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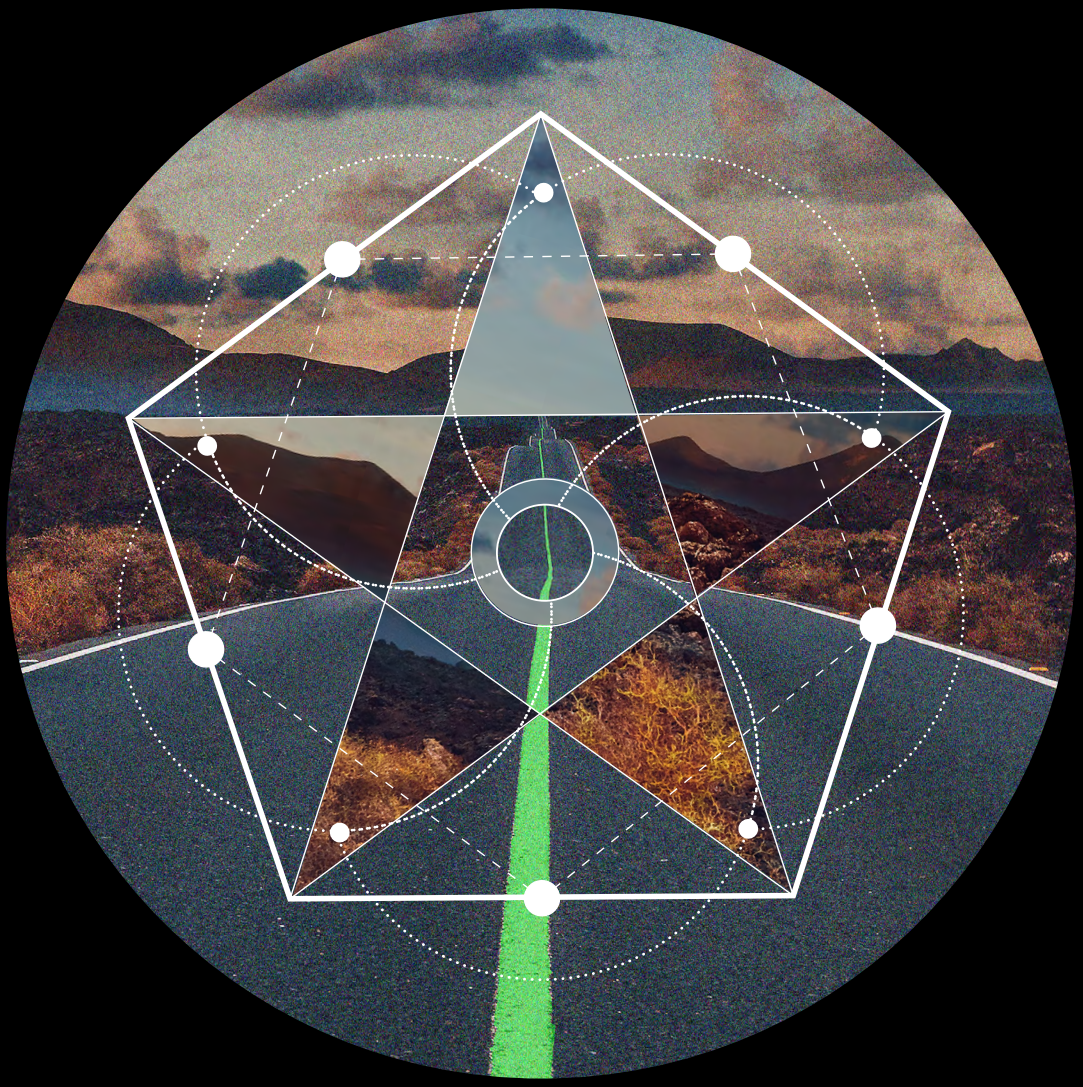
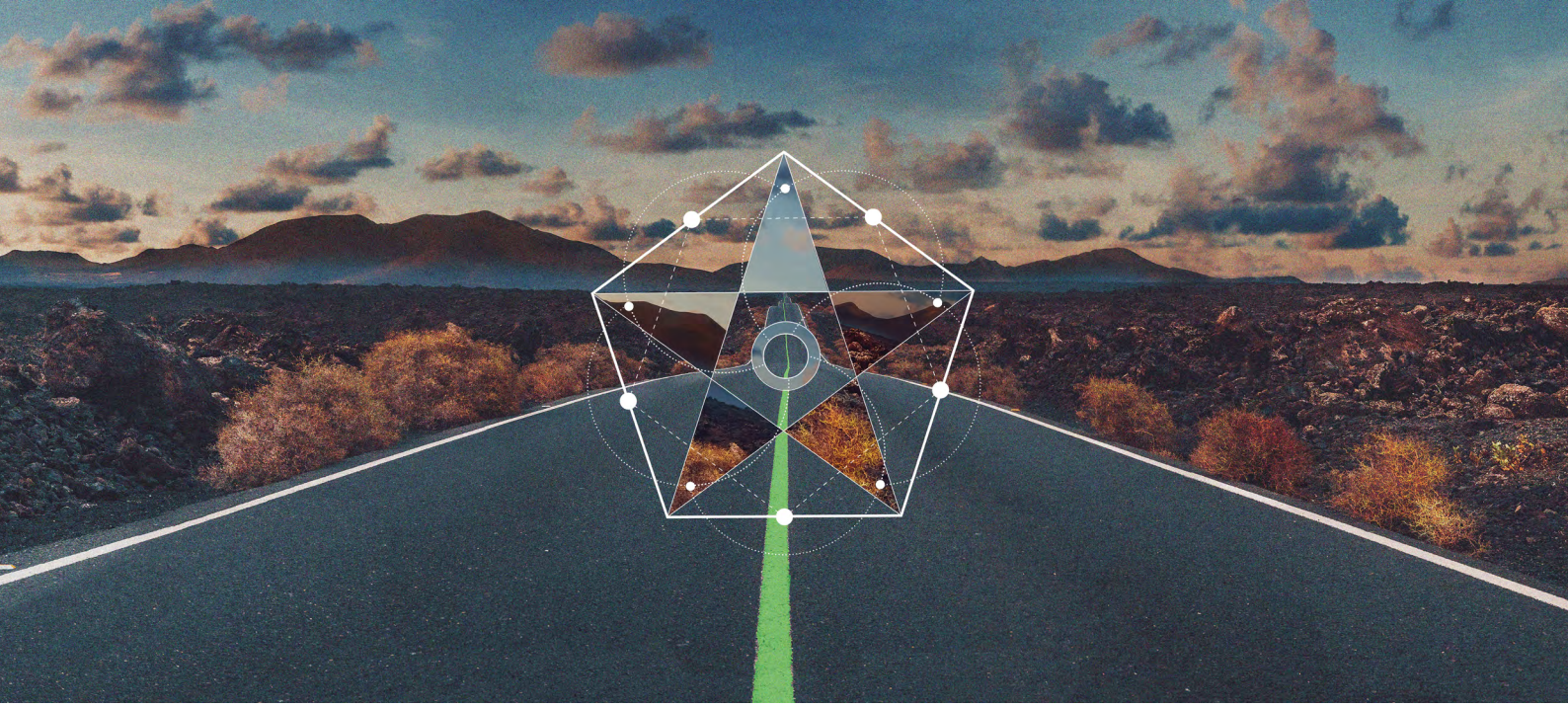


Global Transportation Trends 2022:
Future-ready transportation

MAKING AN IMPACT THAT MATTERS since 1845



Introduction

Transportation plays a fundamental role in supporting economic growth, creating jobs, and connecting people to essential services such as health care or education. However, about a billion people still live more than a mile from an "all-weather" road, and even in developed countries, basic transportation often isn't available to the residents who need it.[1]

Moreover, existing transportation systems often face a variety of hurdles, from congestion to climate change. And the revenues that support these systems are increasingly at risk from tax structures that no longer reflect the way many people move today.

Technology, obviously, will be pivotal in modernizing our transportation systems, but many traditional challenges continue to act as a brake on progress in the sector. Many transportation leaders, planners and ecosystem stakeholders thus face a mix of new and old challenges. For instance, movement toward the development of sustainable funding models to replace the "gas tax" has been slow, as has been the struggle to scale new transportation technologies and successful pilots.

It's generally acknowledged that data can improve transport efficiencies and effectiveness, but this may require new governance structures across the ecosystem related to data sharing, security and privacy. The transportation ecosystem should build resiliency both in the cyber and physical worlds through cybersecurity measures and a climate-resilient transportation infrastructure. And modernization efforts should be made inclusive and equitable to provide greater opportunities in employment, education, health care, shopping and recreation to underserved communities.

Even so, we remain hopeful for significant progress in transportation. In Global Transport Trends 2022, we explore five trends that address the myriad challenges facing transportation as it potentially enters the next era of exponential growth. We see progress in some areas, even as new concerns emerge due to the COVID-19 pandemic and growing concerns over climate change and environmental sustainability.

The Five Trends

Trend 1

Creating sustainable funding mechanisms for transportation

The developing crisis in transportation funding — in many cases, vehicle miles traveled continue to rise while gasoline tax receipts continue to be eroded by greater fuel efficiency and the increasing popularity of electric vehicles — calls for greater urgency in the development, testing and scaling of sustainable alternatives to fuel taxes. To help gain widespread public acceptance and adoption, road user charging (RUC) programs should articulate a clear value proposition for stakeholders; educate stakeholders about the necessity for RUC — and what's at stake in its absence; and build public trust by highlighting the links between how funding is obtained and how and where it's spent.

Trend 2

EVs usher in a generational shift in mobility

The widespread adoption of electric vehicles (EVs) represents a growing technological and cultural transformation. With some countries already seeing exponential growth in EV ownership, transportation leaders and ecosystem partners should focus on addressing the charging infrastructure problem and a potential talent crunch in the EV market.

Trend 3

Modernizing transportation systems in an inclusive, equitable way

By tapping into the momentum generated by the focus on inclusion and equity, transportation leaders can create an equity-centered approach to investment and design that brings underserved and disadvantaged communities into the planning process. Transportation agencies would have to balance equity with innovation, keeping mobility ecosystems functioning and accessible while encouraging modernization.

Trend 4

Making transportation networks more resilient

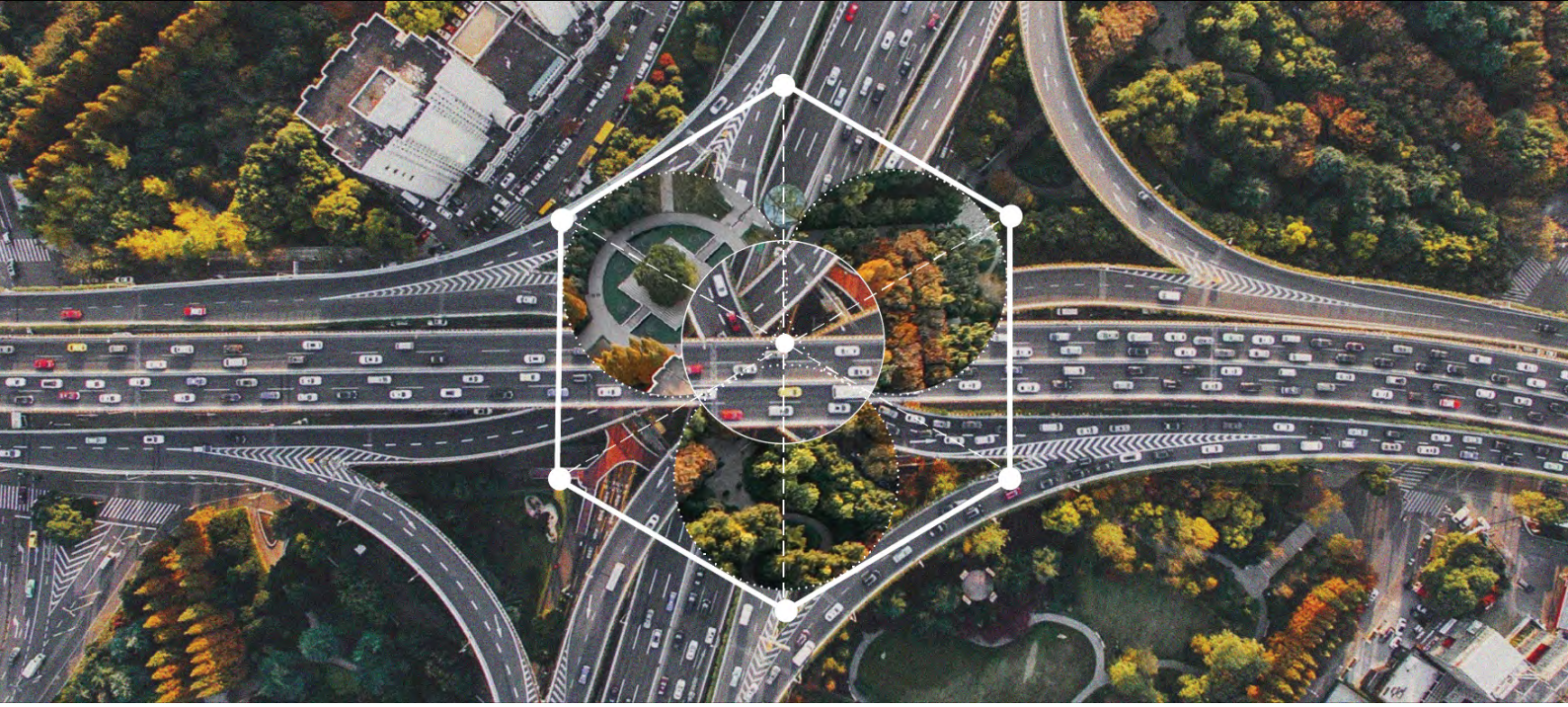
Transportation leaders should fight a two-front war to make the transportation system more resilient to cyber threats and climate change. Both problems are probably unavoidable and will continue to pose growing threats.

To address cyber threats, effective cybersecurity should be embedded in new systems and technologies, from design through implementation. New collaborative governance models are needed to manage the increased risks associated with a growing number of connected physical devices. On the climate front, increasing the resiliency of the transportation system and infrastructure will require significant innovations in design and maintenance, coupled with a more data-driven approach to prioritizing investment decisions.

Trend 5

Turbocharging digital and technological innovation

The pandemic turbocharged digital transformation at transportation agencies. New funding could provide further impetus to experiment with smart infrastructure, connected and autonomous vehicle technologies and innovative mobility-on-demand solutions. To succeed, transportation agencies should address the age-old challenge of scaling successful pilots by improving pilot design and building better systems for scaling innovation.



Trend 1. Creating sustainable funding mechanisms for transportation

In the bestselling book *The 7 Habits of Highly Effective People*, Dr. Stephen R. Covey asks readers to "begin with the end in mind."[2] Covey observed that all things are created twice: first in the mind and then in the physical world.

In the realm of transportation funding, what might the future look like, when highly fuel-efficient vehicles (including hybrids and EVs) make up a majority of the vehicles on our roadways? What changes can we expect when connected technologies become ubiquitous across most of the vehicle fleet?

Today, many traditional funding models still are based largely on taxes levied per gallon or liter on fossil fuels. But they're being undermined steadily by increased fuel efficiency and the growing popularity of EVs. Road user charging (RUC) and vehicle miles traveled (VMT) taxes are being piloted and implemented around the globe.

Imagine a future, then, in which tolls are paid digitally through a telematics-enabled system that uses geofencing to assess vehicle movements, eliminating the need for tolling plazas and physical transponders. Imagine road pricing as simple for users as the gas tax they pay at the pump today. Congestion is managed across the network using geofencing and variable pricing, allowing for smoother traffic flows. Drivers are incentivized to make sustainable travel choices. And transportation is funded by taxes based on actual roadway usage, producing reliable revenue streams that allow agencies to maintain and update our transportation networks to meet our growing needs.

Road usage charges gain traction

In the United States, several states have tested RUC with small-scale pilots; Oregon spearheaded efforts as early as 2015.[3] At the time of this writing, Oregon, Utah and Virginia are implementing live RUC programs. RUC activity can be expected to increase substantially over the next few years thanks to a substantial infusion of federal funds from the Infrastructure Investment and Jobs Act (IIJA), signed into law on 15 November 2021.[4]

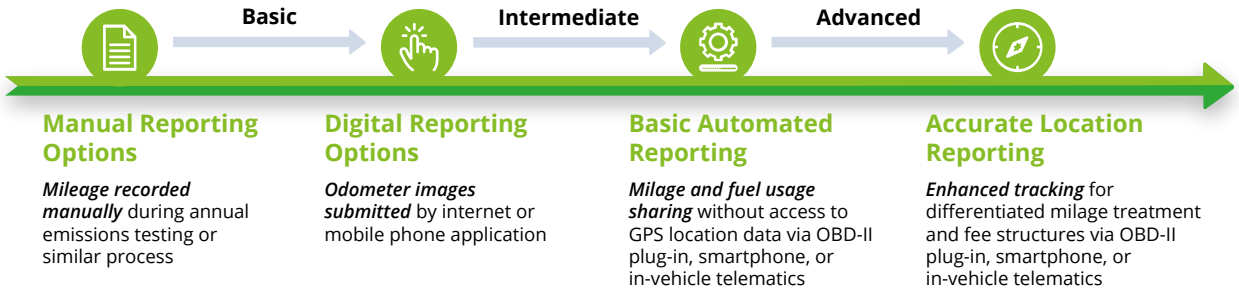
In Australia, fuel excise tax collections on petrol have declined by 30% in the 12 years since fiscal year 2009, equating to a loss of US$1.5 billion in federal revenue.[5] In a move to begin addressing the shortfall, in 2019 the nation's Department of Infrastructure, Transport, Regional Development and Communications (DITRDC) began an opt-in trial for distance-based RUCs on heavy vehicles. DITRDC recruited a number of industry participants for the pilot. In these tests, no actual payments were being made, but mock invoices were produced for comparison between real-world payments and the distance-based trial.

Phase 1 of the trial was completed in February 2021 and focused on testing a distance-based road user charge and co-designing a mock invoice with industry partners. The ongoing Phase 2 involves hub odometers mounted to vehicle axles and a manual "pre-purchase" of kilometers through a permit system. Phase 3 will use telematics to measure distances traveled and will gather data on mass, location, configuration and distance.[6]

Lessons learned from earlier RUC pilots and programs

Many RUC pilots have been completed and some are still in effect, allowing us to consult lessons learned and minimize repeating earlier work. To date, these programs have demonstrated — with varying degrees of success — both the technical feasibility of RUC as a replacement for the gas tax and the viability of multiple methods for mileage reporting (**Figure 1**).

Figure 1: RUC programs can use a variety of reporting solutions



Source: Deloitte Global

This experience has shown that while pilot participants generally supported the "user pays" principle for transportation, they often had relatively little knowledge of the size of the funding challenge transportation faces, or the details of the current tax system that funds roadways. In short, countries and regions should educate the general public about funding challenges and how RUC can address them.

Three outstanding questions

Widespread adoption of RUC likely won't happen overnight. Traditional fuel taxes have been in place for more than a century and replacing them could require a great deal of effort and political savvy. To make the most of the new momentum in the transportation market to test sustainable funding alternatives, nations and regions should invest in programs that address three unanswered questions:

- How should jurisdictions determine the appropriate per-mile fee? In the majority of RUC pilots conducted to date, fees were set to be revenue-neutral, meaning that the RUC revenue collected simply offset anticipated gas tax collections. In practice, though, fees should address the gap between funding needs and existing gas tax revenues (potentially via higher per-mile rates or dynamic fee pricing) or be supplemented with other revenue sources.

- What current reporting solutions are viable at scale, from both a technical and human-centered perspective? The existing fuel tax structure is extremely efficient, with low administrative costs. RUC systems, which calculate tax owed for each driver, likely will entail significantly higher administrative and equipment costs than traditional gas tax, potentially making them difficult to scale. The focus should be on making these reporting solutions more efficient.
- In what ways will the broader public differ from pilot participants? The voluntary nature of RUC pilots is likely to result in self-selecting participants that are proponents of the change rather than a representative sample of the general public. Achieving public support may require a careful balance between education and simplicity of message and experience.

Getting started

While nationwide RUC systems can require some time, bold action today can help meet current system needs — and prepare the way for stable funding solutions. The effort requires action on multiple fronts.

Increase public awareness

Surveys of RUC pilot participants show that their understanding of and support for mileage-based fees increases significantly as a result of participation. Again, though, these small-scale pilots reach only a small, self-selecting share of the population, signaling the need for broader public awareness.

Communication and awareness campaigns can play an important role in building buy-in from a wide variety of stakeholders. A research study from the US Federal Highway Administration gleaned insights from 11 RUC pilots to identify key elements of successful outreach strategies. First, the communication strategy should target a varied group of stakeholders, including political leaders, government groups and agencies, news media, industry or citizen advocacy groups and the general public. Secondly, the study recommends preparing a comprehensive communications plan that articulates the pilot goals clearly and drives a consistent message toward these stakeholders. Such plans may require at least one dedicated communication specialist and an outreach budget. Finally, the study concluded that a web page offering detailed information and personal or in-person communication opportunities provides the most effective delivery mechanism.[7]

Define the value proposition for stakeholders

If the transition to RUCs is to succeed, different stakeholder groups should understand the value it offers them. For rural communities, for instance, it might be greater parity in urban/rural funding for transportation.

For vehicle manufacturers, however, the value proposition hasn't been defined clearly. The transition raises an array of concerns, from obtaining customer consent for vehicle data collection to the question of who should shoulder the costs associated with transferring, storing, processing and securing such information. Further challenges include how to share data among different regional systems and how to handle changes in vehicle ownership that occur outside of dealerships. So far, such challenges haven't been addressed.

Design for trust

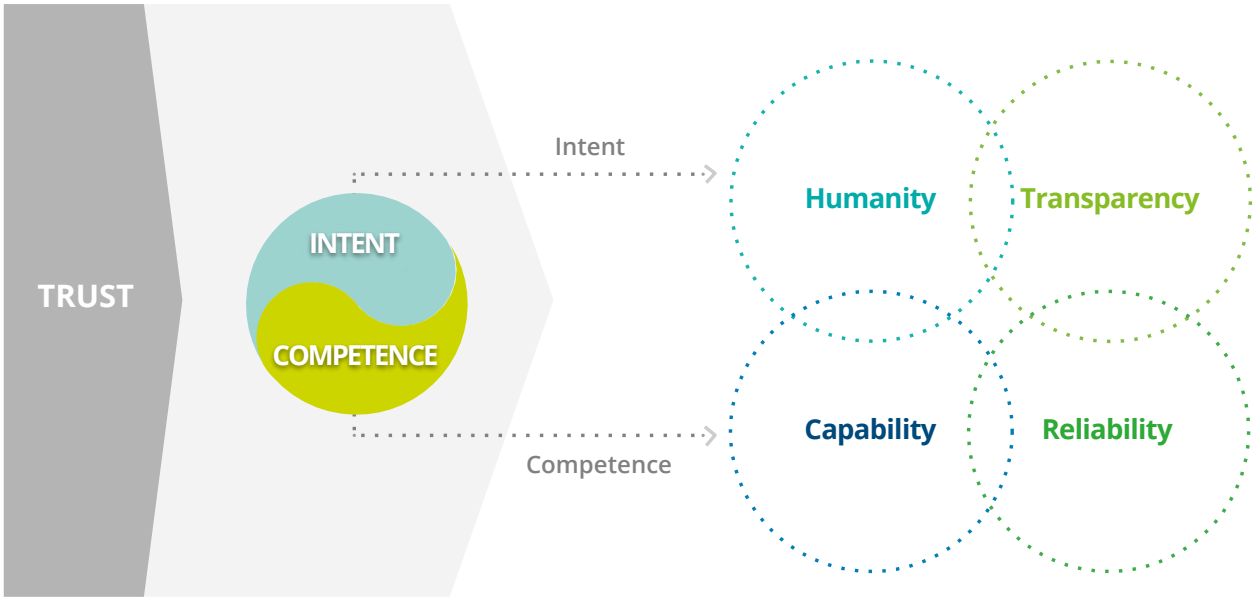
Public trust can make or break any transition to RUC. The current transportation funding system is largely opaque to ordinary citizens. Despite the price indicated on the pump, the average motorist does not know how much or how little they pay to support transportation services over time, in fuel taxes, tolls, license fees and other charges — or who should be held accountable for poor performance.

This opacity, together with the increasing use of highway user fees for non-highway uses, leads motorists to see these fees as more akin to a general tax than a usage fee that directly supports the roadways they use. As a result, many taxpayers are reluctant to support any fuel tax increases. To fund roadways more effectively and equitably, transportation agencies should adopt an approach that highlights the link between how funding is obtained and how and where it's spent.

Our research suggests that trust in this area can be built and sustained by demonstrating two foundational attributes — consistently delivering on promises, with competence, and doing so with good intent.[8]

These attributes manifest themselves in four unique trust signals: humanity and transparency, which can demonstrate intent, and capability and reliability, which can demonstrate competence (**Figure 2**).

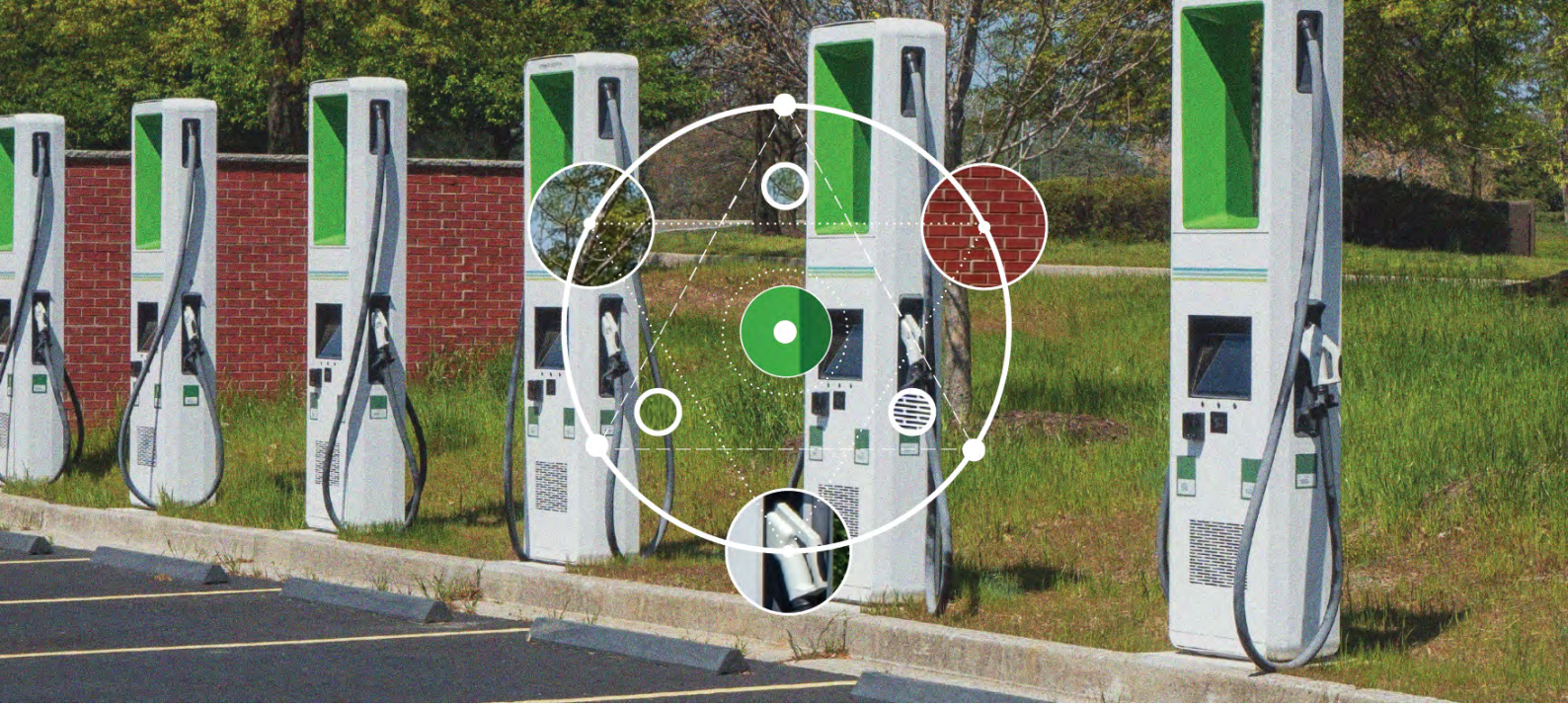
Figure 2: Four signals contribute to greater trust



Source: Deloitte Global

Transportation agencies thus can instill confidence and trust in RUC programs by focusing on these four areas:

- **Humanity** is the perception that an agency genuinely cares for its constituents' experience and well-being by demonstrating empathy, kindness and fairness.
- **Transparency** indicates that an agency openly shares information, motives and choices related to policy, budget and program decisions in straightforward language.
- **Capability** reflects the belief that an agency can create high-quality programs and services and meet expectations effectively.
- **Reliability** shows that an agency can deliver programs, services and experiences consistently and dependably across platforms and geographies.



Trend 2. EVs usher in a generational shift in mobility

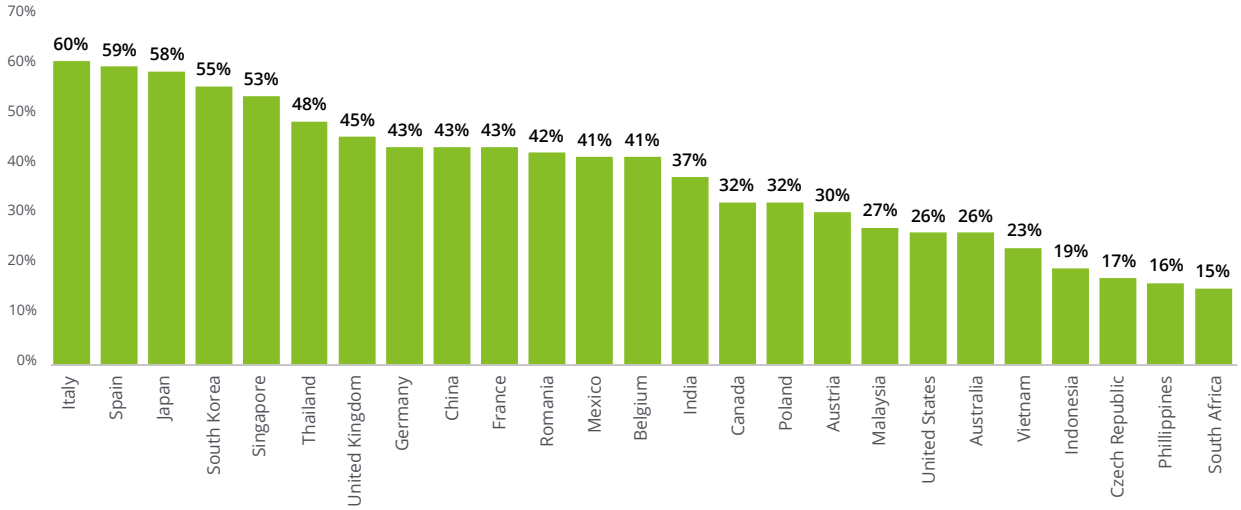
The move to electric transportation isn't as simple as replacing every internal combustion (IC) engine-based vehicle with an EV; it includes wide-ranging implications for the broader transportation ecosystem and its infrastructure.

Billions of individuals worldwide are used to relying on IC-based vehicles. There's a well-established network for their sale and leasing, fueling and maintenance. The patchwork nature of the corresponding infrastructure for EVs may create a psychological barrier in consumers' minds. Recent surveys indicate that some of the biggest concerns about adoption include an inadequate public charging infrastructure, driving range, costs compared to traditional IC vehicles and — given some highly publicized mishaps — safety issues concerning batteries.[9] As with almost any major technological transition, there are bound to be false starts and teething issues along the way.

In the US, the Biden administration is in support of electric transportation and set an ambitious target of EVs representing 50% of all new vehicles sold in the US by 2030.[10] Other countries are even more proactive; Norway intends that all new cars sold by 2025 should be electric or hydrogen-based.[11] The European Commission wants all new registered passenger cars and vans to be zero-emission vehicles by 2035.[12]

According to Deloitte's 2022 Global Automotive Consumer Study, increasing numbers of consumers worldwide plan to buy an EV in the next three years (**Figure 3**). Purchasing intent varies significantly across nations, however, with Italy showing an intent almost double that of Canada, Poland or the US. The reasons for such disparities range from the availability and type of incentives offered to the comparatively low price of fuels in some markets.[13] But with recent disruptions due to the Russia-Ukraine conflict and the rising cost of fuel in most global markets, EV purchasing intent may surge soon.

Figure 3: Global EV purchase intent



Source: Deloitte 2022 Global Automotive Consumer Study

Government transportation agencies face enormous challenges in scaling EVs and their corresponding infrastructure during the next decade. Among these are three important factors agency leaders should consider:

- Building the EV charging infrastructure;
- Scaling EVs equitably; and
- Addressing workforce challenges.

Charging infrastructure could be the biggest short-term hurdle

Building a ubiquitous charging network that resembles today's gasoline and diesel infrastructure may be one of the toughest challenges to address. Among the many questions:

- How many public charging stations should we install?
- Should they be powered by renewable energy?
- How should charging be priced?
- What impact can charging have on the grid during peak consumption hours?
- How can we ensure equity in charging infrastructure?
- How should we maintain the charging infrastructure once it's installed?

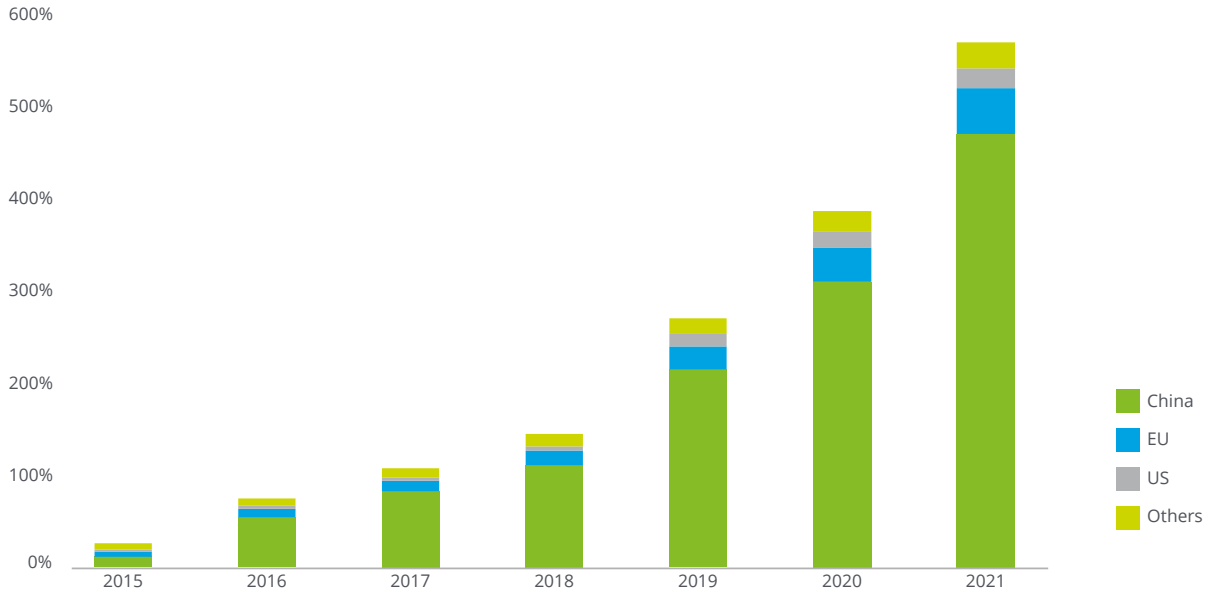
Many national governments are focused on building the charging infrastructure needed to accelerate the move toward EVs. In the US, the IIJA legislation has allocated US$7.5 billion for EV infrastructure programs and grants.[14] Such funding and programs should provide the initial push required to scale the EV charging infrastructure.

China is leading the market in both EV sales and the expansion of its charging infrastructure. In 2022, China's EV penetration exceeded 25% of total vehicle sales, three years ahead of the target timeline of 2025. Furthermore, it aims to build enough charging infrastructure to support more than 20 million cars by 2025. The nation also acknowledges the uneven expansion of its infrastructure, however, as nearly 70% of its sites currently are located in heavily urbanized areas. In January 2022, China's National Development and Reforms Commission issued guidelines to expand the charging infrastructure to regions and villages under its rural revitalization program.[15]

To build out the EV infrastructure, government leaders must prepare for a series of major challenges:

- **Charging technology.** Today's EVs can be charged with three different types of technology that provide different charging speeds. Level 1 chargers operate through 120-volt outlets, the common household current in the US Level 1 chargers can require 40 to 50 hours to charge a fully electric vehicle and five to six hours to charge a hybrid. Level 2 chargers operate at 208 volts or 240 volts and can fully charge an all-electric vehicle in four to 10 hours and a hybrid in one to two hours.[16] Direct Current Fast Chargers (DCFCs) can charge EVs within an hour, but thus far only China has significantly grown its fast-charging infrastructure (**Figure 4**). The number of DCFCs should be scaled upward rapidly to avoid bottlenecks and frustration at charging stations, especially in the commercial vehicle segments.
- **Fleet electrification:** Federal fleets are large and electrifying them can be a significant task. The UK government has set a goal of moving 100% of its fleet of central government cars and vans, about 40,000 vehicles, to zero emissions by 2027.[17] The US Government Accountability Office (GAO) reports that the federal government owned 1,100 charging stations in March 2022 — and would need 100,000 to meet its fleet electrification goals.[18]
- **Smart charging:** Electricity pricing raises the concern of when vehicles should be charged. The timing of vehicle charging could have significant implications for fleet operational costs. Agencies and individuals paying such rates may need to develop protocols to control costs, rather like the route optimization planning performed today for delivery vehicles. The UK's Electric Vehicles (Smart Charge Points) Regulation came into force on June 30, 2022. This regulation requires charge points to come pre-configured with a charging schedule to match off-peak demand and smart functionality allowing them to communicate with the grid to change prices dynamically to match peak demand.[19]

Figure 4. Growth in fast-charging infrastructure in China, Europe and the US, 2015-2021 (in thousands)



Source: International Energy Agency

Scaling the EV market equitably

There's a strong economic case for making the EV market expansion more equitable. Helping lower-income groups purchase EVs may alleviate some of their total transportation costs, since EV maintenance costs are generally lower than those for IC vehicles due to fewer moving parts and the lack of motor oil and filters. A 2020 Consumer Reports study indicated that maintenance and repair costs for EVs average about half of those for conventional vehicles.[20] But those who could benefit the most from EVs often can't afford the ones offered in the current market; in 2021, electric vehicles cost about US$10,000 more than the industry average for all vehicles.[21]

According to a recent Deloitte Access Economic study in Australia, for instance, the price differential between EVs and comparable conventional IC vehicles, even with falling manufacturing and material costs for EVs, is unlikely to close till 2030. The study also noted that 65% of Australians are interested in buying an EV if the price is less than US$32,500 — but 89% of EVs available in their market cost more. Our research suggests that targeted subsidies for lower- and middle-income households could boost EV sales to these groups. Even a US$6,400 government subsidy for private vehicles could help overcome Australians' price parity concerns and change the demand curve for EVs.[22]

Furthermore, such subsidies could be phased out as EVs gain market share and become more affordable in the future.[23] This is already happening in China; its EV subsidy program, which began in 2009, is credited with boosting its domestic EV market. China funded nearly US$14.8 billion in subsidies for buyers, including commercial fleet operators, between 2009 and 2021. It has reduced these subsidies over the years and was planning to stop these subsidies by the end of 2022, but due to current economic conditions, it now plans to extend them through the end of 2023. The subsidies will be rolled back in phases by introducing a purchasing tax first and then reducing the subsidies further.[24]

The second part of the equity equation concerns the charging infrastructure. Initial analysis from the United Kingdom suggest that home charging, while slow, is more cost-effective than public charging.[25] Yet lower-income groups, especially those living in urban areas, often lack access to home charging. For this reason, a concerted effort is needed to locate EV charging stations in easily accessed public places, such as locations near workplaces, retail centers and multifamily housing.[26]

The UK's US$450 million Local Electric Vehicle Infrastructure (LEVI) program aims to expand the charging infrastructure program across England. As part of this program, in August 2022 a US$20 million pilot began installing 1,000 charge points in nine towns and cities. These will include local charging hubs as well as charge points in driveways and near streetside parking.

Addressing the workforce challenge

An even bigger challenge for ecosystem players, including governments, could be the availability of a workforce trained to maintain and repair EVs and the charging infrastructure.[27]

Today, batteries make up almost 30% of the total value of an EV and the cost of replacing one can be daunting.[28] Skilled battery technicians are required for repairs, software issues, calibration of internal systems and diagnostics.[29] Similar challenges are expected in repairing and maintaining charging stations. While EV manufacturers are building a maintenance workforce, a significant need for workers remains.

In June 2022, the US federal government launched its Talent Pipeline Challenge to develop the next generation of infrastructure workers. The program focuses on broadband, construction and electrification; the electrification focus is intended to develop a skilled workforce for charging infrastructure and battery manufacturing. The challenge calls upon state and local governments to use funding from the American Rescue Plan, IIJA and the State Workforce Innovation and Opportunity Act to retrain and reskill workers and create workforce development programs and apprentice opportunities in the three priority areas.[30]

Trend 3. Modernizing transportation systems in an inclusive, equitable way

The COVID-19 pandemic changed many of the ways in which our communities work, move and connect. Some changes — such as the white-collar shift to remote work — happened suddenly and may well prove to be permanent; in 2021, more than two-thirds of companies reported plans to implement hybrid work models.[31] As of August 2022, average peak office occupancy globally was below 40%, according to a report by real estate analytics firm Basking.[32] Other changes have continued to follow shifting patterns of shopping, employment, and leisure activity.

From the first lockdowns, the pandemic changed the transportation landscape. Public transit agencies, in particular were forced to confront inequality as legions of "essential workers" — often lower-income or racially and ethnically diverse travelers — continued to travel to hospitals, grocery stores, warehouses, pharmacies and other critical sites daily to maintain national economic and health systems. This pattern raised basic questions about the role of transportation agencies in addressing broader societal and economic challenges, including climate change, which threatens to outpace humanity's ability to adapt.

Transportation networks should evolve quickly to limit the impact of such challenges on vulnerable populations. Technological innovation will be essential, but it isn't a panacea for all needs and concerns. Transportation agencies face a challenging balancing act in maintaining core services while integrating new technologies that enhance mobility for all travelers.

As new travel modes and services enter the mobility ecosystem, public transportation leaders should design systems that provide access to regional opportunities while allowing travelers to choose the ways in which they move in their own communities. This requires systems that are flexible enough to stay both efficient and inclusive for constituents while offering them multiple ways to reach their destinations.

A renewed focus on equity

Nations around the world are renewing their focus on equity. In the US, the federal government is making a concerted effort to address longstanding societal inequities, notably through its Justice40 initiative. Created by Executive Order 14008 in January 2021, this initiative sets a goal that 40% of the overall benefits of federal investments in climate and clean energy must flow to disadvantaged communities.[33]

At a state level, the California State Transportation Agency's (Caltrans) Climate Action Plan for Transportation Infrastructure outlines several strategies and action steps including an equity index to measure the impacts of its plans on various demographic groups.

Caltrans has sought community and stakeholder input on the environmental, accessibility and socioeconomic indicators it uses to evaluate transportation projects. This process allows stakeholders to share data and evaluate projects from a health and equity perspective by layering and weighing indicators from disparate sources, such as nonwhite and/or Hispanic population percentage, concentration of diesel particulates and incidence of traffic fatalities and injuries. The intent is to prioritize projects that likely have higher social equity benefits.

Equity-centered design

About 15% of the world's population lives with some form of disability.[34] Finding accessible transportation options can be difficult for persons with disabilities, but the picture is improving. Cities worldwide are using innovative approaches to make public transportation more equitable and accessible for everyone. In June 2022, for example, Transport for Wales successfully tested a new onboard digital service called Hearing Enhanced Audio Relay (HEAR) that offers passengers with hearing loss customized journey announcements on their smart devices in real-time. The app supports multiple languages and gives an overview of previous announcements, delayed schedules, etc.[35]

A similar initiative is under way in the Canadian city of Laval in Quebec, which has launched a smartphone app to help citizens with special needs, such as autism or intellectual disabilities, ride their bus network. The app aims to reduce travel anxiety, increase independence and improve their overall public transit experience. Once registered, it provides users with detailed instructions on how to reach various destinations; it even tracks the rider and can send a notification to a friend or family member if they deviate from the path provided.[36]

To help ensure that everyone with a stake in the outcome is included in the design process, leading jurisdictions are spearheading more inclusive and collaborative approaches. In 2020, for example, Scotland tapped more than 60 organizations and 6,500 people to contribute to its National Transport Strategy, its vision for the next two decades, with the aim of protecting the environment and improving lives for those in Scotland.[37]

Connecting remote areas

Access to public transport in both urban and rural areas plays a vital part in shaping our future. Citizens in rural areas often travel long distances to access essential services such as specialized health care, higher education and grocery stores. For these communities in particular, flexibility is critical; they have unique requirements that fixed-route services may not meet effectively.

Demand-responsive transportation, also known as on-demand public transportation, can improve transportation access for population groups who were previously excluded. New South Wales in Australia has successfully piloted various on-demand initiatives for the last three years, providing more than 1.1 million trips. In July 2022, the government made all seven on-demand pilots permanent to provide its communities with better access to public transportation closer to home, improving connections to transport hubs, shopping centers and other townships.[38]

In France, where 54% of the rural population doesn't have access to a bus stop within a 10-minute walk, carpooling is being promoted as an alternative. Citizens can go to the closest assigned carpooling stop and enter their destination through a pushbutton panel, text or mobile application. The details are sent to drivers and displayed on the carpool stop's overhead light panel. A driver can identify their assigned passenger with a membership card or code, which assists in cost-sharing and adds a layer of safety to the service.[39]

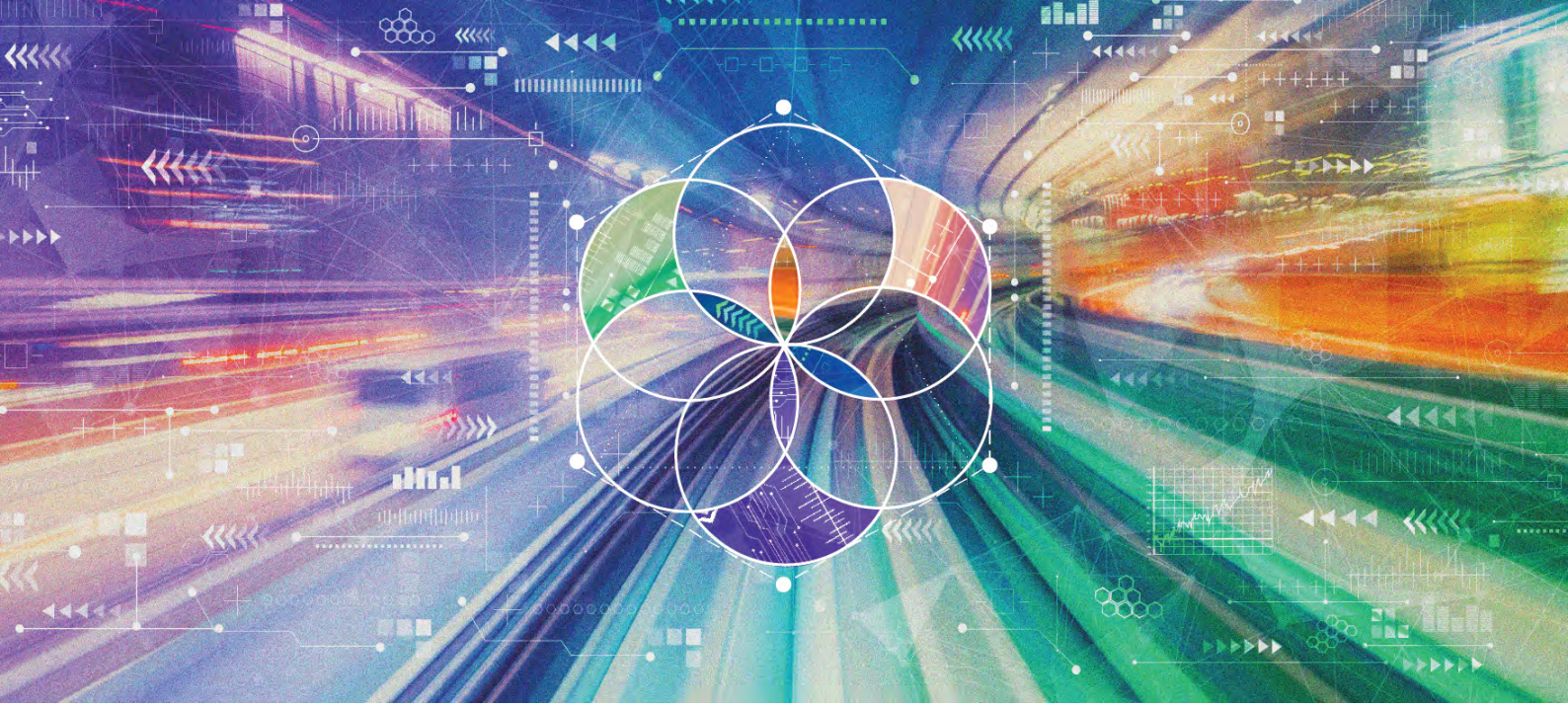
A regional approach for equitable innovation

As travel patterns continue to evolve, transportation agencies should reevaluate their plans and methods to keep pace. To reach a consensus on long-term solutions, transportation agencies should begin by exploring integrated near-term approaches at the regional level, collaborating across the web of ecosystem partners. Local agencies that engage directly with riders can build trust and support for larger transportation initiatives, while regional agencies can tie together local outcomes to serve broader goals including equity.

The private sector is a key player in mobility innovation; disruptive business models such as ride-hailing have highlighted transportation agencies' inability to adapt quickly to market demands. Ride-hailing companies, in fact, owe much of their success to public transportation's failure to meet the need for rapid, flexible, on-demand service.

Where should public transportation leaders begin aligning the vast ecosystem of mobility players to address equity, climate, community and public health concerns? First, they should create a vision and goals for their regions and cultivate support for them. To understand communities' mobility needs and challenges, it's important to include leaders whose organizations engage directly with constituents. Next, leaders should evaluate the roles of and space between transportation agencies in their regions, understanding which are best positioned to develop and deliver innovative solutions. Finally, regions should move to sustainable funding models, identifying the shortcomings of current structures and finding ways to eliminate them with future initiatives.

Ultimately, technology alone can't solve the transportation challenges our communities face; the future of mobility will require a transformation of government processes and a better approach to regional transportation planning and management. A functioning, equitable mobility ecosystem demands support from regional and local agencies, private partners and the community of users.



Trend 4. Making transportation networks more resilient

Connected vehicles and intelligent transportation will change the transportation network. Today, we're seeing a convergence between the physical and virtual worlds, as embedded sensors and controllers link to IT networks. This convergence, however, vastly increases the challenge of cybersecurity. Transportation networks and systems are loaded with vital information, including personal data, which can make their websites, systems and connected devices prime targets.[40]

And there's plenty of evidence of malicious intent. Between June 2020 and June 2021 alone, ransomware attacks on the transportation industry rose by 186%.[41] In July 2021, the UK's Northern Trains' self-service touch-screen ticket machines were hit by a suspected ransomware attack.[42] In October 2021, Toronto Transit Commission in Canada was hit by a ransomware attack that affected its apps and displays showing route information.[43] In April 2022, Puerto Rico's AutoExpreso electronic toll collection system was the target of a cyberattack.[44]

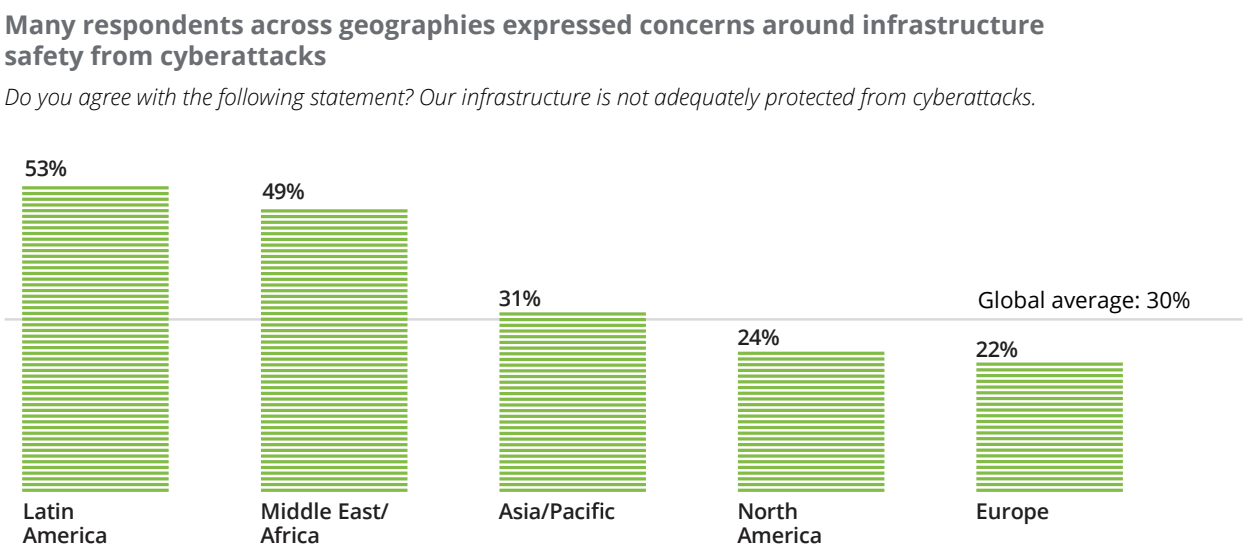
Still another growing risk to transportation networks stems from climate change, which will require significant innovations in infrastructure design and maintenance. Unprecedented heat waves are causing roads to buckle, power lines to fail and pavement to crack. Storms, too, are increasingly violent; "100-year" storms are hitting cities and coastal areas more frequently, wreaking havoc on roads, bridges and mass transit systems.[45] Such disruptions can affect the movement of people and goods and reduce access to employment and critical services such as health care.[46]

Embedding cybersecurity from design to implementation

The growing number of connected devices, as well as their integration with systems such as ticketing management, identity management and real-time processing engines, makes today's transportation system increasingly vulnerable to cyberattack. In a recent survey of 167 global city leaders, 83% of respondents reported investing in real-time public transportation applications; 63% were investing in smart traffic signals and traffic management systems.[47]

According to Deloitte's 2022 global infrastructure survey, the cybersecurity of critical infrastructure including transportation is a concern for many government and private infrastructure leaders alike (**Figure 5**).[48] They no longer can afford to consider cybersecurity as an afterthought. As the transport infrastructure becomes increasingly connected, cybersecurity reviews should be incorporated from the procurement stage onward. Devices should be tested in local facilities to understand their vulnerabilities and develop protocols for breach events. And such steps should be taken before these devices are installed in tunnels, tolling stations, floodgates and other infrastructure.

Figure 5: Cybersecurity is a continued concern for infrastructure leaders



Source: Deloitte analysis.

Governance models and agency culture also should evolve to reflect the increasing convergence between the physical and virtual worlds, bringing engineers into closer collaboration with security teams to increase the cybersecurity posture. In the United States, the Pennsylvania Turnpike Commission's (PTC's) multiyear modernization project to refurbish both tubes of the mile-long Tuscarora Mountain Tunnel is a prime example of what such collaboration looks like in practice.

With the tunnel modernization, PTC faced not only typical engineering challenges but a host of cybersecurity risks directly related to the complex web of connected devices deployed throughout the tunnel. PTC's security team historically focused on securing the traditional computing and network infrastructure. But the tunnel rehab — a US$110 million investment with a 30-year lifespan — required the deployment of connected environmental sensors that measure and report on tunnel conditions, including temperatures and levels of carbon dioxide and other gases; automated ventilation, lighting and video detection systems; and a control system that collects data and enables remote monitoring, among other devices and systems.[49]

With so many embedded devices now part of its tech stack, PTC's security team took a farsighted, preemptive approach to cybersecurity, according to April Rothermel, PTC's assistant chief technology officer. "The security team proactively got involved in the engineering and design of the tunnels, working hand in hand with project engineers to help ensure that cybersecurity was baked in from the beginning," she says. "Before this, our team had never needed to be involved in these types of projects in the very early stages, or with such a high level of involvement."[50] The teams worked together to accommodate security requirements and devise creative solutions when security and business requirements collided.

Cyberattacks often are not about malware attacks or "zero-day" exploits.[51] Connected and autonomous vehicles tap into varied sources of information to understand traffic and road conditions. This information may not always flow from trusted sources, and in many cases might be crowdsourced. This creates potential vulnerabilities malicious players could use.[52]

Climate resiliency

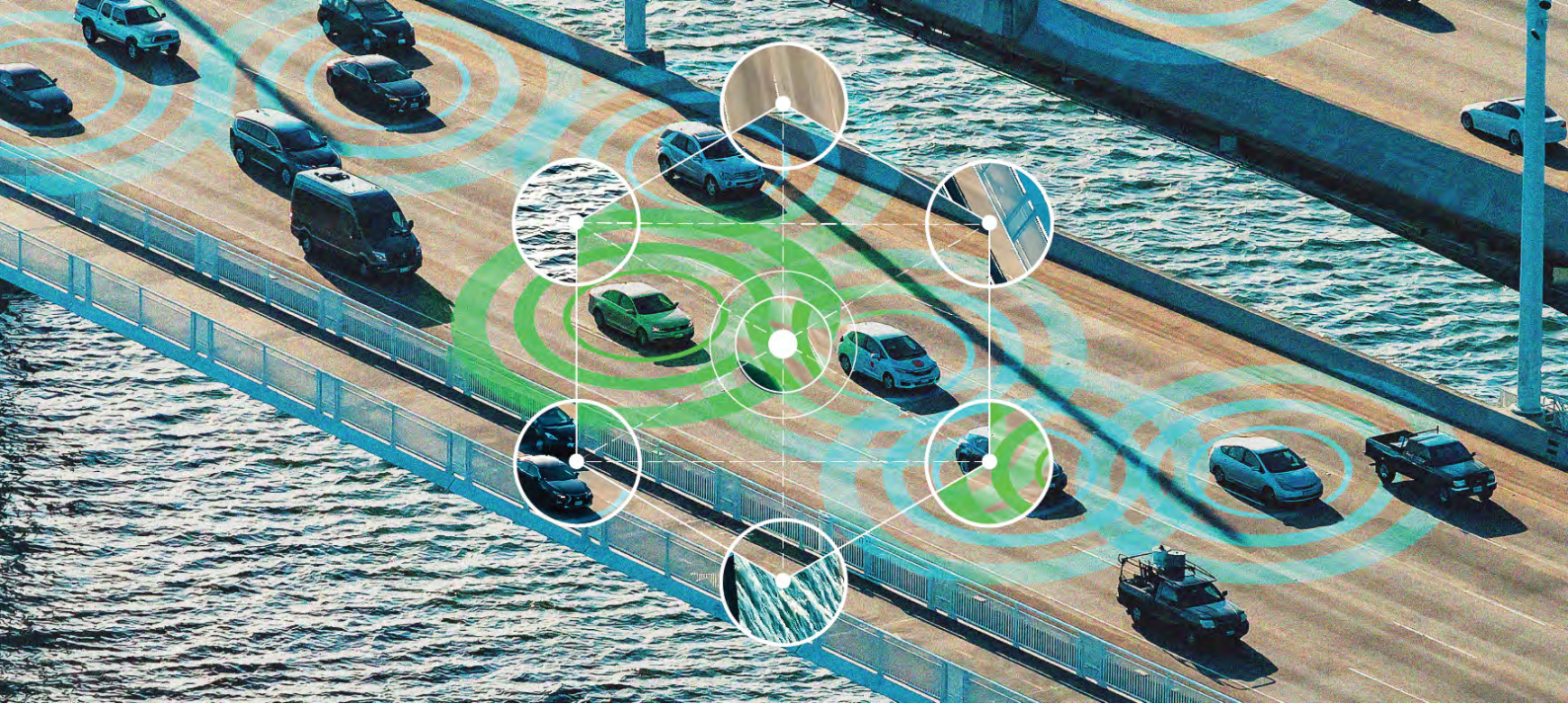
Countries and regions around the world are moving to climate-proof their infrastructure, through a mix of climate mitigation and adaptation solutions. Iceland, for instance, has created a National Adaptation Plan to combat rising sea levels and river flows and manage supply-chain disruptions.[53] Indonesia's capital of Jakarta, in a high-risk coastal area, has prepared a coastal defense strategy including a sea defense wall master plan.[54]

Data can help transportation leaders better understand the impacts of climate change at the local level. Good data can help planners understand collateral issues such as how rising salinity will affect bridges and culverts, how metallurgical requirements for structures should change and what materials should be used for coastal roads that can expect more flooding. Such data also can allow policymakers to determine how best to prioritize funding and to explore policy options that consider sea level rise and frequent inundation.

Often, however, the problem isn't a lack of information, but the challenge of making it understandable and useful for policymakers and planners. The World Meteorological Organization's World Climate research program (WCRP) coordinates climate research initiatives at the international level. WCRP focuses on two primary objectives, determining the predictability of climate effects and gauging the effect of human activities on climate. Such predictions can help policymakers allocate resources effectively.[55]

The British Columbia Ministry of Transportation and Infrastructure requires the potential impacts of climate change to be considered in transportation infrastructure design. It uses climate modeling, risk analyses and infrastructure dependencies data while designing highways and other infrastructure.[56] The ministry also has worked with Engineers and Geoscientists British Columbia, a regional association, to create guidelines for sustainable and resilient infrastructure projects.[57]

Understanding the changes that may be required for infrastructure projects, however, will require a workforce that understands how climate uniquely affects their job functions within the organization — and that can integrate climate resiliency into planning and decision-making.



Trend 5. Turbocharging digital and technology innovation

While the pandemic disrupted public transportation in many ways, it also ushered in a long-overdue wave of smart transportation systems.[58] Digital was no longer a "nice to have" for transportation agencies but an imperative. This digital acceleration also means that transportation agencies can tap into the most compelling features of digital transformation: its ability to serve constituents efficiently, scale cheaply and adapt quickly.

With government investments flowing into mobility-as-a-service (MaaS) programs, smart infrastructure, connected and autonomous vehicle technologies, and mobility-on-demand pilots, this trend is gaining global momentum.

Scaling innovation in transportation

Scaling innovative technologies can be challenging for the public sector. The lack of traditional market indicators can make it difficult for government innovators to assess the effectiveness of a solution and its ability to scale.[59]

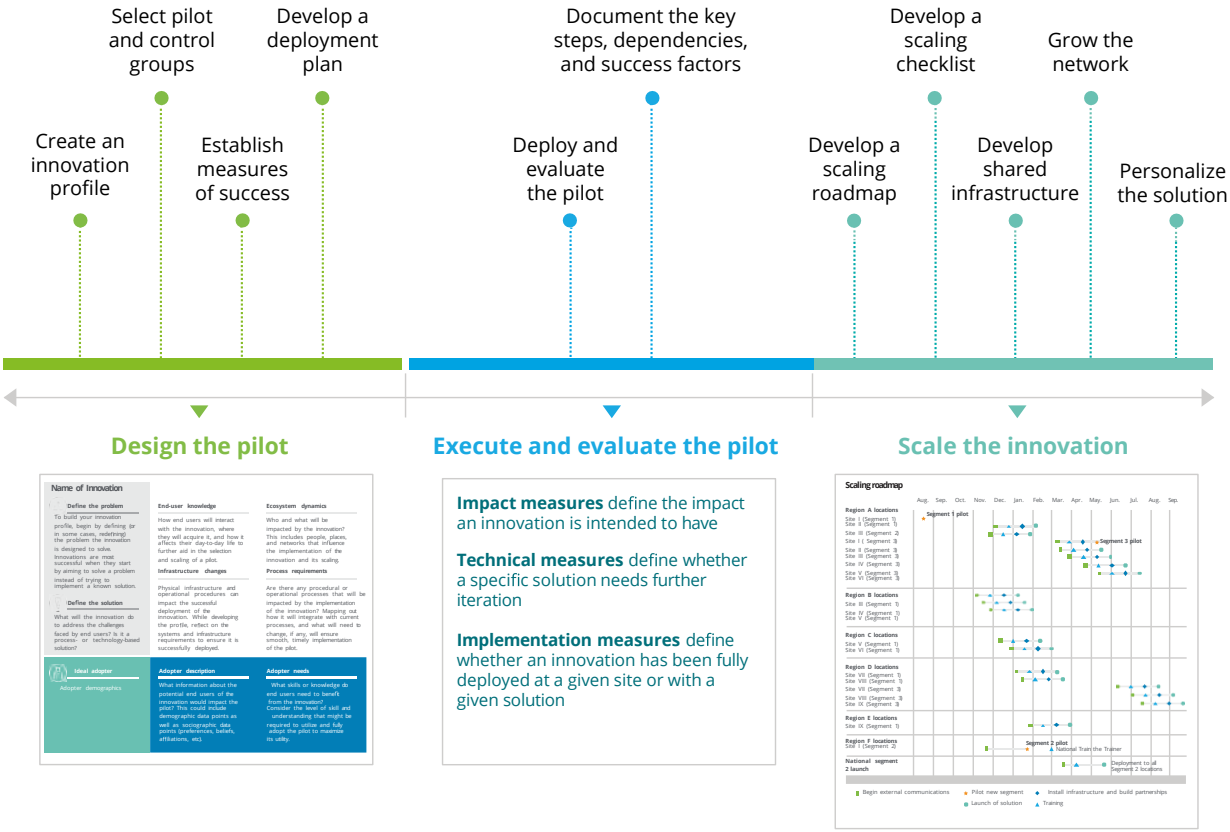
We've seen this play out in the transportation ecosystem; many pilots never take off or scale across regions or states. For instance, cities and states worldwide have initiated many connected and autonomous vehicle projects to provide test beds and sandboxes for new technologies. While they've helped generate knowledge and best practices, few have led to large-scale implementations.

Yet various nations are attempting to advance and scale innovative projects. In August 2022, the UK government introduced ambitious legislation to scale the use of driverless cars on highways by 2023 and on other roads by 2025. To make this a reality, the government has committed US$100 million to improve the safety of these vehicles. "We want the UK to be at the forefront of developing and using this fantastic technology, and that is why we are investing millions in vital research into the safety and setting the legislation to ensure we gain the full benefits that this technology promises," said Grant Shapps, who served as transport secretary. The Department for Transport anticipates that these vehicles will be able to offer more on-demand and personalized connectivity between towns and villages in rural areas and more direct and timely services elsewhere.[60]

The UK government and transportation industry also have a well-established connected and automated mobility (CAM) testbed. CAM Testbed UK's six core facilities work together and share data; in this safe space, ideas can move from the conception stage to development, both virtually and physically.[61] The UK's CAM Scale-Up program, with industry, government and academic participants, has entered its third year, allowing players to test leading-edge CAM solutions quickly.[62]

While scaling innovation in government can be tough, a three-step playbook can streamline the journey (**Figure 6**).

Figure 6: How to scale success



Source: Deloitte analysis.

Improving pilot design

An innovative project may show promise and generate funding for expansion, but once it's tried in multiple locations, the results can be disappointing. This is the case with some MaaS applications, intended to provide one-stop platforms for all transport needs. MaaS has been seen as promising since the concept first emerged in 2010, but the idea is yet to scale widely. While a few early pioneers such as Helsinki, Antwerp and Berlin have seen some success, others are still working on improving their pilots.

But several new MaaS projects have popped up since the start of the pandemic, and various transportation departments are working to scale them to the next level.[63]

Italy's national MaaS4Italy project, for example, involves 13 participating Italian cities. Rome, Naples and Milan are leading in testing innovative MaaS solutions designed to provide Italian citizens with a single national digital platform for their transportation needs. Citizens can access a single app that allows them to manage their trips from planning to payment. Milan also plans to host "living labs" to test the impact of these solutions on citizens in real life. The Italian Ministry of Innovation has set aside US$2.5 million for each city's MaaS efforts and US$800,000 for public transportation digitization, as well as US$7 million for the Milan's Living Labs.[64] MaaS4Italy aims to avoid multiple platforms in different jurisdictions and establish a single national platform for the entire the country.[65]

Spain plans to launch a similar nationwide MaaS platform in 27 cities.[66] This door-to-door multimodal journey planning and booking platform will be introduced in 11 Spanish cities incorporating new services and functions by the end of 2023.[67]

Some nations are adopting an incremental approach to MaaS. The Australian state of New South Wales is upgrading its existing public transportation smartcard Opal system; the upgraded version will allow citizens to link it to digital wallets and use it for a broader range of transport options, including e-bikes, rideshare and taxis, as well as car parking and EV charging. The state also is piloting Opal+, a new MaaS app that will allow subscribers to bundle private and public transport and plan journeys. Collaborating with MaaS experts, operator partners and micro-mobility providers, 10,000 citizens will be chosen to participate in the 12-month Opal+ trial.[68]

Executing and evaluating the pilot

This stage concerns executing the deployment plan, collecting qualitative and quantitative data, documenting lessons learned and regularly checking progress against goals.

The US Strengthening Mobility and Revolutionizing Transportation (SMART) grant program received US$500 million under the IIJA legislation. It includes funding to pilot eight innovative transportation technologies: coordinated automation, connected vehicles, intelligent sensor-based infrastructure, systems integration, commerce delivery, logistics, aviation technology, smart grids and smart traffic signals.[69] The grant program includes a strong focus on documenting lessons learned during the planning and pilot stage, to create a knowledge base of best practices for other jurisdictions. In fact, the program will allow projects to advance to the demonstration stage only if they show a high probability of scaling.[70]

One such project is Chicago's Array of Things (AoT), a network of sensor boxes on light posts.[71] AoT is a joint project between the city, the University of Chicago, Argonne National Laboratory, the National Science Foundation and private technology companies. It launched in 2016 as an experimental urban measurement system; the sensor boxes measure conditions including temperature, humidity, air quality, light intensity, vehicle and pedestrian traffic and flooding.

The AoT project's primary objective is to improve the city's ability to make critical decisions. Data collected from the sensors are published openly to help researchers, organizations and individuals develop new tools and applications for urban and mobility planning. They can help the city build anticipatory capabilities to address challenges such as flooding, heat waves, traffic congestion and traffic safety. The Chicago Department of Transportation has been leading the sensor box installation work and had installed 130 sensor boxes in the city as of January 2020, when work was interrupted due to the pandemic.[72] With clear data to evaluate progress, cities can use IIJA funding to revive or introduce such projects.

Scaling the innovation

Scaling a successful pilot is by far one of the most difficult phases for an organization. Often, transportation agencies struggle with this step because they lack a roadmap and a detailed implementation plan. But expanding the solution incrementally can provide more data and assurance as the pilot moves from one adopter group or location to another.[73]

Brussels, the capital of Belgium, offers a good example of incremental scaling. In 2019, city leaders were looking for a solution that could help them address the growing cost of traffic congestion in the city. They decided to develop and pilot a smart-kilometer charge solution called SmartMove.[74]

SmartMove aims to tackle congestion through a smart per-kilometer charge users pay for road usage, a mobility-as-a-service (MaaS) platform for riders and a "nudging" tool that provides incentives encouraging people to use more sustainable transport options. The city began with a small pilot that allowed it to test the technological components. After encouraging results from this beta test, the city moved to live-testing the solution with 5,000 residents to test different features and aims to expand this testing group further before scaling the solution to the entire city by 2024.[75]

Looking ahead

The transportation ecosystem, globally, is at crossroads. Government transportation leaders should effectively leverage new opportunities and innovations to reverse decades of inadequate investments and modernize key facets of the transportation system. It will require bold action and political will on part of the transportation leaders. They need to reimagine traditional funding models, governance structures, and technology investments to make transportation resilient and future ready.

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Acknowledgements

The authors would like to thank Charlotte Warburton, Yvonne Rene de Cotret, Andrew Pau, Damian Garnham, and Breanna Owen for their critical inputs and feedback in shaping the report.

The authors would also like to thank Shane O'Hagan and Sheyi Okpaise for helping in coordinating the feedback from the Deloitte Global Member Firms.

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