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White Paper

Designing a Seamless Integrated Mobility System (SIMSystem)

A Manifesto for Transforming Passenger and Goods Mobility

In collaboration with Deloitte

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Contents

Preface

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Today, the way people and goods move is on the cusp of a radical transformation. A host of new technologies and innovative services, coupled with disruptive demographic and socio-economic trends, are fundamentally reshaping mobility. From ride-sharing, car-sharing and bicycle-sharing to smart infrastructure (traffic sensors, connected traffic lights, etc.) and soon the emergence of autonomous vehicles, these developments have profound implications for our existing transport system. They offer the promise of mobility that is faster, cheaper, cleaner and safer than today. Without appropriate mechanisms to integrate and coordinate across modes, and a platform for stakeholder collaboration, these powerful forces will likely exacerbate – rather than alleviate – many of the current transport system challenges.

And those challenges are significant. Traffic congestion, air pollution and vehicle accidents impose tremendous human and economic costs on government and society. In many places, access to affordable and convenient transport is far from equitable. Globally, a large and growing shortfall in infrastructure spending means roads, bridges, railways and other critical assets are being pushed to – and sometimes beyond – their literal breakings points. Looking ahead, the strains on the system will only increase. As more than 2 billion people are added to the global population in the coming decades and urban populations continue to grow, the question arises: how will we move them, and the goods they require, more efficiently and effectively than today?

In our view, the answer lies in designing a seamless integrated mobility system (SIMSystem) that connects and integrates different modes of transport – city buses, ride-sharing vehicles, delivery trucks, autonomous pods and beyond – to improve overall efficiency and enable more optimized and accessible mobility for people and goods across geographies. Some emerging technologies, such as road-charging, shared dynamic shuttles and mobility-as-a-service applications, seek to address many of the friction points within the current system. In most countries and cities, the existing transport system is not designed to be efficient across multiple modes of travel or geographies. Rectifying the inefficiencies of the overall transport system requires holistically integrating the diverse actors and interactions that comprise the mobility landscape and building system-wide solutions that can increase efficiency and effectiveness across a complex web of modes, geographies and functionalities like payments, ticketing and insurance.

The need is critical, and the time to act is now. The World Economic Forum's Shaping the Future of Mobility System Initiative and Deloitte Consulting LLP collaborated to articulate the need for a SIMSystem, define its foundational characteristics and to bring together public and private sector stakeholders to develop the vision and principles necessary to make a SIMSystem a reality. Our goal in this manifesto is to accelerate the creation and adoption of a SIMSystem so the world can realize the benefits of the future of mobility much sooner and more broadly.

The Forum and Deloitte thank the SIMSystem project's Steering Committee and Working Group members for their invaluable guidance and insights and the many public and private sector organizations that provided vital perspectives.

We hope that you and your organization will subscribe to the guiding principles and join us in this mission to bring a seamless integrated mobility system – SIMSystem – to life as quickly as possible.

Introduction

Humans are hardwired to move from one location to another. From the origin of the species in Africa hundreds of millennia ago, humankind has travelled to all parts of the globe. From the planet's highest peaks to its deepest oceans – and beyond even to its moon – humans are drawn to what lies over the horizon. Whether it is a transcontinental trip, a commute to the office, a stroll to visit a neighbour, or sending a package, it is *mobility* that connects us to our world and each other. It is through mobility that we are able to earn a living, access goods and services, and enjoy our friends and family. At its best, mobility enables prosperity and equality.

However, mobility is not always safe and secure, clean and sustainable, or inclusive and efficient. For many, getting around is a daily struggle that consumes a significant portion of their time, finances or both. Whether navigating a congested urban environment, commuting reliably from a suburb into a city or determining when an essential package will arrive, the existing transport system can seem as much a hindrance as help. Population growth, urbanization and ageing infrastructure will further strain an already overburdened system in the coming years.

At the same time, a myriad of private sector and government efforts have emerged to address mobility challenges, often driven by new technologies and the rapid proliferation of data. Ride-hailing, connected traffic systems, "mobility-as-a-service", autonomous and electric vehicles and many other innovations could contribute to an improved mobility landscape – if they are deployed in a coordinated and collaborative way that aims to optimize the entire transport system. To date, many of these efforts largely fall short of that goal, limiting potentially significant gains for governments, the private sector and citizens. In many instances, they may be exacerbating transport issues, most notably by adding congestion and complexity while also creating inefficiencies between public and private modes of transport.

In 2017, the World Economic Forum and Deloitte embarked on a systematic effort to bring together a cross-disciplinary multistakeholder group of individuals representing start-ups, established companies, governments, academia and non-profits, to help define how a seamless integrated mobility system (SIMSystem) could better address pressing mobility challenges. Central to this effort has been drafting an initial set of working principles that could guide stakeholders as they begin to work collectively to make the SIMSystem vision a reality.

Our efforts have led us to three key conclusions:

- First, making better use of existing assets and infrastructure will become an imperative for cities and countries facing increasing demand on their transport networks while simultaneously lacking the resources or physical space to add sufficient capacity
- Second, better integration and interoperability across modes, geographies and functionalities will help move people and goods more seamlessly and efficiently through the transport system
- Third, enabling seamless integration will require an extraordinary level of coordination and collaboration between the public and private sectors, across modes and geographies

To be clear: without concerted action now, an integrated mobility system will either fail to emerge, fail to emerge quickly enough to address the world's looming mobility challenges, or emerge in a way that fails to truly meet the needs of government, the private sector and users.

This manifesto aims to accelerate adoption of a SIMSystem, drive coordination among all actors and avoid a proliferation of potentially conflicting standards, rules and technologies. It puts forth the Forum's perspective on the need for a seamless integrated mobility system, the vision for how that system could function and its key characteristics, as well as the challenges that will need to be solved along the way. It provides a set of working principles that can serve as guideposts for the public and private sector to effectively collaborate, creating a shared understanding of the complex obstacles that will need to be – and can be – addressed.

The Forum aims to catalyse broad-based support from public and private sector leaders to mobilize their imagination, expertise, capital and resources to accelerate the integration of diverse modes of transport across geographies and to develop digital platforms that can significantly improve the movement of people and goods. The impact on quality of life, economic growth, environmental sustainability and health is enormous. Arguably, advancing public-private collaboration for a SIMSystem will accelerate the realization of other aims of the Fourth Industrial Revolution. In the short run, the Forum invites governments, enterprises, research and academic institutions, non-government organizations and concerned citizens to join the System Initiative on Shaping the Future of Mobility and the SIMSystem project by expressing their support as a signatory to this manifesto. The Forum envisions this manifesto building momentum to identify candidate sites for SIMSystem pilots as early as 2018 to demonstrate the possible impact.

Challenges in the Transport System

In many parts of the world, transport systems are deteriorating: transport systems are characterized by the inefficient use of assets and infrastructure; limited use of clean technologies; limited functionality; and the dispersed governance of transport networks that causes inefficiencies across modes and geographies. Largely unaddressed, these challenges have led to an unsafe, inefficient and expensive transport system, which creates burdensome – and unnecessary – direct and indirect costs.

The toll on human lives is staggering. In 2013 alone, the World Health Organization estimates there were 1.25 million road traffic deaths.[1] Ninety per cent of those occur in low or middle-income countries, even though those countries account for just over half of the vehicles on the road. In addition, 20 million-50 million individuals suffer non-fatal injuries worldwide each year. Less directly but no less real, an additional 3 million deaths annually are linked to outdoor air pollution, caused in large part by vehicle emissions[2,3].

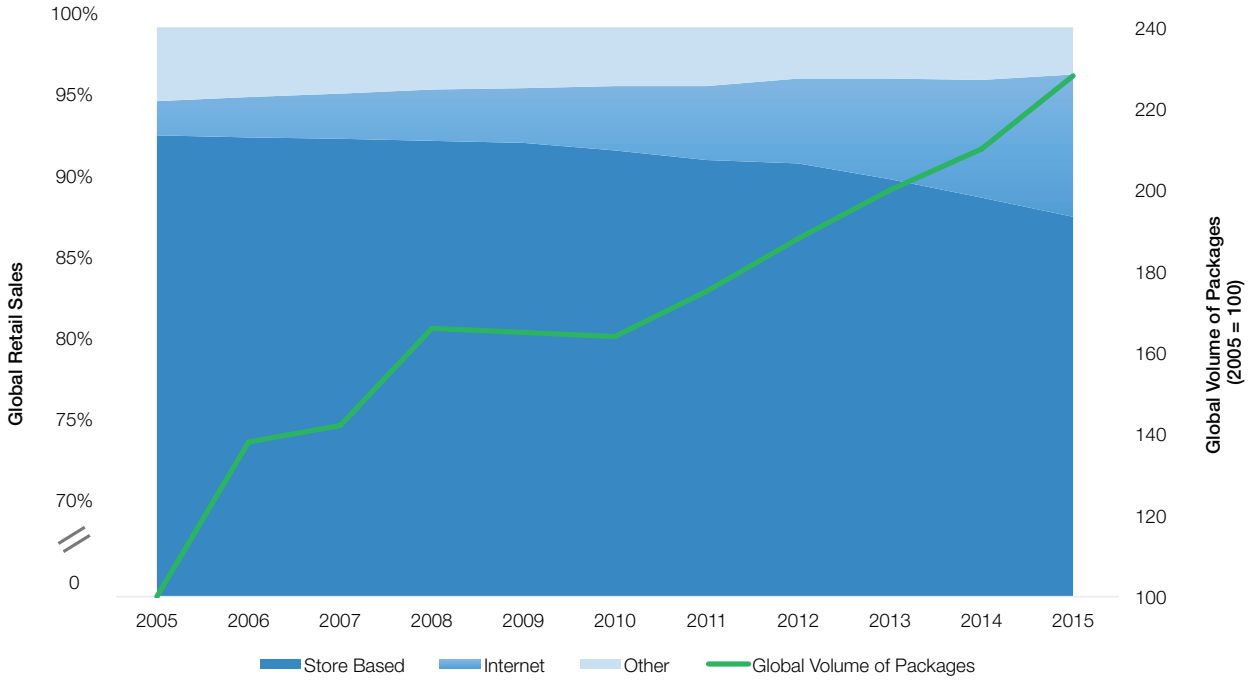
Beyond the costs to human and environmental health, much of the transport system is also remarkably inefficient and expensive to maintain, which limits access to affordable transport and materially impacts economic productivity. In the United States, for example, the poorest one-third of households spend about 16% of their income on transport, while the richest one-third spend about half that amount[4]. In many parts of the world, basic transport infrastructure is limited or non-existent, isolating the people who live in these communities. Roughly, 1 billion people worldwide do not have access to a road that is usable in all weather conditions[5]. In the US alone, traffic on roadways could cost $2.8 trillion by 2030[6]. The United Kingdom, France and Germany could face costs of $480 billion, $468 billion and $691 billion respectively over the same period[7].

Looking ahead, trends in the growth and migration of the world's population will likely push the human, environmental and economic costs of transport far higher. According to the United Nations, the world's population is expected to grow from 7.5 billion people today to 9.7 billion in 2050[8]. By then an estimated two-thirds will live in cities – 60% more than the number that do today. Forty-one "mega cities" are expected to have at least 10 million residents[9]. These demographic and social trends will place additional pressure on an already strained transport system. Even today, global infrastructure spending faces a $1 trillion annual shortfall[10].

In addition to the growing number of travellers, the number of goods being transported – and the means by which they are moved – also is growing rapidly. Just as single occupancy cars impose negative externalities in crowded cities, more fractionalized online shopping with single packages being delivered for each order also results in greater congestion from delivery vehicles, both during the journey and at the kerb. Between 2005 and 2015, as consumers increasingly bought single items online for home delivery, the global number of parcels grew by 128%, to approximately 31 billion a year. An additional 20% growth is expected by 2018.[11,12] In the US, for example, delivery trucks represent up to 7% of urban traffic and 17% of congestion costs due to wasted hours and petrol.[13] Solving congestion problems requires addressing not only the movement of people but also the movement of goods.

Figure 1: Growth in Global Volume of Packages and E-Commerce Retail Sales[14]

Sources: International Postal Corporation: https://www.ipc.be/en/reports-library/publications/ipcreports_brochures/gpir2016-key-findings



Governments and businesses are recognizing these challenges and are undertaking numerous efforts to address them. Increasingly, they are using ubiquitous data to help diagnose and resolve transport issues. A number of cities now have a more sophisticated understanding of traffic patterns and public transit usage, for example. Technologies such as on-demand and shared mobility have grown rapidly as well.

However, these efforts have generally failed to achieve their maximum potential, due in part to insufficient capital to fund infrastructure improvements and system-wide innovation, but even more importantly because of the often narrow way they are conceived and executed. The overall transport system consists of disparate networks that are managed separately. Public trains operate without consideration for how private cars are used, much less for how freight is being shipped. This single-mode focus of transport management creates inefficiencies. Rectifying the inefficiencies of the overall transport system requires a holistic understanding of the complex web of stakeholders and interactions that comprise the mobility landscape. It also requires system-wide solutions that address all the interactions among modes, geographies and functionalities. In short, it requires a SIMSystem.

A Seamless Integrated Mobility System (SIMSystem)

A SIMSystem is a "system of systems" that moves people and goods more efficiently by creating interoperability across physical assets like cars and buses, digital technologies like dynamic pricing and shared data exchanges, and the governance structures, standards and rules by which they operate (see Figure 2). At a SIMSystem's core is a digital platform that overlays on to existing physical assets to provide a holistic, real-time picture of mobility supply and demand as well as the conditions of the overall system (e.g., traffic, infrastructure, weather). When realized, a SIMSystem seamlessly integrates disparate modes of transport for more efficient use of those assets and the infrastructure that supports them (e.g., roads, bike lanes, rail networks, ports). By removing the friction caused by incongruous components, a SIMSystem can enable mobility that is faster, cheaper, safer, cleaner and more efficient than today.

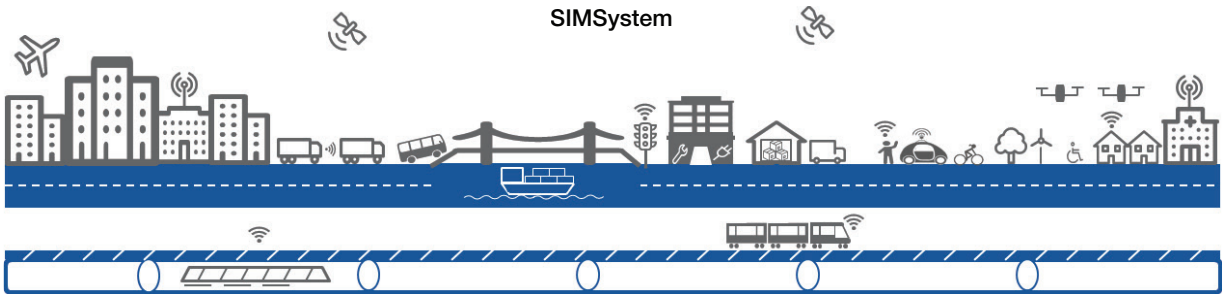
One or Many SIMSystems?

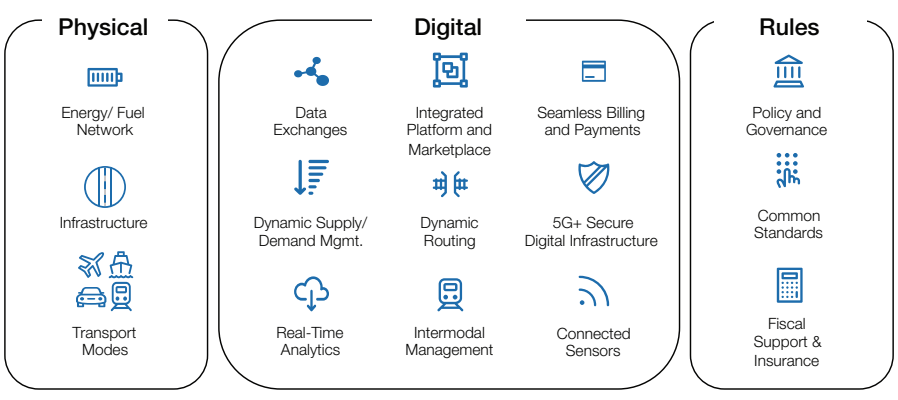
The full realization of the SIMSystem vision includes all modes of transport and the functionality to use and deploy those modes as well as the infrastructure on which they operate, across geographies, for the movement of people and goods, globally. However, the feasibility of a single SIMSystem at a global, regional, national or even city/town level remains an open question. In addition, due to the differences in functionality and governance, it is possible that two interconnected systems might be needed: one for the movement of people and another for the movement of goods. Given the relationship between the movement of people and goods and that many modes use the same infrastructure, the benefits for users will likely be diminished if geographies operate with multiple systems.

This white paper examines a SIMSystem developed in modules that are interoperable, adaptable and scalable – stepping-stones on the way to a single unified system. For example, a city without ports or airports might not require modules for understanding ocean or air transport. By contrast, a city facing severe congestion from delivery vehicles will need to understand how both the movement of goods and passengers affects congestion.

Based on the needs of a particular geography, a SIMSystem should be adaptable to include necessary modules and seamlessly interoperate across component parts. While SIMSystems may be developed in parallel in different parts of the world, it is the goal of this manifesto to help guide public and private sector organizations to create consistency in how they are designed, operated, scaled and integrated on a global level, with the ultimate aim of achieving a single harmonized SIMSystem.

Figure 2: SIMSystem and Foundational Elements





As marketplace inefficiencies are reduced through greater data accessibility and transparency, all the system's users benefit. Government, in its role as the system operator, can use the comprehensive view and analytics built on historical and current data to create parameters (safe, clean, inclusive, etc.) within which the mobility marketplace should operate, creating a more optimal equilibrium of supply and demand across modes. The system operator ensures the marketplace is working fairly and equitably and that participants are adhering to the rules.

Government transit providers can also benefit, as increased system-wide efficiency means fewer buses, trains and other assets are required to move equal or greater numbers of people. They can also gain new insight about which passengers face the greatest transport challenges, enabling them to respond accordingly. This is especially important in rural areas, where populations are expected to decline and investment in accessible transport will be harder to secure[16]. Government agencies could help link these areas and their populations to a regionally focused SIMSystem and offer incentives (e.g., reduced taxes, preferred routes, expedited licensing, subsidies) to private-sector providers or shore up their own services to ensure that reliable and affordable transport is available to all. As data sheds light on the mobility patterns of passengers and goods, the entire system becomes more predictable. Increased availability of data allows for better and more informed transport planning and investment, such as where and when to carry out road maintenance, for example, or whether to add additional bus services to a particular neighbourhood.

Consumers benefit from greater choice in mobility options, dynamically priced based on real-time supply and demand as well as actual market conditions, which allows them to make more informed decisions about how they travel. The same holds true for shippers, carriers and others involved in moving goods. Greater efficiency should also translate into lower costs system-wide which can be passed along to SIMSystem users.

For the private sector, visibility into utilization and operating with a dynamic pricing-based system enable mobility operators to meet customer needs better and to understand how to get the best use out of the assets they have, cutting down on "empty miles" and other waste. Some of these potential savings could be passed along to customers who can make personal choices and trade-offs between convenience, time, cost and other factors. As a SIMSystem stitches together disparate geographies and populations, mobility providers could also gain access to new markets for their services.

SIMSystem Use Case

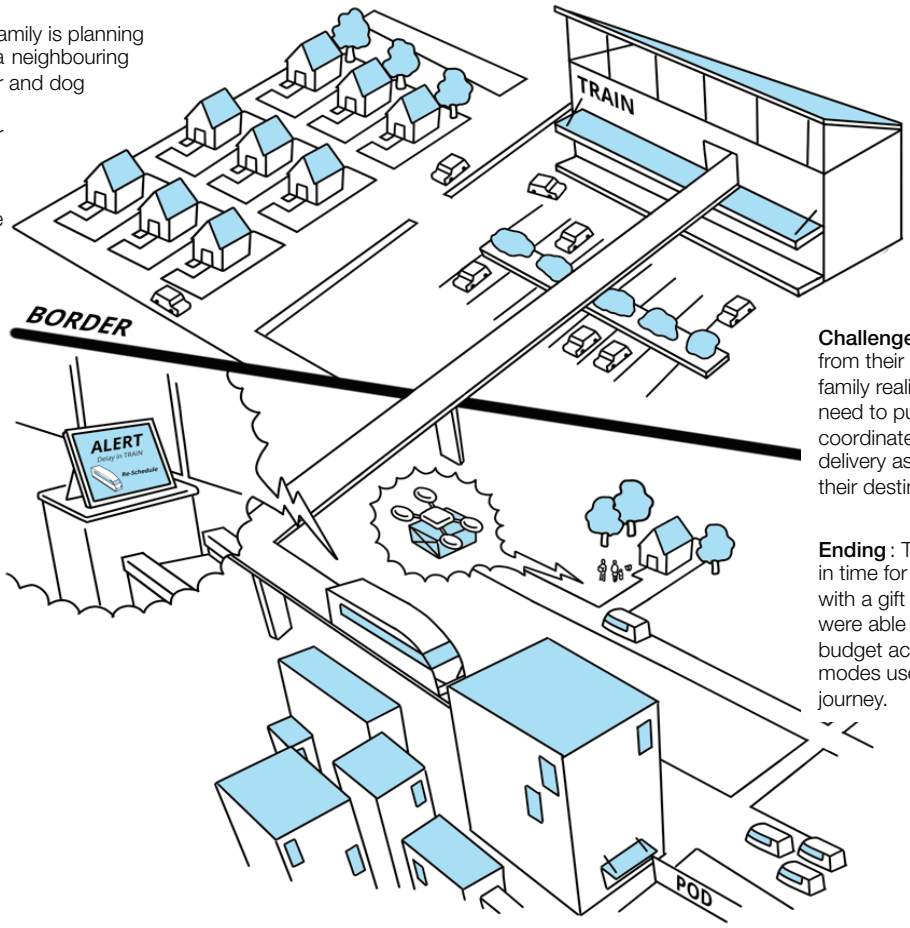
The project's working group developed a number of case studies to illustrate how a SIMSystem could operate in practice and the opportunities and challenges that could emerge (additional case studies available in the appendix):

Figure 3: Case Study: Johnson Family Vacation

Beginning : The Johnson family is planning a vacation to visit family in a neighbouring country. With their daughter and dog coming along, they need to use the SIMSystem for their multimodal journey.

Challenge 1 : Since it is the holiday season, demand is high and so are prices. The Johnsons need to find a combination of modes that meets their needs, budget and timeframe and to purchase tickets asap.

Challenge 2 : Having crossed the border, the family receives an alert that the next leg of their journey is delayed. The Johnsons must find alternate modes to use in the new country.



Challenge 3 : A few hours from their destination, the family realizes that they need to purchase a gift and coordinate just-in-time delivery as they arrive to their destination.

Ending : The family arrives in time for the family dinner, with a gift in hand, and were able to stay within budget across the various modes used during the journey.

Since their needs have changed, logging on and purchasing from their preferred airline aggregator is no longer the best solution for arranging travel. The family uses a SIMSystem platform to determine what multimodal options they could use. After finding an itinerary that meets their requirements and budget, the Johnsons book the trip and make a single payment, which is then divvied up seamlessly across all the mobility service providers.

After taking a rideshare from their home to the station, they use high-speed rail to cross the border. Upon receiving an alert that their next leg is delayed, the Johnsons are able to view other available options in real time via the SIMSystem platform. In this case, the Johnsons easily switch to an autonomous pod and continue their journey.

As the Johnsons approach their destination, the family realizes that they forgot to bring a gift! Dad uses the SIMSystem platform to coordinate the drone delivery of two bottles of wine at the exact time they arrive.

The Johnsons reached their destination on time, and on budget, having used a SIMSystem seamlessly across two countries, multiple modes and for all aspects of their journey, including the delivery of a package.

To enable a trip like the Johnsons', a myriad of actors must collaborate, define standards for the exchange of data, and participate in a platform that enables users to access integrated trip functionality. In this example, a SIMSystem spanned country borders, requiring coordination between national governments and harmonization of protocols to enable the rescheduling and rebooking of trips. Additionally, physical interoperability allowed the family to transfer seamlessly among modes. Finally, in this realization of a SIMSystem, the delivery of goods required the participation of actors involved in the sale and distribution of products. While this use case represents only one possible version of a SIMSystem, the vision remains consistent: the seamless integration of modes for the movement of people and goods across geographies. The interoperability requirements illustrated here are discussed further on pages 14 and 15.

Key Actors and Roles

To fulfil its potential, a SIMSystem will require active engagement from governments, the private sector and consumers to overcome inherent barriers and to interact and collaborate with each other in new ways. As governments juggle a variety of goals – reducing congestion, improving access, lowering carbon emissions and more – their interests may not align with private-sector providers who seek profit maximization or consumers that want a broad array of affordable, convenient, accessible and reliable mobility options. Reconciling these different needs will require close and constant dialogue to arrive at solutions that satisfy many of the core requirements of these stakeholders.

The multiple roles of government

Governments and public agencies occupy a unique position in the mobility ecosystem and serve numerous roles. They are regulators, determining the rules by which the private sector provides and citizens consume mobility, as well as providers of mobility in their own right, owning and operating some of largest transport systems in the world through public transit agencies. Moreover, they are responsible for building and maintaining the underlying public infrastructure on which the entire system rests.

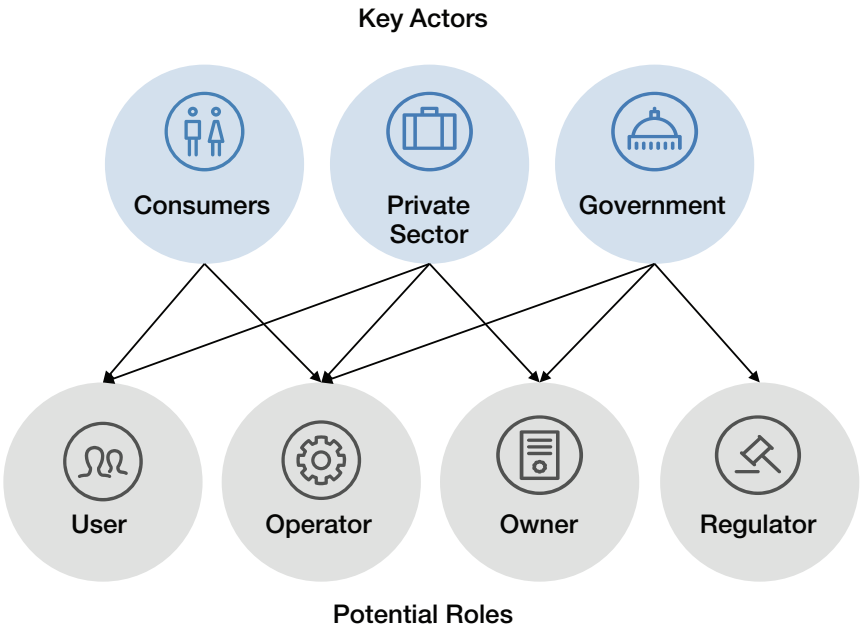
These multiple positions create a host of unique challenges. As rule-makers, governments will need to become more agile at balancing their regulatory obligations while also encouraging innovation. At a minimum, that likely requires greater coordination and communication between and across agencies and departments to streamline decision-making, foster new ideas and drive system optimization.

As owners and operators of transit systems, government agencies will need new structures that allow greater flexibility to manage across modes and geographies. In certain areas, the centralization of transport authorities to a single office responsible for decisions and operations across all modes of public transit could drive greater system-wide accountability and effectiveness. Governments should also negotiate and collaborate with private operators to integrate their networks into the city's mobility system – another area where more concentrated and focused governance can be advantageous.

In London, for example, governance of the formerly multiple transport agencies was centralized with the creation of Transport for London (TfL) under the Greater London Authority Act in 1999. This Act gave the Mayor of London a general duty to develop and apply policies to promote and encourage safe, integrated, efficient and economic transport facilities and services to, from and within London. This has allowed greater control over congestion through the introduction of congestion charging, standardized fare structures, a pan-London electronic ticketing system and network-level capital planning – all of which has resulted in increased customer satisfaction and confidence in TfL-branded services[17].

Ideally, each geography would consider establishing a "chief mobility officer", vested with sufficient authority and independence across transport modes to lead the mobility office. The primary responsibility of the chief mobility officer would be to drive system-wide effectiveness and efficiencies and strike a fair balance across the diverse stakeholders and interests involved in the system. This office could have

Figure 4: Key Actors and Potential Roles



responsibility to oversee the development and operation of a SIMSystem, including setting and enforcing policies and processes to allow the marketplace to operate fairly and equitably. This office will need to consider how the entrance of private services could impact infrastructure, congestion and transport safety. The office would provide a consolidated set of ground rules all parties would need to conform to, and in the process help ensure the safety and security of its citizens, competitive pricing and accessibility in markets, and economic growth for the city. The office's mandate should also consider the commercial viability of private companies' services in its city.

Consideration should be given to the appropriate governance model each geography sets up for the chief mobility office and the operation of the SIMSystem. One similar construct that could be applicable is the way most stock exchanges are established. Many stock exchanges are overseen by a quasi-independent board of directors, which consists of both private sector leaders and public officials. Like a stock exchange, a SIMSystem should have an open marketplace exchange that allows sellers and buyers to transact with less friction, greater transparency and fairness.

In addition to facilitating interactions with private companies, the mobility office for a particular geography should share best practices with others. Collaboration is especially important during the formative period when a significant amount of innovation and experimentation will take place and the exchange of lessons learned could be hugely valuable. Global technological collaboration and knowledge sharing could help increase understanding of defining common mobility policy priorities, participating in technology development initiatives and managing the sharing of information between municipalities and governments on mobility efforts. Formal coordination mechanisms could shorten learning cycles, accelerate more effective adoption and provide the type of collaboration platforms that have been key to the development of other industries, such as space exploration and energy. Moreover, as mobility is often cross-border, governments may increasingly find that they need to coordinate to establish common standards and interoperability protocols in safety, security, privacy, data, service levels, accessibility and other key areas.

Parallels in Net Neutrality

Questions about who should fund transport infrastructure and how transport should be provided and accessed equitably draw parallels with the current debate over net neutrality. Just as authorities have wrestled with the issue of whether all internet content should be treated equally or whether service providers can offer a "fast lane" for some types of traffic, governments will also need to determine whether the preferential use of mobility infrastructure is appropriate – and what those privileged uses might be in a SIMSystem (e.g., public transit, pedestrian or bike lanes, autonomous or electric vehicles). While this could incentivize participation, it could also limit the ability of new entrants to compete effectively. And it certainly has implications for who funds the core infrastructure required for the system to operate.

Call to the private sector

Within a SIMSystem, the private sector also fulfils several important roles as owners, operators or both. Regardless, as cities begin to explore a SIMSystem, the private sector should be an active member in its formation and management. Private-sector organizations will need to collaborate with various levels of government to establish shared goals, articulate their needs and imperatives to generate a reasonable return for their investment, and provide technical resources and know-how to shape how a SIMSystem is designed, operated and scaled.

The integration of mobility is likely to bring together a variety of industries, including telecom, tech and digital, transport, automotive, insurance, financial services, real estate, consumer goods, retail and services, among others. Along with the public sector, these companies will form the key players in the mobility ecosystem and will help underwrite the investment required for a SIMSystem.

As governments expand their use of data to inform transport-related decisions, companies will face increased pressure to be more open in sharing data. This will need to be addressed proactively to reach agreement on what information should be exchanged. This tension over the sharing of data is highly problematic and could be key in determining the pace at which a SIMSystem moves forward. Preventing potential conflicts will require private-sector operators to acknowledge the imperatives of public providers and enable building solutions that generate viable business models. These businesses could be based on the use of assets or delivery of services, or could be rooted in licensing and usage fees for data, analytics or operational responsibilities.

Focus on the consumer

To be successful, a SIMSystem will need to benefit the public, including underserved and disadvantaged groups. Today, these communities face a growing physical, digital, geographic and economic divide that limits access to affordable, reliable and inclusive mobility options[18]. This gap could increase, particularly in rural areas where declining populations and increasingly limited resources may result in fewer transport options for both the movement of people and goods[19]. A SIMSystem presents an opportunity to make mobility more inclusive for these people, which in many countries represent a significant – and often overlooked – portion of the population.

An effective SIMSystem requires aggregation of data from a variety of sources, with important implications for consumer privacy and cybersecurity. Individuals' tolerance and acceptance of personal data collection varies widely. As regulation continues to evolve, operators of a SIMSystem will need to understand and define the specific data elements that are truly required for the system to operate and ensure that only the minimum data required is collected and stored. When collected, this data should be appropriately anonymized, aggregated, encoded and protected. System-level data should only be used to optimize the overall system as opposed to benefiting private operators. Any use of data must rest on explicit permissions provided by the individual consumer.

Bringing the Pieces Together: Interoperability Requirements

Just as a SIMSystem demands sustained dialogue and deep cooperation among all key parties, it also requires integration across three key layers. The need for interoperability seems obvious – although far from trivial – when it comes to core technologies, which necessarily must be compatible. In addition to digital interoperability among technologies, it is also critical to ensure interoperability across the physical and rules-based layers as well.

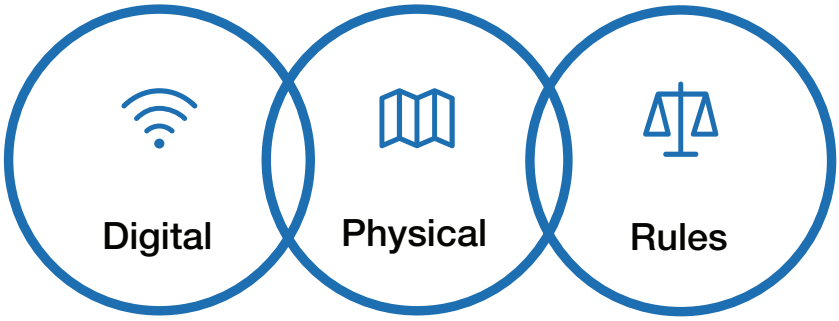
For **digital technologies,** a SIMSystem relies on the availability and standardization of data to help optimize mobility supply and demand in real time through a marketplace that customers and operators access. A SIMSystem requires information about supply (number and utilization of modes, operating times, total capacity, prices, accessibility, container characteristics, etc.), demand (starting and ending locations of trips, price elasticity across modes, etc.) and the environment (traffic conditions, road delays/closures, weather, accidents, etc.). It also requires thinking through the entire data lifecycle. Data will need to be created, captured, acquired, standardized and stored. It will need to be reliable and have syntactic and semantic meaning for the various entities using it. Data must move from where it is created or stored to those entities within a SIMSystem who need it. Analysis will be needed to extract meaning, gain insights and make decisions. Finally, a SIMSystem will need to be a dynamic and evolving system that drives system-wide learning. To manage the volume and complexity of data, a SIMSystem will need to rely on elements of artificial intelligence to self-adjust based on historical, real time and even predicted conditions through multivariate optimization models. Each step of that data journey demands a variety of new and emerging technologies. (See Technology Scan in the appendix for a more complete list of relevant technologies.)

For **physical assets**, a SIMSystem requires interoperability in three key areas: energy networks, infrastructure and transport modes. First, as the vehicle fleet becomes increasingly electric or hydrogen-powered, supporting charging and fuelling must be interoperable and standardized. As vehicles move across geographies, charging or fuelling station networks will need to be readily available to provide sufficient coverage. This becomes especially important as freight vehicles move away from fossil fuel-based powertrains, as they tend to travel longer distances and cross more jurisdictions than typical passenger vehicles.

Second, infrastructure investments should be made to enable multimodal journeys. For passengers, this will require physically connecting modes that might otherwise be isolated and dispersed (by, for example, designing passenger railway stations to be multimodal hubs). For goods, smart lockers that can be reprogrammed for multiple users during a short time period and other consolidated delivery locations can help ensure safe and convenient package delivery, especially in densely populated areas. Many areas are also likely to see the expansion of usage-based infrastructure pricing, which could require enhanced roadways to allow for more optimal management of supply and demand across local, regional and national jurisdictions[20].

New business models that enable innovation tenders or public-private, revenue-sharing agreements should be explored to address infrastructure needs without overtaxing citizens or breaking public-sector budgets. According to the G20 Global Infrastructure Hub, global cumulative infrastructure needs are predicted to total $94 trillion by

Figure 5: Interoperability Layers



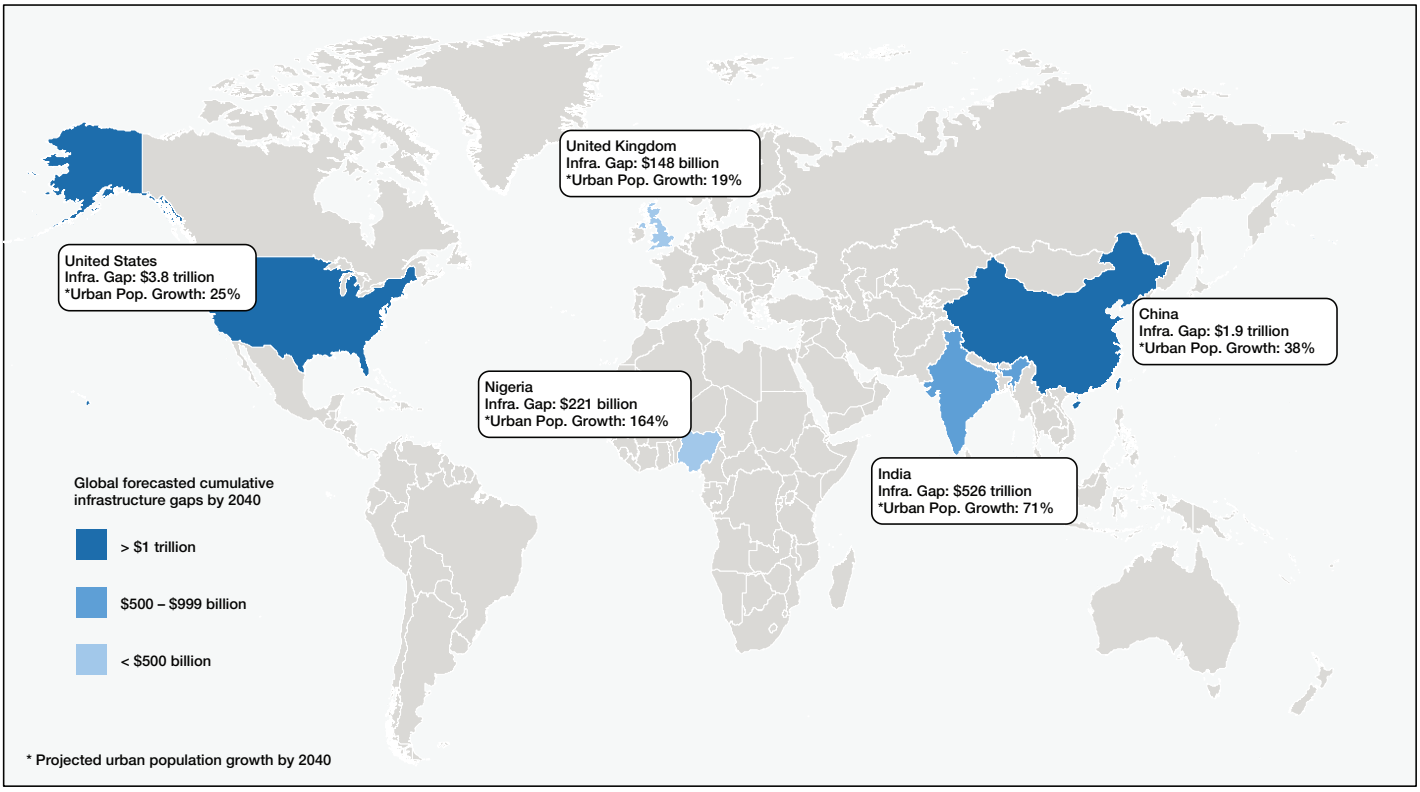
2040, with a potential $15 trillion investment gap[21]. Of this shortfall, approximately two-thirds come from airports, ports, rail and roads[22]. Many of the countries facing the largest cumulative infrastructure gaps are also expected to face dramatic rises in urban population (Figure 6). The private sector could play a larger role in helping close these shortfalls.

Third, achieving interoperability requires considering how different modes interact with each other, their environment, cargo and passengers. Consider just one dimension: the line between passenger and cargo vehicles is growing increasingly blurred. For example, Mercedes-Benz and the drone company MatterNet have announced a concept vehicle that combines a van with a launching pad for drones[25]. There are also prototypes emerging from several companies for multi-purpose vehicles that can adapt the interior based on whether goods or passengers are being moved, potentially enabling these vehicles to run virtually non-stop based on demand patterns. These vehicles will need to be designed to accommodate standards and regulation for the movement of passengers, as well as the requisite safety standards and protocols for containerization and materials handling. Further, as new vehicle types emerge, vehicle design and the overall SIMSystem will need to accommodate the needs of all passengers, especially those who are disabled or disadvantaged.

Finally, in addition to physical and digital interoperability, a SIMSystem relies on having a **rules-based framework** of regulations, standards, agreements, protocols and other intangible elements to operate across modes, geographies and functionalities seamlessly. Today, transport is governed by a wide range of organizations that exist across multiple geographies and transport modes. Organizing the various elements of a SIMSystem will require collaboration among the various governmental and non-governmental entities spanning city, state and national boundaries on laws, protocols and standards. The public sector will have to regulate service providers to ensure consumers are appropriately protected and broader societal goals are met, while also creating conditions that encourage and incentivize private-sector innovation. The private sector, collaborating with non-governmental and intergovernmental organizations as well as academic institutions, should actively lead the development of shared standards for a SIMSystem's underlying technology and data.

Figure 6: Projected 2040 Infrastructure Shortages and Urban Population Growth by Country[23,24]

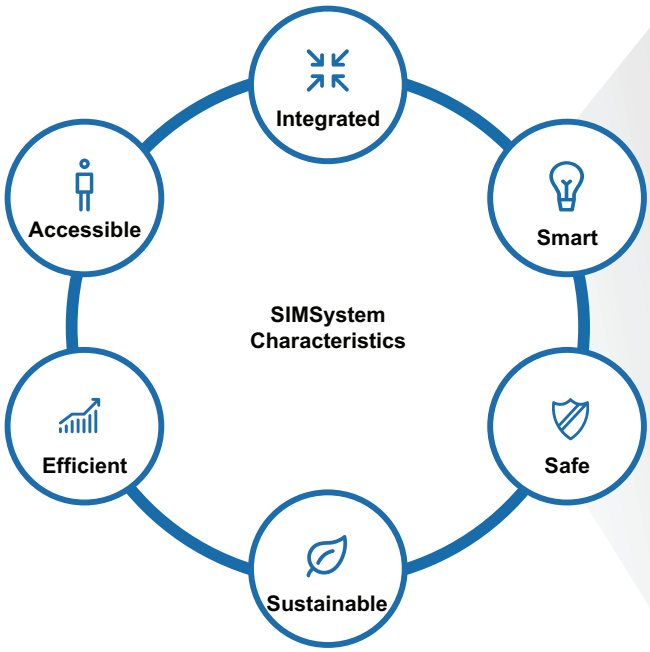
Sources: Infrastructure Global Infrastructure hub https://outlook.gihub.org/, Population: United Nations World Urbanization Prospects



Principles for Seamless Integrated Mobility

Building support for establishing a SIMSystem is an ambitious undertaking given the complexity of the current transport system, the range of public and private-sector entities involved and the speed with which innovation and disruption is occurring. To accelerate the development and adoption of a SIMSystem, a common vision is needed. The Forum believes there are six core, foundational characteristics to a SIMSystem.

Figure 7: Core SIMSystem Characteristics



Integrated: Delivered through a **cohesive interoperable platform** that seamlessly brings together all modes for the transport of passengers and goods across geographies

Smart: Facilitated by a **dynamic, data-driven and technology-enabled architecture** that connects and optimizes the versatile infrastructure and assets operating within the mobility ecosystem

Safe: Enabled by **physically and digitally secure infrastructure assets** that can monitor, defend against and adapt to emerging threats, system failures, and natural conditions

Sustainable: Powered by **future-looking** and globally-compliant manufacturing, operation, maintenance, and disposal of energy-efficient and **clean transport modes** and infrastructure

Efficient: Driven by **delivering increased economic and societal value** that allows for greater quality of life and economic growth inclusive of all people

Accessible: Developed using **modular, scalable, operationally and economically viable solutions** that can be implemented and harmonized globally

With that vision and those characteristics in mind, the following working principles provide a guiding framework for public and private-sector stakeholders to consider in finding common ground to enable a SIMSystem to become a reality.

Principle 1
User-centred: A SIMSystem is designed and operated based on the collective and individual needs of all the users it serves.

Principle 2
Designed to be adaptable: A SIMSystem is designed to be adaptable to the capabilities and operating conditions of the geographic area where it is deployed, the behaviours and needs of its users and improvements in technologies.

Principle 3
Open standards and protocols: The private sector will need to play a leading role in establishing open standards and protocols for the creation and use of mobility-related shared data exchanges and application programming interfaces.

Principle 4
Public-private collaboration: Governments will need to act as conveners to increase collaboration within and between the public and private sectors to enable a SIMSystem to operate across modes, geographies and functionalities.

Principle 5
Participation and value: Maintaining the ability for the private sector to derive value from offering their products, services and intellectual property is essential to encourage broad-based participation and the full realization of a SIMSystem.

Principle 6
Agile governance: Governments should actively undertake efforts to reduce institutional complexity and create more focused governance models to facilitate agile coordination and collaboration with the private sector and other governments.

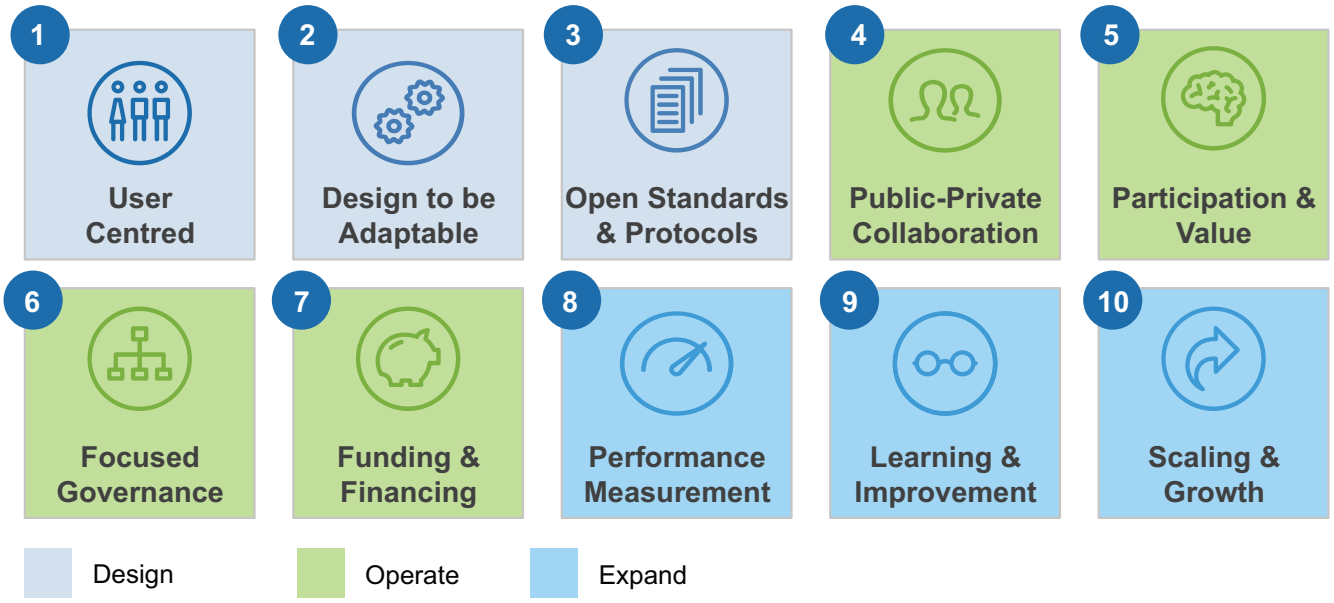
Principle 7
Funding and financing: Governments will need to create innovative funding instruments and business models that enable multiple private-sector actors to underwrite the cost of a SIMSystem and share in the potential monetary benefits.

Principle 8
Performance measurement: Standardized performance indicators should be established to measure the impact of a SIMSystem on accessibility, affordability, sustainability, safety, efficiency and integration.

Principle 9
Learning and improvement: An international public-private coalition should be formed and tasked with the frequent sharing of knowledge and best practices across geographies.

Principle 10
Scaling and growth: A public-private working group of leaders should be established to define and address fundamental framing decisions and enable a series of SIMSystem pilots in various geographies.

Figure 8: SIMSystem Principle Categories



Design Principles

Principle 1
User-centred: A SIMSystem is designed and operated based on the collective and individual needs of all the users it serves. When assessing needs and capabilities, designers of the SIMSytem should consider users (both consumers and businesses), operators (of both physical assets and services), owners and financiers, and regulators.

Government and the private sector will jointly need to understand how to develop and harness existing and emerging technologies to meet the current and future needs of all stakeholders in a SIMSystem. The public and private sectors are responsible for determining which modes of transport to include in a SIMSystem, deciding how to phase the development of a SIMSystem, and identifying the functionality needed for its successful operation. When necessary, governments should set and ensure compliance with minimum service and safety levels, coverage areas and accessibility requirements.

Consideration should be given towards using certification processes to help ensure operators meet certain requirements based on applicable protocols and regulation (e.g., cybersecurity, data collection protocols). As innovation occurs, and new services and technologies are integrated, governments will need to reassess and update these requirements.

Principle 2
Designed to be adaptable: A SIMSystem is designed to be adaptable to the capabilities and operating conditions of the geographic area where it is deployed, the behaviours and needs of its users and improvements in technologies. Through a modular design, a SIMSystem can be flexible and adjustable to changes in transport modes, geography and functionality.

A SIMSystem's success depends on operators and regulators understanding the needs, capabilities and constraints of the geographies and operating environments where it is deployed. The SIMSystem's design should also enable operators to configure SIMSystem modules accordingly (e.g., adding or removing modes, deploying updates to include additional functionality).

A minimum number of users and operators is necessary for a SIMSystem to operate efficiently and effectively. The effectiveness of a SIMSystem increases as additional modes, geographies and functionalities are added. Having the flexibility to reconfigure quickly will require operators and regulators to undertake ongoing assessments of user preferences, available technologies, services, assets and changes to operating conditions to inform how SIMSystem modules should be adapted over time.

Principle 3
Open standards and protocols: The private sector will need to play a leading role in establishing open standards and protocols for the creation and use of mobility-related shared data exchanges and application programming interfaces. These efforts will need to be centrally managed through a neutral multistakeholder public-private consortium tasked with maintaining, expanding and updating these standards as new information, operating models, technologies and mobility services become available.

Government and the private sector will need to collaborate to develop foundational standards and protocols for data-sharing and the operation of a SIMSystem across transport modes, geographies and functionalities.

To allow for fast and widespread adoption of a SIMSystem, standards should not be overly broad and prescriptive. Rather, initial efforts should focus on a core set of standards around specific functional categories (e.g., data, cybersecurity, decision rights) that can be expanded later to facilitate adoption and scaling.

Governments and private-sector actors should strive to develop consistent standards at a global level. Without buy-in from other cities, countries or regions, a SIMSystem will be limited in scope or will require significant adaptation to be usable across geographies, yielding a more fractured and inefficient system.

Government and the private sector will need to undertake efforts to determine which data elements (e.g., supply, demand, utilization, price elasticity, modes, schedules) are critical for the effective operation of a SIMSystem and should establish how, by whom and for what purpose data will be used. Private operators will also need to ensure that regulations and protocols for security and privacy are followed.

Operate Principles

Principle 4
Public-private collaboration: Governments will need to act as conveners to increase collaboration within and between the public and private sectors to enable a SIMSystem to operate across modes, geographies and functionalities. The level of government (municipality, province, region, etc.) driving these efforts should correspond to the geographic and jurisdictional scope of the respective SIMSystem and the specific governance models for transport within that given geography.

To collaborate effectively, public- and private-sector organizations should maintain an open dialogue, which includes the delineation of priorities and the acknowledgement of constraints and dependencies, to align on shared goals for the system.

Accelerating adoption will require private-sector innovation and solutions. Governments can help catalyse this innovation and facilitate the deployment of these solutions by streamlining processes and modifying regulation.

Principle 5
Participation and value: Maintaining the ability for the private sector to derive value from their products, services and intellectual property is essential to encourage broad-based participation and the full realization of a SIMSystem. Governments can facilitate the creation of new multistakeholder models to help balance the private sector's ability to innovate and public sector priorities (e.g., safety, accessibility, equitability).

In certain markets, governments may need to consider providing incentives (e.g., route subsidies, taxation breaks, preferential access to infrastructure) to foster private-sector participation in a SIMSystem. New business models can help ensure that the efficiencies created by the overall system can be shared broadly. Governments will need to ensure open access to a SIMSystem and encourage private-sector players to compete in providing services and solutions on a fair and competitive basis.

Principle 6
Agile governance: Governments should actively undertake efforts to reduce institutional complexity and create more focused governance models to facilitate agile coordination and collaboration with the private sector and other governments. These efforts should include streamlining decision-making across various agencies, modes and geographies to facilitate system-wide transport governance. The jurisdictional span of these governance models should correspond to the modes and geographic area included within the operational scope of a SIMSystem.

To expedite decisions and facilitate collaboration, governments will need to simplify and consolidate decision rights in three key jurisdictional areas: modes, geographic scope and functionality. In certain geographic areas, a centralized office where a chief mobility officer is appointed could streamline and expedite decisions through purview over the following areas:

- Regulation and protocols affecting the operation of transport modes (e.g., rail, buses, bike-sharing, dynamic shuttles, transport network companies, etc.), including when, where and how those modes are used, priced and maintained

- Elements of the mobility landscape (e.g., road use, permits, taxation), which includes how infrastructure is used (such as employing dynamic pricing or instituting fees specifically related to mobility innovation like kerbside pick-ups and drop-offs) and how transport modes physically interact with each other (such as determining the proximity of bike racks to bus stops)

- Enabling transport functionalities (e.g., route-planning, scheduling, electronic/touchless ticketing, payments processing), which includes determining the enabling technologies that are used

Principle 7
Funding and financing: Governments will need to create innovative funding instruments and business models that enable multiple private-sector actors to underwrite the cost of a SIMSystem and share in the potential monetary benefits. These agreements should explore how the private sector participates in revenue sharing in exchange for critical investments (e.g., in infrastructure or data management) and should explore incentives and protections for innovation and intellectual property (e.g., innovation tenders).

When developing these instruments and business models, governments should consider the need for funding for the entire SIMSystem lifecycle, which includes the need to build, operate, maintain and expand the physical and digital infrastructure that enable a SIMSystem to operate. In addition, these instruments should consider the need to conduct regular updates and enhancements to keep pace with changes in technology, products and services, operating conditions and user needs.

Underwriting models should allow for multiple private-sector actors to participate in funding and financing while also allowing them to capture value (through, for example, usage-based revenue sharing agreements or distributed transaction processing). The duration and operational requirements of financing agreements should aim for flexibility to allow for updates and reconfigurations without undergoing lengthy procurement processes and renegotiations.

Scale Principles

Principle 8
Performance measurement: Standardized performance indicators should be established to measure the impact of a SIMSystem on accessibility, affordability, sustainability, safety, efficiency and integration. The public and private-sector organizations should jointly develop a set of indicators and use them as a basis to evaluate how well the system is performing and fulfilling core functions. Indicators should be harmonized across geographies to allow for a common language that can increase understanding, shorten development cycles and accelerate overall adoption.

A core set of measurement standards should be consistently applied across geographies (i.e., dimensions and metrics being used are the same or equivalent) and be able to highlight and normalize for potential differences (e.g., number of modes in operation, functionality in use, user preferences) for different markets.

Performance assessments should be informed by the core characteristics proposed for a SIMSystem and evaluated against defined and agreed upon objectives (e.g., reduction in commuting times, increase in access to transport, reduction in transport caused deaths per capita).

Over time, consistent indicators will aid in evaluations within and among comparable geographies to identify specific improvements that could be made to a SIMSystem (e.g., reconfiguring mode deployment, adjusting pricing algorithms, enhancing trip functionality). Groups of geographies with similar operating conditions (e.g., population densities, modes in use, presence of ports) may be formed to facilitate comparable evaluation for these performance indicators.

Principle 9
Learning and improvement: An international public-private coalition should be formed and tasked with the frequent sharing of knowledge and best practices across geographies. This coalition would serve to accelerate SIMSystem adoption by informing enhancements, expansions and updates through specific shared elements (e.g., governance models, data protocols, standards).

Sharing key data elements, performance metrics and knowledge across cities experimenting with a SIMSystem could accelerate adoption and scaling efforts. Where possible, implementation efforts should be coordinated through formal bodies. The success of these programmes depends on coordination among as wide a membership as possible, at both national and international levels, to maximize the value of participating.

Incentives may be needed, such as access to data insights or technology rights, to encourage public and private organizations to join and contribute, increasing the network effects of membership and reducing duplication of efforts.

Sharing of knowledge for collectively beneficial areas – like cybersecurity and system design – should be facilitated through formalized mechanisms that include periodic studies and reports made available to participating members.

Principle 10
Scaling and growth: A public-private working group of leaders should be established to define and address fundamental framing decisions and enable a series of SIMSystem pilots in various geographies. These pilots serve to test and demonstrate the viability of different SIMSystem versions and will need to have clear objectives and roadmaps for future expansion in modes, geographies and functionalities.

Both public and private modes of transport should be included in initial pilots to form a foundation of collaborative relationships and to develop an understanding of which roles each is best suited to play within a SIMSystem.

Defining the geography (e.g., city, region) as well as modes that conform to those boundaries will help streamline governance and coordination for initial pilots. Governments and private sector organizations should work together to ensure consistency in how pilots are scaled, which will help to drive down costs for expansions or new pilots in other areas.

Initial functionality should include the ability for operators to understand supply and demand across modes; coordinate scheduling, ticketing and payments; and incorporate real-world conditions (e.g., traffic, road closures). Additional functionality, including analytics and supply-demand optimization, could be added in subsequent expansions and updates. These expansions should be built into the planning process to ensure that scaling occurs safely and sustainably.

Conclusion and Call to Action

The transformation of the mobility ecosystem is well under way. Driven by the profound changes in the needs and desires of the world's population and enabled by Fourth Industrial Revolution technologies, these shifts have the potential to improve the efficiency, sustainability and affordability of the movement of people and goods. However, without the collaboration of both the public and private sectors, the promise of the new mobility ecosystem may not be fully realized and the future landscape could see even greater levels of congestion, pollution and inequitable access to transport.

There is a strong case to be made for designing and implementing a SIMSystem that can maximize today's transport system and capitalize on the potential that mobility innovation offers. When operational, a SIMSystem can better optimize the supply of and demand for transport across modes and geographies, while keeping user needs central. Enabling a SIMSystem will require potentially unprecedented coordination within and among private-sector entities, government bodies and the public to help ensure interoperability among the physical, digital and rules-based layers. In the physical layer, efforts should focus on designing and adapting energy and fuelling networks, infrastructure and transport modes to be more interoperable. In the digital layer, integration will rely on the availability and standardization of critical data elements that can be shared among participating actors to create a transport marketplace that can price and clear transactions in real time. Finally, and perhaps most importantly, a SIMSystem cannot exist without enabling protocols, regulations, agreements and other instruments that allow effective governance, control and ownership.

The challenges and capabilities of a SIMSystem will vary widely across the globe. A SIMSystem should be tailored to meet local needs as well as political and economic realities. However, staying true to a shared vision and set of guiding principles for what a SIMSystem can and should be helps to ensure that all stakeholders are pulling towards a common goal. Developing a SIMSystem should be a journey that begins with setting clear outcome-oriented objectives and performance metrics, being willing to start small, push through setbacks and learn along the way, and having a well-defined plan to scale safely, securely and sustainably.

This manifesto is meant to be a catalyst and working guide to help advance the collective understanding of key stakeholders and maximize the benefits of the future of mobility to improve the state of the world. The journey will be filled with challenges and setbacks, but the benefits are worth the risks.

To help us achieve our goal of accelerating the development and adoption of a SIMSystem that meets the six characteristics outlined in this manifesto, the Forum requests that government and private-sector organizations become signatories to this manifesto and undertake the following actions:

1. Express support and agreement with the need for a SIMSystem and the principles laid out in the manifesto
2. Commit to further the SIMSystem principles by becoming members of public-private collaboration bodies and actively promoting the launch of several pilots and living labs in the near future
3. Contribute technical expertise, permission to use core technology, financial investment and/or management resources to accelerate SIMSystem development and adoption efforts
4. Work collectively across private and public sector boundaries to break down barriers that inhibit the capability of a SIMSystem to deliver significant efficacy and social benefit through mobility

In the second phase of the SIMSystem project, the Forum's focus will shift from building the case for a SIMSystem to demonstrating the impact it can deliver. The Forum will seek to further the objectives of this effort by working closely with interested parties on SIMSystem pilots and living labs. If you and your organization would like to engage in the SIMSystem project with the World Economic Forum, please contact John Moavenzadeh and Victor Padilla-Taylor.

Acknowledgements

The World Economic Forum's SIMSystem: Designing Seamless Integrated Mobility project in collaboration with Deloitte Consulting LLP is an expansive and ambitious journey intended to convene public and private organizations to help shape the transformation that is happening in passenger and goods mobility around the world. The project has engaged leaders from private companies, governments and academia in a variety of disciplines to understand the forces and technologies that are reshaping mobility, identify the challenges that will be encountered and define principles to guide collaboration efforts.

The governance and direction for this project has been provided by the System Initiative on Shaping the Future of Mobility, the Steering Committee and the members of the SIMSystem Working Group. This manifesto is the product of research, interviews, workshops and meetings. The opinions expressed herein may not correspond to the opinions of all members and organizations involved in the project.

The World Economic Forum extends its sincerest gratitude to the many organizations and individuals who contributed through interviews, workshops and discussion meetings. The Forum would also like to thank Deloitte Consulting LLP for its leadership and commitment in its capacity as the project advising company, Scott Corwin as the engagement lead, and Juan Danzilo as the secondee to the Forum.

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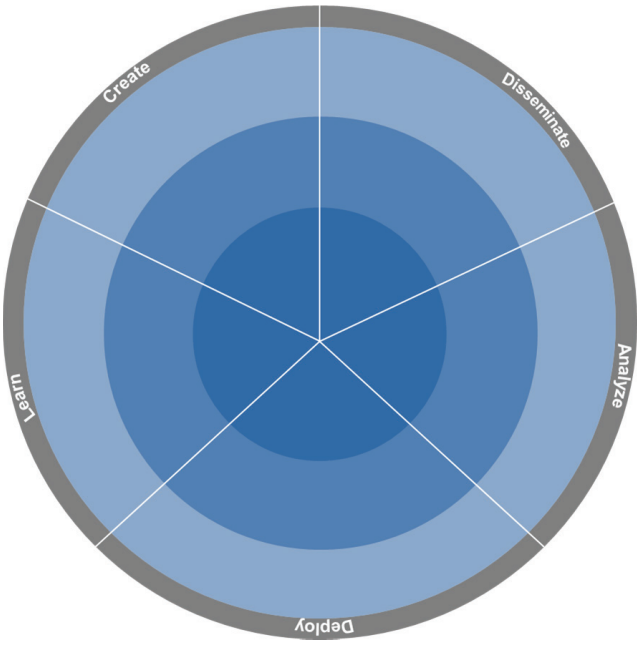
Appendix 1: Interoperability Technology Scan

Interoperability Technology Scan Framework



Technology Functions

Create: Capturing or acquiring, standardizing and storing data elements in a usable format

Disseminate : Moving data from its place of storage or creation to relevant actors based on defined permissions

Analyse : Examining data to extract meaning and insights while discarding or archiving non-relevant information

Deploy: Using analysed data and insights to better understand and make decisions

Learn: Results from data-driven decisions used to drive learning and inform future analyses and decisions

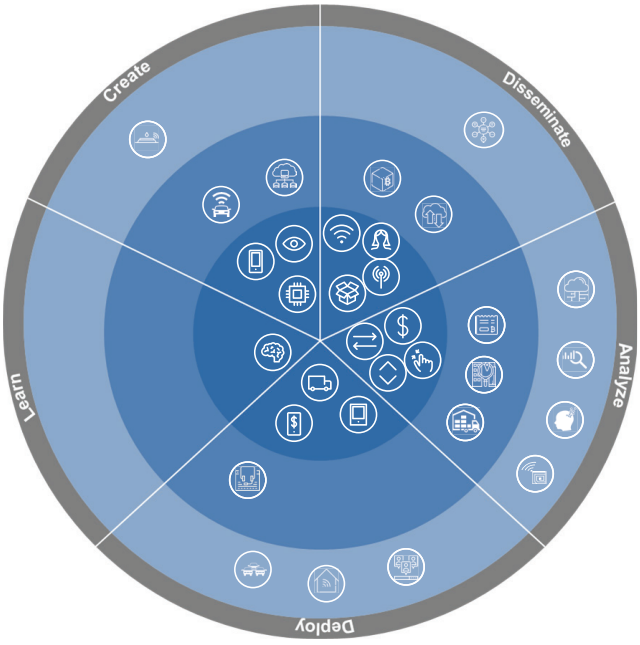
Importance to SIMSystem

Core: Foundational technologies required for the SIMSystem to operate

Adjacent: Non-critical but important technologies that help to enhance the seamlessness with which SIMSystem can operate

Indirect: Technologies that could be applied to the SIMSystem but are not required

Interoperability Technology Scan[1]



Core Adjacent Indirect

1) Technologies have been classified based on their main function. Multiple functions may exist.

	Core	Adjacent	Indirect
Create	Access Devices Geospatial Digital Identity Mgmt. Smart Sensors	Connected Vehicle Cloud (Storage)	
Disseminate	Connectivity Networks Open Data Exchanges Digital Privacy Tools Digital Security Tools	Blockchain Cloud (Data Share)	Data Aggregation
Analyse	Dynamic Pricing Permissions Mgmt. Integrated Trip Planning Supply/ Demand Mgmt.	Smart Contracts Geospatial Optimization Adv. Inventory Mgmt.	Edge/ Hybrid Comp. RFID Customer Intelligence Predictive Intelligence
Deploy	Integrated Fleet Mgmt. APIs Integrated Payments.	Real-time Optimization Smart Infrastructure	Interaction Mgmt. Dynamic Routing
Learn	Artificial Intelligence		

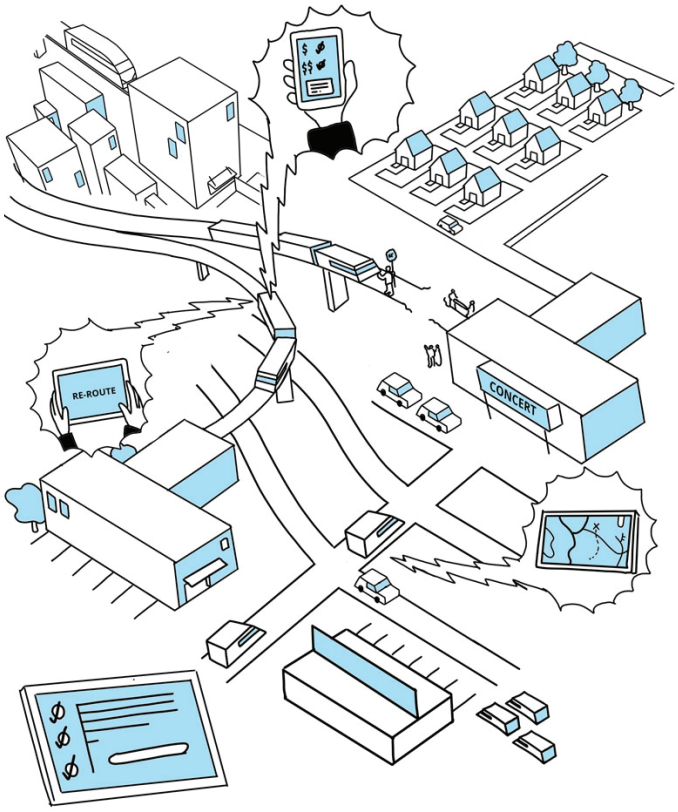
Appendix 2: Case Studies

Additional Case 1: Carlos' Journey

Beginning : Carlos is a young professional trying to balance his work and personal life. He needs to travel across the city to meet his friends for a concert. While on the journey, he also needs to attend a virtual meeting and complete his remaining work.

Challenge 1 : Carlos needs to use SIMSystem to find an affordable combination of transport modes that allows him to join his conference call, remain connected to his work and arrive on time for the start of the show.

Challenge 2 : Smart sensors indicate one of the highways could be collapsing. City managers must use the SIMSystem to determine how to cope with these events. Meanwhile, Carlos is relying on SIMSystem to formulate a Plan B.



Challenge 3 : City managers have not been able to repair the highway. They must now determine how to shift demand from road-based modes to other modes. Through the SIMSystem, Carlos has found and purchased a ticket on the public rail system and is cutting it close for the opening act.

Ending : Carlos made it to the concert just in time and for less cost that he could have if he had not used SIMSystem. City managers were able to alert passengers and establish pricing mechanisms to move demand to underused public transit modes providing them with enough time to address the issues with the highway.

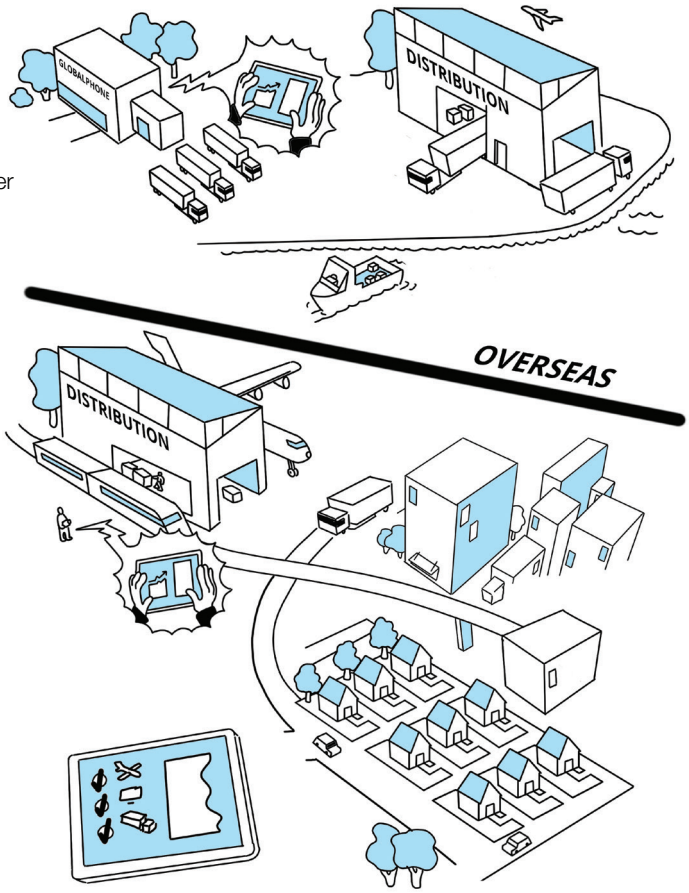
Appendix 2: Case Studies

Additional Case 2: Globalphone

Beginning : Globalphone Inc., an international manufacturer of consumer electronics, needs to deliver its products to a wide range of customers including large retailers, small businesses, and directly to consumers through both traditional and e-commerce channels.

Challenge 1 : Globalphone needs to ship its new product line from the factory to the company warehouse to the port but is facing shortages in its company-owned trucking fleet

Challenge 2 : Having crossed the ocean and now sitting at the distribution centre, the latest shipment must now make its way to both its retail customers and end customers across the country.



Challenge 3 : Retailers are satisfied with the ability of Globalphone's distribution centre to fulfil their needs using SIMSystem. Now both Globalphone and the retailers must coordinate delivery for their online customers in both rural and densely populated areas.

Ending : Using SIMSystem, Globalphone was able to tap into a network of third-party logistics providers with excess capacity to coordinate seamless and transparent delivery from the first mile to the last metre of delivery.

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