NREL On-Demand Transit Research and Fort Erie Case Study

Presented by Bonnie Powell
Washington State Transportation Commission Meeting
March 14, 2023
NREL at-a-Glance

2,926

Workforce, including
219 postdoctoral researchers
60 graduate students
81 undergraduate students

World-class
facilities, renowned technology experts

More than 900

Partnerships
with industry, academia, and government

Campus
operates as a living laboratory
NREL Science Drives Innovation

Renewable Power
- Solar
- Wind
- Water
- Geothermal

Sustainable Transportation
- Bioenergy
- Vehicle Technologies
- Hydrogen

Energy Efficiency
- Buildings
- Advanced Manufacturing
- Government Energy Management

Energy Systems Integration
- Grid Integration
- Hybrid Systems
- Security and Resilience
Motivation & Background

• NREL performing an ongoing series of On-Demand Transit (ODT) case studies
  – Accessing the Mobility Energy Productivity (energy/emissions, travel/wait time, cost)

• Funding - DOE VTO Technology Integration program through the Technologist in Community project

On-demand transit:
• Flexible schedule, flexible stop locations
• Suburban, exurban, rural areas
Fort Erie Case Study

Transition from Fixed-Route to On-Demand Transit
Methodology

• Interviews with Fort Erie Transit and Pantonium (software partner)
• Data provided by Fort Erie Transit and the software partner
• Analyzed trips between October 2017 and July 2022
Fort Erie, Ontario

• Close to Niagara Falls and Buffalo
• Population: 32,901 (plus ~10,000 seasonal residents)
• Area: 64 mi² (166 km²)
• “Community of communities”, spread out population centers
Previous Fixed Route Bus System

- Fixed-route offered about 70% of population reasonable access to transit
- Low ridership, even lower during the pandemic
- Long ride and wait times

Photo from the town of Fort Erie

The fixed routes included four lines: East Blue, East Green, West Yellow, and North Red. Image from the town of Fort Erie.
Options Considered

• Research conducted in 2019/2020
• Options:
  – Switching direction of buses
  – First-mile/last-mile service
  – Partnering with a TNC
  – **Fully on-demand with designated smaller vehicles and software partner**
  • Regional Limousine owns and operates vehicles and manages call center, Pantonium handles scheduling and dispatching software

Photo from the town of Fort Erie.
On-Demand System

• Launched October 2021
  – Two-week overlap with fixed-route system
• Fleet – 7 regular Dodge Caravans, 2 wheelchair-accessible vans
• Schedule using phone call, webpage, or mobile app
• Walk-on boardings allowed at certain stops
• $3/ride – cash, credit/debit, reloadable smart card
• Operating hours: 6 a.m. – 9 p.m., Mon-Sat

Fort Erie’s On-Demand Transit – Rider App. Images from the town of Fort Erie.
Fixed routes (left) were “reasonably accessible” to 70% of Fort Erie residents. On-demand now serves the full town of Fort Erie. Images from the town of Fort Erie.
ADA Accessibility and Other User Features

- 2 wheelchair-accessible vans
- Bikes can be stored on trunk rack
- Strollers can be loaded in truck
- Passengers can bring their own car seats (optional)

Fort Erie Transit wheelchair-accessible van. Photo from the town of Fort Erie.
Fort Erie Results
Ridership has exceeded pre-COVID levels and is still increasing.

Total monthly riders before and after the on-demand system was instituted (October 1, 2017 to November 30, 2022)
Increased Service Area

• On-Demand captures remaining 30% of population

A heat map showing where vehicles providing trips traveled, using latitude and longitude coordinates recorded every 30 seconds for all assigned trips from October 4, 2021, to July 19, 2022.
Pickup/Dropoff Locations

Pickup Locations

Frequency
Low  High

Drop-Off Locations

Frequency
Low  High
Pickup/Dropoff Locations

Top 10 Pickup Locations

Top 10 Dropoff Locations
Wait Times

<table>
<thead>
<tr>
<th>Overall</th>
<th>10.5 minutes</th>
</tr>
</thead>
<tbody>
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<td>For passengers</td>
<td>14 minutes</td>
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* Wait time is the time from trip request to vehicle arrival at pickup site.
**Box and whisker plot: the box extends from quartile 1 (Q1) to Q3 and has a line at the median. The whiskers extend to 1.5x the inter-quartile range.

Average wait time for each operating hour of the day, for all trips between October 4, 2021, and July 19, 2022. Outliers 1.5x the inter-quartile range, representing approximately 1.7% of trips, are not shown.
Average wait time for each operating hour of the day, for all trips between October 4, 2021, and July 19, 2022. Outliers 1.5x the inter-quartile range, representing approximately 1.7% of trips, are not shown.

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Average wait time for each operating hour of the day, for completed trips with a passenger using a wheelchair, between October 4, 2021, and July 19, 2022. 12 outliers 1.5x the inter-quartile range are not shown.
Average ride time for each operating hour of the day, for all trips between October 4, 2021, and July 19, 2022. Outliers 1.5x the inter-quartile range, representing 3.7% of trips, are not shown.
Lower Fuel Consumption

- Lower fuel consumption after on-demand (both total and per-ride)
- Fuel consumption now demand-responsive, proportional to ridership. Vehicles do not move until called.

Average fuel consumption per ride before and after the on-demand system was instituted (October 1, 2017 to May 1, 2022)
### Carbon Dioxide Emissions

#### Emissions per ride decreased by 63%

<table>
<thead>
<tr>
<th>Year</th>
<th>Time Period</th>
<th>System</th>
<th>Total Rides</th>
<th>Km Traveled (miles)</th>
<th>Fuel Consumed [Liters] (gal)</th>
<th>Avg L/100 km (gal/100 mi)</th>
<th>Emissions [kg CO2]</th>
<th>Emissions [kg CO2/km]</th>
<th>Emissions [kg CO2/ride]</th>
</tr>
</thead>
<tbody>
<tr>
<td>2019</td>
<td>Six months*</td>
<td>Fixed Route</td>
<td>19,784</td>
<td>205,976 (127,988)</td>
<td>79,402 (20,976)</td>
<td>38.55 (16.39)</td>
<td>213,590</td>
<td>1.04</td>
<td>10.80</td>
</tr>
<tr>
<td>2021-2022</td>
<td>Six months**</td>
<td>On-Demand</td>
<td>18,381</td>
<td>180,908 (112,411)</td>
<td>31,373 (8,288)</td>
<td>17.34 (7.37)</td>
<td>72,785</td>
<td>0.40</td>
<td>3.96</td>
</tr>
</tbody>
</table>

*Annual 2019 data divided by two

**October 2021 – March 2022

*Table: Distance traveled, fuel consumed, and carbon dioxide emissions for half of 2019 (fixed route system) and a six month period from October, 2021 to March, 2022 (on-demand system).*
• Current on-demand system uses Dodge Caravans.
• Potential to further reduce CO₂ emissions by using hybrid or plug-in hybrid mini-vans, or electric buses.

Estimated emissions per ride for the baseline case (Dodge Caravans) and two hypothetical scenarios where all vehicles are replaced with hybrid all-wheel drive Toyota Siennas or plug-in hybrid Chrysler Pacificas. Both upstream and tailpipe emissions are included, using an electricity grid mix for Buffalo, New York.
Operating Costs

• Single ride costs the customer $3 (same as fixed-route system)
• Costs per ride to Fort Erie Transit
  – On-demand: ~$17/ride
• Annual budget
  – Fixed-route: $1.4 million
  – On-demand: originally proposed at $950,000, increased to $1.4 million after ridership increases offset the decrease in operating costs

*All costs in Canadian dollars
Outreach and Customer Feedback

- Word-of-mouth was the most common way riders heard about the on-demand system.
- 84% of survey respondents rated their overall trip satisfaction as either a 4 or 5, average rating was 4.48

Preliminary results from onboard comment cards, collected April and May 2022, show how riders heard about the on-demand system. The sample size was 46 respondents.
• Fort Erie’s on-demand system moves more people using less fuel and same annual budget
• Guided by Mobility Energy Productivity
  – Travel time / wait time
  – Cost (traveler/agency)
  – Energy & emissions
• High value of automatically collected data, potential to inform future changes to transit
• Scalability is a key consideration
• Just one case study, but shows potential of on-demand transit

Photo from the town of Fort Erie.
Related Work at NREL
## Other On-Demand Projects

<table>
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<tr>
<th>Community</th>
<th>System Details</th>
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<tr>
<td>Innisfil, Ontario</td>
<td>No prior public transit, subsidized Uber rides only (<a href="https://Innisfil.ca">Innisfil.ca</a>, <a href="https://www.nrel.gov">NREL Case Study</a>, <a href="https://Innisfil.ca">Innisfil Report</a>)</td>
</tr>
<tr>
<td>Bastrop, TX</td>
<td>Low-speed electric “cabs”, popular with tourists. Partner is Electric Cab of North America (eCab) (<a href="https://Bastrop">Bastrop</a>)</td>
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<tr>
<td>St. Louis, MO</td>
<td>Low-speed electric vehicles connecting lower-income neighborhoods to downtown St. Louis. Operated by Labyrinth Smart Mobility ([St. Louis Downtown Connect](<a href="https://St">https://St</a>. Louis Downtown Connect))</td>
</tr>
<tr>
<td>Arlington, TX</td>
<td>City-wide on-demand transit system partnered with Via ([Arlington on-demand](<a href="https://Arlington">https://Arlington</a> on-demand))</td>
</tr>
<tr>
<td>Fort Erie, Ontario</td>
<td>Standalone service replaced all fixed routes, software and vehicles/operations contracted out to two separate companies – Regional Limousine and Pantonium ([Fort Erie](<a href="https://Fort">https://Fort</a> Erie), <a href="https://www.nrel.gov">NREL Case Study</a>)</td>
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‘How-to Guide’ for On-Demand Transit

Developing a **slide deck** overview to on-demand transit with background, examples, resources

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Integrated Data and Analysis Tools
Our integrated data and analysis tools inform the development of innovative mobility technologies and systems.

- **MEP**: Mobility Energy Productivity Tool
- **EVI-Equity**: Electric Vehicle Infrastructure for Equity Model
- **EVI-Pro**: Electric Vehicle Infrastructure Projection Tool
- **FASTSim**: Future Automotive Systems Technology Simulator
- **EVI-X Modeling Suite of Electric Vehicle Charging Infrastructure Analysis Tools**
- **HIVE**: Highly Integrated Vehicle Ecosystem Simulation Framework
- **NREL OpenPATH**: Open Platform for Agile Trip Heuristics
- **TSDC**: Transportation Secure Data Center
- See our [full collection of tools](#).