U.S. Department of Transportation (USDOT) Workshop: Transportation, Mobility, and the Future of Infrastructure

*Hosted by USDOT in collaboration with the **Federation of American Scientists***

December 8, 2022 Workshop Report

Developed by the Federation of American Scientists

Workshop Hosts

US Department of Transportation, Office of the Assistant Secretary for Research and Technology

The Office of the Assistant Secretary for Research and Technology (OST-R), works at the dynamic intersection of new and emerging technologies, transportation data, policy, research and all modes of transportation across the Department. Its mission is to facilitate the transformation of our transportation system–making it safer, more efficient, competitive, accessible and sustainable.

OST-R activities include:

- Advance innovation, technology development, and breakthrough knowledge
- Facilitate research and multimodal research collaboration
- Foster technology transfer through partnerships both within the Department and with other Federal agencies, academia and private entities
- Provide decision makers with useful statistics and information of the highest quality and integrity
- Develop a skilled interdisciplinary transportation workforce for the nation

In Collaboration With

The Federation of American Scientists

Science, technology, and innovation have vast potential to generate societal good when harnessed appropriately. Too often, governments struggle to take advantage of the best ideas, talent, expertise, technology, evidence, and partners to drive policy and most effectively govern. The Federation of American Scientists (FAS) exists to change that.

Founded in 1945, FAS envisions a world where cutting-edge science, technology, ideas, and talent are deployed to solve the biggest challenges of our time. We infuse science, technology, innovation, and experience into government and public discourse in order to build a healthy, safe, prosperous, and equitable society.

Disclaimer: The outputs from the USDOT Workshop on December 8th, 2022, published in this report, reflect views and opinions of Workshop participants. These are not endorsed by, and do not necessarily reflect the views of, the US Department of Transportation or the Federation of American Scientists.

U.S. Department of Transportation (USDOT) Workshop: Transportation, Mobility, and the Future of Infrastructure

*Hosted by USDOT in collaboration with the **Federation of American Scientists***

Table of Contents

Summary

On December 8th, 2022, the U.S. Department of Transportation hosted a workshop, “Transportation, Mobility, and the Future of Infrastructure,” in collaboration with the Federation of American Scientists.

The goal for this event was to bring together innovative thinkers from various sectors of infrastructure and transportation to scope ideas where research, technology, and innovation could drive meaningful change for the Department of Transportation’s strategic priorities.

To provide framing for the day, participants heard from Secretary of Transportation Pete Buttigieg and Deputy Assistant Secretary for Research and Technology Robert Hampshire, who both underscored the potential for a new agency – The Advanced Research Projects Agency – Infrastructure (ARPA-I) to accelerate transformative solutions for the transportation sector. Then, a panel featuring Kei Koizumi, Jennifer Gerbi, and Erwin Gianchandani focused on Federal Research and Development (R&D) explored federal advanced research models that drive innovation in complex sectors and explored how such approaches may accelerate solutions to key priorities in the transportation system.

Participants then broke out into separate rooms organized around: 1) safety; 2) digitalization; and 3) climate and resilience. During the breakouts sessions, participants were asked to build on pre-work they had completed before the Workshop by brainstorming future vision statements and using them as the foundation to come up with innovative federal R&D program designs. Participants then regrouped and ended the day by discussing the most promising ideas from their respective breakout sessions, and where their ideas could go next.

USDOT Deputy Assistant Secretary for Research and Technology Robert Hampshire moderating the Federal R&D Discussion Panel with Jennifer Gerbi, Kei Koizumi, and Erwin Gianchandani.

The Workshop inspired participants to dig deep to surface meaningful challenges and innovative solutions for USDOT to tackle, whether through ARPA-I or other federal R&D mechanisms.

This report consists of a variety of outputs developed by participants that were crafted before and during the Workshop. These include visions for the future of transportation and infrastructure and program designs in the form of wireframes, which are raw sketches of potential programs that capture a specific pivotal problem and solution. Each wireframe contains an opportunity (through promising new methods, approaches, or technologies); a program objective that can be demonstrated in 3-5 years; and a future state that becomes possible if the program is successful and fully implemented. Specific ideas from the workshop will be shared with the Secretary of Transportation Pete Buttigieg and other senior USDOT leadership to demonstrate some leading opportunities for innovation.

This Workshop represents an initial step of a broader process to identify topics and domains in which stakeholders can drive transformational progress for our infrastructure and transportation system. Such an effort will require continued engagement and buy-in from a diverse community of experts. **As such, USDOT and FAS appreciate the time and dedication from participants to support this effort, both for this Workshop and beyond.**

Workshop participants listening to remarks from U.S. Transportation Secretary Pete Buttigieg.

Workshop Breakout Sessions

Safety

Summary

Despite progress made since 1975, dramatic reductions in roadway fatalities remain a core, persistent challenge. In 2021, an estimated 42,915 people were killed in motor vehicle crashes. The magnitude of this challenge is articulated in DOT's most recent National Roadway Safety Strategy, a document that begins with a statement from Secretary Buttigieg: "The status quo is unacceptable, and it is preventable… Zero is the only acceptable number of deaths and serious injuries on our roadways."

During the Workshop, participants were asked to think about what steps could be taken to create safer urban and rural mobility spaces for pedestrians across all modes of transportation, as well as what capabilities, systems, and datasets were needed to achieve future visions. Themes that emerged during discussions included underlying needs like real-time data to improve safety outcomes, built environment changes to promote safety, and improvements in efficiency and access for non-vehicle modes of transportation.

Safety breakout room participants working on wireframes.

Future Visions

Before the workshop, participants were asked to envision what our national transportation system and infrastructure could look like in 20 years. Below are the submissions for the topic of safety.

Every street or highway will have a digital "nutrition facts" label available to the public that will feature safety facts, impacts and contribution to climate change, and how well it's performing in the movement of people and goods. This concept is the ultimate success story in the collection and sharing of data in the right way. Knowing and showcasing how safe a street scores for cars, bicycles and pedestrians can help politically shape conversations that are often difficult (such as adding a protected bike lane or reducing speed limits). It will also require all levels of government and multiple industries to work together in collecting data into a shared output.

In 20 years, we have de-centered the car in urban transportation, dramatically lowering transportation emissions in our densest cities while increasing mobility and improving quality of life in cities and suburbs. By 2042, major cities around the country are seeing dramatic mode shifts towards transit and active transportation, brought about by investments in transit service, reallocation of road space, and a shift in subsidy from automobiles to sustainable modes. As more people find themselves leading happy, prosperous lives without a car, a growing political constituency helps drive a positive feedback loop of investment and transformation. Technologies such as electric delivery vehicles, low-speed autonomous vehicles, and automated enforcement help to reduce remaining negative impacts of those vehicles that continue to operate in dense urban areas. In conjunction with these urban shifts, investments in transit extend outward to lower-density suburban areas where regional rail, shared autonomous passenger services, an e-bike trail network, and a fully-electrified private vehicle fleet allows for low-carbon, "car light" lifestyles to become more common in formerly car-dependent communities.

In a perfect world, our national transportation system and infrastructure will be multi-modally integrated with the safe, seamless and efficient movement of people and goods in a financially and environmentally sound manner that serves the varied mobility needs of and supports a good quality of life for all people. Traffic crashes will have been greatly reduced so that fatalities and serious injuries will have been cut by 50% from the 2022 baseline. This will have been achieved by changing the paradigm on traffic fatalities from something that is unavoidably a cost of mobility to one that is unacceptable personally and societally. The root causes will have been identified for why traffic crash and fatality trends have been so different from the rest of the developed countries (except Switzerland), understood and addressed. The integrated safety system of civil aviation overseen by the FAA will have been appropriately replicated in the surface transportation sector and greatly energize the safe system approach.

The U.S. commits to Vision Zero and makes the physical vehicle and roadway changes necessary to make this happen. All vehicles are speed limited on highways, non-highway lanes are narrowed to make

it uncomfortable to drive too fast, and pedestrians/cyclists are afforded physical protection from vehicles. In essence, the costs of roadway deaths are internalized into civil planning rather than externalized. Specifically, within the trucking industry, we will have high market penetration of electric or alternative fuel vehicles. This will include battery electric, fuel-cell electric, and natural gas based on regional advantages for each and partnerships and incentives to build the necessary infrastructure. Battery-electric vehicles will be feasible where the electricity is generated, fuel-cell and natural gas will be feasible where hydrogen and gas are extracted or can be cheaply transported. Diesel will still have a role in filling the gaps and emergency response but will have achieved new improvements in efficiency and emissions. It will be more expensive to maintain these parallel networks, and distribution will re-orient around regional operations in order to utilize the infrastructure and capture the incentives that lead to continued technology developments.

We eliminate roadway deaths and dramatically reduce tailpipe emissions from commercial vehicles. These two issues dominate the respective domains of passenger vehicles and commercial vehicles. The biggest problems we need to address in reaching this goal are roadways that incentivize risky driver behavior and infrastructure needs to support commercial logistics. Efforts to educate drivers have largely failed and sometimes even caused additional crashes. Efforts to reduce tailpipe emissions of commercial vehicles have hit major hurdles around cost and infrastructure.

20 years from now, cities and states across the country will have benefitted from USDOT having established a program where cities/states can receive information and guidance on cutting-edge technology and how to potentially implement that technology into future planning documents. Every mayor has met with numerous companies that have a new technology designed to help them manage and improve their city transportation services and mobility. Among other issues, a mayor and staff don't have the expertise or the time to examine the proposals and are often left wondering if the company has a good idea, is it reliable and well-funded, will the technology work, can the city pay for it, and will it be obsolete before long? There needs to be an honest broker in evaluating cutting edge technology (not companies) in order to move the "good ideas" and technological advances faster and with more symmetry. Within USDOT the envisioning of the future could be coupled with the ideas that are being proposed by our colleges, universities, and the private sector. Ideally, sessions imagining the needs of the future could be coupled with emerging technologies and those technologies would receive the attention necessary to bring them to adoption.

Evidence-based road safety data is produced and disseminated promptly and consistently to inform the planning, design, and operations of road infrastructure. Building safer streets starts with generating the right data, understanding risk factors, and testing mitigation strategies. There is a growing recognition among safety practitioners that reliance on crash data alone does not provide a complete picture of road risks and has well-documented limitations. To achieve Vision Zero, a systemic approach is needed to proactively identify locations that have a high risk of crashes but where the risk has not yet resulted in actual crashes.

In 20 years, over 90% of production vehicles will have advanced driver assistance systems which will lead to a substantial reduction in the severity and in some cases, elimination of some crashes. At the same time, many predict that highly automated driving will be ubiquitous, legal and technology reliability and issues will slow progress. Injury crashes during demonstrations will cool the public's interest in such modes of transportation. More highly automated vehicle demonstrations will be more common, but not yet implemented into production.

Transportation will be reimagined from a car-centric state to a vision where active and shared transportation (including public transit) is the first and easiest choice, enabled by technology and supported by government policies that include equitable taxes on "bads" and incentives for "goods." Current infrastructure is designed for cars and parking, with an estimated 8 parking spaces for each of the 290 million passenger vehicles in the US. For cities, changes for more active and shared transportation are underway and can be accelerated with infrastructure design and governmental incentives to pull people into other modes of transportation that are more equitable and sustainable and that make for better communities. With the introduction of new technologies and infrastructure, public transit will work better and past inequities can be addressed while the transportation system is being reinvented. Public transportation will be given priority and will be used by everyone because it is so easy and so frequent, coming every 10 minutes. Sidewalks will be joyous places to be and roads will be designed to encourage walking and biking and transit that moves faster than cars. With more human interaction on the street and on transit, community values will be strengthened. Household budgets will have the weight of transportation costs reduced.

A transportation system that operationalizes racial equity and mobility justice. The problem we are solving is racialized transportation inequities and related, compounding inequities. The people we are impacting are racially marginalized people. We seek to make all streets multimodal; emerging transportation technologies are focused on improving life outcomes and prioritized in racially and socially marginalized communities, the work to socialize people around the act of mobility is funded at the same level as infrastructure, transit is 100% free for everyone and fully funded, shared mobility systems are community-owned, USDOT funds neighborhood-based e-bike libraries and mobility hubs, and we use. Transportation infrastructure and programming to reduce violence (interpersonal, vehicular, and police). We must stop looking to Europe for transportation models and attempting to replicate these models in U.S. cities with no regard for structural racism, poverty, police violence, and other racialized inequities. We must instead look to the global south and Latin America where transportation solutions are being implemented to solve for inequities.

Smart connected Interstate network with Zero Fatalities and no traffic congestion. The current number of fatalities is simply not acceptable and needs to be dramatically reduced. Even if reduced by COVID-related impacts, traffic congestion is and will be a future problem. We can't build our way out of congestion but need to optimize the use of the existing capacity by using technology for reducing fatalities through vehicle connectivity that exists or is being developed and improve traffic orchestration for roadway capacity enhancements. Deploying at a massive scale in a dedicated network like the Interstate Highway network should be a priority to create the future transportation system.

High-level (SAE) vehicle automation becomes ubiquitous, helping realize the potential for significant reductions in vehicle crashes with commensurate reductions in injuries, fatalities, and property damage; expanded mobility for segments of the population that cannot or should not operate a motor vehicle (e.g., elderly and sight-impaired, etc.); alternative transportation solutions within "transit deserts"; providing first and last mile solutions; increased vehicle occupant productivity and stress-reduction during trips; and AV-enabling infrastructure improvements that also increase safety for conventionally (human) driven vehicles (e.g., less complex roads, clear lane markings and signage, and good sight lines).

Car-optional life in both urban centers and suburban areas supported by efficient and equitable bus service, last-mile options, and inter-regional rail. Despite significant improvements in cycling and walking in the past 20 years, American cities and regions remain stubbornly car-dependent, with light-duty vehicles accounting for 58% of transportation-related GHG emissions. Many efforts to reduce car-dependency focus on influencing individual behavior through education and economic incentives, but they often neglect the role of the built environment, particularly the fact that places where people can perform daily tasks without using a personal car are uncommon and not equitably distributed either socially or geographically. Many investments in aligning housing and transit have not adequately captured land value increases, allowing positive externalities to be privatized while increasing displacement pressure and housing insecurity. Solving this problem will require altering patterns of land use and in particular increasing density and transit access in suburban areas even where there is low market demand. All benefit from reducing car dependence (including car drivers), but particularly the working class, who increasingly live in suburban areas and for whom car dependence, not just for work trips but shopping, school, and leisure trips, is a major economic burden.

Breakout Brainstorming

Participants were asked to build on their pre-work during the breakout sessions through individual brainstorming to generate as many additional "future visions" as they could that solved a substantial problem in transportation and infrastructure. This Word Cloud provides a high-level view of the themes that emerged from this exercise based on **over 100 visions** written by participants, with the full list featured below.

Full List of Vision Statements from Safety Breakout Room

- Multimodal integration
- Improved reliability across the transportation ecosystem
- Digitizing physical infrastructure
- Intelligent intersections seamlessly communicate with vehicles to avoid collisions
- Tools that can perform traffic enforcement without disparate impact or involvement of police
- Eliminate the incidence of reckless driving with technology
- Cars that can assess the condition of the driver prior to starting
- Aircraft that don't make noise
- Electric charging infrastructure that is better than gas stations
- Seamless and in-vehicle standard accident avoidance systems
- Car-optional cities and suburban areas
- As intuitive and dignified to travel by transit, foot, and bicycle as it currently is by car
- Goods distribution within cities reduces the need for superfluous passenger trips
- Free metro passes for all
- Anti-skid roadway materials
- Traffic metering systems nationwide
- World leader in building a safe, sustainable, smart, transportation system
- 15-minute walking distance to a rapid transit stop in every urban/suburban city
- Digital safety scores on roads and highways

- Lighting America: deploying state-of-the-art resilient lighting infrastructure
- Communication between all vehicles on streets and highways
- Society embraces safety as a top priority
- No kids lose their lives in our transportation system
- Crash outcomes are equitable
- Eliminated bias from safety programs and technology
- Perform research and technology deployment that ensures equity
- Leveling of the playing field – improve safety in areas that have seen underinvestment
- Better tools to prioritize safety investments
- More timely data to measure success and track real-time trends
- Personal security is enhanced for all modes of transportation (all modes are equally desirable)
- Building elevated pedestrian and bicycle highways
- Fully protected bike infrastructure on arterial roads
- Implement the design of the safest road possible
- Equitable access to safe travel options for all
- Use the generations of the future to develop a safer future transportation system
- Traffic crashes due to human behavior are mitigated or prevented
- Traffic crashes don't result in fatalities or serious injuries
- Legislated funding for safety truly reflects its first priority position
- Reduced speeds to improve crash outcomes
- Firm understanding of the causes of crashes on U.S. roadways
- Reduced infrastructure costs
- Improved passenger and vehicle protection systems
- Serious crashes involving heavy vehicles cut 75%
- Safety between modes of transportation is equalized, including in urban, suburban, and rural areas
- Those without cars or the ability to drive have equally efficient transportation access to those who own and drive cars
- Safety includes fatalities but also close calls and risk interventions
- Intelligent systems to detect impairment
- Safe autonomous vehicles
- Signalized intersection deaths and serious injuries become rare and newsworthy
- Speed related traffic deaths cut by 50%
- Deaths and serious injuries from vehicle-wildlife related conflicts cut 50%
- Unhackable communications for V2I and V2V
- Digital freight routes in all states to be used for truck control
- Standard methods for crash reconstruction of AVs
- Harmonization of safety standards for Automated Vehicles
- Traffic fatalities and serious injuries for people with disabilities reduced by 50%
- Pedestrian deaths and serious injuries cut by 50% on rural roads
- Vehicles on highways are platooned at optimal speeds to improve efficiency, safety, and reduce energy consumption

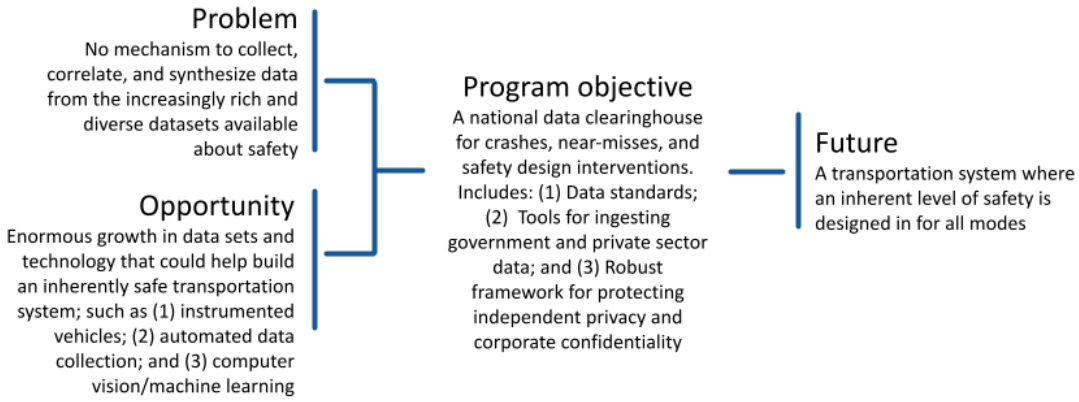
- City traffic speeds are lowered further to reduce pedestrian safety
- National comprehensive crash database with better reconstruction
- Automatic detection for failure to yield
- Bike V2V
- A national data clearinghouse for crashes, near misses, and safety design interventions
- Connected and communicating vehicles that can help drivers safely adopt to the road environment
- Local, short term achievable reductions in VRU crashes
- Zero crash "zones" where combinations of local solutions have dramatically reduced risk
- Standardized work zone data exchange protects drivers and workers
- Bridge failures reduced by two orders of magnitude
- Zero traffic fatalities
- Increase port goods throughput by 50% without increase in cost or safety incidents
- Reduce all pipeline leaks
- Smart roads providing real-time hazard info to all users
- Safe mobility for vulnerable road users is priority
- American attitudes about traffic safety have changed such that traffic fatalities are unacceptable
- Traffic fatalities and injuries are reduced by 50%
- Crashed vehicles communicate the condition of human occupants directly to hospital and emergency service providers
- Road vehicles are lightweight and the fleet is segregated by size and weight
- Vehicles will not operate for drunk drivers
- Smart technology in public transportation
- Digital/automated crossing guards
- Cars, bikes, scooters, and walking as safe as being on a plane
- Intelligence and enhanced automation for safer air traffic and flight deck operations
- Use the same road for multiple uses
- Make cars, people, and bikes more visible at night
- Real-time data analytics to assess current infrastructure in urban areas
- Infrastructure which contributes to increased socialization and decreased violence
- Infrastructure which decreases the need for police and provides automated enforcement
- Vehicles have lighting that pedestrians can interpret to judge vehicle speed and safety
- Multimodal streets integrating transportation, recreation, socialization, and commerce with physical infrastructure designed to separate modes of travel
- Smart technology integrated in traveling public
- Enhanced automation to reduce air traffic and flight deck events
- Highly automated vehicles provide safety "herd immunity" to the surrounding human driven vehicles
- Public transit which is free, safe, reliable, accessible, and fast
- Bicycle highways
- Intelligence vehicles and infrastructure
- E-bikes become a viable, safe mobility option in all urban and suburban areas

- Kids can safely fulfill many of their own mobility needs with biking, walking, and transit
- Older adults maintain their mobility throughout their life
- Enforcement of traffic safety does not expose communities to potential for police violence
- Formalized, automated program for inspecting, inventorying, and maintaining safety infrastructure
- Local governments have a selection of high quality, durable, maintainable materials which can be used to prototype and implement safety infrastructure
- Fewer than half of people in urban areas view car ownership as important to their mobility
- Last-mile mobility services serve urban fringe as effectively as urban core
- Harmonizing physical and digital infrastructure for improved road safety outcomes
- Combination of low cost, high benefit, complete streets with digital infrastructure solutions
- Reduce bicycle fatalities by 2 orders of magnitude
- Passenger vehicle speeds reduced in practice to 20 miles per hour or less across almost all roadways
- Children can get to school and other destinations safely on their own

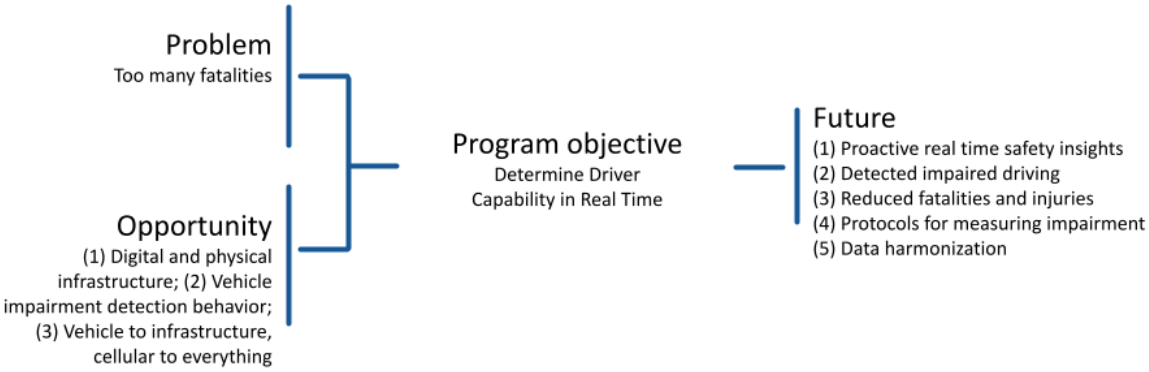
Wireframes

Following individual brainstorming of future visions, participants collaborated with their peers to work backward from their selected future visions to articulate program designs in wireframe format that were transformational, incentivized stakeholder action and involvement, and had a clear role for Federal research and technology activities. Below are the completed safety-related wireframes.

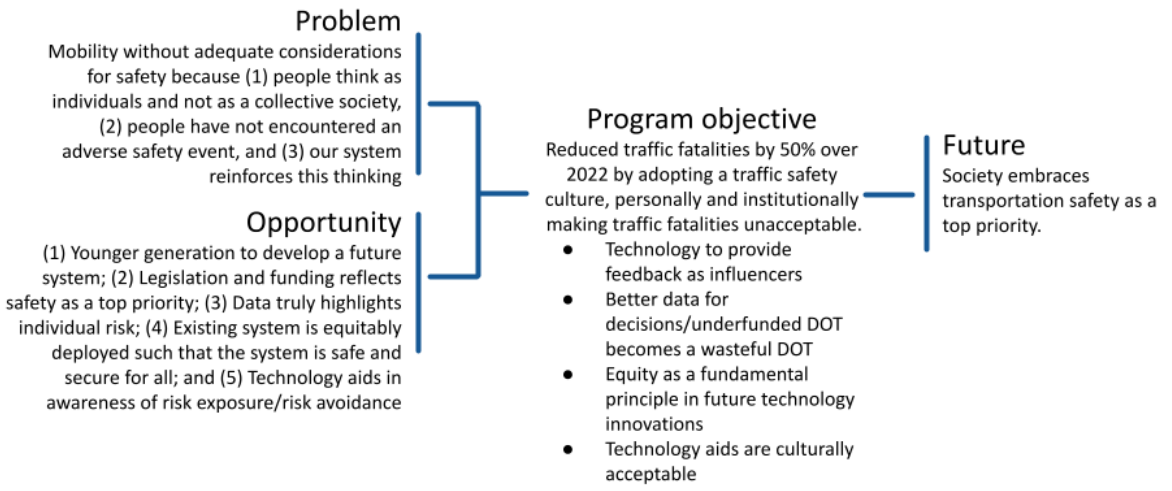
A National Data Clearinghouse



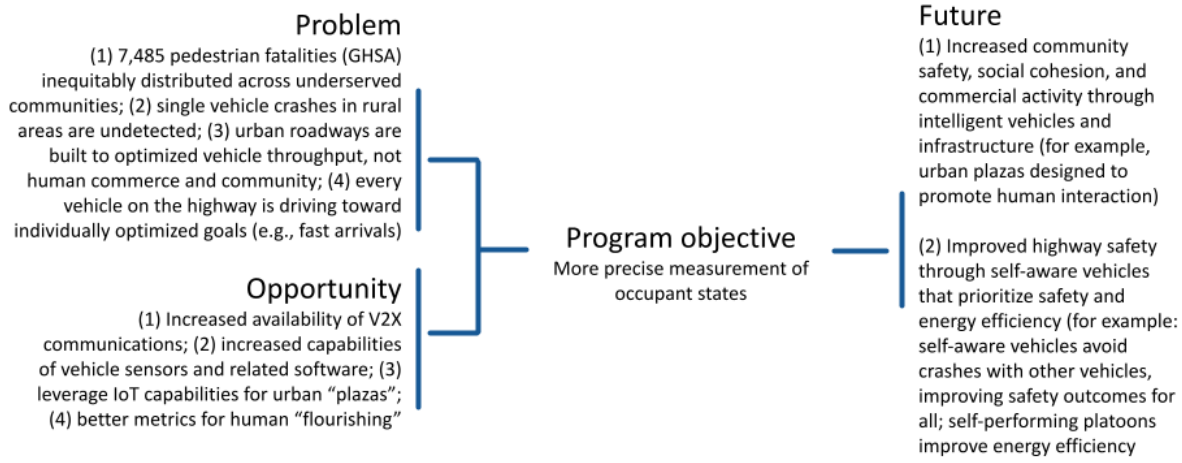
Determining Driver Capabilities in Real-Time

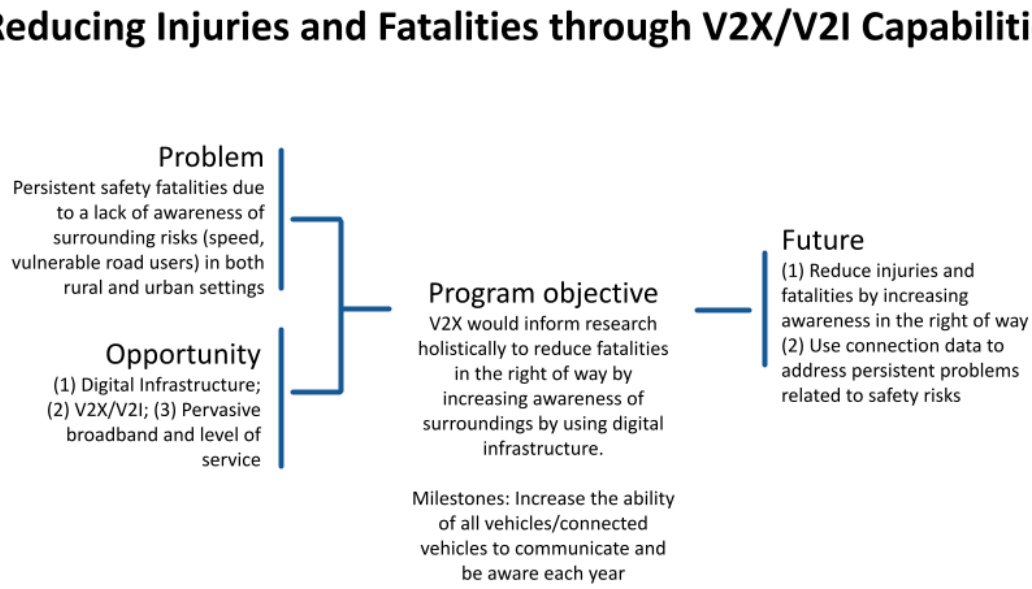


Building a Traffic Safety Culture through Data and Tech



Harnessing Tech for More Precise Occupant State Measurement





Climate and Resilience

Summary

According to the United States Environmental Protection Agency, modern roads and bridges are designed to withstand storms that, at the time of their construction, had a probability of occurring once in every 100 years. Today the effects of climate change have made these events more frequent. In 2020 alone, the U.S. suffered 22 high-impact weather disasters that each resulted in over $1 billion in damages, the National Centers for Environmental Information reported. These catastrophes are likely to intensify as climate change exacerbates the impacts of these events. The USDOT is well-positioned to introduce systems-level improvements to the resilience of our nation's infrastructure to prepare against the uncertainties of climate change while also considering the diverse resiliency needs across the country between urban and rural areas.

During the sessions, participants were tasked with envisioning a future and thinking critically about what transformations and innovations would be necessary to achieve their goals. By thinking through the need to make our infrastructure more resilient, participants developed bold ideas to cut across traditional transportation modes and meet the needs of the most underserved communities. Their ideas, although varied, shared key themes related to innovative materials, shared data networks, and technologies and standards that could facilitate accessibility, equity, and mobility for all people.

Climate & Resilience breakout room participants discussing ideas for their wireframes.

Future Visions

Before the Workshop, participants were asked to envision what our national transportation system and infrastructure could look like in 20 years. Below are the submissions related to climate and resilience.

***Sustainable, equitable, and resilient (adaptive) infrastructure*.** The biggest problem is converting static infrastructure assets to dynamic, on-demand equitable infrastructure services ('shift from public infrastructure ownership to market-driven consumerization'). Who is impacted? Public infrastructure asset managers, public infrastructure users, public and private investors. Additional context: for over 200 years, taxes and bond financing have been the primary policies to fund and finance infrastructure services and physical assets such as roads, bridges, and water systems. This model is being disrupted because of reduced tax receipts, societal behavioral shifts, post-Covid-19 impacts on state and city budgets, the integration of financial innovations such as blockchain tokenization, and the requirement of investors to disclose the climate impact risk of their investments.

In 20 years, our transportation system is helping to solve climate change and reduce economic inequality. Funding for transit is reliable and predictable. Citizens of all backgrounds are impacted as transit services and use expands. Multiple efforts have been made to achieve similar goals, but rarely have these goals been a priority. The last time transportation was seen as a massive priority was in

Defense efforts that created the National Highway System; similar is needed to address the climate impacts of transportation, with transit at the core.

Continuous evolution towards a data-driven, efficient, resilient, and sustainable goods movement system that supports jobs and economic development across the city, region, and across the nation. We achieve alignment in terms of transportation, energy/resource, air quality, labor and industrial planning and policy towards the development and perfection of a national (and international) goods movement system that: empowers end-users to make choices that optimize their supply chain and aligns market incentives to lower carbon and criteria emissions; provide clear signals and guidance to facilitate private and public investment in said system; has successfully transitioned the incumbent workforce and created career pathways for the next generation of workers; enhanced connectivity between exporters and foreign markets; and established new forms of governance to enhance accountability, supports inclusivity, and advances equity goals.

An "Intelligent" system that simultaneously achieves safety, mobility, sustainability, resiliency, and adaptivity through large-scale, distributed and interactive systems to coordinate infrastructure, traffic, users, and technologies. This would address the challenge of the disjointed deployment and lack of coordination between different sectors in the transportation system in current practice and thus improving the overall safety of motorists and pedestrians, improving the efficiency of multimodal traffic, optimizing road construction and maintenance schedules, and enabling more equitable resource allocation and decision making. Infrastructure Owners and Operators (IOOs), fleet vehicles, private vehicles, as well as vulnerable road users (VRUs), will all be impacted.

The right mode for the right task. By right-sizing our transportation for what needs to be moved, we could tackle climate change and road safety issues by being more efficient in our use of energy for mobility (not transporting a full passenger vehicle to deliver a pizza) and potentially decreasing the speed and weight of most vehicles for most trips on roads, thereby reducing momentum and making roads safer. This could have implications both for passengers and goods, but to achieve this vision, we would need flexibility in how we think about vehicle design, infrastructure allocation, and information sharing for coordination. In the passenger transportation space, this would pick up on the trend of using micro-mobility and possibly allow micro-mobility solutions to "scale up" to be more weather and driver-capability capable (i.e., protecting from rain and snow while allowing those who have difficulty standing to use it), but not need to become a full-fledged passenger vehicle. In the case of the movement of goods, this could potentially be better facilitated by sharing information to allow for advanced planning on which mode/size might be needed for which leg of a product's journey.

Corrosion-resistant reinforcement is used in all newly-constructed concrete transportation infrastructure, such as roads, tunnels, and bridges**.** Several solutions currently exist but are limited in adoption due to performance, cost, or lack of availability. By leveraging new technology, these challenges can be overcome. This impacts everyone, but especially people in coastal areas or cold regions where deicing salts are applied in the winter, as the corrosion problem is particularly acute in these environments. Government stakeholders involved in this solution are FHWA and state DOTs.

In 20 years, the U.S. would have implemented sufficient investments in transportation systems to eliminate the negative impact of carbon emissions on our climate. To realize this outcome, every emission point on the value chain of transportation would have been impacted. Who is impacted? The public from the perspective of how projects are scoped, prioritized and funded. Projects would need to be redesigned and delivered in a manner that is more human-centric rather than the car-centric approach of the last half-century. Funding policy would be restructured to align incentives across all stakeholders. Vehicle manufacturers and operators of multimodal transportation assets and systems would need to adjust business models to implement these changes. Investors and financiers would reconsider the performance parameters of projects.

The climate crisis has become even more severe, and the United States is committed to and on track to achieving a zero-emission fleet by 2045. The United States has overcome the political division over whether we need to convert to a zero-emission fleet and is fully committed to doing so. Technology has advanced to the point that electric and fuel cell vehicles are considerably more cost-effective than internal combustion-engined (ICE) vehicles, and the nation is committed to making zero-emission vehicles affordable for everyone. The necessary charging/refueling infrastructure is in place, and energy is being produced and available to fully support the zero-emission fleet.

Across America, the opportunity exists to have diverse mobility options, regardless of urban, suburban, or rural communities or the abilities or income of individuals. With increased urgency on climate change impacts, there needs to be significant expansion and acceptance of mobility options across all communities in America. Economic prosperity, community health, and the independence to age in place are assured when communities can lean on diverse mobility options to navigate within and beyond their community (i.e., walk, bike, roll, transit, passenger rail, maritime, aviation).

Transportation institutions, governance structures, funding arrangements, decision-making mechanisms, and operating practices are reformed to respond adequately and appropriately to the disruptive changes that characterize American society and geography. In this vision, the following would be true: state, regional, and local transportation and transportation-related agencies' jurisdiction, authority, and decision-making reflect the social, economic, and technological changes, new travel patterns; performance monitoring, evaluation, and management are better utilized to support the efficient use of scarce resources and to inform the decisions of elected, and appointed officials; the values and interests of diverse stakeholders are accommodated within transportation policy and planning processes and in investment and operational decision-making.

Utility model that prioritizes infrastructure investment with equitable outcomes. Through this model, we have solved the critical question of how to pay for infrastructure modernization and maintenance and have developed metrics to track and improve equitable outcomes through mobility. All users of the transportation system are impacted, and we have a more resilient transportation system that prioritizes transportation options based on regional needs and available multimodal infrastructure.

All transportation trips have been priced and/or subsidized to accurately reflect externalities (positive and negative) and assigned a climate/community impact score that must be communicated to the general public- from online shopping purchases to driving your kid to preschool to the flights we took to DC. The biggest problem this would solve is to create a shared baseline/understanding to educate the public (consumers and trip-takers), governments, academia, and all facets of the business community about the true "cost" of each transportation trip. This would enable these many different constituencies to have a shared understanding of these transportation impacts- within which to guide policy, regulation, and pricing-related regulatory mechanisms, business decisions related to offerings and pricing, and consumer choices. Granular information about the transportation network at a systems level does not exist- it can be modeled and simulated but there is no source of truth- and nothing to the level of detail around individual choices, externalities, community/equity impacts, and climate that can be communicated to the general public. Many companies, consultants, and agencies work on modeling this information, especially in the passenger transportation space, but again, nothing exists at the holistic level, and the progress on understanding the freight system impacts is still nascent. As a result, consumers especially have very little knowledge of the impacts of their transportation choices- especially those related to shopping and online purchasing.

Every material used in the construction and maintenance of our infrastructure directly addresses our communities resilience, climate, and equity goals. Our paving materials are heat resistant, water permeable, and actively cool our streets. The steel in rebar and bridge spans is produced without emitting carbon. The concrete we pour is carbon negative. Deicing chemicals have net positive effects on local environments. Sidewalks are omnipresent, accessible, modular, and cheap.

Zip code does not determine a person's life potential: access to opportunity/services, access to healthy food and nature, lifespan, housing, clean and healthy environment, safe, comfortable and joyful living, ability to move through their world, and access to information. Communities are redesigned in an integrated way based on the essentials necessary for thriving (housing, transportation, food and health, nature and clean environment, quality education and economic opportunity) and using technology as an accelerator. Historical practices such as redlining and structural racism continue to plague this country and hold back marginalized communities. From housing to transportation to health and more, the disparities are high, and the sense of urgency to address them has not been there. The statistics are well documented, but the action is slow and incremental. It is time to take an integrated approach to designing communities, and we lift people and communities who have been left behind by empowering them with the resources, services and technologies to live their lives to the fullest potential. Prosperity is increased for all by tapping into all the potential and growing the pie.

Long-haul electric trucks will be ubiquitous in the transportation network, with little or no concerns about range limitations, with no significant downtime due to charging needs. Reimagining freight with battery storage in trailers to power tractors eliminates the need for long charging stops. Current battery technology allows a fully loaded tractor-trailer to make 500-mile trips. Relocating most of the battery storage to the trailer facilitates minimal unnecessary downtime of tractors (and drivers) due to charging, so drivers and trucking companies are more productive, reducing overall long-haul transportation costs.

Unlike tractors, trailer operations involve significant stationary "downtime" during loading, unloading and wait times for pick-ups. Hence, battery-equipped trailers can be charged via their integrated solar panels and/or at warehouses and transloading facilities during these stationary periods. The trailer then provides the tractor with the necessary power to complete its trip while simultaneously recharging the tractor's in-vehicle battery during the trip.

In a perfect world, our national infrastructure will offer a point-to-point, zero-emission transit system that is convenient and affordable to all stakeholders and massively reduces congestion wherever deployed. The infamous first/last mile problem and congestion will be past problems taught in business schools to show how new disruptive technologies can fundamentally change society. The public will take for granted that local renewable energy sources entirely power public transit systems. Students in civil engineering will be surprised that, twenty years before, transit systems had fare collection and that many people used expensive ride-hailing systems.

Breakout Brainstorming

Participants were asked to build on their pre-work during the breakout sessions through individual brainstorming to generate as many “future visions” as they could that solved a substantial problem in transportation and infrastructure. This Word Cloud provides a high-level view of the themes that emerged from this exercise based on **over 60 visions** written by participants, with the full list featured below.

Full List of Vision Statements from Climate and Resilience Breakout Room

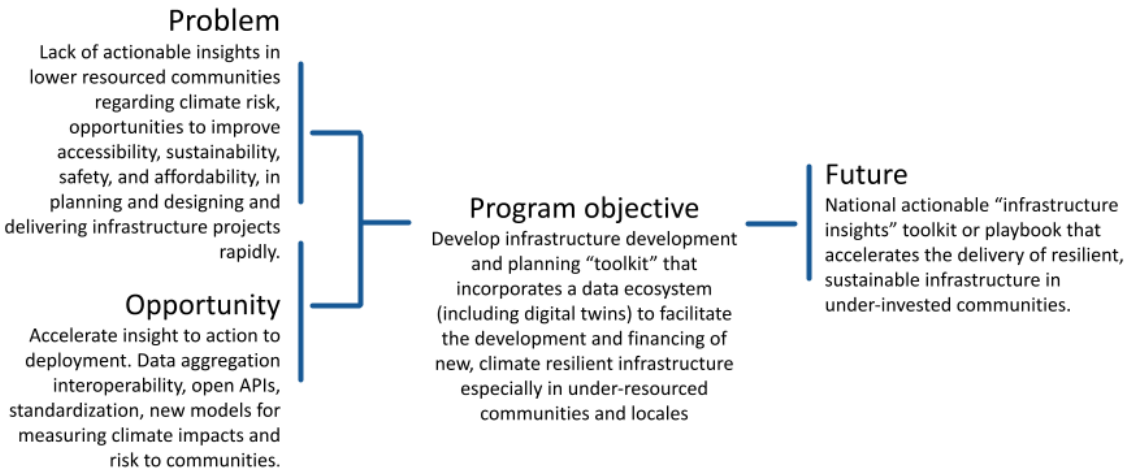
- Prefabricated modular roads to eliminate closures for upkeep, maintenance, replacement
- Fully wireless surface transit charging
- Ubiquitous, point-to-point, zero emission, equitable transit
- Integrated supply chain across the entire ecosystem
- Net negative emission vehicle technologies
- Clean energy for long-haul freight trucking without refueling/recharging disruptions
- Non-disruptive curbside deliveries
- De-coupling of energy bank from semi-tractors
- Low-cost climate resilient materials for roads and sidewalks
- Modular approach to transit, add and remove cars based on demand
- Standards for cars to plug/play between companies
- Data slides/tools for sharing info between companies in freight space to eliminate inefficiency, improve coordination, negative modes
- Consolidation centers enable reduced last mile delivery impacts
- Zip code does not determine a person's' life potential and opportunity
- No Black or Brown communities are at a disadvantage from climate safety/economic risk
- Implemented blueprint for integrated community design (housing, transportation, economic opportunity, etc.) for bottom 50% of underinvested communities
- Transportation ecosystem has data to right-size vehicles for each and incorporate positive and negative externalities in user fees, including climate and equity
- Easy access to climate risk insights for communities to make decisions for planning and response
- Ability to capture waste from all modes and reuse
- Reduce average project delivery time by 50%
- National broadband network on U.S. interstate system
- AV/AI implementation on priority transit corridors in top 10 longest metros
- Eliminate urban heat island effects
- Decarbonize all primary construction material (steel, concrete, asphalt)
- Zero emission container ships/ocean freight
- Data supply and application to accelerate deployment
- Profile and characterize risk to mobilize for action
- Public transit is the most reliable, affordable, utilized, and automated
- Minimize off ramps for fueling through in line charging
- Isolation of climate/warmth risk though modular construction
- Roads become enablement platforms
- In cities, shared cars, bikes, e-bikes, are available at mobility hubs 1/2 mile away
- Freight transfer locations for rail to truck are outside major cities
- Redevelopment of natural barriers for modes of transport
- High-speed rail connection for eastern seaboard
- Bus Rapid Transit is increased by 3x

- Rail replaces 50% of truck freight
- Analysis will include GHG emissions including for new lane miles
- AV shuttles are used for transit in neighborhood
- Transit runs every 10 minutes in cities on dedicated lanes
- National/globally integrated port community system
- Leverage the transportation network to harness energy to electrify diverse mobility devices and manage weather impacts
- Cost effective adaptive green infrastructure that is regenerative
- Infrastructure systems are self-healing and self-repairing
- Construction process is fully automated and adaptive
- Lots of intelligent transportation achieving zero-carbon emission and equity resilient
- Real-time carbon accounting and tracking and adjustment
- End-to-end supply chain, data sharing, including carbon intensity disclosure
- Adaptive reuse of transportation assets
- All maritime goods movement are zero-carbon/zero-emission
- Infrastructure materials are completely carbon negative-neutral
- Dynamic roadway design to manage safety over speed for all users
- Temperature regulated infrastructure
- Multi-benefit electric infrastructure: storage, melting, intelligence
- Zero carbon low cost mobility and access for all
- Diverse, affordable, accessible, scalable mobility options
- National freight system as "living lab" with integrated social infrastructure and continued engagement

Wireframes

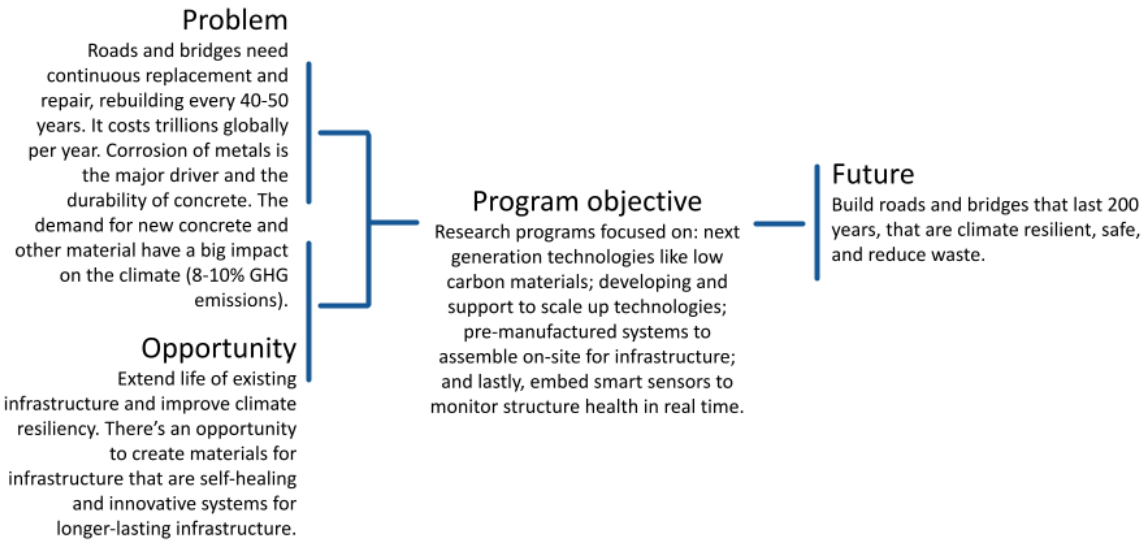
Following individual brainstorming of future visions, participants began working with their peers to work backwards from their selected future visions to articulate program designs in wireframe format that were transformational, incentivized stakeholder action and involvement, and had a clear role for Federal research and technology activities. Below are the completed climate and resilience-related wireframes.

The National "BIM" for Infrastructure

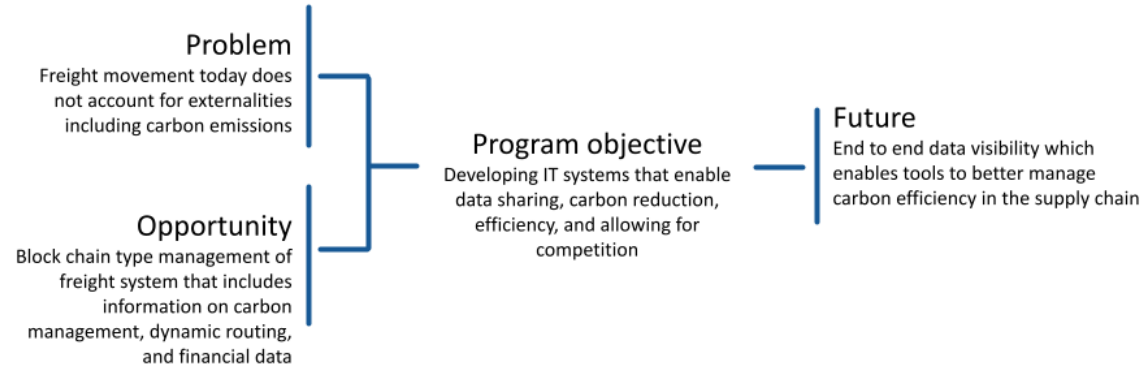


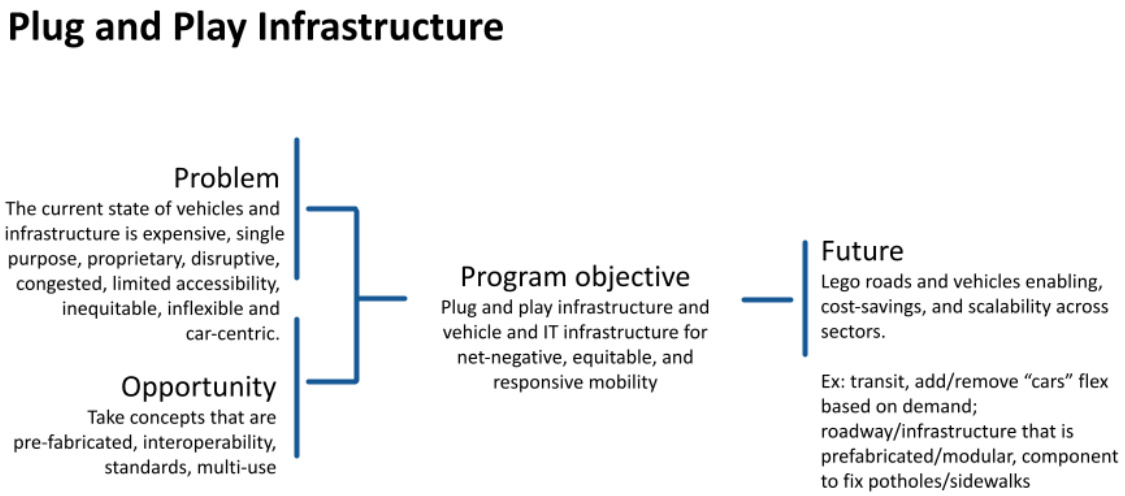
National Transportation Data Network

Next Generation Materials for Resilient Infrastructure



Transportation Management System





Digitalization

Summary

Advancing the systems, tools, and capabilities for digital infrastructure to reflect and manage the built environment has the power to make infrastructure more seamless for the movement of people and goods, particularly in transit, cycling and pedestrian networks, and freight and logistics systems.

When data is accessible by state and local transportation departments, regional planning organizations, and others, it can be harnessed to improve transportation operations and safety. This includes a range of technologies and innovations, including connected and automated vehicles; electrification across transportation modes, and intelligent, sensor-based infrastructure to measure and manage age-old problems like potholes, air pollution, traffic, parking, and safety. During the workshop, participants were asked to think big about digitalization – what steps can we take to leverage data and data systems to radically improve mobility and our transportation system across all modes? This prompt and breakout room activities yielded common themes around data access for decision-making, a focus on equity within digitalization, and integration of the growing number of systems and technologies at play.

Digitalization breakout room participants working on their wireframes.

Future Visions

Before the workshop, participants were asked to envision what our national transportation system and infrastructure could look like in 20 years. Below are the submissions related to digitalization.

Transportation agencies and stakeholders have access to dramatically improved data to make decisions, prioritize, measure impact, and communicate to the public and the tools/expertise required to use this data. Currently, transportation policies and projects are designed/implemented with limited data that is expensive or challenging to collect; is often very limited in geographic and/or temporal coverage (requires manual field collection or hardware installation); and requires expertise to store, make interoperable, and draw insights from. In 20 years it's reasonable, but far from a given, that the proliferation of "big data" will be democratized in a way that public agencies can use it to make better plans faster (and with consistency across geographies). If this is done right, agencies will be able to have greater visibility into transportation problems, impact with limited funds, and documentation of project success (or refining of efforts). This results in much more effective and impactful efforts, with built-in accountability/performance measurement. State and local transportation agencies are increasingly looking at (and undertaking efforts to) leveraging virtual infrastructure and new data insights to address their challenges; however, funds required to access/support this data is limited (or uncertain) and these

efforts aren't distributed equally across the country. There are some instances (e.g. the National Performance Management Research Data Set) where USDOT has sourced data to provide nationwide access to data in an effort to support consistency across jurisdictions. This sort of national sourcing for critical datasets/insights is a model that should look to be replicated and built out. Additionally, producing national data sets (e.g. Justice 40) can provide the required national guidance for local efforts.

New technologies adopted by the industry help increase the productivity and delivery of transportation improvements to benefit the traveling public across all modes. Federal, state, and local governments adopt sustainable funding mechanisms that can provide adequate revenue streams to maintain and improve the systems. This is enhanced by private sector investment.

I envision a system where people traveling outside of private vehicles have a dignified travel experience where they are made to feel just as important and considered as those inside private vehicles. This means having a dignified walking and public transportation experience where sidewalks exist and are maintained. The crossing experience does not imply that people inside cars are more important than those outside of personal vehicles. A future where someone who is waiting for a bus has shade and protection from the elements and where their travel experience is reliable. The biggest problem that has been solved in this scenario is that sidewalks are tracked and addressed at the same level as roads and that bus shelters are considered necessary infrastructure and not "amenities" that are not the responsibility of transit agencies. The people who gain in this vision are people who cannot afford cars, people who cannot or do not want to drive themselves for every trip, people with disabilities, and children who can gain transportation autonomy. On a larger scale, Black Americans and other people of color who have lower levels of car access and income can be positively impacted through this future vision. To my knowledge, there have been no national efforts to provide standards on how sidewalk inventories should be collected, what attributes are critical or optional, nor are sidewalk inventories required for regional travel demand models. This is similarly true for bus shelters which are a part of the transit experience, but most transit agencies are not responsible for inventorying, funding, or providing.

Transportation Networks have the ability to dynamically route services to help people and goods get to their destination more quickly and affordably. This concept is admittedly just that, a concept, but I envision some sort of system that harnesses the power of data, AI, and signals such as a person or goods' location to more effectively move from point A to point B. Lower emissions and increased usage of transportation networks could ideally be solved.

In 20 years, we will have a robust national interoperable, secure digital infrastructure layer that powers physical transportation on the ground and in the air in all communities, transcends the governance silos of transportation among agencies and enables the convergence of transportation and energy sectors. This digital infrastructure layer will contain a transportation operating system allowing public agencies of all types and modes to deliver on goals of safer, more sustainable and equitable mobility for people and goods and to get more out of their physical investments, lowering costs, enabling smarter investments and creating dynamic infrastructure. Biggest problem? 1. Public

agencies do not have the digital tools they need to manage the digitization of transportation and manage the digital right of way. 2. Transportation is governed in silos and systems between agencies who need to manage transportation are not interoperable, data is not shared, etc. 3. Vendor lock-in/proprietary systems. Every single user of transportation on every mode would be impacted.

Technologically, transportation will have mixed levels of automation (fleet-based markets will lead this, such as trucks and taxis), different emerging modes (urban air mobility, drone deliveries, modular vehicles to flexibly adapt to first/last mile problem). Transportation will be sustainable: electric infrastructure supported by clean sources, a myriad of delivery systems (not just fixed charging stations but also dynamic wireless charging, Charging-as-a-Service, V2G, etc.). Dense transit modes will be available in the largest cities; flexible microtransit services will be available in other areas. Trip planning and payments will be much like how we see the airline industry: highly differentiated options customized to differ user segments, integrated with the activities, mobility credits available to ensure equitable services. Transportation will be subsidized more holistically such that goals of sustainability, equity, and efficiency can be visibly measured and rewarded. Car ownership will give way to other types of markets, e.g. fractionally owned car clubs (automated), as they will tend to be used more for leisure trips instead of commutes.

The near future is a more automated, multimodal transportation experience using Intelligent Transportation Systems (ITS) and advanced, national-level transportation logistics. ITS are the blend of vehicles, infrastructure and people using intelligent, automated, and connected technologies to increase the safety, efficiency and accessibility of the transportation network. The biggest barrier to ITS is the critical need for safety assurance and interoperability assurance of automated, connected, and intelligent systems. Regulators, developers, investors, and users are all impacted, as this is the first concern for deploying these ITS technologies into the public transportation network.

A world where operations and maintenance (the lifecycle of a system) is given as much time, R&D hours, and resources as the initial design of a project. Transportation networks and systems are designed and maintained beyond political boundaries, and the workforce has skill sets as “systems integrators” rather than traditional fields we have today. This includes construction leading the way in improved productivity, driving down costs and improving the sustainability of systems, robust climate data allows improved national standards for resilient transportation assets, and technology and access to real-time data will enable strategic operation and maintenance of infrastructure, safer and more resilient neighborhoods, and increasingly sustainable communities.

Cities have the digital infrastructure tools needed to plan, manage and regulate mobility in the public rights of way in all its digital forms to help drive desired outcomes including safety, equity, climate and congestion. One of the biggest problems for public agency mobility managers today is the pace of digitization of mobility and their inability to keep pace with technical knowledge and capacity to implement. This means private transportation providers have the upper-hand in bringing new modes and forms of mobility to market without proper public sector planning, management and regulation. In other words we have a balkanized mobility system on our public streets dominated by services provided

by private operators with little oversight. In 20 years we will have provided a new generation of mobility managers the knowledge and digital infrastructure tools they need to manage a mobility system that is overly digital. This was able to happen because the federal government realized the value and importance of investing in digital infrastructure as well as traditional physical infrastructure - federal dollars enabled state and local governments to hire and train teams that could truly lead and partner with private mobility providers. States and cities find themselves with the technical knowledge, expertise and understanding to use the digital tools to their fullest potential.

***The time and cost involved in delivering transportation infrastructure is cut in half, while dramatically improving its quality*.** The journey started by having a clear mission (cutting cost and time in half); listing elements of current delivery systems that are inefficient; and cataloging alternative approaches. The team then reached out to the following: current practitioners to fully understand the nuances of the current delivery system, transportation industry experts to help identify best-in-class approaches from other geographies in the U.S. and other nations, experts in other industries developing complex infrastructure to borrow practices, policy makers to identify policy changes to help accelerate the transition to twice as much/twice as fast, technologists to identify opportunities to deploy technology at every stage to accelerate decision making and create efficiencies in procurement, delivery, and maintenance, communication experts to ensure the general public, community leaders, and policy makers clearly understand the mission and its impact, researchers and modelers to create enhanced transparency around time and costs of projects, allowing developers to compare time and cost of delivering projects across the country and to suss out best practices.

An active search engine for smart transportation that not only can search through existing data but can actively deploy sensors to get answers. An example of its use would be when after a weather disaster, the emergency management asks, “What was damaged by the weather?”. The search engine not only summarizes all existing reports but also actively requests and analyzes images from dashcams, satellites, drones, and other data sources. This is done in a privacy-conserving and secure manner.

The United States achieves universal access to mobility, approaching zero traffic deaths — because decision-makers can easily access data to understand the impact of their projects and iterate based on learnings. All urban (and eventually all built environment) landscapes are queryable and responsive, i.e. Public realm data that previously was collected only manually once in a while (like most multimodal traffic or visitorship counts today), is instead automatically and anonymously sensed and retrievable at any time, so it can:feed into research quickly and empower iterative intervention design; actuate dynamic changes in infrastructure (e.g. signals, signage, and structures themselves); and inform a national classification system for roadways by street blockface or similar granularity (e.g. 300-foot length), so that autonomous vehicles, insurance companies, and other data-driven infrastructure can code specific planning, financial, and operational settings to perform in these environments seamlessly; enable the built environment to respond to humans, rather than expecting humans to comply with built systems that have been (poorly) designed to optimize for car throughput or some other limiting factor.

Pedestrian fatalities have increased by 62% since 2009, indisputably showing that roadways are not designed for people. This crisis disproportionately affects vulnerable populations: Black Americans are twice as likely to die as pedestrians, and American Indians are more than 3x as likely as white Americans. Lower-income communities, seniors, and children are also disproportionately burdened by this safety/health/economic crisis. Ubiquitous, accessible, safe-to-share (privacy-forward, secure) data is necessary to enable planners and builders to make effective design decisions and be held accountable for outcomes.

Where transportation is a public utility that delivers dividends equitably to everyone. Twenty years from now, we will have a well-designed physical and digital infrastructure where transportation is funded and managed as a public utility with transparent governance. Transportation is a key determinant of economic mobility, public health outcomes, social cohesion, and community happiness. However, in the US, we have allowed a balkanized system of public and private services to emerge with a complex system of payment platforms and scheduling systems that do not serve the majority of trips equitably, safely, and reliably. There are few global examples where a transportation service provider makes money on the trip provided because mobility's return on investment is indirect. Integrated systems that return dividends to users deliver societal outcomes, like climate, public safety, and economic health. Acknowledging this fact and its implications for infrastructure funding is the first step.

Public mobility (e.g., transit + all other publicly available shared mobility modes) is as easy and intuitive to find, navigate, pay for and use as pulling up Google map driving directions in any city in the U.S. (or world). Thanks to blockchain technology, universal interoperability specifications and data feeds, common branding, flexible and inclusive funding and financing policies, and transformative infrastructure investments, taking shared mobility is as easy as driving once was - and far more pleasant! The learning curve to taking transit used to be so difficult that many people never bothered to figure it out (How do I find a bus or know where it goes? Which app do I need in which city? How much is it and how do I pay? What if I miss the bus and how do I get off it once on?). What used to be a fragmented and disjointed system, unique in every city or community, is now easily identifiable and a singular customer experience no matter where you travel across a region or the country. Now that shared mobility is so easy, ubiquitous and fun, few people drive for very short trips (less than a mile or two), carbon emissions from transport are way down, equitable mobility access is way up, and we are making the most of the rare earth materials of electric batteries by using small batteries (and devices) for short local trips (the vast majority) and larger batteries for higher occupancy and longer distance trips.

Fully integrated door-to-door mobility, using the most effective method possible - private, public - with one click/app. Connecting all the transport modes and infrastructure. Using one app, quickly understands how to get from home to office, home to airport to hotel to restaurant and back.

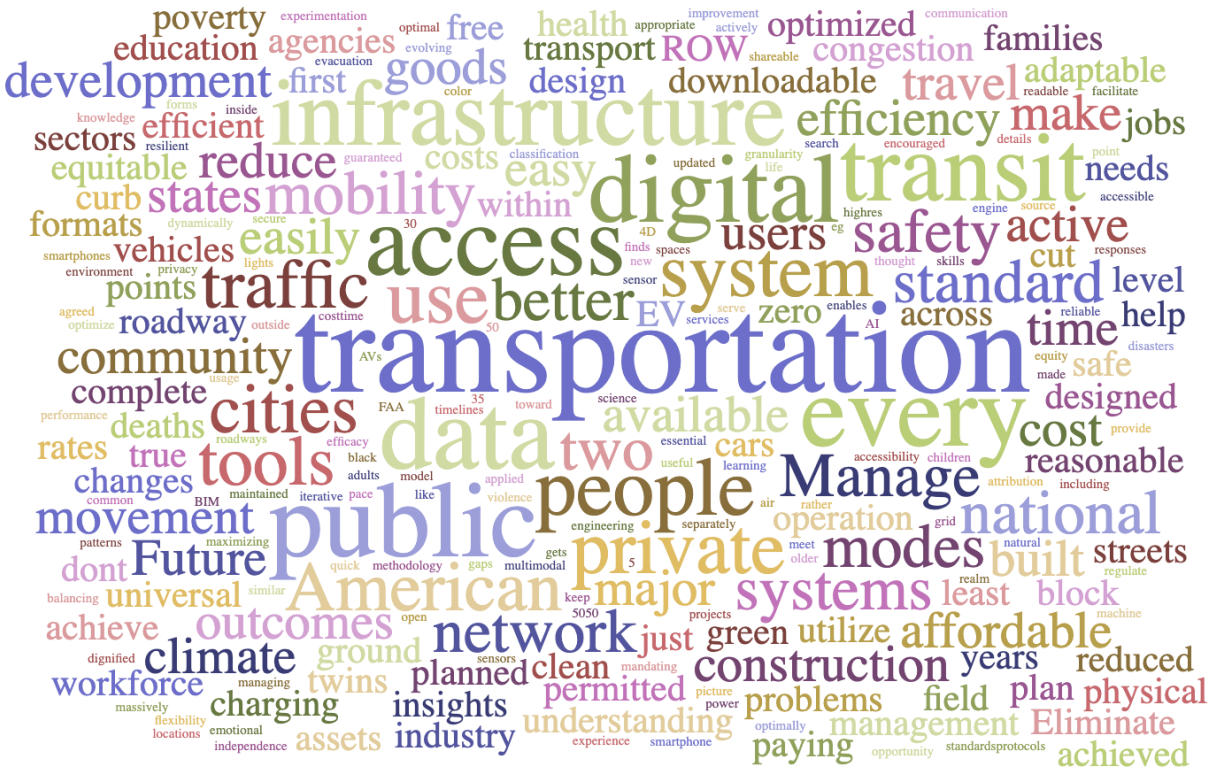
Full automation of all freight and goods movement, door-to-door, nationwide—with a well-governed and transparent system of user fees and cross-subsidies that ensure shipping is green, affordable, and efficient. This vision requires solving two core problems: 1) safe, reliable, and cost-effective Level 4 automation of long-haul trucking and low-speed local/last-mile delivery vehicles and 2) establishment of

an open, interoperable digital ecosystem for logistics that enables competitive markets and effective oversight. Everyone is impacted, but the main impact is to expand the range and lower the cost of logistics services for a vast range of small and medium-sized businesses, support more flexible and diverse supply chains, and improve the overall efficiency and reliability of goods distribution in all communities.

Post-gas tax transportation finance: industry convergence of Gas Tax, Road Pricing and Car Insurance to achieve first-best transportation pricing. Transportation pricing is one of the most irrational practices: 1) it does not respond to the basic demand-supply relations; 2) it largely ignores externality (congestion, pollution, carbon, health and safety); 3) it does not address mobility equity. Transportation financing in the U.S. hinges on the gas tax. With the successful electrification of our mobility system, the tax base will shrink to zero. This should be seen as an opportunity to force the debate, i.e., to redesign the entire transportation pricing system to the first best system.

Breakout Brainstorming

Participants were asked to build on their pre-work during the breakout sessions through individual brainstorming to generate as many "future visions" as they could that solved a substantial problem in transportation and infrastructure. This Word Cloud provides a high-level view of the themes that emerged from this exercise based on **over 90 visions** written by participants, with the full list featured below.



Full List of Vision Statements from Digitalization Breakout Room

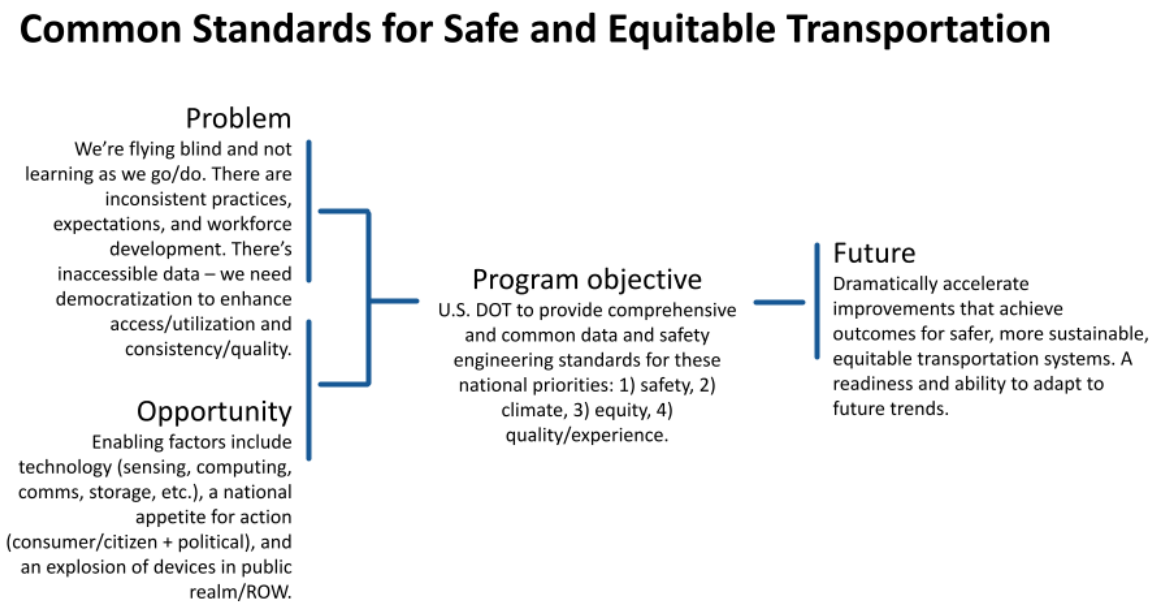
- People can make all the trips they want to live full and complete lives, not just the bare minimum to survive
- Public agencies use the same digital tools that private companies use to level the playing field
- Transportation is not in the top 5 household budget items
- Future communities of small clusters are optimized for movement of people and goods
- Reduce liabilities, and public agencies take on the risk
- Every community has access to safe and green transportation
- All transit is as easy to utilize as cars
- Transportation efficiency/data-cost-time-efficacy is public and easily downloadable
- Better capacity for local jurisdiction to use data and technology in transportation developing and planning
- Understand the true costs of transportation (i.e., don't externalize construction, pollution)
- Better data and transparency tools to help citizens understand transportation infrastructure development to attract/test future innovation
- Dynamic routing of mass transit for faster, safer, and more equitable access
- Eliminate the idea/need for ownership
- Industry convergence for the gas tax, road pricing
- Human-machine collaboration for workforce development
- Free active and shared transportation, viewing transportation as a utility
- Better uses for tools that help drivers/passengers make better choices for cost, climate impact
- A network transportation system that can also be aware of people, animals and all users
- A transportation network system to guide public trust in automated systems
- Every person in the U.S. has the same access to jobs, education, and recreation whether or not they drive
- Paying for public transit is as easy as paying for a cup of coffee at Starbucks, and public transit ridership is at 35% nationally
- Transit in the U.S. is free and we have achieved a 50/50 mode split
- Trauma-informed design guidelines for public space have improved mental health outcomes
- We have achieved basic universal mobility and, in so doing, have poverty cut poverty rates in half
- There is national traffic control for goods movement that manages these fleets in a transparent governance structure
- Future "megacities" are optimized for the movement of goods and people
- Asset databases that don’t know political boundaries
- Interoperability: a national system of tolling prices
- True transit prioritization on city streets and long-distance routes
- A workforce of "systems integrators" that can work with physical and digital assets
- Women and families can travel freely and without stress
- Manage the digital version of the public right of way with sophisticated digital infrastructure to achieve climate, public health, and community outcomes safely

- We have clearly defined the public and private right-of-way in the metaverse and have reduced congestion, lowered crash rates and cut green-house-gas emissions as a result
- Construction times and cost in transportation are slashed
- U.S. is not an outlier among developed nations for roadway fatalities
- Every American can reach 5x more jobs in the same timespan
- Every American has access to clean, affordable, green, safe, and efficient transit
- Every American has at least two reasonable modes of transportation available to them
- Major infrastructure can be planned, designed, permitted and built within two years
- Every major project has to pass a benefit-cost analysis that fully incorporates negative externalities
- Every urban commute is no longer than 30 mins and affordable
- U.S. is the most cost-effective provider of infrastructure
- Digital transit operation system
- Zero deaths in ground transportation
- Transportation efficiency data, cost-time, and efficacy is public and easily downloadable
- All transit is as easy to utilize as cars
- Guaranteed multimodal access to essential services
- Classification system for roadway on a high-res (e.g. block by block) granularity that's dynamically updated and shareable
- Attribution of traffic violence to built environment rather than users
- Design for accessibility first, and separately where appropriate, so most people are encouraged toward active transport
- Make transportation a field where science methodology (experimentation) is applied and enables iterative learning and improvement
- Safety engineering standards/protocols for roadways, similar to Federal Aviation Administration and air travel
- Traffic lights are adaptable to quick responses or needs
- Infrastructure projects costs and construction timelines reduced by mandating use of building information management
- AI that finds problems we have not thought of
- Infrastructure optimally maintained maximizing their useful life by managing 4D digital twins
- All streets have the flexibility to serve as public spaces
- As dignified a transportation experience for people outside of private vehicles as inside of them
- Transportation independence for children and older adults through reliable transportation systems that meet evolving physical and emotional needs
- Massively reduce or eliminate gaps in transportation access to opportunity for black and other people of color
- A complete picture of transportation infrastructure and usage patterns, including the details of that infrastructure
- Cities have the tools, knowledge, and skills to keep pace with the development of new private mobility modes so they can plan and manage all mobility in the right-of-way
- Active, secure search engine to get data that protects citizens' privacy

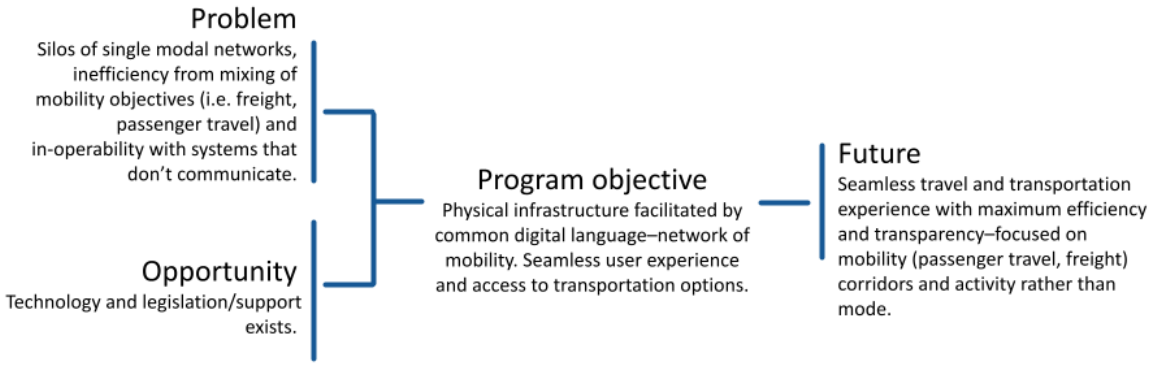
- Optimize travel time and reduce congestion by insights from traffic data from sensors, vehicles, and smartphones, provide network-level traffic performance and data insights
- Electric vehicle charging points at optimal locations, balancing the power grid
- Common standard for digital mobility communication
- Resilient, equitable, and adaptable evacuation in natural disasters
- Data standard to facilitate the management of autonomous vehicles
- Digital infrastructure for cities and states to have the tools to plan, manage, and regulate mobility in all its forms in the public realm to achieve safety, efficiency, and equity outcomes
- Agreed upon open source data across public and private modes made available
- Federally mandated state data access points
- All states using data in standard formats
- Electric vehicle charging network uptime is increased by the use of a national data standard that allows users to see changes and their status
- Digitally managed curb to eliminate safety, climate, and efficiency problems
- Transit systems use the same payment as every other merchant in the U.S.
- Understanding the economic benefits of transportation in other sectors: education, healthcare, economy

Wireframes

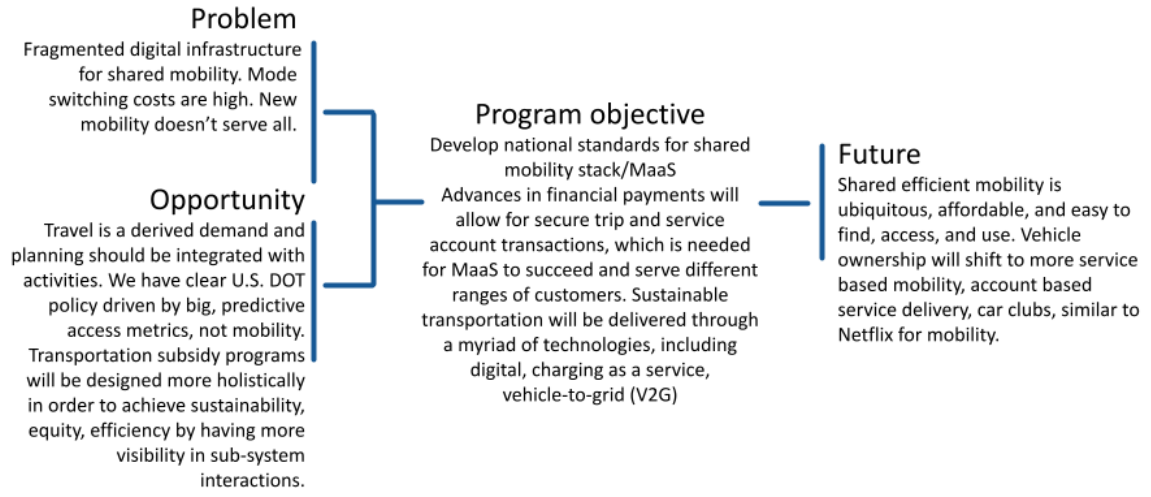
Following individual brainstorming of future visions, participants began working with their peers to work backwards from their selected future visions to articulate program designs in wireframe format that were transformational, incentivized private sector action and involvement, and had a clear role for Federal research and technology activities. Below are the completed digitalization-related wireframes.



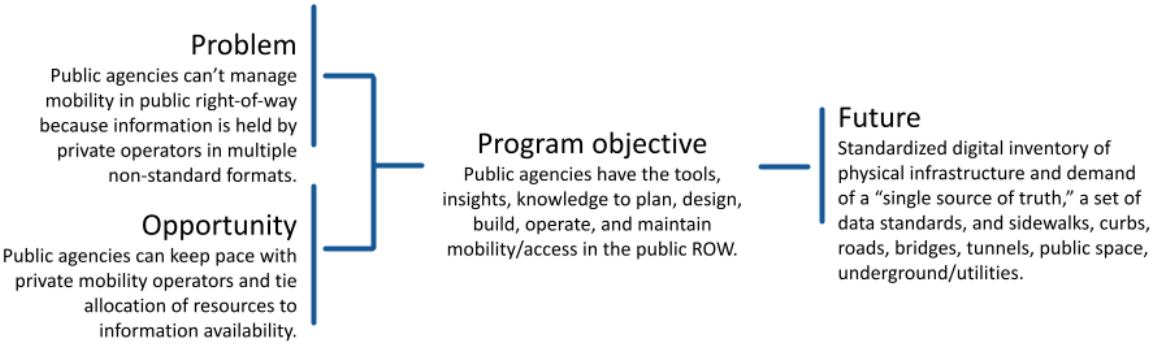
A Network of Mobility for Seamless Travel



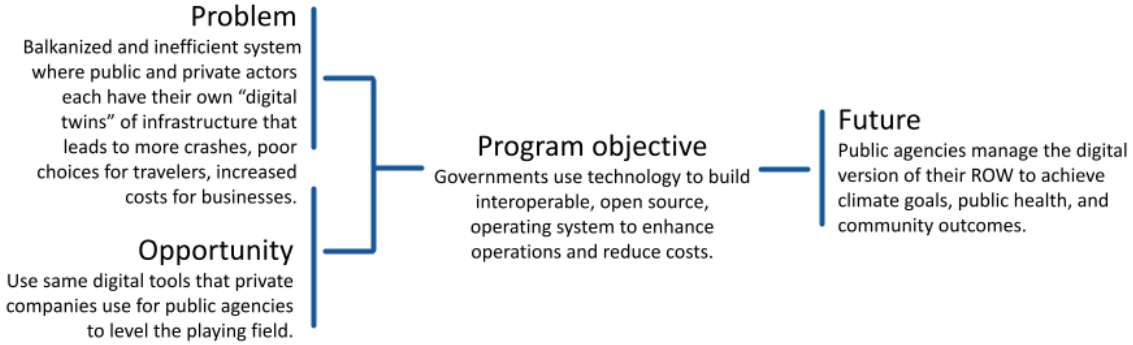
Shared Mobility for Service-Based-Travel



A Digital Inventory of Physical Infrastructure



Open-Source Operating System



Acknowledgements

Thank you to the following participants who joined us on December 8th for their contributions to shaping the Workshop through thoughtful pre-work responses and a willingness to be open-minded and innovative during brainstorming and wireframing in our breakout sessions.

Peter Adriaens
University of Michigan

Alisyn Malek
Newlab Detroit

Emily Feenstra
American Society of Civil Engineers

Marcia Hale
Hale Strategies

David Libatique
Port of LA

Joseph Chow
NYU C2SMART; NYU Tandon School of Engineering

Kevin Grove
American Trucking Associations

Emeka Moneme
Hayat Brown

Pascal Van Hentenryck
Georgia Institute of Technology

Jinhua Zhao
MIT Mobility Initiative

Andrew Glass Hastings
Open Mobility Foundation

King Gee
AASHTO

Torrey Lauermann
American Trucking Associations

Kate Burns (Garman)
MetroLab Network

David Burns
US Conference of Mayors

Jane Lappin
Transportation Research Board

Brittney Kohler
National League of Cities

Franz Loewenherz
City of Bellevue, WA

Daniel McGehee
National Advanced Driving Simulator, University of Iowa

Neil Pedersen
Transportation Research Board

Oboi Reed
Equiticity

Kelly Rula
Urban Freight Lab, University of Washington

Ricardo Sánchez Gómez
Cintra (Ferrovial)

Amitai Bin-Nun
Motional

Ellen Partridge
Equiticity

Leanne Kaplan
New Urban Mobility Alliance

Laura Chace
ITS America

Chris Fall
MITRE

Victoria Sheehan
Transportation Research Board

Jascha Franklin-Hodge
City of Boston

Luna Lu
Purdue University

Christoph Mertz
The Robotics Institute, Carnegie Mellon University

Benito Pérez
Transportation for America

Karina Ricks
Cityfi

John Stehlin
University of North Carolina, Greensboro

Monali Shah
Google Public Sector

Seleta Reynolds
LA Metro

Patrick Sabol
The National Academies

Habib Dagher
Advanced Structures and Composites Center

Prachi Vakharia
Amazon

DJ Gribbin
Madrus

Scott Schmidt
Alliance for Automotive Innovation

Sam McAlpine
Allium Engineering, Inc

Avery Ash
INRIX

Andre Tok
Institute of Transportation Studies, UC Irvine

Jessica Jennings
National Association of Counties

Sunmin Kim
Applied Intuition

Madeline Brozen
UCLA Lewis Center for Reginal Policy Studies

Alison Black
ARTBA

Daniel Tibble
Wejo

Anthony Townsend
Cornell Tech

Samir Saini
Microsoft

Tara Pham
Numina

Tony Choi
USDOT

Kei Koizumi
White House Office of Science and Technology Policy

Grant Farnsworth
White House Office of Science and Technology Policy

Joshua Schoop
Federation of American Scientists

Cristina Velasquez
Federation of American Scientists

Ben Downing
The Engine

Dov Schwartz
USDOT

Sally Benson
White House Office of Science and Technology Policy

Jennifer Gerbi
Advanced Research Projects Agency–Energy

Andy Gordon
Federation of American Scientists

Robert Hampshire
USDOT

Stephen Zoepf
USDOT

Costa Samaras
White House Office of Science and Technology Policy

Erwin Gianchandani
National Science Foundation

Aleksandra Srdanovic
Federation of American Scientists

Chris Atkinson
USDOT

Ben Levine
USDOT

Joel Parriott
White House Office of Science and Technology Policy

Daniel Correa
Federation of American Scientists

Maeve Skelly
Federation of American Scientists