Transit in Greater Minnesota:

Ridership Trends and Technological Opportunities

Alireza Khani, PhD, PE

Associate Professor

Department of Civil, Environmental, and Geo- Engineering

University of Minnesota Twin Cities

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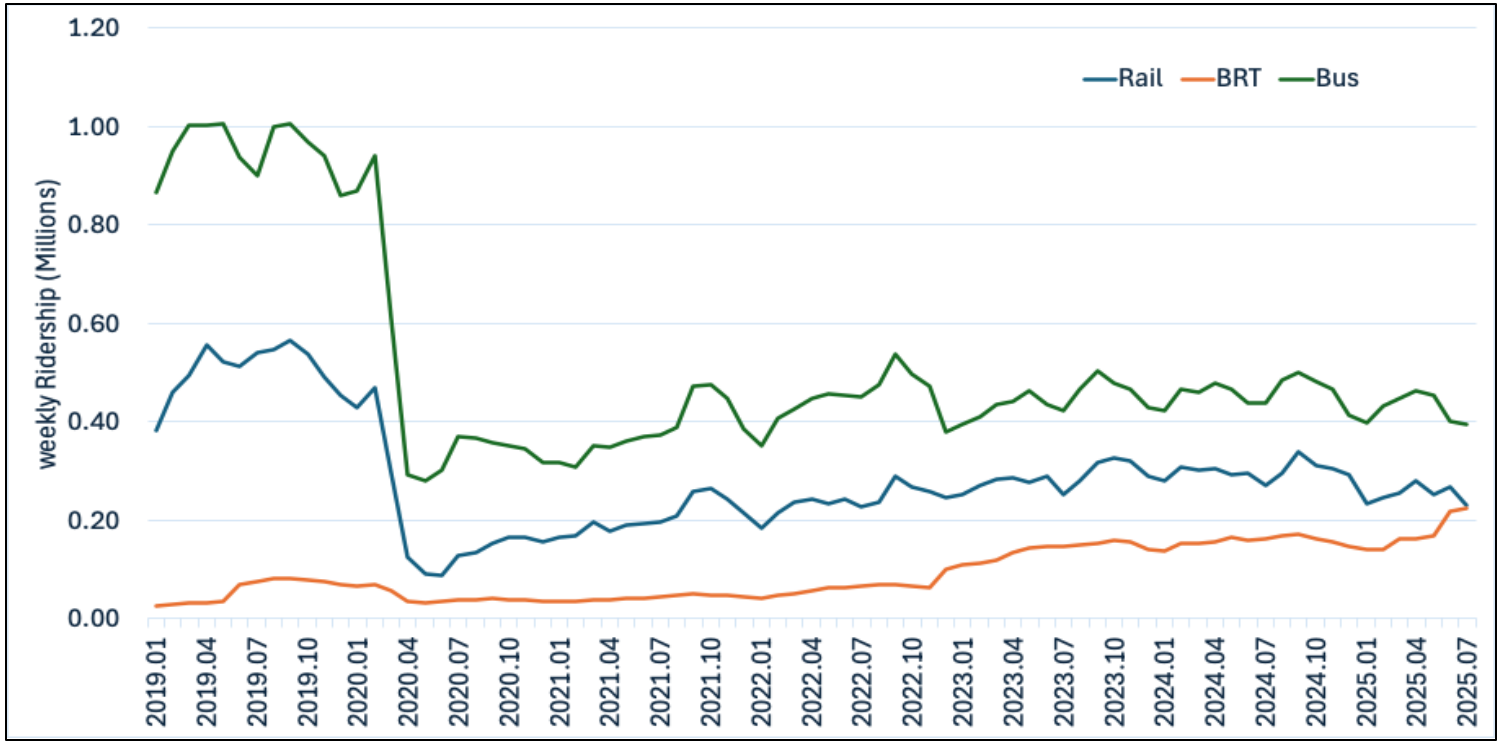
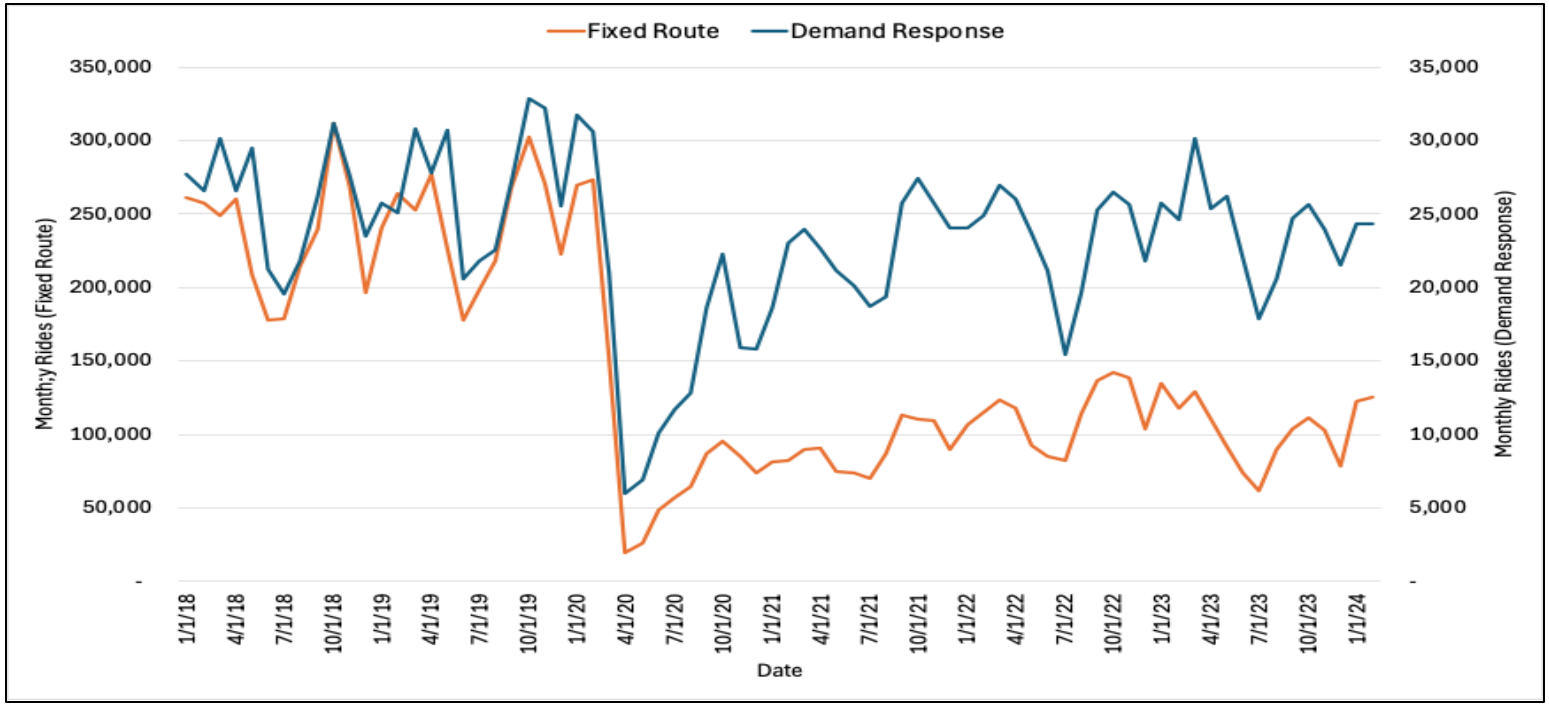
Twin Cities Transit Ridership During the COVID-19 Pandemic



Rural Minnesota Transit Ridership* During the COVID-19 Pandemic



Transit Data Fusion with Machine Learning Algorithms

On-Board Survey (OBS)

+ Detailed demographic info
- Long data collection intervals
- Costly / Less representative

Automatic Fare Collection (AFC)

+ Continuous data collection
+ High precision (time/location)
- Lack demographic info

Training

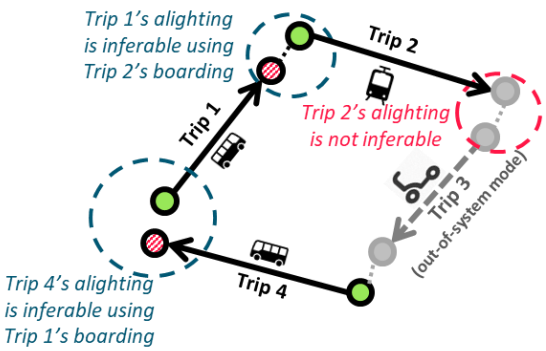
- Date
- Time
- Payment Method
- Fare Type
- Used Route(s)
- # of Transfers
- OD Locations
- Gender
- Age
- ...
- **Trip Purpose (destination type)**

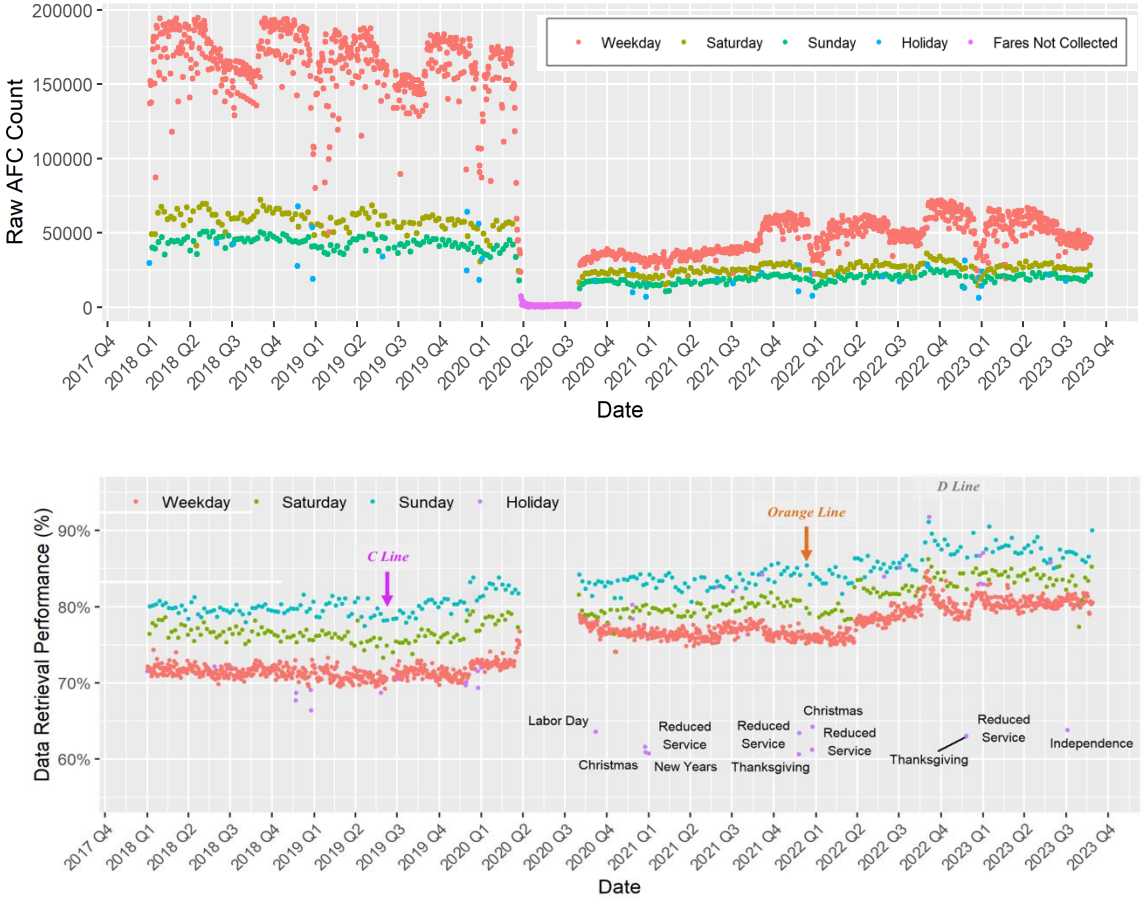
Application

Infer/Label Trip Purposes

+ Large Sample
+ Continuous
+ Trip Context

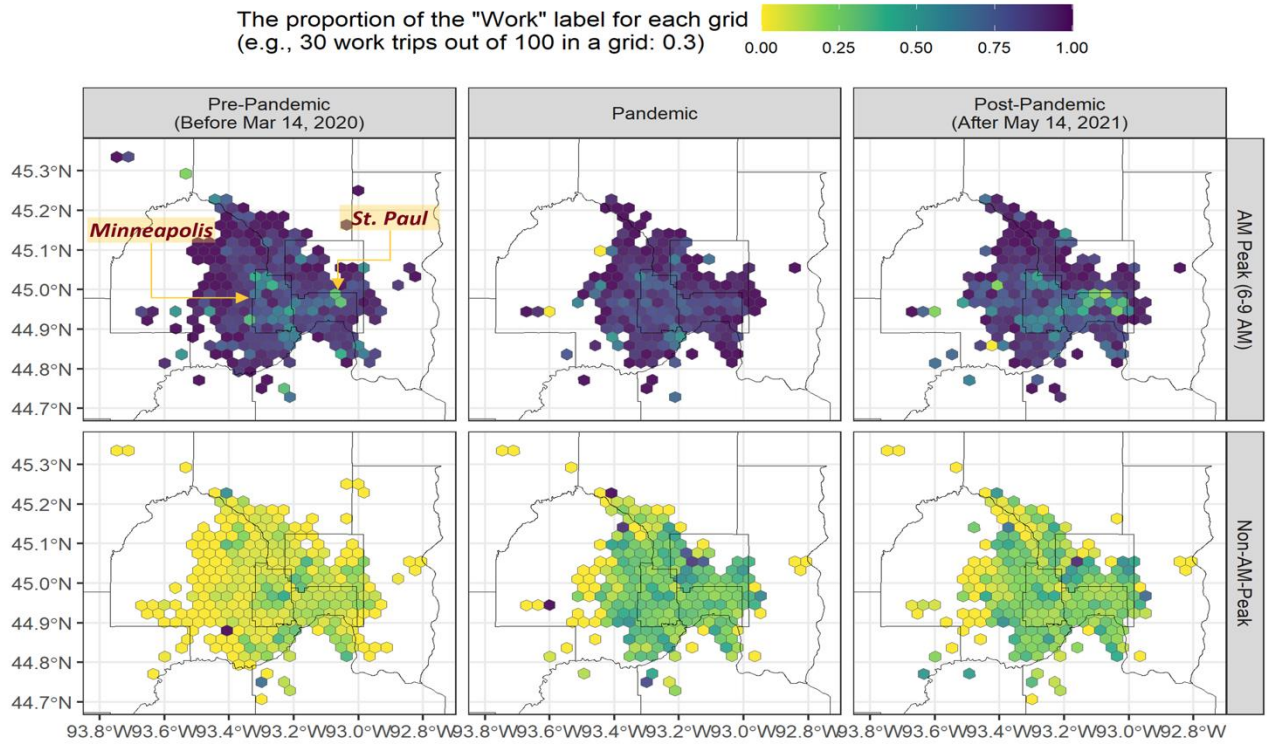
Transit Data Fusion





Baek, K. & A. Khani, Navigating Machine Learning for Travel Behavior Analysis: A Comprehensive Guide to Inferring Trip Purposes Using Transit Survey and Automatic Fare Collection Data Fusion. Transportation Research Part B: Methodological, Under Review. Preprint available on https://dx.doi.org/10.2139/ssm.5277608.

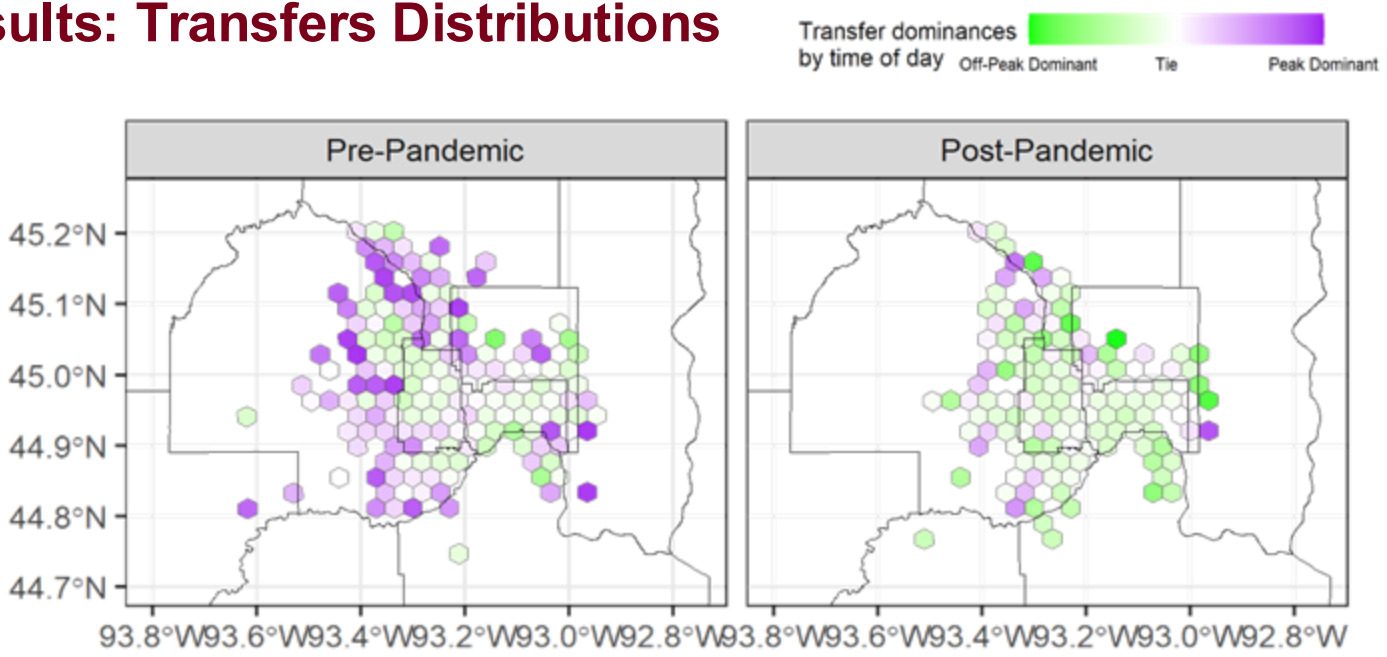
Results: Work Trips Distributions



Peak commute transit trips decreased from **68%** pre-pandemic to **46%** post-pandemic

Off-peak commute trips increased from **18%** pre-pandemic to **28%** post-pandemic

Results: Transfers Distributions



Transfers were at their highest rate **27.2%** at non-peak hours during the pandemic

Part 1

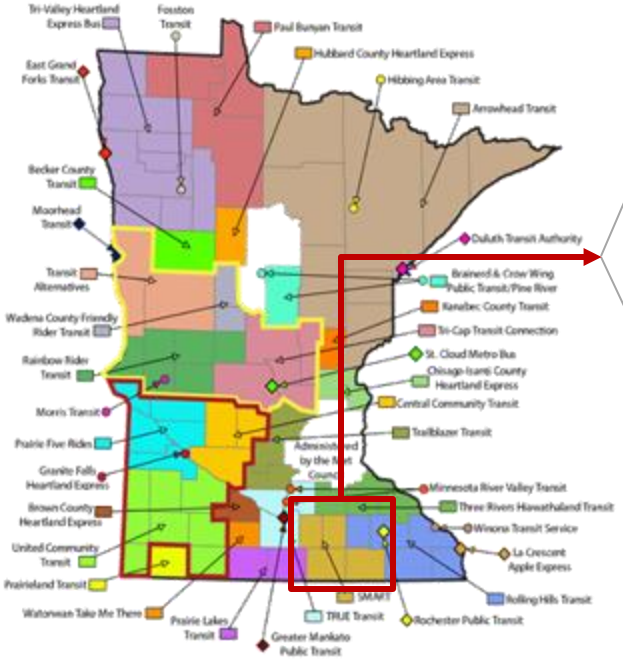
Rural Mobility-as-a-Service (MaaS)

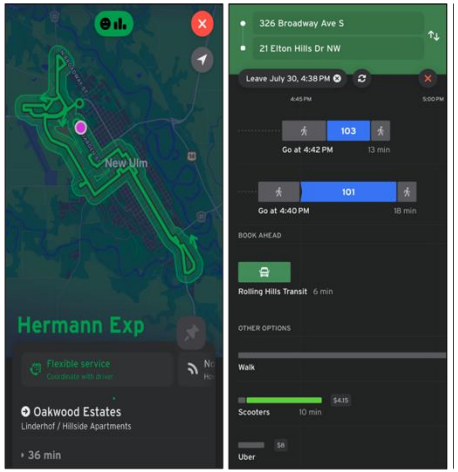
Mobility-as-a-Service (MaaS)

Fixed Route Buses

Demand-Responsive Transit (DRT)

Route Deviation





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 Third Review.

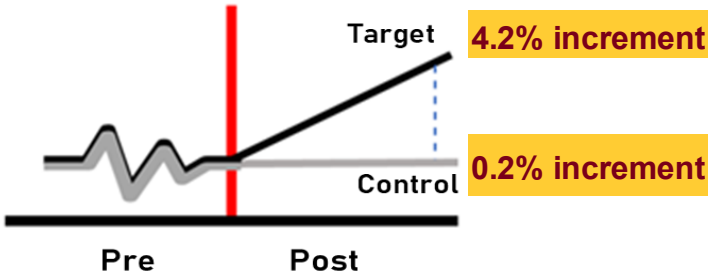
Ridership Growth Analysis (NTD data and SARIMA Model)

United States Department of Transportation

Federal Transit Administration

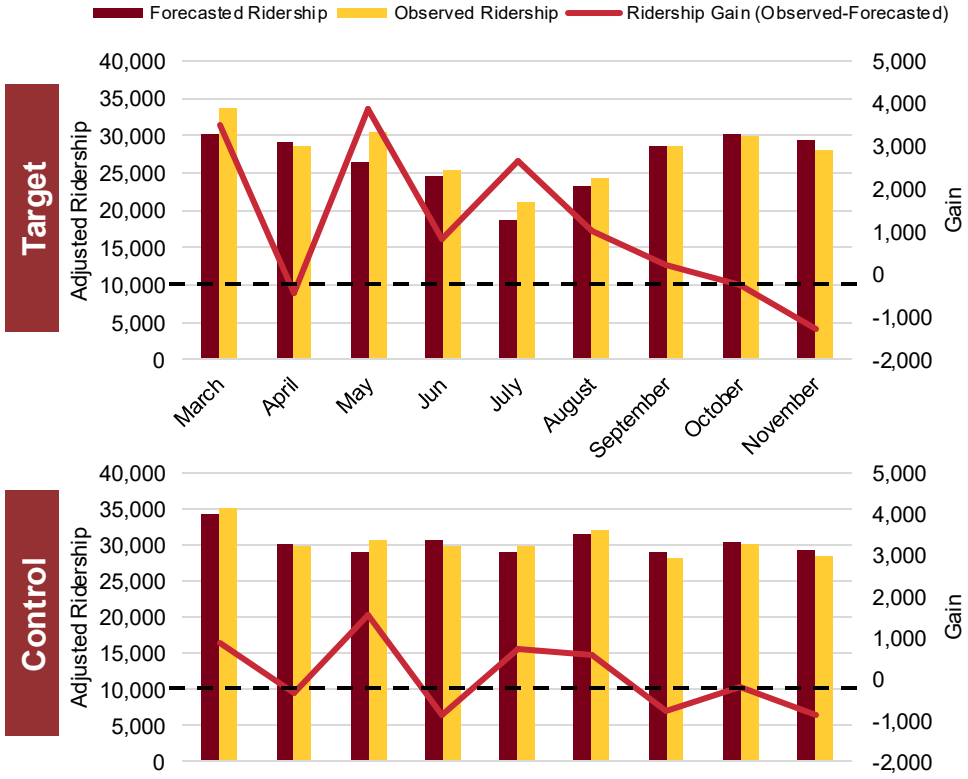
The National Transit Database (NTD)

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



4.2% increment

0.2% increment



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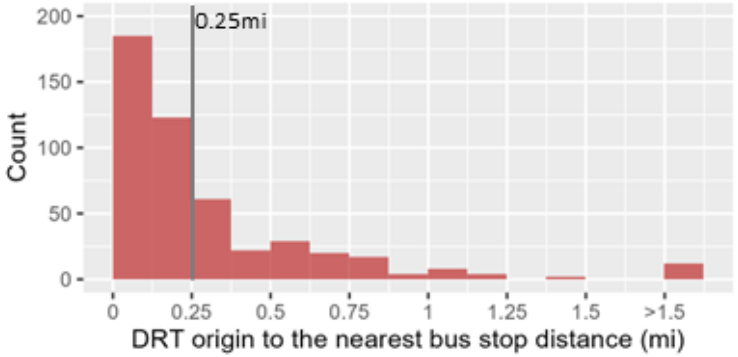
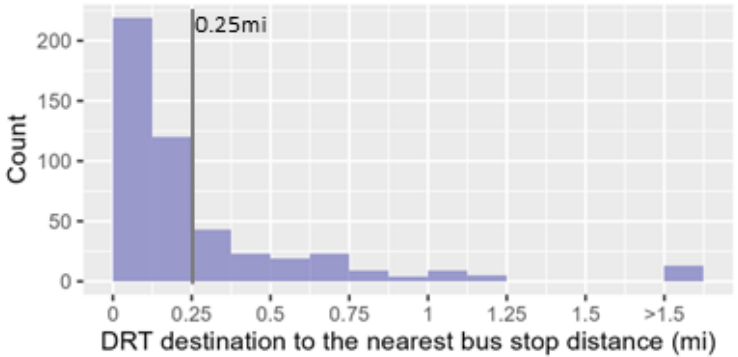
Origin-Destination-Reservation (ODR) Data

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 Departure 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.							





41% of DRT trips have both origin and destination within 0.25 miles of a bus stop!

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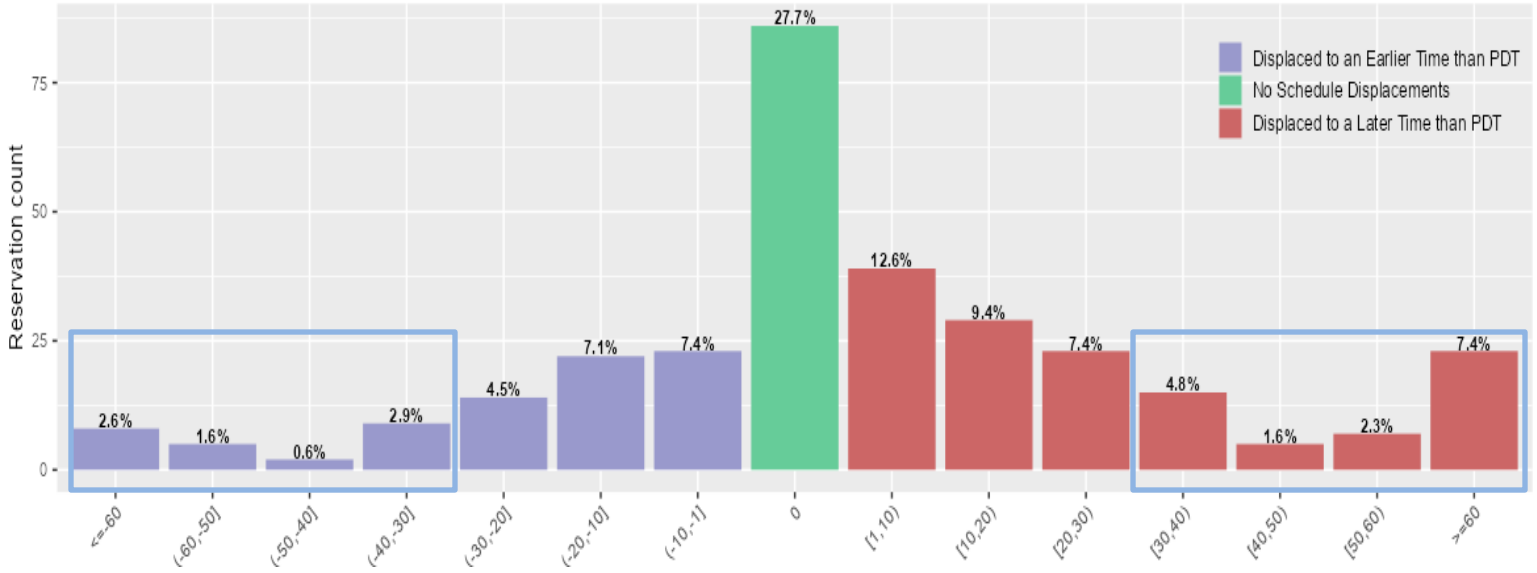
Origin-Destination-Reservation (ODR) Data Collection



More than **20%** of passengers have experienced 30+ minutes of schedule displacement!

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 Third Review.

Part 2
Autonomous Mobility-on-Demand (AMoD) Service

Transit Last-Mile Access Problem

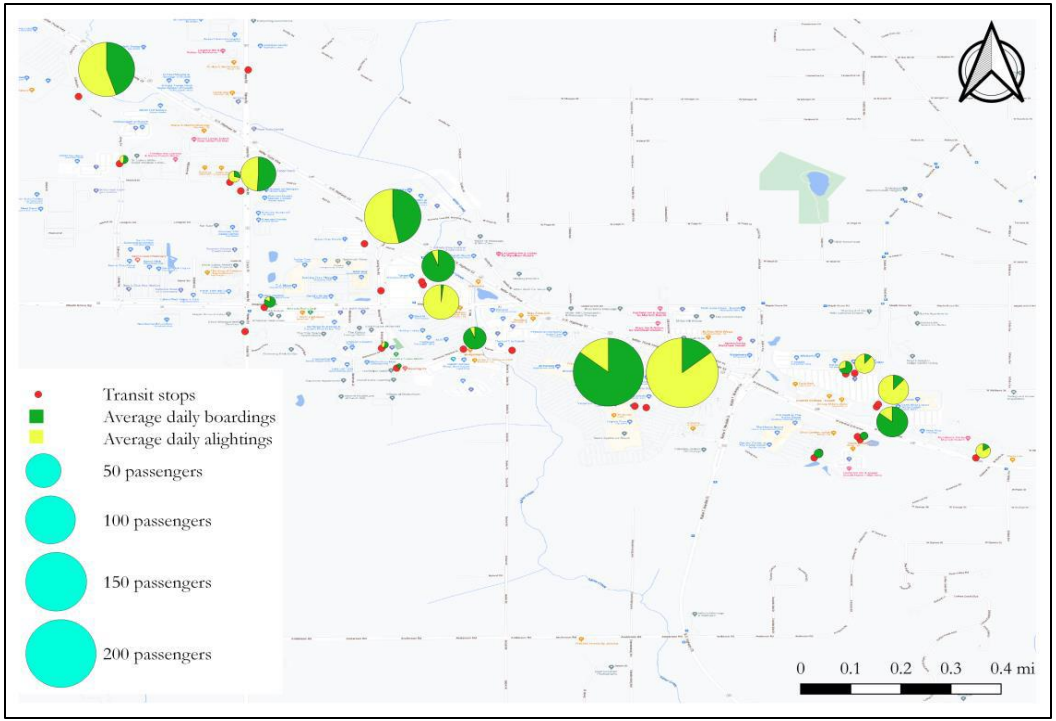
- High vehicle ownership
- High VMT and GHG emissions
- Infrequent and distant buses
- Improper access for riders
- Unsafe for pedestrians
- Low transit ridership

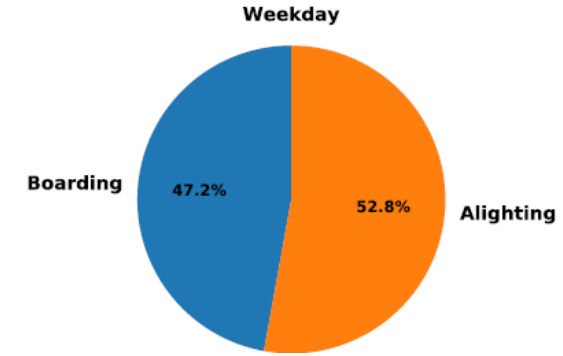
Q1. How can a last-mile service be designed, optimized, and integrated with fixed-route transit?

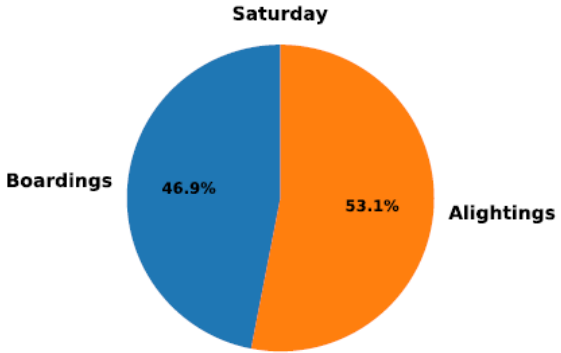
Q2. How much can transit service be improved with a last-mile service?

Transit Ridership at the Miller-Hill Mall Area

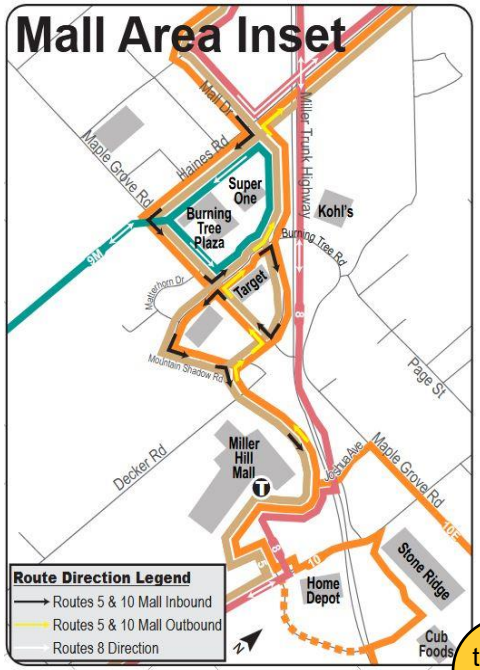
Average daily transit boarding and alighting

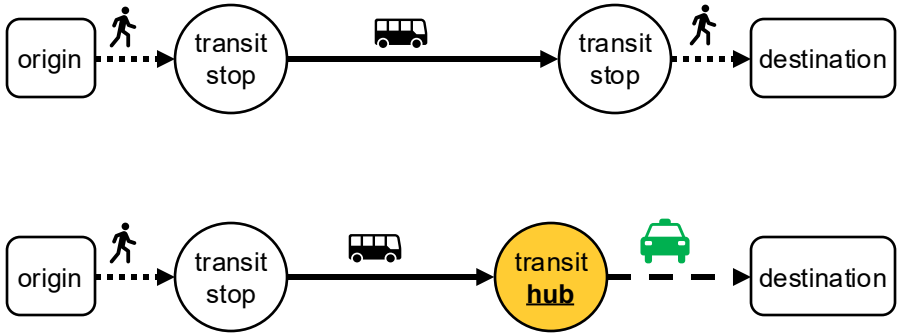


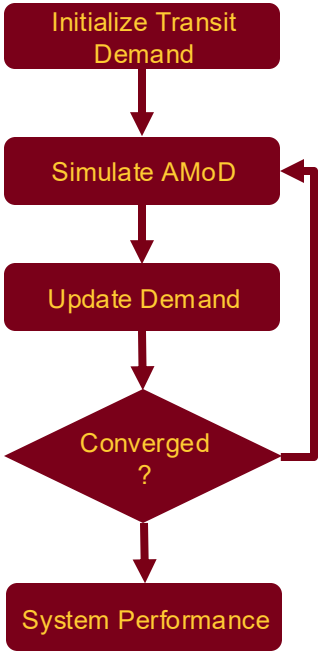




Transit Last-mile Case Study: Miller Hill Mall, Duluth, MN

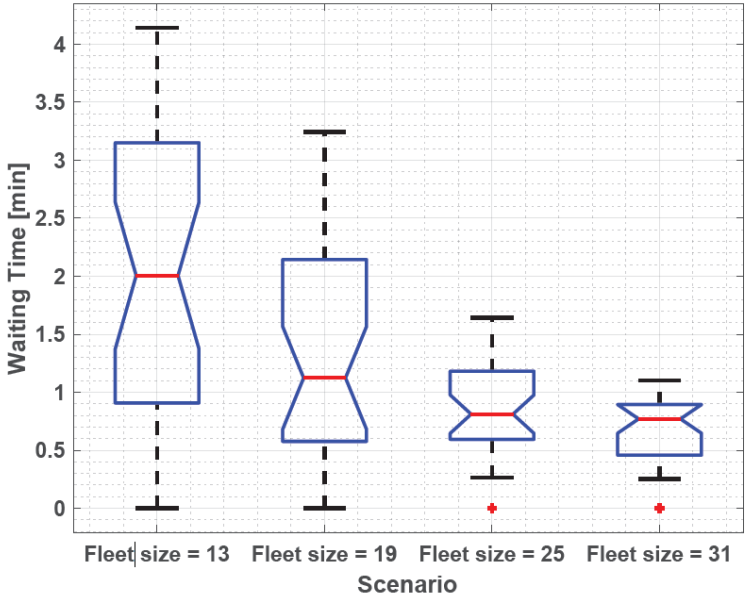




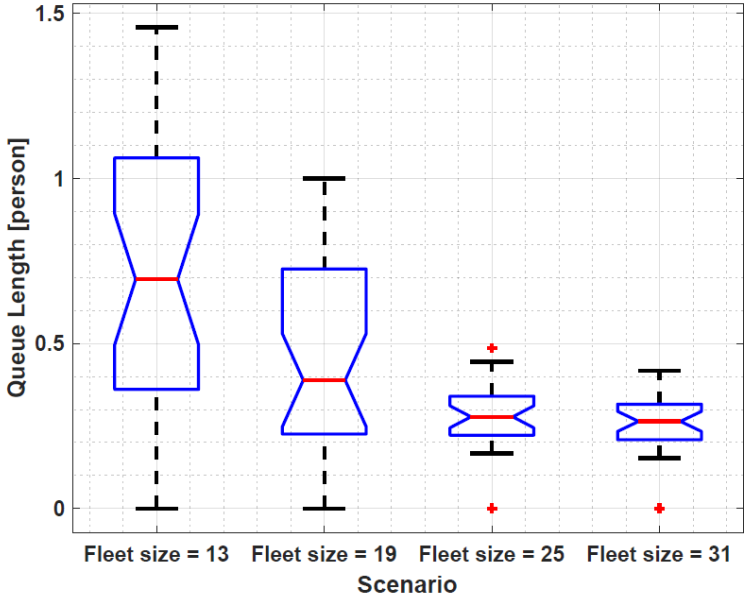


AMoD Simulation – Passengers

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

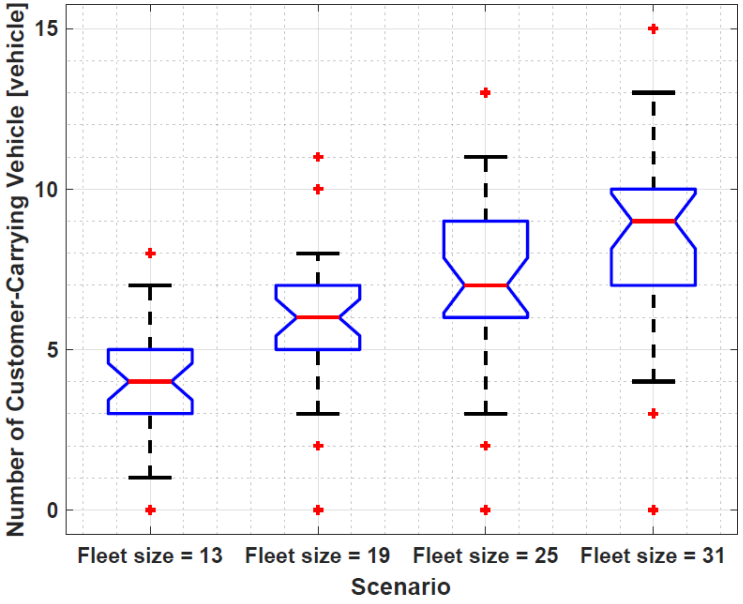


On average, no more than **1 passenger** waits for AMoD at each time.

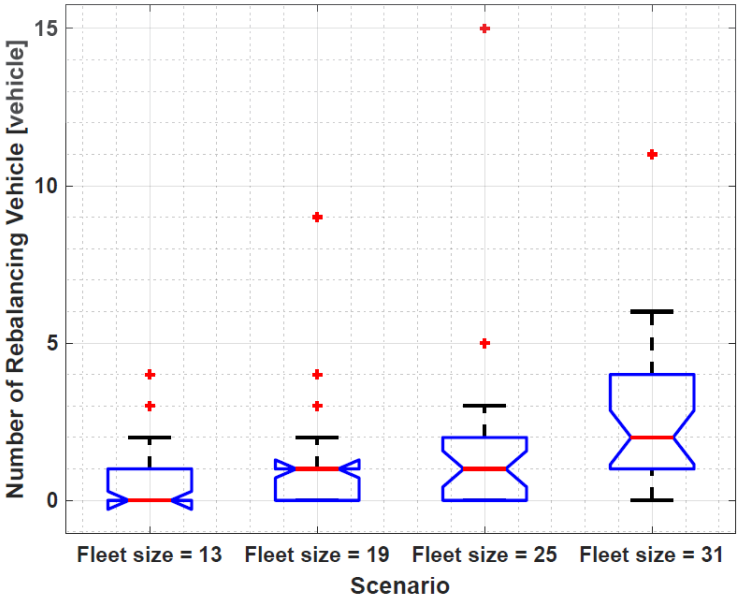


AMoD Simulation – Vehicles

As AMoD fleets increase, AMoD vehicle dispatching is proportional to transit demand

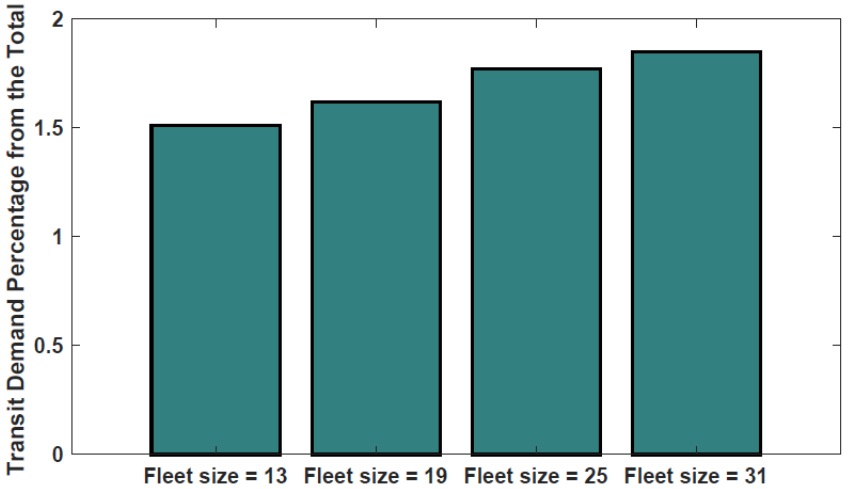


Some AMoD vehicle rebalancing is needed but much less than that of dispatching

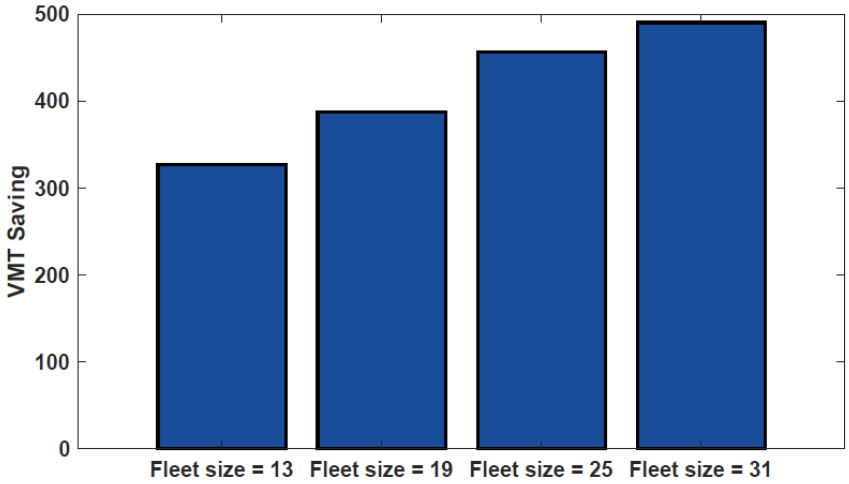


Changes in Transit Ridership and VMT

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

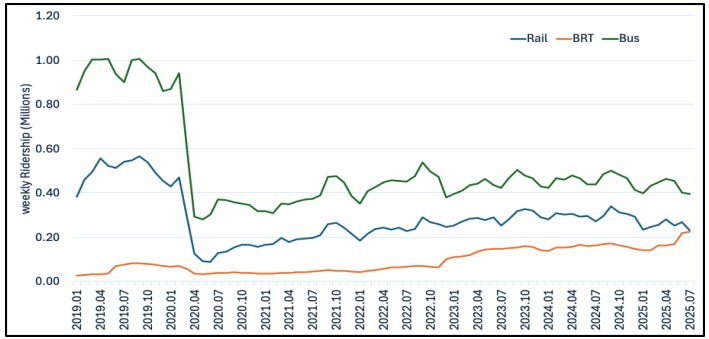


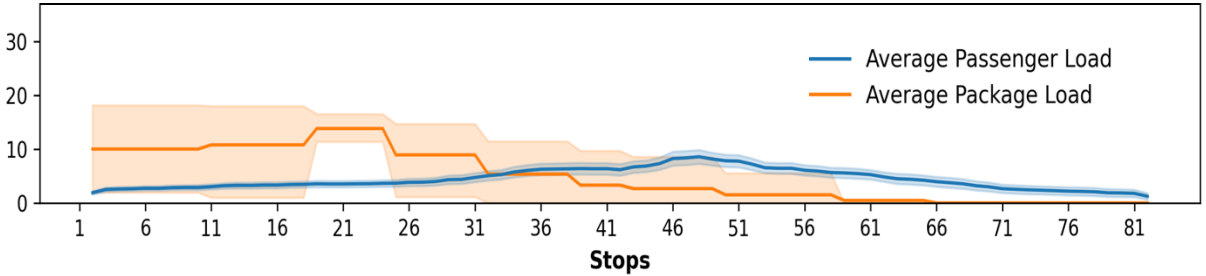
VMT saving ***increases*** as AMoD fleet size increases, asvmore people use transit+AMoD.

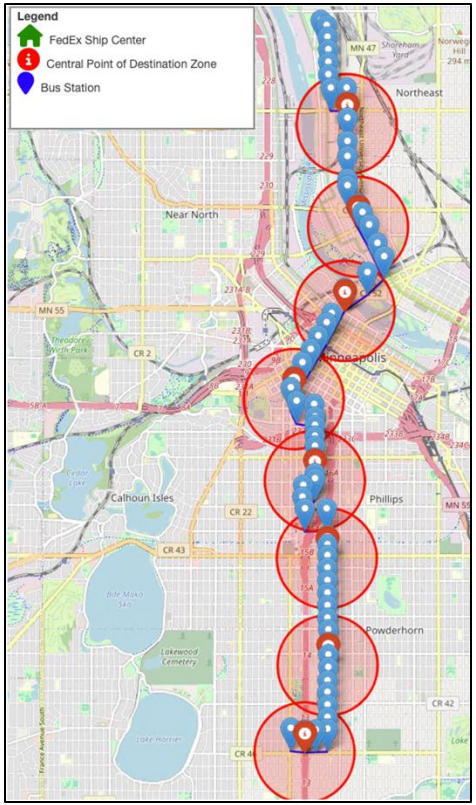


Part 3
Integrated Movement of People and Goods

Freight-on-Scheduled Bus (FoSB)







Empty seat-miles could be reduced by 15-38%

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*, 03611981251350642.

Final Remarks

- Transit systems are in a critical situation, with lower ridership, driver shortage, and in general financial challenges.
- Most current riders rely on transit for their primary transportation and have special needs and travel behavior, which warrant further studies.
- Fixed-route service is the backbone of transit, which should remain available with high frequency and reliability, but complemented with on-demand services.
- New transportation technologies can help (complement) transit by increasing service efficiency, accessibility, and reliability

Acknowledgements

DEPARTMENT OF TRANSPORTATION

MN LOCAL ROAD RESEARCH BOARD

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DTA

Dr. Ali Aalipour
Former PhD student

Kwangho Baek
PhD candidate

Nastaran Tork
PhD student

Questions?

akhani@umn.edu

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