FTA Report No. 0242

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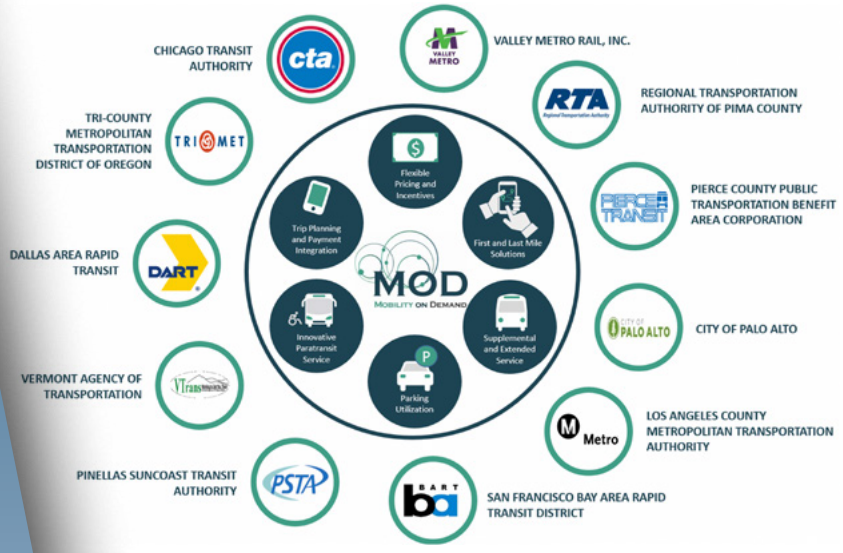
FEDERAL TRANSIT ADMINISTRATION

Synthesis Report: Findings and Lessons Learned from the Independent Evaluation of the Mobility on Demand (MOD) Sandbox Demonstrations



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U.S. Department of Transportation
Federal Transit Administration

FEBRUARY
2023

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Metric Conversion Table

SYMBOL	WHEN YOU KNOW	MULTIPLY BY	TO FIND	SYMBOL
LENGTH				
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
VOLUME				
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
NOTE: volumes greater than 1000 L shall be shown in m^3				
MASS				
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
TEMPERATURE (exact degrees)				
^oF	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	^oC

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
February 2023	Final	January 2017–September 2021

4. TITLE AND SUBTITLE

Synthesis Report: Findings and Lessons Learned from the Independent Evaluation of the Mobility on Demand (MOD) Sandbox Demonstrations

5a. CONTRACT NUMBER

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)

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5d. PROGRAM NUMBER

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESSE(ES)

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8. PERFORMING ORGANIZATION REPORT NUMBER

FTA Report No. 0242

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

U.S. Department of Transportation
Federal Transit Administration
Office of Research, Demonstration and Innovation
1200 New Jersey Avenue, SE,
Washington, DC 20590

US Department of Transportation
Office of the Assistant Secretary for Research and Technology
Intelligent Transportation Systems Joint Program Office (ITS JPO)
1200 New Jersey Ave., SE, Washington, DC 20590

10. SPONSOR/MONITOR'S ACRONYM(S)
FTA

11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12 . DISTRIBUTION/AVAILABILITY STATEMENT

Available from: National Technical Information Service (NTIS), Springfield, VA 22161; (703) 605-6000, Fax (703) 605-6900, email [orders@ntis.gov]; Distribution Code TRI-30

13. SUPPLEMENTARY NOTES [www.transit.dot.gov/research-innovation/fta-reports-and-publications] [https://www.transit.dot.gov/about/research-innovation] [https://doi.org/10.21949/1527655 Suggested citation: Synthesis Report: Findings and Lessons Learned from the Independent Evaluation of the Mobility on Demand (MOD) Sandbox Demonstrations. Washington, D.C.: United States Department of Transportation, 2022. https://doi.org/10.21949/1527655.

14. ABSTRACT

The Federal Transit Administration (FTA) Mobility on Demand (MOD) Sandbox effort developed around a vision of a multimodal, integrated, automated, accessible, and connected transportation system in which personalized mobility is a key feature. FTA selected 11 MOD Sandbox demonstration projects that tested strategies intended to advance the MOD vision. An independent evaluation (IE) is required by federal public transportation law 49 U.S.C. § 5312(e)(4) for demonstration projects receiving FTA Public Transportation Innovation funding.

This report provides a synthesis of findings from the 11 MOD Sandbox Demonstrations independent evaluation. The report presents an overview of the IE methodology and evaluation framework employed for developing test procedures and conducting the evaluations. Cross-cutting findings from the data analysis on user impacts and systems operations are explored alongside a variety of institutional factors that influenced project development and outcomes (data sharing, public-private partnerships, characteristics of service provision, cost-effectiveness, marketing of services). Considerations for future mobility innovation demonstration programs gathered through interviews with project partners are also included. Finally, site-specific summaries of findings from each of the 11 evaluations are shared in an appendix. The report offers transportation practitioners an overview of the impacts of the MOD Sandbox program and individual demonstration projects and gives insights for the planning, procurement, operations, and evaluation of technology-enabled mobility initiatives.

15. SUBJECT TERMS

Mobility on Demand, MOD, Evaluations, Shared Mobility, Public Transit Connections, Microtransit, Ride Sharing, Paratransit, Traveler Incentives, Trip Planning, Payment Integration, Accessibility, Public Private Partnerships, Transportation Network Companies

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			19b. TELEPHONE NUMBER
Unclassified	Unclassified	Unclassified	Unlimited	65	

Standard Form 298 (Rev. 8/98)
Prescribed by ANSI Std. Z39.18

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

Acknowledgments

ICF and the Transportation Sustainability Research Center (TSRC) of the Institute of Transportation Studies at the University of California, Berkeley, would like to thank the U.S. Department of Transportation for generously funding this study. The authors also thank the transportation professionals, public agencies, and service providers that made this research possible.

Abstract

The Federal Transit Administration (FTA) Mobility on Demand (MOD) Sandbox effort developed around a vision of a multimodal, integrated, automated, accessible, and connected transportation system in which personalized mobility is a key feature. FTA selected 11 MOD Sandbox demonstration projects that tested strategies intended to advance the MOD vision. An independent evaluation (IE) is required by federal public transportation law 49 U.S.C. § 5312(e)(4) for demonstration projects receiving FTA Public Transportation Innovation funding.

This report provides a synthesis of findings from the 11 MOD Sandbox Demonstrations independent evaluation. The report presents an overview of the IE methodology and evaluation framework employed for developing test procedures and conducting the evaluations. Cross-cutting findings from the data analysis on user impacts and systems operations are explored alongside various institutional factors that influenced project development and outcomes (data sharing, public-private partnerships, characteristics of service provision, cost-effectiveness, marketing of services). Considerations for future mobility innovation demonstration programs gathered through interviews with project partners are also included. Finally, site-specific summaries of findings from each of the 11 evaluations are shared in an appendix. The report offers transportation practitioners an overview of the impacts of the MOD Sandbox program and individual demonstration projects and gives insights for the planning, procurement, operations, and evaluation of technology-enabled mobility initiatives.

Executive Summary

Background

The Federal Transit Administration (FTA) Mobility on Demand (MOD) effort was developed around a vision of a multimodal, integrated, automated, accessible, and connected transportation system in which personalized mobility is a key feature. In 2016, FTA selected 11 MOD Sandbox demonstration projects to test strategies that advance the MOD vision. In partnership with public transportation agencies, the MOD Sandbox Program explored the potential for innovations to support and enhance public transportation services by allowing agencies to explore partnerships, develop new business models, integrate public transit and MOD strategies, and investigate new, enabling technical capabilities through demonstration projects.

Broadly, MOD Sandbox projects took several approaches including the development of new or improved trip planners, integration of innovative mobility services with traditional public transportation functions, and implementation of new integrated payment and incentive structures for travel using public transportation. Several MOD Sandbox demonstrations focused on improving first/last mile access to public transportation through collaboration with private sector operators including bikesharing, carpooling, ridesourcing/transportation network companies (TNCs), and other shared mobility operators. Many of the MOD Sandbox demonstrations explored public-private partnerships serving a variety of use cases including trip planning and payment integration, first and last mile strategies, supplemental and extended service, flexible pricing and incentives, innovative paratransit service, and parking utilization.

Evaluation Objectives and Principles

An independent evaluation (IE) is required by federal public transportation law 49 U.S.C. § 5312(e)(4) for demonstration projects receiving FTA Public Transportation Innovation funding. As part of this assessment, the independent evaluation sought to understand:

- Project impacts
- Achievement of project goals
- Lessons learned
- Needed policies
- Most successful business and partnership models
- Scalability of innovations considering a variety of context-specific variables (e.g., built environment, mode split)

The independent evaluation approach was driven by four FTA programmatic guiding principles:

1. **System Integration:** The MOD Sandbox integrates new technology into its existing infrastructure.
2. **Partnership Driven:** The MOD Sandbox is built upon a partnership between the participating public organization and at least one other public and/or private entity.
3. **Innovative Business Model:** The MOD Sandbox uses an innovative business model and fosters a marketplace that creates opportunity for further growth and development.
4. **Equity of Service Delivery:** The MOD Sandbox creates equitable mobility strategies that serve all customers and users, regardless of their socioeconomic status.

Evaluation Methods

The evaluation planning process developed a site-specific evaluation framework through interaction and coordination with the key stakeholders and players of the demonstration projects. This interaction and information-gathering phase informed the development of a logic model (a conceptual model that links the demonstration activities to outputs, outcomes, and impacts). Based on the project-specific goals, specific hypotheses for each site were developed. These hypotheses are generally grouped according to three categories:

- User impact hypotheses that measure changes to behavior, decisions, commute, or lifestyle of travelers
- System operational hypotheses that evaluate impacts on system operations or cost
- Institutional hypotheses that evaluate lessons learned and best practices from project stakeholders

The project-specific performance metrics were established in coordination with each MOD Sandbox project team based on the project goals and hypotheses during the development and revision of the project's logic model. Broadly, these performance metrics can be grouped in terms of (1) ridership, (2) travel behavior, (3) user satisfaction, (4) operational metrics, (5) financial metrics, and (6) environmental metrics.

Most of the site evaluations employed multimethod quantitative and qualitative approaches comprised of user and traveler surveys; interviews with project partners (i.e., expert interviews); and analysis of data from various sources including ridership data, energy data, activity data, and operational data (as defined in the report). Additionally, Americans with Disabilities Act (ADA) level of service assessments were conducted for demonstration projects that

introduced new, subsidized demand response service comparing service characteristics of wait (response) times and travel times for wheelchair accessible vehicle (WAV) trips and non-WAV trips.

Evaluation Findings

Evaluations were conducted for each of the 11 MOD Sandbox demonstrations. In many cases, site-specific evaluation plans created in consultation with project partners in early phases of the project were later modified to account for unanticipated changes to a project's scope or to the availability or format of data required to conduct the planned evaluation. In these cases, the best feasible evaluation alternative was employed and changes to the original evaluation plans were documented in subsequent plan addenda.

A selection of notable findings from the data analysis and from interviews conducted with project partners is highlighted below. Detailed findings are documented in the individual evaluation reports published on FTA's MOD Sandbox Program website: https://www.transit.dot.gov/research-innovation/mobility-demand-mod-sandbox-program.

Notable Findings from the Data Analysis

Addressing First Mile/Last Mile (FMLM) Challenges. Deployment of a microtransit system in Dallas led users to report improved public transit system connectivity, while deployment of a carpooling app in the San Francisco Bay Area improved use of that region's rail transit system by addressing overcrowding issues at area park-and-rides. Similarly, analysis of the Portland region's trip planner enhancements found effective routing performance to optimize pedestrian use of sidewalks and safe low-speed residential streets following inclusion of sidewalk data.

Improving Access and/or Travel Information for Customers with Disabilities. Introduction of an on-demand, curb-to-curb paratransit service and integrated planning, booking, and payment services led to an increase in mobility, accessibility, and travel activity for paratransit customers in Pinellas County, Florida. The evaluation also found that these customers experienced shorter wait and travel times as well as enhanced satisfaction with new payment options. Passengers with disabilities experienced improved access to transit and reduced travel times in Dallas as a result of microtransit service. Finally, disabled users of the Phoenix area's Pass2Go® trip planning app reported enhanced satisfaction and usability after the implementing agency hired an independent tester to improve digital accessibility and conform to Web Content Accessibility Guidelines (WCAG).

Improving Access for Disadvantaged Travelers. Low-income commuters participating in the Bay Area Fair Value Commuting (FVC) Demonstration

benefited more than their higher-income counterparts when savings were measured as a percentage of these groups' respective incomes. In the Puget Sound region of Washington, nearly all underserved residents surveyed about the region's FMLM ridesourcing service reported use of new integrated fare payment options that enabled riders to pay for trips with the ORCA card (the region's contactless smart card system for public transit). However, unbanked users reported a moderately lower adoption rate of this integrated fare payment option than other underserved groups surveyed.

Decreasing Personal Automobile Use. Analysis of carpooling activity from a carpooling app demonstrated by the Bay Area Rapid Transit (BART) Integrated Carpool to Transit Access project found that a considerable share of the app's users would have driven alone or traveled alone in a for-hire vehicle had the app not been available. Combined analysis of survey and trip activity data for the Bay Area FVC demonstration in the Silicon Valley found that the introduction of an integrated trip planning and travel incentives platform led to a 40% reduction in vehicle miles traveled (VMT). Similarly, the introduction of an on-demand FMLM service in the Tacoma area led to an estimated 30% VMT reduction; evidence from the analysis also suggested the service was influencing vehicle purchasing decisions. Additionally, 45% of surveyed users of a Dallas FMLM microtransit service reported shifting from personal or for-hire vehicles to reach public transit stations, while 11% indicated they would not have made the trip to transit. Conversely, surveyed users of an on-demand mobility service in the Tucson, Arizona, region did not indicate a reduction in personal automobile trips.

Providing and/or Improving Multimodal Trip Options with Enhanced Travel Information. Deployment of such systems resulted in improved ease of use, information accuracy, and overall experience in Dallas, faster trip options in Portland, and decreased planning and wait times in Phoenix. However, while the deployment of a trip planner that incorporated flexible trip planning options in Vermont led to an increase in viable trip options compared to conventional trip planning alternatives, results of a user survey found this did not result in increased public transportation ridership.

Decreasing Emissions and Fuel Consumption. Survey and trip activity data from the Bay Area FVC project showed that the total commute VMT, energy consumption, and carbon dioxide (CO_2) emissions decreased by 40%, 46%, and 10.2 metric tons, respectively. However, a similar analysis of VMT, energy consumption, and CO_2 emissions resulting from the introduction of FMLM ridesourcing service in the Los Angeles and Puget Sound regions found a net increase in each of these areas; these findings were significantly influenced by the high proportion of passenger-empty non-revenue miles of these services.

Decreasing the Overall Cost of Public Transit Systems. Microtransit service was found to be more cost-effective than low-ridership fixed route public transit in low-density areas of the Dallas region, but it was not more cost-efficient than the region's average fixed-route transit cost performance. Similarly, while WAV-enabled FMLM services in the Dallas region were more cost-effective than paratransit service on a per ride basis, they were less cost-effective than other publicly sponsored transportation options including fixed route buses, bikesharing, and vanpool. Finally, while on-demand service in the Tucson region provided services to users at a lower per-trip cost than other options, the per-trip cost to the implementing agency was substantially higher than conventional demand response transit services in the region.

Lessons Learned from Project Partners

A number of cross-cutting findings related to institutional and other lessons learned were identified during interviews with MOD Sandbox demonstration project partners. An overview of these findings is summarized below.

Forming and Managing Public-Private Partnerships. The primary lesson learned from the MOD Sandbox demonstrations involved public and private sector partnerships and vendor relationships. Several demonstrations (e.g., Chicago Transit Authority and Bay Area Rapid Transit District) emphasized that mergers, acquisitions, and changes in partner business models contributed to project delays, changes in partners and partnership terms, and in some cases cost overruns. Many demonstration sites noted challenges working with TNCs/ridesourcing and technology vendors, such as over promising and under delivering and the inability to move forward with partnerships due to challenges agreeing to data sharing terms. Some demonstrations also reported their satisfaction with public-private partnerships because they allowed their agencies and service providers to work together and overcome challenges.

Data Sharing. Many demonstration sites noted challenges in working with private vendors, particularly related to contracting and data agreements with TNCs/ridesourcing. In some cases, partners were unable to agree to terms. In others, partners employed a range of techniques to more narrowly tailor data sharing requests to include less frequent reporting, more aggregate data reporting, and higher levels of geospatial data to protect consumer and proprietary vendor information.

Demand-Responsive Service Areas. Some demonstration sites noted challenges building ridership for demand-responsive service within areas lacking mixed-use land development. Other demonstrations, such as Tucson, noted affluence and near ubiquitous vehicle ownership coupled with very low-density and lack of mixed-uses can present notable challenges for demand-responsive MOD service. Many demonstrations emphasized the importance of

rightsizing fleets (i.e., number of vehicles), vehicle sizes, and service area sizes (i.e., geography served). A few demonstrations also emphasized the importance of creating a service area that connects to high-capacity fixed route transit service.

Equity and Accessibility. Several demonstration sites expressed concern that private sector goals focused on optimizing operations and business potential may conflict with public sector equity and accessibility goals. MOD Sandbox demonstrations revealed that private-sector partners may be less interested in providing services perceived as less profitable, such as lower density/lower ridership areas, lower income neighborhoods, late-night service times, and services for people with disabilities.

Customer Awareness of Services. Education, outreach, and knowledge of consumer interactions are key to effectively marketing services. Employing community engagement that introduces a pilot can help build an early user base. Social service organizations can also leverage MOD services to provide trip planning and transportation services for their clients.

In addition to challenges encountered, multiple project partners reported that the MOD Sandbox was instrumental in testing new service models and that demonstrations would not have been possible without FTA funding and institutional support.

Programmatic Takeaways

The evaluation of the MOD Sandbox demonstrations identified a number of practices that could make similar projects more replicable in additional locations. First, the evaluation identified the importance of flexible contracting terms, which allow projects to be more agile and responsive so partners and vendors may pivot more readily in response to institutional and customer needs or goals. Second, the evaluation found that public agencies should dedicate time and resources to stakeholder engagement. Several MOD demonstrations noted the stakeholder engagement process was more involved and time-consuming than expected. These demonstration sites emphasized the importance of engagement that incorporates institutional and public feedback at the right times in the planning process. They also encouraged smaller and more focused stakeholder engagement to obtain feedback on specific demonstration components (e.g., cash payment alternatives, wheelchair accessible vehicle access). Finally, the evaluation highlighted the limited public sector technical expertise to deploy fare payment and trip planning integration. Conducting an internal public-private partnership feasibility assessment prior to commencing a project can help to ensure that a partnership augments and fills identified technical and institutional gaps prior to its execution.

The evaluation team concluded that more research and guidance are needed to better understand:

- Policies and practices to prepare for MOD automated vehicle deployments, and their impacts on public transportation
- Potential impacts, opportunities, and challenges of artificial intelligence and machine learning
- Life cycle cost estimation of MOD
- Impacts of MOD on communities (e.g., land use, travel behavior)
- Physical and digital infrastructure needed to support MOD
- Guidance for incorporating MOD into modeling and scenario planning
- Best practices for ensuring MOD meets the needs of all users (e.g., definitions of equity, overcoming technology and banking challenges)

Section 1 Introduction

Overview of MOD Sandbox Demonstrations

The Federal Transit Administration (FTA) Mobility on Demand (MOD) effort developed around a vision of a multimodal, integrated, automated, accessible, and connected transportation system in which personalized mobility is a key feature. As detailed in Table 1-1, FTA selected 11 MOD Sandbox demonstration projects in 2016 that tested strategies to advance the MOD vision. In partnership with public transportation agencies, the MOD Sandbox Program demonstrated the potential for innovations to support and enhance public transportation services by allowing agencies to explore partnerships, develop new business models, integrate transit and MOD strategies, and investigate new, enabling technical capabilities.

Table 1-1 *Overview of MOD Sandbox Projects*

Region	Project	Description
Chicago, IL	Incorporation of Bikesharing Company Divvy	Releases updated version of Chicago Transit Authority's (CTA) existing trip planning app. New version incorporates Divvy, a bikesharing service, and allows users to reserve and pay for bikes within the app.
Dallas, TX	Integration of Shared-Ride Services into GoPass Ticketing Application	Releases updated version of Dallas Area Rapid Transit's (DART) existing trip planning app. Updated version incorporates shared-ride services to provide first/last mile connections to public transportation stations and allows users to pay for services within the app.
Los Angeles and Puget Sound	Two-Region Mobility on Demand	Establishes partnership between Via and LA Metro. Via provides first/last mile connections for passengers going to or leaving from transit stations. There is a companion project in Seattle.
Phoenix, AZ	Smart Phone Mobility Platform	Releases updated version of Valley Metro's existing trip planning app. New version updates trip planning features and enables payments.
Pinellas County, FL	Paratransit Mobility on Demand	Improves paratransit service by combining services from taxi, ridesourcing/TNCs, and traditional paratransit companies.
Portland, OR	OpenTripPlanner Shared Use Mobility	Releases updated version of TriMet's existing multimodal app. New version offers more sophisticated functionality and features, including options for shared mobility.
San Francisco Bay Area	Bay Area Fair Value Commuting (Palo Alto)	Reduces single-occupant vehicle (SOV) use within Bay Area through commuter trip reduction software, a multimodal app, workplace parking rebates, and first/last mile connections in areas with poor access to public transportation.
	Integrated Carpool to Transit (BART System)	Establishes partnership between Scoop and Bay Area Rapid Transit (BART). Scoop matches carpoolers and facilitates carpooling trips for passengers going to or leaving from BART stations with guaranteed parking.

Table 1-1 (cont.) *Overview of MOD Sandbox Projects*

Region	Project	Description
Tacoma, WA	Limited Access Connections	Establishes partnerships between local ridesourcing companies/ TNCs and Pierce Transit. Ridesourcing companies provide first/last mile connections to public transportation stations and park-and-ride lots with guaranteed rides home.
Tucson, AZ	Adaptive Mobility with Reliability and Efficiency	Builds integrated data platform that incorporates ridesourcing/ TNC and carpooling services to support first/last mile connections and reduce congestion.
Vermont	Statewide Transit Trip Planner	Releases new multimodal app for VTrans that employs fixed and flexible (non-fixed) transportation modes to route trips in cities and rural areas.

Broadly, MOD Sandbox projects took several approaches including the development of new or improved trip planners, integration of innovative mobility services with traditional public transportation functions, and implementation of new integrated payment and incentive structures for travel using public transportation. Several Sandbox projects focused on improving first/last mile access to public transportation through collaboration with private sector operators, including bikesharing, carpooling, ridesourcing/ transportation network companies (TNCs), and other shared mobility operators. As shown in Table 1-2, many of the MOD Sandbox demonstrations explored public-private partnerships serving a variety of use cases, including trip planning and payment integration, first and last mile solutions, supplemental and extended service, flexible pricing and incentives, innovative paratransit service, and parking utilization.

Table 1-2 *Cross-cutting Use Cases*

Lead Organization	Trip Planning/ Payment Integration	First Mile/ Last Mile (FMLM)	Supplemental/ Extended Services	Flexible Pricing / Incentives	Innovative Paratransit Services	Parking Utilization
Chicago Transit Authority (CTA)	X	X				
Dallas Area Rapid Transit (DART)	X	X	X			
Los Angeles Metro	X	X				
City of Palo Alto				X		
Pierce Transit		X	X			X
Regional Transportation Authority (RTA) of Pima County	X	X	X	X		

Table 1-2 (cont.) *Cross-cutting Use Cases*

Lead Organization	Trip Planning/ Payment Integration	First Mile/ Last Mile (FMLM)	Supplemental/ Extended Services	Flexible Pricing / Incentives	Innovative Paratransit Services	Parking Utilization
Pinellas Suncoast Transit Authority (PSTA)	X				X	
Bay Area Rapid Transit (BART)		X		X		X
Tri-County Metropolitan Transportation District (TriMet)	X	X				
Valley Metro	X	X				
Vermont Agency of Transportation (Vtrans)	X	X	X			

More information about the MOD Sandbox Program can be found at https://www.transit.dot.gov/research-innovation/mobility-demand-mod-sandbox-program.

Synthesis Report Overview

An independent evaluation (IE) is required by federal public transportation law 49 U.S.C. § 5312(e)(4) for demonstration projects receiving FTA Public Transportation Innovation funding. The IE for the MOD Sandbox demonstration projects was sponsored by the USDOT Intelligent Transportation Systems Joint Program Office (ITS JPO) and FTA.

As part of this assessment, the independent evaluation sought to understand:

- Project impacts
- Achievement of project goals
- Lessons learned
- Needed policies
- Most successful business and partnership models
- Scalability of innovations considering a variety of context-specific variables (e.g., built environment, mode split)

This report presents a synthesis of the findings and results of the independent evaluation of the MOD Sandbox demonstrations. The report is organized into five sections. The first section summarizes the methods employed as

part of the independent evaluation. The second section summarizes notable findings from the quantitative analysis of the MOD Sandbox demonstrations, broadly categorized into user impacts and systems operations impacts. The third section describes lessons learned from conducting interviews with project partners. The fourth section provides considerations for future similar programs. Finally, the fifth section (appendix) offers short summaries of site-specific findings for each of the 11 MOD Sandbox demonstrations. Ultimately, the evaluation of each project's benefits and impacts seeks to guide the future implementation of mobility innovations throughout the country.

Section 2 Evaluation Methodology and Framework

The independent evaluation approach was driven by four FTA programmatic guiding principles:

1. **System Integration:** The MOD Sandbox integrates new technology into its existing infrastructure.
2. **Partnership Driven:** The MOD Sandbox is built upon a partnership between the participating public organization and at least one other public and/or private entity.
3. **Innovative Business Model:** The MOD Sandbox uses an innovative business model and fosters a marketplace that creates opportunity for further growth and development.
4. **Equity of Service Delivery:** The MOD Sandbox creates equitable mobility strategies that serve all customers and users, regardless of their socioeconomic status.

Table 2-1 provides an overview of how each MOD Sandbox demonstration project fulfils the four guiding principles of System Integration, Partnership Driven, Innovative Business Model, and Equity of Service Delivery.

Table 2-1 *Guiding Principles Overview*

Region / Lead Organization	System Integration	Partnership Driven	Innovative Business Model	Equity of Service Delivery
Chicago / CTA	Integrates Divvy bikeshare into the Ventra app	Ventra partners with Divvy	Uses Ventra application to capitalize on existing infrastructure of Divvy bikeshare	Leverages Ventra app to allow users to have access to Divvy bike rentals
Dallas / DART	Integrates microtransit (GoLink) and a TNC into DART's regional mobile application GoPass	Dallas Area Rapid Transit partners with microtransit service provider and TNC	Employs GoPass planning, ticketing, and payment app to reserve and pay for microtransit trips and implement a soft integration into TNC app	Integrates wheelchair accessible GoLink vehicles, and mobility application and account-based fare payment systems to accommodate unbanked users
LA County & Puget Sound Region / LA Metro	Integrates Via rides into regional transit payment cards (TAP and Orca, respectively)	LA County and Puget Sound partner with Via	Provides Via as a publicly supported first/last mile option	Provides subsidies for riders and addresses needs for Limited English Proficiency users and those without smartphones

Table 2-1 (cont.) *Guiding Principles Overview*

Region / Lead Organization	System Integration	Partnership Driven	Innovative Business Model	Equity of Service Delivery
San Francisco Bay Area / City of Palo Alto	Uses mobility aggregation	Leverages a consortium of Silicon Valley municipalities	Uses a "six-way win" of mutual benefit	Provides low-income commute gap-filling work
Pierce County, WA / Pierce Transit	Offers riders a selection of mobility options familiar to most of the region's transit customers	Pierce Transit, Pierce College Puyallup, and Sound Transit partner with rideshare organizations	Offers cost-effective method to overcome temporal and geographic travel barriers	Increases equitable geographic access to transit
Pima County (Tucson), AZ / RTA of Pima County	Integrates three multimodal transportation services	Partners include RTA, Metropia, RubyRide TNC/ ridesourcing, and other stakeholders	Transports residents of a low-density neighborhood more efficiently	Encourages users to donate unused ride credits to charity
Pinellas County, FL / PSTA	Integrates overarching software by TransLoc	United Taxi partners with CareRide, develops a new partnership with Lyft	Increases efficiency through flexible and responsive mode choices	Provides service to more than 12,500 eligible ADA paratransit customers
San Francisco Bay Area / BART	Targets transit facilities as a destination and integrates BART's parking payment and reservation system	Scoop (private sector) partners with MTC and BART (public sector)	Targets transit facilities instead of employment centers as focal point for destinations and origin	Implements service equally at all 33 BART stations, with parking facilities in four Bay Area counties
Portland, OR / TriMet	Integrates shared-use mobility (SUM) options in the OpenTripPlanner (OTP)	Two public transportation agencies partner with three for-profit organizations	Uses OTP to create multiple shared-use mobility options for all users	Allows for more pedestrian and wheelchair access
Phoenix, AZ / Valley Metro	Allows Valley Metro Mobility Platform to build upon Ridekick app to produce multimodal Pass2Go app; adds transit fare payment to Pass2Go app	Valley Metro partners with TNCs to develop public-private partnerships	Employs a combination of OTP SUM platform and GR:D bikeshare to give users multiple transit forms	Uses smartphones to enhance trip planning and payment methods for smartphone users
Vermont / VTrans	Permits the trip planner to use an emerging open data specification, GTFS-Flex	Private and public partners who have worked together for years	Uses OTP SUM platform, combined with GTFS-Flex data	Develops a trip planner that works well in rural areas

The evaluation planning process developed a site-specific evaluation framework through interaction and coordination with the key stakeholders and players of the demonstration projects. This interaction and information-gathering phase informed the development of a logic model (a conceptual model that links the demonstration activities to outputs, outcomes, and impacts). The approved logic models and stakeholder engagement informed the development of draft and final evaluation plans for each site. Evaluation plans can be accessed at https://www.transit.dot.gov/research-innovation/mobility-demand-mod-sandbox-program. Each evaluation plan is comprised of the following components:

- Project background
- Project goals
- Evaluation hypotheses
- Performance metrics used to measure hypotheses
- Data sources required to evaluate demonstration hypotheses
- Qualitative and quantitative methods of evaluation

Based on the project-specific goals, specific hypotheses for each site were developed. From an overall perspective, the test hypotheses can be generally grouped according to the following three categories:

- User impact hypotheses that measure changes to behavior, decisions, commute, or lifestyle of travelers
- System operational hypotheses that evaluate impacts on system operations or cost
- Institutional hypotheses that evaluate lessons learned and best practices from project stakeholders

Table 2-2 lists the projects and their associated hypothesis categories.

Table 2-2 *MOD Sandbox Projects and Hypothesis Categories*

	User Impact						Systems Operations			Institutional
	Addresses FMLM issues	Improves and/or simplifies payment process	Improves access and/or process for customers with disabilities	Improves accessibility for the disadvantaged	Decreases personal automobile use	Reduces wait and/or travel times	Provides and/or improves multimodal trip options	Decreases emissions/ fuel consumption	Decreases overall cost of public transit system	Uses public-private partnership
CTA	X	X	X	X	X		X			X
DART	X	X	X	X	X	X	X	X	X	X
LA Metro / Puget Sound	X	X	X	X		X	X		X	X
Palo Alto	X			X	X		X	X		X
Pierce Transit	X		X		X	X	X	X	X	X
RTA of Pima County	X		X	X	X	X	X	X		X
PSTA		X	X			X			X	X
BART	X				X		X	X		X
TriMet	X		X		X	X	X	X		X
Valley Metro	X	X	X		X	X	X	X		X
VTrans	X			X	X	X	X	X		X

The project-specific performance metrics were established in coordination with each MOD Sandbox project team based on the project goals and hypotheses during the development and revision of the project's logic model. Broadly, these performance metrics can be grouped in terms of (1) ridership, (2) travel behavior, (3) user satisfaction, (4) operational metrics, (5) financial metrics, and (6) environmental metrics. Table 2-3 summarizes the performance metrics that were applied across all 11 sites.

Table 2-3 *Select Cross-reference of Generalized Performance Measurement Categories*

Project	Transit Ridership	SOV VMT	Shared Ride VMT	Vehicle Occupancy	Travel Times	Transit Travel Wait Times	Travel Time Flexibility	Accessibility for Persons with Disabilities	Transit System Operating and Capital Cost	Parking Utilization	Accessibility for Disadvantaged Populations	User Satisfaction	User Costs	Access to Destinations
CTA	X						X				X	X	X	
DART	X	X	X		X	X		X	X			X	X	X
LA Metro / Puget Sound	X		X		X			X	X		X	X	X	X
Palo Alto	X	X	X	X							X		X	
Pierce Transit	X	X			X			X				X	X	X
RTA of Pima County	X	X	X					X	X				X	X
PSTA	X				X	X	X	X	X			X		X
BART	X	X	X	X			X			X			X	
TriMet						X	X	X				X		
Valley Metro					X	X		X				X	X	X
VTrans	X						X		X		X	X		X

Most of the site-specific evaluations employed multimethod quantitative and qualitative approaches. Figure 2-1 highlights cross-cutting examples of qualitative and quantitative data sources used in the evaluation, which are then described in more detail below.

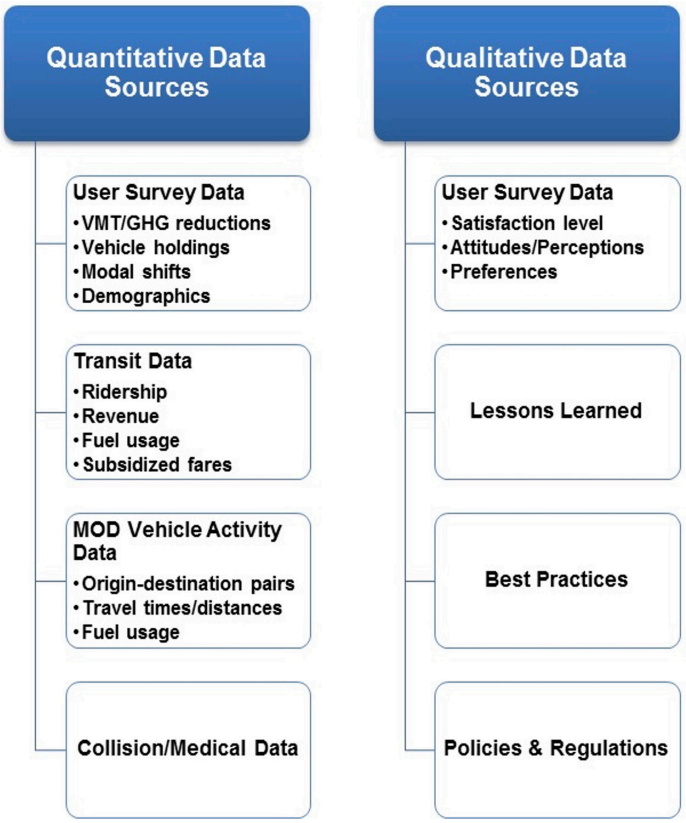


Figure 2-1 *Breakdown of data types*

User and Traveler Surveys: User and traveler surveys consisted of surveys of people who were using the applications and services being developed, augmented, and/or deployed by the project teams. The site-specific evaluation plans detailed the population to be surveyed, the steps required to conduct the survey, and the general analytic approach to be taken with the data. Surveys were proposed for the population that was directly impacted by the demonstration project. In addition, general population surveys that were collected separately by public transit agencies as part of their routine operation may have been used as supporting control surveys where they were available, and when their application may have supported the evaluation.

Ridership Data: Ridership data consist of public transit ridership data. Data were requested from agencies in cases where impacts on ridership were to be measured. Ridership data were also collected as a data type for control, to evaluate impacts of the project in the context of ridership that may be

increasing or declining. Being a broader measure of activity, ridership data were requested over longer historical periods. This allowed the IE team to assess whether observed trends were potentially the result of the project or part of a longer trend occurring over the course of years.

Energy Data: Energy and fuel data were collected in cases where the analysis of substantive energy impacts on the transit agency were likely. For example, the reduction of certain services may be implemented in substitution of new experimental services. Taking the example of paratransit, the reduction of conventional paratransit services in substitute of alternative service delivery may result in a net fuel consumption (and emissions) impact. Energy data would be collected from transit agencies where such measurements were relevant. Further, energy impacts may occur from changes in individual travel behavior. Unfortunately, fuel consumption of personal vehicles is not directly measurable. When necessary and relevant, changes in fuel consumption of personal vehicles were estimated based on anticipated changes in miles driven (such as in the BART project with SCOOP).

Activity Data: Activity data can cover a wide variety of data types, the most common type being traveler activity data. This consisted of data describing the movements of people as recorded on smartphone apps. These data, while anonymized, provided high resolution information on movements that could be translated into mode used, travel times, wait times, and other critical evaluation data. Most activity data of this kind is new to research, and methods of processing and analysis are experimental and cutting edge. But effective use of activity data for the analysis of travel behavior impacts provides insights that no other resource can.

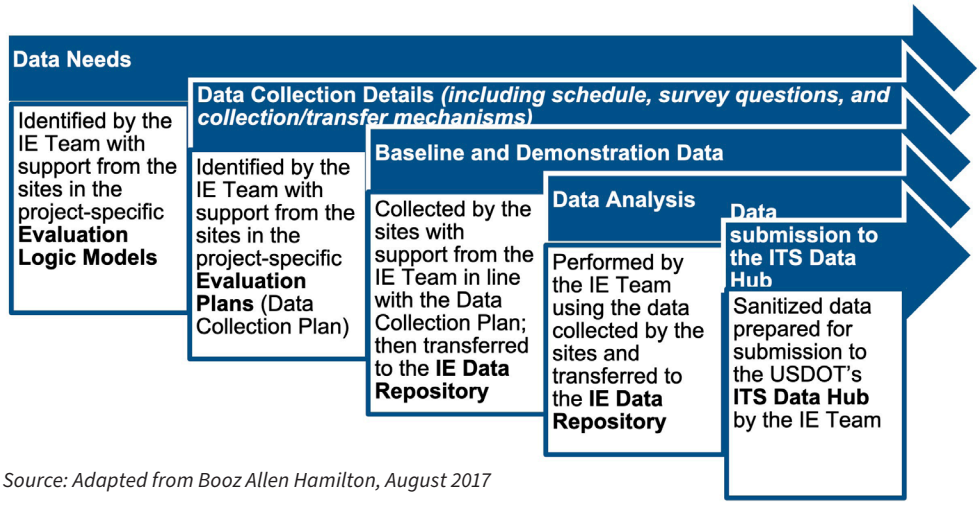
Operational Data: Operational data describe how a system is performing. For example, operational data may describe bus, light rail frequency, or paratransit activity. They also could describe online activity, such as payment data, hits to a website, geocoding accuracy, or other comparative measures of system activity. These data were important inputs for evaluating performance, particularly in cases where the project was more focused on development than deployment, such as with TriMet.

Expert Interviews: Interviews with project stakeholders played a key role in the evaluation and covered lessons learned from the experience of the project. The interviews were conducted with at least three project stakeholders to gain their qualitative perspective of what worked well and what could have worked better. While subjective in nature, some of the most important lessons learned emerged from talking to those directly involved with the ups and downs of the project.

ADA Equivalent Level of Service Assessment for New Demand Responsive Service: FTA identified sites requiring an Americans with Disabilities Act (ADA) equivalent level-of-service assessment for the MOD Sandbox demonstrations that included subsidized, new demand response service. Those sites included:

- DART (partnering with MV Transit [GoLink])
- LA Metro / Puget Sound (partnering with Via)
- Pierce Transit (partnering with Lyft)
- RTA of Pima County (partnering with RubyRide)
- PSTA (partnering with Lyft)

From an overall perspective, the general steps followed for data collection across the entire evaluation are summarized in Figure 2-2. Final evaluation plans for each of the 11 MOD Sandbox demonstrations are available at https://www.transit.dot.gov/research-innovation/mobility-demand-mod-sandbox-program.



Source: Adapted from Booz Allen Hamilton, August 2017

Figure 2-2 *Overall data collection framework*

The methodological approach of the evaluation focused on assessing the behavioral and operational impacts of the projects as they were deployed. The independent evaluation team analyzed each hypothesis within the logic model framework and determined the degree to which it was supported, mostly supported, partially supported, not supported, or inconclusive. Many of the MOD Sandbox demonstrations focused on evaluating behavioral change resulting from operational change. The operational change may service first/last mile access, facilitate better paratransit mobility, or improve access to or from shared mobility modes.

Section 3 Notable Findings from the Data Analysis

This section summarizing notable findings from the data analysis is organized into two subsections. First, findings from the social and behavioral analysis (user impacts) that were obtained through surveys and activity data analysis are reviewed. Next, findings from the operational analysis are reviewed.

The findings described in this section follow the structure of hypotheses categories described in Table 2-2. It is important to note that the findings in the following sections are not exhaustive and are merely illustrative of the types of impacts these projects have had. Appendix A provides summaries of the evaluation results for each of the MOD Sandbox demonstration projects, along with additional information for each site. The details and full evaluation results may be found in the evaluation reports for each site, which are available at https://www.transit.dot.gov/research-innovation/mobility-demand-mod-sandbox-program. A comparative summary of findings across all sites for key performance metric categories are summarized in Table 3-1.

Table 3-1 *Evaluation Summary of Generalized Performance Measurement Categories*

Project	Ridership	SOV VMT	Shared Ride VMT	Vehicle Occupancy	Travel Times	Travel Wait Times	Travel Time Flexibility	Accessibility for Persons with Disabilities	Transit System Operating and Capital Cost	Parking Utilization	Accessibility for Disadvantaged Populations	User Satisfaction	User Costs	Access to Destinations
CTA	■						■				■	■	■	
DART	●	●	◎		●	●		●	●			●	●	●
LA Metro	●		◎		●	●		●	◉		●		●	●
Puget Sound	●		◎		●	●		●	◉		●	●	●	●
Palo Alto	●	●	●	●							●		■	
Pierce Transit	◎	●			◉	●		■	●	◉		●	■	●
RTA of Pima County	■	◎	■					■	■				◉	■
PSTA	●				●	●	●	●	■			●		●
BART	●	●	●	◉			●			●			●	
TriMet					●	●	●	●				●		◍
Valley Metro					◉	●		■	●			●		●
VTrans	◎						●		◉			◎		■

KEY: ● Supported; ◍ Mostly Supported; ◉ Partially Supported; ◎ Not Supported; ■ Inconclusive
Note: Blank cells without a symbol indicate a performance measure was not evaluated as part of a demonstration's evaluation.

User Impacts

The following findings (text identified in bold) from the social and behavioral analysis are provided about user-related impacts across the demonstration projects.

Findings Related to FMLM Challenges

Microtransit service improved FMLM connectivity in Dallas. As a part of its First and Last Mile Solution MOD Sandbox project, DART implemented GoLink, an on-demand microtransit shuttle service across three zones in the Plano, Texas, area for point-to-point travel within a given zone and FMLM travel to or from a DART transit station. The user survey showed greater FMLM connectivity with the DART transit system after using GoLink.

The TriMet OTP was enhanced with improved sidewalk data and pedestrian routing. The evaluation explored whether sidewalk data was accurate and whether the OpenTripPlanner effectively provided safer pedestrian routing using random origin/destinations. The analysis found effective routing performance to optimize pedestrian use of sidewalks and safe low-speed residential streets. Street segments were assessed for sidewalk data accuracy using streetscape imagery (e.g., Google Street View), which found 96% of the observations were correct. The incorrect observations reported no sidewalks when sidewalks in fact existed. Overall, the sidewalk data and pedestrian attribute functionality performed very well.

Due to implementation of the Valley Metro Pass2Go app, transit customers increased their use of first mile/last mile modes through measured activity. The frequency of use of connecting modes to/from public transportation increased to a degree that is statistically significant.

BART's carpooling app resulted in increased transit ridership. User survey data revealed that Scoop (a carpooling app) helped increase the frequency of transit use.

Findings Related to Improving Access and/or Travel Information for Customers with Disabilities

An integrated platform and app that provided on-demand curb-to-curb service led to multiple improvements for Pinellas County, Florida, paratransit customers. User survey and trip activity data showed an increase in mobility, accessibility, and travel activity for paratransit customers as a result of the new system. These users also reported shorter wait and travel times, as well as enhanced satisfaction with the new e-wallet payment options.

Microtransit improved access to transit for customers with disabilities in Dallas. DART GoLink's passengers with disabilities experienced improved access to transit and reduced travel times. All survey respondents with disabilities considered their access to DART as average or above average, and the average in-vehicle travel time of all GoLink wheelchair accessible vehicle (WAV)[1] trips was consistently faster than the analogous fixed route travel times during the evaluation period. Additionally, a comparison of travel times and wait times for WAV passengers and non-WAV passengers using the GoLink service suggests a relatively common range of experiences.

Trip Planning app's users with disabilities found that trip planning methods were improved for Valley Metro. Most users with disabilities of the Pass2Go app reported improvements in their trip planning capabilities due to the app, although this sample size of respondents was not large.

Findings Related to Improving Access for Disadvantaged Travelers

Passing on benefits of non-single occupancy vehicles to lower income users. The City of Palo Alto and Bay Area Fair Value Commuting (FVC) demonstration project benefitted lower-income workers more than higher-income workers. The savings experienced by lower-income participants were higher as a percentage of their income relative to higher-income participants.

Underserved populations in the Puget Sound, Washington, region widely adopted integrated fare payment options to pay for shared ridesourcing service. Nearly all underserved populations surveyed used the region's contactless public transit smart card, ORCA, to pay for the FMLM shared ridesourcing service being demonstrated, indicating widespread usage of the payment mechanism and equity in terms of payment accessibility. However, some underserved people experienced difficulty using the ORCA card when paying for Via to Transit service. This was most pronounced for unbanked individuals, although it was not drastically different from the full sample.[2]

Findings Related to Decreasing Personal Automobile Use

Adoption of a carpooling-to-transit app helped reduced single occupancy driving to BART stations. Analysis of carpooling activity from the Scoop app showed that a Scoop carpool vehicle had an average of 2.41 carpooling passengers per trip for every vehicle parked at participating BART stations.

[1] All GoLink vehicles were wheelchair accessible

[2] King County Metro noted that the fare collection devices in the vehicles were at the end of their life cycle and were often faulty. As a result, the reported difficulty in using the ORCA card to pay for Via could be interpreted several ways. One possibility was that the devices were not working. Another was that there could have been difficulty loading money onto an ORCA card. A third possible explanation could have been the expense of fare. The reasons for these difficulties were not clear.

The evaluation also found that a considerable share of Scoop users would have driven alone or traveled in a single-occupant vehicle (including TNCs/ridesourcing) had Scoop not been available.

Use of an integrated trip planning and travel incentives platform by Silicon Valley commuters led to a 40% reduction in VMT. Combined analysis of survey and trip activity data showed that the total commute vehicle miles traveled for participating employees decreased by 40% as a result of the demonstration. Survey responses showed this decrease in driving was accompanied by a significant increase in alternative modes use such as public transit, personal bicycle, walk, and carpool.

Introduction of FMLM service in the Tacoma area led to an estimated 30% VMT reduction and substituted for personal vehicle trips. When factoring for mode shift and trip substitution resulting from the introduction of FMLM service, as well as VMT generated by FMLM service itself, an estimated 30% reduction in net VMT was observed. Additionally, one user reported getting rid of a personal vehicle as a result of the demonstration, while some in the post-demonstration survey reported they acquired a car or were considering doing so because the program ended. These factors suggest the service was at least partially substituting for the mobility provided by a personal vehicle.

Microtransit helped shift FMLM trips from personal cars to DART stations. Respondents to DART GoLink's user survey who made FMLM trips to DART stations were asked to identify how they would have made their trip prior to the existence of GoLink. A notable portion of respondents would have driven in a personal car (25%), taken a taxi, Uber, or Lyft vehicle (20%), or would not have made the trip (11%) prior to the implementation of the GoLink service.

Carpooling integration with a trip planning app failed to attract carpoolers in low-density area of Dallas. The evaluation sought to determine whether improvements to GoPool resulted in an increase in carpool travel to DART services. The survey results of GoPass app users showed that a very small percentage (5%) indicated they would have replaced a trip previously made through carpooling or vanpooling.

Integrated multimodal deployment failed to reduce personal automobile use in Pima County. The Adaptive Mobility with Reliability and Efficiency (AMORE) project for Pima County, Arizona, sought to form an integrated multimodal, community circulation-based mobility service that could be accessed, paid for, and managed through a single platform. The user survey had little evidence to suggest that the project reduced the use of personal automobile trips. Trips were also generally single occupant or conducted by members of the same household. As a result of this dynamic, and the fact

that there was a significant overlap of origins and destinations, there is little evidence to suggest that users reduced the use of personal automobiles because of the project.

Systems Operations

The following findings involve impacts related to systems operations across the demonstration projects.

Findings Related to Providing and/or Improving Multimodal Trip Options

DART's GoPass app integration increased multimodal trip options. The implementation of GoLink microtransit service and its inclusion on the GoPass app in DART's MOD Sandbox project expanded the geographic scope of locations reachable by DART services. It increased transit coverage in the Plano, Texas, region from 44% to 82%. Nearly all of DART's user survey respondents had above average experiences with the GoPass app in terms of ease of use, information accuracy, and overall experience, which indicates that it improved the transportation options for users.

Incorporating shared mobility into trip planning led to faster travel times by users in Portland, Oregon. A key objective of the TriMet OTP Shared-Use Mobility MOD Sandbox project was to incorporate shared mobility options into existing trip planning services. The evaluation sought to measure travel times for origin-destination pairs in OTP using shared-use mobility (SUM) options compared to travel times for identical origin-destination pairs using conventional trip planners that did not incorporate SUM options. The analysis found that the OpenTripPlanner with SUM options produced consistently faster trip times than options provided by more conventional transit trip planning applications that lacked SUM options.

Valley Metro's Pass2Go app helped reduce the average planning and wait times for users and increased connectivity. The Pass2Go app for Valley Metro showed a significant decrease in planning and wait times for bus and rail trips; a sizable minority reported that the app had reduced their planning and wait times. The rating of Pass2Go app's ability to connect to/from public transportation increased and a sizable majority reported improved access to public transportation due to the app.

The Go! Vermont trip planner effectively provided options for flexible public transit travel but failed to increase transit use. The Go! Vermont trip planner was tested using a sample of origins and destinations within Vermont to evaluate performance in delivering viable public transit options to complete a trip. The results found that on average the planner could provide more viable

travel options than a leading conventional trip planner. All respondents to the survey for the Go! Vermont trip planner reported that their use of public transit was about the same due to the trip planner, suggesting that transit ridership was not influenced by the trip planner.

Findings Related to Decreasing Emissions/Fuel Consumption

Incentivizing non-SOV (single-occupant vehicle) commutes reduced VMT, energy consumption, and CO_2 emissions in the San Francisco Bay Area. Survey and trip activity data from the Bay Area Fair Value Commuting project showed that the total commute VMT, energy consumption, and CO_2 emissions decreased by 40%, 46%, and 10.2 metric tons, respectively.

FMLM shared ridesourcing service (Via) led to a net increase in VMT, energy consumption, and CO_2 emissions in the Los Angeles and Puget Sound regions. When accounting for vehicle miles traveled, passenger miles traveled (PMT), vehicle fuel economy, and mode substitution rates, the analysis found that FMLM deployments of Via in both regions resulted in increased emissions, gasoline consumption, and VMT compared to travel prior to the demonstration. The fact that a majority of Via's VMT were passenger-empty, non-revenue miles contributed significantly to this finding for both regions.

Findings Related to Decreasing Overall Cost of Transit Systems

Microtransit was more cost-effective than fixed route transit in low-density areas of Dallas. DART replaced a low ridership fixed route bus service in the Legacy West region of Plano, Texas, which required a subsidy of about $33.71 per rider. GoLink microtransit shuttles performed with an average subsidy per rider of $16.37. This comparison shows that GoLink had lower operational costs than low-ridership fixed route transit, which is operational within the same low-density environment. Across the entire DART system, the subsidy per rider for fixed route transit was $6.80 and for buses system-wide it was $8.28. Hence, GoLink's cost performance exceeded that of low ridership routes, but it was not more efficient than the DART system fixed route average cost performance.

In the Los Angeles and in the Puget Sound regions, shared ridesourcing FMLM subsidies were most cost-effective on an hourly basis, **but less cost-effective on a per trip basis**. When compared to the average performance of the LA Metro and King County Metro systems, Via to Transit service in both regions had relatively low cost per revenue hour. Comparisons were less favorable in both regions on a per trip basis, where the average cost per trip for Via to Transit service was higher than the average cost for other modes. However, shared ridesourcing FMLM costs in both regions were within range of and perhaps competitive to specific routes or regions where fixed route transit

operated but did not carry a significant number of passengers (e.g., lower ridership fixed route bus services).

Implementing a subscription-based transit hailing service increased the cost of operations in Pima County. The Regional Transportation Authority of Pima County's AMORE project provided services to users at lower per-trip costs than other options, but the cost-effectiveness of trips to the agency was unfavorable. AMORE trip costs were affordable and competitive to most other modes, and many of the trips were free to users. The cost of the project on a per trip basis suggests that agency spending per trip was not competitive with the average per trip operating expenses of conventional demand responsive transit within the region.

Findings related to the institutional hypothesis category are described in Section 4.

Section 4

Institutional and Other Lessons Learned Across Sites

This section summarizes lessons learned from the MOD Sandbox demonstrations. Topic areas covered include forming and managing public-private partnerships, data sharing, service area selection, cost-effectiveness, equity and accessibility, and consumer awareness of programs. Considerations for similar future programs and projects are also provided based on feedback from various demonstrations.

Findings Related to Forming and Managing Public-Private Partnerships

Working with Technology Providers

Public-private partnerships can present unforeseen risks, such as mergers and acquisitions. The Chicago Transit Authority (CTA) MOD Sandbox demonstration encountered a novel risk among the other demonstrations—the acquisition of a primary project partner/vendor by another company. Although these acquisitions were beyond the control of CTA, it is one of the most notable factors that contributed to the project's delay. However, the project stakeholders worked diligently to ensure continuity in this transition through consistency of personnel, strong communication, and commitment to following through with the initial scope and goals of the initiative.

Trip planning and fare payment integration requires patience. The CTA Ventra–Divvy Integration MOD Sandbox project showed that trip planning and fare payment integration is about overcoming the challenges of ready, willing, and able stakeholders integrating complex technologies, different partnerships, and customer segments into a seamless multimodal system. In some cases, trip planning and fare payment integration challenges can come down to branding issues (e.g., branding a platform, a public transit agency, or a mobility service provider).

Working with TNCs

Working directly with TNCs may pose contracting difficulties. Several MOD Sandbox sites identified challenges working with the private sector, including contracting with TNCs. For example, Valley Metro learned that they could not partner with TNCs using traditional contracting terms and vendor relationships due to concerns about open records laws and non-disclosure agreements. Because Lyft required a non-disclosure agreement, which conflicted with Arizona's public records law, Routematch (a vendor of Valley Metro) formed a relationship directly with the TNC partner to overcome this challenge.

Other Risks

Align project scope and feasibility. Many MOD Sandbox demonstrations were downsized or rescoped from initial project scope and design plans. Reworking plans can cause delays in project implementation. Improved public-private relations may help public agencies and private sector partners create more focused project scope and design elements that are realistic to develop given project constraints (e.g., cost, technology availability). Due to the limited time to respond to funding opportunities, public agencies need a vision for potential projects in advance of a funding opportunity becoming available. A clear and defined vision may also help guide project scope and design from a project's onset.

Data Sharing

Public-private partnerships may face challenges reaching data sharing agreements. The data collected as part of the MOD demonstrations allows for performance evaluation of the measures listed in Table 2-2. Several public agencies noted challenges in working with private vendors, particularly related to contracting and data agreements with TNCs. In some cases, partners were unable to agree to terms. In others, partners employed a range of techniques to more narrowly tailor data sharing requests to include less frequent reporting, more aggregate data reporting, and higher levels of geospatial data to protect consumer and proprietary vendor information.

Findings Related to Service Area Selection for Demand-Responsive Service

Land use mix influences ridership in a service area. Some demonstrations noted challenges building ridership for demand-responsive service within service areas lacking mixed-use land development. For example, Tucson's MOD demonstration was based in a low-density, exurban, and primarily residential neighborhood. Residents often wanted to travel outside the service area, resulting in low use of services. Other demonstrations noted affluence and near ubiquitous vehicle ownership coupled with very low-density and lack of mixed-uses can present notable challenges for demand-responsive MOD service.

Public agencies should not assume there is latent demand in low-density areas. Rightsizing vehicles (fleet and vehicle size) and operational zones is key and often highly unique to the local context in which MOD strategies are deployed. Several demonstrations noted that developing an ideal service area (typically for demand-responsive services) represented one of the most prominent challenges. In some cases where service areas were not selected based on demand but instead based on the presence of low-frequency public transit service with limited ridership, MOD demonstration services

also exhibited low ridership. A number of these demonstrations noted the importance of creating a service area that integrates high-capacity fixed route service, connecting travelers to areas outside of the demand-responsive service area.

Findings Related to Equity and Accessibility

Third-party accessibility testing should be strongly considered. Many MOD Sandbox sites incorporated digital accessibility into their trip planning and fare integration initiatives. In one example, Valley Metro hired an independent third-party accessibility tester to enhance digital accessibility and ensure compliance with Web Content Accessibility Guidelines (WCAG). Another demonstration had staff with visual disabilities test their trip planner to ensure it was compatible with screen readers. They also released an early beta version and watched new users work through trip plans, allowing the agency to test and refine the user interface before making it publicly available.

Equity-related goals may conflict with private sector goals to optimize operations and business potential. An important role of the public sector is to ensure MOD deployments are equitably serving underserved and vulnerable populations. Additionally, public-private sector collaboration is needed to connect services that overcome equity issues (e.g., job training and placement, economic development, affordable housing, transportation).

Trade-offs with respect to equity outcomes should be considered. In a handful of cases, demonstrations received a few concerns that their MOD program was inadvertently skewed toward higher income areas because of its emphasis on serving difficult-to-serve lower density areas (generally more affluent suburban and exurban areas). Although MOD in these cases was not intended to replace better performing fixed route service (often in more urban and lower income neighborhoods), agencies attempted to address these concerns by adding service areas in lower-income communities.

Findings Related to Consumer Awareness of Services

Trip planners play a role in improving mobility information among non-traditional users. To help overcome challenges associated with rural mobility, the Vermont Agency of Transportation (VTrans) partnered with transportation dispatchers, employment services, and vocational rehabilitation programs to use their developed trip planner to help carless and car-lite households access jobs, training, and healthcare. Public and nonprofit social service organizations trained their dispatchers and case workers on how to use the trip planner to provide mobility information over the phone. This allowed telephone dispatchers and case workers to identify transportation options quickly and

systematically for clients. The Vermont demonstration lends support to the idea that trip planning platforms can provide benefits to travelers who ultimately access their trip information over the phone in rural communities.

Education, outreach, and knowledge of consumer interactions is key for effectively marketing services. When branding a new project or program, public agencies should carefully consider whether their current marketing is appropriately tailored to target audiences and determine how to market new app-based and demand responsive services. Public transit agencies should evolve from measuring individual trips (i.e., connectivity between point A and point B) to measuring their "mobility relationship" with customers (i.e., loyalty to using not only public transportation but also affiliate, partner, co-branded, and new service offerings). Finally, developing a community engagement strategy that includes education and onboards users to the demonstration or pilot can encourage use of the MOD strategies employed.

Section 5

Considerations for Similar Future Programs

Based on the findings from the independent evaluation of the MOD Sandbox demonstrations, the project team identified four key considerations for deploying similar programs in the future:

Ensure flexibility in contract arrangements. Some MOD Sandbox funding recipients preferred working with existing partners (often through sole source agreements), while others would have preferred competitive solicitations to identify an ideal partner in a pre-proposal phase. The former allows recipients to leverage and strengthen existing vendor relationships to cultivate a shared vision of the MOD demonstration; the latter may provide a more objective procurement process while spurring innovation and cost competitiveness. Flexible contracting terms can allow projects to be more agile and responsive, enabling partners and vendors to pivot more readily in response to institutional and customer needs or goals.

Dedicate time and resources for stakeholder engagement. Several MOD demonstrations noted the stakeholder engagement process was more involved and time-consuming than expected. These demonstrations emphasized the importance of engagement that incorporates institutional and public feedback at the right times in the planning process. They also encouraged smaller and more focused stakeholder engagement to obtain feedback on specific demonstration components (e.g., cash payment alternatives, wheelchair accessible vehicle access). For example, one demonstration started with a stakeholder engagement process comprised of more than 30 key players. They found planning sessions of this size to be ineffective and opted to divide participants into smaller groups of approximately 6 to 10 stakeholders to efficiently advance the project.

Internal due diligence prior to project commitment is important. Because many public agencies do not have in-house technical expertise to deploy fare payment and trip planning integration, or other emerging transportation technology types, some interviewees recommended that agencies conduct an internal public-private partnership feasibility assessment prior to commencing a project. Such a step can help ensure that a partnership augments and fills identified technical and institutional gaps prior to its execution.

More research and guidance are needed to better understand:

- Policies and practices to prepare for MOD automated vehicle deployments and their impacts on public transportation

- Potential impacts, opportunities, and challenges of artificial intelligence and machine learning
- Life cycle cost estimation of MOD
- Impacts of MOD on communities (e.g., land use, travel behavior)
- Physical and digital infrastructure needed to support MOD
- Guidance for incorporating MOD into modeling and scenario planning
- Best practices for ensuring MOD meets the needs of all users (e.g., definitions of equity, overcoming technology and banking challenges)

Appendix A

Independent Evaluation Report Summaries

Appendix A provides summaries of the independent evaluation results for each of the 11 MOD Sandbox demonstration projects. These summaries are organized into the following five sections:

- Project Background
- Project Objectives
- Project Evolution
- Independent Evaluation Findings and Conclusions
- Project Benefits

The details and full evaluation results may be found in the evaluation reports for each site, which are available at https://www.transit.dot.gov/research-innovation/mobility-demand-mod-sandbox-program.

Chicago Transit Authority (CTA) Ventra–Divvy Integration

Background

Through a partnership between the Chicago Department of Transportation (CDOT) and CTA, travelers have access to more than 650 Divvy bikeshare stations and more than 9,500 bicycles located throughout the region. The CTA MOD Sandbox demonstration proposed two modifications to the Ventra app that would provide customers with improved access to Divvy bikes and establish a platform to expand this opportunity to other shared modes in the future. CTA's Ventra–Divvy integration is comprised of two phases.

Phase 1 incorporated Divvy station locations and system status in the Ventra trip planner to allow customers to check real-time availability of bikes at transit stops and the availability of docking stations at their destination. The initial phase also included a "deep link" that connected the Ventra trip planer to the Divvy app so new customers could create a Divvy account and existing Divvy members could obtain an unlock code to access a bicycle. Phase 1 was deployed in September 2020.

Phase 2 will further integrate Divvy functionality into the Ventra app so that customers can pay for their Divvy bike with their Ventra transit value or other payment source to receive an unlock code. This innovation will allow Ventra customers to use their Ventra transit value to pay for shared mobility.

Objectives

Through the MOD Sandbox Program, FTA enabled Chicagoland to explore innovative business models and partnerships to deliver high-quality, seamless, and equitable alternative mobility options. The project set out with two objectives: (1) improve access to Divvy bikes by integrating real-time bikesharing information in the Ventra app and (2) leverage cash payments as an option for the unbanked through Divvy and Ventra payment integration.

Evolution

CTA planned to partner with the vendor that created the original Ventra app. However, it became apparent that the original Ventra app would not accommodate the enhancements and CTA developed a contractual relationship with a new vendor.

Findings and Conclusions

This case study revealed the difficulties faced during integration of multimodal and multiagency trip planning and payment.

The key findings include the following:

- Private sector mergers and acquisitions contributed to program delays. The delay in integration was attributed to the complex relationships and a series of vendor merger and acquisitions that led to a combination of delays and changes in program partners. When CTA's MOD Sandbox project was initially conceived, Divvy was operated by Motivate, which was later acquired by Lyft in 2019. CTA recognized that the change in bikesharing vendors would lead to a duplication of efforts; hence, CTA intentionally delayed the integration until Divvy was transitioned to Lyft. CTA also had to change its Ventra app vendor from Moovel to Cubic.
- To conduct fare payment integration, CTA and Cubic must track two different types of account balances, a pre-tax and a total account balance, which can create traveler confusion. Pre-tax and post-tax benefits also create challenges to bundling services together and offering mobility-as-a-service discounts.
- Trip planning and fare payment integration requires patience. The project overcame the challenges of ready, willing, and able stakeholders integrating complex technologies, different partnerships, and customer segments into a seamless multimodal system. In some cases, trip planning and fare payment integration challenges can come down to branding issues (e.g., branding a platform, a public transit agency, or a mobility service provider).

Dallas Area Rapid Transit (DART) First and Last Mile Solution

Background

DART, the regional public transportation agency serving the Dallas/Fort Worth area of Texas, provides multimodal transit options including bus, light rail, commuter rail, streetcar, paratransit, and vanpool services. DART has expanded its transit services significantly to accommodate the explosive growth in the Dallas/Fort Worth area, although increasing service frequency and ridership has been challenging. Thus, the DART First and Last Mile Solution MOD Sandbox project was created to address these issues by leveraging DART's GoPass app and implementing an on-demand microtransit service (GoLink) and TNC service (UberPool) to improve travel for passengers in the Plano area and to increase connectivity to the overall DART transit network. In this MOD Sandbox demonstration, DART partnered with DoubleMap, Unwire, PayNearMe, MV Transit, and Uber.

Objectives

DART sought to improve first mile/last mile (FMLM) connectivity to its transit network, increase satisfaction among customers, and enhance service for passengers with disabilities. The project objectives included (1) increasing transit use through FMLM improvements, (2) improving accessibility to transit among persons with disabilities, (3) improving multimodal travel, (4) decreasing wait and overall travel times through better FMLM connectivity, (5) expanding the geographic scope of locations reachable by DART services, (6) improving wait and overall travel times for passengers with disabilities, (7) increasing customer satisfaction, (8) enhancing the perception of the DART brand, and (9) producing lessons learned for future projects.

Evolution

The project originally envisioned incorporating multiple MOD services into the GoPass app. However, the project was not able to incorporate carpooling or shared micromobility into the app.

Findings and Conclusions

The evaluation revealed that the project had positive impacts on FMLM connectivity to DART service, reduced travel times, improved services for passengers with disabilities, increased geographic scope of DART, and increased satisfaction among transit users.

The evaluation was guided by 12 hypotheses analyzed using survey data, agency data on vehicle activity, costs, and transit system coverage, and interviews with DART representatives. Key findings include the following:

- Users reported greater FMLM connectivity with DART services after using GoLink. Most of the survey respondents indicated their FMLM mobility to transit stations had improved as a result of GoLink.
- Users reported experiencing lower travel times than they would have without the GoPass app. While average travel times fluctuated modestly during the study period, survey results suggest that users were satisfied with travel times for both GoLink shuttle and UberPool services.
- Passengers with disabilities experienced improved access to transit and reduced travel times. All survey respondents with disabilities considered their access to DART as average or above average, and the average in-vehicle travel time of all GoLink wheelchair accessible vehicle (WAV)[3] trips was consistently faster than the analogous fixed route travel times during the evaluation period. Additionally, a comparison of travel and wait times for WAV and non-WAV passengers using the GoLink service suggests a relatively common range of experiences.
- The geographic scope of locations reachable by DART services increased. Before the GoLink program, 44% of the city of Plano was considered accessible via DART. After the implementation of GoLink and UberPool services, 82% of Plano was covered by DART services.
- Users were generally satisfied with their DART experiences as a result of the project. A majority of survey respondents rated their overall experiences and specific aspects of GoLink and UberPool services as above average.

Benefits

The DART First and Last Mile Solution project was a learning experience for all stakeholders in the areas of project planning with committed partners, flexible contracting terms, metrics for adjusting service coverage, vehicle rightsizing, and understanding customer needs. Stakeholder and project partner interviewees reported they were generally satisfied with its outcome.

Ultimately, the DART project expanded the geographic scope of DART services and improved accessibility for travelers with disabilities. It demonstrated the ability of a public transit agency to provide greater connectivity, decrease overall travel times, and improve the traveler experience. Lessons learned from the pilot project should allow for future projects to build on this experience and advance common objectives with similar initiatives within other transit systems.

[3] All GoLink vehicles were wheelchair accessible.

Los Angeles County and Puget Sound First/Last Mile Partnership with Via

Background

Within this project, the Los Angeles County Metropolitan Transportation Authority (LA Metro), King County Metro, and Sound Transit partnered with Via to develop and demonstrate a first mile/last mile (FMLM) system to connect people to rail and bus rapid transit systems within their respective regions.

Fixed route transit traditionally struggles to deliver robust mobility within auto-oriented environments. This often results in low ridership and high net costs of service delivery. The transportation agencies leading this project faced localized challenges with providing FMLM service to rail and bus rapid transit stations. By incorporating FMLM ridesourcing into zones around major transit stations within the Los Angeles and Seattle metropolitan regions, they sought to improve access to and from stations for the surrounding community. The agencies and Via worked together on two analogous pilot programs designed to test the viability of public-private partnerships to deliver the FMLM service. Three transit zones were selected in the Los Angeles region and five zones were selected in the Puget Sound region for the pilot.

Objectives

Through the MOD Sandbox program, FTA enabled the participating agencies to explore the design of partnerships and systems to deliver an innovative and effective FMLM service. The project objectives were to (1) improve users' accessibility and mobility to and from public transit, (2) increase public transit usage and the number of riders, (3) reduce vehicle miles traveled (VMT), greenhouse gas (GHG) emissions, and congestion, (4) improve mobility for persons with disabilities, (5) improve rider safety, (6) improve the cost-efficiency of mobility, and (7) produce lessons learned for future projects.

An independent evaluation was conducted to assess the demonstration impacts and outcomes based on the project goals and objectives. The evaluation explored 13 hypotheses covering mobility, accessibility, public transit ridership, fuel consumption, safety, costs, and lessons learned.

Evolution

LA Metro submitted the MOD Sandbox demonstration funding opportunity application with the plan to integrate the on-demand service with its TAP fare card. However, the agency acknowledged that it did not understand both the technical and contractual complexities in the application phase and decided that fare integration could not be completed within the demonstration timeline.

In Puget Sound, King County Metro was able to integrate the service with its ORCA card.

Both LA Metro and the Puget Sound partners (King County Metro and Sound Transit) initially contracted with Lyft for the FMLM partnership. However, Lyft declined to enter into a mutually agreeable data sharing agreement and was not able to work with the public agencies to provide WAV service. In the end, LA Metro took the issue to its board of advisors who unanimously recommended starting over with a new partner. LA Metro invited approximately five other TNCs to submit a proposal expressing interest in providing FMLM MOD service. A multidepartment team evaluated the proposals and selected Via as the replacement vendor. The Puget Sound partners also cancelled their partnership with Lyft for similar reasons and selected Via as the replacement vendor.

Findings and Conclusions

The project evaluation revealed that the program achieved several objectives regarding improvements to user mobility and accessibility, public transit ridership, safety, and cost-efficiency. It was concluded that it did not reduce VMT, GHG, or congestion.

Survey, travel activity, ridership, cost, and other data, as well as insights from expert (stakeholder/project partner) interviews, were used to evaluate the project. Key findings include the following:

- The system reduced wait and travel times for users. Survey data showed that average travel and wait times of users decreased because of the system.
- The system increased public transit ridership. Survey data found that riders increased their use of public transit stations as a result of the system.
- The system improved perceptions of safety for users. Users reported that they felt safer traveling to and from transit stations as a result of the system.
- The system did not reduce VMT or GHG emissions. Net VMT and GHG emissions rose due to the system's operation.
- The system offered users mobility at a higher cost-efficiency. The system offered users faster travel at greater cost-efficiency relative to travel by bus.

Benefits

The Los Angeles and Puget Sound MOD Sandbox project was a learning experience for the agencies providing FMLM ridesourcing service to rail and bus rapid transit systems. The agencies in the Los Angeles and Puget Sound regions contributed valuable lessons in contractual negotiations, service provisions, and system design that can serve future projects. These lessons learned may

improve the implementation of FMLM service to support or replace existing traditional transit services, facilitating connections to the broader public transportation system.

Valley Metro Mobility Platform

Background

Valley Metro provides multimodal transit options, including the regional bus and light rail systems, to the 4.25 million residents of Maricopa County, Arizona. The Mobility Platform MOD Sandbox project developed and demonstrated the pilot Pass2Go mobile phone app, which aimed to update and replace Valley Metro's existing Ridekick app, a basic trip planner for light rail and buses. The Pass2Go pilot was divided into two phases. Phase 1 included developing the app as a trip planner with real-time information and a single payment system for public transit. Phase 2 aimed to integrate bikesharing and on-demand ridesourcing services and payment into the Pass2Go app. In this MOD Sandbox demonstration, Valley Metro partnered with Routematch, Lyft, GR:D BikeShare, West Group, and the City of Phoenix.

Objectives

Through the MOD Sandbox program, Valley Metro was able to explore innovative business models and partnerships to deliver high-quality, seamless, and equitable mobility options. The project objectives were to (1) reduce trip planning, wait, and travel times, (2) encourage the adoption of mobile-based technology for public transit, (3) improve first/last mile connectivity, (4) improve accessibility and trip planning methods for travelers with disabilities, (5) enhance the traveler experience, (6) provide an open data platform that allows public transit agencies to exchange travel information, and (7) produce lessons learned for future projects.

Evolution

Although it was initially envisioned that the app would include integration with Lyft, Valley Metro learned it could not work with TNCs using traditional contracting terms and vendor relationships. Lyft was concerned about data protection as Arizona had a relatively open sunshine law. To overcome these challenges, Valley Metro decided to have Routematch form a direct relationship with Lyft since no rides were being subsidized by Valley Metro. Later, Lyft expressed concerns about the user experience and Pass2Go functions that would occur outside of Lyft's app. In addition to these issues, Valley Metro realized that a single payment integration strategy could not be supported by GR:D as it used a subscription-based payment model. Ultimately, Lyft and GR:D BikeShare integration did not go forward, and Phase 2 was not deployed.

Findings and Conclusions

The project had positive impacts on trip planning and wait times, connectivity with public transportation, use of first/last mile modes, trip planning for travelers with disabilities, and the traveler experience.

The evaluation was guided by 12 hypotheses analyzed using survey data, app activity data, and expert (stakeholder/project partner) interview data. Key findings include the following:

- The average planning and wait times of Pass2Go users declined. Planning and wait time measurements showed significant decreases for bus and rail trips, and a sizable minority reported that the app had reduced their planning and wait times.
- Users reported greater connectivity with public transportation using information augmented in Pass2Go. Ratings of the app's ability to connect to/from public transportation increased and a sizable majority reported improved access to public transportation due to the app.
- User behavior showed greater use of connecting first/last mile modes through measured activity. The frequency of use of connecting modes to/from public transportation increased to a degree that was statistically significant.
- Pass2Go users with disabilities found that trip planning methods were improved. Most users with disabilities reported improvements in their trip planning capabilities due to the app, although this sample size of respondents was not large.
- Pass2Go users considered their travel experience to be enhanced with real-time travel information and routing. Around 50% of users experienced improved access to real-time traveler information and improved trip planning methods.

Benefits

The Valley Metro Mobility Platform project was a learning experience for all stakeholders in the areas of project operation and expansion, accessibility challenges, and other issues related to continuation of the project. Stakeholder and project partner interviewees reported that participants were generally satisfied with the project and lessons learned from it. Ultimately, the Pass2Go app reduced trip planning and wait times, provided real-time information for public transit, and improved trip planning and payment information accessibility for travelers with disabilities. It demonstrated the capabilities of a trip planning app to shift traveler behavior, streamline the payment process, and improve the traveler experience. The lessons learned from the pilot project should allow future projects to build on this experience and advance common objectives with similar initiatives within other transit systems.

Pinellas Suncoast Transit Authority (PSTA) Public-Private Partnership for Paratransit

Background

PSTA partnered with Lyft, United Taxi, Care Ride, Wheelchair Transport, and Goin Software to develop and demonstrate an approach to provide paratransit service more efficiently and cost-effectively.

PSTA has spent around 10% of its operating budget to offer service to more than 12,500 eligible customers of Americans with Disabilities Act (ADA)–required paratransit, performing more than 275,000 annual paratransit trips through its Demand Response Transportation (DART) Program. DART's lack of flexibility and limited pickup time reliability were general complaints from paratransit customers. To increase the cost-effectiveness and efficiency of paratransit services while improving customer mobility and accessibility throughout Pinellas County, the project aimed to deploy an integrated platform and app that provided on-demand curb-to-curb paratransit service.

To evaluate user response to the integrated platform and app, and the effects on service operation and user mobility, a study was developed where participants were asked to take a pre-study survey and a post-study survey. The evaluation team collected data relevant on this MOD Sandbox demonstration between June 2019 and August 2021. Paired observations from both surveys, travel activity, payment data, paratransit operating expenses, fare revenues, and insights from expert (stakeholder/project partner) interviews were used to evaluate the pilot project.

Objectives

Through the MOD Sandbox program, FTA enabled PSTA to explore innovative business models and partnerships to deliver a high-quality, seamless, and equitable paratransit service. The project objectives were to (1) improve user accessibility and mobility, (2) improve user quality of life and satisfaction with paratransit services, (3) reduce wait and travel times, (4) reduce spending on paratransit trips, (5) facilitate payments for paratransit, (6) diversify trip purposes, and (7) produce lessons learned for future projects.

Evolution

During the project, riders paid a fare of $4.50 for a one-way trip or $9.00 for a roundtrip. This price was later reduced to $3.50 per trip. ADA paratransit costs remained at $4.50 for most of the duration of the demonstration. However, PSTA ultimately switched to a fareless paratransit model in response to the pandemic.

Project partners also noted that the high costs and difficulties of acquiring WAV insurance posed a major challenge, as did the lack of applicable data standards to promote information exchange and interoperability between vendor systems. However, they were ultimately able to resolve these issues despite less-than-ideal circumstances.

Findings and Conclusions

The project evaluation revealed that the program had positive impacts on user mobility, accessibility, wait and travel times, payment experience, satisfaction with paratransit services, and diversity of trip purposes.

The evaluation was guided by 12 hypotheses analyzed using survey data, activity and other data, and expert (stakeholder/project partner) interview data. Key findings include the following:

- Users of PSTA reported greater mobility and accessibility with the new system. Survey and trip activity data showed an increase in user mobility, accessibility, and travel activity as a result of using the new system.
- Wait and travel times for users declined. Around half of pilot participants experienced shorter wait times and a decline or no change in their travel times.
- Users of PSTA reported satisfaction and an easier payment experience with the new system. A majority of pilot participants reported enhanced satisfaction with the new system and an easier payment process due to e-wallet payments.
- The trip purpose of system users was diversified and the spatial diversity of locations to which users traveled increased. Survey and trip activity data showed that the new system provided users with access to a greater number of diversified trip purposes that met their needs.

Benefits

The Public-Private Partnership for Paratransit project was a learning experience for all stakeholders about contractual negotiations, project operation, technology challenges, and other issues related to continuation of the project. Demonstration partners reported their satisfaction of the public-private partnership because it allowed PSTA and mobility providers to work together and overcome challenges.

Ultimately, the pilot increased the mobility and accessibility of system users within Pinellas County and enhanced their reported quality of life. It demonstrated the capabilities of an integrated platform to reduce wait and travel times, streamline the payment process, and improve access to diversified locations. The lessons learned from the pilot project may allow future projects to build on this experience and advance common objectives with similar initiatives within other public transit systems.

Tri-County Metropolitan Transportation District of Oregon (TriMet) OpenTripPlanner (OTP) Shared-Use Mobility

Background

TriMet is a special district of the state of Oregon governed by a seven-member board appointed by the governor. TriMet serves a population of approximately 1.8 million in the 533 square miles of the urban portion of a three-county Portland metropolitan area.

Trip planning is a core component of public transit agency user services. However, developing and operating a customized trip planning platform requires considerable resources that are beyond the budget of many public transit systems. Also, external strategies may be required that provide the functionality but can lack the capacity for desired customization specific to unique urban environments. The OpenTripPlanner (OTP), released as an open-source project by TriMet in 2009, was the first to introduce multiple modes in one trip. Adoption of OTP has been strong, with implementation in dozens of cities and countries worldwide.

Objectives

The objective of the OTP Shared-Use Mobility project was to advance the development of online trip planning through the OTP by expanding it to include shared mobility modes, offer pedestrian friendly routing, and provide real-time information on transit vehicle arrivals. The project also sought to improve upon an open-source geocoder, Pelias, to lower the cost barriers for agencies to implement trip planning strategies. The project was implemented by TriMet with key partners Conveyal, IBI Group, Cleared For Takeoff, Moovel, and Oregon Metro.

Evolution

Initially, TriMet allowed people with disabilities to plan a trip that included a wheelchair accessible TNC. Portland requires TNCs operating in the city to offer this service. However, when the agency conducted a field test with users (including a person with disabilities), it found out that wheelchair accessible TNCs were simply unavailable. TriMet learned that just because the city may require accessible TNCs, the policy does not necessarily result in accessible vehicle availability. Rather than compensate with its own resources to ensure that equivalent service was available to all OTP users, TriMet decided to remove the ability to summon an accessible vehicle from the platform.

Additionally, a core goal of the OTP was to incorporate additional information, such as the presence and absence of sidewalks, to improve trip planning for people with disabilities and older adults. While TriMet was able to include the presence and absence of sidewalks into trip planning, the agency elected not to incorporate more accurate curb level data into the app due to lack of existing data and the inability to initiate the necessary data collection activities within the scope of this project.

Findings and Conclusions

The enhanced TriMet OTP incorporated shared mobility into trip planning that allowed faster travel times, enhanced pedestrian routing, and provided valid results; the Pelias geocoder showed good performance compared to other geocoders.

The evaluation was guided by 11 hypotheses that explored the OTP's technical performance and user response to several design and interface features and tested the performance of Pelias with other leading geocoders for accuracy and comparability. Key findings include the following:

- Incorporating shared mobility options into the OTP provided most users with faster travel times. These options were evaluated by randomly drawing origin/destination pairs from the property records dataset and running them through the TriMet OTP, which provided shared mobility options, and Google's trip planner, which provided transit-only options. On average, the results found that the shared mobility options tested were faster than the same trip when planned using public transit alone.
- Pedestrian routing was enhanced. The TriMet OTP was enhanced with improved sidewalk data and pedestrian routing, and the evaluation found effective routing performance to optimize pedestrian use of sidewalks and safe low-speed residential streets. Street segments were assessed for sidewalk data accuracy, which found that 96% of observations were correct. Overall, the sidewalk data and pedestrian attribute functionality performed well.
- Users found the OTP provided valid results. A survey of TriMet riders asked them to test the enhanced OTP with trips of their own choosing and evaluate the validity of results and the user interface design. Users responded favorably to the OTP, reporting that results from their searches were correct, and the user interface was highly rated, including high marks for the real-time information on transit activity and other information display. Overall, users considered the OTP to be a considerable improvement in design and function over the previous trip planner.
- Pelias generally performed comparably to other geocoders. Compared against Google Earth, MapBox, and ArcGIS geocoding using two address datasets and two approaches, Pelias performed well with the property

record dataset. However, it showed some accuracy and comparability limitations with the TriMet-supplied test dataset, generally due to factors such as unintentional misspellings. Overall, Pelias performed well, and the results broadly show that it offers the necessary level of accuracy and consistency for application in a consumer-facing trip planner.

- Mobility for persons with disabilities, particularly wheelchair users, is an ongoing issue. TriMet learned that TNCs/ridesourcing cannot be relied upon to deliver wheelchair accessible service, even when local regulations compel them to do so. Further, TriMet learned that additional data collection activities will be required to build out the pedestrian components of the OTP and ensure compliance with ADA Title II program access requirements.

Benefits

The TriMet MOD Sandbox demonstration produced several lessons learned and innovations that advanced the trip planning state of practice, including improving existing open-source geocoding with Pelias, enhancing the OTP design, and improving the quality and accuracy of pedestrian routing and real-time transit operations information. These advances can be further developed by other public transit agencies and offer agencies a viable option for deploying customizable trip planning strategies that can meet user and regional needs.

City of Palo Alto and Bay Area Fair Value Commuting (FVC)

Background

Despite having several major public transportation systems and higher-than-average transit mode share, commuting in the San Francisco Bay Area is predominantly by single-occupant vehicles (SOVs). This is in part due to the limited number of alternative modes within low-density areas connecting to traditional public transportation serving key congested corridors. Broadly, Bay Area commuters are hindered from conducting multimodal or non-SOV mode trips. To encourage non-SOV commuting, the Bay Area FVC project aimed to develop an integrated commute planning platform and mode shifting incentive system. The project provided users the ability to plan, compare, and pay for alternative transportation modes, and it incorporated different commute incentives and benefits when applicable. The cash-out system paid an incentive to employees who used non-SOV commute modes. In this MOD Sandbox demonstration, the cities of Palo Alto, Cupertino, Menlo Park, and Mountain View partnered with Prospect Silicon Valley, RideAmigos, and Commuter Wallet to implement the FVC system.

Objectives

Objectives of the project were to (1) reduce overall SOV commuting, (2) reduce SOV vehicle miles traveled and fuel consumption, (3) benefit lower income workers, (4) improve access to pre-tax payments for transit use, (5) develop a mobility aggregator, a sustainable feebate or cash-out policy, and gap-filling analytics to encourage reduced use of SOVs, (6) enhance employee attitudes toward public transit, and (7) produce lessons learned for future projects.

Evolution

The project initially envisioned a revenue-neutral feebate program where single-occupant vehicle drivers were charged a fee for commuting and non-SOV commuters received rebates. However, the feebate component could not be implemented as originally planned and was dropped from the demonstration.

Findings and Conclusions

The evaluation revealed that the program had positive impacts in the form of shifting commuting away from SOVs, reducing VMT and fuel consumption, shifting benefits to lower-income workers, and improving attitudes toward public transit.

The evaluation was guided by nine hypotheses analyzed using survey data, activity and other data, and expert (stakeholder/project partner) interview data. Key findings include the following:

- The mode share of commuting by SOVs declined and by non-SOVs increased. Survey and trip activity data showed a decline in the mode share of commuting by SOVs, an increase in that by non-SOVs, and a majority reported reduced driving due to the pilot.
- The total commute VMT, energy consumption, and CO_2 emissions declined. Survey and trip activity data showed that the total commute VMT, energy consumption, and CO_2 emissions decreased by 40%, 46%, and 10.2 metric tons, respectively.
- The FVC benefitted lower-income workers more than higher-income workers. The savings experienced by lower-income participants were higher as a percentage of their income relative to higher-income participants.
- Employee attitudes toward public transit became more positive. The FVC strategy enhanced the perception of public transportation by pilot participants.

Benefits

The Bay Area FVC project was a learning experience for all stakeholders about contractual negotiations, project operation, technological challenges, and other issues related to continuation of the project. Project partners reported

their satisfaction of the multi-city partnership because it allowed cities to work together and overcome challenges. Participants liked the gamified experience and leaderboards for non-SOV use to compare their progress with coworkers.

Overall, the demonstration reduced SOV use, benefitted lower-income workers, and improved employee attitudes toward public transit. It demonstrated the capabilities of a trip planning platform and a cash-out system to shift traveler behavior, streamline the payment process, and improve the traveler experience. The lessons learned from the pilot project can support future projects through building on this experience and advancing common objectives within other transit systems.

Bay Area Rapid Transit (BART) Integrated Carpool to Transit Access Program

Background

BART is a rapid transit public transportation system serving the San Francisco Bay Area in California and is the fifth-busiest heavy rail rapid transit system in the United States, carrying more than 430,000 daily riders. BART offers a total of 48,000 parking spaces at 34 of its 46 stations. Parking demand has been high as most spaces fill by 8:00 AM each weekday. Most parking spaces are filled by single-occupancy vehicles for the entire day, thus serving one rider per parking space. The existing legacy carpool program at BART provides first-come, first-served parking spaces for carpools, but had limited capacity and filled up early. It also required enforcement that was challenging and labor intensive. BART does not provide its legacy carpool program at one-third of its stations.

The BART MOD Sandbox demonstration aimed to address the capacity and enforcement challenges of carpooling by using Scoop's carpool platform to match drivers and riders with similar destinations into carpools. The program was operated by BART and Scoop Technologies, Inc., with support from the Metropolitan Transportation Commission (MTC). Scoop's carpooling matching algorithm enabled drivers to connect with one to two riders for travel to the station. BART permit parking spaces were available to Scoop carpools until 10:00 AM, which offered riders later arrival times than legacy carpool spaces. The pilot program initially launched at the Dublin/Pleasanton station and expanded to 16 additional stations.

Objectives

Objectives of the project were to (1) improve carpool access to BART, increase carpooling to stations, and increase ridership, (2) distribute rider demand over the morning peak commute period, (3) reduce the cost of enforcement for carpool spaces and the rate of fraudulent use, (4) improve access to parking spaces at stations and use the parking supply more efficiently, (5) reduce

traveler cost and increase BART's revenue relative to the long-run operational costs, and (6) lower vehicle miles traveled.

Evolution

The demonstration did not incorporate parking payment or Americans with Disabilities Act (ADA) functionality into the app, which were key project goals.

Findings and Conclusions

The evaluation revealed that the program had positive impacts on carpooling, ridership, parking, enforcement, costs, and VMT.

Key findings include the following:

- Carpooling increased to and from BART stations. Analysis of survey data revealed that a large share of respondents shifted from driving alone to carpooling.
- Scoop resulted in increased frequency of BART use. Survey responses suggested that those using Scoop were riding BART more due to the project.
- Carpool trips to BART were more widely spread over the morning hours. The project enabled carpools to arrive later in the morning, and trip start times became more evenly distributed between the hours of 6:00 and 10:00 AM.
- The cost of enforcement per carpool space decreased given the large number of dedicated carpool spaces added. Fraudulent use of carpool spaces was reported to decrease based on qualitative interviews. However, data limitations prevented the quantitative evaluation of changes in fraudulent carpool space use.
- Scoop lowered the cost of travel for some users. A sizable minority of users reported that Scoop was lowering their net cost of travel to BART.
- The project reduced VMT. A considerable share of Scoop users shifted away from single-occupancy vehicle trips, which resulted in VMT declines.

Benefits

The BART Integrated Carpool to Transit Access Program was a learning experience for all stakeholders about carpooling to and from public transit and the different types of enforcement challenges related to carpool parking. It raised the visibility of carpooling and made it a key strategy for improving the efficiency of dwindling parking resources and advancing BART's parking management. The pilot also enabled the inclusion of a carpool parking and verification feature into BART's app. The investment required to include this feature into BART's app was significant and would likely not have been made had the Scoop to BART pilot not created a precedent for an improved and

successful carpool program. Survey responses indicated that participants were generally happy with the program. While the Scoop to BART pilot eventually ended, project partners agreed that the partnership was a model that could be replicated elsewhere and offered a blueprint for future projects to build on and advance common objectives with similar initiatives within other public transit systems.

Pierce Transit Limited Access Connections (LAC)

Background

Pierce County Public Transportation Benefit Area Corporation (Pierce Transit) partnered with Lyft and Sound Transit to develop and demonstrate an approach to first mile/last mile access to public transit within the Tacoma, Washington, region.

The Pierce Transit LAC project sought to provide additional transportation options to local areas that had limited access to public transit services within Tacoma and surrounding areas within Pierce County. The implementation of these services was delivered through the TNC/ridesourcing service Lyft in coordination with the local Pierce Transit and Sound Transit agencies. The project deployed zone-based FMLM services, a guaranteed ride home after public transit operating hours, and trips to and from park-and-ride lots. Collectively, the project aimed to deploy a more dynamic mobility system to complement existing fixed route and paratransit services.

Objectives

Through the MOD Sandbox program, FTA enabled Pierce Transit to explore the integration of a TNC-based FMLM partnership to deliver dynamic and cost-effective mobility in support of the broader public transit system. These goals were pursued through subsidized rides for several use cases including (1) FMLM travel to local fixed route public transit routes, (2) guaranteed rides home for students returning from Pierce College Puyallup after public transit operating hours, and (3) trips to and from park-and-ride lots around the Tacoma and Puyallup Sounder Transit stations.

An independent evaluation was conducted to assess the demonstration impacts and outcomes based on the project goals and objectives. The evaluation involved exploring hypotheses surrounding the project's impact on the mobility and accessibility of users, vehicle miles traveled greenhouse gas emissions, public transit ridership, congestion, safety, cost-effectiveness of mobility, and lessons learned from deployment. Evaluation data were collected between May 2018 and December 2019.

Evolution

Pierce Transit's FMLM partnership with Lyft evolved out of failed negotiations with Uber. While terms of data sharing presented some concerns, Pierce Transit noted that the negotiations with Uber did not fail exclusively over data, as the agency would have accepted a limited data sharing scope. The primary reasons negotiations ceased were that Uber did not offer a service that would allow Pierce Transit to book rides for customers without smartphones and for paratransit customers. Pierce Transit also had concerns about public records requests under state or federal law. Uber did have UberCentral, a tool similar to Lyft's Concierge, but the version available at the time of negotiations was not ready for use by a public agency and was associated with data privacy concerns. Ultimately, Pierce Transit offered their own telephone dispatch using public transit agency customer service employees to book paratransit rides. Lyft's Concierge desktop-based service supplemented the normal app-based approach to engage with the system. The employee union was not satisfied with this arrangement, however, because it was outside of their negotiated scope. After further negotiations, they were paid more per hour to take those calls.

Findings and Conclusions

Project evaluation revealed that the program had positive impacts on public transit use, wait and travel times, cost-effectiveness, and VMT.

Observations from surveys, travel activity, ridership, and other agency data, as well as insights from expert (stakeholder/project partner) interviews, were used to evaluate the project. Key findings include the following:

- Users of the system reported using public transit more and an improved perception of Pierce Transit as a result of the project. The project improved the perception of Pierce Transit quality among more than 70% of survey respondents and they reported using public transit more because of the rides provided by the system.
- The cost-effectiveness of the TNC-based system was better than previously demonstrated fixed route services. The analysis found that the project delivered mobility at costs per trip that were significantly lower than those of previously demonstrated fixed route services designed to achieve the same objectives during 2014 and 2015.
- The project facilitated a reduction in VMT. The reduction in VMT estimated as a result of personal vehicle shedding and personal vehicle suppression was relatively large compared to the estimated system VMT.
- Wait and travel times were reported lower because of the project. Survey data were mixed but on balance suggested that wait and travel times were reduced due to the project.

Benefits

The Pierce Transit LAC project was a learning experience for stakeholders in relation to project design, contractual negotiations, project operation, technology challenges, and other issues related to continuation of the project. Demonstration partners reported advances in strategic thinking with respect to project development. Ultimately, the pilot increased transit use, reduced travel and wait times, reduced VMT, and demonstrated cost-effectiveness over systems previously deployed to address the same mobility concerns. The lessons learned from the pilot project may allow for future projects to build on this experience and advance common objectives with similar initiatives within other public transit systems.

Regional Transportation Authority (RTA) of Pima County Adaptive Mobility with Reliability and Efficiency (AMORE)

Background

RTA, the regional public transportation agency of Pima County, Arizona, partnered with Metropia and RubyRide to implement a pilot aimed to provide more dynamic mobility services to residents of the Rita Ranch area within the Tucson region.

RTA faced a common dilemma for public transit operators in the greater Rita Ranch service area, a relatively low-density, auto-oriented exurban community. It operated a financially constrained fixed route bus service with limited capacity and low ridership. It further had challenges delivering service with sufficient flexibility for the land use of the region. The AMORE project sought to enhance mobility, access to work and other destinations, and to reduce personal car dependency. It sought to integrate attributes of multiple emerging mobility services and technologies and deliver additional options for travel to residents. Users engaged the system through an app, which enabled them to book door-to-door service within the region.

Objectives

Through the MOD Sandbox program, FTA enabled RTA to explore innovative business models and partnerships with the goal of creating high-quality, seamless, and equitable mobility options.

The project had multiple objectives including (1) establishing a financially sustainable mobility ecosystem, (2) introducing a subscription-based mobility service, RubyRide, as a viable and affordable option for accessing work or other destinations, (3) integrating community-based social-carpooling via the

mobile technology Metropia Driving UP Occupancy (DUO) with RubyRide, and (4) achieving higher occupancy of personal vehicles to make the total system capacity-dynamic, adaptive, and capable of meeting peak-hour demand. An independent evaluation was conducted to access the demonstration impacts and outcomes based on the project goals and objectives.

Evolution

The project partners considered moving the service location and/or adding specific pickup and drop-off points outside of the service area (e.g., downtown, airport) to address low use influenced by a lack of major employers or destinations within the original service area. However, RTA opted not to do this due to budget constraints and instead expanded the service area slightly to an adjacent community (i.e., Vail) to the south of Rita Ranch within the final months of the project. Similarly, the small geographic area and population size covered by the service hindered the ability of project partners to promote the service through a geographically targeted digital media campaign.

Additionally, the project partners experienced challenges and delays related to hiring drivers, insuring the service, procuring a WAV, and the inability of users to download the service app from any app store. Finally, during the onboarding process, users were asked if they had a credit/debit card and smartphone access. Users who needed to acquire a credit/debit card were encouraged to purchase a Visa gift card. In addition, a feature was available to allow people to call and request rides to address the digital divide, although this was ultimately not used likely because of the limited overall user participation.

Findings and Conclusions

The project had limited impacts on travel and behavior. System usage was low and dropped off during the project. Limited participation in the survey offered few insights into project performance. The resulting level of participation led to a high cost per trip that was ultimately not competitive with existing fixed route or on-demand services.

The evaluation was guided by 10 hypotheses analyzed using survey data, activity data, and expert (stakeholder/project partner) interview data. Key findings include the following:

- The project provided services to users at lower per-trip costs than other options, but the cost-effectiveness of trips to the agency were unfavorable. The trip costs of AMORE were priced at a level affordable and competitive to most other modes. Many of the trips were free to the user. The project cost on a per-trip basis suggests that agency spending per trip was not competitive with the average per-trip operating expenses of conventional demand responsive transit within the region.

- The project did not reduce VMT. The findings of the activity data analysis suggest that the use of personal automobiles either did not change or increased due to the project.
- The service area was found to be too constrained to be effective. The service area of the project was problematic due to a lack of destinations within the service area. This limited the utility of the project since many residents wanted to be taken outside the service area. The exurban environment required people to regularly travel 10 to 20 miles out of the pilot service area and was not conducive to making connections to the broader transit system within Tucson. Low-density areas within Tucson were less ideal for this type of project.

Benefits

The AMORE project was an ambitious undertaking to deliver innovative mobility services to a low-density exurban environment. It provided lessons learned with respect to service area selection, issues of labor cost and reliability, insurance provisions, marketing, and other technical challenges. The lessons learned may allow future projects to provide better mobility service choices for low-density areas.

Vermont Agency of Transportation (VTrans) Go! Vermont Flexible Trip Planner

Background

Vermont is the nation's second least populated state and is predominantly rural. As a result, the state's public transit systems must service many origins and destinations that are spread across regions with low population density. Vermont's answer to this is flexible public transit, where fixed bus routes can deviate from their predefined routes to pick up or drop off riders at locations closer to their desired origins or destinations. However, this kind of unconventional transit operation is not handled by traditional trip planners.

The standard data format for trip planners is the General Transit Feed Specification (GTFS), which is used by public transit agencies to specify their schedules. A variant of GTFS, known as GTFS-Flex, specifies flexible schedules of public transit systems. However, due to the rarity of such systems, many online trip planners have not made use of this specification. The Go! Vermont trip planner was developed to demonstrate a GTFS-Flex trip planner that could project information from this specification using OpenTripPlanner (OTP), an open-source software application. It was implemented exclusively as a website that could thematically adapt to mobile platforms. Go! Vermont's target audience was all public transit users including travelers, human services case workers, and transit agency call centers. The trip planner was intended to be

of special use to residents who lived in rural areas, residents with disabilities, and older adults. VTrans partnered with Cambridge Systematics and Trillium Solutions to design and deploy the Go! Vermont trip planner to advance the state of practice for flexible transit systems.

Objectives

The VTrans project aimed to be an example to other states and local municipalities of the benefits of integrating flexible transit data into publicly available trip planners. The project objectives were to (1) develop an online trip planner for both "fixed" and "flexible" services, (2) improve the data presentation for transit agencies in Vermont, (3) improve information for transit riders in the state, (4) improve mobility for transit riders, (5) increase public transit use, (6) be used by Vermont transit riders, (7) cut call/response time on relevant inquiries pertaining to route information and travel options, and (8) obtain lessons learned about project implementation.

Evolution

The VTrans project did not change significantly from project planning to the deployment phase.

Findings and Conclusions

The combined effect of the results of this project is a demonstration that flexible transit trip planning is possible and practical in trip planners.

The evaluation was guided by eight hypotheses analyzed using survey data, activity data, and expert (stakeholder/project partner) interview data. Key findings include the following:

- The Go! Vermont planner effectively provided options for flexible public transit travel. The trip planner was tested using a sample of origins and destinations within Vermont to evaluate performance in delivering viable public transit options to complete the trip. The results found that on average it could offer more viable travel options than a leading conventional trip planner.
- Public transit operators surveyed generally considered Go! Vermont to be an improvement. A small survey sample of transit operators explored their opinions and perceptions of the trip planner. Responses were not universally positive, but in general transit operators considered several key performance functions to be improvements, such as format and display of information.
- Lessons learned from deployment of Go! Vermont will inform future efforts to develop GTFS-Flex compatible trip planners. The experience of constructing and deploying a trip planner produced several

recommendations, such as increasing investment in public transit technology in rural communities to bridge the technological gap with urban centers, establishing/supporting leadership roles for integrated trip planning across public transit agencies, and developing strategic methodologies that focus on the long-term performance and success of projects.

Benefits

The Go! Vermont trip planner provided a live demonstration of a GTFS-Flex OTP within a public transit environment and produced an ongoing application that is still being improved. Lessons learned are being applied to expanding capabilities and options such as carpools and vanpools. Future development of the trip planner may incorporate scheduling, booking, and paying for rides through modes such as paratransit and TNC/ridesourcing vehicles. Further improvements may also extend to the GTFS-Flex data structure and content.

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