Community Public Mobility Using On-Demand, Low-Speed Electric Vehicles: A Case Study in Downtown St. Louis, Missouri

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TRBAM-24-03831
TRB 2024 Annual Meeting
January 2024

Introduction & Motivation

- **This study focused on the St. Louis Downtown Connect as a unique opportunity to capture data and bring analysis forward on a new electrified on-demand transit (ODT) system in a dense urban area.**
- **Neighborhood ODT services using low-speed electric vehicles (LSEV) are an innovative technological solution that can help fill gaps left by public transit service (e.g., short, high-frequency trips) for diverse populations and trip types.**
- **The goal of the analysis was to motivate and inform holistic public mobility systems where different services are optimized to meet specific community needs.**

Electric On-Demand Transit (ODT)

- **ODT services enable passengers to book and pay for rides via an app or a phone call, and drivers receive pick-up and drop-off instructions through the app.**
- **Combined with ODT, vehicle fleet decisions—such as high-efficiency electric vehicles sized to operate and maneuver well in congested urban settings—can help mitigate negative outcomes and provide accessibility and emissions benefits.**
- **ODT provides door-to-door service, scheduling flexibility, digital data collection and real-time decision making—leverageable to extend public transit coverage to new population groups (e.g., elderly, disabled) and regions outside of rural and suburban settings.**

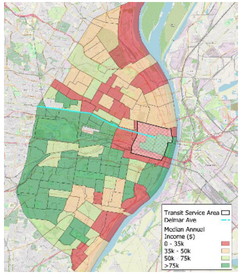
Case Study: St. Louis, Missouri

Problem: The "Delmar Divide", where lower-income and vulnerable population groups have resided north of Delmar Ave, cut-off from critical services, poverty rates >25%.

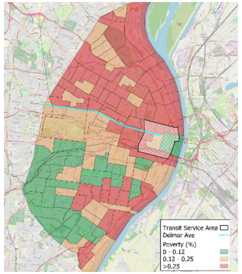
System: 2 LSEV ODT vehicles in a dense urban area (5,400ppl/mi²).

Objective: providing free, intra-zonal rides to area residents, with a focus on connecting lower-income neighborhoods to downtown jobs and amenities.

Service: 9 a.m. – 9 p.m. Monday – Friday, in a 2 – 3 square mile region. Labyrinth Smart Mobility, St. Louis City funded, $600k/year.



St. Louis Median Income.



St. Louis Poverty Rate.

Surveys & Data Collection

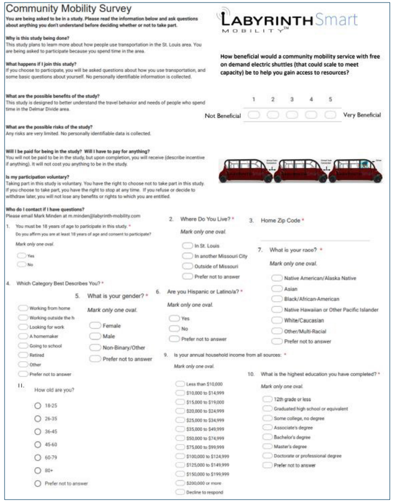
Community Mobility Survey

- n=244, collected Sept. 2022 – Mar. 2023.
- Survey data included age, residency, income, education, opinions on transportation access, and what they valued most in their transportation options.

Ridership Survey

- n = 5,536, collected Mar. 2022 – Mar. 2023.
- Ridership data includes travel behaviors, such as pick-up/drop-off locations, purpose for their travel, and wait times.

Survey Deployment.

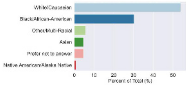


Sample Paper Survey.

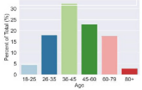
Survey Results

Community Mobility Survey

- The neighborhood ODT service attracted more elderly riders (20%) than the national transit average (7%) and leading TNCs (2.5% – 13%).
- Neighborhood ODT service saw disabled ridership (14.8%) outperform national averages of disabled transit riders (5.9% aged 18 – 64, 2.8% aged 65+).

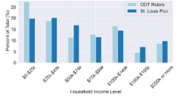


Racial Demographics.



Age Demographics.

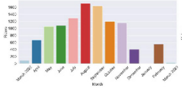
- With respect to lower-income users, ODT service (27%) significantly outperformed TNC low-income ridership (~17%) and remained competitive with national averages of low-income transit ridership (33%).



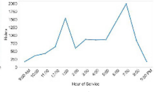
Income disparity between ODT shuttle riders and St. Louis median incomes.

Ridership Survey

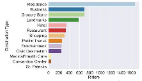
- After the summer, ridership declined until December 2022, when the pilot program ended. Limited funding was provided in February 2023 to provide partial service.
- Aside from private residences, businesses and grocery stores were the most traveled destinations.
- Since the service was designed to connect under-served riders to places of work, food, and healthcare, these highly frequented destinations are a strong signal that the shuttle is serving its intended purpose.



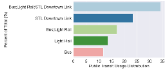
Monthly Ridership.



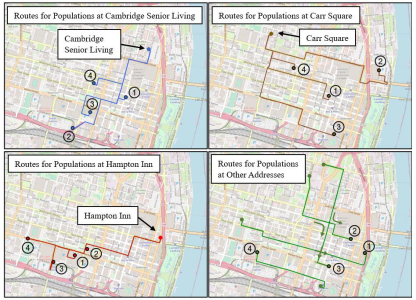
Rider total for each hour of service.



Destination Types for Riders.



Public Transit Usage.



Routes chosen for multidimensional analysis. The four routes include Cambridge Senior Living (Top Left), Carr Square neighborhood (Top Right), Hampton Inn (Bottom Left), and four non-hot spot routes (Bottom Right).

Multidimensional analysis of travel time and emissions between Labyrinth's shuttle, fixed-route bus transit, and TNC.

Route Origin	Walk Distance (mi)	Total Travel Time (min)			Emissions ($g\ CO_2$)[4]		
Cambridge	Transit	Transit[1]	Labyrinth[2]	TNC[3]	Transit	Labyrinth	TNC
1	0.28	17	12 (↓ 29.7%)	9.5 (↓ 44.3%)	239	57	244
2	0.59	23	15 (↓ 35%)	12.5 (↓ 45.8%)	244	114	488
3	0.55	24	14 (↓ 41.8%)	11.5 (↓ 52.2%)	362	98	418
4	0.25	18	14 (↓ 22.5%)	11.5 (↓ 36.4%)	307	82	349
Carr							
1	0.37	18	14 (↓ 22.5%)	11.5 (↓ 36.4%)	242	98	418
2	0.88	27	16 (↓ 40.9%)	13.5 (↓ 50.1%)	263	155	662
3	0.64	26	16 (↓ 38.6%)	13.5 (↓ 48.2%)	336	139	592
4	0.32	13	10 (↓ 23.5%)	7.5 (↓ 42.6%)	182	41	174
Hampton							
1	0.11	14	13 (↓ 7.6%)	10.5 (↓ 25.4%)	194	90	383
2	0.26	15	13 (↓ 13.7%)	10.5 (↓ 30.3%)	193	90	383
3	0.31	22	15 (↓ 32%)	12.5 (↓ 43.4%)	297	131	558
4	0.66	24	16 (↓ 33.5%)	13.5 (↓ 43.9%)	256	131	558

[1] Total Travel Time includes walk time to transit stop, wait time, in-vehicle time, and walk time from transit stop.
[2] Total Travel Time includes pickup wait time and in-vehicle time.
[3] Total Travel Time includes pickup wait time and in-vehicle time.
[4] TNC: Alternative Fuels Data Center (AFDC), Properties of Fuels, Gasoline.
Transit: Congressional Budget Office (CBO), Average Carbon Dioxide Emissions per Passenger-Mile, by Mode
Labyrinth: EIA, Missouri Energy Mix Emissions Factor

Discussion

- The neighborhood ODT service reduced travel times by 30% compared to fixed route alternatives and produced only 41% and 23% of CO_2 emissions compared to fixed route and TNCs, respectively.
- From a cost perspective, since ODT is currently a free service, it clearly outperforms TNC for the same O-D pairs (TNC fares were $10.90 on average, Transit was $1).
- If the St. Louis ODT service adopts the pricing schemes used by similar ODT systems at around $2 – $3 per ride, the cost per minute of travel for an ODT service was approximately $0.21 per minute of travel, while TNC costs were $1.01 per minute of travel.
- Projecting forward, urban ODT services have scaling concerns as demand increases. With the increase in demand comes increases in VMT, congestion, and GHG emissions. To combat these challenges, LSEVs can provide higher efficiency mobility that will continue to improve with higher renewable energy penetration rates.
- The on-demand, door-to-door service model presents an opportunity to fill a growing mobility void due to unaffordability and inaccessibility.

Conclusions and Future Work

- ***Survey results highlighted the need for improved mobility options to support the transportation disadvantaged in downtown St. Louis, particularly intra-zonal trips.***
- ***ODT experienced steady growth in ridership during the service period, high customer satisfaction scores, and increased accessibility; demonstrated by the elevated ridership levels of the elderly, disabled, and lower-income population in downtown St. Louis.***
- ***Innovative technological solutions like neighborhood ODT support the diversification of public mobility options to meet short, high frequency trips while also promoting vulnerable group participation in the mobility system.***
- ***The primary challenge going forward will be working with local transit authorities to successfully integrate these new modes with existing transit services effectively.***
- ***sustainable funding mechanisms will be integral to successfully integrate emerging modes and technologies with existing fixed route systems.***
- ***Future research related to exploring new financial models to ensure sustainable and equitable expansion of public mobility services is also an important future research direction.***

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This work was authored by the National Renewable Energy Laboratory, operated by Alliance for Sustainable Energy, LLC, for the U.S. Department of Energy (DOE) under Contract No. DE-AC36-08GO28308. Funding provided by U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, Vehicle Technologies Office – Small Business Innovative Research grant. The views expressed in the article do not necessarily represent the views of the DOE or the U.S. Government. The U.S. Government retains and the publisher, by accepting the article for publication, acknowledges that the U.S. Government retains a nonexclusive, paid-up, irrevocable, worldwide license to publish or reproduce the published form of this work, or allow others to do so, for U.S. Government purposes.

NREL/PO-5400-88265

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