Low-Speed Automated Shuttles Foundational Research

Elizabeth Machek, U.S. DOT

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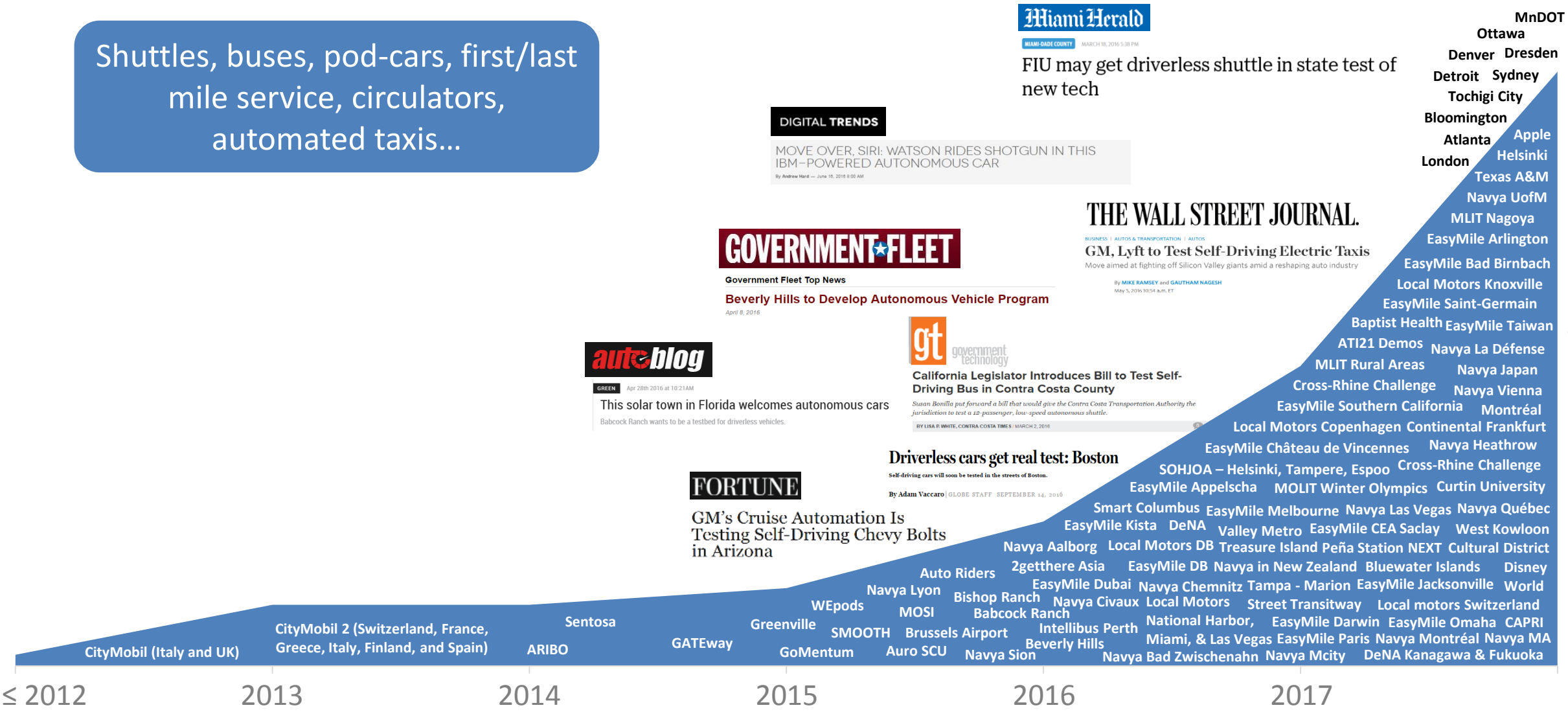
Overview of Low-Speed Automated Shuttle Market

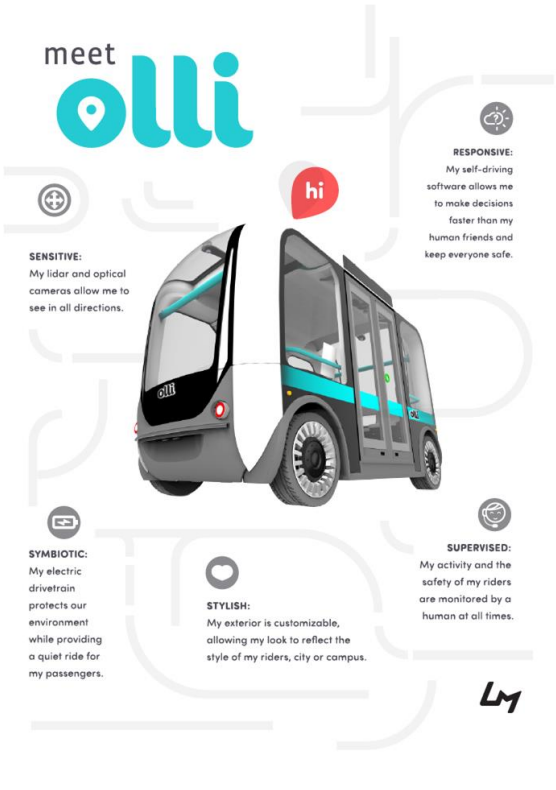
Vehicles, Manufacturers, and Suppliers

Interest in Low-Speed Automated Shuttles

Shuttles, buses, pod-cars, first/last mile service, circulators, automated taxis…



Low-Speed Automated Shuttles: Major Manufacturers



Local Motors

Olli

Navya

Arma

EasyMile

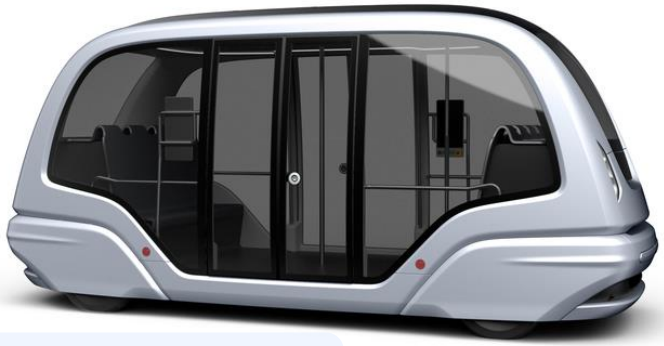
EZ10

Comparison of Major Manufacturers

Specification	Local Motors Olli	Navya Arma	EasyMile EZ10
Capacity	12	15	12
Cruising Speed	12 mph	15.5 mph	12 mph
Maximum Speed	30 mph	28 mph	25 mph
Battery	Lithium (unspecified)	LiFeP04	LiFeP04
Battery Capacity	18.5 kWh	33 kWh	20 kWh
Battery Life	Up to 5 hours	Up to 12 hours	Up to 14 hours
Vehicle Weight	4,057 lbs.	5,291 lbs.	3,900 lbs.
Fully Loaded Weight	6,261 lbs.	7,606 lbs.	6,000 lbs.
Sensors	GPS, radar, lidar, camera, ultrasonic	GPS, lidar, camera	GPS, radar, lidar, camera
Communications	DSRC (optional)	DSRC (optional)	

Note. Information in this table comes from multiple specification sheets provided by Local Motors, Navya, and EasyMile; specifications may differ slightly vehicle to vehicle.

Low-Speed Automated Shuttles: Other Manufacturers



2getthere

Westfield Sportscars/
ULTra Global PRT

2getthere

RDM Group

Low-Speed Automated Shuttles: Retrofit Vehicles

Auro Robotics

Varden Labs *Alvin*

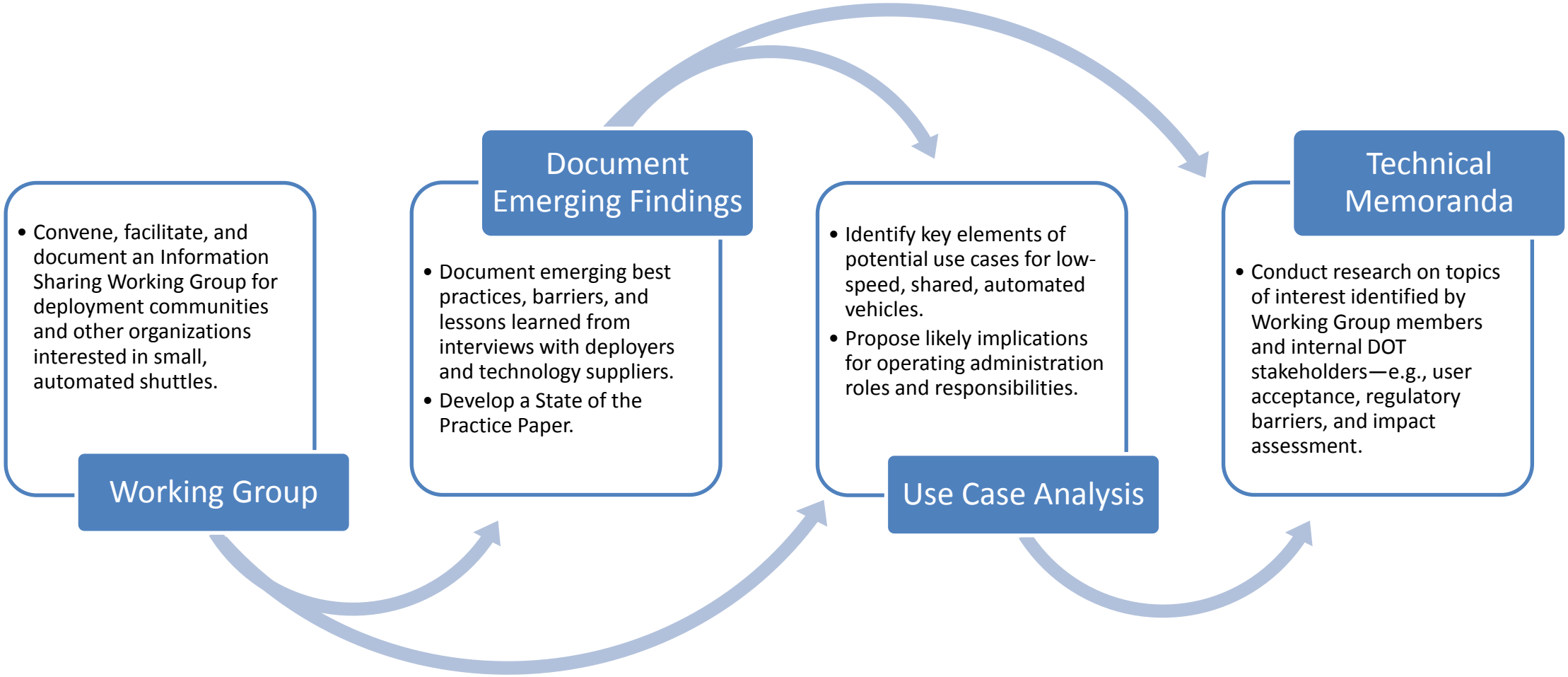
TARDEC (ARIBO)

Waymo Minivan

Project Overview

Tasks and Approach

ITS JPO/ Volpe Project Overview



Low-speed Automated Shuttle Information-sharing Working Group

MnDOT (Twin Cities)

Mcity (Ann Arbor)

Boston

GoMentum Station (Contra Costa County)

PennDOT (Middletown)

Treasure Island (San Francisco)

Columbus

Santa Clara University

Fort Bragg

Greenville

Valley Metro (Phoenix)

Jacksonville

Denver

Arlington

Tampa

Treasure Island Shuttle

Organizations

- San Francisco County Transportation Authority (SFCTA)
- San Francisco Municipal Transportation Agency (SFMTA)

ATCMTD Grant

- $10.9 million award from the Advanced Transportation and Congestion Management Technologies Deployment (ATCMTD) grant program
- Funds will be used to creating dynamic pickup curbs for ridesharing and carpooling, set up regional carpool lanes, install smart connected traffic signals, deploy a connected tolling system and create an automated shuttle service.

Source: SFCTA

Treasure Island Shuttle

- In addition to SFCTA and SFMTA, partners include Treasure Island Development Authority and UC Berkeley
- Automated shuttle service to carry passengers around Treasure Island and Yerba Buena Island
- Planning work has suggested a system with three 12-pax shuttles, though the number of shuttles and their specifications have not been set

ARIBO Shuttle

Organizations

- U.S. Army Tank Automotive Research Development and Engineering Center (TARDEC)
- Robotic Research, LLC

Applied Robotics for Installations and Base Operations (ARIBO)

- Three different locations: Fort Bragg (NC), Fort Leonard Wood (MO), and West Point (NY)
- Multi-phase approach: Phase 0 (development), Phase 1 (human operation), Phase 2 (human supervision), Phase 3 (unmanned operation)

Fort Bragg Project

- Began in 2014 and transitioned to Greenville, NC in August 2017
- On-demand transport for soldiers and staff around the WTB barracks and Womack Medical Center
- Five pickup/drop-off locations on a route that includes a four-lane divided road, intersections, parking lots, patient drop-off locations, and walkways
- The base platform is a Cushman Shuttle 6 electric vehicle

Source: FHWA Public Roads 80(2)

Interface & Monitoring

- Scheduling System with kiosks and smartphone application
- Text-based reminder system
- Remote monitoring (cameras inside and outside of the vehicle)
- On-board black-box data recorder

University of Michigan Shuttle

Organization

- Mobility Transformation Center, University of Michigan

Mcity Testing

- In December 2016, Mcity began working with a Navya Arma shuttle.
- The shuttle has been used to conduct research and provide tours.

North Campus Pilot

- Beginning in fall 2017, the shuttles will be used in a new campus mobility service for students, faculty, and staff.
- The shuttles will drive along a two-mile route between the Lurie Engineering Center and the North Campus Research Complex (NCRC), picking up passengers every 10 minutes.
- The study will examine passenger reactions and user acceptance of the technology.

Source: University of Michigan

Minnesota Automated Bus

Organization

- Minnesota Department of Transportation (MnDOT)

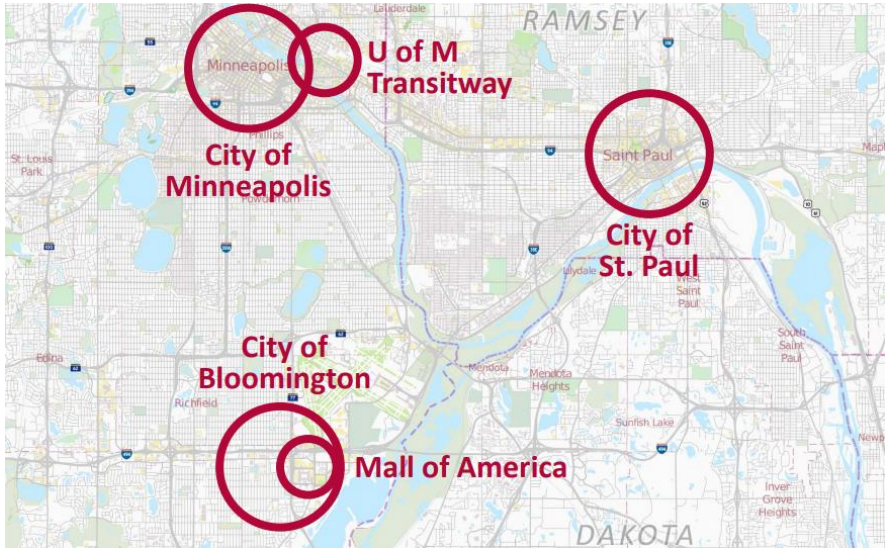
Automated Bus RFP

- MnDOT issued an RFP for an automated bus demonstration, but it did not receive proposals for automating a full-size bus that met its goals, so it is focusing on low-speed automated shuttles.

Testing and Demonstration

- MnDOT is leasing a shuttle for the testing and demonstration.
- Initial testing at MnROAD will include cold-weather testing with ice, snow, and wind.
- The project will culminate with a five-day demonstration in early February during the Super Bowl (demonstration site TBD).

Source: EasyMile



Source: MnDOT

City of Arlington, Texas

Organization

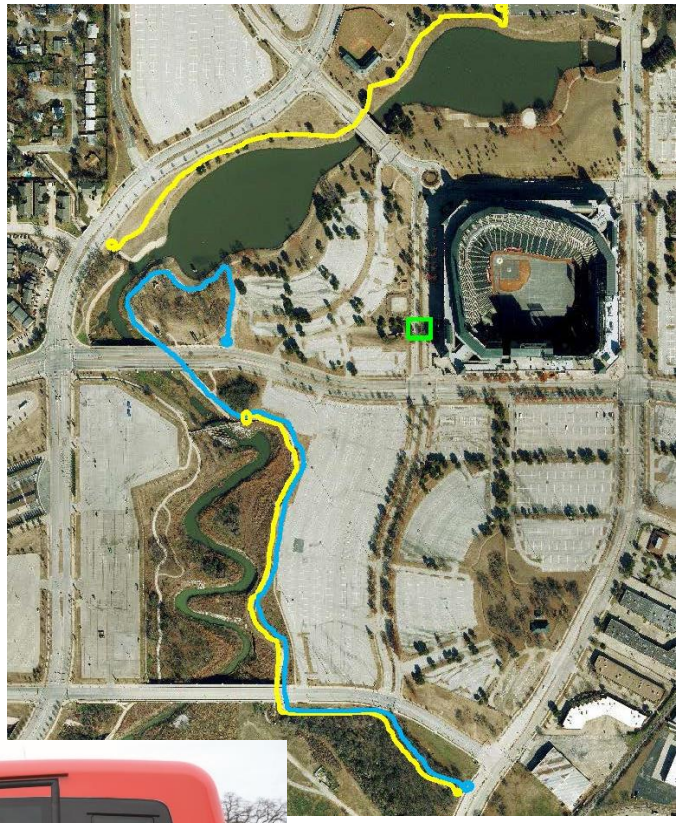
- City of Arlington

Demonstration

- The Arlington Convention Center was the third stop of the “2017 Autonomous Vehicle Road Trip” event in February 2017.
- Community and media were invited to attend, and Arlington City Council members were among some of the first riders.

Milo Pilot Project

- In March 2017, the Arlington City Council approved a one-year lease agreement for Two EasyMile EZ10 shuttles.
- In August 2017, shuttles began providing rides to the general public along select off-street trails in the Arlington Entertainment District.



Source: City of Arlington, TX

Source: City of Arlington, TX

Site Visits and Interviews

Site Visits

- ARIBO shuttle at Fort Bragg, NC
- GATEway pods in Greenwich, UK
- Michi-no-eki in Japan
- Navya shuttle at Mcity, MI
- Valley Metro, AZ

Industry Interviews

- 2getthere
- BestMile
- Coast Autonomous
- *Delphi - Upcoming*
- EasyMile
- Local Motors
- May Mobility
- Navya
- Panasonic
- *Optimus Ride - Upcoming*

Deployer Interviews

- Arlington, TX
- Atlanta, GA
- Boston, MA
- Contra Costa, CA (GoMentum Station)
- Denver, CO
- Fort Bragg, NC (TARDEC)
- Greenville, SC
- Jacksonville, FL
- Kansas City (KCATA)
- Los Angeles (Access Services)
- Mcity, MI
- Middletown, PA (PennDOT)
- Phoenix Metro (Valley Metro)
- Pinellas County (PSTA)
- Twin Cities, MN (MnDOT)
- Santa Clara, CA (University and VTA)
- United States Marine Corps

Tracking the Deployment Landscape

25+ Demonstrations and Pilots in Asia

- Auto Riders (EasyMile EZ10) @ Gardens by the Bay – Singapore
- MOLIT-Hyundai Shuttles for 2018 Winter Olympics – South Korea

60+ Demonstrations and Pilots in Europe

- CityMobil2 (EasyMile EZ10) – Multicity
- SOHJOA (EasyMile EZ10) – Finland
- Deutsche Bahn Pilot (Local Motors Olli) – Germany

50+ Demonstrations and Pilots in North America

- Mcity tours and testing (Navya Arma) – Ann Arbor, MI
- Transdev/ EasyMile nationwide demo tour – Multicity

5+ Demonstrations and Pilots in Oceania

- Waterfront circulator (EasyMile EZ10) – Australia
- Airport pilot (Navya Arma) – New Zealand

Image Sources: EasyMile, Navya Tech & Deutsch Bahn AG

Use Cases

Use Case Analysis *(currently in progress):*

Identifying potential points of interest and/or relevance for U.S. DOT modes in plausible automated community shuttle use cases.

Agency Responsibilities	Service Characteristics	Vehicle Characteristics
• Civil Rights • Data • Freight • Fuel Economy • Grants Administration • Infrastructure • Planning • Safety • Management & Operations	• Operating Environment • Path/Route • Waypoint • Schedule • Cargo Type • Revenue Service • Interstate Commerce • Specialized Infrastructure • Federal Funding • Human Operator	• Remote Intervention • Weight • Maximum Speed • Maximum Capacity • Powertrain Type

Preliminary Findings

Based on Working Group meetings, stakeholder interviews, site visits, ongoing use case analysis, and literature review

Key Findings

- **Market overview**
  - The marketplace is rapidly evolving, with many new companies.
  - Partnerships and roles are constantly changing.
- **Activity overview**
  - There are dozens of pilots and demonstrations worldwide.
  - Most projects are testing technology feasibility and basic user acceptance.
  - Deployments are largely passenger-oriented, but some are interested in freight use cases.
  - Additional attention is needed on accessibility and universal design.
  - Most deployments have used onboard operators.
  - Deployers are generally proceeding with caution.
- **Known challenges**
  - Both technical and policy/institutional challenges remain.
  - Further piloting will be required to understand use cases, costs, benefits, and demand.

Known Challenges

- **Technical**
  - Constrained to low speeds and highly controlled environments
  - Need for operator interventions and stops
  - Limited accessibility for travelers with disabilities
  - Tradeoffs in service type
  - Interactions with other road users and animals
  - Operation in inclement weather and extreme conditions
  - Perception of signs and traffic lights
- **Policy/Institutional**
  - Safety validation and certification
  - Vehicle accessibility requirements
  - Requirements related to federal funding
  - Regulations regarding remote intervention
  - Uncertain passenger demand

For More Information

Kevin Dopart
ITS Joint Program Office
Kevin.Dopart@dot.gov

Elizabeth Machek
Technology, Innovation, and Policy Division
John A. Volpe Transportation Systems Center
Elizabeth.Machek@dot.gov