessary infrastructure, such as fifth- and sixth-generation mobile telecommunications technology are available.
» I just want to get to my job on time and without hassle at the lowest cost; the usability and efficiency of public transport have not changed drastically in the past decade even though the government stresses its efforts to adopt emerging technologies in transport.

» I use public transport; even though it’s not always reliable, it’s the most cost-effective option for me.

» I wish the government would invest in safe, eco-friendly solutions for public transport.

COMMUTER
Lucia

» I feel like transport-related industries are not eager to change. Digital transformation has been a hot topic since the late 2010s, but I’ve had a hard time creating consensus among stakeholders in public transport.

» Climate change–related technology is easy to implement because of strong interest of politicians.

» I wish I could promote technologies that lead consumer behavioral changes, such as real-time transport monitoring to make public transport more convenient, so we can curb emissions.

URBAN PLANNER
Miguel

» How do I provide the best, most-innovative service when it is hard to get government support to implement? How can I collaborate with governments better?

» I need to be creative to obtain funds for my real-time apps so I can provide better, timely customer service.

» Climate change has been a major factor in the transport sector, and maybe I need to diversify the services that I offer so they are carbon free, such as bicycle sharing services.

CEO OF MOBILITY SOLUTIONS
Maria

» Because the pandemic is not the biggest concern anymore, people have started to move around again, and carbon dioxide emissions have increased. Climate change is again the administration’s greatest concern.

» The roads are safer than 10 years ago. Monitoring mechanisms in urban areas are reliable and accepted.

» I need to be creative and develop strategies to encourage private sector participation in eco-friendly transport solutions.

TRANSPORT MINISTRY OFFICIAL
Ricardo
SCENARIO D
Private Sector Blossoms
(High Tech without Pandemics)

- In 2030, people barely remember when COVID-19 was widespread around the globe. Technology has gained political support and the funding necessary to make society more digitized and data driven.

- AI-based data analysis services have become a critical part of local decision making for city planning. Data from individual vehicles are collected through IoT devices and traded in a distributed ledger technology–based ecosystem for local administrative processes and for the private sector to develop services and products.

- Technologies to solve challenges related to demographic and climate change have advanced drastically. Increased investment has enabled innovative projects to provide inclusive transport and decrease temperatures globally.

- Flying cars are becoming closer to reality. Some countries with strong technological capability have implemented legal and regulatory reforms for this new mode of transport. International travel by flying cars is still not allowed in 2030, although it is expected that it will be soon.

- Fare collection on public transport has moved to mobile devices, with passengers able to pay using a digital wallet. On days when air quality is poor, fares for public transport automatically decrease to encourage citizens to use greener modes of transport. Buses and trains are powered almost entirely with renewable resources (e.g., solar, green hydrogen, wind).

- Several startups, backed up by local finance, have developed new transport modes and merged with tech giants.
» I feel safe taking public transport and see that real-time monitoring and services make using it an easy choice. The rapid bus is so affordable that I am able to use it regularly.
» Although I do not know much about technology, the benefit I am gaining through data-sharing platforms and AI is apparent, and I do not have much concern about privacy.
» I am still skeptical about the safety of new transport modes such as flying cars.

COMMUTER
Lucia

» I am able to develop strategies to implement efficiency upgrades and real-time monitoring of transport systems.
» Transport upgrades have led to people viewing public transport as reliable and efficient and the most cost-effective choice for most people, particularly poor and vulnerable people.
» People are interested in advanced transport modes, but I do not believe we can propose such modes anytime soon, mainly because of lack of funding.

URBAN PLANNER
Miguel

» Smart mobility has become a huge investment trend because of government support of transport system upgrades.
» Private companies, including mine, are seeing the widening gap between existing public transport systems and what society wants as a huge business opportunity.
» My goal is to develop an app-based service in the region and sell the business to a tech giant that can implement the solution in other countries.

CEO OF MOBILITY SOLUTIONS
Maria

» My work portfolio is completely different from that of 10 years ago. Automated maintenance of the transport system is fully functional, and I do not need to worry about it much.
» I am confident about my expertise in tech infrastructure and can start planning for autonomous vehicles while retraining people for the workforce of the future.
» Budgetary restrictions are still a challenge but in a different way than before. The region’s dependency rate is expected to start to rise sometime soon, and we may face an economic downturn. We need to create a sustainable budgetary strategy.

TRANSPORT MINISTRY OFFICIAL
Ricardo
Key Takeaways and the Role of Governments

Key Takeaways

The Foresight exercise provided some useful takeaways.

1. **Technology is key to shaping the future.**
   - Regardless of the pandemic situation, investment in technology can lead to better transport systems, although technological solutions are different under each scenario.
   - Data collection, management, and use are key components in high-technology scenarios, and sensitive data handling and cybersecurity are going to become priorities for government organizations and private companies.

2. **Frequent pandemics are triggers for social transformation.**
   - Frequent pandemics widen the economic gap within and between countries and create a weak, unpredictable customer base, leading to a decrease in funding. Pandemics create momentum for drastic policy change to update transport through regulatory reform and support of safe transport.
   - Frequent pandemics will cause technology to become completely different. More-individual and -automated transport options become the default. Without frequent pandemics, the future transport system is expected to be similar to the current one.

3. **Climate change will be a key driver of policy consensus.**
   - Under scenarios of less-frequent pandemics, climate change remains a major political concern, which helps politicians reach policy consensus to advance greener transport. Pressure for climate adaptation generates investment in upgrading mobility solutions, which focus on mass transit and environmentally friendly mobility modes such as walking and cycling.
   - With increased concerns about climate change and mass transport becoming the default, car ownership and use decreases drastically, changing urban landscapes.

4. **Demographic change significantly influences the future of mobility.**
   - Latin America’s and the Caribbean’s dependency rate is expected to start to rise in the 2030s, and the favorable demographic “window” will close. This change requires a long-term sustainable budgetary strategy for governments to account

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Because of limitations in public resources, the role that the private sector plays in providing transport becomes much larger, and hiring technology experts may become difficult for certain companies.

Role of National and Regional Governments

The team developed recommendations for national and regional government entities, but because this report’s Foresight exercise was held at a high level, it did not incorporate specific country contexts.

ROLE OF NATIONAL GOVERNMENTS

1. Develop national strategies to foster smart mobility through strategic investment, consumer protection, and standard setting.
   - Invest in research and development of technology infrastructure and building blocks for smart mobility.
   - Support new requirements for consumer protection, data privacy, and explainability of algorithms to avoid bias and data exclusion errors.
   - Establish data-exchange mechanisms through standard setting and encourage open data.

2. Bridge the gap between haves and have-nots that COVID-19 exacerbated.
   - Seek ways to address inequalities by making mobility more affordable and convenient for poor people.

3. Refer to smart mobility scenarios to develop an action roadmap suitable for cities by considering local context.
   - Components specific to this Foresight exercise such as key uncertainties, drivers, and signals of change should be fine-tuned for future iterations depending on the local context.
   - Consult with technology stack (Appendix A) and smart mobility examples (Appendix B) in this report to determine implications and ideas for policy development.

20 These recommendations are not exhaustive.
ROLE OF REGIONAL GOVERNMENTS

1. Pursue social innovations through partnerships with the private sector, communities, and academia to encourage digital solutions.
   - Develop infrastructure and policies to encourage all stakeholders to play a larger role in enabling smart mobility. Deepen knowledge of technology-enabled business and funding models.
   - Explore ways to close the gap between existing skills and skills needed to develop emerging technologies, considering that use of emerging technologies requires expertise.

2. Anticipate and mitigate emerging technology risks.
   - Support and certify data protection and cybersecurity for technology lifecycles.
   - Ensure and encourage responsible adoption of emerging technologies following national and international standards.

3. Address digital exclusion in mobility.
   - Ensure access to transport for vulnerable groups such as the urban poor, women and girls, older adults, and digitally unconnected groups.
Inspirations to Develop Future Action Plans

This section introduces some ideas and frameworks for developing action plans as sources of inspiration. The Foresight exercise conducted for this report was not intended to create action plans for any specific city because action plans depend on local context. Readers should use these inspirations as a starting point for the process of developing concrete action plans.

Assessing Gaps Between Current and Future Status of Smart Mobility

To develop a roadmap for future actions, smart mobility maturity dimensions (Figure 9) should be considered. Users will be able to measure and address gaps between the current and future state of smart mobility by using these dimensions:

1. Leadership and governance
2. Stakeholder engagement and citizen focus
3. Effective use of data
4. Integrated information and communications technology infrastructure
5. Existing levels of smartness

There are two steps users can take to leverage smart mobility maturity dimensions. In the first step, the current state of these five dimensions is mapped out, and smart mobility goals are mapped against the current state, processed, and tailored accordingly. In the second step, users gain insight from global best practices of similar cities and countries, and a smart mobility vision and strategy are developed. A goal map shows stakeholders what they need to accomplish and allows them to strategize on how to accomplish them.
Smart Mobility Framework

**1ST STEP**
SMART MOBILITY MATURITY ASSESSMENT
- Current state baseline across all smart mobility maturity dimensions (1-5)
- Future smart mobility ambitions articulated in line with expectations of maturity
- Processed results and tailored analysis

**2ND STEP**
SMART MOBILITY STRATEGY & PRIORITIZATION
- Global best practice insights & comparisons to similar cities
- Smart mobility ideation, vision, and strategy
- Prioritized roadmap & business case to execute smart mobility goals

Defining Future Technology Capabilities and Architecture

Emerging technologies are a critical component of smart mobility. This report covers several frequently used technologies, including autonomous vehicles, drones, the metaverse, AI, blockchain, and IoT. Figure 10 illustrates the use of these technologies, divided into two categories.

- The first category is primary area of opportunity, where technologies that work as infrastructure or generic enablers are located.
- The second category is secondary area of opportunity, in which more complicated technologies that require combinations of elements from the first category are classified. Appendix A provides detailed descriptions of some of these technologies.

Figure 11 illustrates a generalized technology architecture designed to handle data through various layers. Digital device users and citizens living in the city produce data, which are collected and initially handled through technology devices such as street cameras and smartphones and transmitted via IoT. Data collected in the technology layer are then stored in the data layer, where they can be merged and integrated with additional data, such as identity data. When various types of data are integrated, they can be used to develop technology capabilities such as AI in the capability layer. Finally, capabilities developed based on data will be used to provide a smart mobility experience to users and citizens through solutions in application layers.
**FIGURE 10. Smart Technology Building Blocks**

<table>
<thead>
<tr>
<th>Secondary area of opportunity</th>
<th>Autonomous vehicles</th>
<th>Drones Unmanned aerial vehicles</th>
<th>Metaverse</th>
<th>Digital Twin</th>
</tr>
</thead>
</table>
| Technologies dependent on data infrastructure, AI, connectivity, & real-time compute. | • Connected autonomous vehicles  
  • Traffic pattern optimization  
  • Driver & pedestrian safety  
  • Less energy consumption  
  • Need AI & infrastructure connectivity, edge computing | • Traffic & city monitoring  
  • Fast, safe delivery  
  • Need AI, infrastructure connectivity, edge computing | • Citizen and engagement services  
  • Augmented and virtual reality capabilities  
  • Need infrastructure: mobile broadband, AI, IoT, digital twins | • Digital representation of mobility across cities, regions, countries, connected  
  • Need infrastructure – mobile broadband, AI, IoT, three-dimensional mapping |

<table>
<thead>
<tr>
<th>Primary area of opportunity</th>
<th>Blockchain</th>
<th>Edge computing</th>
<th>Data platforms</th>
<th>Artificial intelligence (AI)</th>
<th>Infrastructure connectivity</th>
<th>Internet of things (IoT)</th>
</tr>
</thead>
</table>
| Invest in data infrastructure, IoT, and high-speed mobile broadband required for connection and handling data for optimization | • Blockchain-based Internet of vehicles  
  • Secure, trustworthy ride sharing & car-pooling | • High-speed computing near the user & data locations.  
  • Computer resource distribution across networks | • Big data analytics for city management  
  • Open data initiative for public and private use  
  • Three-dimensional geographic data to include locations and maps to connect entire mobility infrastructure | • Traffic management  
  • Surveillance and security  
  • Administration & planning management | • Enhanced mobile broadband  
  • Required infrastructure for massive IoT solutions  
  • Real-time autonomous vehicle navigation  
  • Low earth orbit and medium earth orbit satellites providing connectivity | • Smart utility meters  
  • Traffic monitoring  
  • Smart grids  
  • Water level monitoring  
  • Video surveillance  
  • Connected streetlights |
FIGURE 11. Generalized technology architecture

Disclaimer: For illustrative purposes only.
Incorporating Time Needed for Technology Adoption

Figure 12 illustrates how technologies could be classified according to time needed to adopt and the importance of considering that time when implementing policies to enable technologies. The speed of technology adoption changes according to future discoveries and national and municipal contexts.

Figure 12. Timeline for Adoption of Technological Applications for Smart Mobility

<table>
<thead>
<tr>
<th>Micro-mobility, on-demand rides</th>
<th>Connected mobility infrastructure</th>
<th>Traffic infrastructure monitoring with Internet of things sensors, drones</th>
<th>Three-dimensional printing for transport parts</th>
<th>Robotics services</th>
<th>Metaverse capabilities for transport, augmented &amp; virtual reality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Digital solutions for shared mobility</td>
<td>Connected mobility infrastructure</td>
<td>AI for predictive maintenance &amp; safety</td>
<td>Enhanced mobile broadband</td>
<td>Blockchain tokens and crypto cities</td>
<td>Quantum computing</td>
</tr>
<tr>
<td>Digital twins, three-dimensional spatial imaging</td>
<td>Cities platform</td>
<td>Electric mobility and low carbon/carbon neutral</td>
<td>Mobility analytics and prediction</td>
<td>AI in traffic management</td>
<td>Flying cars</td>
</tr>
<tr>
<td>Multimodal mobility shared mobility, mobility as a service</td>
<td>AI in surveillance &amp; security</td>
<td>AI-based planning, optimized infrastructure</td>
<td>Fifth-and sixth-generation connectivity</td>
<td>Connected and autonomous vehicles</td>
<td>Satellite Connectivity</td>
</tr>
</tbody>
</table>

NEAR TERM (1-3 years) | TIME TO ADOPTION (3-7 years) | LONG TERM (7-15+ years)

Disclaimer: Technical adoption speed may vary depending on a social context. The diagram above is for illustrative purposes only.

Note: AI=artificial intelligence
Another way to include time needed for technology adoption is a hype cycle (Figure 13), which is a graphic used to represent the maturity, adoption, and social application of a technology. Lessons learned in the market are incorporated before the technologies move to the plateau of productivity and become mainstream.

**Figure 13. Hype Cycle for Connected Vehicles and Smart Mobility**

![Hype Cycle for Connected Vehicles and Smart Mobility](https://www.sae.org/news/2020/09/2020-hype-cycle-for-connected-vehicles-and-smart-mobility)

<table>
<thead>
<tr>
<th>Category</th>
<th>Time to Plateau</th>
</tr>
</thead>
<tbody>
<tr>
<td>Innovation Trigger</td>
<td>less than 2 years</td>
</tr>
<tr>
<td>Peak of Inflated Expectations</td>
<td>2–5 years</td>
</tr>
<tr>
<td>Trough of Disillusionment</td>
<td>5–10 years</td>
</tr>
<tr>
<td>Slope of Enlightenment</td>
<td>more than 10 years</td>
</tr>
<tr>
<td>Plateau of Productivity</td>
<td></td>
</tr>
</tbody>
</table>


**Key takeaways**

- Gartner Inc.’s annual **Hype Cycle** has become a much-anticipated metric of the maturity and market viability of numerous technologies related to automated driving and new mobility.
- For 2020, the COVID-19 pandemic has disrupted the technology-development chain.
- Data marketplaces and exchanges, blockchain, the Internet of things, digital personalization, micro-mobility, mobility as a service, and virtual assistants have become mainstays of smart mobility.
- “Over the next five years or so, many technologies on this Hype Cycle will become productive parts of the automotive and smart-mobility ecosystem.” Prediction for 2025
Designing an Action Roadmap

An action roadmap should be developed to start to determine priorities aligned with goals and technology capabilities in the short, medium, and long term (Figure 14). Goals and elements of the future include cleaner environment, climate resiliency, sustainable transport systems, inclusivity, and safety. This is a starting point and is meant to be enhanced and reiterated as emerging capabilities become effective and local, regional, and national priorities change.

**Figure 14. Sample Action Roadmap for Smart Mobility**

<table>
<thead>
<tr>
<th>SHORT-TERM</th>
<th>MID-TERM</th>
<th>LONG-TERM</th>
<th>Goals and elements of the future you want to make</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1–3 years)</td>
<td>(3–7 years)</td>
<td>(7–15+ years)</td>
<td></td>
</tr>
<tr>
<td>• Perform community outreach for priorities, digital training</td>
<td>• Invest in drones to monitor traffic patterns</td>
<td>• Metaverse - invest in citizen engagement services for transport and supporting infrastructure</td>
<td></td>
</tr>
<tr>
<td>• Invest in electric mobility &amp; low carbon solutions</td>
<td>• Invest in digital twins, three-dimensional geographic mapping</td>
<td>• Invest in augmented, virtual, &amp; mixed reality capabilities</td>
<td></td>
</tr>
<tr>
<td>• Develop integrated information and communications technology infrastructure to support innovation</td>
<td>• Invest in autonomous vehicle infrastructure, computer vision, AI capabilities, connectivity, edge computing</td>
<td>• Invest in autonomous vehicles, connected autonomous vehicles, &amp; supporting infrastructure</td>
<td></td>
</tr>
<tr>
<td>• Open public data through data sharing standards and protocols</td>
<td>• Exploring blockchain economy, tokens to encourage consumer behavior &amp; nonfungible tokens for financing</td>
<td>• Invest in &amp; develop robotics capabilities in transport sector</td>
<td></td>
</tr>
<tr>
<td>• Invest in three-dimensional geographic data to include locations and maps to connect entire mobility infrastructure</td>
<td>• Continue developing data platform infrastructure and AI capabilities for forecasting and prediction</td>
<td>• Develop further automation capabilities in transport sector</td>
<td></td>
</tr>
<tr>
<td>• Develop data platforms infrastructure, three-dimensional geographic mapping</td>
<td>• Continue developing connectivity infrastructure</td>
<td>• Smart infrastructure</td>
<td></td>
</tr>
<tr>
<td>• Develop connectivity, mobile broadband infrastructure</td>
<td>• Continue investing in IoT solutions and edge computing to support high-speed computing near user &amp; data locations</td>
<td>• Safe infrastructure</td>
<td></td>
</tr>
<tr>
<td>• Invest in IoT sensors to connect infrastructure</td>
<td>• Explore blockchain capabilities</td>
<td>• Climate resilient</td>
<td></td>
</tr>
<tr>
<td>• Invest in edge computing</td>
<td></td>
<td>• Low carbon or carbon neutral</td>
<td></td>
</tr>
<tr>
<td>• Develop AI capabilities for traffic management, surveillance, planning, maintenance, safety</td>
<td></td>
<td>• Community accessibility &amp; inclusiveness</td>
<td></td>
</tr>
<tr>
<td>• Explore blockchain capabilities</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Adapted from Institute for the Future “Foresight Toolkit”

Note: AI=artificial intelligence; IoT=Internet of things.
Appendices
Emerging Technology Opportunities

Artificial Intelligence

Artificial intelligence (AI) is critical technology with great potential to change smart mobility. Urban AI can be defined as “artifacts operating in cities, which are capable of acquiring and making sense of information on the surrounding urban environment, eventually using the acquired knowledge to act rationally according to pre-defined goals, in complex urban situations when some information might be missing or incomplete.”\(^{21}\) It is expected that AI will enable more than 30 percent of smart city applications, powering the top urban mobility solutions by 2025.\(^{22}\)

AI in Surveillance and Security

AI-powered surveillance systems have capabilities such as face recognition, license plate recognition, suspicious behavior alert, and traffic misconduct alert.

AI in Traffic Management

AI-enabled traffic management solutions vary widely. For example, AI has introduced smart traffic signals that adjust their timing according to the flow of traffic to respond to real-time traffic, reducing road congestion. Route optimization and real-time forecasting allow computer vision models to capture dynamic changes in traffic and document congestion flow as vehicles move throughout the day. Connected cars can communicate with parking meters and electric vehicle charging docks and direct drivers to the nearest available spot. AI-based computer vision applications identify objects through surveillance cameras and can detect vehicles that disobey traffic laws such as by speeding or running a red light.

AI Administration and Planning Management

AI networks provide a complete picture of population density and traffic flows around a city, which can help governments optimize resources for better urban planning.

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Internet of Things and Connectivity

The Internet of things (IoT) is a network of physical objects with sensors, processing ability, software, and other technologies that connect and exchange data with other devices and systems over the Internet or other communications networks. The IoT is frequently used in smart mobility and smart cities. Connected sensors, lights, and meters collect and analyze data and combine them with other data to provide further real-time analysis to the city. Public sector entities and policy makers can leverage these data to improve infrastructure, public utilities, and services.

Electric Vehicles and Charging Stations

Electric vehicles are growing in use, and electric vehicle charging stations are being deployed at an increasing rate in smart cities. These charging stations are connected to a smart energy grid, allowing utility companies and cities to manage energy flow more effectively.

Connected Vehicles

The market for connected vehicles is growing fast, and adoption of smart transit is increasing in tandem. New York City is piloting a connected vehicle project to reduce traffic-related deaths and injuries and damage to vehicles and infrastructure. The connected vehicle infrastructure is focused on safety applications, relying on vehicle-to-vehicle, vehicle-to-infrastructure, and infrastructure-to-pedestrian communications.23

Traffic Monitoring

The IoT can help manage traffic flow. For example, to increase mobility on congested local highways and streets, the Los Angeles Department of Public Works implemented several multi-jurisdictional intelligent transport systems, embedding a network of sensors in the pavement that transmit real-time traffic updates to a traffic management platform that adjusts the timing of traffic signals to optimize traffic flow.24

Video Surveillance

Smart video surveillance using cameras and IoT devices is commonly used to police roads and highways. Law enforcement uses automatic license plate recognition cameras to identify stolen cars, for traffic control purposes, to collect tolls, and to deter crime.25

Connected Streetlights
Cites are using connected streetlights to reduce energy and maintenance costs, increase public safety, and reduce environmental impact. Connected streetlights can be used to charge electric vehicles, monitor emissions, and provide wireless broadband connection points.26

Robotics
Autonomous vehicles, also called driverless or self-driving cars, can navigate without a driver. They monitor their surroundings using a variety of technologies such as visual sensors, radar (using radio waves to determine range, velocity, and angle of objects), LiDAR (measuring distance by shining a laser onto a target), odometry, and night vision. The input is processed using AI and transformed into orders that the car systems execute without human intervention. Numerous technology companies, car manufacturers, and ride-sharing companies are collaborating to develop autonomous vehicles and supporting technologies.

Connected autonomous vehicles, which use AI and real-time cloud-based data to choose the fastest, most-fuel-efficient routes, can help meet economic, social, and sustainability goals.27 They can be programmed to follow rules for maximum efficiency all the time—in contrast to human drivers, who tend to overuse the accelerator and brakes, which burns excessive fuel. Self-driving cars have the potential to cut energy consumption in transport by up to 90 percent. This is an economic and an environmental benefit, with reduced fuel consumption decreasing carbon emissions.28

Drones offer many benefits, including cost-effective services such as environmental monitoring and traffic management, offering real-time data on traffic conditions. They can also be used to inspect and maintain infrastructure and map out transport projects, create more-efficient bus routes, and identify good places for bike paths.29

---


Blockchain

Blockchain can enable many consumer applications. Collective ride sharing and car-pooling can be made more secure, transparent, and trustworthy through blockchain, which can combine multiple sources to verify drivers to create trust and accountability for passengers. Drivers receive authentication credentials in the form of a digital identity card that includes biographic and biometric data for verification. Smart contracts enable users to share their encrypted data with the blockchain network and enact transactions with other participants once both parties agree to transaction rules. Manufacturers of the systems that support autonomous vehicles to enhance safety measures are also using blockchain and smart contracts to ensure the authenticity and integrity of the firmware update process.

Mobility as a Service

Mobility as a service (MaaS) is a growing model that focuses on seamless integration of transport modes enabled by digital solutions. This integration covers transit-sharing services such as car sharing, ride sharing, bike sharing, buses, trains, trams, and scooters and can reduce the number of vehicles on the road. Major players in the on-demand ride industry have been integrating supplemental transport models such as electric bike and scooter services, often called micro-mobility, into their existing platforms, including rental services such as Uber Jump, Lyft Scooters, and GrabWheels. The model offers temporary use of various means of transport without the user having to own a transport mode. With this model, consumers avoid expenses and challenges associated with ownership, such as capital and maintenance costs, insurance, and parking. Another benefit of MaaS platforms is that they integrate various mobility options, including prices and means of transport, into one ecosystem with a single payment method, streamlining the experience for consumers.

Digital Twins

Digital twins\textsuperscript{34} will be an important component of three-dimensional mapping to simulate the urban environment, which will enable policy makers to preview how different investments, such as a transit system upgrade, might affect people and their environment. Important use cases include modeling traffic congestion strategies, mapping out the smart mobility infrastructure, and achieving net-zero climate goals by testing energy-saving technologies. Digital twins could reduce the need for corrections and adjustments once a project has been built, which can be expensive. According to a report by global tech market advisory firm ABI Research, digital twins could save cities US$280 billion by 2030.\textsuperscript{35}

Metaverse

A metaverse is “a collective virtual open space, created by the convergence of virtually enhanced physical and digital reality,”\textsuperscript{36} often leveraging augmented, virtual, and mixed realities in three dimensions from the consumer point of view. Even though adoption of metaverse technology is in early stages, it is envisioned that various activities taking place in real life such as shopping, socializing, and building houses will eventually take place in the metaverse. Development of the metaverse also provides great potential with respect to smart mobility. The metaverse is nascent, but public- and private-sector entities are starting to explore and use it to engage with customers and promote brand potential. The smart mobility sector is also slowly leveraging metaverse technology and its applications. For example, Hyundai Mobility Adventure is the first virtual experience content on Roblox (a global gaming platform) developed by a global automotive brand to showcase future mobility lifestyles in the metaverse.\textsuperscript{37} U.K.-based carmaker Jaguar Land Rover uses augmented reality technology to train employees, such as teaching them how to repair cars in a virtual space.\textsuperscript{38}

\textsuperscript{34} Digital twins are virtual models on which simulations of new policies or infrastructure projects can be run and their potential impacts previewed before making a decision in the real world. See \url{https://www.bloomberg.com/news/features/2022-04-05/digital-twins-mark-cities-first-foray-into-the-metaverse}.


**Electrification**

Adoption of electric vehicles is increasing rapidly because of the increase in public awareness of the need to protect the environment, as well as decreases in production costs. Replacing fossil fuels with electrification has been a major shift for the industry. Electrification helps create a cleaner urban space by reducing fossil fuel–related emissions (e.g., carbon dioxide, carbon monoxide, various nitrogen oxides, particulate matter), noise pollution, and waste associated with gas-powered vehicles. Electrification has also enabled micro-mobility solutions such as electric bikes and scooters for shorter trips and smart infrastructure such as photovoltaic roads and sidewalks.

**Quantum Computing**

Quantum computing allows calculations and computations to be performed much more quickly than on traditional computers. It is not yet a proven technology, but investment has been growing. National governments have invested more than US$25 billion in quantum computing research. Quantum bits, called qubits, can be in a mixed state, in which they are 1 and 0 at the same time, rather than only two possible states, as with binary language (1 and 0), which allows for a high compute state. Quantum computing can greatly affect many sectors of society at a fundamental level and be used with IoT devices to connect and improve how entire cities operate, with efficiency gains in public transport; rapidly verify IoT devices; and optimize IoT systems, with large amounts of data being transported over multiple networks.

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APPENDIX B

Smart Mobility: National and International Examples

National-Level Use Cases

Some countries have been promoting smart city policies since the 2010s. This appendix describes how various countries have created smart mobility strategies and set up their pillars, infrastructure, platforms, and applications to build smart cities. Table B.1 highlights national level use cases. The examples cited here are for illustrative purpose and are not exhaustive.

### TABLE B.1. Smart Mobility Components and Use Case Overview

<table>
<thead>
<tr>
<th>COUNTRY</th>
<th>PILLARS</th>
<th>INFRASTRUCTURE</th>
<th>PLATFORMS</th>
<th>EXAMPLES</th>
</tr>
</thead>
</table>
| ASIA: Japan | • Eco-cities (Environmentally symbiotic cities)  
• Transit-oriented development)  
• Disaster-resilient cities | The data-driven smart cities that Japan is working on involve a bottom-up approach to realizing data-driven smart cities by integrating digital transformation that is underway in various fields. This will also assure free, trustworthy, credible norms by focusing on privacy and security. | • Data linkage platform  
• Super City can ask governments to provide data  
• Data linkage platform is required to follow the safety standard and open the APIs to the public. | Otsumi City and Mount Hieizan: In addition to free digital passes for multiple public transport systems, providing MaaS that can be used at hotels, tourist facilities, retail stores, restaurants, etc. to promote excursions using public transport. |
<table>
<thead>
<tr>
<th>COUNTRY</th>
<th>PILLARS</th>
<th>INFRASTRUCTURE</th>
<th>PLATFORMS</th>
<th>EXAMPLES</th>
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</thead>
</table>
| South Korea | • Research development  
  • Smart Solution Challenge  
  • Deregulation  
  • National pilot program for smart cities | Korean Research Institute for Human Settlements classified the Smart City in three types: a smart city equipped with advanced infrastructure, a platform-centered smart city, and a smart city for innovation space. | The government plans to expand integrated platform distribution to 229 local governments nationwide by 2023 and establish a regional center that will serve as a hub by linking the basic local government with police, fire brigade and ambulance service. The goal is to improve crime prevention, disaster prevention, and traffic operated by local government | Several Cities started to introduce platforms in various areas such as social welfare, transportation, water management, better management etc. For example, Seoul introduced a blockchain-based platform to store and verify citizen’s information; Busan created a platform for monitoring the quality of water |
| Singapore | • Digital economy  
  • Digital government  
  • Digital society | Singapore is continuously upgrading its information technology infrastructure, data collection & analytics, telecommunications, & mobility solutions to power holistic transformation. One relevant technology is the Internet of Things, and it is expected to improve the urban infrastructure. | Most transactions between citizens and the government can be done online, and the number of integrated apps that reduce the time needed to fulfill inter-agency requests has been growing, but such efforts have been sporadic, or agency led. A central coordinating entity can accelerate the process, which was why the Smart Nation and Digital Government Group was formed in May 2017. | Singapore launched five strategic national projects (National Digital Identity, E-payments, Moments of Life, Smart Nation Sensor Platform, & Smart Urban Mobility), most of which are digital platforms upon which more use cases can be explored over time. |
<table>
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<tr>
<th>COUNTRY</th>
<th>PILLARS</th>
<th>INFRASTRUCTURE</th>
<th>PLATFORMS</th>
<th>EXAMPLES</th>
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<tr>
<td><strong>AMERICA</strong></td>
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</table>
| Brazil      | Since 2009, when it was chosen to host the Olympic Games, Rio has experienced one of the greatest urban transformations in its history, with more than 200 structural works and initiatives simultaneously executed in the areas of infrastructure, mobility, accessibility, the environment, social integration, and connectivity. | • More than 30 agencies and 500 professionals working 24 hours a day/7 days a week  
• Video wall with 100 47-inch full high-definition LED screens  
• More than 1,000 video surveillance cameras  
• More than 15,000 sensors monitored  
• Geoportal system with more than 250 thematic layers  
• Adoption of new system, apps, and social networks | • The Rio Operations Center Integration Platform is a core service-oriented technology platform based on open standards and rules that allow multiple data sources to be interconnected and provides services for consumption by other applications.  
• Data from various sources are received through various protocols (FTP, SOAP, REST) in different formats (XML, JSON, KML, GeoJSON) and monitored for integrity and availability. | GeoPortal is a smart map. The Rio Operations Center monitors and adds transport, traffic, weather, and rainfall information; location of schools and hospitals; social media applications; and other information that could affect citizens’ routines to this map. |
<p>| United States | In December 2015, the Ministry of Transport launched the Smart City Challenge, asking mid-sized cities across America to develop ideas for an integrated, first-of-its-kind smart transport system that would use data, applications, and technology to help people and goods move more quickly, cheaply, and efficiently. | Over the past year, the U.S. Department of Transportation has leveraged nearly $350 million in public and private funds for smart city and advance transport technologies. Building on Beyond Traffic 2045, the Smart City Challenge, provided a spark for cities looking to revolutionize their transport systems to help improve people’s lives. | Intel and the City of San Jose, CA, are collaborating on a public-private partnership project to implement Intel’s IoT Smart City Demonstration Platform to further the city’s Green Vision initiative. The project (Smart Cities USA) will help San Jose drive economic growth, foster 25,000 clean technology jobs, create environmental sustainability, and enhance the quality of life of its citizens. By installing a network of air quality, sound, and microclimate sensors, Intel and San Jose are creating a “sustainability lens” for the city. | The main initiative in San Jose is to use air quality and other climate sensors to monitor the quality of the atmosphere. The San Jose smart city program includes a range of components including public safety, inclusiveness, sustainability, and usability. |</p>
<table>
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<tr>
<th>COUNTRY</th>
<th>PILLARS</th>
<th>INFRASTRUCTURE</th>
<th>PLATFORMS</th>
<th>EXAMPLES</th>
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<tbody>
<tr>
<td></td>
<td>Finland's approach to smart cities focused centers with unique identity, functional traffic that feeds the good of the whole city, conserving and developing landscape and recreation, and retaining the city's social sustainability.</td>
<td>The development of new services resulted in three new artefacts: a smart mobility ecosystem, a smart mobility platform, and smart mobility services.</td>
<td>The smart mobility platform must provide a common application for operation and maintenance of the vehicle fleet. It defines the interactions of various actors within the smart mobility ecosystem and provides common interfaces for interacting in a well-defined way with the platform. The smart mobility platform must be capable of extending its functionality and be easily integrated with other applications.</td>
<td>In 2015, Turku began a collaboration with mobile ticketing firm PayiQ. The city's public transport authority—known as Turku Region Traffic—wanted to explore the possibilities of mobile ticketing as a more sustainable and convenient opportunity for customers. It tailored PayiQ's Microsoft Azure-hosted white-label application to its needs, creating a new app called Föli.</td>
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<tr>
<td></td>
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</tr>
<tr>
<td>United Kingdom</td>
<td>1. implementing a flexible regulatory framework;</td>
<td>U.K Government introduced several public platforms to coordinate city services, established a cloud-based city data platform to increase access to city data, and delivered a range of smart city demonstrations such as intelligent street lighting, smart energy, and smart mobility.</td>
<td>U.K Government introduced several public platforms to coordinate city services, established a cloud-based city data platform to increase access to city data, and delivered a range of smart city demonstrations such as intelligent street lighting, smart energy, and smart mobility.</td>
<td>London focused on multimodal transport and pricing options that promote walking, cycling, and using public transport. It has also invested in intelligent transport systems technology such as cameras, radar, and traffic counters, using data from the internet and smartphones to provide a real-time view of traffic patterns and congestion. These are in addition to existing regulatory programs for zero-emission vehicles, self-driving vehicles and maritime autonomy.</td>
</tr>
<tr>
<td>COUNTRY</td>
<td>PILLARS</td>
<td>INFRASTRUCTURE</td>
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<td><strong>United Arab Emirates</strong></td>
<td>National Smart Mobility Strategy outlines several strategic priorities, including developing safer, more sustainable, efficient, reliable, and seamless travel options for users</td>
<td>Implementation will be accomplished through a combination of the following smart mobility solutions and services: Connected ecosystem, Autonomy Electrification, Micro-mobility services, Mobility as a service and Intermodality and integration</td>
<td>The newly conceived Smart Dubai Platform unites city services, the IoT, cloud services, big data, and digital identity across all city dimensions to build the most comprehensive exchange point for government and private sector services, delivering unprecedented value for the city. Du Telecom Company will develop and implement the platform in an ambitious, unique public-private partnership model that will set new benchmarks for cross-sector partnerships for smart city initiatives globally.</td>
<td>There are several applications for Smart transport, Optimizing energy resources, Smart parks and beaches, Police smartphone apps etc.</td>
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| **Rwanda** | • Smart governance and planning  
• Smart, efficient services and utilities  
• Localized innovation for social and economic development | Rwanda has installed a comprehensive broadband network, although end user connectivity is in most cases limited to fourth-generation connections, which could limit implementation of solutions that require broadband connectivity. | The Ministry of Infrastructure proposed an online platform with data on infrastructure, planning, urban and rural development, transport, water, and sanitation. Rwanda has an e-government platform where citizens can access more than 30 different government services in one platform. | In 2015, the Irembo Digital Platform was introduced to provide government services. It is a web-based platform to enhance the accessibility of government services such as applying for driving license and birth certificate, |

Sources:


In 2020, the European Commission developed the Sustainable and Smart Mobility Strategy (Figure B.1) to provide a smart, competitive, safe, accessible, affordable transport system, with the intention of decreasing emissions by 90 percent by 2050.\(^\text{41}\) It highlights that many nations strive to enhance public transport in an environmentally friendly, sustainable manner by reducing carbon emissions. This is an interesting strategy because it was created at the global level rather than the local or national level.

**European Commission Smart Mobility Strategy**

In 2020, the European Commission developed the Sustainable and Smart Mobility Strategy (Figure B.1) to provide a smart, competitive, safe, accessible, affordable transport system, with the intention of decreasing emissions by 90 percent by 2050.\(^\text{41}\) It highlights that many nations strive to enhance public transport in an environmentally friendly, sustainable manner by reducing carbon emissions. This is an interesting strategy because it was created at the global level rather than the local or national level.

**FIGURE B.1. Sustainable and Smart Mobility Strategy**

- **SUSTAINABLE**
  - Boosting the uptake of zero-emission vehicles, vessels, & airplanes; renewable & low-carbon fuels and related, for instance by installing 3 million public charging points by 2030
  - Creating zero-emission airports and ports, for instance through new initiatives to promote sustainable aviation and maritime fuels (e.g., sustainable aviation fuels, green hydrogen); greening freight transport
  - Making interurban and urban mobility healthy and sustainable, for instance by doubling high-speed rail traffic and developing extra cycling infrastructure over the next 10 years
  - Pricing carbon and providing better incentives for users, for instance by pursuing a comprehensive set of measures to deliver fair and efficient pricing across all transport

- **SMART**
  - Innovation and digitization will shape how passengers and freight move around in the future if the right conditions are established. The strategy prioritizes:
    - Developing data infrastructure to support smart mobility; shared data services; and product lines that use transport data to make it more efficient, resilient, and sustainable
    - Boosting innovation and use of data and artificial intelligence for smarter mobility, for instance by fully supporting deployment of drones and unmanned aircraft and further actions (e.g., build a common mobility data space)
    - Making connected and automated multimodal mobility a reality, for instance by making it possible for passengers to buy tickets for multimodal journeys and freight to switch seamlessly between transport modes

- **RESILIENT**
  - Transport has been one of the sectors hit hardest by the COVID-19 pandemic, and many businesses in the sector are facing immense operational and financial difficulties.
  - Reinforce the single market, for instance by reinforcing efforts and investments and helping the sector build back better through increased investments, both public and private, in the modernization of fleets in all modes (e.g., Trans-European Transport Network by 2030).
  - Make mobility fair and just for all, for instance by making the new mobility affordable and accessible in all regions and for all passengers including those with reduced mobility, and making the sector more attractive for workers.
  - Increase transport safety and security across all modes, including by bringing the death toll close to zero by 2050.

APPENDIX C
Further Reading

1. Challenges for Smart Cities in Latin America (2020)
2. Deloitte Benchmarking of Sao Paolo Mobility (2020)
3. Deloitte City Mobility Index (2020)
7. European Commission JRC: Research and Innovation in Smart Mobility and Services in Europe (2020)
8. Fast Company—We Need to Redesign Cities to Tackle Climate Change (2022)
9. Gender Equity and Public Transit (2021)
10. Interview with Tiffany Chu (Remix) on the Future of Mobility
11. Japan’s Smart Cities: Solving Global Issues such as SDGs, etc. through Japan’s Society 5.0
13. KPMG Smart City Maturity Assessment (2017)
14. List of Innovation Labs in Latin America (2019)
15. McKinsey Center for Future Mobility
17. Mobility Data and Solutions for Emerging Markets
20. Smart Green Research Group, Architecture & Urban Research Institute
23. The Korea Transport Institute
25. WEF’s Latin America Smart City Network Initiative (2021)