The ABCs of On-Demand Transit (ODT)

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ASCE ICTD Conference

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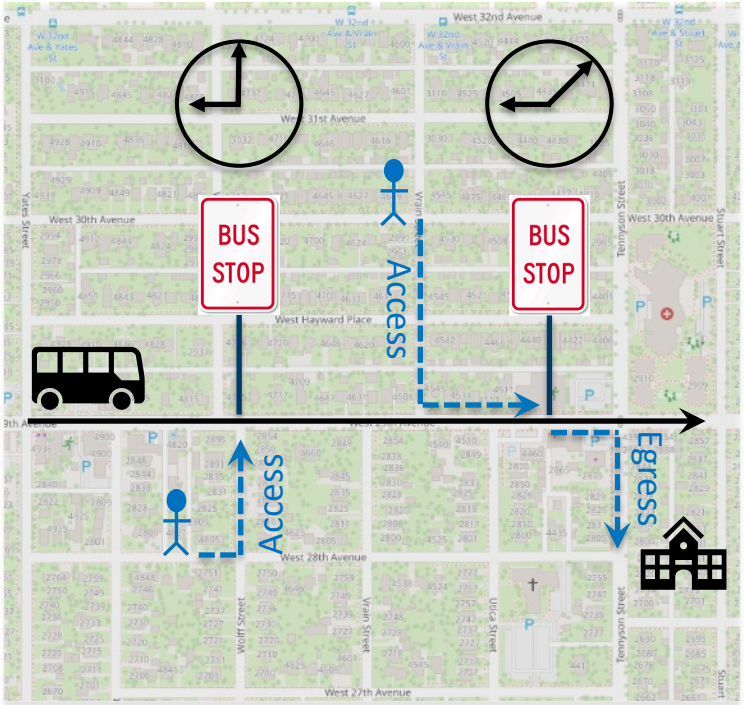
Photo by Joshua Bauer, NREL 61725

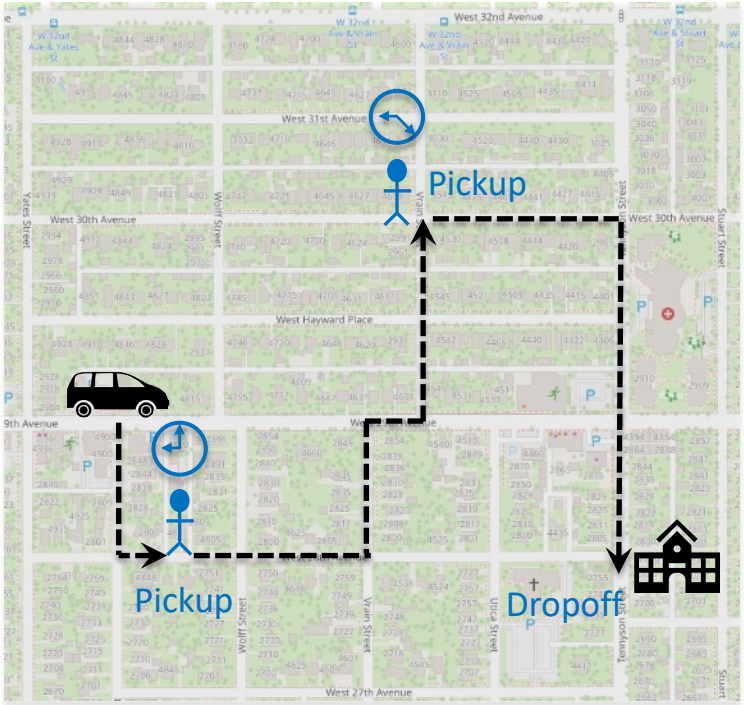
What is on-demand transit?

Comparison of Fixed Route & On-Demand



Fixed Route:

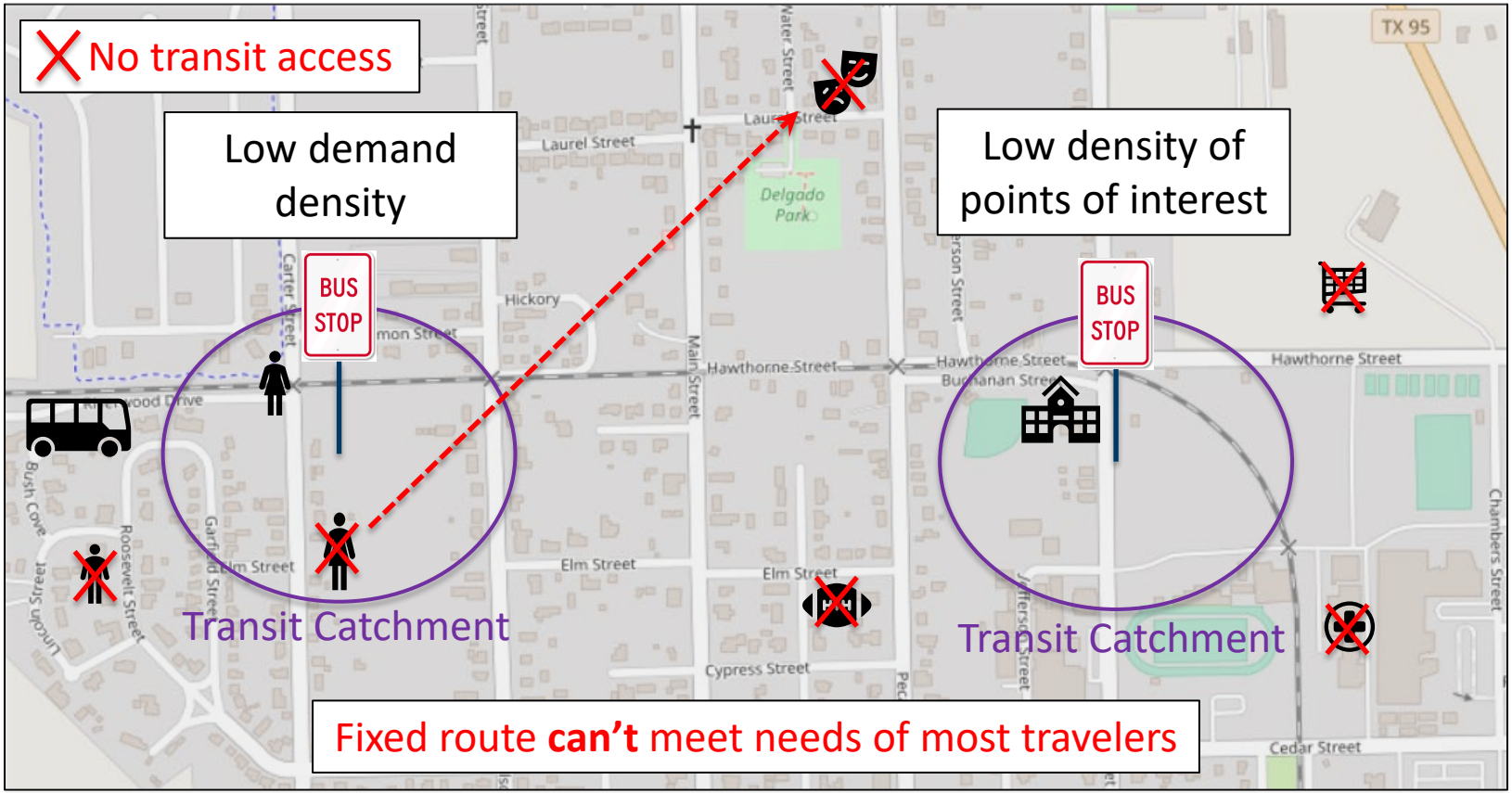
- Fixed schedule, fixed stop locations



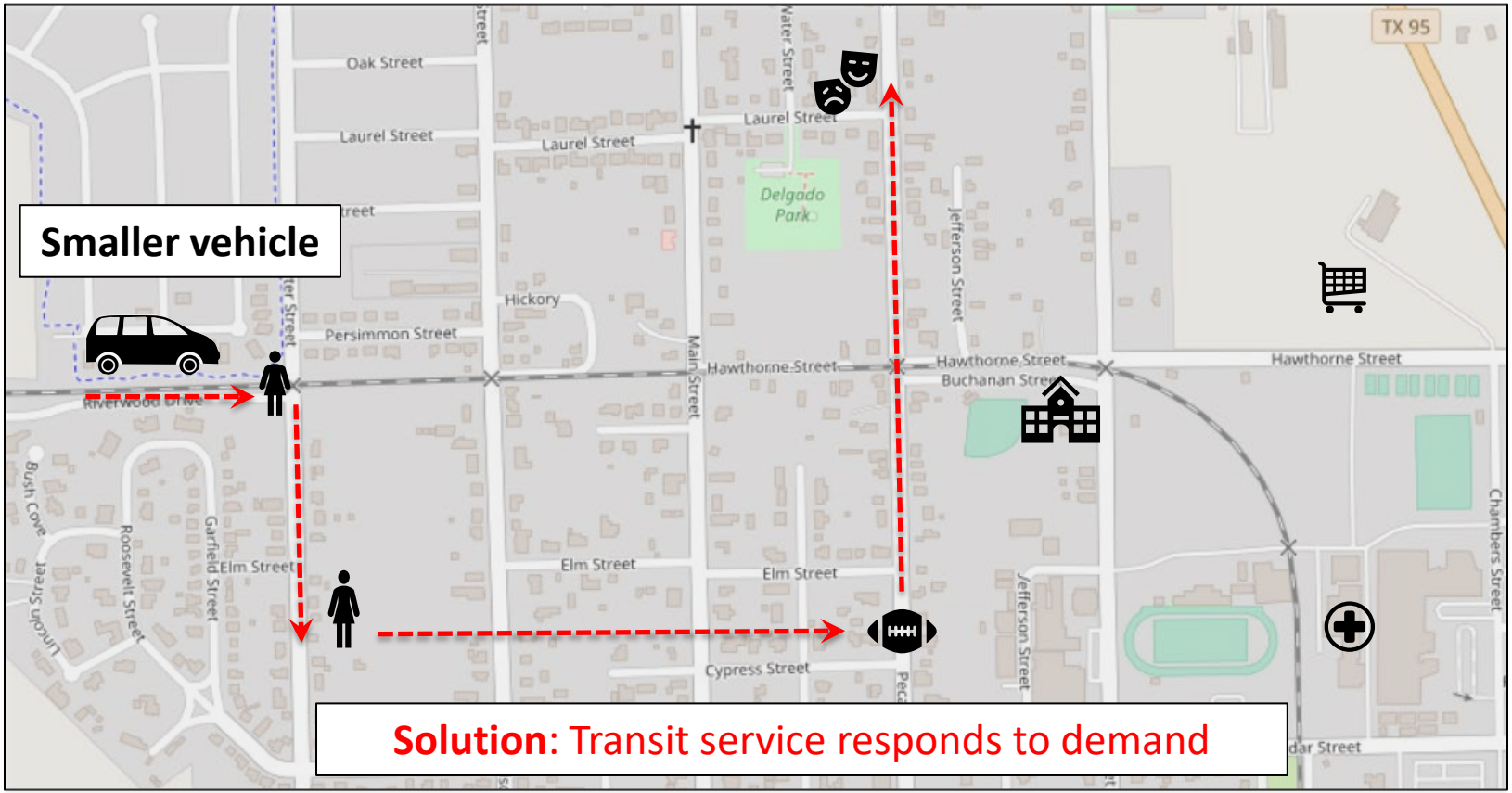
On-demand transit:

- Flexible schedule, flexible stop locations

Inefficient Operating Environment: Fixed Route



Optimal Operating Environment: ODT



U.S. ODT Deployment Trends

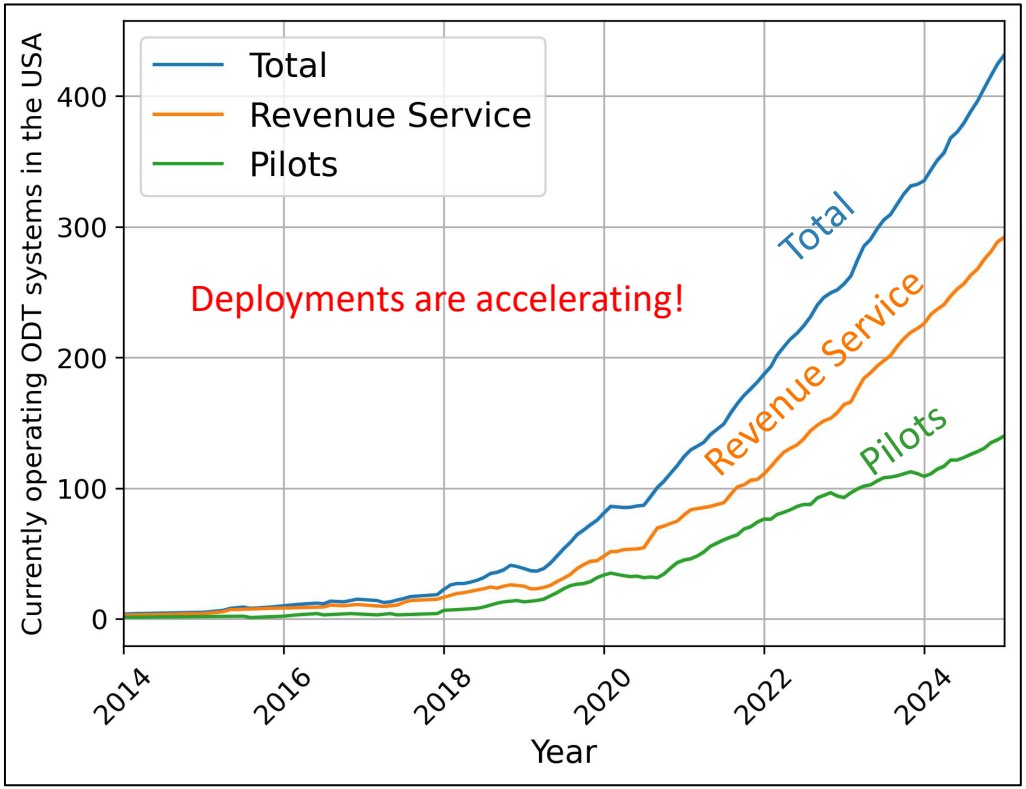


Figure created by NREL using data from Lukas Foljanty's On-Demand Transit World Map (February 2025)

- Growth accelerated during the pandemic
- While most of early pilots failed, deployment of more recent commercial services have accelerated indicating success.

ODT Service Designs

ODT providers in the U.S.

Ridehailing Services: Subsidized Uber/Lyft trips

Software as a Service (SaaS): Dispatching & operations software

Transportation as a Service (TaaS): Vehicles, drivers, and operations

$ **Lightest Touch** — **Turnkey Solutions** $$$

Uber

spare

Liftango

RIDECO

TransLōc

VIA

lyft

THE ROUTING COMPANY

Pantonium

CIRCUIT

Flexibility in service design

Can be tailored to meet specific objectives under tight constraints

Spatial

- Geofenced service areas
- Fixed/flexible stops
- Origin/destination constraints
  - Transit stop, downtown

Financial

- Capped subsidies
- Dynamic pricing
- Varying level of subsidies
- Incentives: free trips to transit

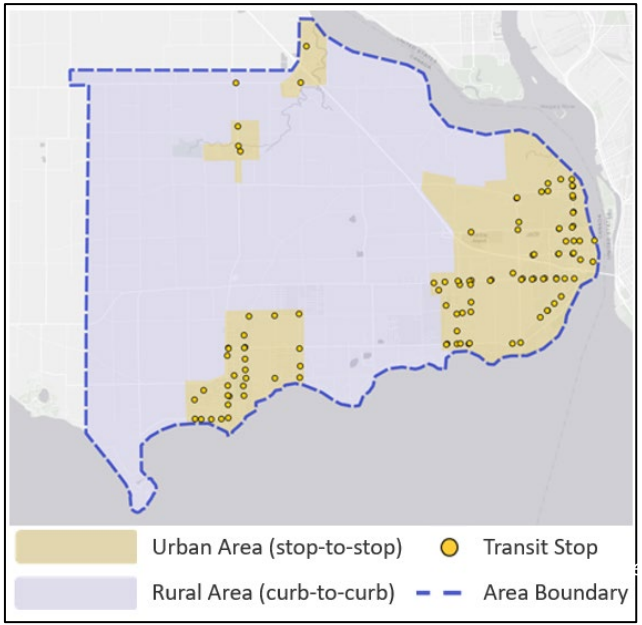
Operational

- Customize algorithms
  - Min. wait times, emissions
  - Max. reliability
  - Max. occupancy, reliability
- Dynamic policies

Temporal

- Service hours
  - Dynamic, vary in space
- Time of day service offerings

Spatial + Operational:
Fixed + flexible stops geofencing



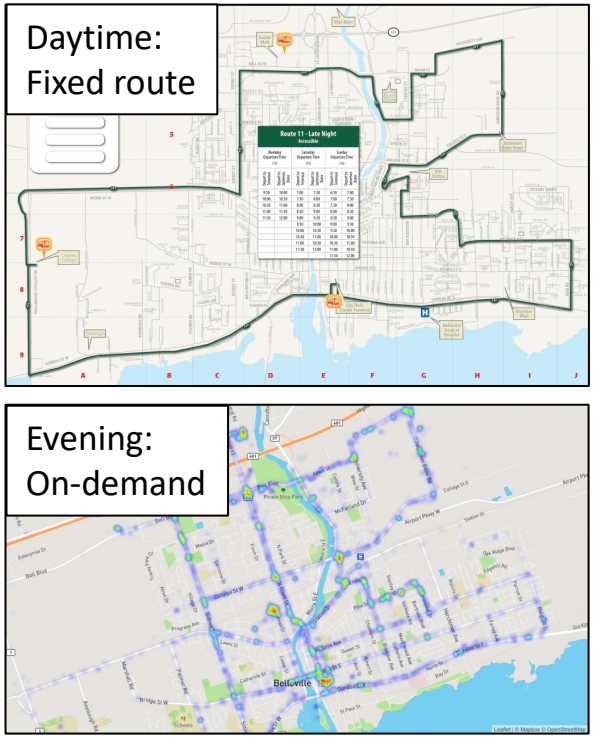
Fort Erie, Ontario

Note: Fort Erie's service has since changed and is now curb-to-curb everywhere

Spatial + Financial:
Free zonal connections to public transit, geofencing

Seattle, Washington

Temporal:
Late night door-to-door (safety, accessibility)



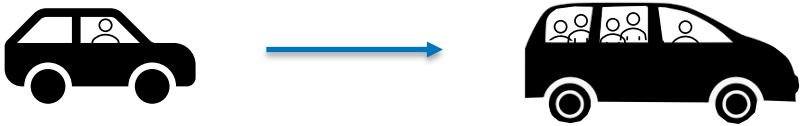
Belleville, Ontario

Benefits of On-Demand Transit

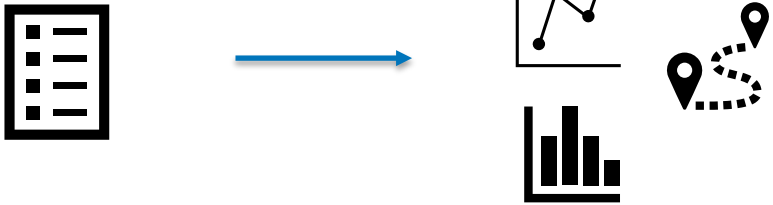
Energy Efficiency & Emissions

‘Right-sized’ vehicles
Reduced fuel consumption, easier to electrify

Greater use of shared modes
Reduces single-occupancy vehicles



Dispatching/routing optimization
Real-time decisions based on current network information



A Note on Vehicle Fleets

ODT vehicles can be:

- Small: GEM vehicles, mini-vans, SUVs
- Mid-size: Full-size passenger vans
- Large (less common): Full-size buses

Photo from New Rochelle

Photo by Werner Slocum , NREL 15931

Evolution of ODT vehicles

Volkswagen I.D. Buzz;
Photo from: Bonnie Powell, NREL

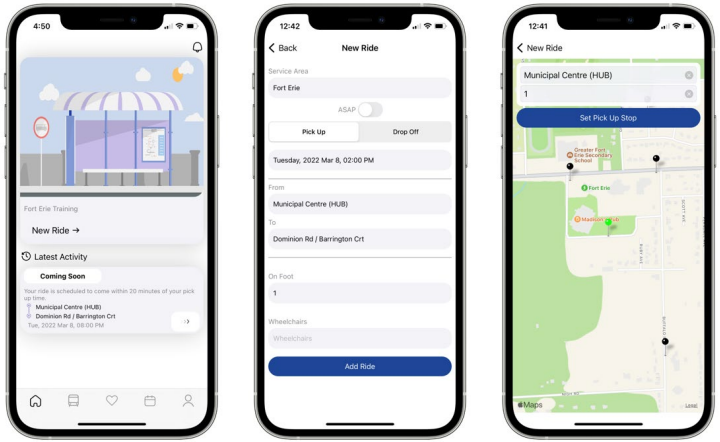
Energy Efficiency

Location/Author	Service Description	Energy/Emissions Impacts	Source
Fort Erie, ON	City-wide micro-transit (rural)	**52% reduction in fuel consumption per passenger/kilometer** compared to fixed route	NREL Case Study
Innisfill, ON	City-wide subsidized TNCs (rural)	**26% reduction in annual fuel consumption** while providing 2x the trips compared to modeled fixed route	NREL Case Study
Sacramento, CA	Geofenced micro-transit zone	Micro-transit **reduced emissions by 22%** compared to other mode alternatives	City of West Sacramento
Lolland, Denmark	Rural micro-transit simulation	**Smaller, more fuel-efficient vehicles** compared to fixed-route	Dytckov et al. 2022

In rural areas, vehicle efficiency typically makes up for the increased mileage, resulting in fuel savings

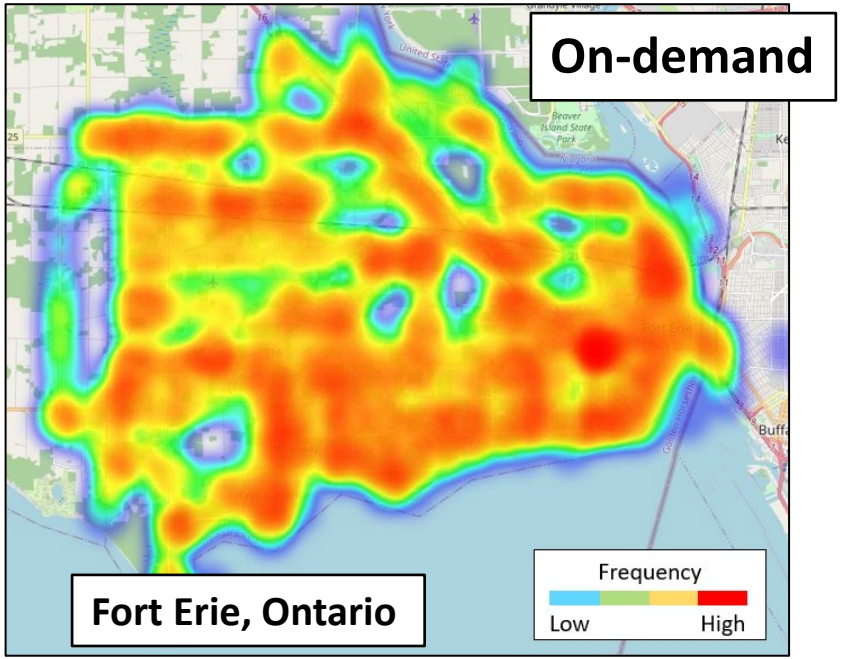
Increased Flexibility for Users

- Stop-to-stop or door-to-door service
- Does not require pre-planning
- Real-time information
  - Vehicle location
  - Estimated pick-up/arrival time
- Digital, frictionless payment systems



Fort Erie's On-Demand Transit – Rider App
(Powell et al. 2023)

Improved Accessibility/Coverage



Powell et al. 2023

70% had transit access with fixed-route:

- Must live within ¼ mile of bus stop

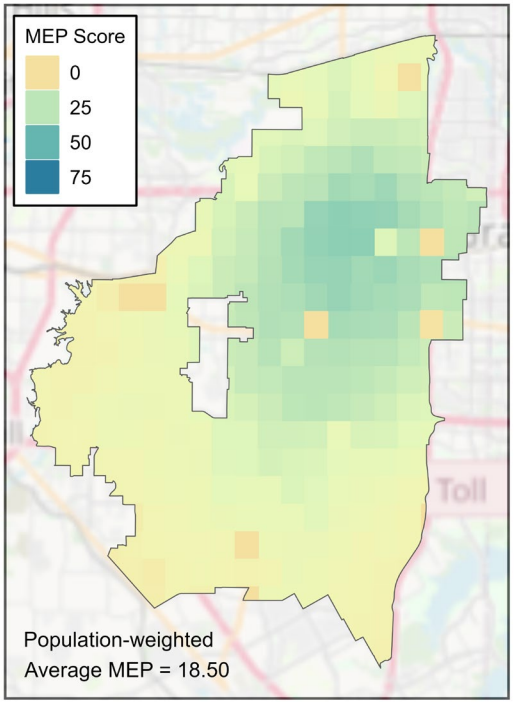
100% coverage:

- Includes disabled/elderly populations

Arlington Mobility Energy Productivity (MEP) Analysis

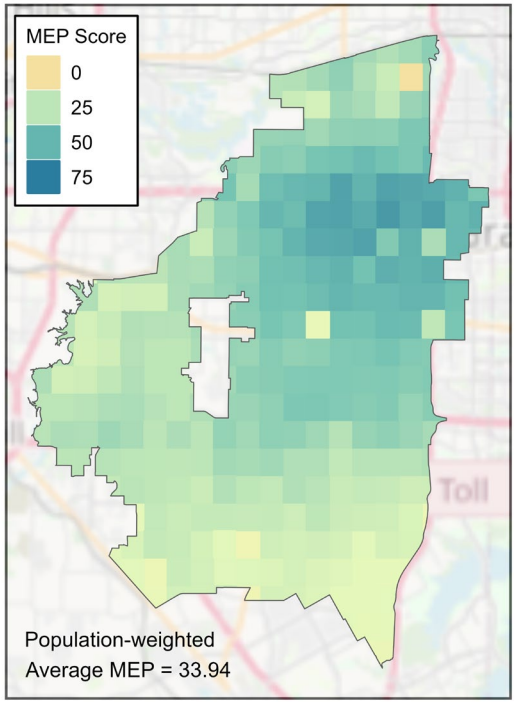
- Visualized impacts of the ODT system on those without a car and unable to afford TNC rides
- Average MEP score **increased 83%**
- MEP scores improved throughout the service area.

Bike + Transit



Average MEP: 18.50

Bike + Transit + ODT



Average MEP = 33.94

Source: Powell et al. 2024

High Level of Service

- When designed well, high level of service
- Potential for lower ride times compared to fixed route
- Customer surveys show high satisfaction

Stringer Presentation at TRB TRANSED 2022

Example

Dallas Area Rapid Transit (DART) GoLink

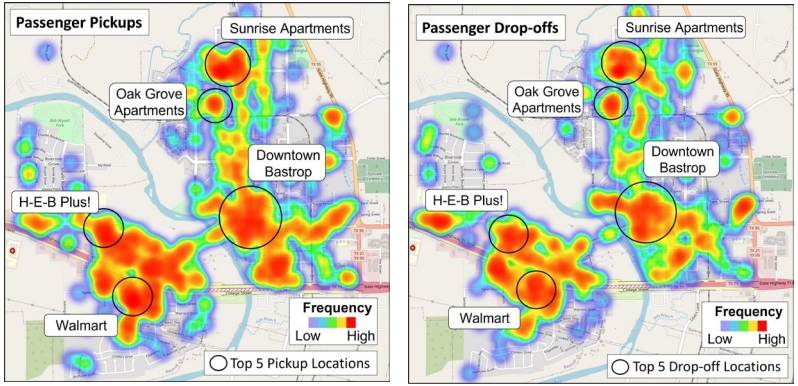
- *Average wait time:* 13 minutes*
- *Average ride time:* less than 10 minutes
- *Average ridership:* + 130%
- *Customer satisfaction:* 91% of users rated their FMLM trip experience as “good” or “excellent”

Source: Presentations at TRB TRANSED 2022 and USDOT. Used with permission.

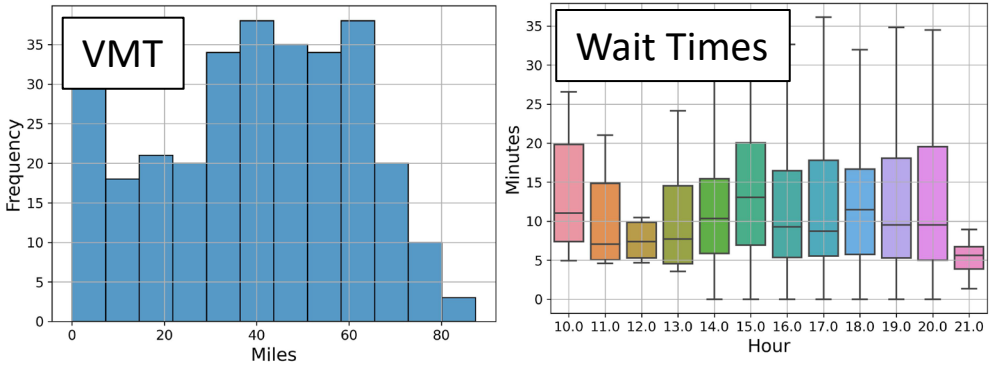
Johnson Presentation at TRB TRANSED 2022

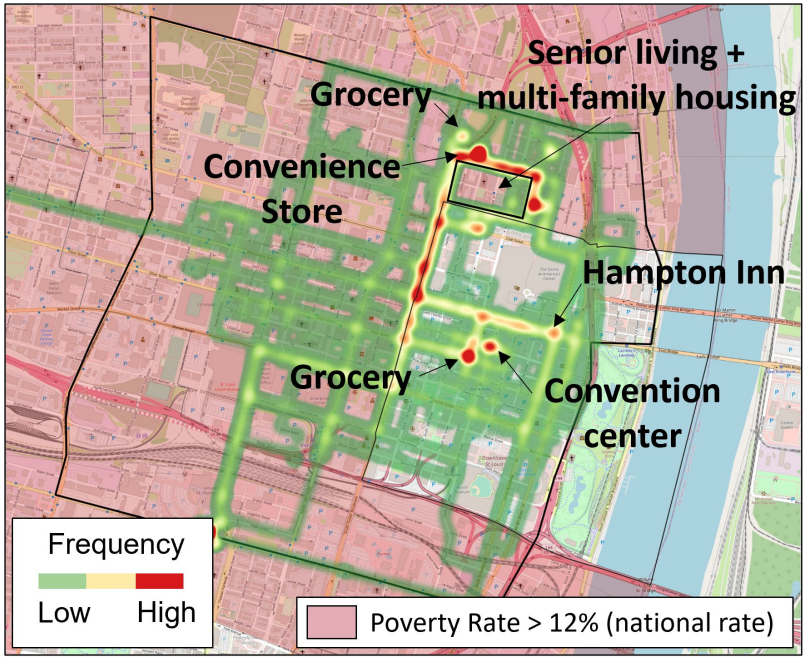
Rich Data Streams

Data can be used to assess service quality and more accurately plan improvements



Bastrop, TX





St. Louis, MO

Key Data Metrics

System Operation:

- Dispatch & Route Planning
- Hours of Operation

Vehicle Fleet:

- Fleet Composition
- Origin-Destination Pairs
- Vehicle Miles Traveled
- Environmental Impact

Ridership:

- Passenger Travel Time
- Ridership Numbers
- Passenger Wait Time
- Demographics
- Passenger Satisfaction

System Operation Efficiency

- Percentage of Shared Rides
- Trip Cancellation Rate
- Trip Denial Rate

Challenges of ODT

Challenges

- **Scaling up** – small increases in ridership will require additional supply to keep service quality (vehicles + drivers)

- Serving **peak times** – system reliability and keeping low wait times
- No fixed schedule (uncertainty) can be **challenging for commuters**

- **Integration** with nearby transit systems (data streams, real-time info)
- Still some travelers **without smartphones** (can call to schedule, but can't track vehicle)

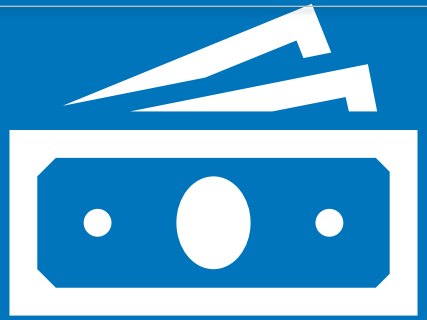
Initial Failures Have Pointed the Way to Success

1. **Bridj (Kansas City, MO) – Served only 1,480 people from Mar-Aug 2016 (Eno Center)**
   - No marketing, limited knowledge of service, no community outreach, service was not designed to meet the needs of residents.
2. **Ride Cell (Santa Clara, CA) – 0.4 boardings/revenue hour (Jan-Jun 2016) (Eno Center)**
   - Limited marketing, multiple mobile payment systems, limited options for unbanked customers.
3. **Ford Chariot (New York, San Francisco, among others) – very low ridership (2014-2019)**
   - Targeted dense cities with reliable public transit and TNCs.

What has changed?:

- Improved payment systems, integrated mobility apps, marketing/outreach, new funding mechanisms and subsidies (federal/state), B2G2C (business-to-government-to-consumer) service model, well-defined metrics/objectives, improved rider experience (estimated pickup times, frictionless payment), better dispatching/routing algorithms, greater public awareness of micro-transit.

ODT System Costs

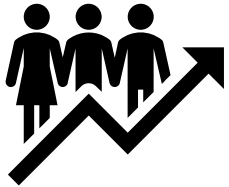


ODT System Costs

Factors influencing cost (compared to a fixed route system):

‘Right-sized’ vehicles

- *Reduced fuel and maintenance costs*
- *Reduced capital costs*



Demand

- *More efficiently serve sparse demand patterns*
  - *Logistics, optimization, not constrained to a route*

ODT **System** Costs – Examples

Note: costs to rider is ~$3-5/ride

ODT System	Operating Costs[1]	Fixed-route Cost/Ride[2]	ODT Cost/Ride[1]	Source
Wilson, NC RIDE[3]	$2.2M annually (2022)	~$16/ride	~$10/ride	*TRB Webinar 2022*
Fort Erie, Ontario[3]	$1.4M annually (2022)	~$24/ride	~17/ride	*NREL Case Study*
Hall County, GA[3]	-	~$25/ride	~$13/ride	*Mass Transit*
Utah Transit Authority	$3.6M annually (2022)	-	~$19/ride	*TRB Webinar 2022*
Arlington, TX	$11M annually (2023,2024)	-	~13-15/ride	*City of Arlington*

[1]The definition of "operating costs" and "cost/ride" may differ between agencies.
[2]Different costs associated with fixed-route and on-demand systems which might not capture the complete picture (E.g., driver wages and benefits)
[3] Replaced fixed-route with on-demand transit

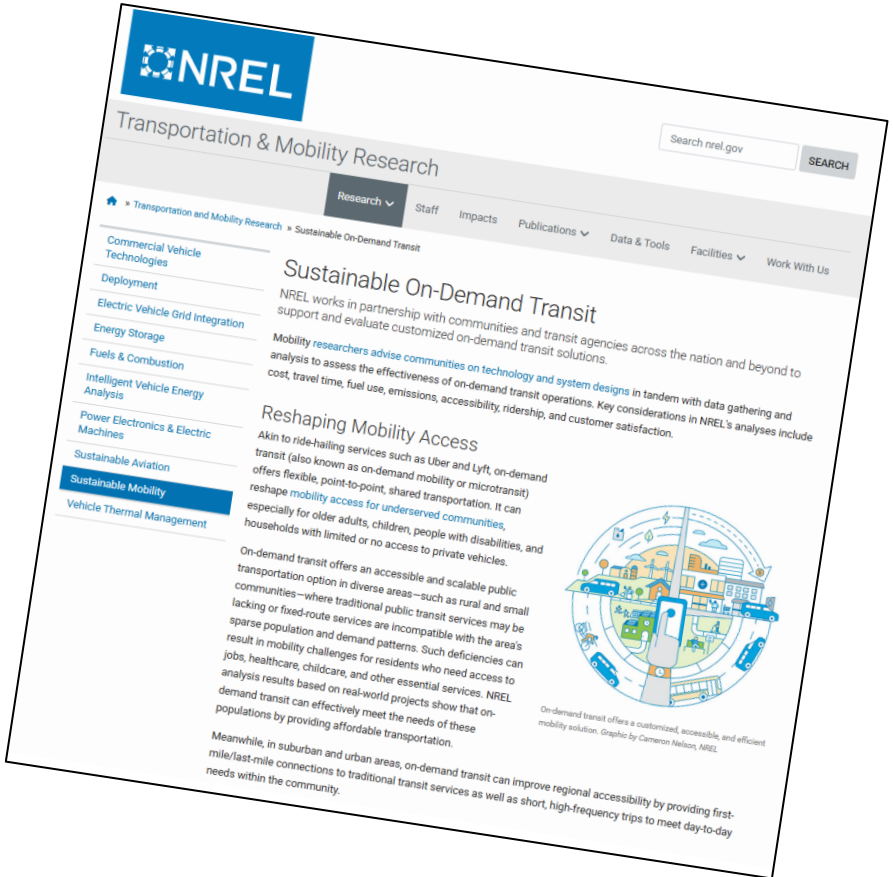
More research needed….

Resources

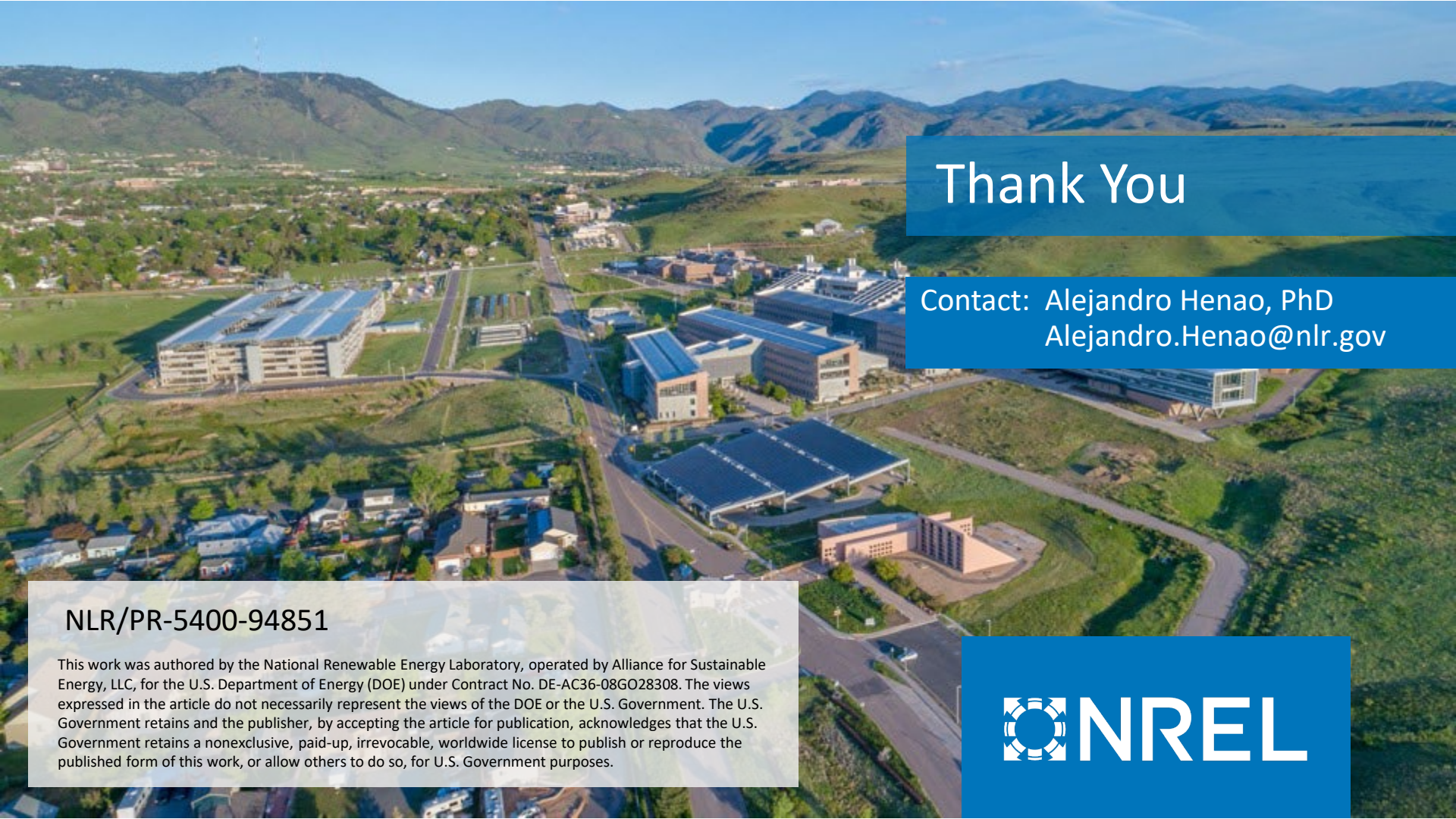
NREL ODT Case Studies

Density	Community	Description	Study Links
Rural	**Innisfil, Ontario**	Subsidized Uber trips, no prior transit.	NREL Case Study Report
	Fort Erie, Ontario	On-demand transit minivans replaced fixed-route transit in the entire region.	NREL Case Study Report and Presentation
	Bastrop, Texas	Pilot project, low-speed electric vehicles in Bastrop's downtown, popular with tourists.	NREL analysis previously on the Lone Star Alliance website
Suburban	**Arlington, TX**	One of the largest ODT systems in the country with 75+ vans. No prior transit in the region. Study conducted a Mobility Energy Productivity (MEP) analysis.	NREL Case Study Paper and Presentation
	Missouri City, TX	Houston METRO's curb2curb on-demand transit system. One of our researchers completed 50 trips using the system.	NREL Case Study Report and Presentation in progress
	New Rochelle, NY	Low-speed electric vehicles in New Rochelle's downtown.	NREL Case Study Presentation, full paper pending publication
Urban	**St. Louis, MO**	Low-speed electric vehicles in St. Louis' downtown. Analysis included community survey data.	NREL Case Study Paper and Poster

NREL ODT Webpage



https://www.nrel.gov/transportation/sustainable-on-demand-transit.html



Thank You

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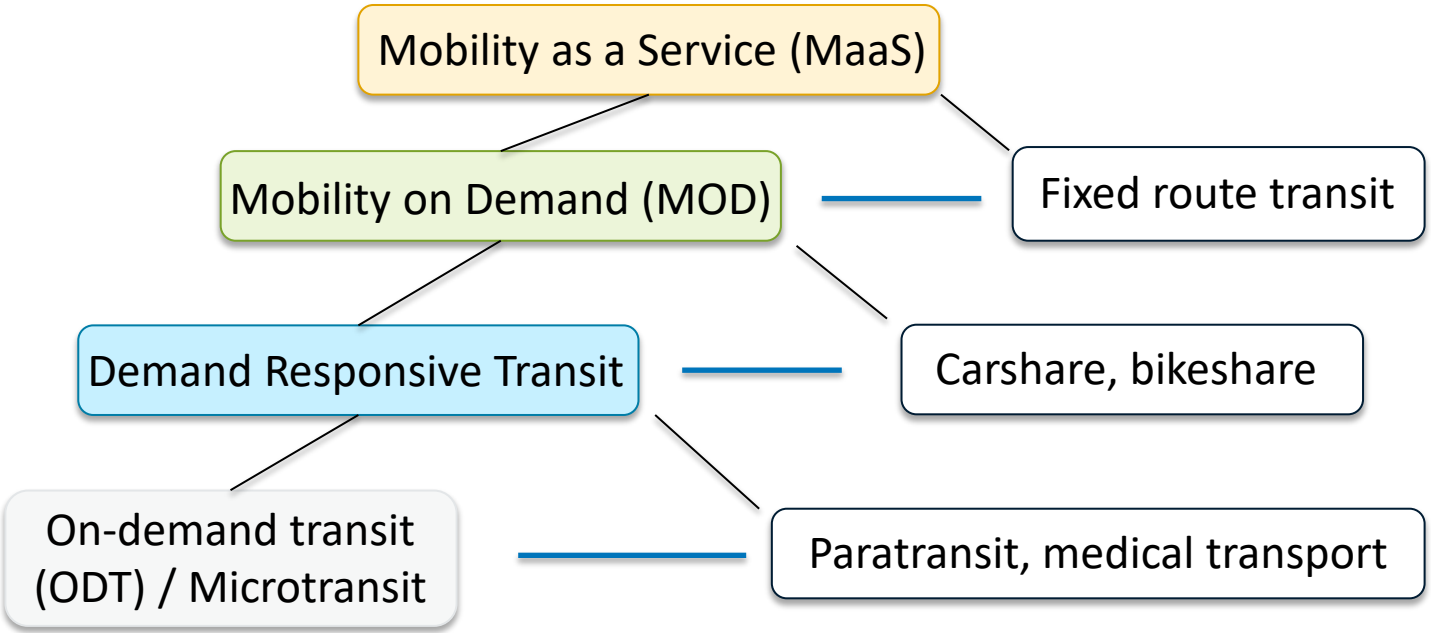
NREL

ODT in the mobility landscape



ODT definition – shared public mobility that responds to requests in real-time

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