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Insights

Transportation trends 2022–23
Making the most of a huge infusion of federal funds

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Modernizing America's infrastructure

THE 2021 INFRASTRUCTURE Investment and Jobs Act (IIJA) and the 2022 Inflation Reduction Act (IRA) represent historic investments in America's infrastructure, increasing federal spending close to New Deal-era levels. The New Deal funded a series of transformative infrastructure projects that had an indelible impact on the American landscape—from the Hoover Dam and the Lincoln Tunnel to the Bay Bridge and the country's first freeway. Likewise, this generation-defining infusion of federal funding is intended to reverse decades of inadequate investment and to modernize major facets of the nation's transportation system, ranging from funding and finance to energy sources and design specifications.

On the modernization front, the laws will address challenges, including:

- a projected Highway Trust Fund shortfall of US$215 billion in the next decade due to the continued decline of gas tax receipts[1];

- electric vehicle adoption and supporting infrastructure;

- increased cyber vulnerability in an expanding ecosystem of smart technologies, infrastructure providers, and transport modes;

- infrastructure risks due to the increasing frequency and severity of extreme weather events; and

- the need to reconnect communities adversely affected by the construction of the interstate highway system.

Modernizing America's transportation ecosystem will require transportation leaders, planners, and ecosystem partners to address three primary needs.

First, the developing crisis in transportation funding—vehicle miles traveled continue to rise while gas tax receipts continue to be eroded by greater fuel efficiency and the increasing popularity

This generation-defining infusion of federal funding is intended to reverse decades of inadequate investment and to modernize major facets of the nation's transportation system.

of electric vehicles—requires greater urgency in the development, testing, and scaling of sustainable alternatives to the gas tax. While the *technological* challenges associated with road user charging largely have been solved, more focus is needed on the *governance* challenges associated with data-sharing, cybersecurity, and privacy. Meaningful progress on the modernization agenda will require establishing the political will to act, along with public acceptance of a new approach to user-based transportation funding. Moreover, governments will need to determine where they should take the lead and where they should orchestrate the broader ecosystem.

Second, modernization will also require addressing current and future inefficiencies in the transportation ecosystem, whether it's revenue losses associated with electronic tolling or the administration of road user fee programs. Improved transportation efficiency will require a broader use of data and analytical tools to drive decision-making in both policy and investment.

Third, America has a well-recognized need to modernize transportation systems inclusively and equitably, to make opportunities in employment, education, health care, shopping, and recreation more accessible to underserved communities. Doing so will require not just greater funding but a fundamental rethinking of our transportation system so that new models can take root and flourish.

This year's *Transportation Trends* report explores five key trends shaping the transportation agenda in 2022. While we see a clear progression in some areas, new focus areas have emerged due to the pandemic and growing concerns over climate change and environmental sustainability.

Trend No. 1: Creating a sustainable funding mechanism for America's transportation system

The developing crisis in transportation funding—vehicle miles traveled continue to rise while gas tax receipts continue to be eroded by greater fuel efficiency and the uptick in electric vehicles—drives greater urgency in the development, testing, and scaling of sustainable alternatives to the gas tax. To gain widespread public acceptance and adoption, road user charging (RUC) programs should articulate a clear value proposition for

stakeholders, educate the public about why the transition to RUC is necessary and what's at stake if it doesn't occur, and adopt an approach that highlights the link between how funding is obtained and how and where it's spent to build public trust.

Trend No. 2: EVs usher in a generation shift in mobility

The move to electric transportation is a massive technological and cultural transformation. With the US market on the cusp of an EV expansion, transportation leaders and ecosystem partners should focus on solving the EV charging infrastructure problem and addressing a potential talent crunch in the EV market. EV expansion should be designed with equity and affordability in mind to ensure the inclusion of economic groups that could benefit the most from it.

Trend No. 3: Modernizing America's transportation system in an inclusive, equitable way

New federal funding represents a historic opportunity to reset the way we develop new transportation infrastructure. Tapping into the momentum of new broader federal initiatives like Justice40, transportation leaders evolve a more equity-centered design approach to new investments and bring underserved and disadvantaged communities into the planning process. Transportation agencies will need to

balance equity and innovation, keeping mobility ecosystems functioning and accessible while encouraging modernization.

Trend No. 4: Making America's transportation network more resilient

Transportation leaders need to be agile to fight a two-front war to make their systems more resilient to cyberthreats and climate change. Both problems are unavoidable and will only continue to grow in terms of the threat posed to the transportation system. Cybersecurity needs to be embedded right from the design stage all the way up to implementation of new systems and technology. New collaborative governance models are needed to manage the increased risk associated with the growing number of connected physical devices that are now part of the tech stack. On the climate front, increasing the resiliency of the transportation system will require significant innovations in infrastructure design and maintenance, coupled with a more data-driven approach to prioritizing investment decisions.

Trend No. 5: Turbocharging digital and technology innovation

The pandemic turbocharged digital transformation efforts at transportation agencies. New federal funding will provide further impetus to experiment with smart infrastructure, connected and autonomous vehicle technologies, and innovative mobility-on-demand solutions. Transportation agencies need to solve the age-old problem of scaling successful pilots by improving pilot design and building a better road map for scaling innovation.

Trend 1

Creating a sustainable funding mechanism
for America's transportation system

N HIS BESTSELLING book *The 7 Habits of Highly Effective People*, Dr. Stephen R. Covey asks his 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, but not only, hybrid and electric vehicles (EVs)) make up a materially substantial portion of vehicles on our roadways?

What changes can we further expect when connected technologies are ubiquitous across most of the vehicle fleet?

Today, traditional funding models still are based largely on taxes levied per gallon on fossil fuels. But they're being undermined steadily by increased fuel efficiency and the growing popularity of EVs. And that's why most, if not all, US state and federal transportation jurisdictions are considering funding systems based on miles driven.[3]

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 being as invisible and uncomplicated as the gas tax paid at the pump today. Imagine congestion is managed across the network using geofencing and variable pricing, allowing for smoother traffic flows, with drivers incented to make more sustainable travel and mode 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 charging gains traction

Several states have tested road usage charging (RUC), sometimes called mileage-based user fees (MBUFs) or a vehicle miles traveled (VMT) tax with small-scale pilots; Oregon spearheaded efforts as early as 2015.[4] As of this writing, Oregon, Utah, and Virginia are implementing live RUC programs (figure 1). RUC activity is expected to increase substantially in 2022 and beyond, thanks to a massive infusion of federal funds.

The IIJA provides significant funding to support the shift to a sustainable, usage-based funding

FIGURE 1

Mileage-based user fee activity is expanding across the United States

■ Piloting ■ Research/exploration ■ Implemented ■ No or limited progress

Source: National Conference of State Legislature, "NCSL road usage charges summit", June 27, 2022.

system, including US$75 million to continue support of state, local, and regional pilots and US$50 million for a national RUC program.[5] The IIJA-funded Strategic Innovation for Revenue Collection Program will support pilot projects testing the feasibility of road-use charges and other user-based alternatives to ensure the long-term solvency of the federal Highway Trust Fund.

Lessons learned from earlier RUC pilots and programs

Many RUC pilots have been completed and some are still in effect, allowing states considering the concept to consult lessons learned and avoid 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 2).

Early experience has shown that while pilot participants generally were supportive of the "user pays" principle for transportation, they had relatively little knowledge of the size of the funding challenge and the intricacies of the current tax system that funds roadways. In short, states should educate the public about the transportation funding challenges and how RUC can address them.
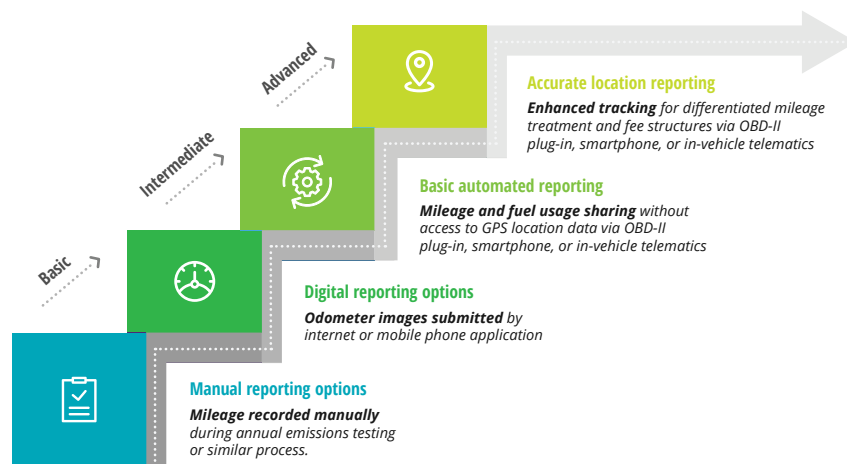
THREE OUTSTANDING QUESTIONS

Widespread adoption of RUC won't happen overnight. Traditional fuel taxes have been in place for more than a century and replacing them will require a great deal of effort and political savvy. To make the most of the opportunity that IIJA offers to test sustainable funding alternatives, states should consider investing in programs that address three unanswered questions:

States should educate the public about the transportation funding challenges and how RUC can address them.

FIGURE 2

RUC programs can use a variety of reporting solutions

Advanced

Accurate location reporting
Enhanced tracking for differentiated mileage treatment and fee structures via OBD-II plug-in, smartphone, or in-vehicle telematics

Intermediate

Basic automated reporting
Mileage and fuel usage sharing without access to GPS location data via OBD-II plug-in, smartphone, or in-vehicle telematics

Basic

Digital reporting options
Odometer images submitted by internet or mobile phone application

Manual reporting options
Mileage recorded manually during annual emissions testing or similar process.

Source: Deloitte analysis.

- **How should states determine the appropriate per-mile fee?** In most 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 revenue (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 centralized gas tax structure is extremely efficient, with low administrative costs. RUC that calculates tax owed for each driver will likely entail significantly higher administrative and equipment costs, potentially making it difficult to scale.

Bold action *today* can help meet the current system needs—and prepare the way for a truly stable funding solution.

- **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 who are proponents of the change rather than a representative sample of the general public. Achieving public support is a careful balance between education of the change and simplicity of the message and experience.

Getting started

While a 50-state RUC system will require some time, bold action *today* can help meet the current system needs—and prepare the way for a truly stable funding solution. In addition to building political will through pilots and engagement on the part of transportation agencies (e.g., DOTs, DMVs,

tolling authorities, etc.), 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 their participation. These small-scale pilots, however, reach only a small, self-selecting share of the population, necessitating broader public awareness.

From Smokey the Bear to the Crash Test Dummies safety belt campaign, many public service announcements have raised public awareness about various issues. Here too, broad outreach is needed to educate the public about why the transition to RUC is needed—and what's at stake if it doesn't occur.

DEFINE THE VALUE PROPOSITION FOR STAKEHOLDERS

If the transition to MBUFs is to succeed, different stakeholder groups must understand the value it offers them. For rural communities, for instance, it might be greater parity in urban/rural funding for transportation since residents of rural communities tend to drive larger and older vehicles with lower fuel efficiency.

For vehicle manufacturers, however, the value proposition hasn't been defined clearly. The transition raises a daunting array of issues, from obtaining customer consent for vehicle data collection to the question of who should shoulder the costs associated with transferring, processing, and securing such information. Even thornier issues include how to share data with different state systems and how to handle changes in vehicle ownership that happen outside of dealerships. So far, such issues haven't been addressed.

DESIGN FOR TRUST

Public trust will make or break any transition to RUC.

The current transportation funding system is largely opaque to ordinary citizens. With few exceptions (e.g., tolls), the average motorist has no idea of how much or how little they pay for transportation services—or who should be held accountable for poor performance. This stands in sharp contrast to most other vital infrastructure. In the case of household

Our research suggests that trust can be built and sustained by demonstrating two foundational attributes—delivering on promises all the time, with *competence*, and doing so with good *intent*.[6]

These attributes manifest themselves in four unique trust signals: humanity and transparency, which demonstrate intent, and capability and reliability, which demonstrate competence (figure 3).

Trust can be built and sustained by demonstrating two foundational attributes—delivering on promises all the time, with *competence,* and doing so with good *intent.*

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

electricity and water, for example, customers receive a monthly bill that itemizes the number of kilowatt hours or thousands of gallons of water used, the rate per unit of use, and the amount due.

This opacity, together with the increasing use of highway user fees for nonhighway uses, leads motorists to see these fees as being more akin to a general tax than a narrowly tailored usage fee that directly supports the roadway they used. The resulting consequence is that taxpayers are reluctant to support any fuel tax increases. To fund America's roadways more effectively and equitably, transportation agencies should consider adopting an approach that highlights the link between how funding is obtained and how and where it's spent.

- **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.

FIGURE 3

Four trust signals contribute to greater trust
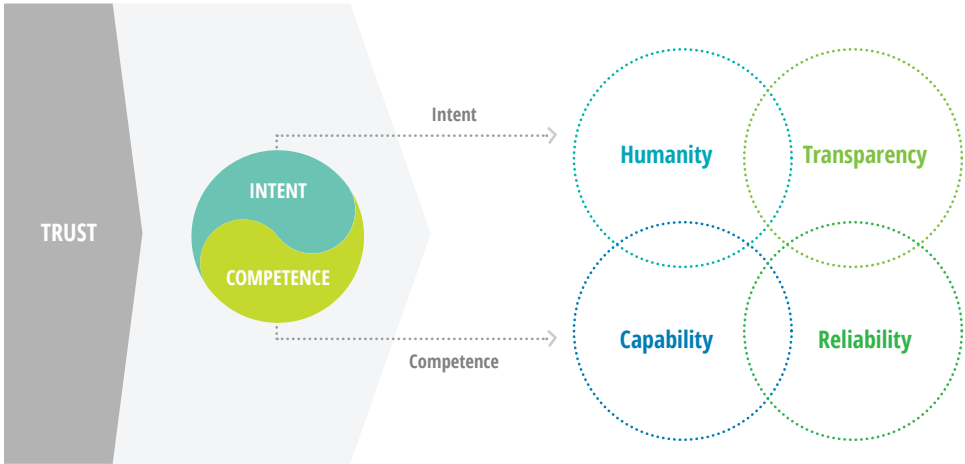
Source: Deloitte analysis.
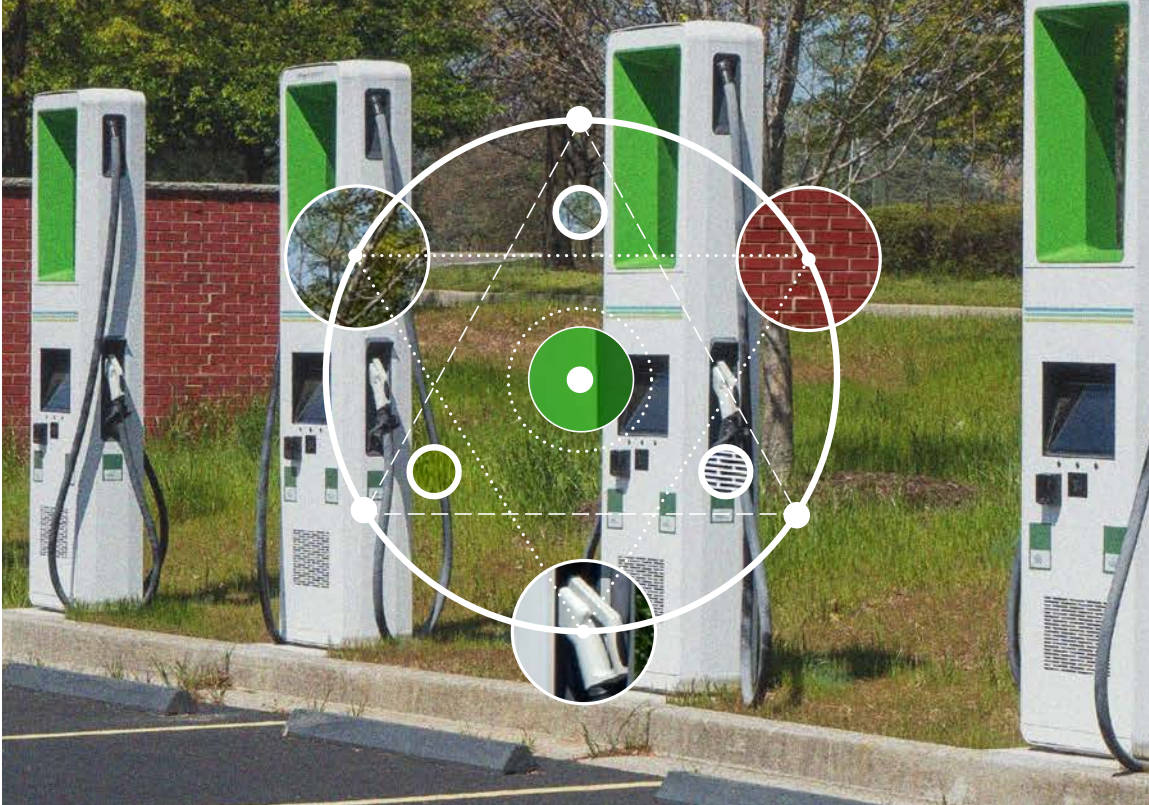
Trend 2
EVs usher in a generation shift in mobility

THE MOVE TO electric transportation is a massive technological and cultural transformation. It's not 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 corresponding transportation and power infrastructure.

Millions of Americans—and billions worldwide—are used to relying on IC-based vehicles. There's a well-established network for their sales 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 Americans' biggest concerns about adoption include inadequate public charging infrastructure, a lack of charging options at home, the time required to charge vehicles, and—given some highly publicized mishaps—safety issues concerning batteries.[7] As with any major technological transition, there are bound to be false starts and teething issues along the way.

The Biden administration is bullish on electric transportation, however, and has set an ambitious target of EVs representing 50% of all new vehicles sold in the United States by 2030.[8] In line with the

administration's broader climate agenda, it also wants to move the federal vehicle fleet to 100% acquisition of zero-emission vehicles (ZEVs) by 2035, including 100% light-duty ZEV acquisition by 2027.

Manufacturers, too, are betting on an EV future. In 2021, for instance, General Motors announced that it plans to become carbon-neutral by 2040 and to introduce 30 new EV models by 2025. The company has committed to spending US$27 billion on its zero-emission goals.[9]

According to Deloitte's Global Automotive Consumer study, increasing numbers of consumers worldwide plan to buy an EV in the next three years.[10] US EV sales nearly doubled between 2020 and 2021, from 308,000 to 608,000, while overall light-vehicle sales rose by just 3%.[11] Yet US purchasing intent remains relatively low (26%) compared to that in other nations such as Italy, Spain, Japan, South Korea, and Singapore (figure 4). However, the US market reached a critical EV tipping point recently with EVs accounting for 5% of new car sales. The threshold of 5% of car sales is

generally seen as a tipping point for mass EV adoption in global markets.[12]

However, US consumer interest in EVs could rise quickly in the near future. The ongoing Russia–Ukraine conflict has pushed US fuel prices to a decade high, and the passage of the IIJA should incentivize and accelerate the move to EVs. The IIJA has allocated US$15 billion for EVs and associated infrastructure, with more than 80% of the total going to grants for state and local governments. At the state level, in August 2022, California announced a ban on the sale of new gasoline-powered cars by 2035.[13] The state of Washington is expected to take a similar step soon.[14]

All signs point toward an EV expansion in the coming decade. Government transportation agencies face enormous challenges involved in scaling EVs and their corresponding infrastructure in 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.

FIGURE 4

While EV sales have risen in the United States, the purchasing intent remains relatively low compared to other countries
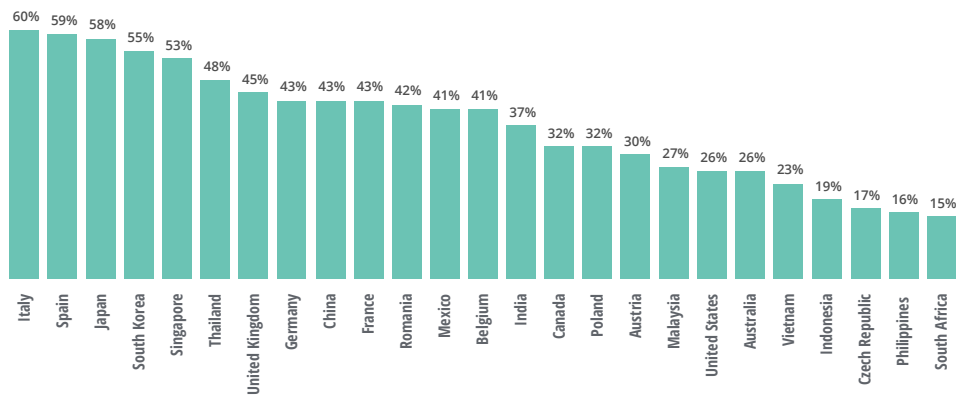
Source: Deloitte 2022 global automotive consumer study.

Charging infrastructure could be the biggest short-term hurdle

Building a ubiquitous charging infrastructure that resembles today's gasoline and diesel infrastructure may be the toughest problem to solve. Among the many questions that leaders face today are:

- How many public charging stations should we install?

- Should they be powered by renewable energy?

- How should charging be priced?

- What impact will charging have on the grid during peak consumption hours?

- How can we ensure equity in charging infrastructure?

- How can charging infrastructure be maintained once it's installed?

The IIJA allocates US$7.5 billion for EV infrastructure programs and grants. States must submit an EV infrastructure deployment plan to the Joint Office of Energy and Transportation, an entity facilitating collaboration between the US Department of Energy and the Department of Transportation, to access US$5 billion in formula funds for the next five years. The remaining US$2.5 billion will be made available in discretionary funding to deploy electric charge stations and other alternative fueling infrastructure such as hydrogen, propane, and natural gas.[15]

This funding will provide an initial push, but states will need long-term business models to create and sustain the charging infrastructure. New York state has been a pioneer in expanding its EV charging infrastructure; its EV Make-Ready program is designed to support the construction of more than 50,000 charging stations by 2025.[16] Under this program, the state's six utilities have been authorized to spend US$701 million from existing ratepayer surcharges to incentivize businesses and local authorities to set up these stations.[17] A similar effort to spur the expansion of charging infrastructure is underway in California, which already has the nation's largest network.[18]

The number of US public EV charging outlets has nearly doubled in the last few years and could see exponential growth with IIJA funding (figure 5).
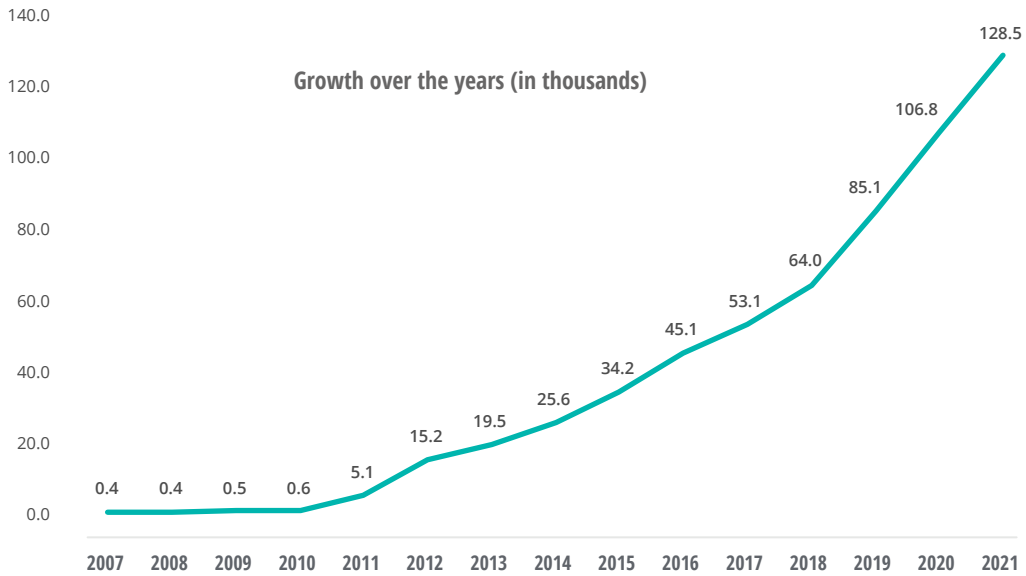
However, the rapid growth in charging outlets has been uneven across the country. There are large swathes of the country without any foundational public charging infrastructure in place. In 2021, 32% of all public charging outlets were in California, which is almost the same as the number of charging outlets in the next eight states combined (figure 6).[19] 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. According to the US Department of Transportation, Level 1 chargers can require 40–50 hours to charge a fully electric vehicle and 5–6 hours to charge a hybrid vehicle. *Level 2 chargers* operate at 208 volts or 240 volts and can fully charge an all-electric vehicle in 4–10 hours and a hybrid in 1–2 hours; most public charging stations in the United States are Level 2. *Direct Current Fast Chargers* (DCFCs) can charge EVs within an hour, but at the end of 2021, only 676 of these were spread across the country.[20] Obviously, the number of DCFCs nationwide must be scaled upward rapidly to avoid bottlenecks and frustration at charging stations, especially in the commercial vehicle segments.

FIGURE 5

Public and private electric charging outlets have grown between 2007–21

Growth over the years (in thousands)

Year	Value
2007	0.4
2008	0.4
2009	0.5
2010	0.6
2011	5.1
2012	15.2
2013	19.5
2014	25.6
2015	34.2
2016	45.1
2017	53.1
2018	64.0
2019	85.1
2020	106.8
2021	128.5

Note: Data does not include private residential charging outlets.
Source: US Department of Energy.

FIGURE 6

The number of public and private charging outlets vary widely across the United States
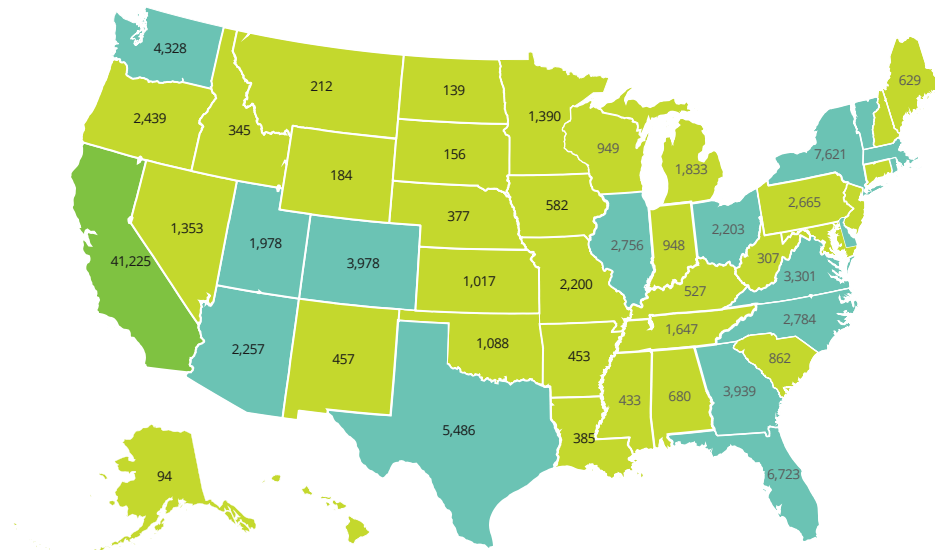
Source: US Department of Energy.

- **Fleet electrification:** Federal fleets are large and electrifying them will be a significant task. The 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.

- **Smart charging:** Electricity pricing raises the issue of *when* vehicles should be charged. Most consumers around the United States pay flat rates for residential electricity, but many utilities across the nation are moving toward various types of "dynamic" rates that fluctuate with demand and production costs.[21] For this reason, the timing of vehicle charging could have significant implications for fleet operational costs. Agencies paying such rates may need to develop protocols to control these costs similar to the route optimization planning performed today for delivery vehicles.

Scaling the EV market equitably

There's a strong economic case for making the EV market expansion more equitable. Transportation is the second-largest expenditure in American households after housing. In 2019, American households spent on average of US$10,742 on transportation, about 17% of total expenditures. Transportation spending, moreover, was higher than this average for households in the second and third income quintiles (those with incomes between US$22,488 and US$72,233), ranging from 17.7% to 18.6% of total household expenditures (figure 7). Households in these income categories also spent a greater share of income on fuel, motor oil, maintenance, and repairs.[22]

FIGURE 7

Transportation spending was higher than the average for people with incomes between US$22,488 and US$72,233

| $0 to $22,487 | $22,488 to $43,431 | $43,432 to $72,233 | $72,234 to $120,728 | $120,729+ |
| 16.0% | 17.7% | 18.6% | 18.1% | 15.8% |
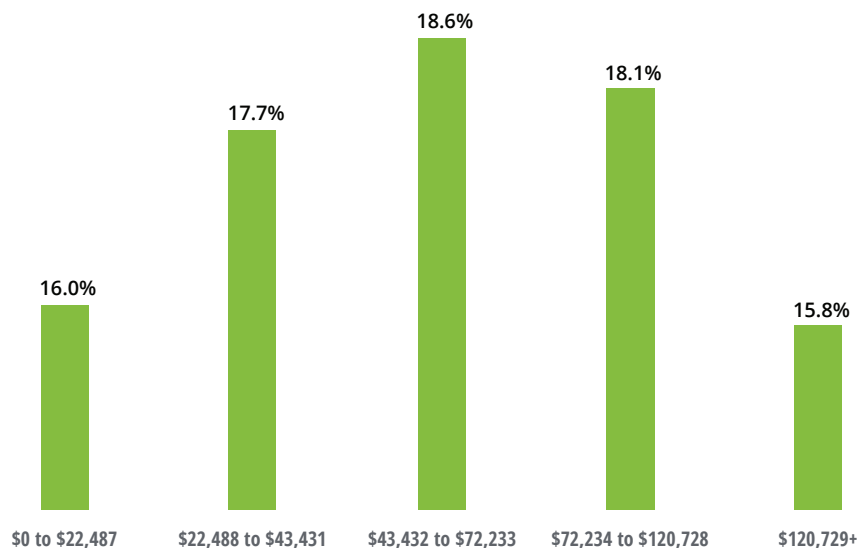
Source: Bureau of Transportation statistics.

Helping lower-income groups purchase EVs would alleviate some of their transportation costs. EV maintenance costs are 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.[23] But those who could benefit the most from EVs often can't afford the ones offered in the current market; in 2021, EVs cost about US$10,000 more than the industry average for all vehicles.[24]

Research suggests that targeted subsidies for lower-income households could boost EV sales to these groups. The subsidies could be phased out as EVs gain market share and become more affordable.[25] Some states already provide such subsidies. California's Clean Cars 4 All program provides up to US$9,500 for EV purchases, with the highest subsidies reserved for low-income individuals and those living in disadvantaged communities.[26] Similarly, Oregon's Clean Vehicle Rebate Program offers up to US$5,000 in purchase rebates to individuals in low- and moderate-income categories.[27]

The second part of the equity equation concerns the charging infrastructure. Initial data from the United Kingdom suggests that home charging, while slow, is more cost-effective than public charging.[28] Yet lower-income groups, especially those living in urban areas, often lack access to home charging. About 78% of resident-owned homes in the United States have a garage or carport where charging apparatus can be installed, but only 37% of rented homes feature a garage or a carport.[29]

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. New York's 2020 EV Make-Ready program will reimburse businesses for setting up charging stations for their employees and provide 100% reimbursement for stations placed at multifamily apartment buildings in economically disadvantaged communities.[30]

Addressing the workforce challenge

An even bigger challenge for ecosystem players, including governments, will be the availability of a workforce trained to maintain and repair EVs and the charging infrastructure.[31]

Today, batteries make up almost 30% of the total value of an EV and the cost of replacing one can be daunting.[32] Skilled battery technicians are required for repairs, software issues, calibration of internal systems, and diagnostics.[33] 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 federal government launched the Talent Pipeline Challenge to develop the next generation of infrastructure workers. The program focuses on broadband, construction, and electrification; the electrification focus is 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.[34]

Trend 3

Modernizing America's transportation system in an inclusive, equitable way

ITHOUT WARNING, THE COVID-19 pandemic altered how communities work, move, and connect. Two years later, some of these changes—such as the white-collar shift to remote work—have proven durable; more than two-thirds of companies report that they will be implementing a hybrid work model of some kind.[35] As of June 2022, office buildings in the 10 largest US cities averaged just 43% occupancy, according to office security provider Kastle Systems, while public transit ridership remains well-below prepandemic levels (figure 8).[36] Other changes have continued to follow shifting patterns of shopping, employment, and leisure activity.

The transportation industry has been on the front lines of COVID-19 disruptions and the emergence of new travel patterns. The pandemic's impact, however, has been distributed unevenly across different sectors and demographic groups. Inequalities embedded in our transportation system have become clear to many observers, as has the important stabilizing role played by public transit agencies.[37]

FIGURE 8

Public transit ridership in the United States is yet to fully recover

Public transit ridership recovery in the United States (as of June 2022)

Transit Agency	Recovery %
Metro Tr Auth of Harris Co	68.3%
Miami-Dade Transit Agency	65.6%
Los Angeles County MTA	64.8%
RTC of Southern Nevada	63.9%
San Diego Metrop Transit System	61.7%
MTA Bus Company	59.8%
Tri-County Metro Trp Dist	56.9%
Port Auth of Allegheny Co	55.2%
Sound Transit	53.0%
MTA Metro-North Railroad	52.3%
New Jersey Transit Corp	51.7%
City & Cnty of Honolulu DOTS	50.1%
San Francisco Muni Rwy	50.0%
National (US)	49.6%
Southeastern Penn TA	49.5%
MTA New York City Transit	49.0%
King County Dept of Trp	46.8%
Alameda-Contra Costa TD	45.8%
Massachusetts Bay Tr Auth	45.2%
Chicago Transit Authority	44.0%
MTA Long Island Rail Road	43.9%
Metro Transit	43.3%
Metro Atlanta Rapid Tr Auth	42.9%
Maryland Transit Admin	42.7%
Washington Metro Area TA	40.5%
Dallas Area Rapid Transit	40.1%
Regional Trp District	35.7%
Metra	29.2%
San Francisco Bay Area RTD	23.5%

Source: Deloitte analysis of data from the American Public Transportation Association.

Throughout the worst surges and business closures, these agencies provided critical access to mobility for millions of "essential workers," often low-income and minority travelers, who continued to report to hospitals, grocery stores, warehouses, and other critical sites daily. The situation highlighted new opportunities for transit and mobility agencies to address broader societal challenges, from growing transportation insecurity to the looming impacts of climate change on vulnerable populations and society at large.

To achieve a sustainable post–COVID-19 recovery while meeting equity goals, transportation agencies should make a strategic commitment to real change. Holistic, multimodal approaches can advance these objectives—and should be accompanied by meaningful performance metrics to measure success and guarantee accountability.

A renewed focus on equity

Equitable transportation systems offer travelers fair access and opportunities, eliminating historical and systemic barriers. True equity includes physical accessibility, of course, but also the types of destinations available to travelers and the freedom to use modes that best fit their abilities and preferences. People today have more mobility options than ever before, and public agencies can play a critical role in ensuring these options benefit *all* travelers.

There's a business case to be made for prioritizing equity in transportation. A Harvard study found that low-income communities with greater access to jobs within a 15-minute commute have higher upward economic mobility.[38]

The federal government's Justice40 initiative directs federal agencies—including the US

Department of Transportation—to collaborate with states and local communities to deliver at least 40% of the overall benefits from federal investments in climate and clean energy to disadvantaged communities.[39] IRA includes US$3.2 billion for the Neighborhood Access and Equity program to improve walkability, safety, and affordable transportation projects. DOT's Reconnecting Communities Pilot program will

To achieve a sustainable post–COVID-19 recovery while meeting equity goals, transportation agencies should make a strategic commitment to real change.

provide US$1 billion over five years to reconnect communities that were previously cut off from economic opportunities by transportation infrastructure. This focus, when combined with new funding opportunities, makes the case for pursuing inclusive mobility innovations more compelling and more urgent.

The federal government has provided several tools to help identify communities that are marginalized, underserved, and overburdened by pollution, including EPA's environmental justice screening and mapping tool, EJSCREEN; the Council on Environmental Quality's Climate and Economic Justice Screening Tool, CEJST, which provides socioeconomic, environmental and climate information at the census tract level; the Department of Transportation's (DOT's) Areas of Persistent Poverty and Historically Disadvantaged Communities map; and the Agency for Toxic Substances and Disease Registry's Environmental Justice Index (EJI), which measures the cumulative health impacts of environmental burden.

For its part, DOT has developed an agency-specific definition of "disadvantaged community status."[40] Among common tools used in DOT discretionary grant programs are the Transportation Disadvantaged Census Tracts, which can be used to map project areas to determine levels of disadvantage according to DOT's Justice40 definition. As Christopher Coes, DOT's assistant secretary for Transportation Policy, says, "What we now have is the government finally asking the fundamental question of the data that we have: How do we take X number of census tracts that have been designated as disadvantaged and move them to [becoming] thriving American communities?"[41]

At the state level, the California State Transportation Agency's Climate Action Plan for Transportation Infrastructure outlines several strategies, frameworks, and action steps. For instance, Caltrans, the state transportation department, is developing an equity index to measure transportation plans' impacts on various demographic groups.

To ensure that everyone with a stake in the outcome is intentionally included in the design process, leading jurisdictions are spearheading more inclusive and collaborative approaches.

Caltrans has also 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. Its intent is to prioritize projects with the most significant social equity benefits.

Equity-centered design

Until the 1960s, most sidewalks in America lacked a "curb cut," that tiny slope that seamlessly connects the sidewalk to the street. Curb cuts were scarce until wheelchair activists took protest signs and hammers to sidewalks around the country. Such actions created positive change for everyone who uses sidewalks.[42]

To ensure that everyone with a stake in the outcome is intentionally included in the design process, leading jurisdictions are spearheading more inclusive and collaborative approaches.

In 2018, the Broward Metropolitan Planning Organization (Broward MPO) in Florida started developing a process to evaluate its plans more consistently and comprehensively against Title VI and other federal and state nondiscrimination policies. The goals of this assessment included greater consistency and efficiency in planning as well as more meaningful community outcomes and the proactive identification of potentially adverse impacts. "We wanted to assess equity at all levels of the project life cycle," says Peter Gies, the agency's systems planning manager. "We knew that looking at equity through just one lens doesn't give the full picture."[43]

To perform the evaluation, Broward first analyzed demographic data to identify areas with a higher proportion of populations protected under federal nondiscrimination laws as part of a broader environmental justice process.[44] This process was complemented by engagement with entities

including with Broward MPO's Citizens Advisory Committee, which provided fact-checking to confirm or refute quantitative findings. The assessment mapped specific "equity areas" in the region, as defined by a composite equity score that can be used to accommodate planning efforts across a variety of regional agencies. The tool is designed to be iterative so that it remains flexible to community input and feedback.[45]

Balancing equity and innovation

Transportation agencies across the nation are implementing a range of strategies to balance equity and innovation, keeping mobility ecosystems functioning and accessible while encouraging modernization. Successful efforts can be models for government leaders aiming to put principles into practice.

Serving a sprawling 700 square miles, Dallas Area Rapid Transit (DART), faces different challenges than its counterparts in more dense regions, as it must address the needs of constituents in comparatively remote areas while serving a total population expanding faster than its transit infrastructure. DART looked to private transportation companies to fill the gap. In 2018, it launched a pilot first mile/last mile (FM/LM) partnership with Uber to explore ways to increase system access, ridership, and efficiency. The agency has integrated the program as a booking option in its GoPass app, making riders eligible for reduced Uber fares due to their presence in a designated on-demand FM/LM service area.

Needless to say, app-based services cannot be accessed by riders lacking ready access to smartphones, credit cards, or banking abilities. Not to mention those who are simply uncomfortable with new technologies. DART, therefore, needed to find a way to work with private partners to integrate new mobility technologies in a way that would provide FM/LM service to all potential customers. The agency now allows riders to book rides by phone and use multiple payment options, such as loading cash payments into the GoPass Mobile App through retail partners. According to DART's chief innovation officer, Greg Elsborg, "We're working to make sure cash-paying customers continue to have the same ease of experience as riders with digital payment methods, and we're exploring additional opportunities such as upgrading our ticket vending machines to accept cash as well as cards to add digital account balances to our GoPass Tap Cards and Mobile App."[46]

As travel patterns continue to evolve, transportation agencies must reevaluate their plans and methods to keep pace.

A regional approach for equitable innovation

As travel patterns continue to evolve, transportation agencies must reevaluate their plans and methods to keep pace. To reach a consensus on scalable solutions in the long term, transportation agencies should explore integrated and iterative near-term approaches at the regional level, powered by collaboration across the web of ecosystem partners. Local agencies that engage directly with riders can build trust and support for 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; commercial disruptive business models like ride-hailing have highlighted transportation agencies' inability to adapt quickly to market demands. Ride-hailing companies, for example, owe some of their success to public transportation's failure to meet the need for rapid, flexible, on-demand service.

Where should public transportation leaders begin in aligning the vast ecosystem of mobility players to address equity, climate, community, and public health concerns? First, they should align their 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 and space between transportation agencies in their regions, understanding which are best positioned to develop and deliver innovative mobility solutions. Finally, regions should move to sustainable funding models, identifying the shortcomings of current structures and finding ways to eliminate them in 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.
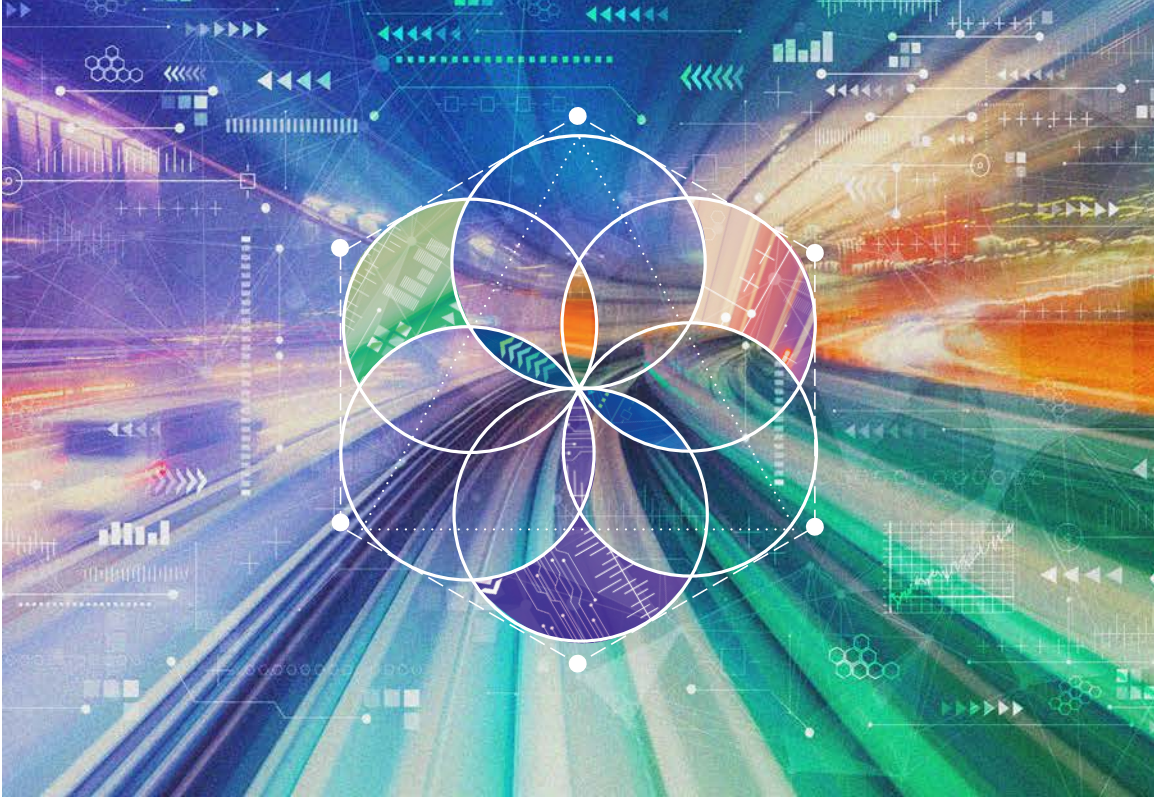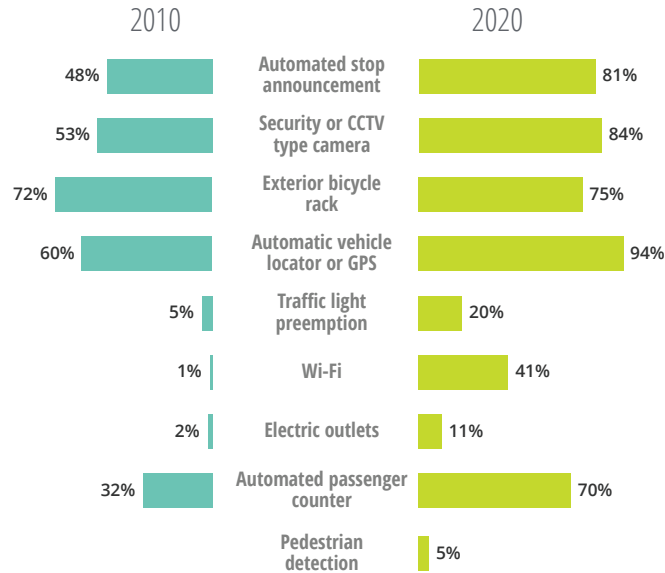
Trend 4

Making America's transportation network more resilient

I N *The Roads That Built America: The Incredible Story of the U.S. Interstate System*, author Dan McNichol observes that, "As long as the Interstate is the highway supporting our society, economy and national security, it will forever need to be the beneficiary of our attention and investment."[47] Nearly seven decades after President Dwight D. Eisenhower signed the Federal-Aid Highway Act of 1956 into law, the world has evolved in ways that necessitate major *new* investments in America's transportation network.

Connected vehicles and intelligent transportation will change that network utterly. Today, we're seeing a convergence between the physical and virtual worlds, as digital devices at the edge (embedded sensors and controllers) are linked to IT networks (figure 9). This convergence, however, vastly increases the challenge of cybersecurity. Transportation networks and systems are loaded with vital information, including personal data, which makes their websites, systems, and connected devices prime targets.[48]

FIGURE 9

Percentage of buses with connected and other technologies in the last 10 years (2010–20)

2010 | | 2020

48%	Automated stop announcement	81%
53%	Security or CCTV type camera	84%
72%	Exterior bicycle rack	75%
60%	Automatic vehicle locator or GPS	94%
5%	Traffic light preemption	20%
1%	Wi-Fi	41%
2%	Electric outlets	11%
32%	Automated passenger counter	70%
	Pedestrian detection	5%

Source: Mineta Transportation Institute.

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%*.[49] In August 2020, for instance, the Southeastern Pennsylvania Transportation Authority was hit by a ransomware attack that affected its TrainView service, which provides information about train arrivals, and exposed the personal information of 9,300 employees, including Social Security numbers and banking information. Another attack in April 2021 breached the New York Metropolitan Transportation Authority's systems.[50] In 2022, Puerto Rico's AutoExpreso electronic toll collection system was the target of a cyberattack.[51]

Another growing risk to transportation networks stems from climate change, which will require significant innovations in infrastructure design and maintenance.

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 pavements 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.[52] Such disruptions affect the movement of people and goods and limit access to employment and critical services such as health care.[53]

Embedding cybersecurity from design to implementation

In May 2021, the White House heightened its focus on cybersecurity with an executive order to strengthen critical information systems and networks against cyberthreats.[54] Transportation was one of 16 infrastructure sectors designated in the order. Yet many transit agencies across the United States remain relatively unprepared for this threat. According to a 2020 Mineta Transportation Institute survey of transit agency leaders, only 60% had a cybersecurity response plan; 36% lacked a cyber disaster recovery plan.[55]

Transportation system owners no longer can afford to consider cybersecurity as an afterthought. As their 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 must be taken *before* these devices are installed in tunnels, tolling stations, floodgates, and other infrastructure.

Transportation system owners no longer can afford to consider cybersecurity as an afterthought.

Furthermore, governance models and agency culture must evolve to reflect the increasing convergence between the physical and virtual worlds, bringing engineering teams into closer collaboration with security teams to increase the agency's overall cyber posture. Pennsylvania Turnpike Commission's (PTC) 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 civil 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 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, 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.[56]

With so many physical devices now part of the 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 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."[57] The teams worked together to accommodate security requirements and devise creative solutions when security and business requirements collided.

The IIJA offers funding for cyber resilience. It allocates US$2.5 billion in grant funding to state, local, and tribal governments to enhance EV charging and fueling infrastructure, and recipients must ensure that their plans address cybersecurity and privacy considerations to use the funds. An additional US$500 million is allocated for Strengthening Mobility and Revolutionizing Transportation (SMART) grants; cybersecurity and individual privacy protection are integral components of this

program as well. Such funding requirements will nudge transportation agencies to ensure that cybersecurity principles are baked into every stage of the modernization process, from strategy and design to implementation and operations.

Beyond funding, the federal government also provides state and local transportation agencies with guidance on addressing cyber challenges. The Department of Homeland Security and Department of Transportation are designated as risk management agencies for US transportation systems, including aviation, highways, maritime transport, mass transit, pipeline systems, freight rail, and postal shipping. The Cybersecurity and Infrastructure Security Agency (CISA) has issued guidelines calling for transportation system owners to implement a cybersecurity framework created by the National Institute of Standards and Technology.[58]

In addition, the US Transportation Security Administration (TSA) is working to create a more secure and resilient transportation sector. In 2021, TSA announced cybersecurity directives that require critical rail and transit systems to identify a cybersecurity point person, report incidents to CISA, create an incident recovery plan, and complete a vulnerability assessment to identify potential gaps in their operations.[59]

However, cyberattacks do not always involve malware attacks or "zero-day" exploits.[60] Connected and autonomous vehicles are more likely to tap into varied sources of information to understand traffic and road conditions. This information may not always flow from a trusted source. In many cases, it may be crowdsourced. This creates a potential vulnerability that malicious actors can leverage to manipulate data.[61]

Such vulnerabilities and their potential risks need to be tested through connected vehicle testbeds and pilot programs. Georgia's connected vehicle pilot program recently deployed connected vehicle environment along 18 miles of I-85 to collect, process, and share real-time data from vehicles and the surrounding infrastructure. Such pilots can help the transportation ecosystem to test and understand different vulnerabilities and safety concerns in a real-world setting.[62]
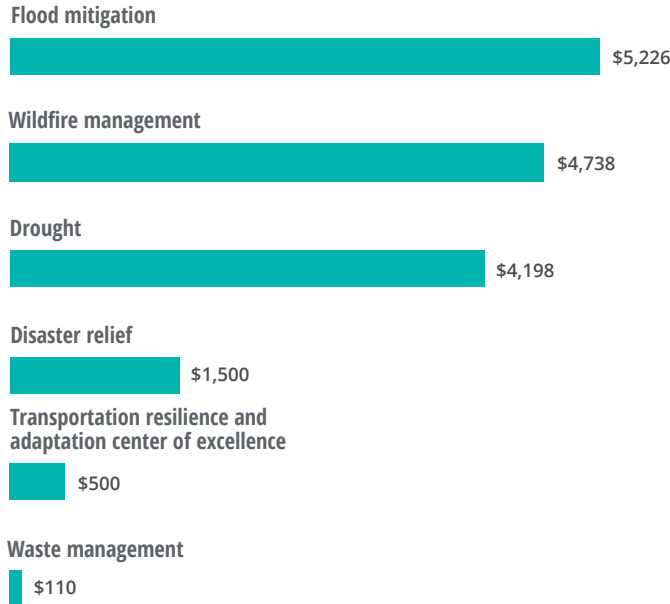
Climate resiliency

Some state and local agencies are making strides toward climate-proofing their infrastructure. New York City, for example, hopes to build a six-mile-long sea wall and flood gates to protect lower Manhattan from future flooding, as part of a broader Lower Manhattan Coastal Resiliency project intended to protect the city's critical infrastructure and economic center.[63] A recent Colorado regulation requires the state's transportation planners to redirect some funding from highway expansion to projects that reduce vehicle pollution.[64]

All transportation agencies should consider climate-driven complexities during the project design and selection phase.

All transportation agencies should consider climate-driven complexities during the project design and selection phase. With billions in IIJA funding to build climate-resilient infrastructure (figure 10), transportation agencies can move toward a more data-driven approach to investment.[65]

FIGURE 10

IIJA has allocated funds to build adaptation and mitigation plans in different areas (US$ million)

Flood mitigation
$5,226

Wildfire management
$4,738

Drought
$4,198

Disaster relief
$1,500

Transportation resilience and adaptation center of excellence
$500

Waste management
$110

Source: Deloitte analysis of IIJA funding.

Data can help transportation leaders better understand the impact of climate change at the local level. The Virginia Institute of Marine Sciences at the College of William and Mary, for instance, has developed a model that can project sea-level rise through the year 2050, and now issues annual sea-level "report cards."[66] This project is helping state transportation and infrastructure 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. It also will allow policymakers to determine how best to prioritize funding and explore policy options that take into account sea level rise and frequent inundation.

Similar tools, including the Federal Emergency Management Agency's National Risk Index database and the National Oceanic and Atmospheric Administration's county-level database of natural-disaster hazard information, can be used to inform climate mitigation projects related to heat waves, high-intensity rains, flooding, hurricanes, and forest fires.

Some states already have adopted data-driven approaches for project selection. Virginia's System for the Management and Allocation of Resources for Transportation (SMART) Scale, for instance, can be used to evaluate potential transportation projects based on multiple factors, including safety, congestion mitigation, accessibility, economic development, and environmental impacts.[67]

Each project is scored based on objective, outcome-based parameters and includes a public engagement phase to attract community feedback. The SMART Scale is intended to keep the selection of critical infrastructure investments data-driven, minimizing subjective human judgments.[68]

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.
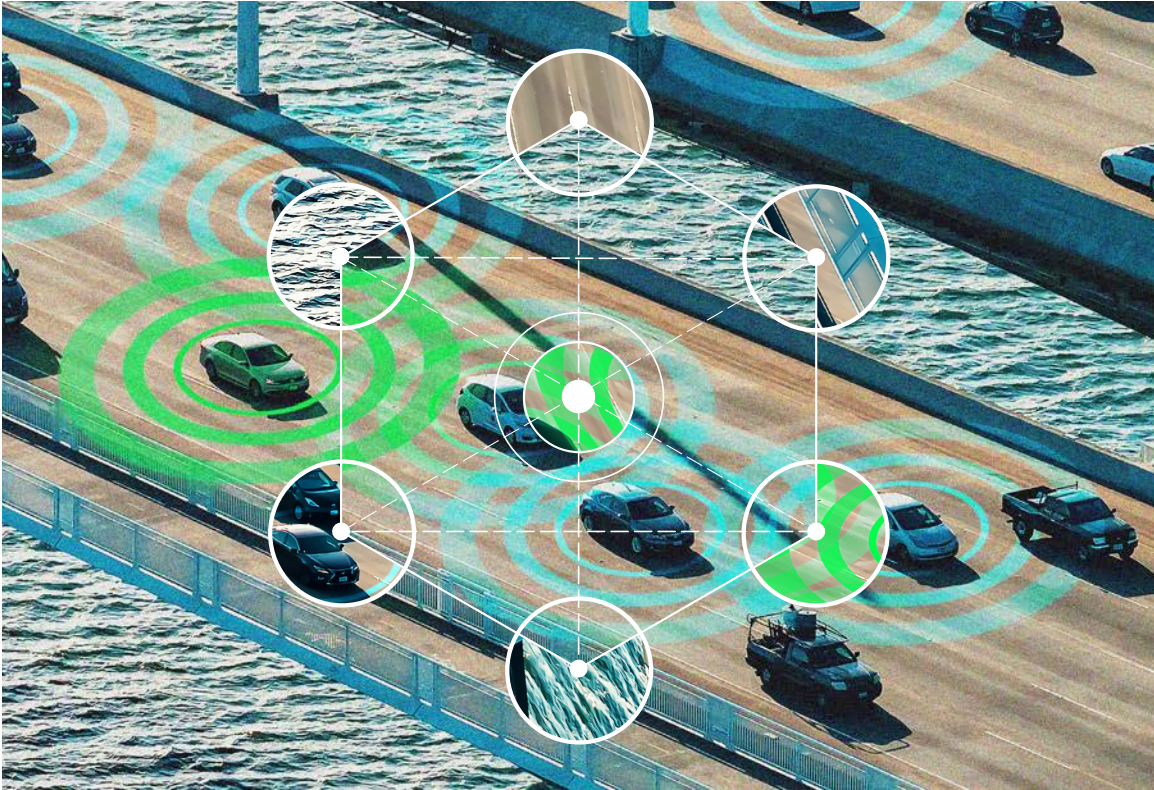
Trend 5

Turbocharging digital and technology innovation

N OUR *TRANSPORTATION TRENDS 2020* report, Deloitte explored two trends on the cusp of scaling.[69] One concerns the innovation ecosystem coalescing around connected autonomous vehicles and RUC pilots. The other trend focuses on the growing toolkit of AI technologies that can enable intelligent transportation systems in areas ranging from traffic management and smart signaling to road safety, transit scheduling, and real-time commuter information.[70]

While the pandemic disrupted public transportation in many ways, it also ushered in a long-overdue wave of smart transportation systems.[71] 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.

The passage of IIJA provides further impetus for this trend, with investments flowing into smart infrastructure, connected and autonomous vehicle technologies, and mobility-on-demand pilots.

Scaling innovation in transportation

Scaling innovative technologies can be challenging in the public sector. The lack of traditional market indicators tends to make it difficult for government innovators to assess the effectiveness of a solution and its ability to scale.[72]

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 across the United States have initiated a plethora of connected and autonomous vehicle

The lack of traditional market indicators tends to make it difficult for government innovators to assess the effectiveness of a solution and its ability to scale.

projects to provide test beds and sandboxes for new technologies.[73] While they've helped to generate knowledge and best practices, few have led to large-scale implementations so far.

While this is still true as of this writing, promising advances are being made by the Jacksonville Transportation Authority as they work to advance and scale their Ultimate Urban Circulator ("U²C") project. The project builds upon JTA's AV test and learn activities, to a multiphase project that will introduce autonomous vehicles into Jacksonville's Bay Street corridor; transforms its aging Skyway monorail circulator into an elevated roadway for autonomous vehicles providing connectivity to

their multimodal transportation hub; and will eventually extend the system into neighborhoods with autonomous vehicles operating in a mixed traffic environment.[74]

While scaling innovation in government can be incredibly tough, a three-step playbook can streamline the journey (figure 11).

Improving pilot design

Pilots often fail to scale. An innovative project may show promise and generate funding for expansion, but once it's tried in multiple locations, the results are disappointing.

DOT aims to break this cycle of "death by pilots" by streamlining the process for testing innovative technologies. The SMART grant program, which received US$500 million under the IIJA, aims to help transportation agencies scale new innovative technology solutions. It includes wide-ranging funding to pilot eight innovative technologies: coordinated automation, connected vehicles, intelligent sensor-based infrastructure, systems integration, commerce delivery and logistics, aviation technology, smart grids, and smart traffic signals.[75]

The grant program aims to bridge the gap in areas where public transportation agencies struggle the most identifying the right "problem" to solve and designing the pilot for success. The program requires agencies to start by identifying the problems they'd like to solve and then to focus on the technologies that help change the status quo. It requires transportation agencies to work with the broader ecosystem, including the private sector, academia, nonprofits, and community organizations, to build prototypes and obtain

FIGURE 11

A path to scaling success
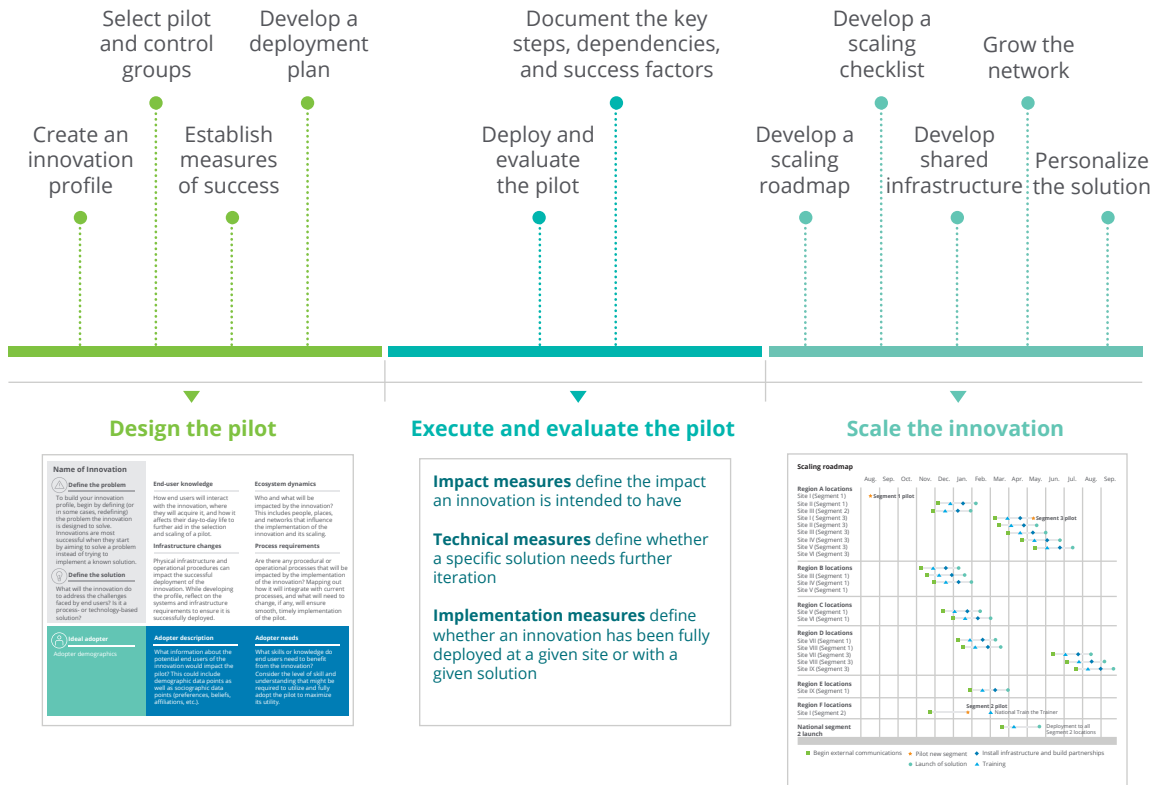
Source: Deloitte analysis.

broad buy-in. The resulting consultations and partnerships can help agencies decide whether or not to proceed.[76]

As noted above, coordinated automation is one of the technologies agencies can pilot and test with SMART grants. This technology ultimately could lead to fully automated road transport without human intervention. The program can help advance existing coordinated automation projects under way in different states.

The state of Washington, for instance, launched its Cooperative Automated Transportation (CAT) policy framework in December 2020. The state intends to pilot connected and autonomous

technologies that enable "all modes of transportation to work together through interdependent vehicle and systems automation and information exchange."[77] CAT has developed clear policy goals including improved shared mobility, better access to transportation, improved infrastructure and street design, and increasing land use in cities.[78] It aims to pilot automated shuttles to plug first- and last-mile connection gaps in transit services. It's also working closely with stakeholder groups to improve connected and autonomous vehicle technology, including the state's Autonomous Vehicle Working group, the Intelligent Transportation Society of America and the American Association of State Highway and Transportation Officials.[79]

Another technology that the SMART grant is encouraging is advanced air mobility (AAM). The Federal Aviation Administration (FAA) and the National Aeronautics and Space Administration (NASA) are collaborating on a national AAM campaign to develop use cases for urban air mobility, build public confidence, reevaluate the regulatory environment, and facilitate ecosystem learning.[80] With advances in electric vertical takeoff and landing (eVTOL) technologies, the AAM market could help alleviate urban congestion and improve rural connectivity.[81]

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 SMART grant program includes a strong focus on documenting lessons learned during the planning and pilot stage, to create a knowledge base of best practices that can be used by other jurisdictions. In fact, the program will allow projects to advance to the demonstration stage *only* if they show a high probability of scaling.[82]

One such project already underway is Chicago's Array of Things (AoT), a network of sensor boxes on light posts.[83] 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.[84] They can help the city build anticipatory capabilities to address issues 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. With clear data to evaluate progress, cities can use IIJA funding to revive such projects.

Scaling the innovation

Scaling a successful pilot is by far the most difficult phase for any organization. Often, transportation agencies struggle with this step because they lack a road map 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.[85]

Brussels in 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 congestion in the city. The city decided to develop and pilot a smart-kilometer charge solution called SmartMove.[86]

SmartMove aims to tackle congestion holistically through the implementation of a smart 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.[87]

Looking ahead

Effectively leveraging the historic federal investments that have been made to reverse decades of inadequate investment and to modernize key facets of the nation's transportation system will require bold action and political will on the part of transportation leaders. A business-as-usual approach by the public sector will waste an important opportunity to make the most of this historic investment and leave a lasting legacy.

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Acknowledgments

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Our insights can help you take advantage of change. If you're looking for fresh ideas to address your challenges, we should talk.

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