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**U.S. Department of
Transportation's
Mobility on Demand
Initiative**

*Moving the Economy with
Innovation and Understanding*

The National Academies of
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U.S. Department of Transportation's Mobility on Demand Initiative

*Moving the Economy with
Innovation and Understanding*

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Executive Summary

The market for personal mobility is changing rapidly due to shifting social and cultural trends, as well as technological advances such as smartphones, information processing, and widespread data connectivity. Mobility on Demand (MOD) is an innovative transportation concept. On the supply side, transportation providers manage mobility rather than traffic through demand-responsive service, shifting use to alternate modes. On the demand side, mobility consumers reserve, dispatch, or use innovative mobility, public transportation, and goods-delivery strategies in place of privately owned vehicles. The most-advanced forms of MOD incorporate trip planning and booking, real-time information, and fare payment into a single-user interface. Modes facilitated through MOD providers can include carsharing, bikesharing, ridesharing, ridesourcing, or transportation network companies (TNCs), scooter sharing, microtransit, shuttle services, public transportation, and other emerging transportation solutions. Common goals among MOD providers can include:

1. Offering short-term access to mobility solutions for users;
2. Enhancing convenience by facilitating trip planning, payment, and other functions into a single interface;
3. Providing cost savings since customers generally pay-per-use, often resulting in cost savings over private vehicle ownership, maintenance, repair, and insurance;
4. Improving transportation network efficiency through enhanced traveler information, demand management, and pricing management mechanisms;
5. Increasing mobility options (e.g., journeys previously inaccessible by a single mode, first-and-last mile connections, and additional service offerings during off-peak or high-congestion travel times); and
6. Urban goods delivery that reduces or eliminates the need for retail, shopping, and dining trips. Enablers of MOD include business models and partnerships, infrastructure, policies and regulations, and emerging technologies.

On January 7, 2018, the U.S. Department of Transportation (DOT) and the Transportation Research Board (TRB) of the National Academies of Sciences, Engineering, and Medicine co-hosted this workshop on U.S. DOT's MOD Initiative: Moving the Economy with Innovation and Understanding at the 97th Annual Meeting of the Transportation Research Board, held at the Walter E. Washington Convention Center in Washington, D.C. The workshop was sponsored by the following committees:

- Emerging and Innovative Public Transport and Technologies Committee (AP020);
- Shared-Use Mobility and Public Transit Subcommittee [AP020(1)];
- Emerging Ridesharing Solutions Joint Subcommittee [AP020(2)];
- Automated Transit Systems Committee (AP040);
- Transportation Demand Management Committee (ABE50); and
- Regional Transportation Systems Management and Operations Committee (AHB10).

Organization of this workshop was made possible by the sponsoring committees and the organizing committee members: Susan Shaheen, Jeffrey Chernick, Bob Sheehan, Steve Mortensen, Prachi Vakharia, and Adam Cohen.

The workshop facilitated a dialogue among more than 150 participants from public-sector organizations, private companies, nonprofit research groups, and educational institutions. The workshop featured U.S. DOT MOD Program leadership, thought leaders, and grantees (public agencies and vendors) from Federal Transit Administration's (FTA) MOD Sandbox. The workshop featured an introduction to the Intelligent Transportation Systems Joint Programs Office (ITS JPO) MOD Concept of Operations; a moderated panel with representatives from three MOD Sandbox sites; and a panel on big data, key metrics, and early findings. Government, industry, and academic thought leaders presented and participated in panel discussions with the audience about the pilot projects, research, and next steps, emphasizing the importance of public-private partnerships. In the second half of the workshop, attendees participated in interactive breakout sessions on opportunities and challenges from the public- and private-sector pertaining to:

1. Managing/Understanding Pilot Data;
2. Equity and Accessibility;
3. Economic Impacts and Innovative Business Models; and
4. Planning for MOD (land use, zoning).

At the conclusion of the breakout sessions, each group reported back on next steps for advancing research and policy understanding in public transport innovation.

Five key goals of the workshop included:

- Discussing the interrelated nature of big data, equity, accessibility, economic impacts, and planning for MOD;
- Enhancing public transit industry preparedness for MOD;
- Advancing the dialogue between public organizations and private companies;
- Exploring early lessons learned with three of the MOD Sandbox sites; and
- Discussing current research and policy in light of rapidly evolving technology and service disruption.

Dignitaries and industry experts spoke at length about lessons learned from U.S. DOT's MOD Program including FTA's ongoing MOD Sandbox program and the role of public-private partnerships. Key insights and discussion points from the workshop include

- The U.S. DOT's MOD Program is multimodal and supported across multiple U.S. DOT agencies and offices.
- Lessons learned and best practices are still emerging from the MOD Sandbox with respect to public-private partnerships. Workshop participants had lots of questions pertaining to the structuring of public-private partnerships, revenue sharing, data sharing, and serving people with special needs.
- The management and understanding of pilot data including the protection of personal privacy (i.e., how can data be stored and shared to protect privacy) and the safeguarding of proprietary data (i.e., identifying who owns proprietary data and who has access to the data) were

identified as two prominent issues requiring standardization and guidance to support future MOD public–private partnerships.

This workshop synopsis covers findings and discussions from the event and summarizes the key topics explored throughout the day. The workshop commenced with introductions from the day’s facilitators: Shaheen from the University of California, Berkeley (UC Berkeley) and Chernick of RideAmigos, the respective chairs of the Shared-Use Mobility and Public Transit Subcommittee and Emerging Ridesharing Solutions Joint Subcommittee. Following participant introductions, summaries from the three expert panel sessions, along with key points made by each panel are provided. Next, interactive breakout sessions are discussed, along with a synopsis provided by the lead moderators. Please note that the breakouts were organized by 1) managing/understanding pilot data; 2) equity and accessibility; 3) economic impacts and innovative business models; and 4) planning for MOD (land use, zoning). Finally, closing thoughts and key takeaways from the workshop are presented. The workshop agenda is provided, along with key takeaways.

PUBLISHER’S NOTE

The views expressed in this publication are those of the committee and do not necessarily reflect the views of the Transportation Research Board or the National Academies of Science, Engineering, and Medicine. This publication has not been subjected to the formal TRB peer review process.

Panel Sessions

SESSION 1: WORKSHOP OVERVIEW AND PARTICIPANT INTRODUCTIONS

The workshop started with an overview by Shaheen and Chernick. Shaheen set the stage for the day by presenting a review of the agenda and kicked off participant introductions. More than 150 people attended the two-part workshop.

SESSION 2: U.S. DEPARTMENT OF TRANSPORTATION'S MOBILITY ON DEMAND PROGRAM: NUTS AND BOLTS

The first panel session of the morning, moderated by Vince Valdes, Associate Administrator for Research, Demonstration, and Innovation, FTA, consisted of four U.S. DOT expert panelists: Gwo-Wei Torng, Director, Office of Mobility Innovation, FTA; Egan Smith, Managing Director, ITS JPO; Martin Knopp, Associate Administrator for Operations, Federal Highway Administration (FHWA); and Bob Sheehan, Multimodal ITS Program Manager, ITS JPO.

Torng opened the session providing an overview of the MOD Program: “MOD is a vision for an integrated multimodal network of safe, carefree, affordable, and reliable transportation options available to all.” He described the FTA approach to MOD and uniqueness within the U.S. DOT. Torng emphasized that the FTA MOD Sandbox has five key program components: 1) development of performance metrics to measure MOD success; 2) on-ramp planning support; 3) innovation and knowledge acceleration; 4) stakeholder engagement and outreach; and 5) policies and practices.

Egan Smith from ITS JPO first introduced his office's role in facilitating collaboration across the U.S. DOT in the field of ITS and supporting multimodal efforts. The JPO's role includes supporting research to understand the challenges and opportunities that ITS has in addressing the impact of technology in disrupting traditional mobility, including the movement of goods and people. Smith discussed the advent of the smartphone and cloud technologies coupled with the sharing economy and its impacts on transportation services. The combination of technological advancement and the sharing economy has led to the mainstreaming of sharing, renting, and borrowing of transportation services as a viable concept. Smith discussed how technology is changing mobility, travel, and the consumption of resources. Smith emphasized how technology enables the U.S. DOT and the transportation sector to take these applied concepts to the next level. Smith emphasized that the U.S. DOT's MOD Program is a multimodal program to study emerging mobility services, public transit operations, goods delivery services, real-time data services, and other concepts that can advance access to mobility, goods, and services for all.

Martin Knopp from FHWA talked about the multifaceted role of FHWA in supporting multimodality and MOD. Knopp emphasized that MOD cannot be focused solely on the movement of people, but it must also focus on goods movement. Knopp emphasized his office's focus on MOD related to active transportation demand management. Knopp discussed a number of trajectories toward connected vehicle (CV) and automated vehicle advancement including changes in investment decisions, policy, technology, and mobility consumption. From an operations and active transportation demand management perspective, Knopp emphasized the importance of

maximizing capacity within the existing infrastructure footprint and working together to respond to ongoing and future changes that are impacting the transportation network.

Bob Sheehan from ITS JPO began by introducing a number of trends that are impacting the transportation sector including a growing population, an aging population, an expanding number of travelers with special needs, and increasing technology adoption. Sheehan introduced the MOD concept of operations to the workshop participants including: its traveler-centric emphasis, MOD enablers, and the flexibility of MOD solutions that can be applied across an array of built environments and land uses. Sheehan emphasized the importance of accessibility and briefly introduced the U.S. DOT's Accessible Transportation Technologies Research Initiative (ATTRI). ATTRI is a joint U.S. DOT initiative, co-led by FHWA, FTA, and ITS JPO, with support from the National Institute on Disability, Independent Living, and Rehabilitation Research, and other federal partners. The purpose of ATTRI is to develop and implement transformative applications to improve mobility options for all travelers, particularly those with disabilities. Sheehan concluded by introducing four potential future scenarios:

1. Maintaining the status quo;
2. A future with integrated public transit;
3. A future with connected mobility; and
4. An integrated automated and connected future.

Sheehan finished by sharing with workshop participants the recently released "Mobility on Demand Operational Concept Report." This report is available at <https://rosap.ntl.bts.gov/view/dot/34258>.

At the conclusion of the presentations, Valdes moderated a panel discussion about the economic impacts of MOD, both from the public agency and the household perspective. Torng opened the panel discussion reminding workshop participants that every trip a person makes is generally for an economic purpose (either productivity or consumption) and all mobility activity translates into economic value. Sheehan emphasized the importance of understanding the micro- and macro-economic impacts of MOD and stated that we are just beginning to understand the evolution of the business models within the MOD marketplace. Knopp stated that the public sector needs to monitor and respond to implications of emerging transportation technologies on transportation finance (e.g., the Highway Trust Fund, increased capital, and operational costs associated with designing for automation).

SESSION 3: FEDERAL TRANSIT ADMINISTRATION'S MOBILITY ON DEMAND SANDBOX: EXPLORING INNOVATIVE BUSINESS MODELS AND ECONOMIC IMPACTS

In the second session, experts in this panel spoke about the business models and economic impacts of MOD. Moderator Rik Opstelten of FTA opened the session by stating that "Nothing happens if people are not mobile." Opstelten then explained the vision of MOD is to ensure universal mobility.

Torng reminded workshop participants that the MOD Sandbox provides a venue through which integrated MOD concepts and solutions—supported through local partnerships—are demonstrated in real-world settings. Torng provided an overview and history of the Sandbox

program that began with an \$8-million funding allocation to conduct research on emerging service options in combination with available technologies that allow for greater individual mobility. Torng introduced three of the 11 Sandbox grantee sites (public agencies and vendors) represented at the workshop:

1. Valley Metro (Phoenix, Arizona);
2. Bay Area Rapid Transit (BART) District (San Francisco, California); and
3. Los Angeles County Metropolitan Transportation Authority (LA Metro) (representing sister project locations in Los Angeles, California, and Seattle, Washington).

Marla Westervelt stated that LA Metro wanted to form an equitable, affordable, and accessible service delivery partnership with a TNC. Westervelt stated that to accomplish this goal, the service had to be smartcard-compatible (for unbanked users), wheelchair-accessible, and provide a telephone dispatch option for users without access to a smartphone. Zachary Wasserman representing Via, LA Metro's vendor, discussed the ongoing partnership to subsidize rides that makes it affordable for users and economically sustainable for LA Metro. Wasserman highlighted their ongoing effort to support tap card integration, so riders will be able to use an integrated fare payment card for both Via and LA Metro services.

Nikki Foletta provided an introduction to the BART rail system and its role as a parking manager. BART owns and operates more than 47,000 parking spaces across the entire system. Foletta explained that the current carpool parking program has problems with single-occupant vehicles (SOVs) parking in carpool spots, and part of the motivation to partner with Scoop was to create an innovative parking program that allows BART riders to dynamically find carpool matches. "Scoop is a technology company that allows carpooling to scale," said Robert Sadow of Scoop. Scoop's focus is to systematically break down the challenges associated with carpooling, such as separating morning and evening trips and allowing a person to change their carpooling schedule day-to-day. Sadow sees particular opportunities at end-of-line public transit stations. Scoop also partners with BART to enforce carpool parking by sharing license plate data. Partnership goals include reducing SOV travel, increasing ridership, and reducing the vehicle miles traveled associated with first-and-last-mile connections to the BART network. The program has already launched at seven BART stations.

Hannah Quinsey of Valley Metro introduced their two-part Sandbox demonstration consisting of a mobility platform and an AV pilot. Valley Metro wanted to enhance the customer experience and create a seamless mobility app connected to other modes. Additionally, Valley Metro wanted to incorporate real-time bus data and mobile ticketing. In terms of equity, Valley Metro wanted the app to be accessible to unbanked users. Valley Metro is planning on employing reloadable passes at retail stores, allowing the app to be used without a credit card. Valley Metro's vendor Route Match is creating geofences around all of the stops in the public transit network to provide audible queues for riders to enhance accessibility for visually impaired users. Valley Metro has worked with a lot of private companies to develop the app and related functionalities. With respect to Valley Metro's AV pilot, the agency will pursue a handful of test cases. Valley Metro's RideChoice program offers discounted taxi fares to qualified seniors and people with disabilities. Valley Metro plans to offer AV rides as a vehicle choice within the RideChoice program. Quinsey stated that Valley Metro would also like to explore providing shared AV rides for users traveling to or from a parking-and-ride facility or a rail station.

Sharon Feigon of the Shared-Use Mobility Center served as a commentator on the panel. She emphasized the importance of public agencies to think holistically and traveler-centric mobility. Feigon also highlighted the importance of moving fast and being flexible to find solutions to make MOD work. Feigon also said that the BART project offered an opportunity to spread peak-hour demand and improve operational performance by reducing train crowding. Feigon concluded by recognizing the challenges associated with public-private partnerships. Feigon emphasized the importance of including all stakeholders in program success, even if it slows the pilot process down.

At the conclusion of the moderated panel discussion, Opstelten opened the panel to audience questions. A member of the audience asked a question about marketing the pilot projects. The panel members explained that marketing was a big part of their project. Foletta of BART explained that the local news media had been reporting on the pilot project. Westervelt of LA Metro explained that although their pilot was still in the planning stages, LA Metro intended to invest heavily into marketing efforts for the program. Quinsey explained that Valley Metro had assembled a beta test group for their app, which is also serving a dual function of education and outreach about their pilot program.

SESSION 4: EVALUATION OF MOBILITY ON DEMAND: BIG DATA, KEY METRICS, AND EARLY FINDINGS

As part of the third panel, Steve Mortensen of FTA moderated an expert discussion of big data, key metrics, and early findings from the MOD Sandbox evaluation. The independent evaluation is being led by panelists Gustave Cordahi of Booz Allen Hamilton and Shaheen of UC Berkeley.

Cordahi and Shaheen began the session with an overview of the independent evaluation for the MOD Sandbox program. Cordahi and Shaheen reminded workshop participants that the innovations developed in the MOD Sandbox have the potential to transform how public transit is delivered nationally and that a comprehensive independent evaluation helps to guide future program direction based on the benefits and impacts identified during the study. The comprehensive independent evaluation of the MOD Sandbox will describe lessons learned, identify business and partnership models that are most likely to succeed, and highlight innovations and best practices.

Cordahi and Shaheen also presented the site-specific evaluation framework consisting of:

1. Identifying project goals and evaluation hypotheses;
2. Developing performance metrics;
3. Identifying types of data and data sources; and
4. Developing methods for evaluation (e.g., quantitative versus qualitative methods).

The evaluation team presented to workshop participants the three types of hypotheses that are being studied:

1. User-impact hypotheses (e.g., impact on behavior, decisions, commute, or lifestyle of travelers);
2. System operations hypotheses (e.g., impacts on system operations or cost); and
3. Institutional hypotheses (e.g., lessons learned and best practices from project experience).

They also discussed the categorization of the 11 MOD Sandbox projects by use case (i.e., trip planning/payment integration, first/last mile, supplemental/extended service, flexible pricing/incentives, innovative paratransit services, and parking utilization) and data management/warehousing.

Sarah Oleksak of the U.S. Department of Energy described her agency's interest in working with the MOD Sandbox program to identify energy-related metrics that can be studied on up to five of the MOD Sandbox locations. Oleksak explained that these metrics, once defined, will be incorporated into the logic models and data collection plans for the independent evaluation of the 11 MOD Sandbox projects. Oleksak said that the data will be analyzed and studied through a case study approach. To conduct this analysis, Oleksak explained, DOE anticipates requiring:

1. The make, model, year, and fuel efficiency of the vehicles providing services;
2. Origin and destination;
3. Number of occupants for a trip; and
4. The estimated energy consumption of the trip that would have occurred in substitution of the trip facilitated by the project.

Oleksak emphasized the importance of finding partners that are able to share these types of data.

At the conclusion of the presentations, Steven Mortensen moderated a panel discussion about the independent evaluation asking panelists about the data types that are difficult to obtain, the approach for gathering data, and if the data are not available, how can the data be obtained (either through an alternative means or a proxy). Shaheen responded stating that "the most challenging types of data to obtain are data involving people's privacy and proprietary interests. When you get into data collection and analysis, it is not surprising to find that you can identify an individual based on origin–destination travel patterns. Figuring out the right proxies or the right level of aggregation is the workaround. Furthermore, there is the challenge of protecting proprietary vendor information. Similarly, the workaround is to find the right level of aggregation (e.g., combining data among companies or to go to a higher level of data aggregation)." Shaheen emphasized that trip-level data represents some of the most sensitive data. Cordahi stated that user self-report data through surveys can help fill gaps in knowledge where actual behavior data are unavailable. Cordahi reminded workshop participants that it is not only important to have a sufficient sample size but also a sufficient sample size within representative groups (e.g., low-income, minority). Oleksak emphasized the importance of having access to data, advancing knowledge, and the importance of return-on-investment from taxpayer dollars in public–private partnerships, such as MOD.

Lessons learned identified from the panelists included the following:

- A reminder that project stakeholders remain focused on project goals (and not get sidetracked on overcoming technological and implementation challenges);
- The importance of remaining flexible and open to change (e.g., technologies, partners); and
- The need to protect personal identifiable information and proprietary data from public records requests.

Shaheen talked about three levels of MOD data in management/warehousing: MOD site level and partner data (for operations and internal reporting); controlled access data for independent evaluation purposes; and public research and access data from the U.S. DOT.

Breakout Sessions

After Session 4, Bob Sheehan and Christina Gikakis of FTA facilitated the breakout group discussions. The workshop attendees organized into one of four breakout sessions and discussed different aspects of MOD implementation: 1) managing/understanding pilot data; 2) equity and accessibility; 3) economic impacts and innovative business models; and 4) planning for MOD (land use, zoning, etc.). Breakouts were conducted at each table by facilitators and note takers and summarized by four breakout moderators (one for each topic area). Facilitators at each table followed a standard protocol intended to probe key questions applicable to each MOD focus area. The protocol asked participants to spend 75 min (approximately 25 min per topic area) discussing the following questions/themes:

- Identify key issues to advancing focus area from public- and private-sector perspectives.
- Identify possible solutions for addressing (what we know, what don't we know, what are the key questions) this area from public- and private-sector perspectives.
- What role can research play in advancing these areas in the context of public-private partnerships?

After a lively exchange of ideas in the breakout sessions, lead moderators of each breakout reported back the key ideas that came out of their respective discussions. Special thanks go to the following individuals for their role as facilitators and note takers during the breakout session:

1. **Managing and Understanding Pilot Data.** Jean Ruestman, Emerging and Innovative Public Transport and Technologies Committee co-chair and Michigan DOT; Gustave Cordahi, Booz Allen Hamilton; and Jana Sochor, Chalmers University of Technology and RISE Viktoria.
2. **Equity and Accessibility.** Carol Schweiger, Emerging and Innovative Public Transport and Technologies Committee co-chair and Schweiger Consulting LLC; Prachi Vakharia, Steer Davies Gleave, Inc.; and Chris Pangilinan, Transit Center.
3. **Economic Impacts and Innovative Business Models.** Dan Baxter, Stantec; Balaji Yelchuru, Audi; and Allen Greenberg, FHWA.
4. **Planning for Mobility on Demand.** Adam Cohen, Transportation Sustainability Research Center; Sharon Feigon, Shared-Use Mobility Center; and Alexandra Cohen, Foursquare Integrated Transportation Planning, Inc.

MANAGING AND UNDERSTANDING PILOT DATA

Managing and understanding pilot data was summarized by Jean Ruestman. Key issues related to the management and understanding of the pilot data identified included:

1. Protecting personal privacy (i.e., how can data be stored and shared to protect privacy);

2. Safeguarding proprietary data (i.e., identifying who owns proprietary data and who has access to the data); and
3. The need for better communication between the public and private sectors on both why and what data are needed.

This breakout group thought it was critical to define research questions prior to MOD pilot solicitation and require a data sharing and management plan as part of all federally funded grantee–vendor contracts as a key strategy for data exchange. Session participants also highlighted the importance of communication to private-sector partners on pilot data requirements (and separating these) from long-term or operational data that are needed if the project continues in perpetuity. Other possible strategies identified included inviting the private sector to participate in the development of research questions and the data toolbox that includes sample data metrics and data needs. This breakout group concluded that:

1. Research can aid the public and private sectors in overcoming privacy and proprietary concerns by acting as an independent intermediary between stakeholder groups;
2. Academia can establish a research-focused secure data repository to collect, manage, and protect data; and
3. Research can define what “privacy” and “proprietary” means within the transportation community.

EQUITY AND ACCESSIBILITY

Equity and accessibility was summarized by Prachi Vakharia and Carol Schweiger. Key issues related to equity and accessibility identified included opportunities and challenges of MOD to enhance accessibility for:

1. People with disabilities;
2. Low-income and underbanked households;
3. Digitally impoverished households; and
4. Rural communities.

Additional issues identified included defining the government’s role in regulating and enforcing equity and accessibility among private sector and quasi public–private services and identifying the right “carrots and sticks” to ensure equitable accessibility for all. Potential strategies identified included:

1. Identifying methods for scaling MOD across multiple land use and built environments;
2. Developing enabling technologies and accessible vehicles (e.g., ATTRI program); and
3. Increasing competition to develop accessible vehicles.

Key research needs identified included:

1. More research on users;

2. Greater research on attractive incentives for companies and drivers to provide accessible services;
3. What happens to accessibility if a service provider has replaced an incumbent mode and that service provider later leaves the marketplace; and
4. Identifying lessons learned from other industries.

Additional research needs that were also discussed include:

1. The role of public–private partnerships (from across the world),
2. Methods for establishing service delivery options, and
3. Options for more accessible bikesharing.

ECONOMIC IMPACTS AND INNOVATIVE BUSINESS MODELS

Economic impacts and innovative business models was summarized by Balaji Yelchuru. Key issues to advancing innovative business models associated with MOD included supporting public–private partnerships, first-and-last mile connections to public transportation, flexible route and free-floating services, and shared AVs. Key issues for understanding the economic impacts of MOD included a greater understanding of the affordability of MOD and its role in lowering personal and household transportation costs and the role of MOD in facilitating new service delivery options that bridge gaps within the existing transportation network. Additional issues identified included:

1. Understanding the economic impact of regulation;
2. The government's role in incentivizing innovation;
3. Understanding what business models are needed to make pilot programs sustainable, and
4. Understanding how to maximize opportunities and minimize challenges associated with public–private partnerships, particularly in the areas of revenue and data sharing.

Possible solutions to advance innovative business models included:

1. Leveling the regulatory playing field across all modes;
2. Supporting innovative fare policies and management;
3. Leveraging incentives and gamification to support the adoption of MOD; and
4. Recognizing that mod should be customized to meet local needs (i.e., one solution does not fit all).

There was also some discussion in the breakout group about how the government can remove obstacles to support public–private partnerships that can further expand MOD adoption. The breakout session identified three key research needs:

1. The need to understand personal and household economic decision-making pertaining to modal choice (and the decision to use or not to use MOD);
2. The need for greater understanding about lessons learned and best practices for MOD (e.g., why is MOD successful in one location but not another); and

3. The need for more MOD pilots (including some public–private partnerships).

PLANNING FOR MOBILITY ON DEMAND

Planning for MOD was summarized by Alexandra Cohen and Sharon Feigon. Key issues to advancing MOD planning from public- and private-sector perspectives included:

1. The role of public rights-of-way (e.g., curb access and parking for mod modes),
2. Incentive zoning to encourage higher-density development for the inclusion of MOD planning and disincentivizing sprawl,
3. Scaling mod across a variety of built environments, and
4. Incorporating mod into transportation planning and modeling.

Possible strategies for advancing MOD planning included incorporating MOD into the public rights-of-way and through inclusionary zoning and encouraging mixed-use development and shared parking that encourages active transportation modes and “park once” (e.g., driving to a destination and walking to subsequent destinations rather than moving a vehicle) behaviors. Additional strategies to advance MOD planning included the development of mobility hubs that include not only MOD modes but also mixed-use transit-oriented development around the mobility hub and digital integration through common apps and fare payment platforms. The breakout group also discussed how public policy research, best practices, and lessons learned can lead to the advancement of MOD policy. Additionally, participants noted the importance of MOD travel behavior research for the inclusion in transportation planning models.

Closing Thoughts and Key Takeaways

Shaheen and Chernick reunited workshop participants in the closing plenary session for a brief final workshop summary. The workshop featured the U.S. DOT's MOD Program and provided information on recent innovations and lessons learned from three of the MOD Sandbox sites. The panel and breakout sessions highlighted opportunities and challenges from experts representing public agencies, academia, private companies, and technology futurists. The role of data and MOD was discussed in a variety of contexts (e.g., how data should be shared, stored, and protected; and the implications of data on structuring public-private partnerships). The need for equity and not leaving anyone behind was also a key theme discussed throughout the panel and breakout sessions.

Key insights and discussion points from the workshop are listed below:

- The U.S. DOT's MOD Program is multimodal and supported across multiple U.S. DOT agencies and offices;
- Lessons learned and best practices are still emerging from the MOD Sandbox with respect to public-private partnerships. Workshop participants had lots of questions pertaining to the structuring of public-private partnerships, revenue sharing, data sharing, and serving people with special needs;
- The management and understanding of pilot data including the protection of personal privacy (i.e., how can data be stored and shared to protect privacy) and the safeguarding of proprietary data (i.e., identifying who owns proprietary data and who has access to the data) were identified as the two prominent issues requiring standardization and guidance to support future MOD public-private partnerships.

The interactive breakout sessions provided an opportunity for the audience to get directly involved with the speakers after listening to the three panel sessions. A vibrant discussion ensued on focus areas, solutions, and research needs for expanding MOD. Many participants expressed the need to improve collective understanding of travel behavior, equity, and economic impacts of MOD modes and opportunities for data sharing, revenue sharing, and physical and digital multimodal integration. Broadly, the workshop facilitated a much-needed forum among experts and practitioners from diverse backgrounds and informed the audience about developments, challenges, and the future of MOD.

Workshop Agenda

SUSAN SHAHEEN

Transportation Sustainability Research Center, UC Berkeley, presiding

JEFFREY CHERNICK

RideAmigos, presiding

Sunday, January 7, 2018, 9:00 a.m. to 4:30 p.m.
Walter E. Washington Convention Center, Room 150A
Washington, D.C.

Sponsored by the following committees:

- Emerging and Innovative Public Transport and Technologies Committee (AP020);
- Shared-Use Mobility and Public Transit Subcommittee [AP020(1)];
- Emerging Ridesharing Solutions Joint Subcommittee [AP020(2)];
- Automated Transit Systems (AP040);
- Transportation Demand Management Committee (ABE50); and
- Regional Transportation Systems Management and Operations Committee (AHB10).

Session 1: 9:00 a.m. to 9:30 a.m. (1/2 hour)

Workshop Overview and Participant Introductions

Susan Shaheen, *UC Berkeley*, and Jeffrey Chernick, *RideAmigos*

Session 2: 9:30 a.m. to 10:30 a.m. (1 hour)

U.S. Department of Transportation's Mobility on Demand Program: Nuts and Bolts

Vince Valdes, *FTA*, *moderator*

- MOD Program Leadership: *Gwo-Wei Torng, FTA; Egan Smith, ITS JPO; and Martin Knopp, FHWA*
- Introduction to MOD Concept of Operations, *Bob Sheehan, ITS JPO*
- Audience Q&A

BREAK: 10:30 a.m. to 10:45 a.m.

Session 3: 10:45 a.m. to Noon (1 hour and 15 minutes)

Federal Transit Administration's Mobility on Demand Sandbox:

Exploring Innovative Business Models and Economic Impacts

Rik Opstelten, *FTA*, *Moderator*

- 11 MOD Sandbox Overview. 3-Site Panel, representing public-private perspectives. *Gwo-Wei Torng, FTA*
- Two-Region MOD partnership: Los Angeles, CA, and Seattle, WA. *Marla Westervelt, LA Metro and Zachary Wasserman, Via*

- Integrated carpooling at BART: San Francisco Bay Area, CA. *Nikki Foletta, BART and Robert Sadow, Scoop*
- Valley Metro AV Shuttle and Mobility Platform: Phoenix, AZ. *Hannah R. Quinsey, Valley Metro Rail*
- Commentator, *Sharon Feigon, Shared-Use Mobility Center*

LUNCH BREAK: 12:00 p.m. to 1:30 p.m.

Session 4: 1:30 p.m. to 2:30 p.m. (1 hour)

Evaluation of Mobility on Demand: Big Data, Key Metrics, and Early Findings

Steve Mortensen, *FTA, Moderator*

- Evaluation Framework. *Gustave Cordahi, Booz Allen Hamilton*
- Hypothesis Testing and Data Management. *Susan Shaheen, UC Berkeley*
- Research Partnership/Energy Data. *Sarah Olexsak, U.S. Department of Energy*

Interactive Breakouts: 2:30 p.m. to 3:45 p.m. (1 hour and 15 minutes)

Deeper Dive: MOD Opportunities and Obstacles: Overview and Objectives

Bob Sheehan, ITS JPO, and Christina Gikakis, FTA

Breakouts include facilitated discussions on opportunities and obstacles. Each breakout group will follow a guided protocol to foster a lively discussion on opportunities and challenges from both the public and private sector perspective in each focus area:

1. Managing and Understanding Pilot Data;
2. Equity and Accessibility;
3. Economic Impacts and Innovative Business Models; and
4. Planning for Mobility on Demand.

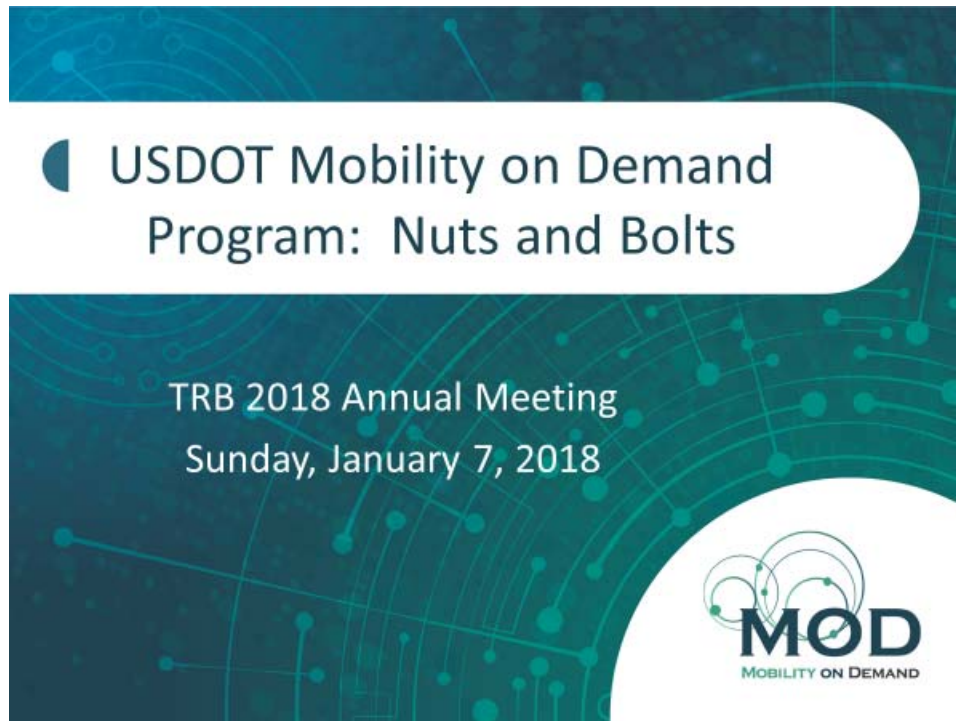
BREAK: 3:45 p.m. to 4:00 p.m. (15 minutes)

Rapporteurs Report Back and Final Wrap Up: 4:00 p.m. to 4:30 p.m. (1/2 hour)

Susan Shaheen, UC Berkeley, and Jeffrey Chernick, RideAmigos, Rapporteurs

APPENDIX A

PowerPoint Slide Presentations



Session Review

- Vincent Valdes, Associate Administrator, FTA Office of Research, Demonstration and Innovation
 - Introduction to the session/panelists/purpose
- Gwo-Wei Torng, Director, FTA Office of Mobility Innovation
 - MOD program overview
- Egan Smith, Managing Director, USDOT ITS Joint Program Office
 - ITS JPO's role in the MOD
- Martin Knopp, Associate Administrator, FHWA Office of Operations
 - FHWA's role in the MOD
- Robert Sheehan, Program Manager, USDOT ITS Joint Program Office
 - Introduction to the MOD Concept
- Vincent Valdes – Moderator
 - Audience Q&A

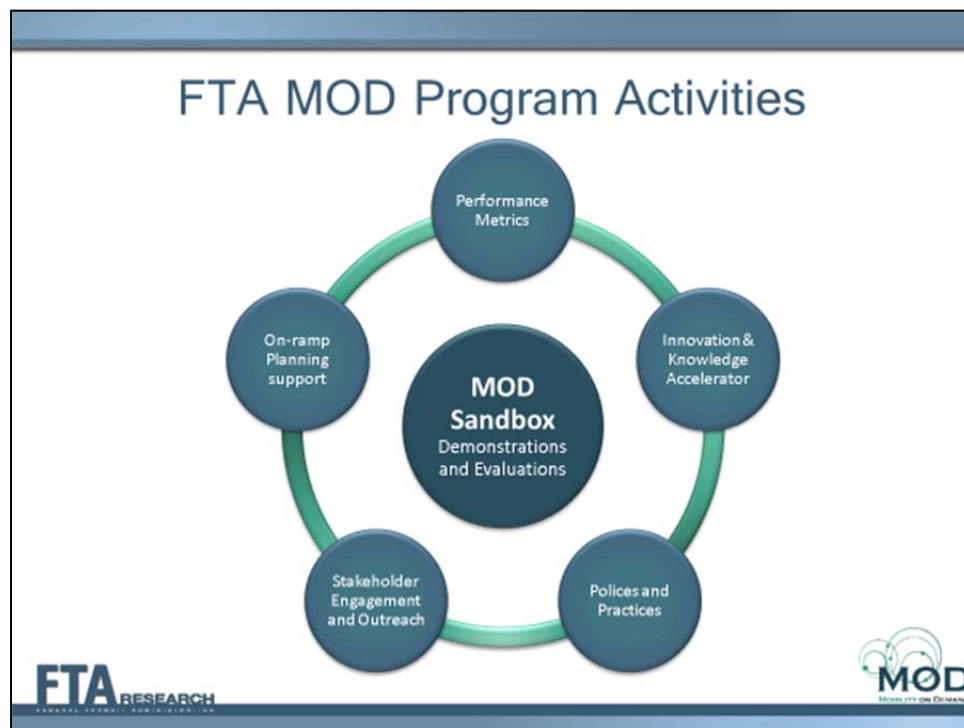
MOD and Transit

Mobility on Demand

MOD is a **vision** for an integrated **multi-modal** network of **safe, carefree, affordable**, and **reliable** transportation options that are **available to ALL**



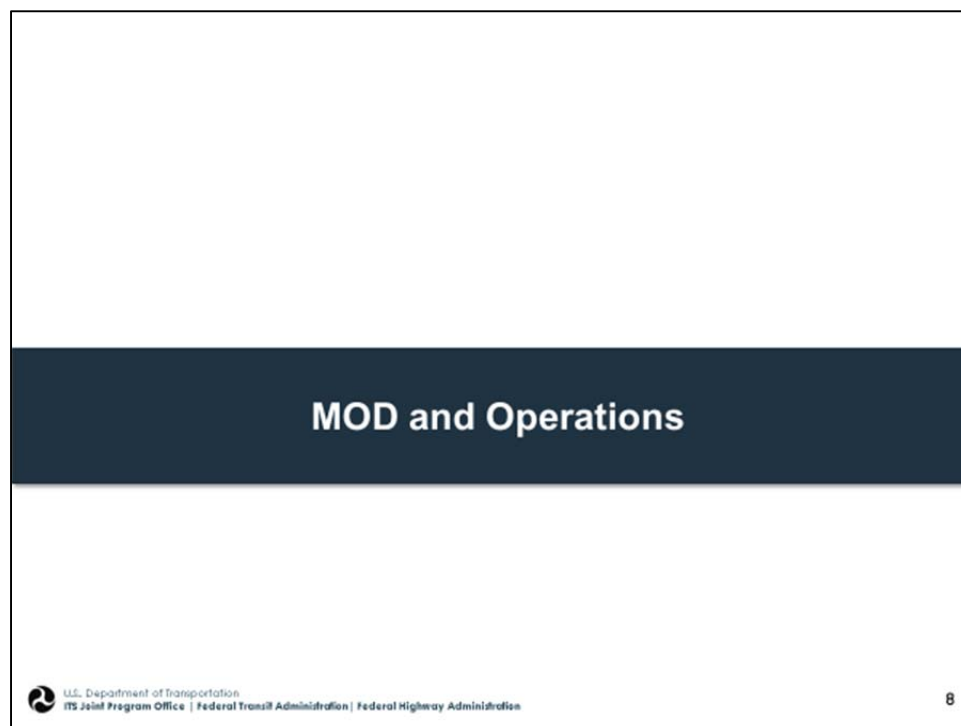
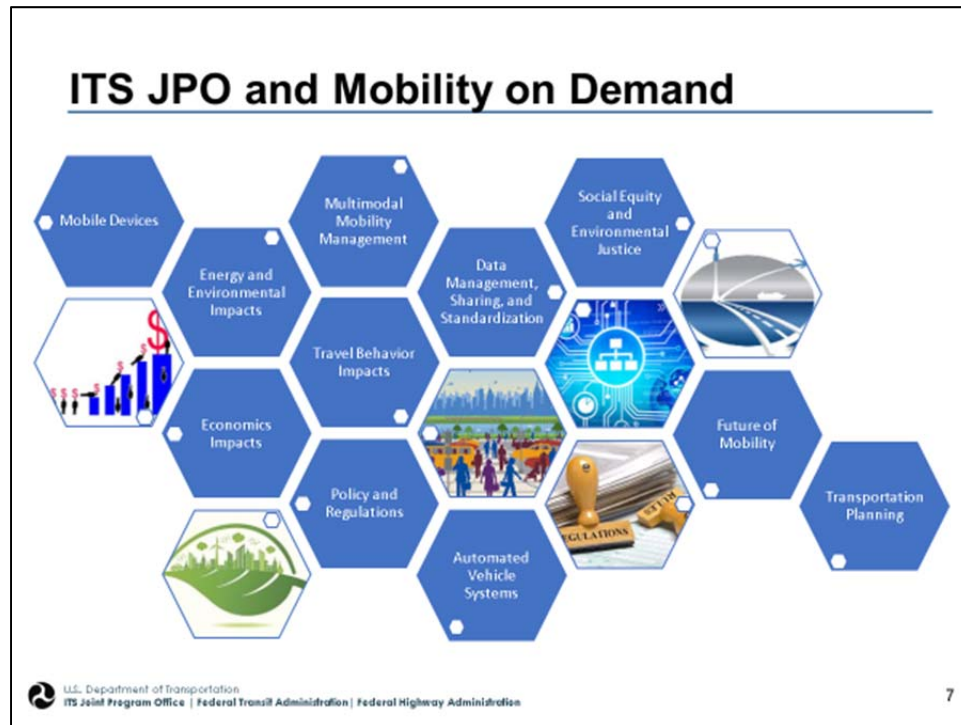
- Traveler-centric
- Technology-enabled
- Partnership-driven
- Mode-agnostic



MOD and Intelligent Transportation Systems

U.S. Department of Transportation
ITS Joint Program Office | Federal Transit Administration | Federal Highway Administration


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MOD and Operations

Travel today...

- Transportation is multi-modal
- Travelers expect a seamless trip



By working together, TDM professionals and traffic managers...



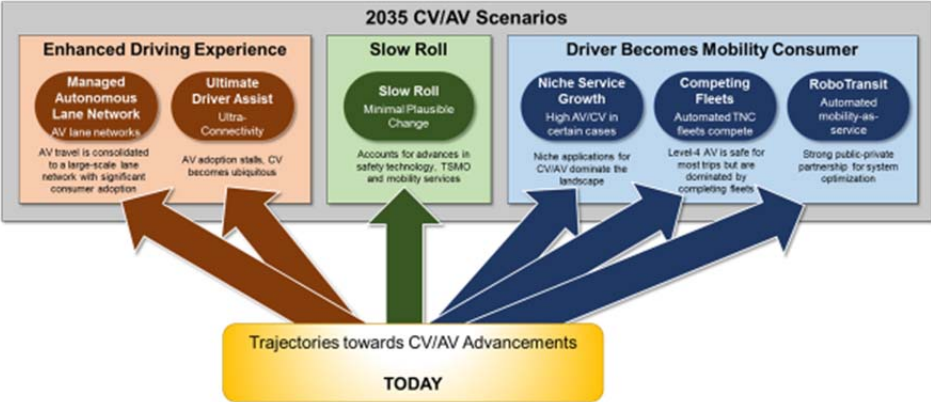
- Create more traveler choices
- More effectively manage travel

U.S. Department of Transportation
ITS Joint Program Office | Federal Transit Administration | Federal Highway Administration

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MOD and Operations

2035 CV/AV Scenarios



Enhanced Driving Experience

Managed Autonomous Lane Network

AV travel is consolidated to a large-scale lane network with significant consumer adoption

Ultimate Driver Assist

Ultra-Connectivity

AV adoption stalls, CV becomes ubiquitous

Slow Roll

Slow Roll

Minimal Plausible Change

Accounts for advances in safety technology, TSMO and mobility services

Driver Becomes Mobility Consumer

Niche Service Growth

High AV/CV in certain cases

Niche applications for CV/AV dominate the landscape

Competing Fleets

Automated TNC fleets compete

Level-4 AV is safe for most trips but are dominated by competing fleets

RoboTransit

Automated mobility-as-service

Strong public-private partnership for system optimization


Trajectories towards CV/AV Advancements

TODAY

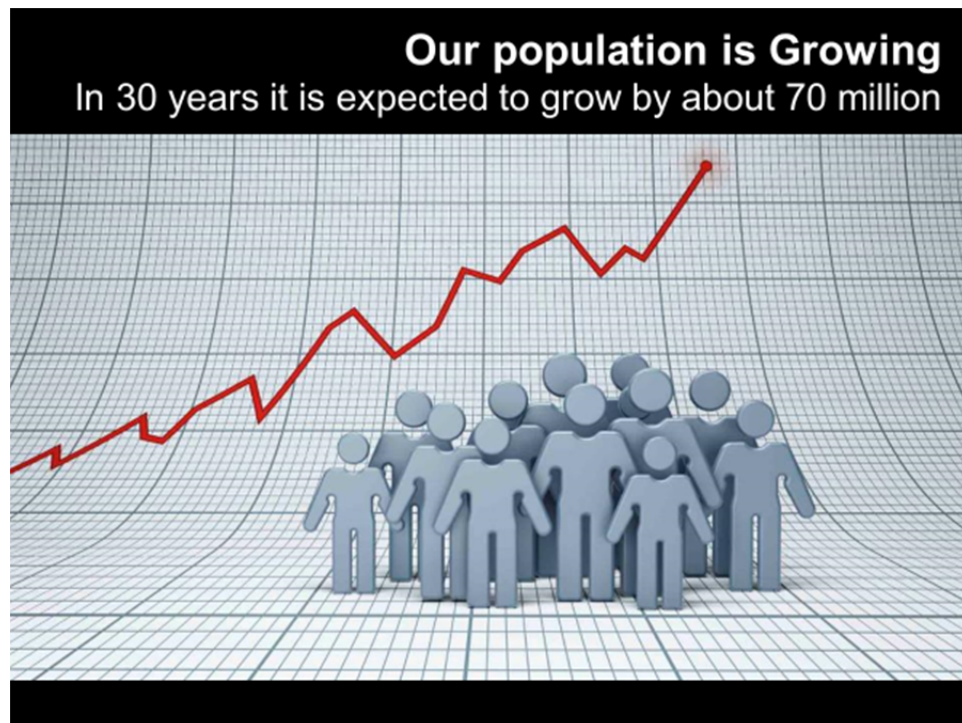
U.S. Department of Transportation
ITS Joint Program Office | Federal Transit Administration | Federal Highway Administration

10

Mobility on Demand Concept

 U.S. Department of Transportation
ITS Joint Program Office | Federal Transit Administration | Federal Highway Administration

11



Older Americans are Redefining Longevity

By 2045, the number of Americans over age 65 will increase by 77%



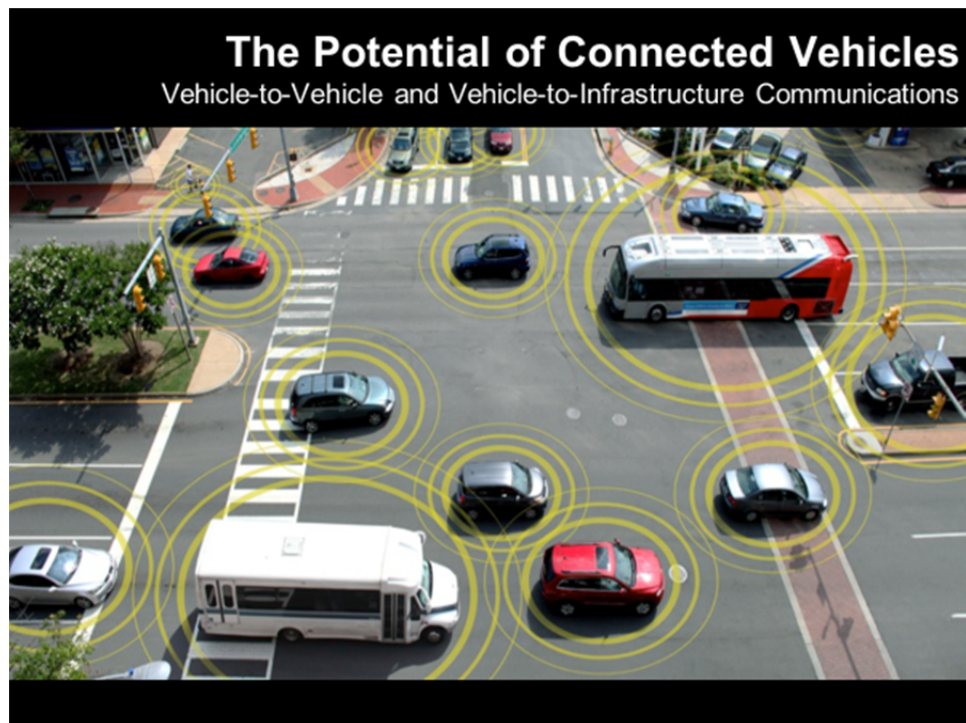
All Travelers Need Mobility Choice

Persons with disabilities comprise nearly 20% of the U.S. population





Vision for Mobility and Accessibility



Rebranding as Mobility Companies

Interest in MOD by the automotive sector has taken a variety of forms including acquisitions, investments, partnerships, and internal development of technologies and services that were previously not on the radar of automotive OEMs

| Automotive Company | Activity |
|-----------------------|---|
| Ford | Acquisitions: Chariot (microtransit) Investments: Lyft (ridesourcing/TNC) Internal Developments: Ford Smart Mobility LLC; a Ford subsidiary working to design and invest in emerging mobility services |
| General Motors | Acquisitions: Sidecar (ridesourcing/TNC) Investments: Lyft (ridesourcing/TNC) Partnerships: Lyft; leases electric Bolt cars to Lyft drivers Internal Developments: Maven (carsharing) |
| Fiat Chrysler | Partnerships: Google/Waymo (shared automated vehicles); provides Chrysler vans to Waymo as test vehicles |
| Daimler | Acquisitions: car2go (one-way carsharing), Moovel (multimodal trip payment), Hailo (e-Hail taxi app) Partnerships: Matternet (drones) |
| Volvo | Partnerships: Uber (ridesourcing/TNC); joint venture to develop fully autonomous vehicles Partnership: Volvo with its new digital key app paired with Urb-it, a shopping and delivery startup, to deliver goods. |
| Toyota | Investments: Uber (ridesourcing/TNC) Partnerships: Uber; lease vehicles to Uber drivers |

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Supply Chain/Goods Movement Sector

Whether it is a startup (e.g., Instacart, Uber Eats, Postmates, Doordash), an Internet-based retailer (e.g., Amazon), or a supply chain and logistics firm, advancements in courier services (both technologies and service models) are transforming how consumers access goods and services. FedEx, UPS, and DHL are all developing faster delivery services using automation and robotics for both ground-based and aerial vehicles. Innovative technologies and business models to deliver goods and services have the potential for MOD to reimagine goods movement.

MOD Activity in the Goods Movement and Logistics Sector

| Supply Chain Company | Activity |
|----------------------|---|
| FedEx | Internal Developments: Developing AV delivery vans and robots Partnerships: Volvo, Freightliner, and Daimler; developing hybrid AV van and drone delivery system |
| UPS | Internal Developments: Piloting a drone system that launches from the top of a truck |
| DHL | Internal Developments: Pilot program testing automated parcel station and aerial delivery drones |
| Amazon | Internal Developments: Amazon Prime Air drone delivery patent filed for the U.S. |

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Public or Private?



Public or Private?



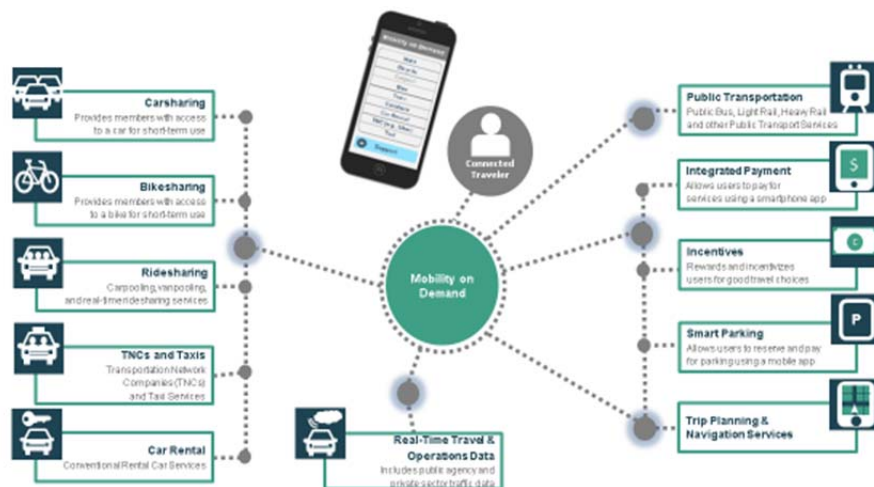
What is Mobility on Demand (MOD)?

An **integrated and connected multi-modal** network of **safe, affordable, and reliable** transportation options that are **available to all**



- User-focused options to improve personal mobility and access to more destinations
- Promotes choice in personal mobility & optimizes the transportation system through Intelligent Transportation Systems
- Advances connected vehicles & automation applications
- Uses emerging technologies & data exchange to enable personal mobility
- Encourages multimodal connectivity & system interoperability

User-centric Travel Options



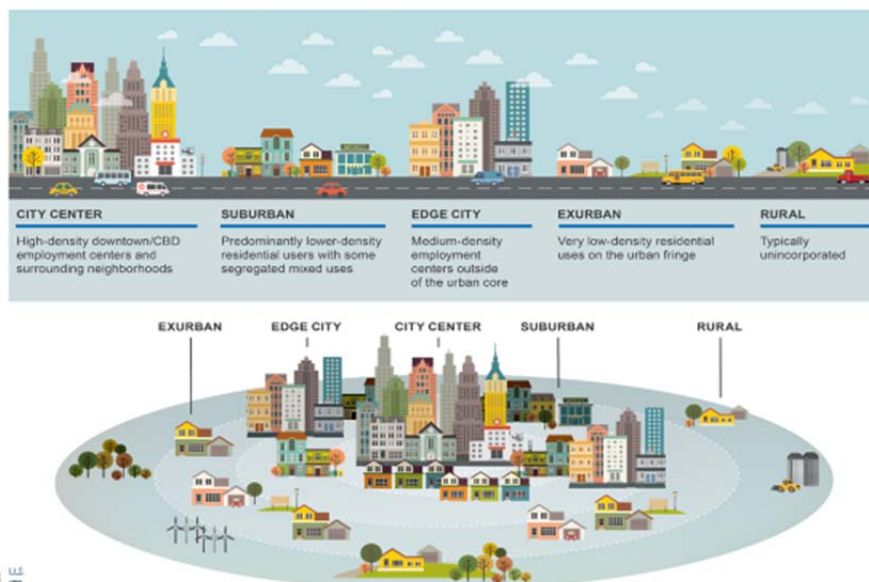
Holistic View and Enablers



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MOD – Not just city center



U.S.
ITS

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Who Benefits from MOD?



Travelers

- Access to more transportation options
- Builds a more efficient, effective, and customer-centered transportation network



Public Transit Providers

- Connects ALL regional transportation services and assets into a seamless public transit network
- Extends service quality and coverage



Shared Transportation Providers

- Connects travelers to provider services
- Provides an easy to use, common technology platform for mobility options



Mobility Managers

- Streamlines information for transportation options
- Growing employment and transportation partnerships

MOD Enablers



Business Models & Partnerships

Strategic Partnerships
Financing
Incentives



Infrastructure

Land Use
Built Environment
Transportation Infrastructure



Policies & Regulations

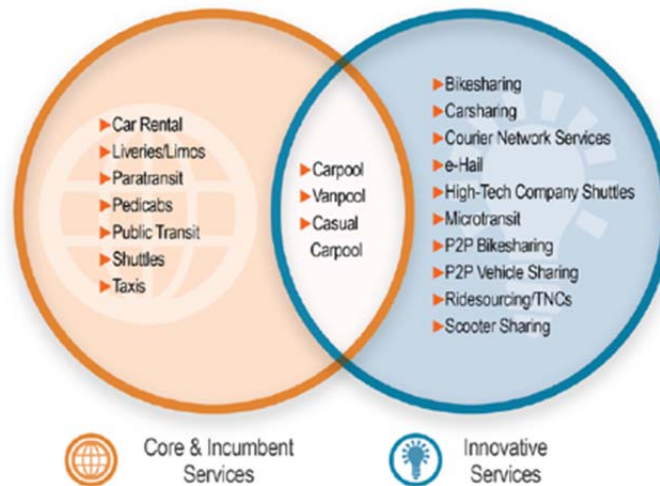
Equity Considerations
Safety Considerations
Mobility Issues
Standardization



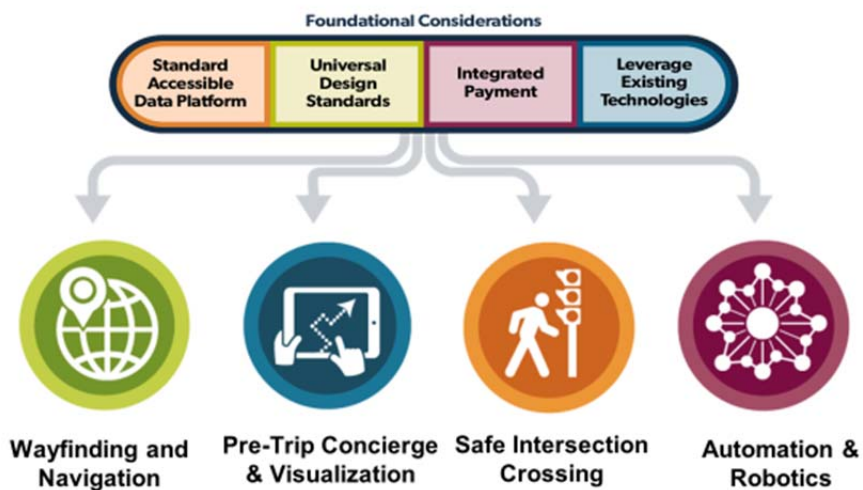
Emerging Technologies

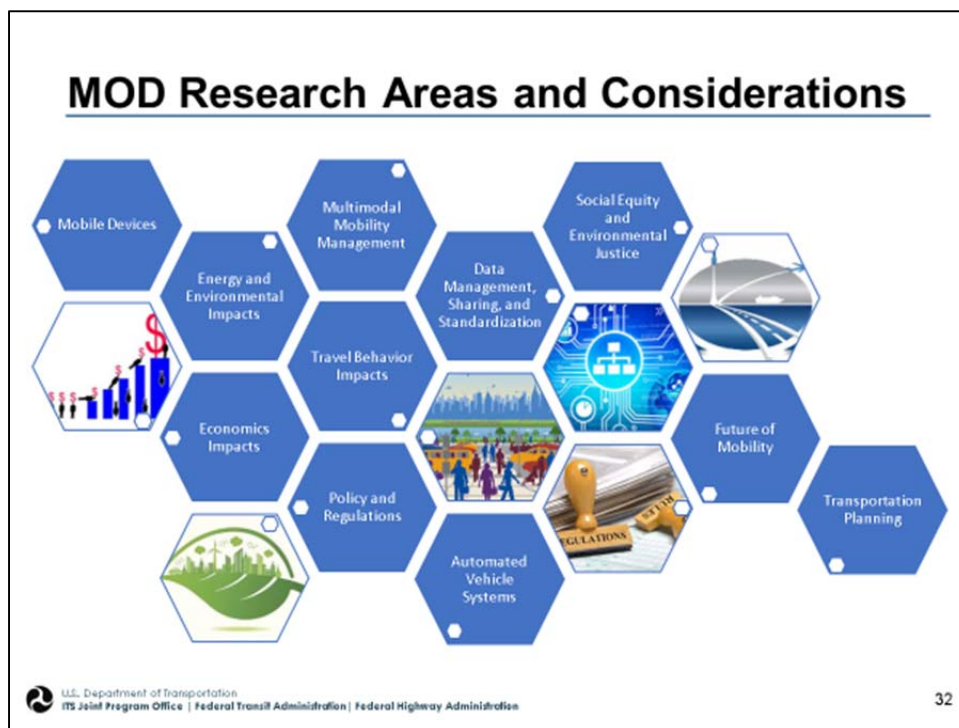
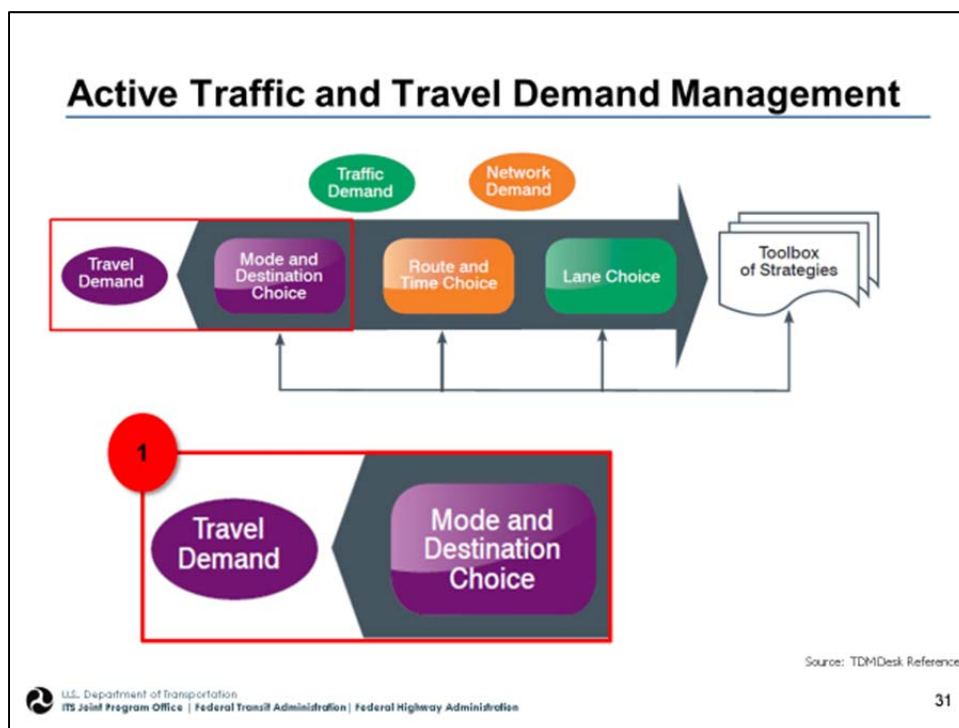
Wireless Networks
GPS/Sensors
Big Data and Predictive Analytics
Mobile Devices

MOD and Shared Mobility Ecosystem



Accessible Transportation





Scenario #1 – Status Quo

- Continued congestion
- Failing infrastructure
- Disjointed policy
- Financial challenges persist
- Some advances in efficiencies and technology, but not widespread
- Ad hoc private solutions for mobility exist, but not well coordinated or integrated



Scenario #2 – Integrated Transit

- Technology advances and creative collaborations support innovative solutions like semi-integrated payment systems
- Bikeshare, carshare, and transit coordination extends mobility options to customers
- Transit prioritized in some urban cores and arterials



Scenario #3 – Connected Mobility

- Connected transportation
 - V2V and V2I communication technologies are widespread
- Demand Response Transit
 - Advanced Mobile Trip Planning provides choices and options on how and when to travel based on user profiles and preferred way of travel
- Systems and infrastructure are optimized to move people not vehicles



Scenario #4 – Automated and Connected

- Vehicle Automation
 - First/last mile connections
 - On-demand, automated carsharing services
 - Vehicle ownership models drastically change
- Advanced, integrated, and holistic mobility services that provide real mobility options to all travelers – mobility at our fingertips





USDOT's MOD Initiative: Moving the
Economy with Innovation and
Understanding

Session 4: Evaluation of MOD: Big Data,
Key Metrics, and Early Findings

January 7, 2018



U.S. Department of Transportation
Federal Transit Administration

Steve Mortensen
Senior ITS Engineer


Session 4 Panel

Steve Mortensen, FTA: Moderator

Gustave Cordahi, Booz Allen Hamilton:
Evaluation Framework

Susan Shaheen, UC Berkeley: Hypothesis Testing
and Data Management

Sarah Olexsak, US Department of Energy:
Research Partnership/Energy Data



2

Session 4 Structure

- Brief presentations for topic background and context
- Moderated panel discussion
- Audience questions and panel answers



www.wikihow.com/Conduct-a-Panel-Discussion

MOD Sandbox Demonstrations Independent Evaluation (IE) Objectives

- Conduct a comprehensive independent evaluation of the MOD Sandbox Demonstrations to:
 - Measure impacts
 - Assess MOD business practices
 - Examine how existing FTA policies and regulations support or impede these new transportation service models




MOD Sandbox Demonstrations IE Activities




- Plan Evaluation
 - Evaluation framework
 - Evaluation plan for each site
- Conduct Evaluation and Report Results
 - Quantitative and qualitative data analysis for each site
 - Evaluation report for each site
 - Synthesis report of key findings and lessons learned
- Coordinate With Related Activities
- Provide Knowledge Transfer
 - Industry conferences
 - Journal/magazine article
 - Public webinar



Steve Mortensen: steven.mortensen@dot.gov 202-493-0459

Booz | Allen | Hamilton


UNIVERSITY OF CALIFORNIA Berkeley
Transportation Sustainability
RESEARCH CENTER

MOBILITY ON DEMAND (MOD) SANDBOX DEMONSTRATIONS INDEPENDENT EVALUATION (IE)

Evaluation Approach & Framework

TRB Annual Meeting 2018

Gustave A. Cordahi
Booz Allen Hamilton
Washington, D.C.

Susan Shaheen, Ph.D.
Co-Director, TSRC
UC Berkeley

JANUARY 8, 2018

CONSULTING | ANALYTICS | DIGITAL SOLUTIONS | ENGINEERING | CYBER

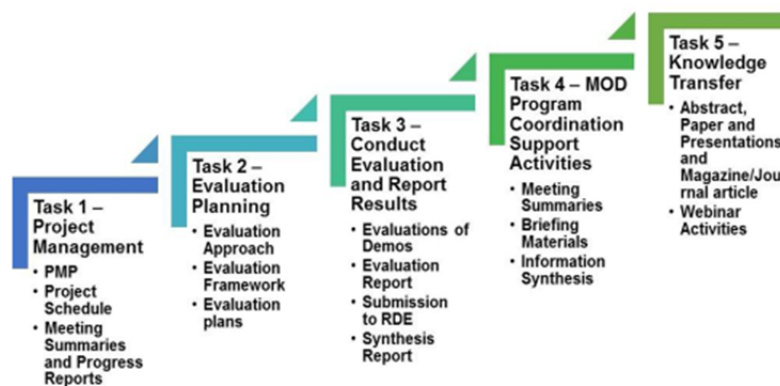
| CONTENTS | |
|----------|--|
| | INDEPENDENT EVALUATION: PROJECT BACKGROUND & TASK OVERVIEW |
| | EVALUATION PLANNING OVERVIEW |
| | SITE-LEVEL EVALUATION: |
| | MOD Sandbox demonstrations overview |
| | Site-specific Evaluation Framework: Logic Model Structure |
| | Site-by-site Evaluation Frameworks |
| | OVERALL EVALUATION PERSPECTIVE (SYNTHESIS ACROSS SITES): |
| | Overall Evaluation Framework |
| | Guiding Principles |
| | Hypothesis Development |
| | Performance Metric Establishment |
| | Data Design and Collection |
| | Analysis Planning: Methodological Approach |
| | 1 |

INDEPENDENT EVALUATION: PROJECT BACKGROUND

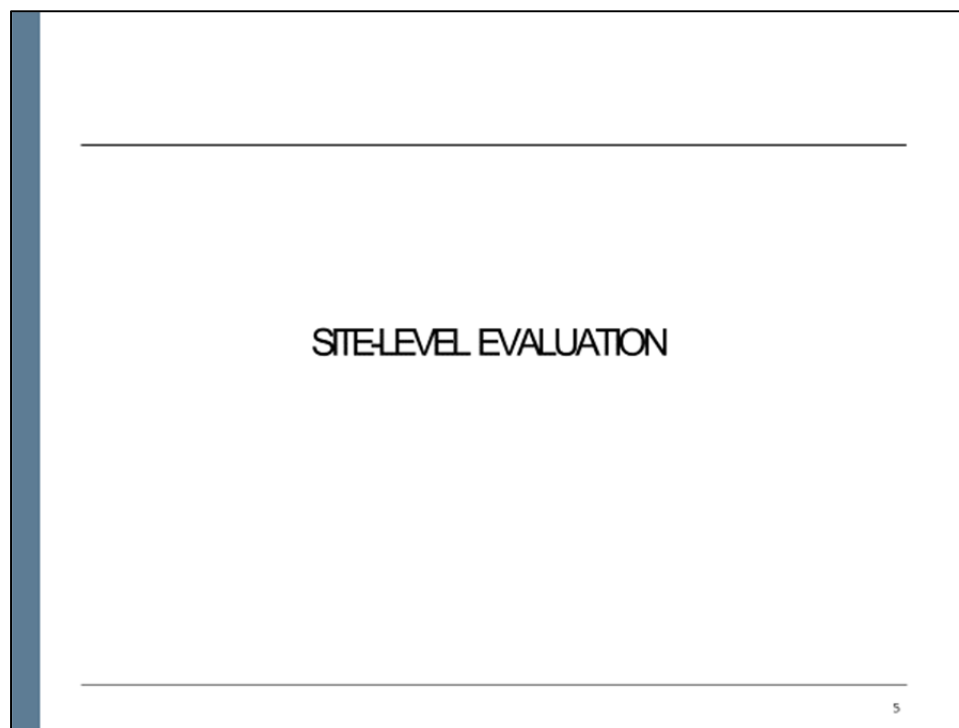
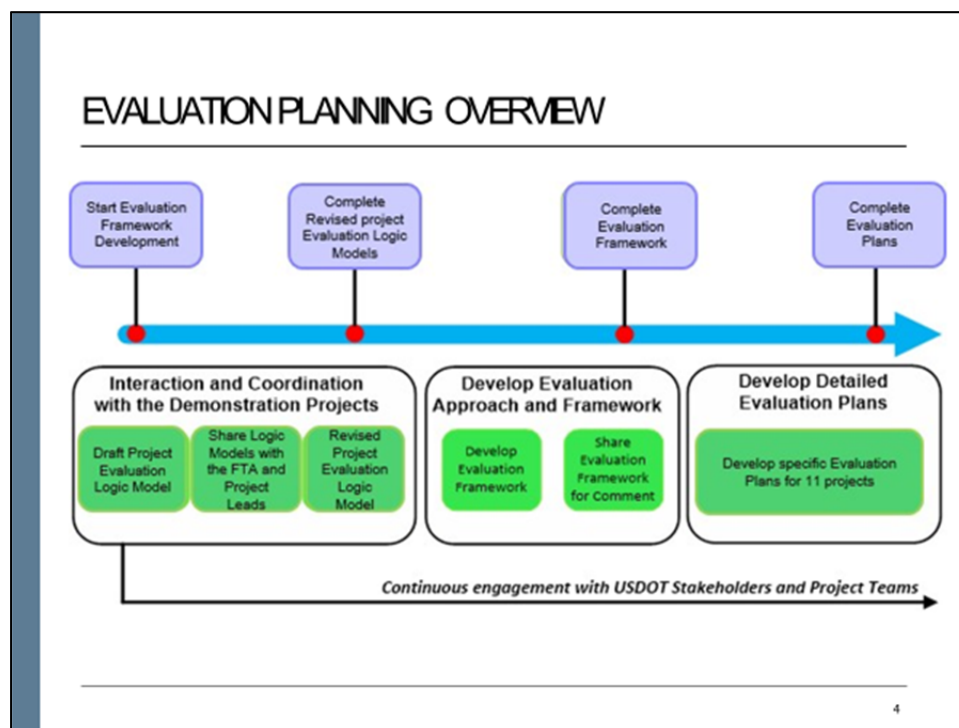
- The MOD Sandbox Demonstration Program provides a forum where integrated MOD concepts and solutions supported through local partnerships are demonstrated in a real-world setting.
- The innovations developed in the MOD Sandbox have the potential to alter how public transit is delivered nationwide and a **comprehensive evaluation** will help focus future direction based on benefits and impacts.
- The rigorous, comprehensive IE of the MOD Sandbox demonstrations will describe:
 - Lessons learned
 - What business and partnership models are most likely to succeed
 - Which innovations work best

2

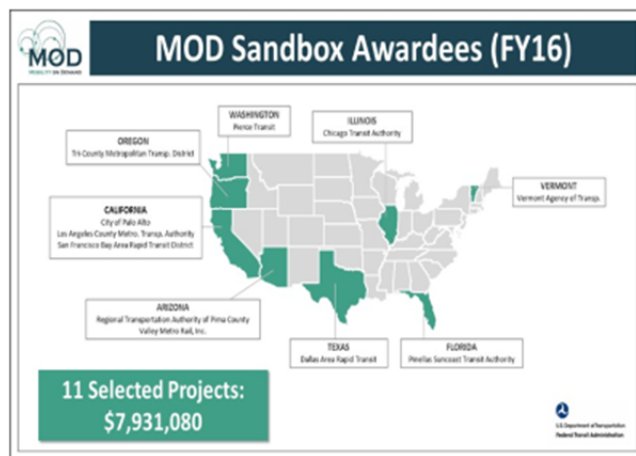
IE PROJECT TASKS OVERVIEW



3



MOD SANDBOX AWARDEES (FY16)



6

MOD DEMONSTRATIONS OVERVIEW

| STATE | PROJECT SPONSOR | DESCRIPTION |
|---------|--|---|
| IL | Chicago Transit Authority (CTA) | Incorporate the local bike sharing company, Divvy, a 580-station bike share service, into CTA's existing transit trip planning app (\$400,000). |
| TX | Dallas Area Rapid Transit (DART) | Integrate ride-sharing services into its GoPass ticketing app to solve FMLM issues (\$1,200,000). |
| CA (WA) | Los Angeles County Metropolitan Transportation Authority | Two-region mobility on demand partnership with the ridesourcing company, Via, in Los Angeles and Seattle to provide FMLM mile solutions (\$1,350,000). |
| CA | City of Palo Alto | Proposed solutions seek to reduce Bay Area single occupancy vehicle (SOV) commute share from 75% to 50% through a Fair Value Commuting (FVC) solution (\$1,080,000). |
| WA | Pierce County Public Transportation Benefit Area Corporation | Utilize Limited Access Connections project, an initiative connecting Pierce Transit local service and Sound Transit/Sounder regional service with local ride-share companies to increase regional transit use (\$206,000). |
| AZ | Regional Transportation Authority (RTA) of Pima County | Adaptive Mobility with Reliability and Efficiency (AMORE) project, integrating fixed route, subscription based ride-sharing and social carpooling services into an existing data platform to provide affordable, convenient and flexible service (\$670,000). |
| FL | Pinellas Suncoast Transit Authority (PSTA) | A set of partnerships with Lyft, United Taxi, CareRide, the Center for Urban Transportation Research (CUTR), and Goin' Software to develop a model to provide more cost-effective on-demand door-to-door paratransit service (\$500,000). |
| CA | San Francisco Bay Area Rapid Transit | Partnership between Scoop Technologies, Inc. (Scoop), the San Francisco Bay Area Rapid Transit (BART) District, and the Metropolitan Transportation Commission (MTC) to better integrate carpool access to public transit by matching passengers according to their destination, and by providing a way to reserve and pay for parking spaces at BART stations (\$358,000). |
| OR | Tri-County Metropolitan Transportation District | Incorporate shared use mobility (SUM) options into the Open Trip Planner (OTP) project, that will create a platform integrating transit and shared-use mobility options (\$678,000). |
| AZ | Valley Metro Rail, Inc. | Smart phone mobility platform that integrates mobile ticketing and multimodal trip planning (\$1,000,000). |
| VT | Vermont Agency of Transportation | Statewide transit trip planner that will enable flex-route, hail-a-ride, and other non-fixed route services to be incorporated in mobility apps (\$480,000). |

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SITE-SPECIFIC EVALUATION FRAMEWORK: LOGIC MODEL STRUCTURE

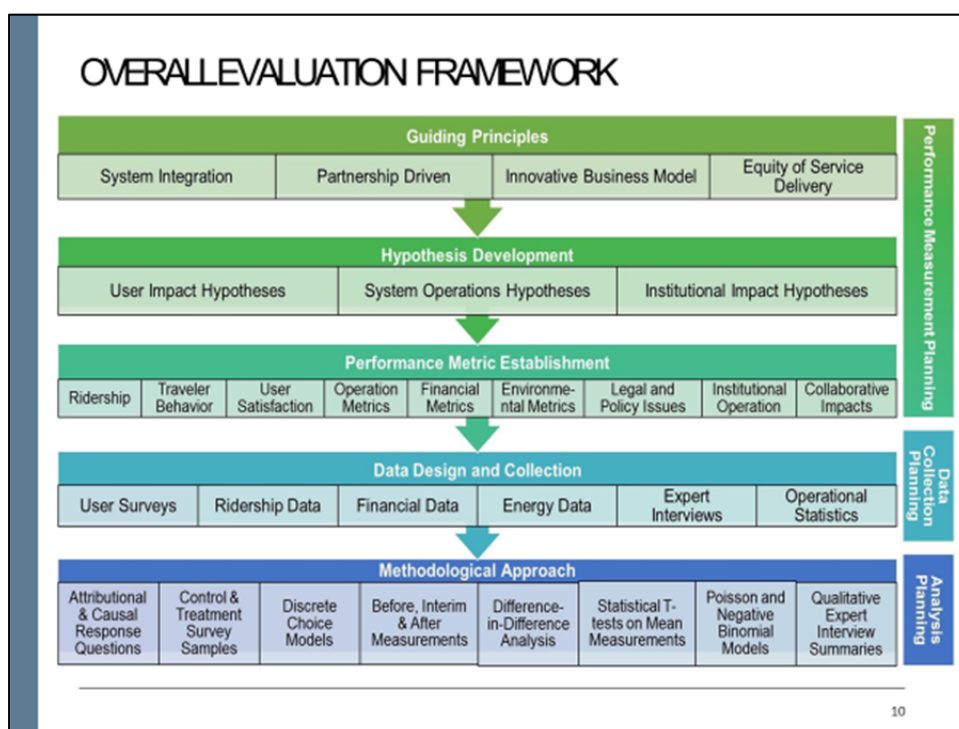
| MOD Sandbox Project | Project Goals | Evaluation Hypothesis | Performance Metric | Data Types | Data Sources | Method of Evaluation |
|---------------------|---------------|-----------------------|--------------------|------------|--------------|----------------------|
| | | | | | | |

- **MOD Sandbox Project** – Denotes the specific MOD Sandbox project.
- **Project Goals** – Denotes each of the project goals for the specific MOD Sandbox project. The project goals capture what each MOD Sandbox project is trying to achieve.
- **Evaluation Hypothesis** – Denotes each of the evaluation hypotheses for the specific MOD Sandbox project. The evaluation hypotheses flow from the project-specific goals.
- **Performance Metric** – Denotes the performance metrics used to measure impact in line with the evaluation hypotheses for the specific MOD Sandbox project.
- **Data Types, Elements, and Sources** – Denotes the Data Types, Elements, and the Data Sources used for the identified performance metrics.
- **Method of Evaluation** – Denotes the quantitative and qualitative evaluation methods used.

8

OVERALL EVALUATION PERSPECTIVE (SYNTHESIS ACROSS SITES)

9



GUIDING PRINCIPLES

| | System Integration | Partnership Driven | Innovative Business Model | Equity of Service Delivery |
|-----------------------------------|---|--|---|--|
| Chicago CTA | Integration of Divvy Bike Share into the Ventra App. | Partnership between Ventra and Divvy. | Utilizes Ventra application to capitalize on existing infrastructure of Divvy bike share. | Ventra App allows all users to have access to Divvy bike rentals. |
| Dallas DART | Soft integration for TNCs and car share companies into DART's "GoPass" | Dallas Area Rapid Transit partners with TNCs. | Utilizes "GoPass" ticketing app to implement a soft integration into TNC Apps | Integrated Mobility application and account-based fare payment systems to accommodate unbanked users |
| LA County MTA/ Puget Sound | Integrate TNC rides into the regional TAP pass. | LA Metro is partnering with Via. | Provide Via as a publicly supported option | Provide subsidies for riders |
| City of Palo Alto | Utilizes Mobility Aggregation | Consists of a 31 member consortium | Utilizes a "Six-way win" of mutual benefit | Provides low-income commute gap-filling work |
| Pierce County WA | Riders will select from pilot service app that most transit customers already possess. | Pierce College Puyallup, Sound Transit, and ride share partners. | Cost-effective method to overcome geographic barriers | Equitable geographic access to transit |
| Pima County AZ | Integrates 3 multimodal transportation services | RTA, Metropia, RubyRide and other stakeholders | Transport Rita Ranch residents more efficiently | Encourage users to donate unused credits to charity |
| Pinellas Suncoast FL | Overarching software integration will be hosted by Transloc, Inc. | Partnership with United Taxi and CareRide, develop a new partnership with Lyft | Increased efficiency through flexible and responsive mode choices | Provides service to over 12,500 eligible AOA paratransit customers |
| San Francisco BART | Target transit facilities as a destination and integrates BART's parking payment and reservation system | Partnership of Scoop (Private Sector), with MTC & BART (Public Sector) | Targets transit facilities instead of employment centers, as focal point for destinations and origins | Implemented equally at all BART stations, with parking facilities in four Bay Area counties |
| Tri-Met OR | The Open Trip Planner (OTP) will create shared-use mobility (SUM) options. | Two public transportation agencies and three for-profit organizations | Open Trip Planner creates multiple shared-use mobility options for all users. | Allow for more pedestrian and wheelchair access |
| Valley Metro AZ | Valley Metro Mobility Platform will build upon RideKickTM. | Public-Private Partnerships (PPS) formed between Valley Metro and TNC's (Lyft & GRD Bike Share). | Utilizes a combination of OTP SUM platform and GRD Bike Share to give users multiple transit forms | Utilizes smartphones to enhance trip planning and payment methods for smartphone users |
| Vermont VT | Trip Planner will utilize an emerging open data specification, GTFS-Flex. | Contains both private and public partners who have worked together for years | Utilizes OTP-SUM platform, combined with GTFS-Flex data | Develop a trip planner that works well in rural areas |

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HYPOTHESIS DEVELOPMENT

In general, there are 3 types of hypotheses that are explored in this evaluation.

User Impact Hypotheses

- Address some kind of impact on behavior, decisions, commute, or lifestyle of travelers.

System Operations Hypotheses

- Evaluate impacts on system operations or cost.

Institutional Hypotheses

- Evaluate lessons learned and best practices from project experience.

- Hypotheses are designed to be declarative statements that can be confirmed or denied with a yes or no answer.
- Hypotheses do not always have to be answered so concretely to be useful. However, structuring statements this way helps formulate the appropriate data needs and methods to address the key questions and project goals motivating the hypothesis.

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USE CASES

| Use Cases | Trip Planning/Payment Integration | First/Last Mile | Supplemental/Extended Services | Flexible Pricing / Incentives | Innovative Paratransit Services | Parking Utilization |
|----------------|-----------------------------------|-----------------|--------------------------------|-------------------------------|---------------------------------|---------------------|
| CTA | X | X | | | | |
| DART | X | X | X | | X | |
| LA/Puget Sound | X | X | | | | |
| Palo Alto | X | | | X | | X |
| Pierce Transit | | X | X | | X | X |
| Pima County | X | X | X | X | | |
| PSTA | | | | | X | |
| BART | | X | | X | | X |
| Tri-Met | X | | | | | |
| Valley Metro | X | X | | | X | |
| VTrans | X | | | | | |

*For the DART project, there are no plans to integrate ADA paratransit service into real-time scheduling. However, there are commitments to address accessibility through service options which include taxi for real-time accessible vehicles and concierge services for those without smart phones.

13

PERFORMANCE METRIC ESTABLISHMENT

Ridership

- Ridership on public transit and supporting systems (such as Uber, Lyft, or other systems).

Traveler Behaviors

- Measurements in Changes in behavior or Vehicle Ownership (and Avoided Vehicle ownership).

User Satisfaction

- Measurements in Changes or Levels of User Satisfaction

Operation Metrics

- Measurement in System Activity, such as trips, O/D information, Energy, and other Activity measurements

Financial Metrics

- Measurement of system Costs, User Costs, System Revenue

Environmental Metrics

- Measurements of Emissions resulting from Traveler Behavior and System Changes

Legal & Policy Issues, Institutional Operations, and Collaborative Impacts

- Measured through Qualitative Insights from Stakeholder Interviews and Project Activity

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SELECT CROSS REFERENCE OF GENERALIZED PERFORMANCE MEASUREMENT CATEGORIES

| Project | Transit Ridership | SOV VMT | Carpool VMT | Vehicle Occupancy | Travel Times | Transit Travel Wait Times | Travel Time Flexibility | ADA Accessibility | Transit System Operating and Capital Cost | Parking Utilization | Accessibility for Disadvantaged Populations | User Satisfaction | User Costs | ADA Equivalent Service |
|----------------|-------------------|---------|-------------|-------------------|--------------|---------------------------|-------------------------|-------------------|---|---------------------|---|-------------------|------------|------------------------|
| CTA | X | | | | | | X | | | | X | X | X | |
| DART | X | X | X | X | | | X | X | | | X | X | X | X |
| LA/Puget Sound | X | | | | X | | | X | | | X | | X | X |
| Palo Alto | X | X | X | X | X | | | | | X | | | | |
| Pierce Transit | X | X | | | X | | | X | | | | | X | X |
| Pima County | X | X | X | | X | | | X | | | X | | X | X |
| PSTA | X | | | | | X | X | X | X | | | | X | X |
| BART | X | X | X | X | | | X | | | X | | | X | |
| Tri-Met | X | X | | X | | X | X | X | | | | | | |
| Valley Metro | X | X | | | X | X | | X | X | | | | X | X |
| VTrans | X | | | X | X | | X | X | X | | X | | | |

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DATA DESIGN AND COLLECTION

User Surveys

- Coordination with Sites on Developing and Deploying Surveys to Sample populations impacted by the System or Project.
- Surveys can be Run by UC Berkeley on the Qualtrics Online survey Platform.
- Design of Clipboard surveys should also be done in collaboration with the IE team, but Agencies would have to deploy them.

Ridership Data

- Transit Agencies would have to supply Ridership data.

Financial Data

- Transit Agencies would have to Supply Financial data.

Energy Data

- Transit Agencies would have to Supply Energy data.

Expert Interviews

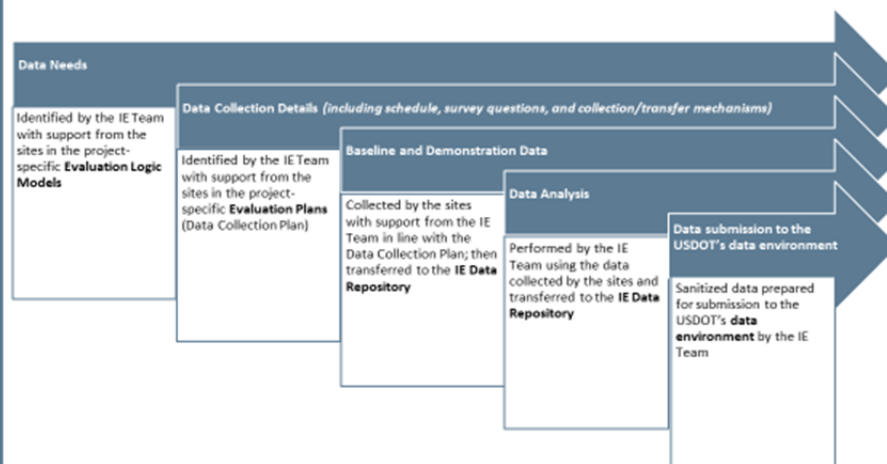
- Experts would be Identified and Interviewed Following a Protocol.

Operational Data

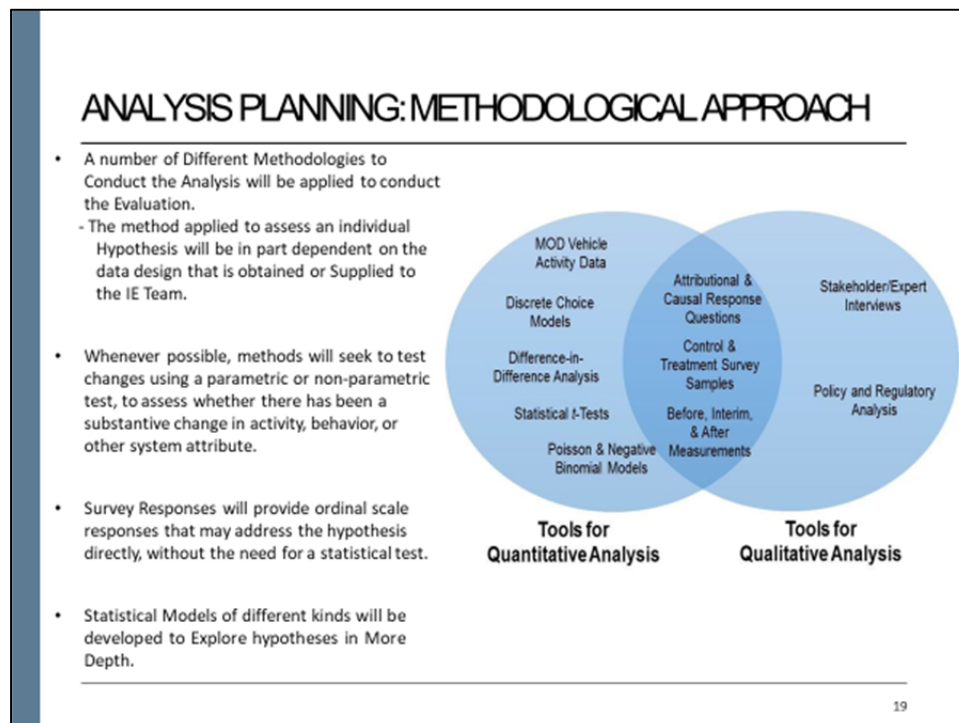
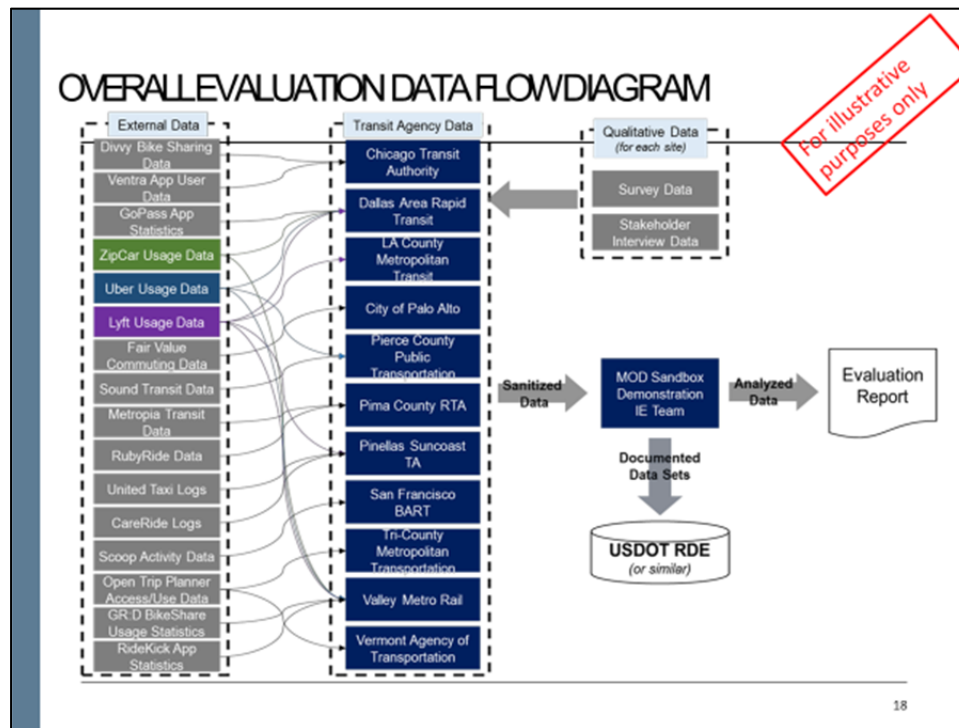
- Transit Agencies and Project Partners will have to Supply Operational Data.

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DATA COLLECTION FRAMEWORK



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THANK YOU!

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UNIVERSITY OF CALIFORNIA, Berkeley
 Transportation Sustainability
 RESEARCH CENTER

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U.S. DEPARTMENT OF
ENERGY
 Office of
 ENERGY EFFICIENCY &
 RENEWABLE ENERGY

Energy Efficient Mobility Systems

Sarah Oleksak
 Energy Efficient Mobility Systems Program
 Vehicle Technologies Office

MOD Sandbox Demonstrations Evaluations
 Research Partnership / Energy Data
 January 7, 2018



Large potential transportation energy impacts on the horizon

Unprecedented Disruption

+200%

Potential Increase in Energy Consumption

2050 Baseline Energy Consumption

Potential Decrease in Energy Consumption

-60%

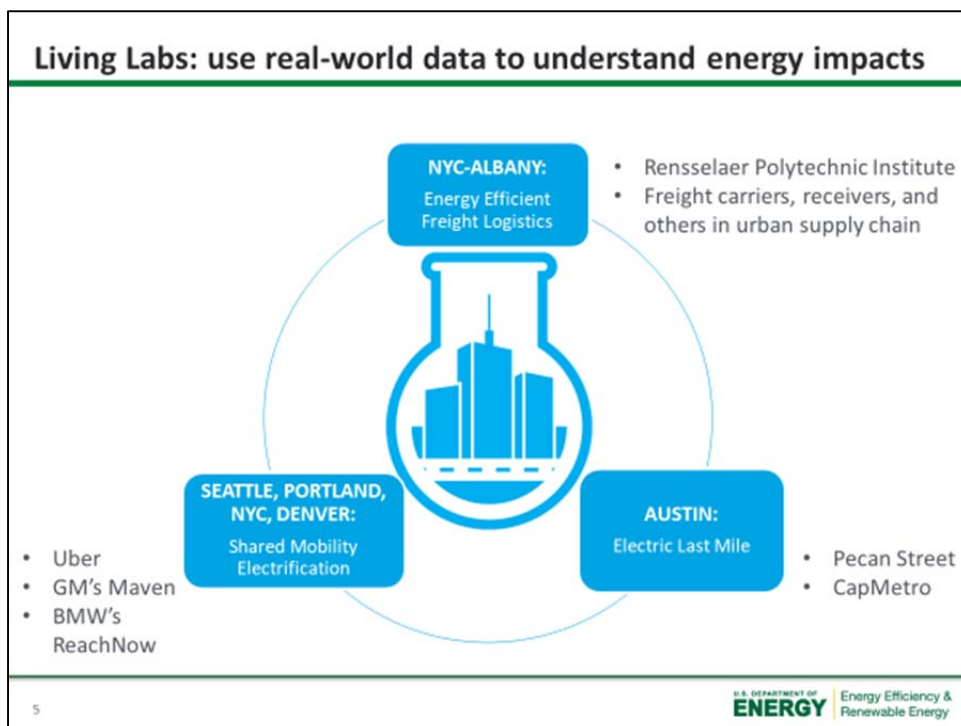
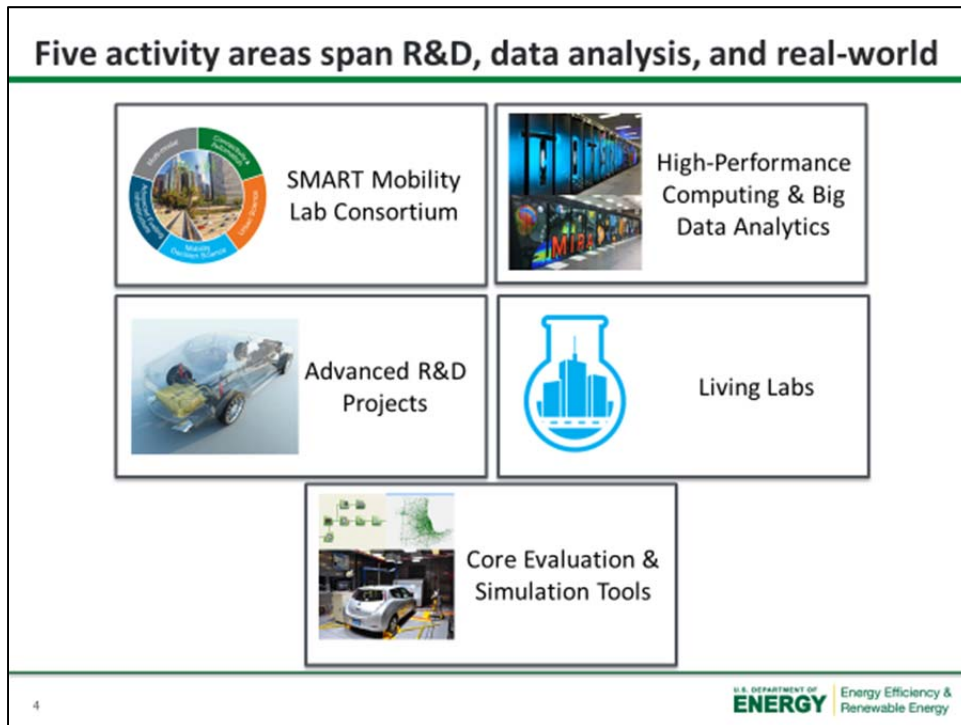
... with dramatic energy implications

U.S. DEPARTMENT OF **ENERGY** | Energy Efficiency & Renewable Energy

A new challenge calls for a new vision, a new program

DOE's Energy Efficient Mobility Systems (EEMS) Program envisions an affordable, efficient, safe, and accessible transportation future in which mobility is decoupled from energy consumption

The EEMS Program will conduct early-stage R&D at the vehicle, traveler, and system levels, creating new knowledge, tools, insights, and technology solutions that increase mobility energy productivity for individuals and businesses.



Can supplementing public transit with first/last mile and/or shared mobility solutions decrease passenger trip energy?



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U.S. DEPARTMENT OF
ENERGY | Energy Efficiency &
Renewable Energy

Interagency collaboration with FTA MOD Sandbox

UC Berkeley/LBNL researchers will work with DOE/FTA to:

1. Select up to five MOD Sandbox projects to evaluate
2. Define metrics
3. Incorporate metrics into Logic Model & Data Collection Plan
4. Collect data and conduct analysis
5. Develop case study

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U.S. DEPARTMENT OF
ENERGY | Energy Efficiency &
Renewable Energy

Interagency collaboration with FTA MOD Sandbox

What kind of data will be needed?

- Make, model, and year of vehicles providing service,
- Fuel economy ratings (see fuelconomy.gov),
- Number of people in vehicle,
- Origin/destination information of passenger,
- Origin/destination information of vehicle,
- Public transit vehicle energy consumption, and
- Estimated energy consumption of trip that would have occurred in substitution of trip facilitated by project.

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U.S. DEPARTMENT OF
ENERGY | Energy Efficiency &
Renewable Energy

U.S. DEPARTMENT OF
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The National Academies of **SCIENCES • ENGINEERING • MEDICINE**

The **National Academy of Sciences** was established in 1863 by an Act of Congress, signed by President Lincoln, as a private, non-governmental institution to advise the nation on issues related to science and technology. Members are elected by their peers for outstanding contributions to research. Dr. Marcia McNutt is president.

The **National Academy of Engineering** was established in 1964 under the charter of the National Academy of Sciences to bring the practices of engineering to advising the nation. Members are elected by their peers for extraordinary contributions to engineering. Dr. C. D. Mote, Jr., is president.

The **National Academy of Medicine** (formerly the Institute of Medicine) was established in 1970 under the charter of the National Academy of Sciences to advise the nation on medical and health issues. Members are elected by their peers for distinguished contributions to medicine and health. Dr. Victor J. Dzau is president.

The three Academies work together as the **National Academies of Sciences, Engineering, and Medicine** to provide independent, objective analysis and advice to the nation and conduct other activities to solve complex problems and inform public policy decisions. The National Academies also encourage education and research, recognize outstanding contributions to knowledge, and increase public understanding in matters of science, engineering, and medicine.

Learn more about the National Academies of Sciences, Engineering, and Medicine at www.national-academies.org.

The **Transportation Research Board** is one of seven major programs of the National Academies of Sciences, Engineering, and Medicine. The mission of the Transportation Research Board is to increase the benefits that transportation contributes to society by providing leadership in transportation innovation and progress through research and information exchange, conducted within a setting that is objective, interdisciplinary, and multimodal. The Board's varied committees, task forces, and panels annually engage about 7,000 engineers, scientists, and other transportation researchers and practitioners from the public and private sectors and academia, all of whom contribute their expertise in the public interest. The program is supported by state transportation departments, federal agencies including the component administrations of the U.S. Department of Transportation, and other organizations and individuals interested in the development of transportation.

Learn more about the Transportation Research Board at www.TRB.org.



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