NATIONAL ACADEMIES Sciences Engineering Medicine

TRB TRANSPORTATION RESEARCH BOARD

TRB Webinar:

Connected Mobility Futures—Integrating Transit and Technology

December 16, 2025

1:00 – 2:30 PM (eastern)

PDH Certification Information

1.5 Professional Development Hour (PDH) – see follow-up email

You must attend the entire webinar.

Questions? Contact Andie Pitchford at TRBwebinar@nas.edu

The Transportation Research Board has met the standards and requirements of the Registered Continuing Education Program. Credit earned on completion of this program will be reported to RCEP at RCEP.net. A certificate of completion will be issued to each participant. As such, it does not include content that may be deemed or construed to be an approval or endorsement by the RCEP.

ENGINEERING RCEP REGISTERED CONTINUING EDUCATION PROGRAM

AICP Credit Information

One (1.5) American Institute of Certified Planners (AICP) Certification Maintenance (CM) Credit

You must attend the entire webinar

Log into the American Planning Association website (https://www.planning.org/) to claim your credits

Contact AICP (AICPCM@planning.org), not TRB, with questions

Purpose Statement

This webinar will highlight strategies and technologies transforming the future of connected mobility. This session will explore how public agencies and technology partners are addressing fragmented systems through open platforms, integrated trip planning, and seamless fare payment.

Learning Objectives

At the end of this webinar, participants will be able to:

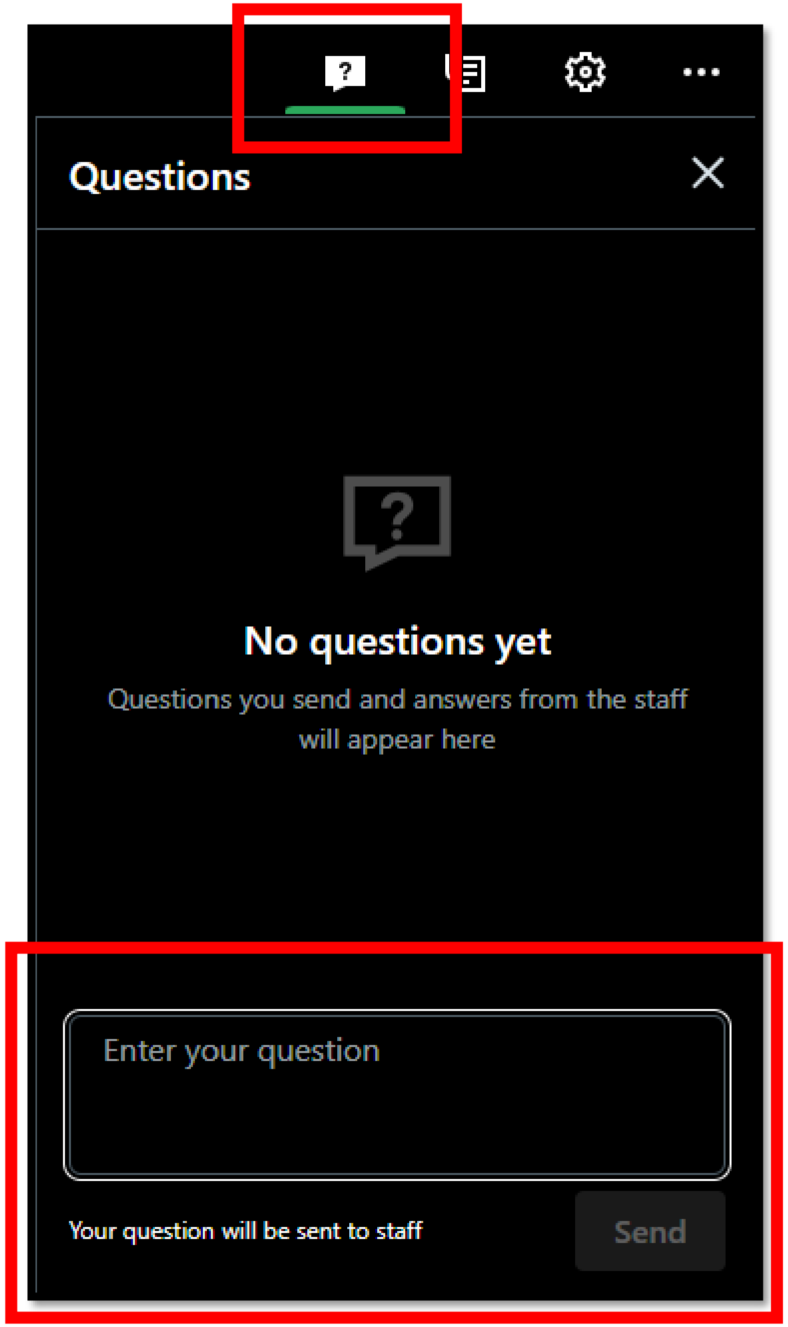
(1) Unify trip planning, booking, and payments across services using open-source tools

(2) Leverage MaaS, AMoD, and digital tools to improve last-mile access, reliability, and the overall rider experience

(3) Understand ridership patterns, pandemic impacts, and scalable approaches to reconnect users through innovative and integrated transit services

Questions and Answers

- Please type your questions into your webinar control panel
- We will read your questions out loud, and answer as many as time allows



NATIONAL ACADEMIES Sciences Engineering Medicine
TRB TRANSPORTATION RESEARCH BOARD

Today's Presenters

Tiffany Dubinsky
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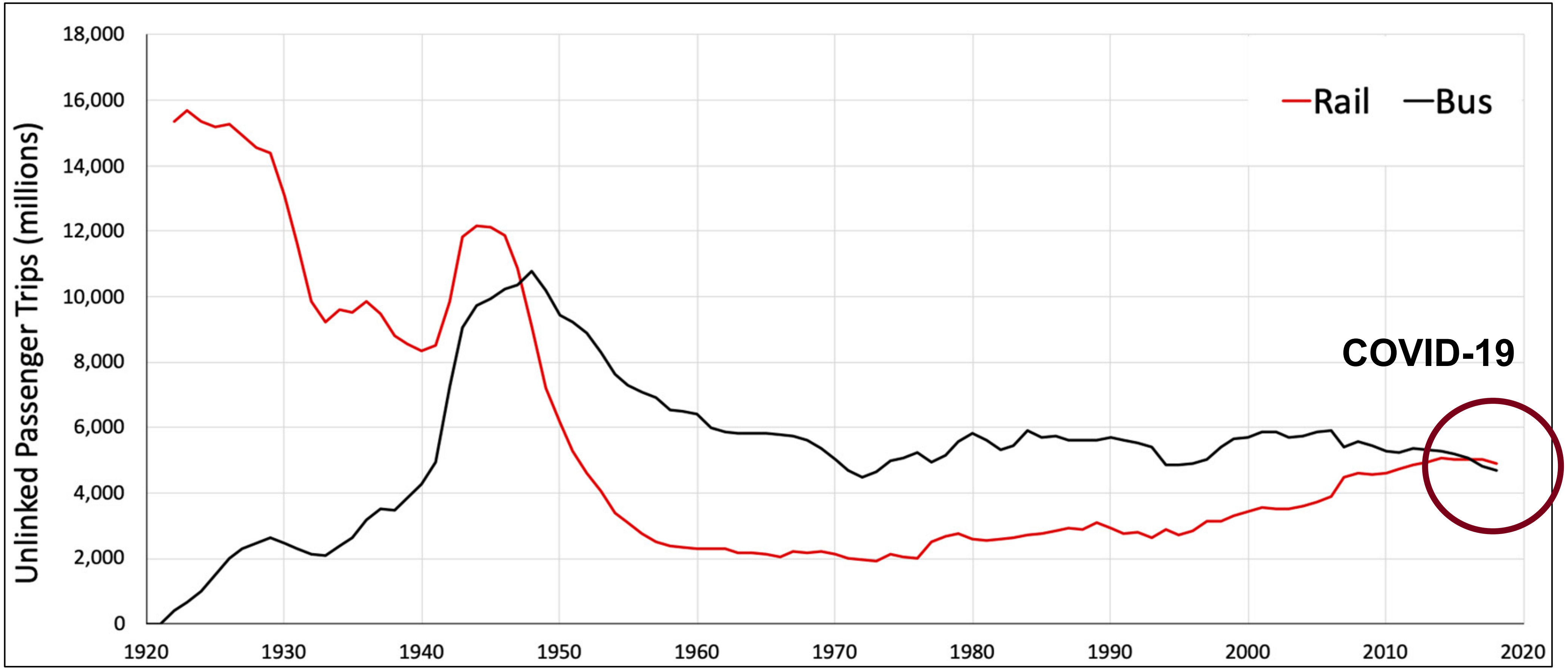
Transit Ridership Trends, Access Gaps, and Technology Solutions

Alireza Khani, PhD, PE
Associate Professor
Department of Civil, Environmental, and Geo- Engineering
University of Minnesota Twin Cities

Transportation Research Board Webinar, December 16, 2025

University of Minnesota
Driven to Discover®

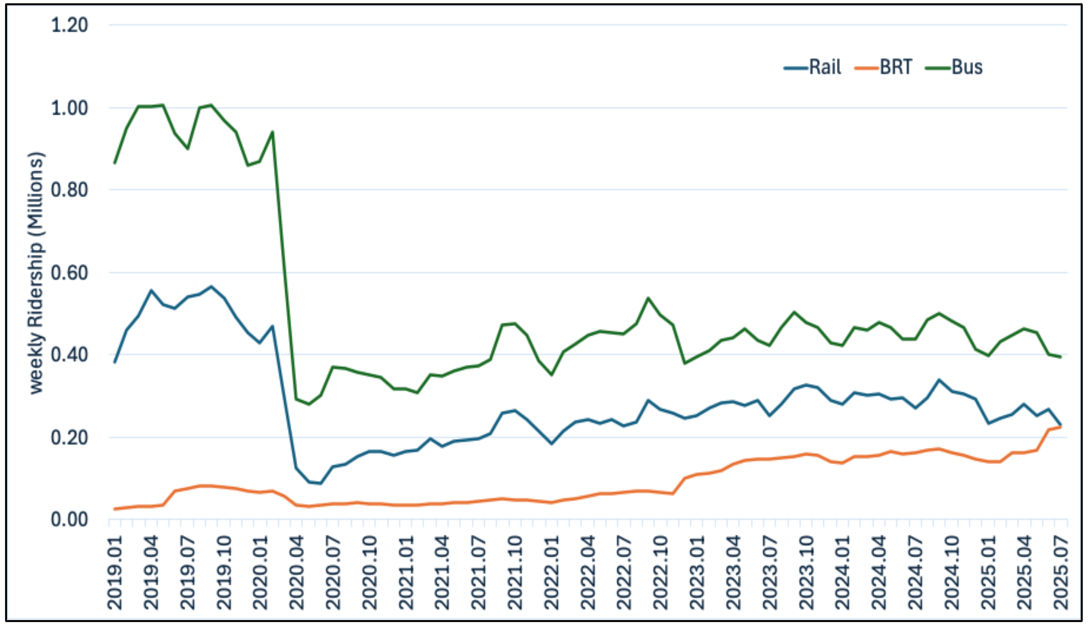
US National Transit Ridership Tends



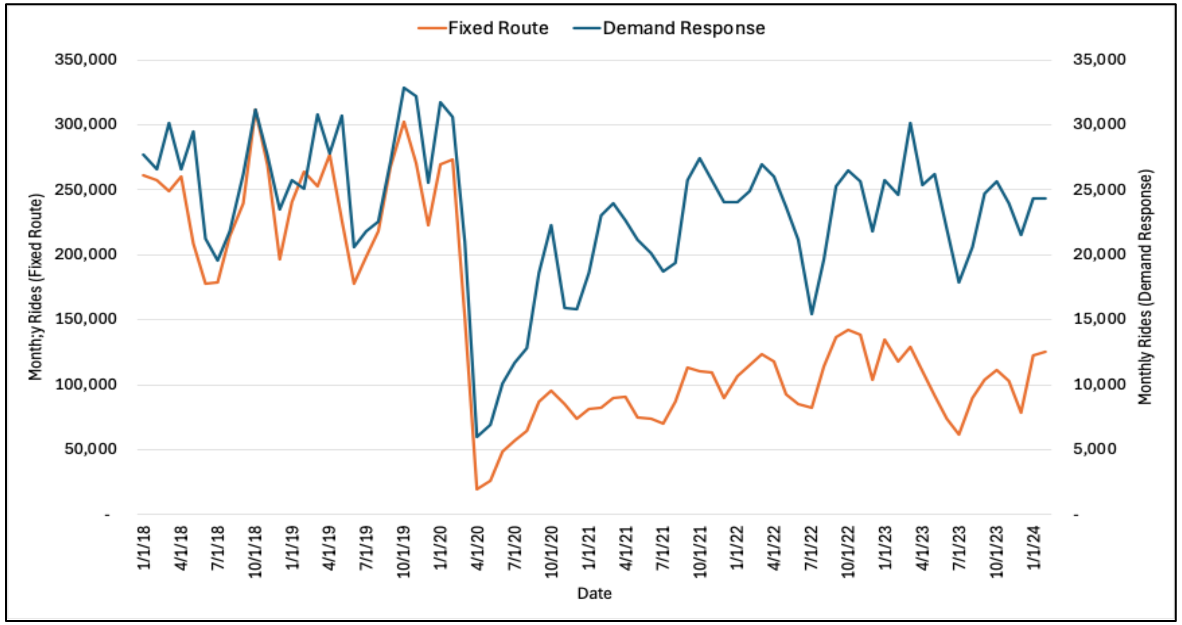
Source: APTA Factbook

Transit Ridership Before and After the COVID-19 Pandemic

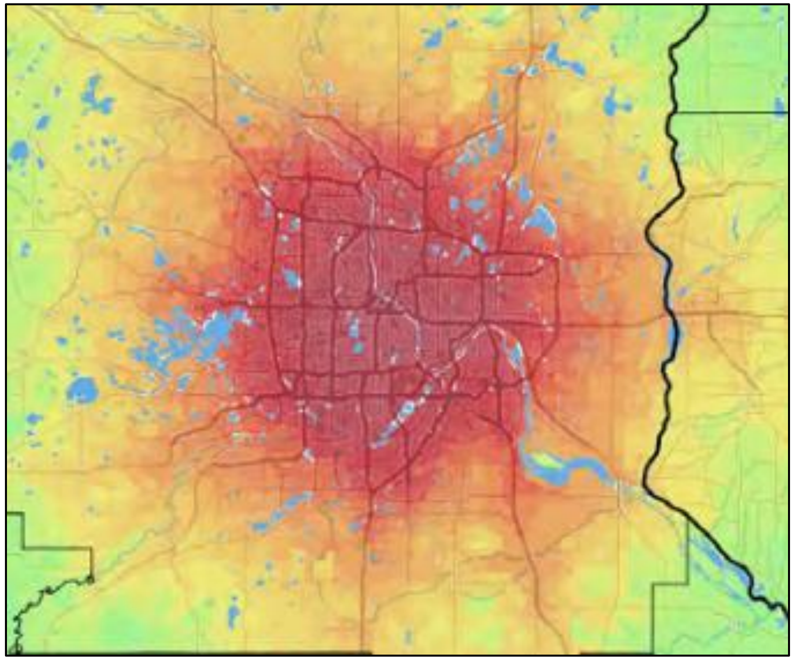
Twin Cities Metro Region



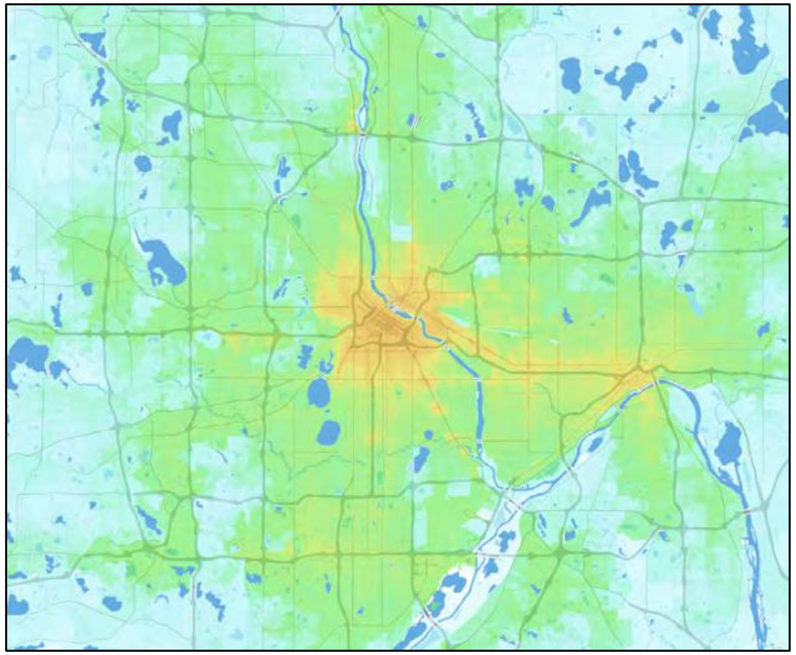
Sample* Rural Minnesota Services



Modal Accessibility Gap – Access to Jobs



Accessibility Observatory, University of Minnesota

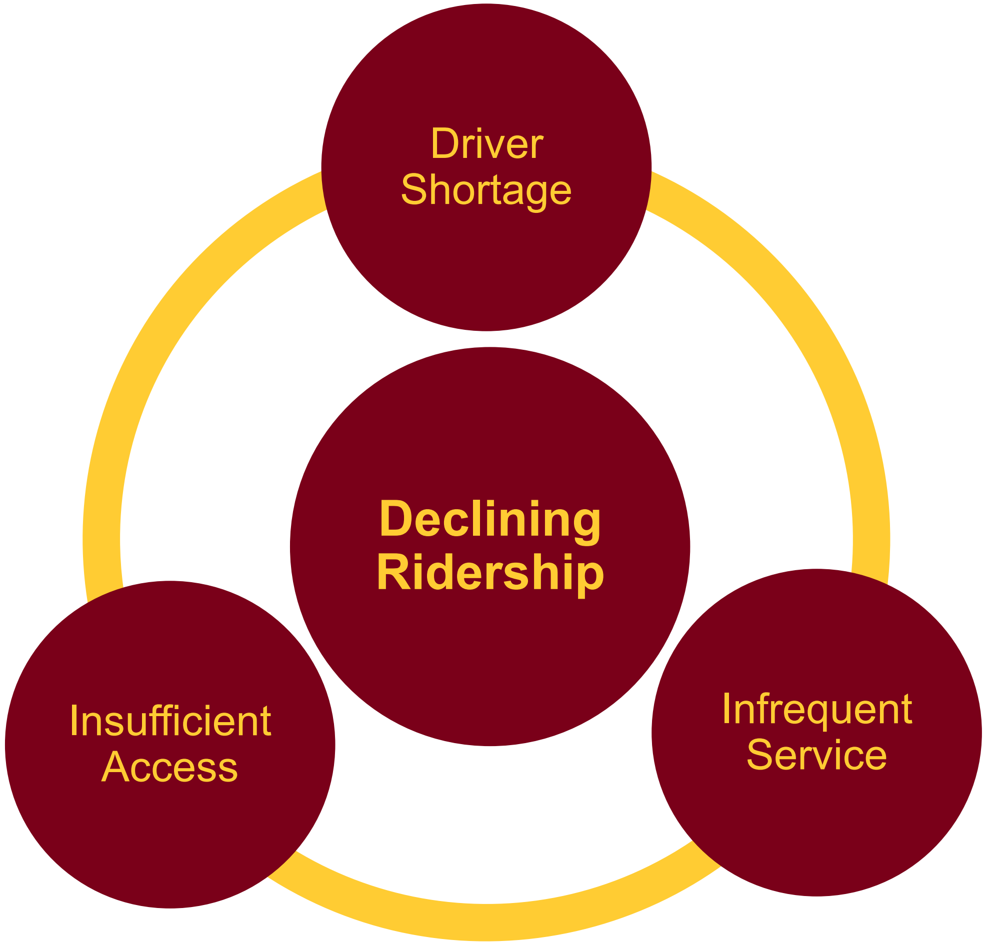


Accessibility Observatory, University of Minnesota

400k in 20 min
1.8M in 1 hour

5k in 20 min
150k in 1 hour

Transit Challenges and Technology Solutions



Mobility-as-a-Service (MaaS)

- Integrates information from multiple services
- Allows trip planning, booking, payment, etc.

Mobility-on-Demand (MoD) Systems

- More responsive to varying demand
- Suitable for the first/last mile services

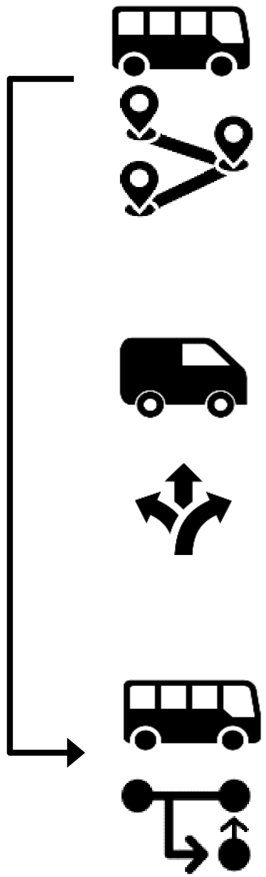
Autonomous Vehicles

- Cost effective, do not need drivers
- Can be fully controlled

Part 1

Rural Mobility-as-a-Service (MaaS)

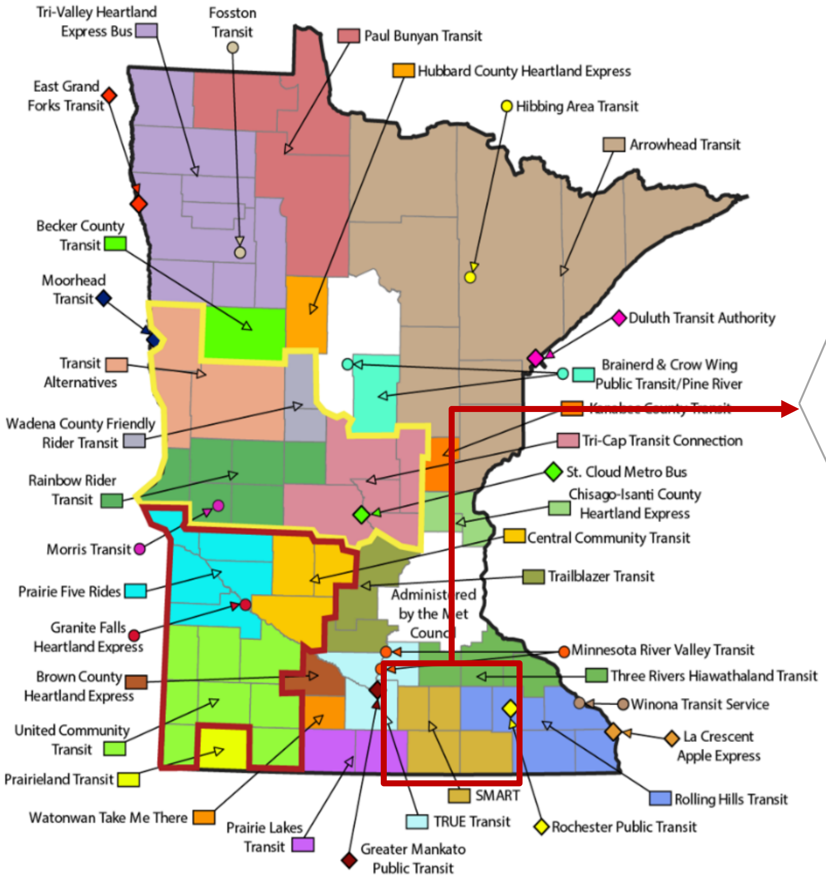
Southern Minnesota Rural Mobility-as-a-Service (MaaS)

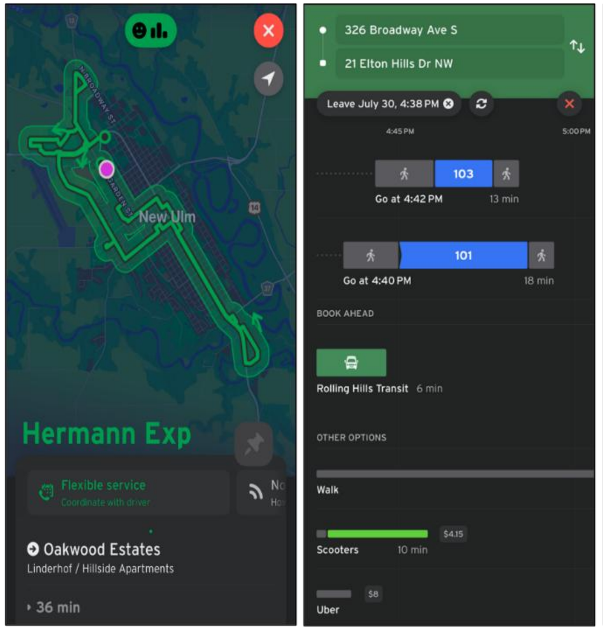


Fixed Route Buses

Demand-Responsive Transit (DRT)

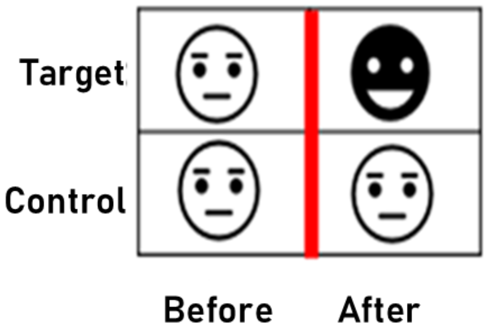
Route Deviation

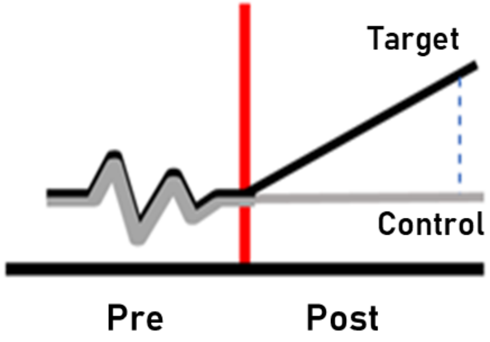


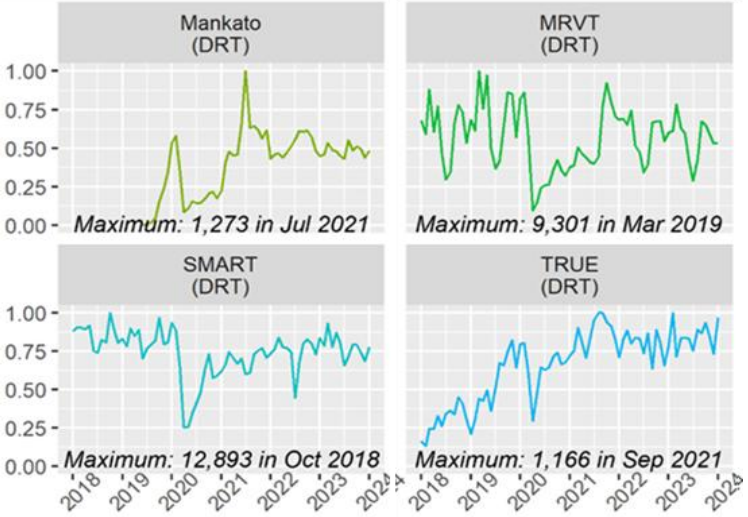


1. Ridership Analysis - National Transit Database (NTD)

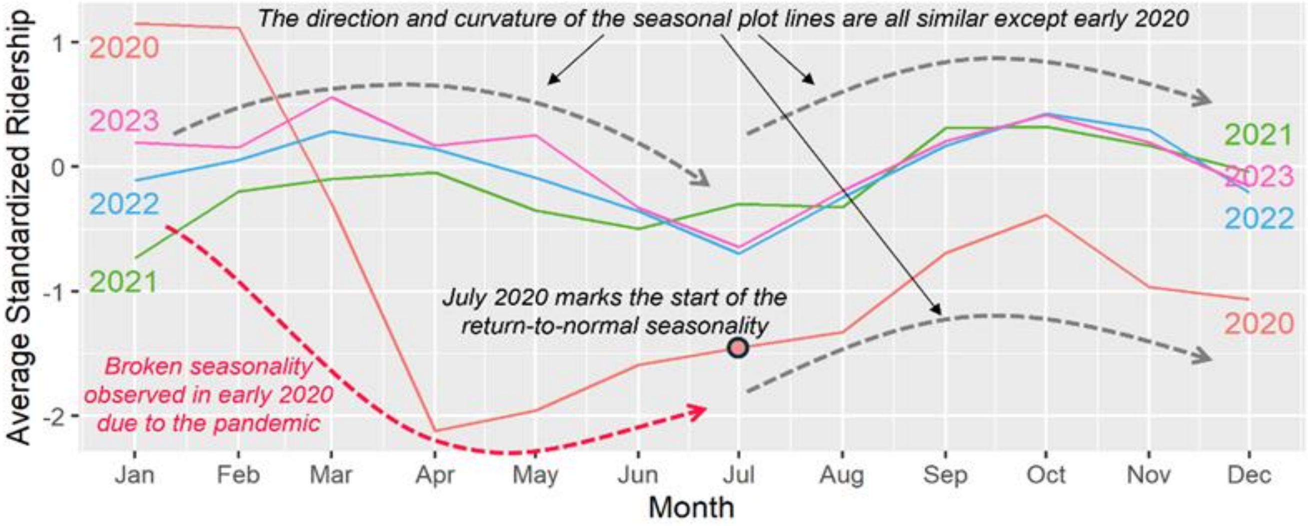
Agency	Route	Service Type	Year	Month	Trips
City of Mankato	Kato Flex	Demand Response	2023	January	321
City of Mankato	North Mankato Flex	Demand Response	2023	January	248
City of Mankato	North Mankato Flex #2	Demand Response	2023	January	4
City of Mankato	1B South	Fixed Route	2023	January	2743
City of Mankato	Campus Express	Fixed Route	2023	January	1759
City of Mankato	MSU episodic	Fixed Route	2023	January	34
City of Mankato	Route 10	Fixed Route	2023	January	838
City of Mankato	Route 11	Fixed Route	2023	January	352





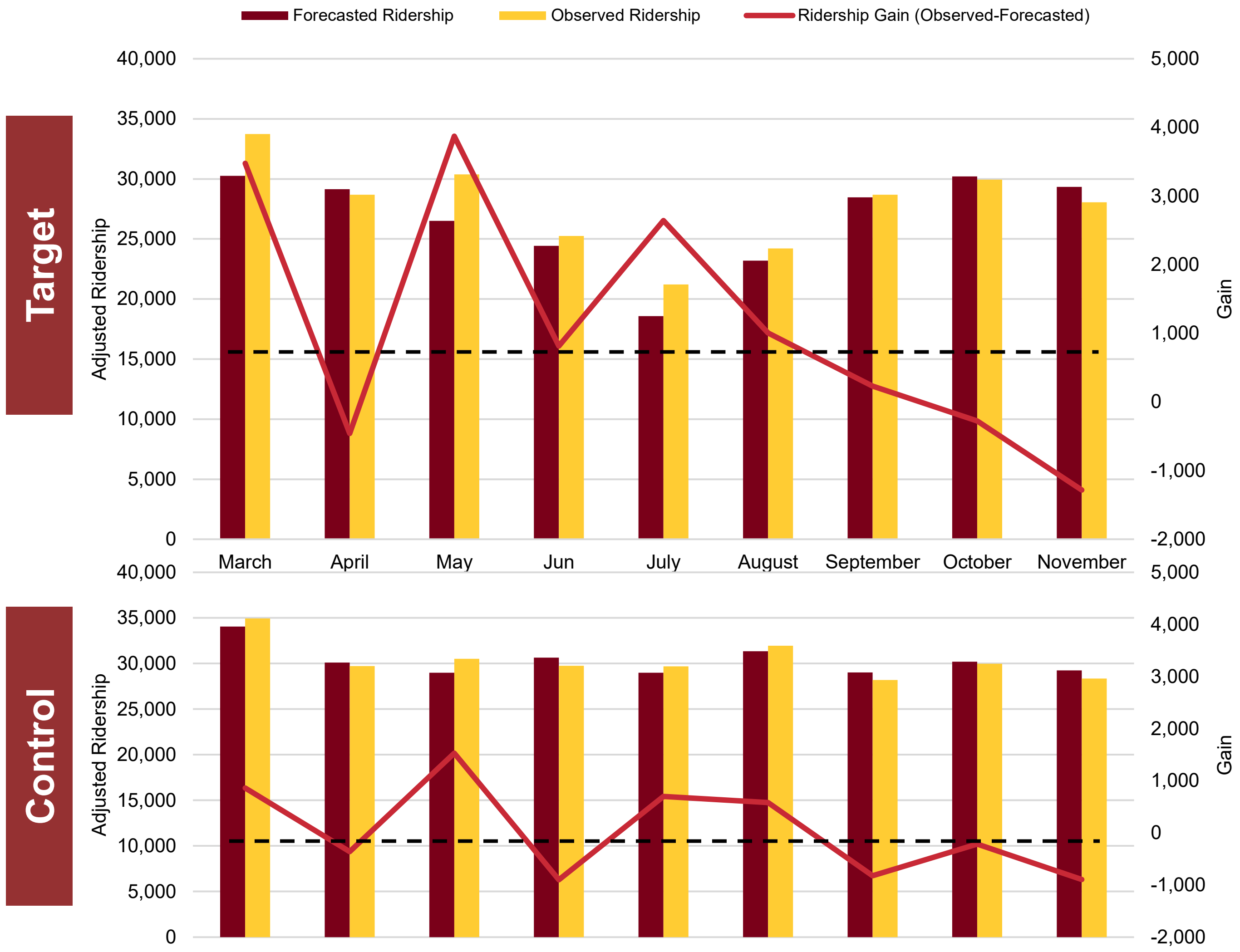


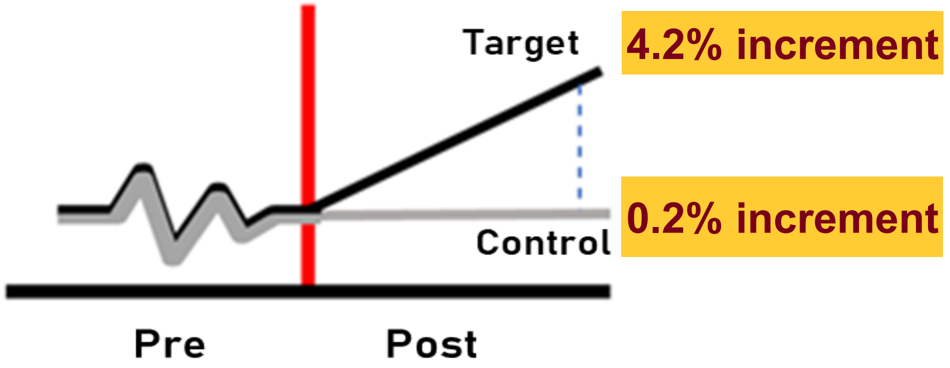
Standardize
& Aggregate



Baek, K. & A. Khani, Evaluating the Effects of Mobility-as-a-Service (MaaS) Platform in Increasing Equity and Transit Ridership in Rural Areas. *Transportation Research Record, Journal of Transportation Research Board*, Under Review.

1. Ridership Analysis - Time Series Modeling





Results Interpretation

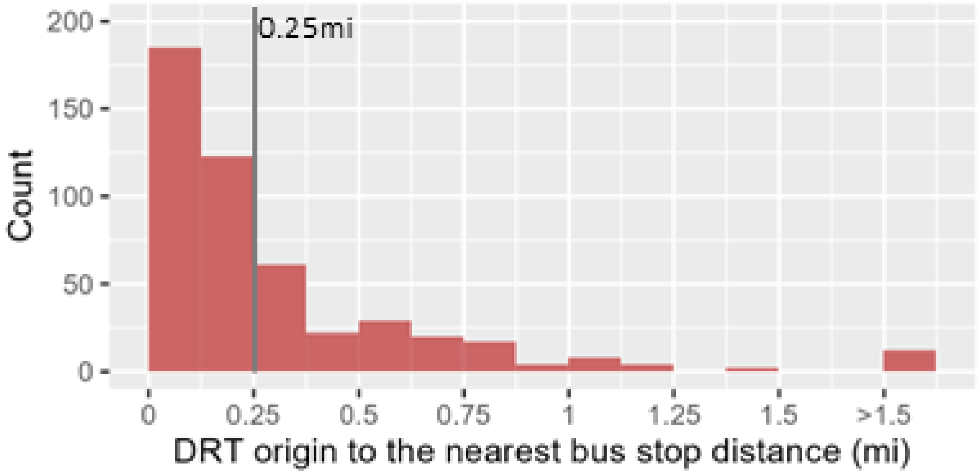
- Gains are mostly above the reference line for the target, but fluctuating around it for the control
- This indicates that MaaS positively impacts ridership growth

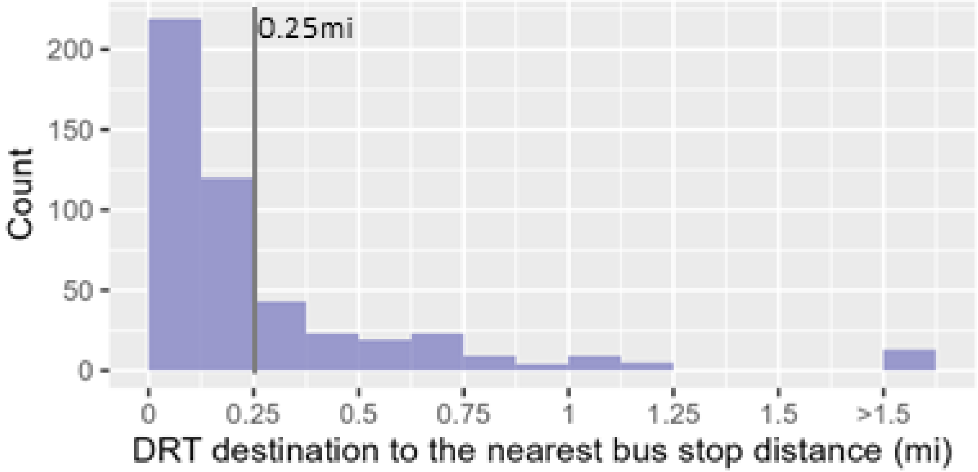
Baek, K. & A. Khani, Evaluating the Effects of Mobility-as-a-Service (MaaS) Platform in Increasing Equity and Transit Ridership in Rural Areas. *Transportation Research Record, Journal of Transportation Research Board*, Under Review.

2. Access Distance Analysis with Origin-Destination-Reservation (ODR)

A	B	C	D	E	F	G	H
Header	**Request ID**	**Request Received Date (Call-in Date)**	***(Optional) Request Received Time (Call-in Time)***	**Passenger's Requested Pick-up Date**	**Requested Pickup Time or Preferred Departrure Time (PDT in the manual)**	**Trip Origin (Pick-up)**	**Trip Destination (Drop-off)**
Example	1111	9/28/2023	11:49:44 AM	10/17/2023	10:35 AM	1201 Vine St, Le Sueur	504 S 2nd St, Le Sueur
	1112	10/17/2023	1:55:37 PM	10/17/2023	2:05 PM	413 Madison Ave, Mankato	River Hills Mall
Instructions	(Integer) ID; Should be unique for every trip request	Pressing Ctrl and semicolon (;) keys together will auto-fill current date	Pressing Ctrl, Shift, and semicolon (;) keys together will auto-fill current time	Normally, it will differ from the call-in date (column C)	Columns E and F collectively constitute preferred departure date & time that passenger requested & submitted	We can accept both addresses and coordinates; if using addresses, please **specify at least Bldg #, Street, and City (or lat/lon coordinates) Alternatively, you can type as you would do normally, and share us your address book**	
Please see this link: Removing optional columns and/or adding your own columns that would help the data collection are always welcomed.							

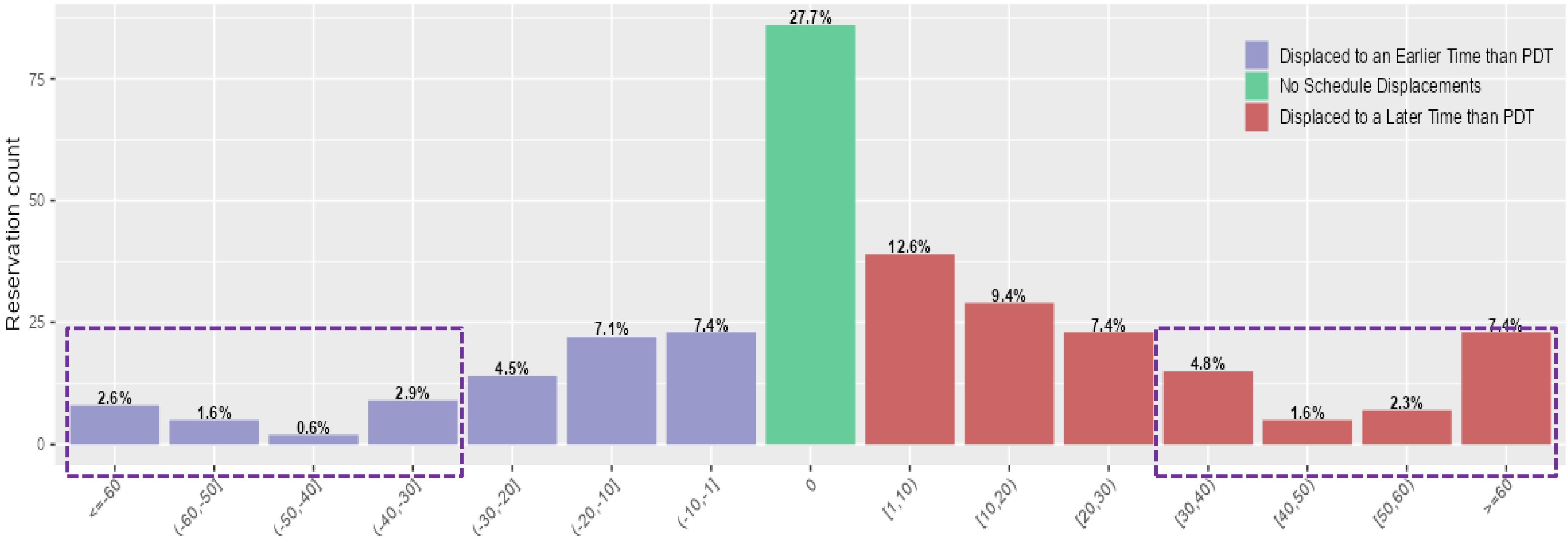
- **69.6%** of trip origins within 0.25 miles
- **63.3** of trip destinations within 0.25 miles
- **41.1%** have both origin and destination within 0.25 miles of a bus stop!





Baek, K. & A. Khani, Evaluating the Effects of Mobility-as-a-Service (MaaS) Platform in Increasing Equity and Transit Ridership in Rural Areas. *Transportation Research Record, Journal of Transportation Research Board*, Under Review.

3. Schedule Displacement Analysis with ODR Data

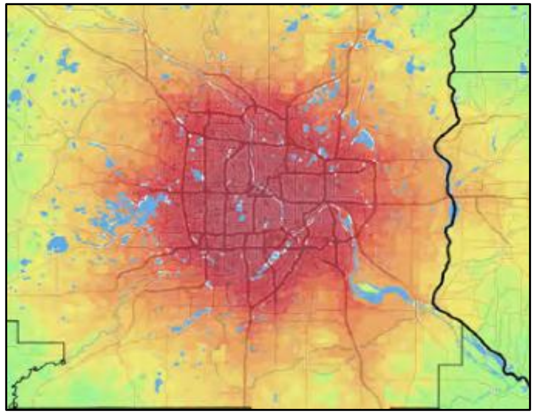


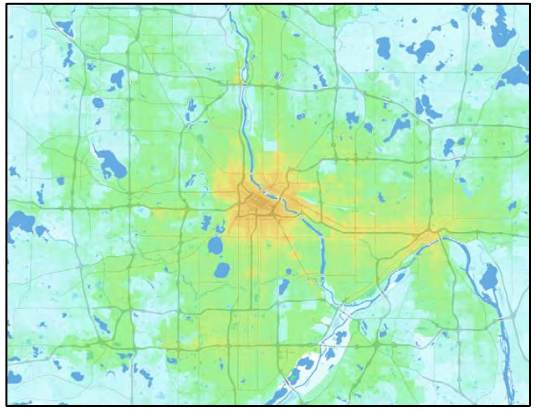
- More than **20%** of passengers have experienced 30+ minutes of schedule displacement.
- Simulation results show that serving more riders with **intermodal itineraries** could reduce DRT loads and schedule displacements without significant increase in travel times.

Baek, K. & A. Khani, Evaluating the Effects of Mobility-as-a-Service (MaaS) Platform in Increasing Equity and Transit Ridership in Rural Areas. *Transportation Research Record, Journal of Transportation Research Board*, Under Review.

Part 2
Autonomous Mobility-on-Demand (AMoD)

Transit Last-Mile Access Problem





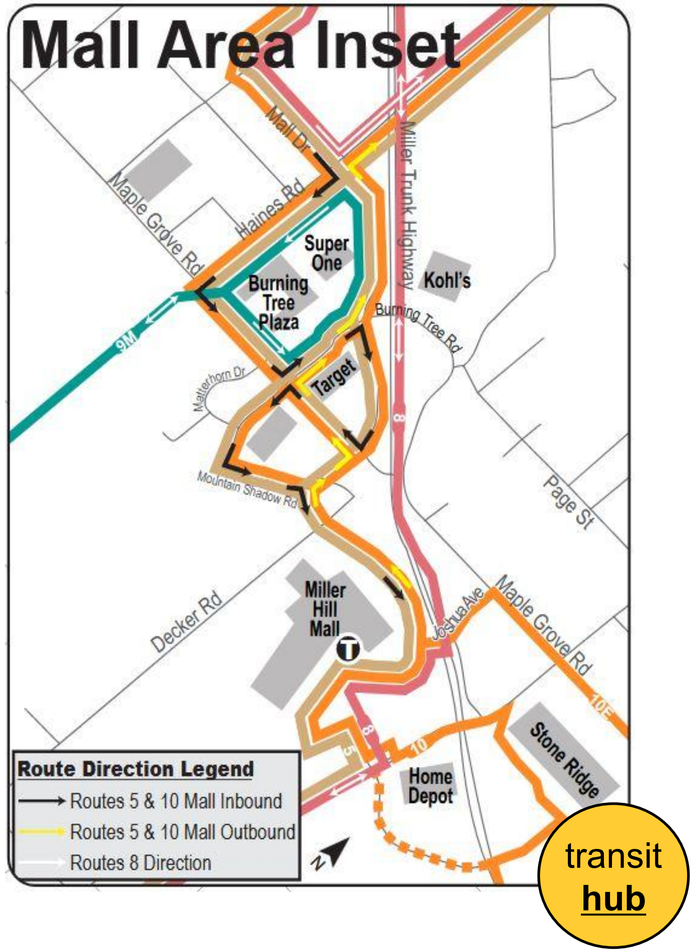
- High vehicle ownership
- High VMT and GHG emissions
- Infrequent and distant buses
- Improper access for riders
- Unsafe for pedestrians
- Low transit ridership

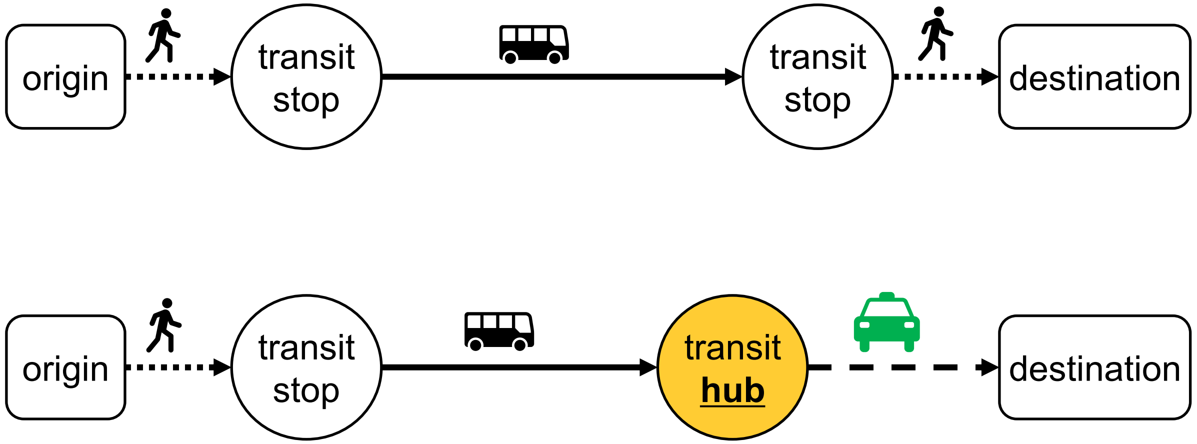
Q1. How can a last-mile service be designed, optimized, and integrated with fixed-route transit?

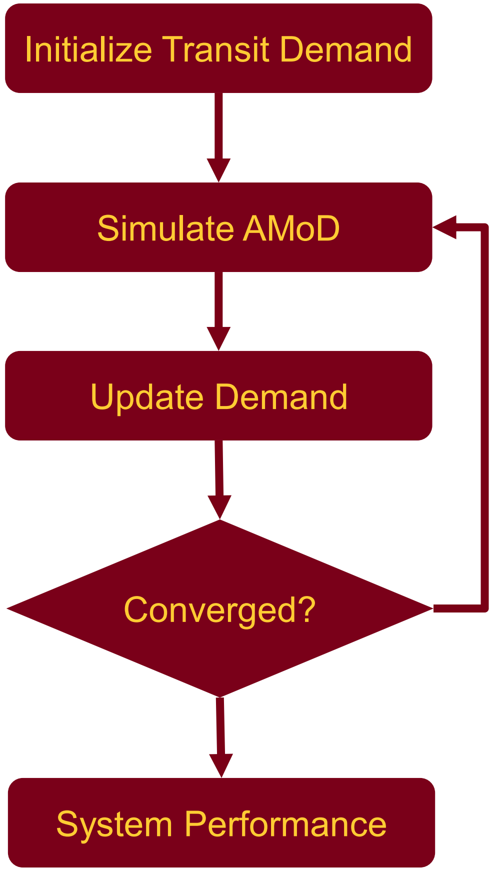
Q2. How much can transit benefit from a last-mile service?

AMoD as Transit Last-mile Service

Case Study: Miller Hill Mall, Duluth, MN



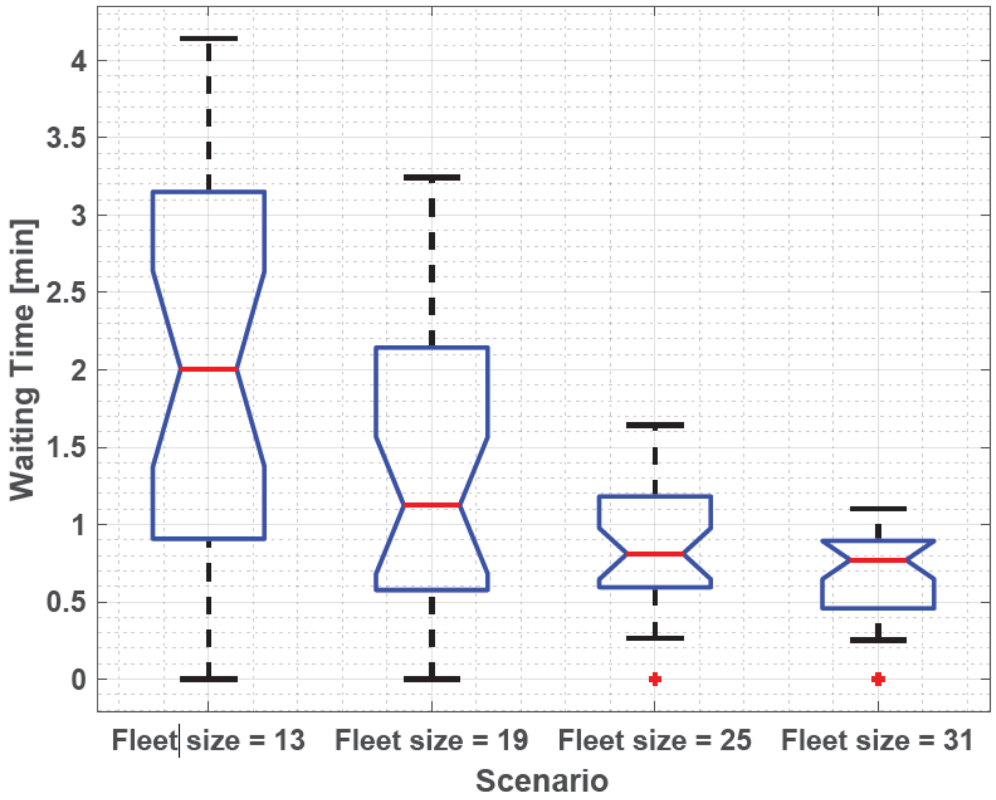




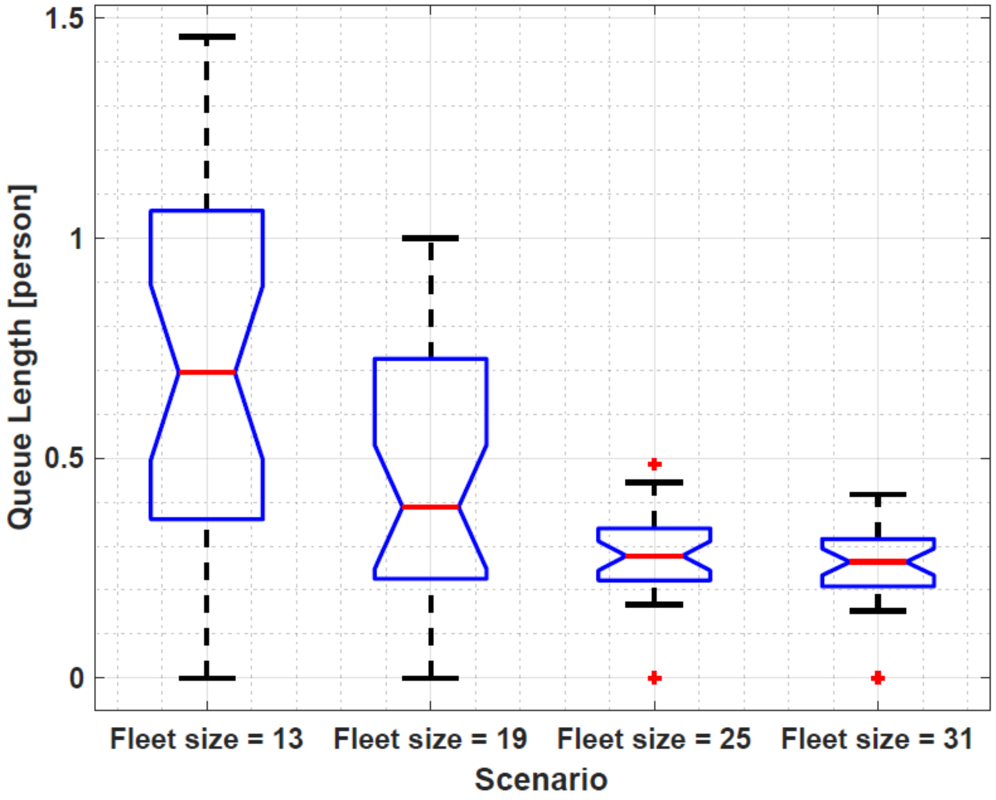
Aalipour, A., & Khani, A. (2024). Designing an autonomous mobility-on-demand service for transit last-mile access. *Transportation Research Record*, 2678(11), 2181-2194.

AMoD Simulation – Passengers

On average, AMoD passengers wait no more than **3 minutes** for the AMoD service



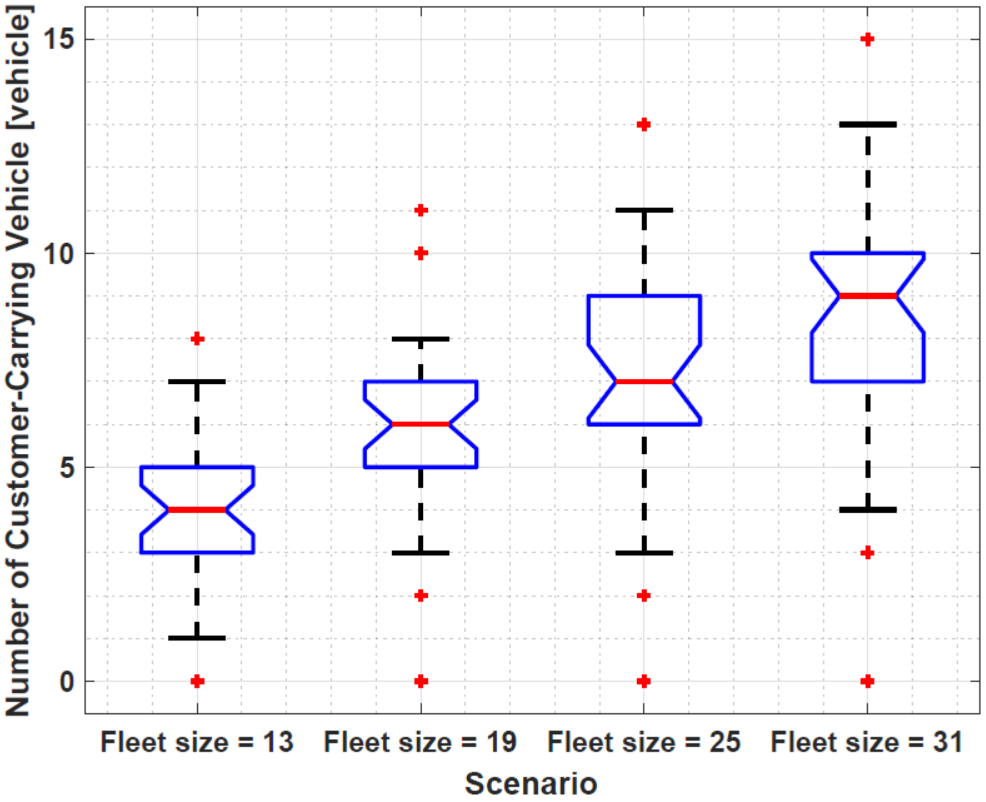
On average, no more than **1 passenger** waits for AMoD at each time.



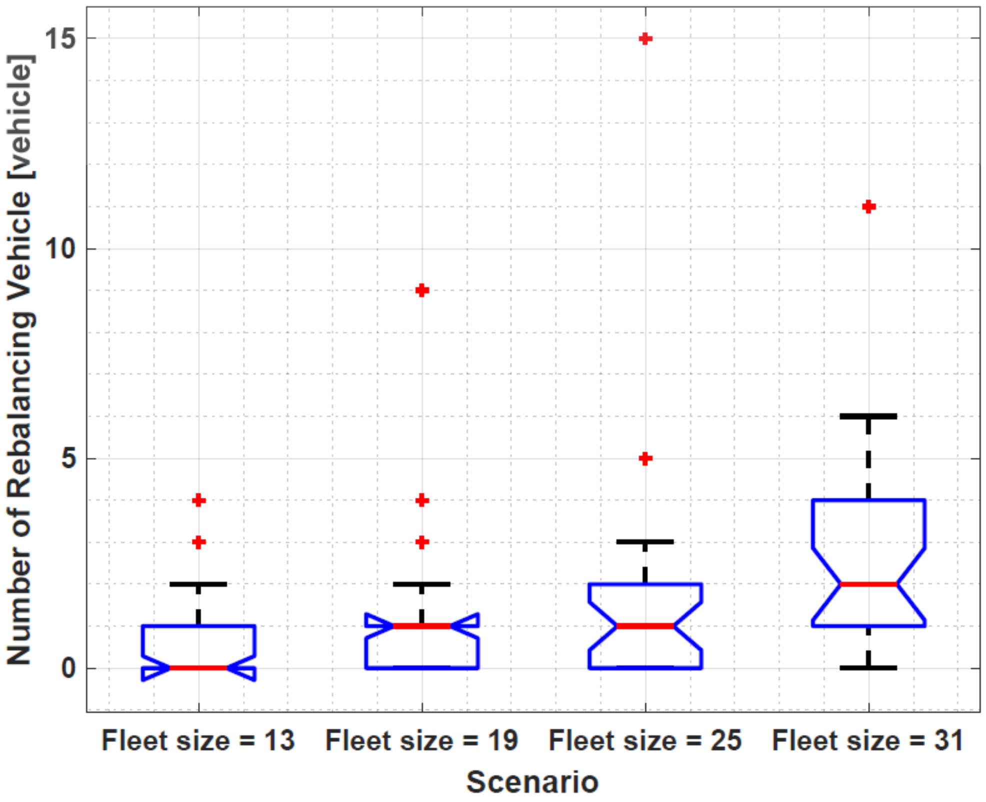
Aalipour, A., & Khani, A. (2024). Designing an autonomous mobility-on-demand service for transit last-mile access. *Transportation Research Record*, 2678(11), 2181-2194.

AMoD Simulation – Vehicles

As fleet increases, AMoD vehicle dispatching increases proportional to transit demand



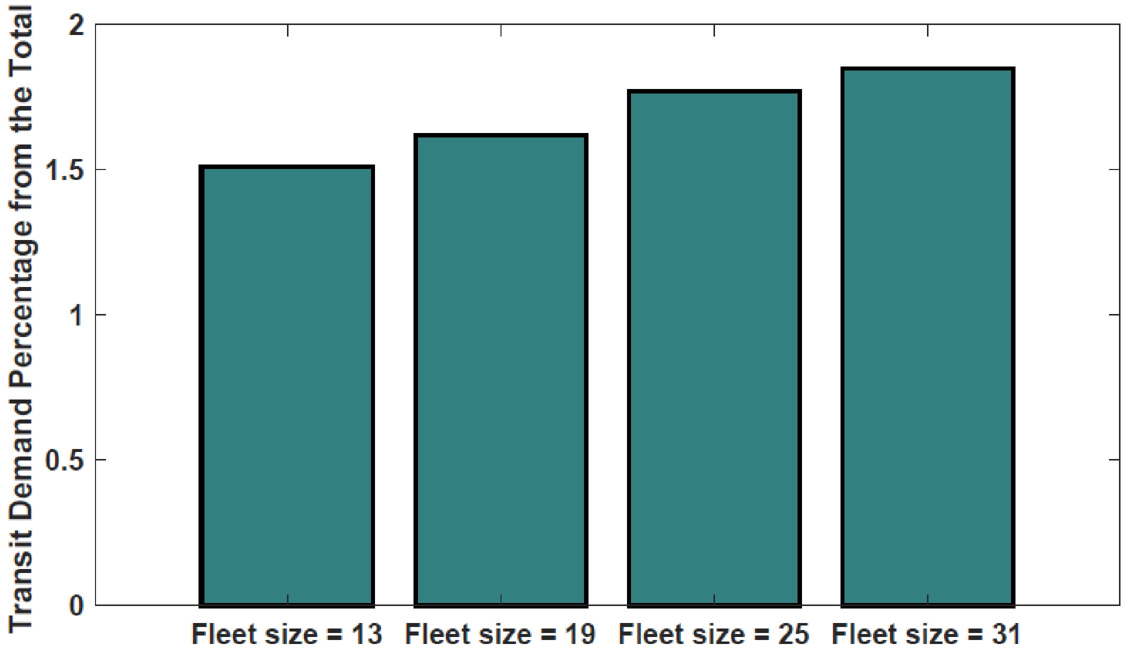
Some AMoD vehicle rebalancing is needed but much less than that of dispatching



Aalipour, A., & Khani, A. (2024). Designing an autonomous mobility-on-demand service for transit last-mile access. *Transportation Research Record*, 2678(11), 2181-2194.

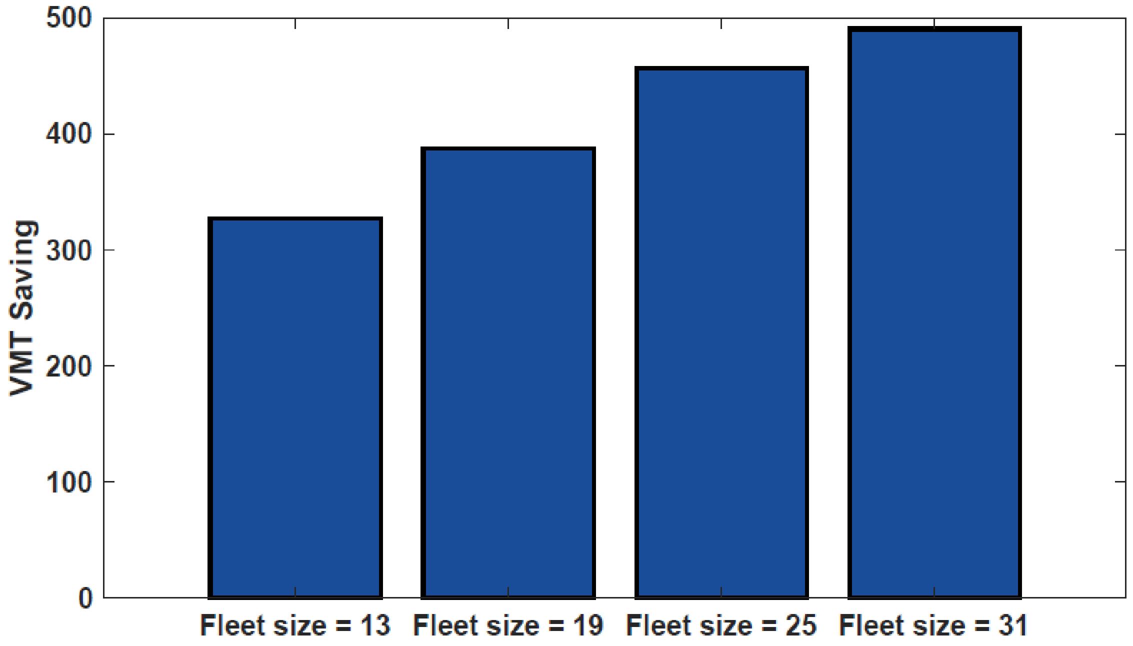
AMoD Simulation - Transit Ridership and VMT

Transit ridership to the MHM area ***increases*** as AMoD fleet size increases.



** Baseline transit mode share is about 1%*

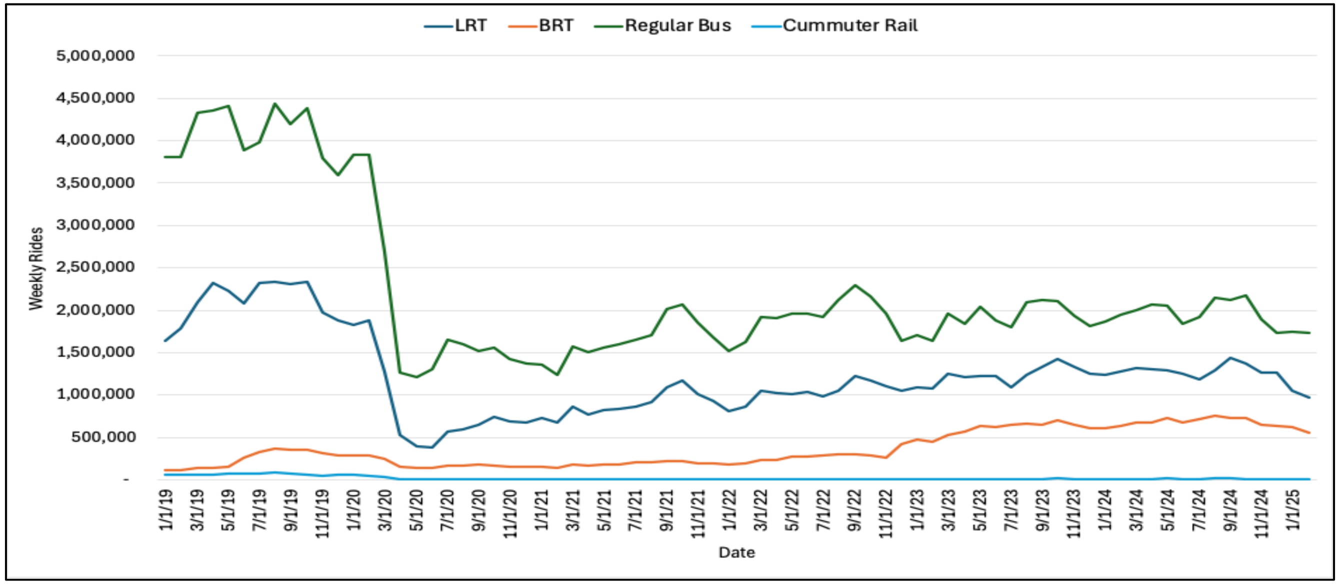
VMT saving ***increases*** as AMoD fleet size increases, as more people use transit+AMoD.



Aalipour, A., & Khani, A. (2024). Designing an autonomous mobility-on-demand service for transit last-mile access. *Transportation Research Record*, 2678(11), 2181-2194.

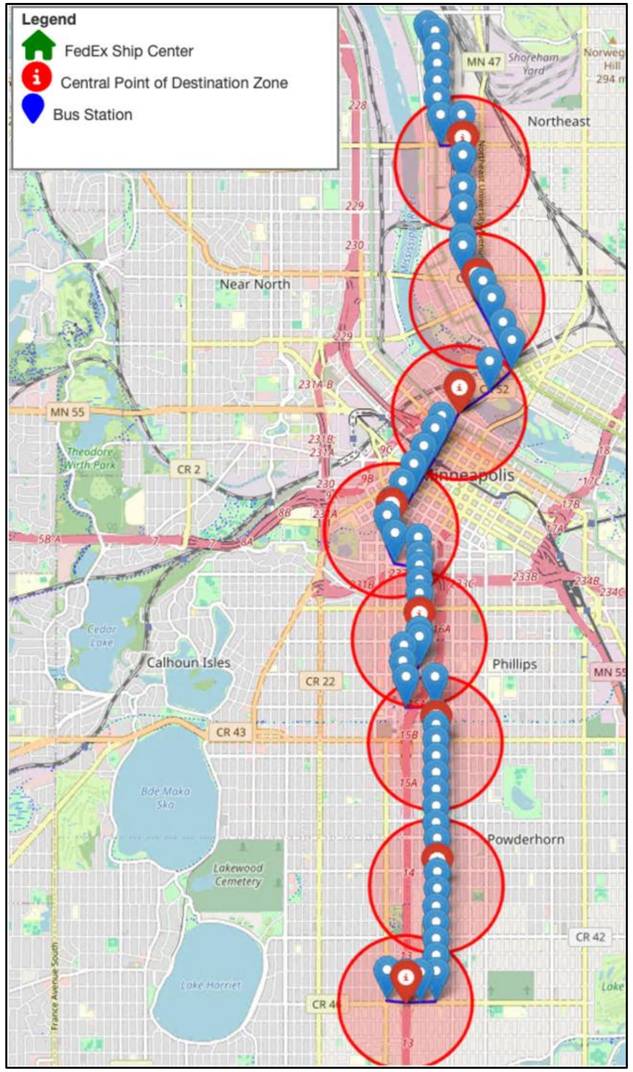
Part 3
Freight on Scheduled Bus (FoSB)

Last-mile Delivery with Freight-on-Scheduled Bus (FoSB)



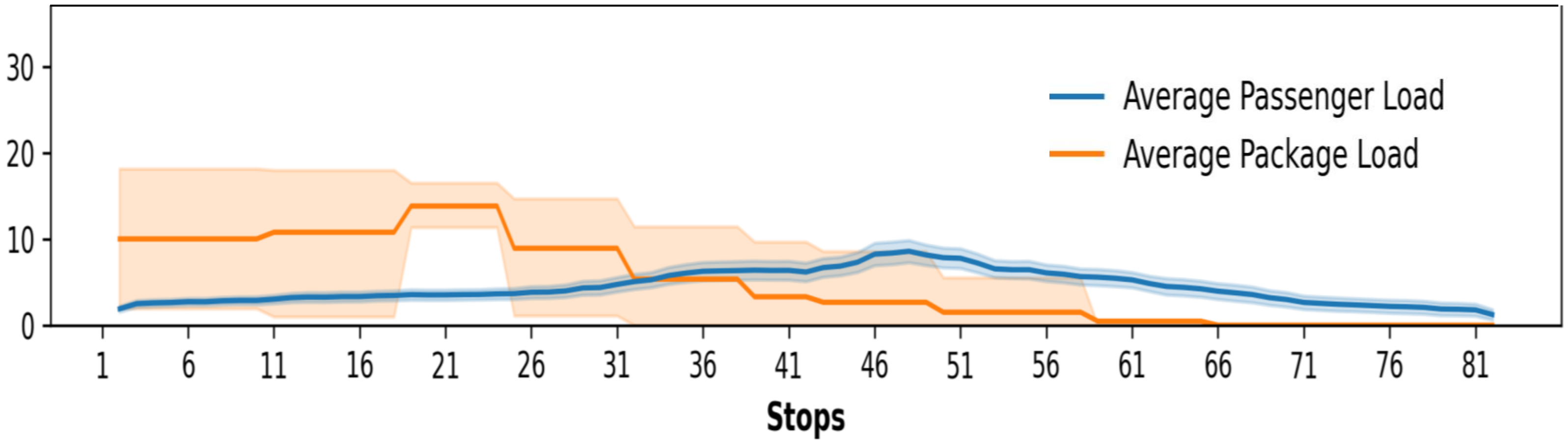
Schwerdfeger and Boysen, 2020

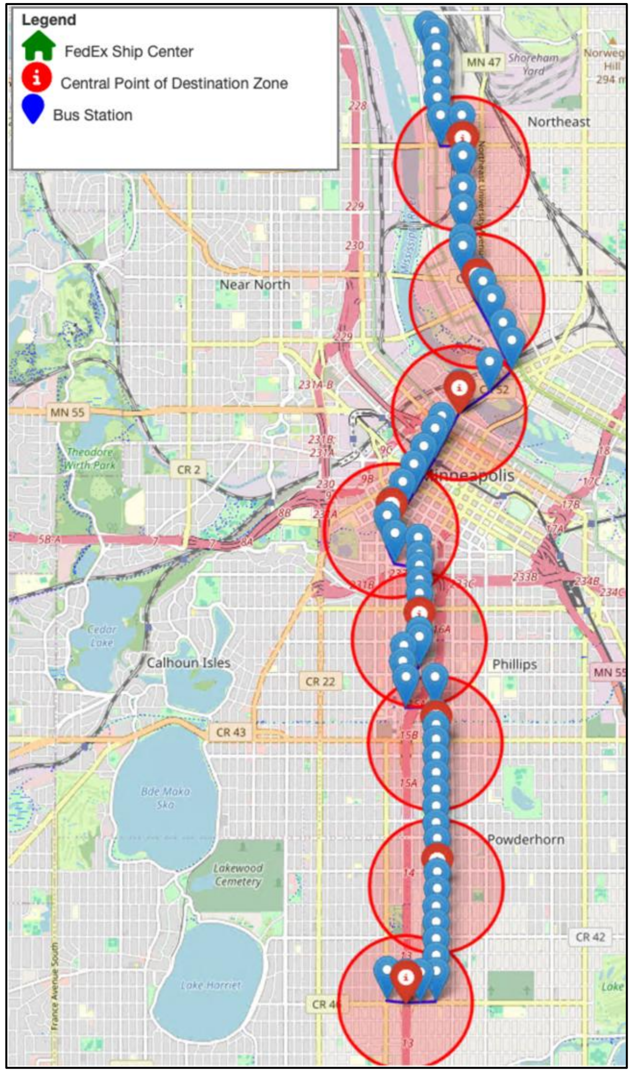
Urban Freight Lab



Tork, N., K. Baek, & A. Khani, (2025), Efficient Urban Transit Systems: Bridging Freight Logistics and Passenger Transport. *Transportation Research Record, Journal of Transportation Research Board*, 2679(11), 782-804.

Optimal Package Allocation: Prioritizing Passengers

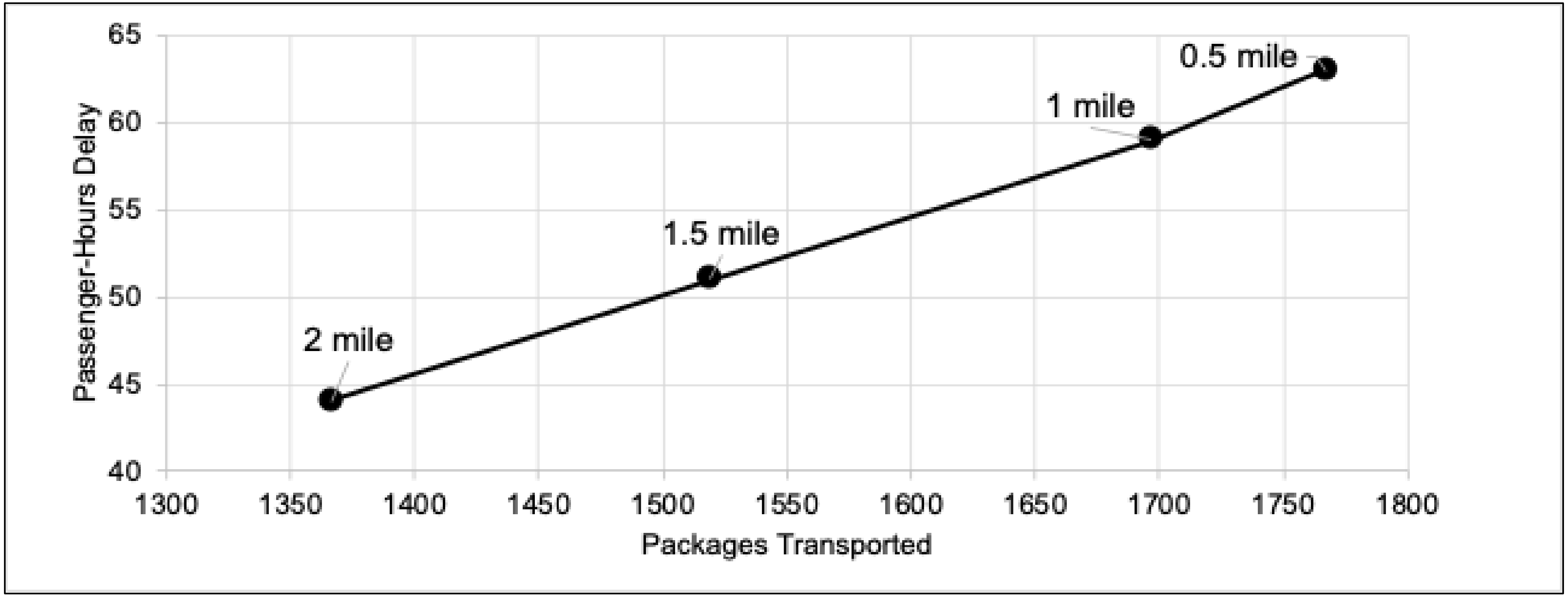




- Empty seat-miles could be reduced by **15-38%.**
- Gains vary by route type; suburban and express routes provide the greatest opportunity.

Tork, N., K. Baek, & A. Khani, (2025), Efficient Urban Transit Systems: Bridging Freight Logistics and Passenger Transport. *Transportation Research Record, Journal of Transportation Research Board*, 2679(11), 782-804.

FoSB Impact on Passengers Experience



There would be an additional **2 passenger-minute** delay per package

Tork, N., K. Baek, & A. Khani, (2025), Efficient Urban Transit Systems: Bridging Freight Logistics and Passenger Transport. *Transportation Research Record, Journal of Transportation Research Board*, 2679(11), 782-804.

Final Remarks

- Transit systems are facing challenges, with low ridership at the core of them
- Fixed-route service is the backbone of transit, which should remain available with high frequency and reliability, and be complemented with on-demand services
- New transportation technologies can help (complement) transit by increasing accessibility, reliability, and sustainability:
  - Mobility-as-a-Service Platforms
  - Mobility-on-Demand Services
  - Multimodal Last-mile Delivery
- Advanced OR and AI tools are essential for adopting and optimizing new technologies

Acknowledgements

DEPARTMENT OF TRANSPORTATION

MN LOCAL ROAD RESEARCH BOARD

NSF

Federal Transit Administration

Metro Transit

METROPOLITAN COUNCIL

DULUTH-SUPERIOR METROPOLITAN INTERSTATE COUNCIL

DTA

Dr. Ali Aalipour
Former PhD Student

Kwangho Baek
PhD candidate

Nastaran Tork
PhD student

Thank You!

Alireza Khani, PhD, PE

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University of Minnesota
Driven to Discover®

Seamless Mobility

Pete Costello

What Do People Want?

"...people want a **seamless integration** of **sustainable solutions** into their **everyday routines**. They **seek simplicity** where products, services and experiences allow them to make positive contributions to the environment **without disrupting their lifestyle**"

Further with Ford - 2024 Trend Report | Ford Motor Company

1999


NOW!
compass
child/youth
VICTOR VALLEY TRANSIT
TouchPass
DÉCOUVERT
Tap & Go
RTS FAST PASS
RTS
Enjoy the Ride.
Customer Service Line : 6496 8300
ezlink
八達通 Octopus
SmarTrip
metro
TRIMET
GRT
easyGO
fare card
Region of Waterloo
DE WITH PRIDE
tap
RapiPass
Terminal + MetroBus + Metro
30256404
METROBUS
METRO DE PANAMA
OMNY
compass
ADULT
VONS
14 Sep 14
WisGo
umo

ITS AMERICA

Control Number: ______________

PROJECT REQUEST/STATUS FORM

Last Updated by: ______________________________ Date: ____________

Project Title: Concept of operations for clearinghouse development	
Start Date: November 2002	Completion Date: December 2003
Lead Forum: TSOP	Lead Program: Information
Scope: (brief statement): Explain the difference between a customer service center and a clearinghouse. Write guidelines that provide a concept of operations for clearinghouses and address the issues that affect clearinghouse model development and implementation. Address business rules from individual agency, multi-agency and inter-application perspectives and tier impact on clearinghouse model development.	
Major Milestones (include dates): Research of clearinghouse models - June 2003 Draft clearinghouse concept or operations document – September 2003 Workshop – September 2003 Final Guidelines document reporting results of research and potential - December 2003	

A 20+ Year Search!

ITS America

never initiated project

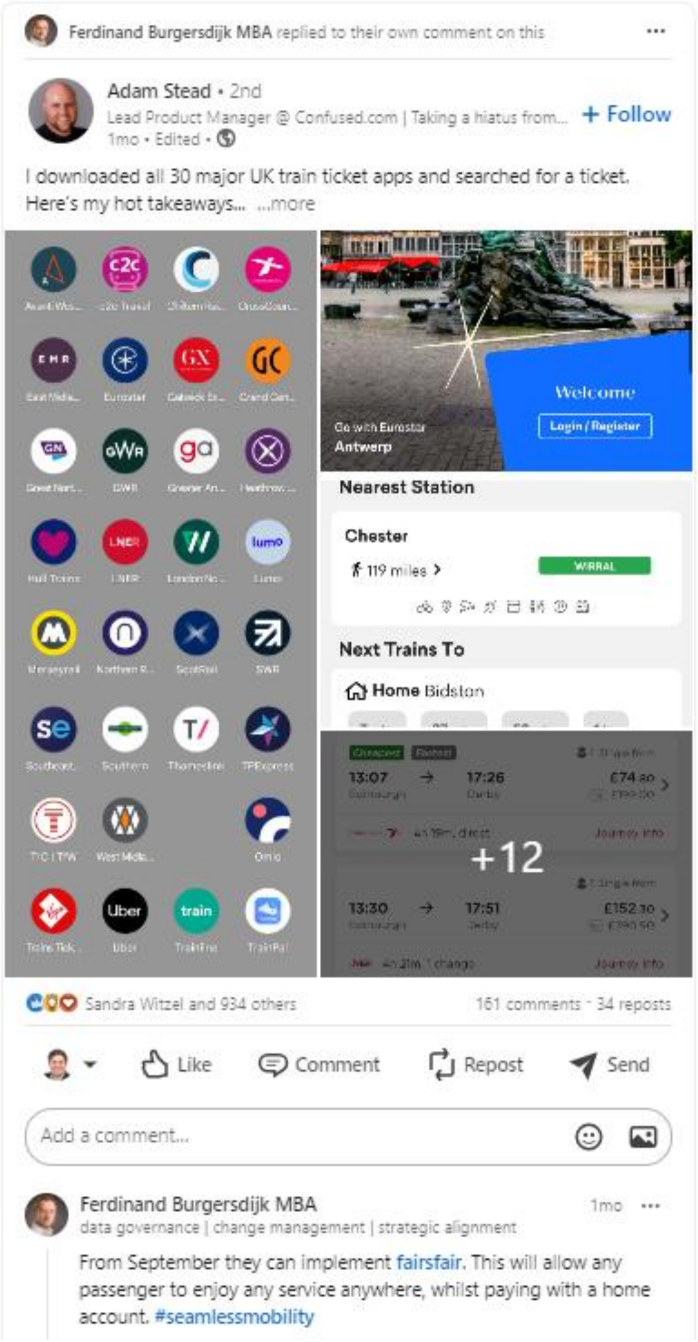
- Conversation of Consequence – Ferdinand & Pete
  - Los Angeles ITS WC 2022
  - Focus on Privacy
  - Watching Ferdinand’s progress on LinkedIn
  - #SeamlessMobility comment

Ferdinand Burgersdijk MBA 1mo •••
data governance | change management | strategic alignment

From September they can implement fairsfair. This will allow any passenger to enjoy any service anywhere, whilst paying with a home account. #seamlessmobility

> **Fairsfair**
> Thanks to the European regulatory framework on data, the value related to acts, facts, information and compilations thereof finds its way to the...

Celebrate 6 · Reply 1



What agencies DO want

INTEROPERABILITY

A TRUSTED DATA SHARING PROTOCOL

CONNECTING LEGACY SYSTEMS

A trusted data sharing protocol enabling individuals, businesses and agencies to easily manage data, catering to the outcomes they want without neither compromising on convenience nor privacy

fairsfair.org

let the protocol work for you

REGIONAL

NATIONAL

GLOBAL

How Do We Change People's Behavior?

What Do People Want?

"...people want a **seamless integration** of **sustainable solutions** into their **everyday routines**. They **seek simplicity** where products, services and experiences allow them to make positive contributions to the environment **without disrupting their lifestyle**"

Further with Ford - 2024 Trend Report | Ford Motor Company

What is the true, total cost of each personal vehicle journey we take?

© Orlando Sentinel

- Friday, May 22, 2015 driving by myself from Orlando to Tampa to meet my cousin for a playoff hockey game
- How many other people driving by themselves to the game?

What is the true, total cost of each personal vehicle journey we take?

- 70 cent IRS mileage reimbursement rate?
  - Annual study of the fixed and variable costs of operating an automobile
- American Automobile Association's (AAA) 2024 estimate for the annual cost of owning and operating a vehicle: $12,297 / year or $1,025 / month?
  - Depreciation
  - Financing
  - Fuel
  - Insurance
  - Fees
  - Maintenance

- Do these cover every cost?
- What about societal and environmental costs?
- Total Cost of Ownership (TCO) offers a holistic approach
  - Operational Costs
  - Ownership Costs
  - Societal Costs
  - Environmental Costs

Comprehensive costs of transportation in Vancouver, BC

Component	Passenger Vehicles		Transit Buses°		SkyTrain		Cycling	Walking
	Low	High	Low	High	Low	High	Average	Average
Air Pollution	$5,504,964	$66,879,168	$819,781	$9,442,516	N.A.	N.A.	N.A.	N.A.
Climate Change ($CO2$)+	$8,236,685	$31,742,807	$202,814	$780,550	N.A.	N.A.	N.A.	N.A.
Hydro	N.A.	N.A.	$0↑	$0↑	$6,385,835		N.A.	N.A.
Road Infrastructure	$123,466,569		$10,191,586		N.A.	N.A.	$0	N.A.
Noise	$21,944,154	$41,145,290	$494,246	$926,712	$1,722,100	$2,410,940	N.A.	N.A.
Congestion	$433,760,000	$725,910,000	$12,630,000	$21,140,000	N.A.	N.A.	$0	$0
Accidents	$383,277,847		$11,363,328		$0↑	$0↑	$212,814	$2,933,622
Operating	N.A.	N.A.	$149,783,163‡		$102,574,173		$0↑	$0↑
Capital	See Road Infrastructure		$35,686,824↑	$46,966,366↑	$85,290,906	$151,971,454	$0↑	$0↑
Charges	-$113,947,485		-$168,965,109×		-$84,104,447×		-$7,498,482	N.A.
Healthcare Savings	N.A.		N.A.		N.A.	N.A.	-$16,884,693	-$18,941,581
Productivity Gains*	N.A.		N.A.		N.A.	N.A.	-$7,210,079	-$8,084,821
Total	**$862,242,734**	**$1,258,474,196**	**$52,206,634**	**$81,196,647**	**$111,868,567**	**$179,237,955**	**-$31,380,440**	**-$24,092,780**

+ Climate Change Costs are restricted to those caused by the emissions of carbon dioxide (CO_2)

* Productivity Gains illustrated above are only 50% of total Productivity Gains. The remaining 50% are internal benefits

‡ Operating Costs for transit buses do not include administrative costs

↑Indicates total costs are unavailable in this analysis yet significant and warranted in the future

× Charges are derived from fare revenues only

°"Transit buses" represent a composite average of all Diesel, Electric, and Hybrid Bus models operated in Vancouver

Notes:

- Aggregate values were calculated on the basis of all purpose trip making in the City of Vancouver in 2011
- Costs in indicated as "$0" in the above Table are applicable yet negligible
- "High" and "Low" in the above Table indicate "High Case" and "Low Case" scenario estimat

George Poulos (2014)

Component
Air Pollution
Climate Change (CO2
Hydro
Road Infrastructure
Noise
Congestion
Accidents
Operating
Capital
Charges
Healthcare Savings
Productivity Gains*
Total

Components of TCOPV

- Operational Costs
  - Fuel / Electric Charging
  - Maintenance and Repairs
  - Parking
  - Time
  - Tolls
  - Tickets
  - Driving Style
- Ownership Costs
  - Purchase Price & Sales Tax
  - Depreciation
  - Insurance
  - EV Home Charging Station
  - Vehicle Aftermarket Modifications
  - Registration, Fees, Taxes, etc.
  - Garage / Storage

Components of TCOPV

Societal Costs

- Road Infrastructure Costs
- Traffic Congestion
- Crashes
- Public Health Impacts
- Socioeconomic Inequality and Access to Transportation
- Equity and Accessibility

Environmental Costs

- Greenhouse Gas Emissions
- Noise Pollution
- Air Pollution
- Resource Extraction and Vehicle Production
- Land Use and Infrastructure Costs
- End-of-Life Disposal and Recycling

Components of TCOPV

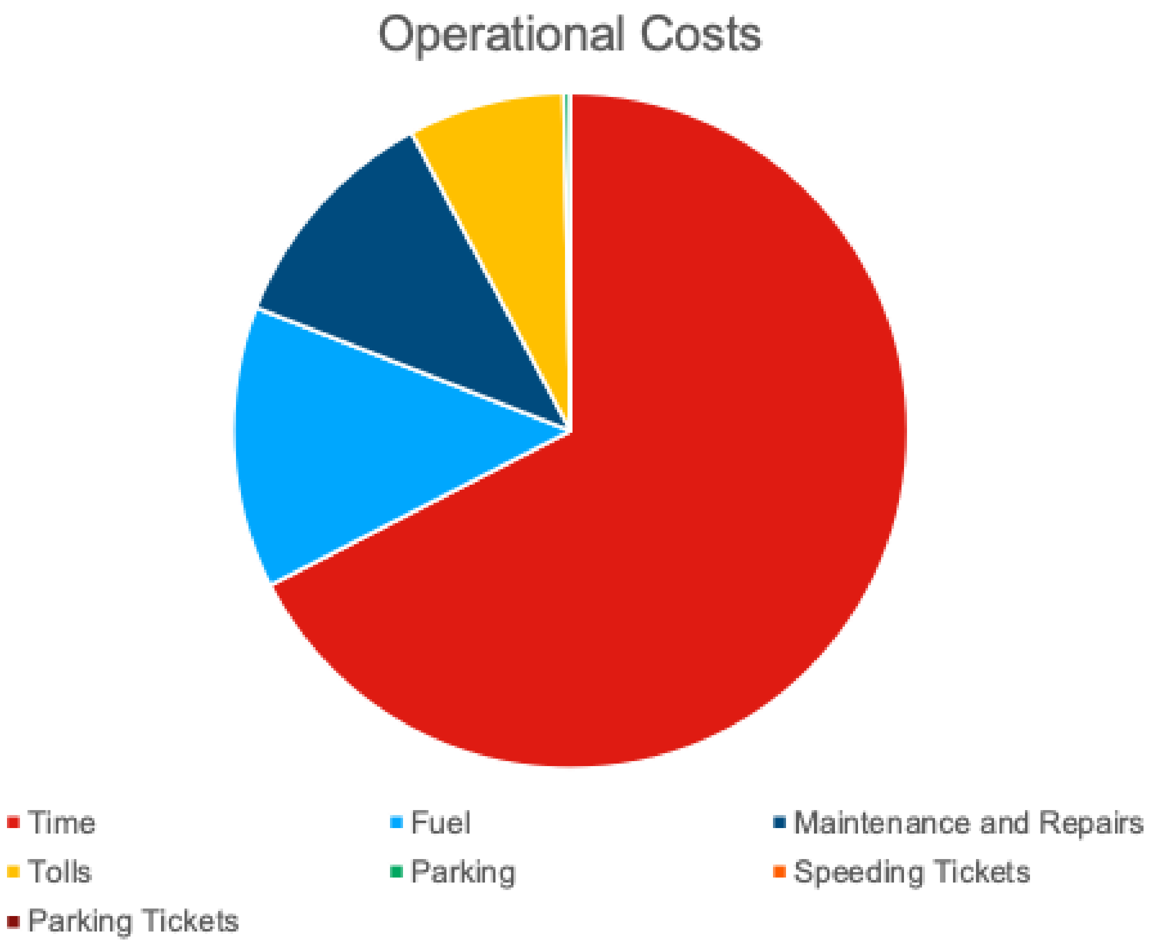
Hypothesis

- TCO of a personal vehicle > actual cost per mile for shared/public transit journeys
- *(ceteris parabus, all else being equal, including current taxes and / or effective subsidies applicable to other modes)*

Methodology

- Reviewed published evidence for the cost per mile across private vehicle cost-categories
- All evidence / costs are $US
- Adjusted to current year values and prices

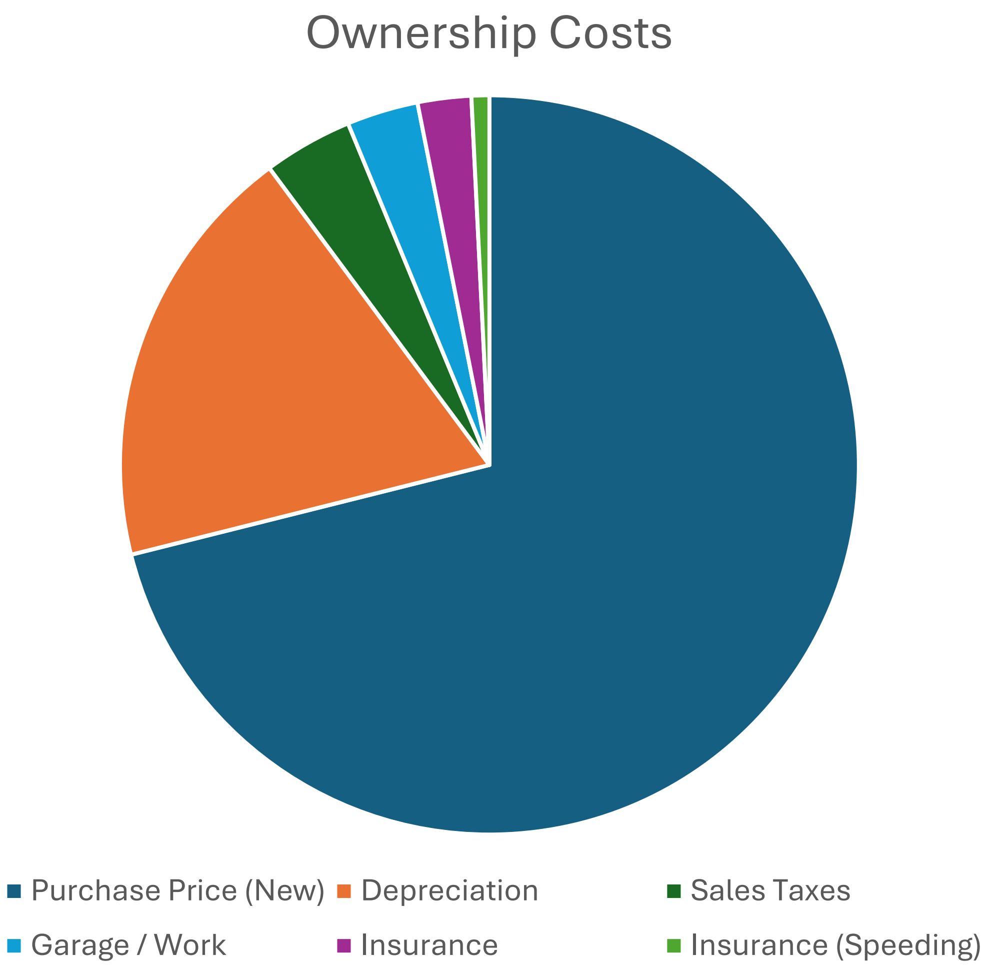
Components of TCOPV



Operational Costs / Mile
$0.905

• Time	$0.605
• Fuel	$0.125
• Maintenance and Repairs	$0.105
• Tolls	$0.067
• Parking	$0.003
• Speeding Tickets	$0.000
• Parking Tickets (approx. 25%)	$0.000

Components of TCOPV



Ownership Costs / Mile
$0.180

- Purchase Price (New) $0.095
- Depreciation $0.040
- Storage $0.006
- Sales Taxes $0.005
- Garage / Work $0.004
- Insurance $0.003
- Insurance (Speeding) $0.001

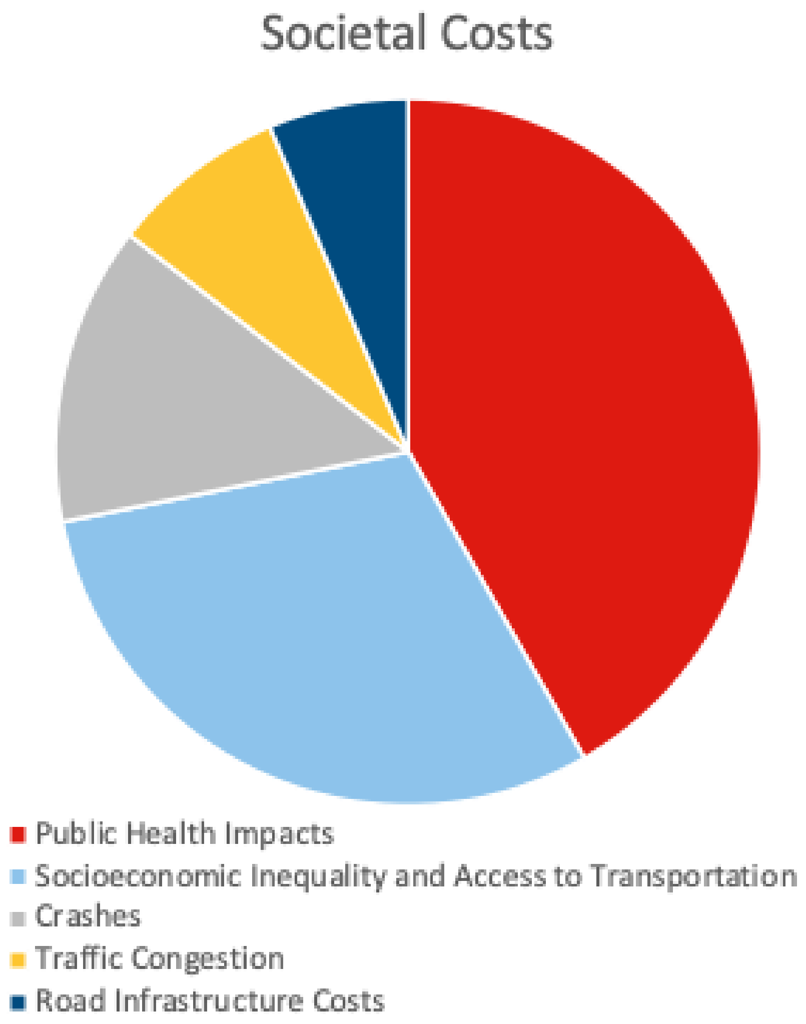
- Assumptions:
- Insurance and Garage Work converted from price per minute to price per mile assuming average 3 minutes per mile.
- Other Taxes e.g. Vehicle Excise Duty, Annual Road taxes not considered. These are significantly higher in other countries.

Components of TCOPV

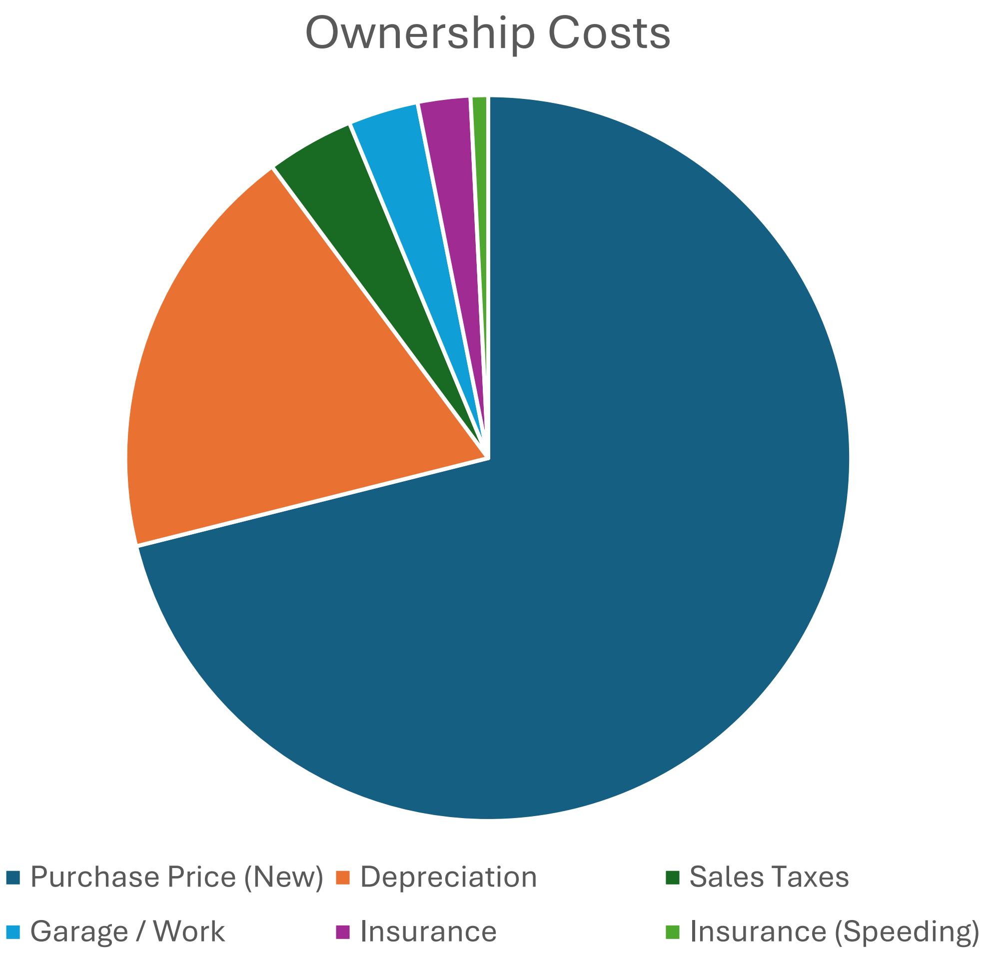
Societal Costs / Mile
$1.11

• Public Health Impacts	$0.444
• Socioeconomic Inequality & Access to Transportation	$0.330
• Crashes	$0.146
• Traffic Congestion	$0.110
• Road Infrastructure Costs	$0.079
• Equity and Accessibility	

- Notes:
- Marginal Congestion Costs c. 1/6th of time costs per mile. I.e. for every mile driven, traffic congestion adds 20% to time cost and 2% to total cost, and public health costs adds >8% to total cost per mile.



Components of TCOPV



Environmental Costs / Mile
$3.58

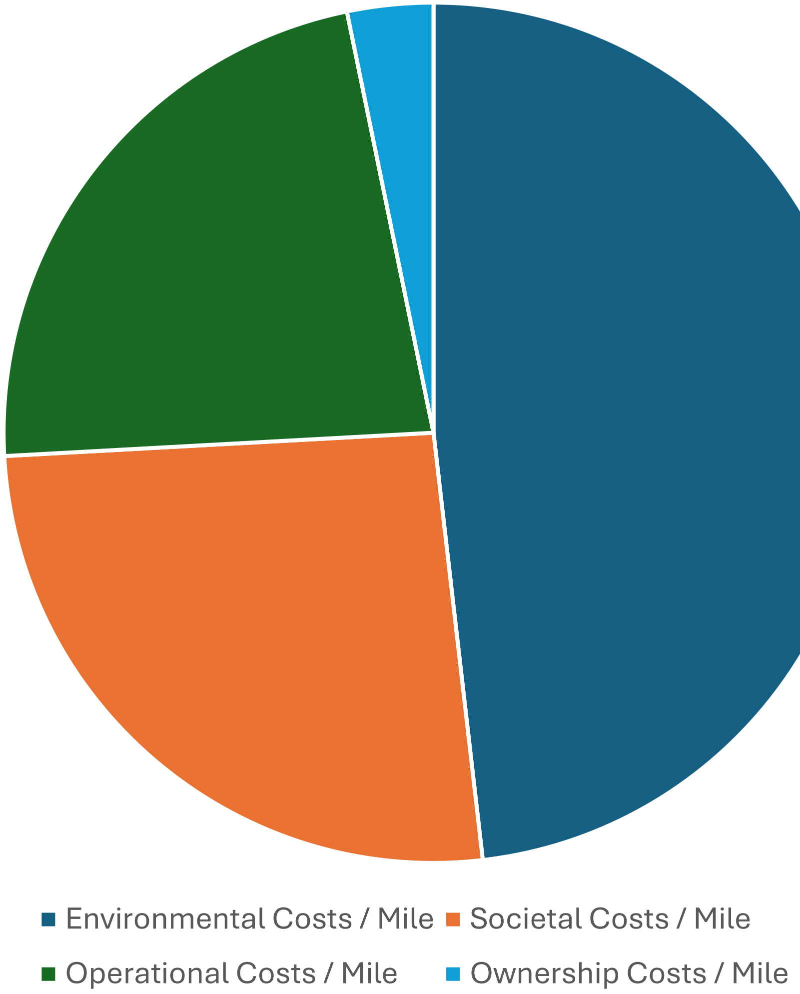
• Land Use and Infrastructure Costs	$3.297
• Greenhouse Gas Emissions	$0.106
• Resource Extraction & Vehicle Production	$0.086
• End-of-Life Disposal and Recycling	$0.041
• Noise Pollution	$0.034
• Air Pollution	$0.014

- (limited published research into costs available)

- Notes:
- We have dedicated large areas of land to our transport networks, imposing maintenance costs. Should we consider these an Opportunity Cost rather than an actual cost per mile, accounted for in taxes?

TCOPV Costs / Mile $5.77

- **TCOPV > Transit Cost per mile**
- The order of magnitude of costs might surprise you?
- External, Social and Environmental costs far exceed operational and ownership costs over any trip length
- US-based research, thus reflects low cost of fuel, highly competitive vehicle market and lower taxes than elsewhere in the world
- **Given TCOPV is so high and drives externalities, why don't policies and practice not seek to influence it more heavily?**



Transit cost per passenger mile

Street Car Rail	$8.22
Trolleybus	$2.74
Bus Rapid Transit	$1.84
Light Rail	$1.70
Demand Response	$1.17
Heavy Rail	$1.05
Commuter Rail	$0.80
Bus	$0.70
Commuter Bus	$0.39
Vanpool	$0.17

What is the true, total cost of each personal vehicle journey we take?

Almost $6 per mile!

Pete Costello
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Thank you!

Using Data and Technology to Effect Behavior Change in Transportation

TRB Webinar: Connected Mobility Futures—Integrating Transit and Technology

December 16, 2025

DRPT

VIRGINIA DEPARTMENT OF RAIL AND PUBLIC TRANSPORTATION

Problem

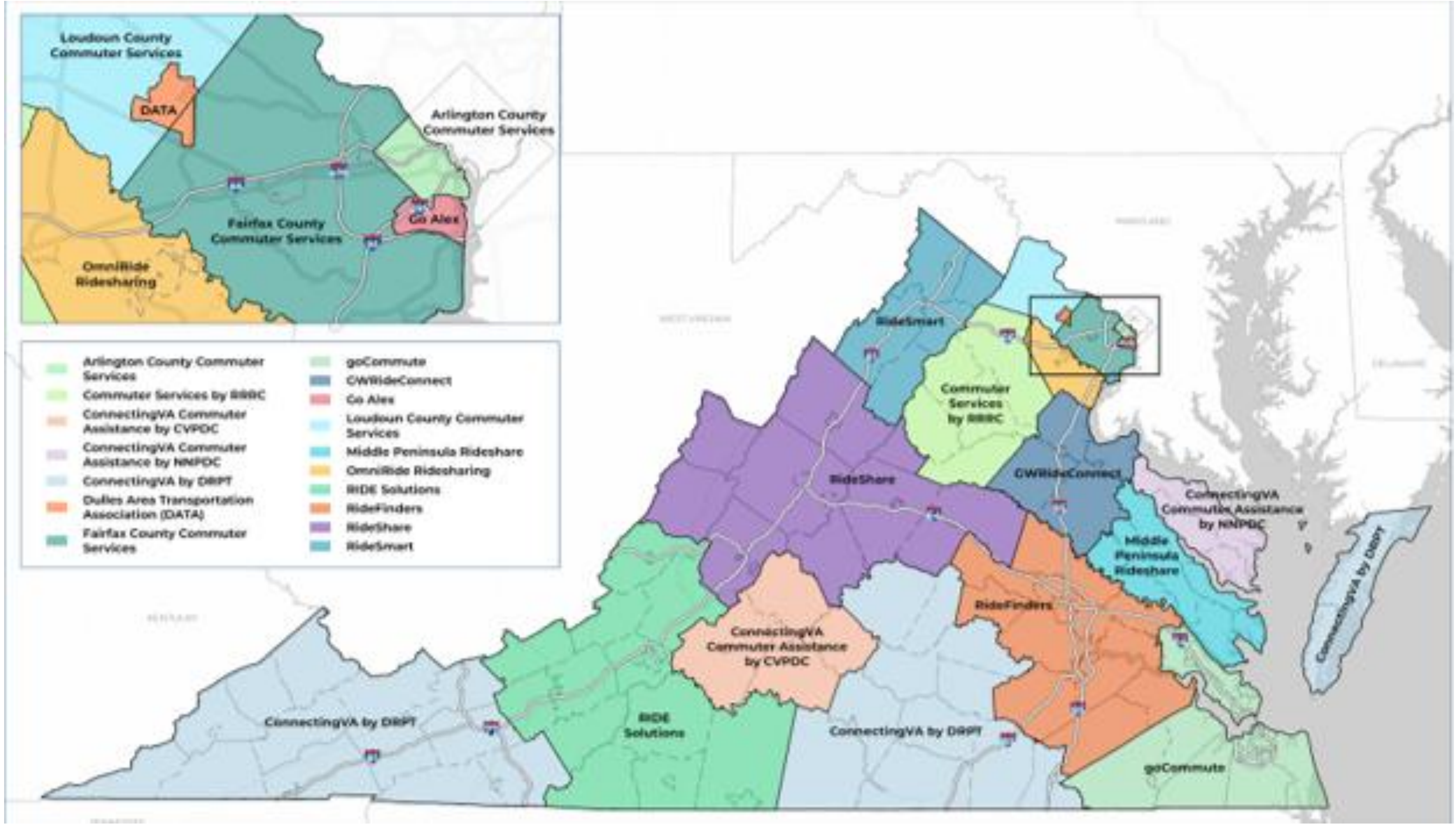
How do we get more people to:

- *Use transit (bus, commuter bus, commuter rail)*
- *Carpool*
- *Vanpool*
- *Bike commute*

Technology Limitations

- **Transit and ridematching mobile apps and website are mostly for people that already made a mode decision.**
- **Mobile apps and websites are not truly multimodal for trips.**
- **A lot of apps and websites.**
- **Google Transit not multimodal**

Virginia's Commuter Assistance Programs



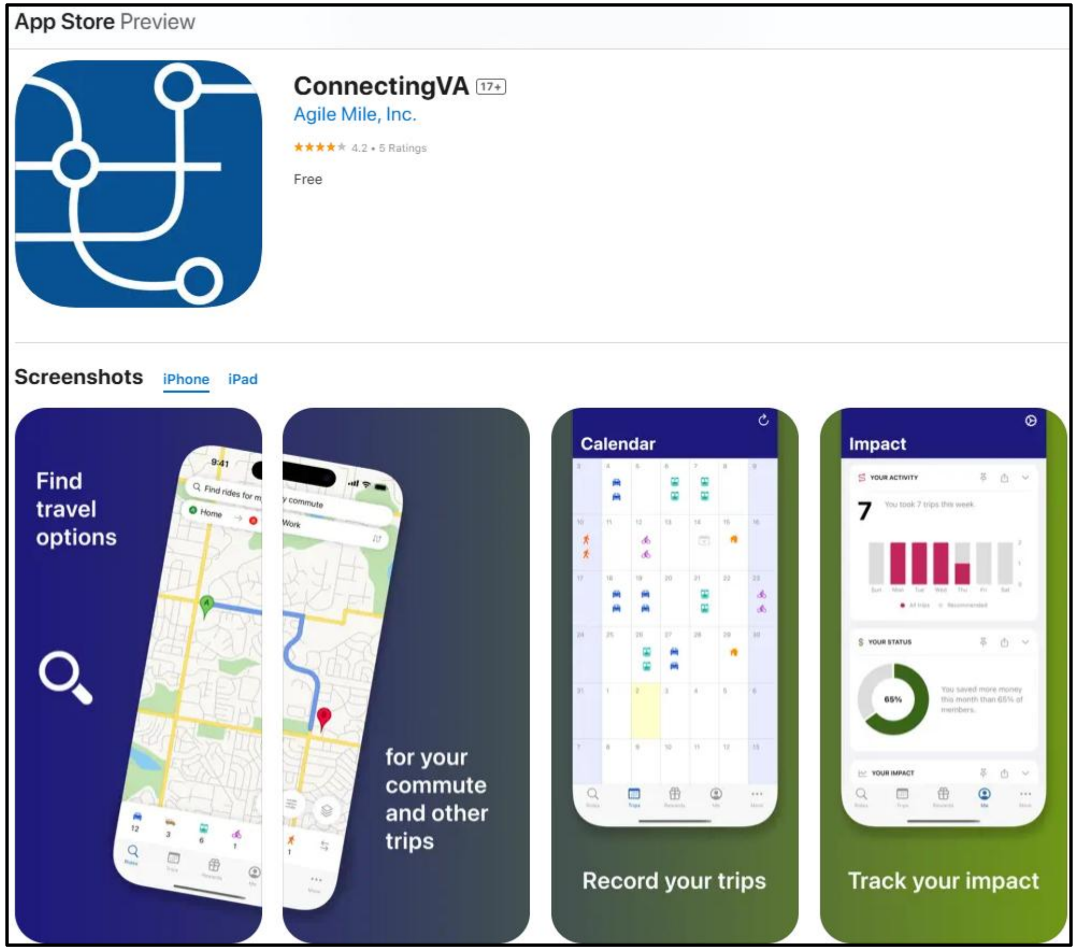
DRPT's Quest for a Single Ridematching System

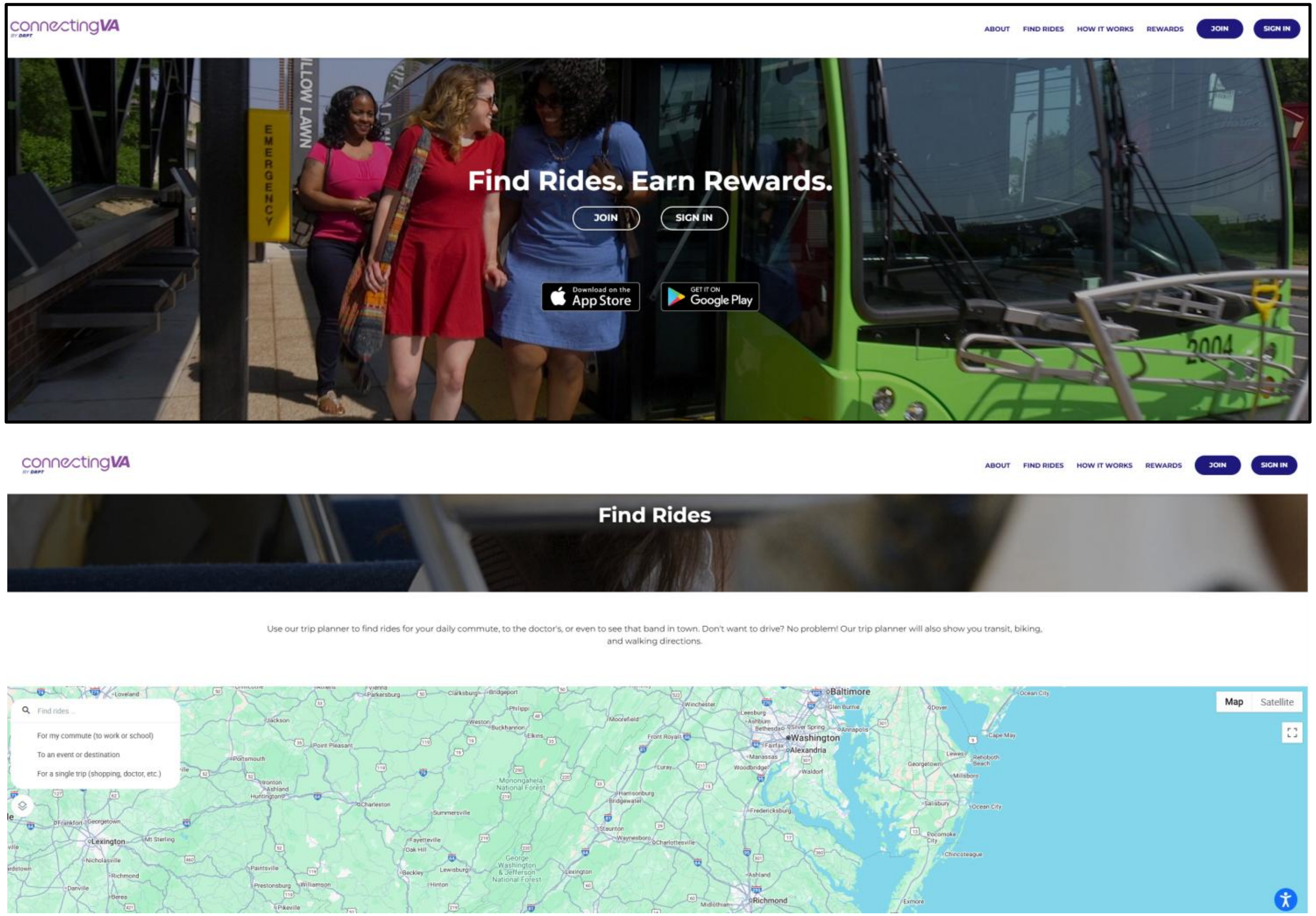
- 2013: DRPT begins a search for a multimodal ridematching system all Virginia commuter assistance programs can use.
- Needs to be web-based.
- Must allow ridematching across all of Virginia for one-stop ridematches.
- Allow the public to obtain ridematches directly.
- Must include transit.

- 2013 – 2015: DRPT researches the best ridematching systems on the market.
- Evaluation committee from commuter assistance program representatives.
- 2017: DRPT secures funds and embarks on securing a vendor.
- 2017: Through an open RFP process (with the help of RVARC) a vendor is selected.

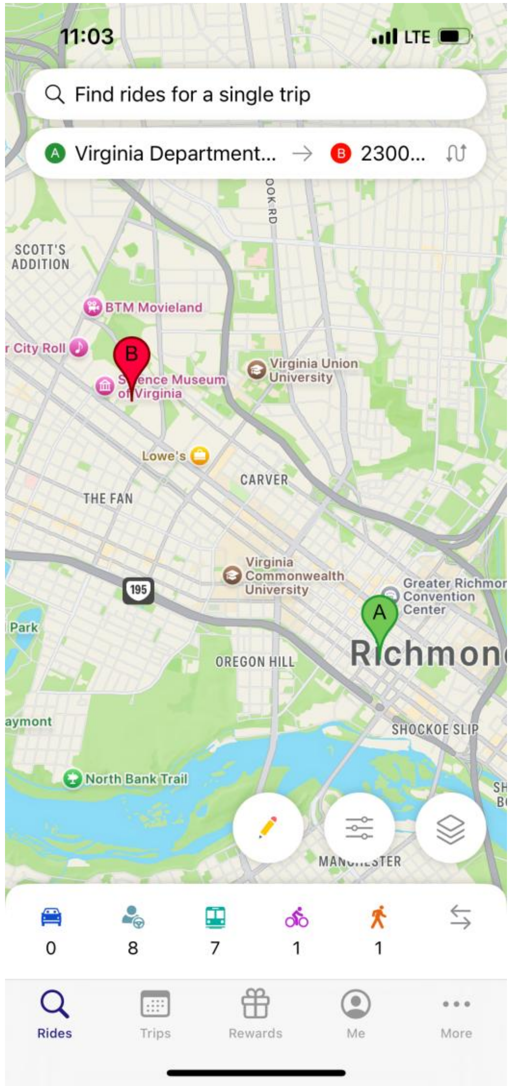
ConnectingVA is launched in 2018

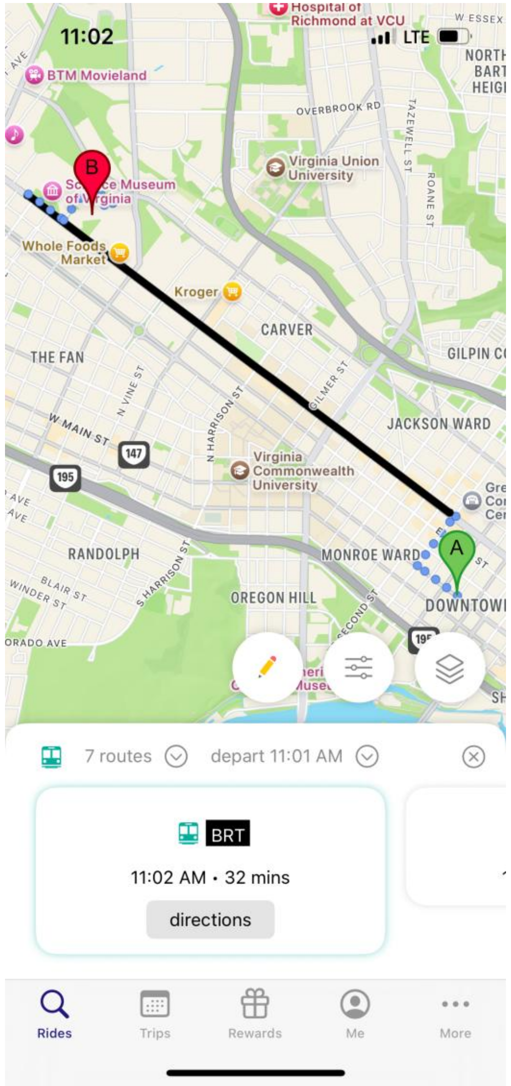
ConnectingVA – Mobile App and Website

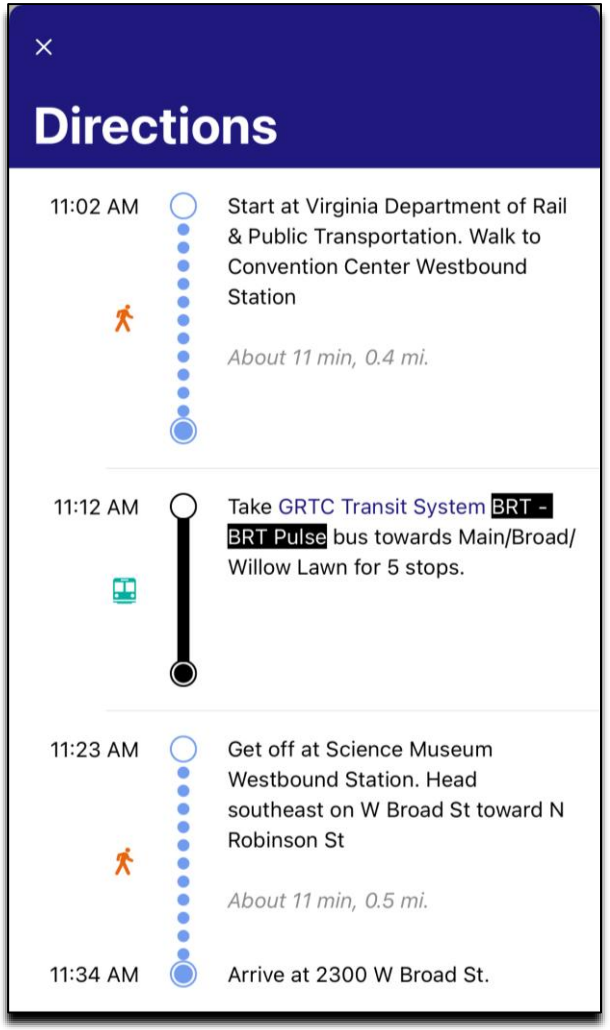




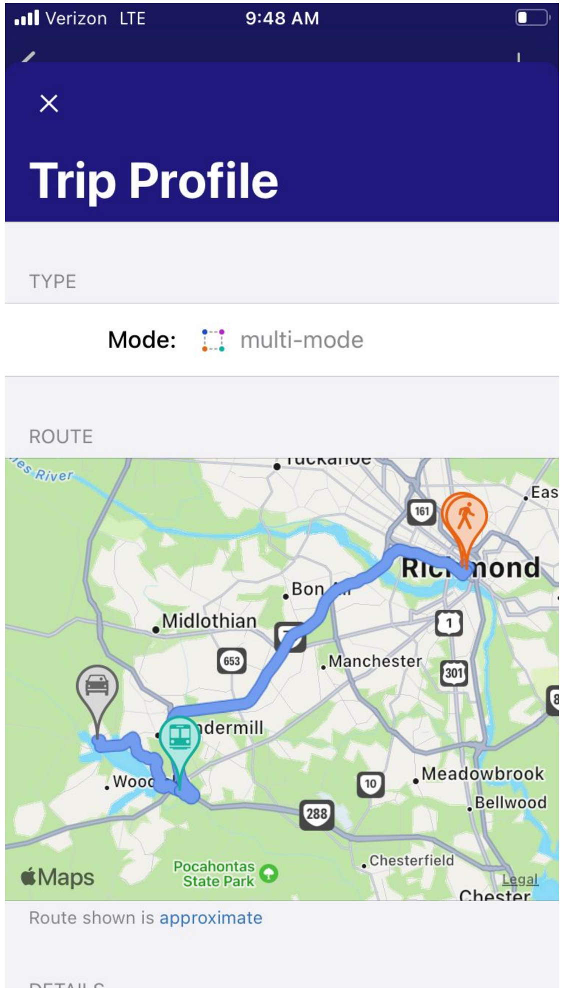
ConnectingVA – Mobile App and Websites

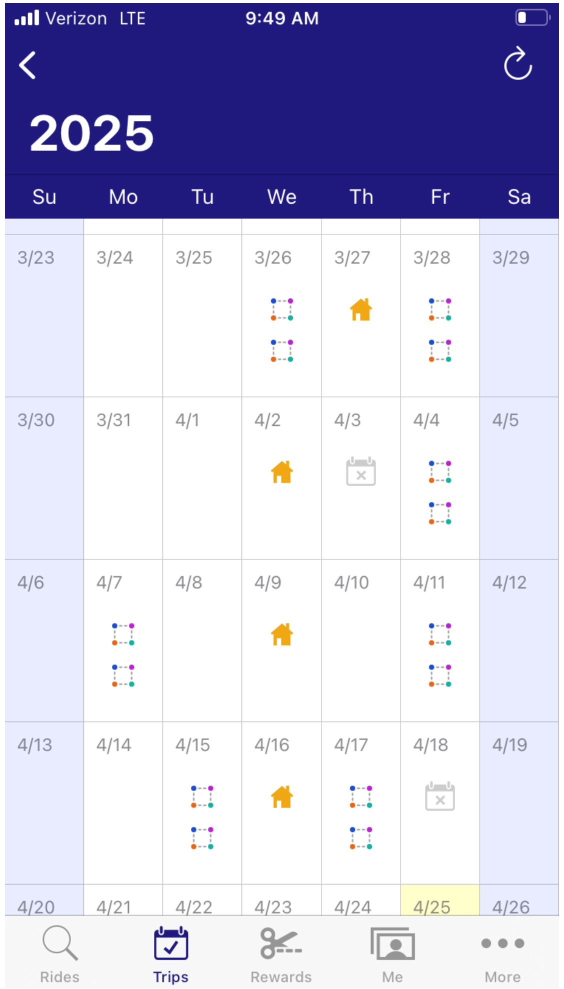


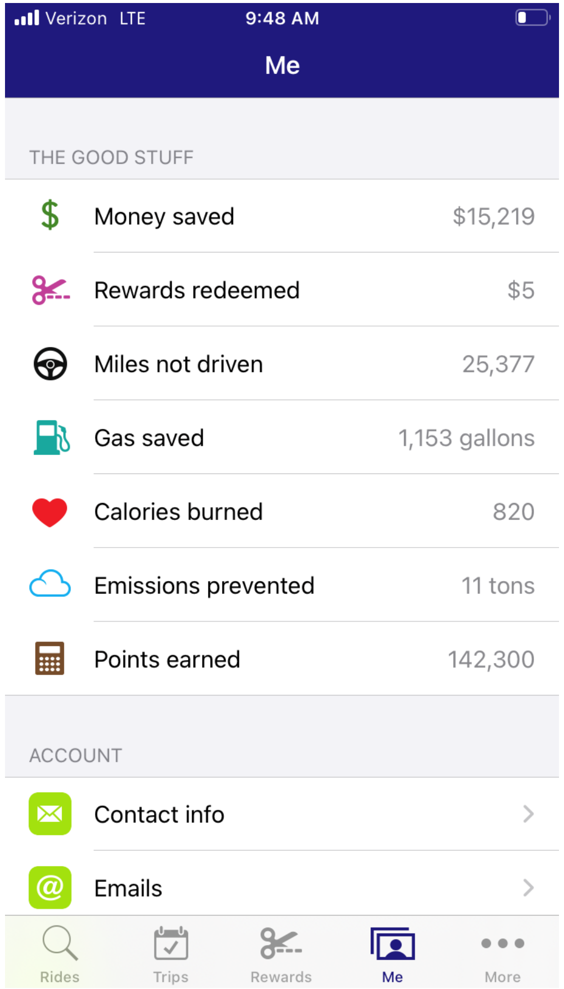


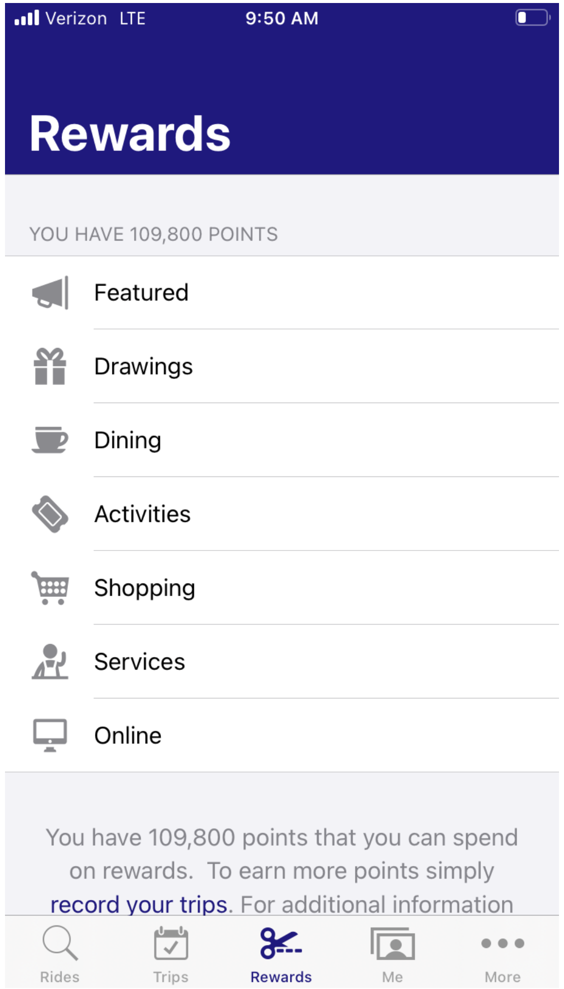


Using the ConnectingVA App









Much better. But can we change behavior dynamically?

Much better. But can we change behavior dynamically?

Regional Multi-Modal Mobility Program (RM3P)

RM3P

Travel Decisions Powered by Data

The RM3P's mission is to leverage the collaborative use of real-time data by Virginia's public and private sectors to improve:

- travel safety
- reliability
- mobility

And to give the public the tools to make more informed travel choices.

Manage Demand

Dynamic Incentivization

Provides travel mode options, and incentives to travelers to **change travel behavior** – don’t drive, use transit, carpool, vanpool, bike, travel later! Information and incentives are provided through the GoMyWayVA mobile app using loyalty rewards, challenges, and dynamic incentives.

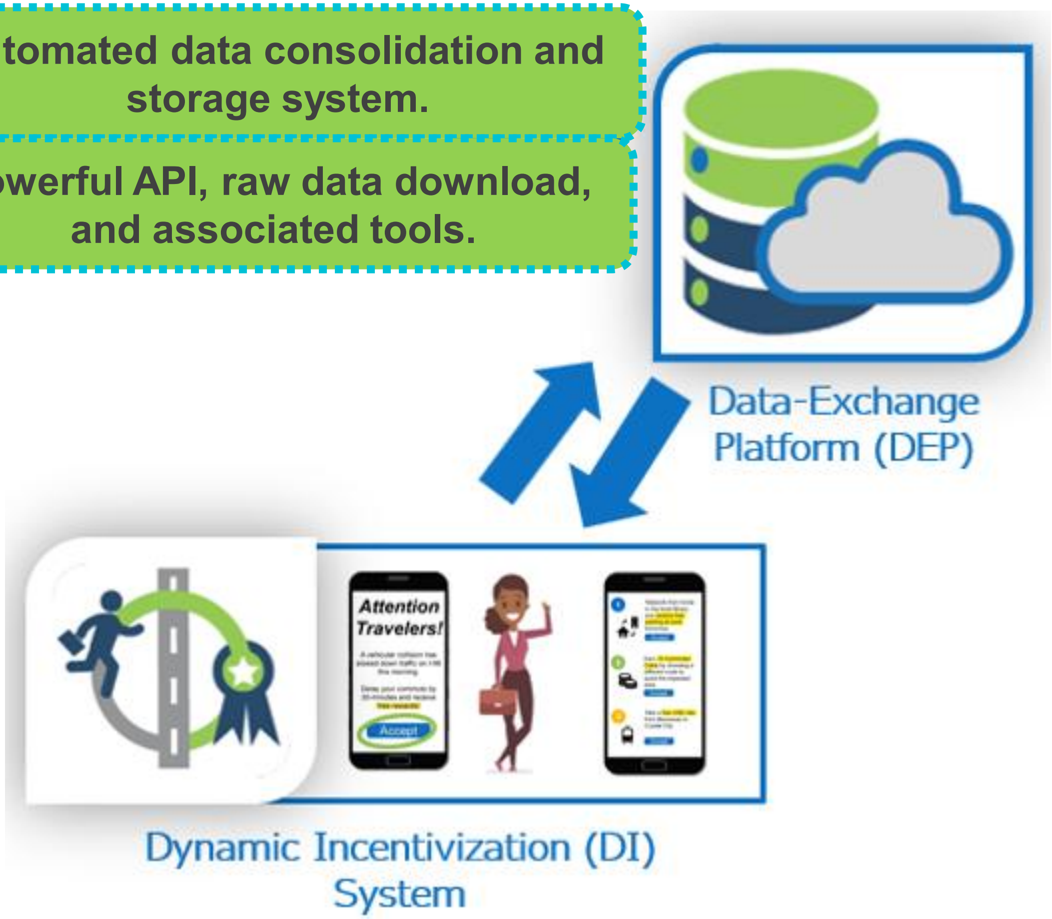
Behavior Change App

GoMyWayVA™

Data

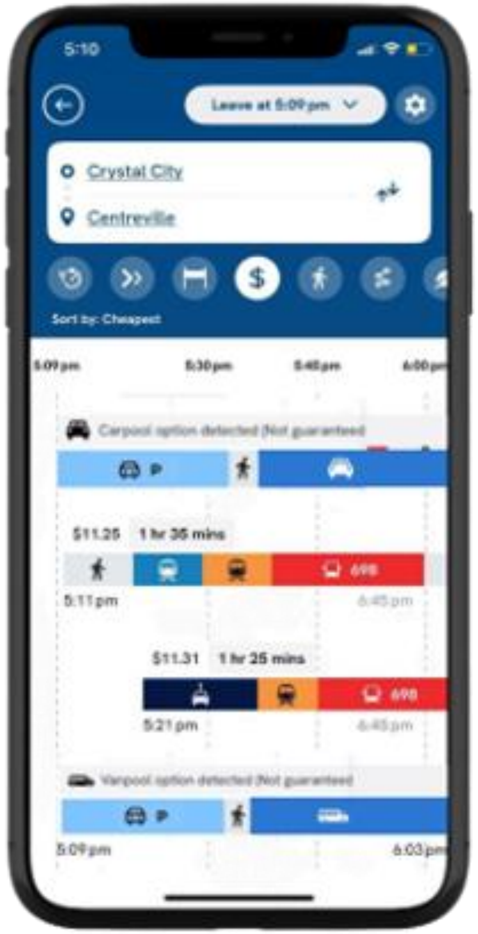
Automated data consolidation and storage system.

Powerful API, raw data download, and associated tools.



GoMyWayVA™: Achievements

The first trip planner to combine all modes including vanpool, slugging, driving, biking, walking, and transit in a linked trip.



GoMyWayVA™: Achievements

First trip planner to include multimodal and intermodal travel cost comparisons.

GoMyWayVA™: Achievements

First trip planner to provide routes with express lanes and adapt to region-specific estimated dynamic toll rates.

GoMyWayVA™ - Dynamic Incentivization

TRB Webinar: Connected Mobility Futures—Integrating Transit and Technology

Using Data and Technology to Effect Behavior Change in Transportation

DRPT
VIRGINIA DEPARTMENT OF RAIL AND PUBLIC TRANSPORTATION

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January 11-15, 2026

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Washington, DC

https://trb-annual-meeting.nationalacademies.org

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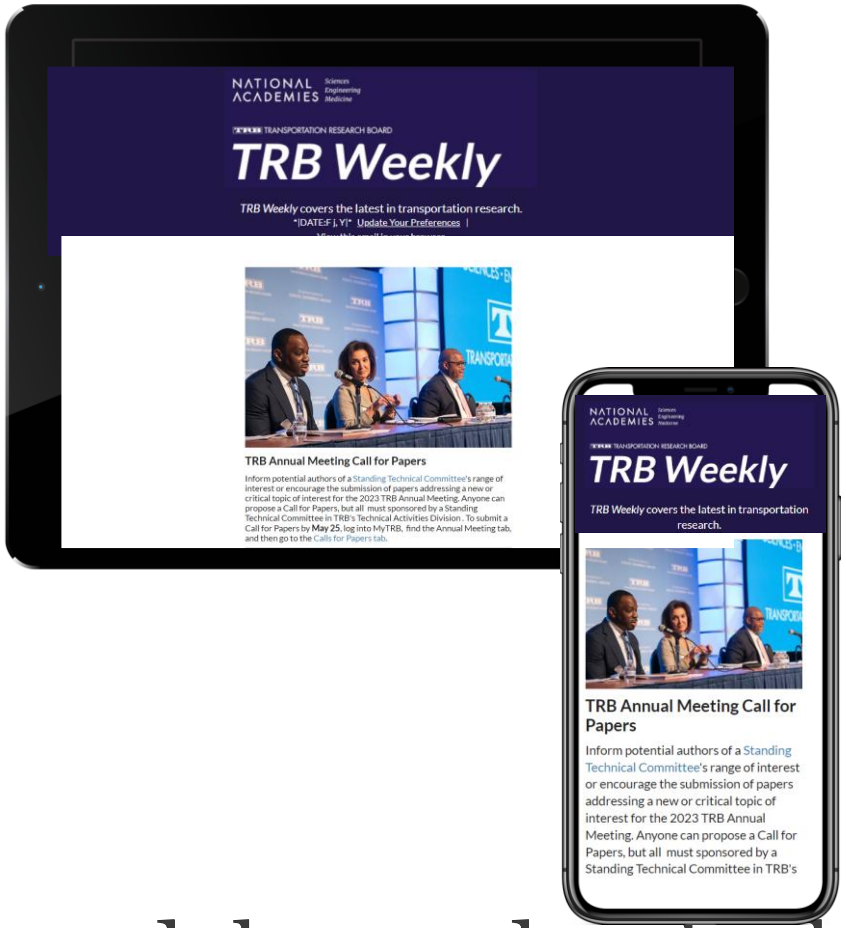

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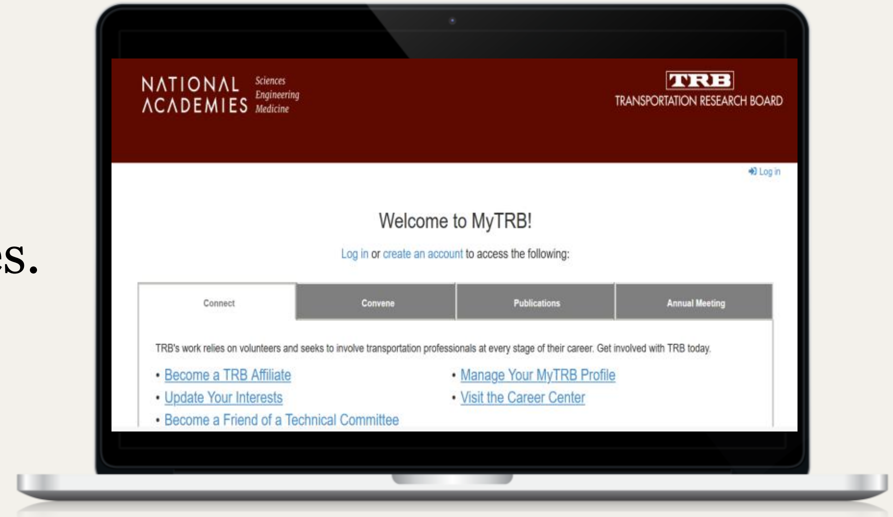

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