n-catt

National Center for Applied Transit Technology

# Autonomous Vehicle Pilots and Beyond

Sept. 16, 2020

**What is N-CATT?**

- National Technical Assistance Center
- Launched in late 2019
- Operated by Community Transportation Association of America (CTAA)
- Through a cooperative agreement with the Federal Transit Administration (FTA)

National Center for Applied Transit Technology

## The N-CATT Mission

- N-CATT’s mission is to provide small-urban, rural, and tribal transit agencies with practical, replicable resources that help them apply technological solutions and innovations.

- N-CATT is carrying out this mission by analyzing information, communicating it, helping transit systems plan, and encouraging implementation of cost-effective, value-adding technology.

n-catt

National Center for Applied Transit Technology

# FIND US AT

https://n-catt.org/

# Automated Vehicles (AVs) in Transit

Carol Schweiger
President, Schweiger Consulting
N-CATT Webinar
Wednesday, September 16, 2020

# PRESENTATION OUTLINE

National Center for Applied Transit Technology

01 What is an **automated vehicle**?

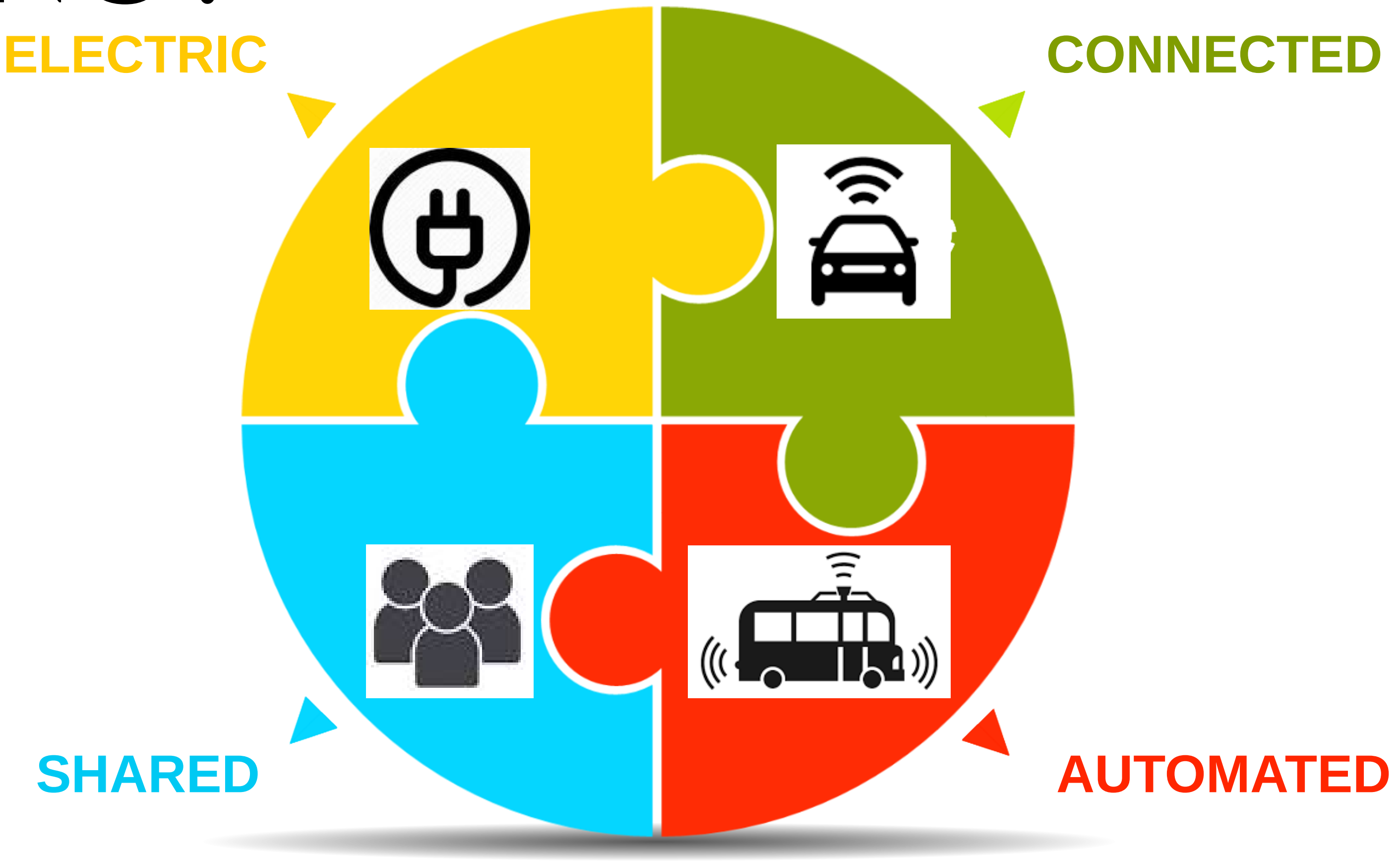
02 **Technology deployment** and **safety**

03 **Regulations, policies, and legal issues**

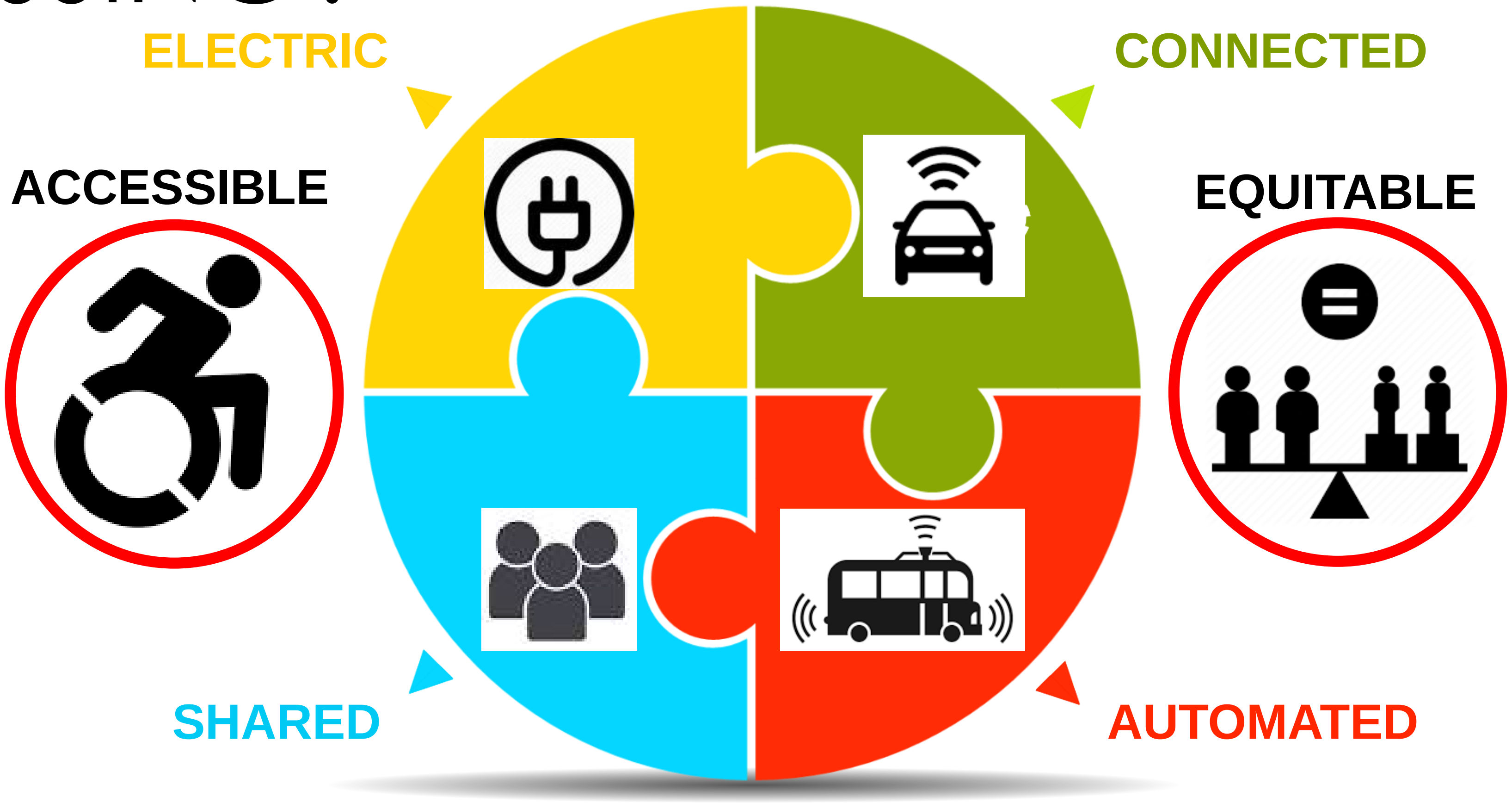
04 **Pilot projects**

05 **Public transit automated vehicles**

# FUTURE OF MOBILITY: WHAT IS MISSING?



# FUTURE OF MOBILITY: WHAT IS MISSING?



# Implications for Complete Rural Trip

| Trip Stage | Implications |
|---|---|
| **Pre-trip** | • If automated reservations, can traveler access reservations?<br>• If payment necessary, can traveler pay if un-banked or no credit card? |
| **Trip origin** | • Can AV reach trip origin? |
| **Between trip origin and location where first mobility service accessed** | • Can AV reach stop? |
| **Where first mobility service accessed** | • Is stop accessible? |
| **Board first mobility service** | • If no driver, can traveler board AV? |
| **On-board access** | • If payment on-board, can traveler pay with no assistance?<br>• If automated payment, can traveler pay if un-banked or no credit card? |
| **En-route using first mobility service** | • If travel disrupted, how can traveler re-book or change itinerary?<br>• If behavior issues on-board, how will it be addressed with no driver? |
| **Before alighting first mobility service** | • If no driver, can traveler move within AV to prepare to alight vehicle? |
| **Alighting first mobility service** | • If no driver, can traveler alight with no assistance? |
| **Travel between alighting point and transfer point** | • Does traveler need directions?<br>• Is the path accessible? |
| **Travel between final mobility service stop and final destination** | • Does traveler need directions?<br>• Is the path accessible? |

# VEHICLE AUTOMATION TECHNOLOGIES

- **Automated Vehicles (AVs) -** at least one element of vehicle control (e.g., steering, speed control) occurs without direct driver input
- AVs work by gathering information from suite of **sensors**, which may include:
  - Cameras
  - Radar
  - Light detection and ranging (LiDAR)
  - Ultrasonic
  - Infrared
- **Positioning** systems may include GPS, inertial measurement units, and detailed map data
- AVs may combine these data with other inputs, including **Vehicle-to-Vehicle (V2V) and Vehicle-to-Infrastructure (V2I) inputs**

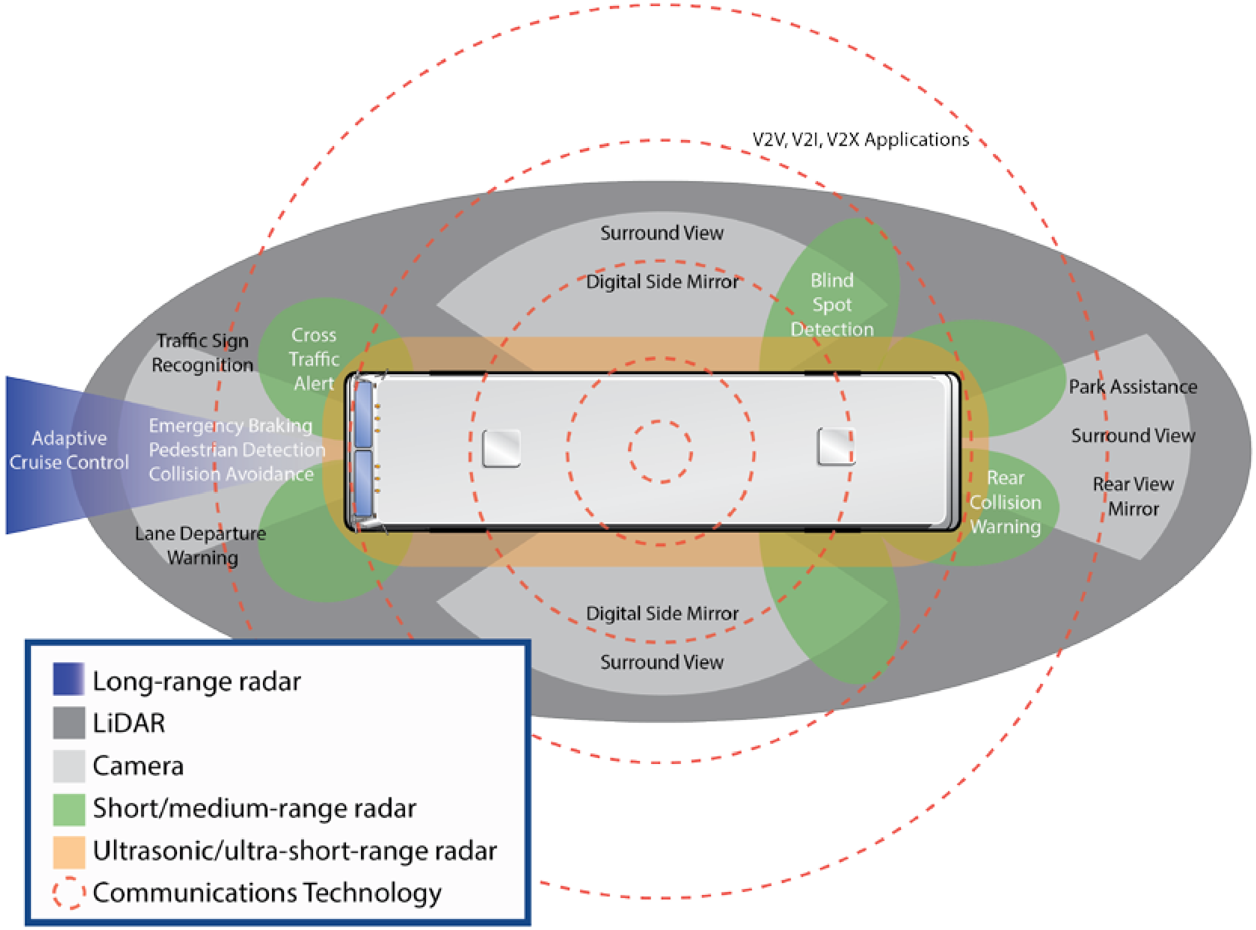



*Image Adapted from the Texas Instruments ADAS Solutions Guide*

# LEVELS OF AUTOMATION ACCORDING TO SAE


| | Level 0 | Level 1 | Level 2 | Level 3 | Level 4 | Level 5 |
|---|---|---|---|---|---|---|
| Driver's role | Performs all tasks | Controls vehicle | Engages in driving and monitoring the environment | Necessary to take control | May have the option to control | May have the option to control |
| Automation features | - | Driver assist features | Some automated functions | Some automation functions and monitoring the environment | Vehicle performs all driving functions under certain conditions | Vehicle performs all driving functions under all conditions |

Mojdeh Azad, Nima Hoseinzadeh, Candace Brakewood, Christopher R. Cherry, and Lee D. Han, "Fully Autonomous Buses: A Literature Review and Future Research Directions," Hindawi Journal of Advanced Transportation, published 10 Dec 2019, Volume 2019, Article ID 4603548, https://doi.org/10.1155/2019/4603548, https://www.hindawi.com/journals/jat/2019/4603548/

# TRANSIT INDUSTRY READINESS FOR AV TECHNOLOGY

N-CATT National Center for Applied Transit Technology

## Unions and Labor

- Will workers (primarily bus operators) be **eliminated?**
- **Concern** regarding timing of implementation, displacement of workers, and need to be actively involved

## **Human drivers/operators** versus trusting in AV technology

## **Operational benefits**

- Can AV transit systems be **more reliable** than human-driven systems?
- Automation **may improve scheduled operations**

## **Management and organization structures** will probably need modification

- Labor force may shift away from being dominated by operators and mechanics
- Organizational models may need new divisions

# SAFETY

advocacy | action | answers on aging

**Few safety and security concerns** among riders or potential riders. Examples:

- Perception of safety positive due to **reduction in distracted driving and bad driving behavior**
- **Less risk of a crash** for autonomous buses compared to conventional buses
- **Greater sense of traffic safety** in driverless shuttle buses compared to conventional buses. However, driverless shuttle buses **worse in terms of in-vehicle security**, probably due to the lack of a driver

Other safety-related studies investigated or evaluated the **impacts of new technologies** on safety, such as collision avoidance technology.

# POLICIES, REGULATIONS AND LEGAL ISSUES

1

**Risk analysis** in autonomous bus systems

2

Discussion about **liability and the lack of a legal framework** are critical issues. Need to develop a **framework with recommendations to address liability issues**

3

Key policy areas for public transportation and shared mobility in an era of automation, such as **accessibility, equity, inclusivity**, safety and public–private integration

n-catt
National Center for Applied Transit Technology

# MARKET ASSESSMENT

### Driver Warnings

Some buses are using **sensor-based, non-automated systems** that provide warnings to drivers, although these are not particularly common.

### Specific Components

No suppliers offer commercialized product for **automating steering or braking** in transit buses, although some of the components needed to support those systems exist

### Small Automated Shuttles

Becoming more widely available for early pilot testing and demonstrations, but they are **not currently produced at scale and don't comply with Federal requirements**

### Bus Automation

Development of automation systems for transit buses has been **gradual**, and such systems are not yet commercially available

### Most Automated Shuttles

Limited to carrying **relatively few occupants and operating at low speeds** (typically between 10 and 15 miles per hour), which may preclude many transit use cases

# US TRANSIT AUTOMATION PROJECTS

| Status | States | Rural? | Location |
|---|---|---|---|
| Planned | AL, CA, CT, FL, GA, IA, IL, MI, MN, NY, NV, OH, TX, VA | Y | • Anniston, AL<br>• Treasure and Yerba Buena Islands, CA<br>• From Iowa City through rural areas and small towns, IA<br>• Huron Transit Corporation, aka Thumb Area Transit, MI |
| In-progress | AZ, CA, CT, FL, IN, MI, NV, OH, RI, SC, TX, UT, WA | Y | • City of Columbus, IN<br>• County of Greenville, SC |
| Completed | CA, CO, IN, MN, ND, NV, OH, OR, WA | Y | • Yolo County Transit District (YCTD), CA<br>• Capital Area Transit, ND |

# PUTTING AVs IN ACTUAL PUBLIC TRANSIT SERVICE

- **Jacksonville Transportation Authority** (JTA) Ultimate Urban Circulator ($U^2C$) Program - Autonomous Avenue Project
- Future Autonomous Bus Urban Level Operation Systems (FABULOS) Project
- Shared Personalised Automated vEhicles (SPACE) Toolkit
- Hamburg Electric Autonomous Transportation (HEAT) Project
- Connecticut DOT (CTDOT) deployment of three 40-foot battery electric buses with key automation features on CTfastrak bus rapid transit corridor between New Britain and Hartford

Presented by Bernard Schmidt, VP of Automation, Jacksonville Transportation Authority, Automated Vehicle Symposium, Breakout 17, July 16, 2019.

**Skyway Modernization Program**

↓

**U$^2$C Program Development**

↓

- **Bay Street Innovation Corridor**
- **Autonomous Avenue**
- **Remaining Skyway Conversion**
- **Neighborhood Extensions**

# GOLDEN 20 – AV REQUIREMENTS

| | |
|---|---|
| 1. Full ADA Compliance | 11. May Operate during Inclement Weather (Rain, Fog, Wind, and Extreme Heat) |
| 2. Buy America/Buy American Compliance | 12. Internal Cab – Environment control with Rapid Cool capability & Sustained temperature with Full Passenger Load |
| 3. Cybersecurity | 13. Ability to be towed; Push/Pull and Steer AV Manually or towed via another AV |
| 4. Remote Route Programming with Low Latency | 14. Crash Worthy up to 35 MPH |
| 5. National Highway Traffic Safety Administration (NHTSA) Approval to operate on Public Road | 15. Ability for Fast Charge/Opportunity Charging |
| 6. Vehicle to Infrastructure and V2X Capabilities (DSRC & 5G) | 16. Ability to regulate passenger capacity |
| 7. Traverse Slope of ± 12 Degrees w/ Full Passenger load (Sustained Acceleration/Deceleration) | 17. System for recording/storing video for at least 30 days (Black Box) |
| 8. Operate bi-directionally up to 35 MPH | 18. Emergency button to contact Authority/Agency control center |
| 9. ≥12 hours of battery life | 19. Remote command & control operations of vehicles with low latency |
| 10. Operate at speeds of 15 MPH within ± 1 foot of Stationary Object and Operate at speeds of 15 MPH within ± 3 feet of Moving Object | 20. Complete Vehicle Monitoring system, including health monitoring |

# FABULOS PILOT LOCATIONS

In Gjesdal, there is a 12% incline due to the mountainous terrain

In Lamia, high temperatures must be successfully managed

In the Netherlands, the large number of cyclists must be taken into consideration

In Helsinki, the route passes the second busiest train station in the country

In Tallinn, the connection to the airport will be improved, leading to challenges with factors such as existing bus traffic

# FUTURE AUTONOMOUS BUS URBAN LEVEL OPERATION SYSTEMS (FABULOS)

# SPACE TOOLKIT

The SPACE toolkit consists of everything you need to know about shared automated vehicles (AVs). It can serve cities, operators, the industry and planners by providing a guidance on how to integrate AVs with public transport.
https://space.uitp.org/toolkit

## Chapter 1

Practical scenarios and how to get there

## Chapter 2

Integration of automated vehicles in public transport

## Chapter 3

Impact assessment

# HAMBURG ELECTRIC AUTONOMOUS TRANSPORTATION (HEAT)

# HEAT (Cont'd)

- Decentral infrastructure: Sensors and digital communication systems on the road (including high precision maps)
- Permanent supervising control center at HOCHBAHN
- Vehicle:
    - 8 sitting passengers plus wheelchair (or 2 additional seats)
    - 10 m turning radius
    - 2.88 t total weight
    - 4 t gross load weight
    - Equipped with 5 radar and 8 lidar

n-catt National Center for Applied Transit Technology

# CTDOT AUTOMATED BUSES

# CTDOT AUTOMATED BUSES

- **First automated heavy-duty buses** in revenue service in North America
- Project set to **go live in approximately a year**
- Includes deployment of **three battery-electric 40-foot New Flyer Xcelsior CHARGE™ vehicles**. CTDOT scheduled to take delivery of first vehicle in December 2020.
- Will operate on CTfastrak bus rapid transit (BRT) guideway — **9.4-mile dedicated BRT route** connecting downtown Hartford and downtown New Britain
- New Flyer will **integrate Robotic Research LLC's proprietary AutoDrive® automated driving technology** into new buses
- Demonstrating SAE **Level 4 automation**

# RESOURCES

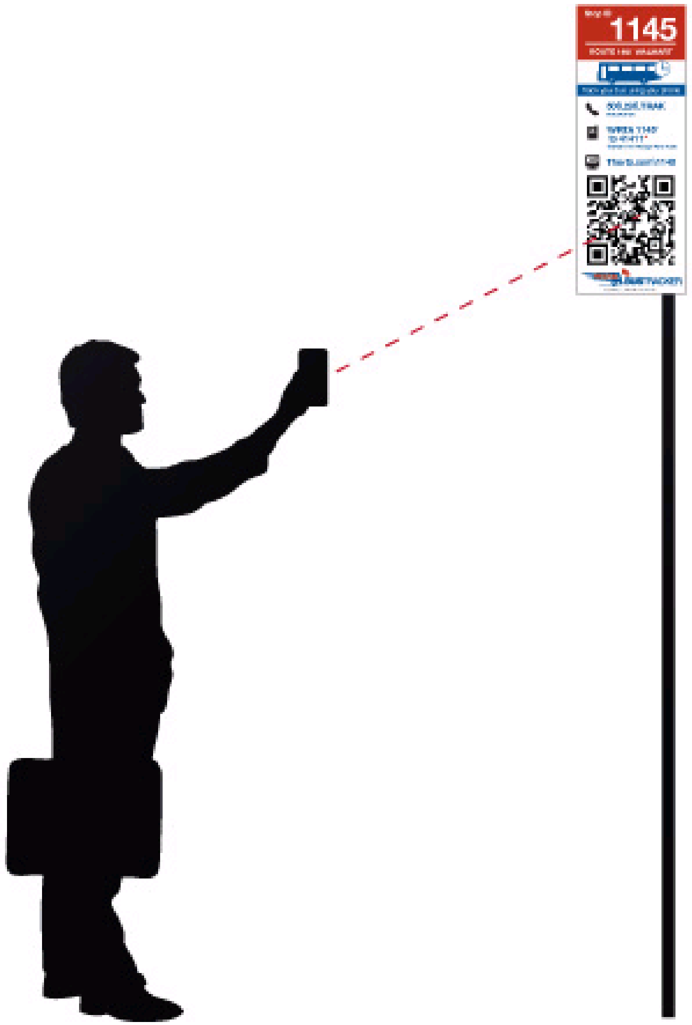

- Elizabeth Machek, Eric Burkman, Travis Crayton, Joshua Cregger, Danyell Diggs, Stephanie Fischer, Steven Mortensen, Sean Peirce, Heather Richardson, Anthony Thomas, Gwo-Wei Torng and Vincent Valdes, ***Strategic Transit Automation Research Plan***, prepared for the Federal Transit Administration, FTA Report No. 0116, January 2018, https://www.transit.dot.gov/sites/fta.dot.gov/files/docs/research-innovation/114661/strategic-transit-automation-research-report-no-0116_0.pdf
- "Transit Bus Automation Overview Factsheet," February 2018, https://www.transit.dot.gov/sites/fta.dot.gov/files/docs/research-innovation/114726/bus-transit-automation-overview-factsheet_1.pdf
- "Challenges of Transferring Automation Technologies from Light-Duty Vehicles and Commercial Trucks to Transit Buses Factsheet," October 2018, https://www.transit.dot.gov/sites/fta.dot.gov/files/docs/research-innovation/118906/transferability-factsheet_1.pdf
- Transit Bus Automation Risks, Barriers, & Mitigations Factsheet, February 2019, https://www.transit.dot.gov/sites/fta.dot.gov/files/docs/research-innovation/130786/transit-bus-automation-risks-barriers-mitigations-factsheet-07242019.pdf

# RESOURCES (CONT'D)


- Bill Bortzfield, "JTA Tests First ADA Accessible Autonomous Transit Vehicle in the US," WJCT-FM 89.9, October 31, 2019, https://news.wjct.org/post/jta-tests-first-ada-accessible-autonomous-transit-vehicle-us
- "Understanding the Business Case for Automated Bus Technologies," October 21, 2019, https://www.volpe.dot.gov/news/understanding-business-case-automated-bus-technologies
- Thomas Walbrun, "Demand-responsive transportation with autonomous shuttles," 26th ITS World Congress, Singapore, 21-25 October 2019, Paper ID AP-CP1813
- Timo Woopen, „Addressing Equity, Accessibility, Inclusivity and Acceptance in the Development of new Architectures for Automated Vehicles in UNICARagil," presentation at Automated Vehicle Symposium 2019, Breakout Session 17, June 16, 2019, Orlando, FL
- Douglas Gettman, Ph.D., J. Sam Lott and Tom Harrington, "Working Paper #1: Automated Vehicle Technology Deployment Scenarios for Public Transit," National Highway Cooperative Research Program (NCHRP), Project 20-102 (02): Impacts of Laws and Regulations on Automation Technology for Transit, June 2016, Revised March 2017, http://onlinepubs.trb.org/onlinepubs/nchrp/docs/NCHRP20-102(02)_WP1_AV_Transit_Deployment_Scenarios.pdf

# THANK YOU!

**Carol Schweiger**
**President**
**Schweiger Consulting LLC**
**781-424-2208**
**carol@tech4transit.com**



# Transit Innovation in Michigan

# MDOT Supporting and Encouraging Transit Innovation

- Sharing risk – funding projects
- Providing technical support
- Facilitating partnerships
- Gathering and sharing lessons learned
- Clearing policy and regulatory roadblocks

# Recent Projects

- $8 Million Michigan Mobility Challenge
- NAIAS 2020 Mobility Challenge
- Automated Bus Consortium
- Statewide MaaS
- Michigan Connected Corridor

eight million dollar

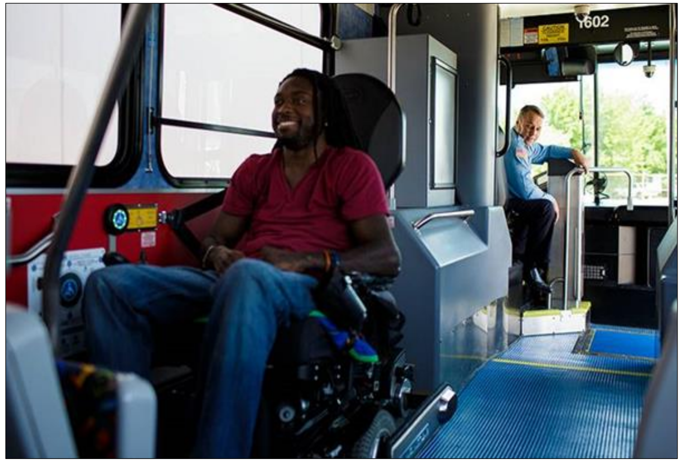
# Michigan Mobility Challenge

**Goal:** Use technology to solve mobility gaps for seniors, persons with disabilities and veterans

**Launch event:** Daylong workshop to bring together transportation providers, technology companies, advocates for target populations

Received over 40 proposals

Thirteen projects selected – awards ranged from $100,000 to $2.1 million




NEW HOUSING
ARCADIA FLATS
COMPLETED 2020
BRONCOS ARE STRONG
PRATT MILLER

# More information

www.Michigan.gov/mobilitychallenge


NAIAS 2020 MICHIGAN MOBILITY CHALLENGE

## Purpose

Provide and demonstrate INNOVATIVE SOLUTIONS and CUTTING-EDGE TECHNOLOGIES that showcase AV technology capabilities

## Need

Further solidify NAIAS and Motor City as the PREEMINENT ENVIRONMENT for new transportation solutions

Showcase technology that embodies how AV TECHNOLOGY TRANSFORMS how we live, work and play


AIRPORT SHUTTLE

# The Challenge

Provide AV services for select media between DTW and Downtown

## TECHNOLOGY

- Minimum Level 3 AV services
- Safety driver/liaison required in vehicle

## RIDERS

NAIAS media attendees and VIPs

## OPERATIONAL DATES

NAIAS Media/Press Preview

## FEATURES

In-vehicle experience


DOWNTOW
N DETROIT
CIRCULATOR

# The Challenge

Provide AV services for NAIAS attendees within predefined boundaries

## TECHNOLOGY

- SAE Level 3+ AV services
- Safety driver/liaison required in vehicle

## RIDERS

Public/NAIAS attendees

## FEATURES

In-vehicle experience

## OPERATIONAL DATES

Preview and Public Days (2 weeks)

## SERVICE OPTIONS

- Multiple providers and vehicles
- Fixed-route (4)
- On demand (1)

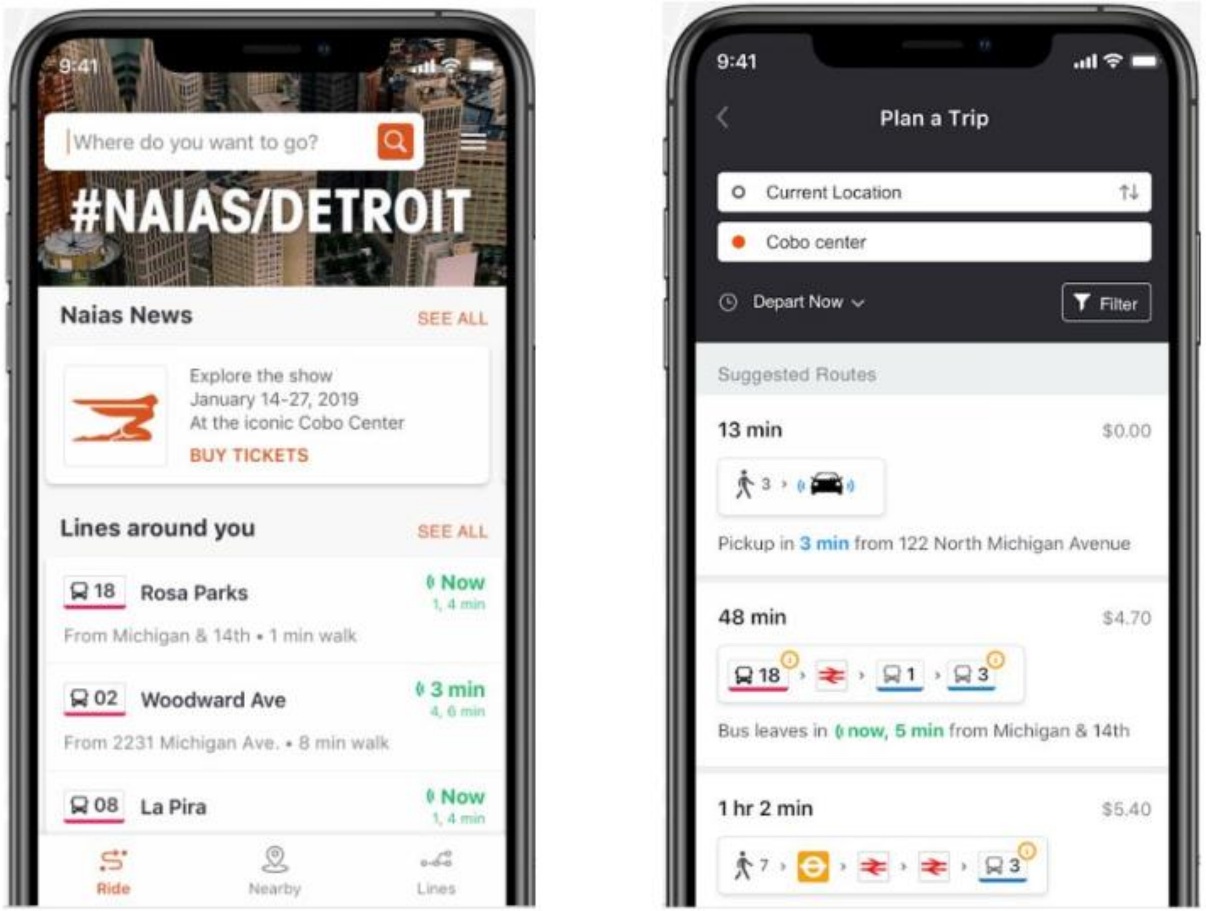
TEAMING PARTNER

## PROPOSAL

- Provide an integrated, seamless user experience
- Custom NAIAS 2020 Michigan Mobility Challenge App
- Integrates AV Mobility Solutions with existing mobility options (i.e. transit, Uber, scooters)

## FUNCTIONALITY

- Allow users to schedule AV rides
- Displays vehicle location, time to pickup, trip duration, etc.
- Links with NAIAS Application and existing mobility options



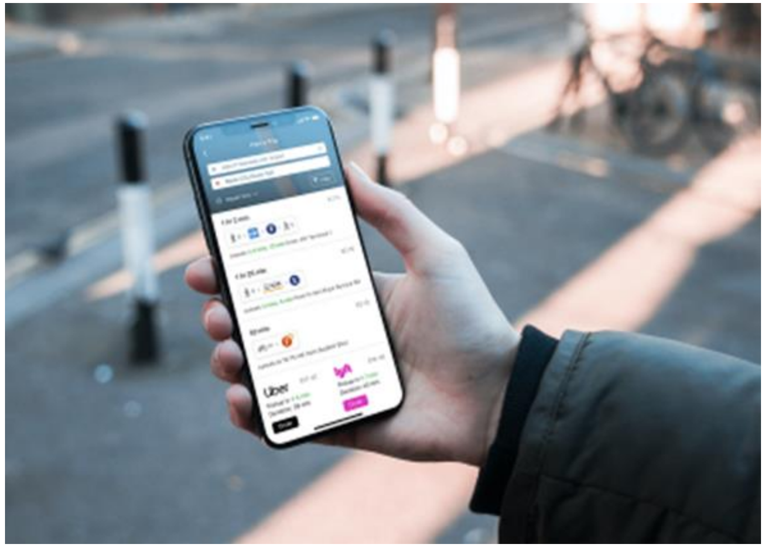

**Sample MaaS app User Interface for June 2020 NAIAS event**

ABC Automated Bus Consortium
ACCELERATED BY AECOM

Partnership of 13 state DOTs and transit agencies to develop and test full-size, full-speed, accessible automated buses

www.automatedbusconsortium.com

# Statewide MaaS



MDOT is exploring a statewide MaaS project that would enable people anywhere in the state to connect with available transit options in their area. Additional features, such as mobile trip planning, reservations and fare payment, could be added in various regions.

# Michigan Connected Corridor

# •Notice

•**It is important to note** that this presentation and the information contained, referred to, referenced, or linked to herein (collectively this "Presentation") is intended for informational and discussion purposes only and is not, and may not be relied on in any manner as, legal, tax, investment, or accounting advice or as an offer to sell or a solicitation of an offer to buy any securities or equity interests or other interests in Sidewalk Infrastructure Partners, LLC, SIP OperationsCo, LP, SIP ManagementCo, LLC or any affiliates thereof or any other company, fund, or vehicle sponsored thereby (collectively "SIP"). The information in this Presentation should not be relied upon as a representation or warranty, and no liability shall attach to any person or entity as a result of such information. Nothing in this Presentation constitutes advice relating to legal, taxation, accounting, regulatory, or investment matters, and recipients of this Presentation are advised to consult their own professional advisors.

•**SIP does not make any representation or warranty**, express or implied, as to the accuracy or completeness of the information contained herein and nothing contained herein should be relied upon as a promise or representation as to past or future performance of SIP or any other entity. This Presentation contains a highly abbreviated summary of certain key terms, and the information set forth herein does not purport to be complete. Recipients of this Presentation agree that neither SIP nor any of its directors, committee members, officers, employees, members, partners, advisors, consultants, third-party contractors, lenders, representatives, or agents (collectively "SIP Persons") shall have any liability for any misstatement or omission of fact or any opinion expressed herein.

•**This Presentation must be kept strictly confidential** and may not be reproduced or redistributed, in whole or in part, in any format without the prior express written approval of SIP. Statements in this Presentation are as of the date of this presentation unless stated otherwise, and the delivery of this Presentation shall not under any circumstances create an implication that the information contained herein is correct as of any time after such date. The information provided herein will not be updated or otherwise revised to reflect information that subsequently becomes available, or circumstances existing or changes occurring after the date of the information set forth herein. Each recipient agrees that it will (i) not copy, reproduce, or distribute this Presentation, in whole or in part, to any person or party without the prior written consent of SIP and will keep this Presentation strictly confidential and (ii) use this Presentation solely for its intended purpose of facilitating evaluation of one or more negotiated transactions involving the parties as described herein.

•**The distribution of this Presentation may be restricted by law** in certain jurisdictions. This Presentation is only directed at persons to whom it may lawfully be distributed.

•**This Presentation may contain material non-public information** about certain companies with publicly traded equity or debt securities, some of which information has not been made available to the investing public. Accordingly, by accessing, or receiving a copy of, any such information, recipients acknowledge the foregoing and agree not to trade, or recommend that others trade, in the securities of any company described herein on the basis of the information herein and further agree not to pass along any of such information to others.

•**This Presentation may contain forward-looking statements**, and statements herein (including those relating to current and future market conditions and trends in respect thereof) that are not historical facts are based on current expectations, estimates, projections, opinions and/or beliefs of SIP. Such statements involve known and unknown risks, uncertainties and other factors, and undue reliance should not be placed thereon. In addition, no representation or warranty is made with respect to the reasonableness of any projections, estimates, forecasts, illustrations, prospects, or returns, which should be regarded as illustrative only, or that any profits will be realized. Certain information contained in this Presentation constitutes "forward-looking statements," which can be identified by the use of forward-looking terminology such as "may," "will," "should," "expect," "anticipate," "target," "project," "estimate," "intend," "continue," or "believe," or the negatives thereof or other variations thereof or comparable terminology. Furthermore, any projections, forecasts, and targets in this Presentation, including estimates of returns or performance, are "forward-looking statements" and are based upon certain assumptions that may change. Any projections, forecasts, and targets set forth herein have been prepared and are set out for illustrative purposes only, and no assurances can be made that they will materialize. Any assumptions should not be construed to be indicative of the actual events that will occur. Actual events are difficult to predict and may depend upon factors that are beyond the control of SIP and any relevant third parties. Certain assumptions have been made to simplify the Presentation, and accordingly actual results may differ, perhaps materially, from those presented. Any changes in the applicability of assumptions may have a material effect on actual results and the performance of SIP and hence any projections, forecasts, and targets. Actual results could be materially worse than any projections, forecasts, and targets presented herein. Due to various risks and uncertainties, actual events or results or the actual performance of SIP may differ materially from those reflected or contemplated in such forward-looking statements.

•**Target or estimated returns may not be achieved and are not guaranteed**, and any target returns referenced in this Presentation may not take into account of all relevant factors, including fees, carried interest, expenses, financing costs, transaction costs, or taxes. While SIP believes that the assumptions that underlie the target returns are reasonable, there can be no assurance that SIP or any other entity will achieve its objectives or its target returns. Any target returns will be subject to a number of risks. The target returns (including any data related thereto) contained herein are based upon subjective estimates and assumptions about circumstances and events that have not have occurred yet and may never occur. If any of the assumptions used do not prove to be accurate, results may vary substantially from the target returns set forth herein. Actual individual investments may have different degrees of associated risk. The performance of each investment may vary substantially over time and may not achieve the target returns set forth herein, which may have a material effect on overall portfolio performance over time. Actual returns will be affected by numerous factors, including, but not limited to, infrastructure asset values, cash flow from operations, and other changes related to economic, political or financial developments and may also depend on exchange rates and local tax laws. The target returns are subject to change at any time and are current as of the date hereof only. Target returns are being shown for information purposes only and should not be relied upon to make predictions of actual performance. The target returns are not a guarantee, forecast or prediction of performance. The target returns are included in this Presentation to establish a benchmark for future evaluation of performance, to assist in assessing the anticipated risk and reward, and to facilitate comparisons with other investments. Recipients of this Presentation are encouraged to contact representatives of SIP to discuss the procedures and methodologies (including assumptions) used to determine the target returns set forth herein.

•**Certain information contained herein comes from published sources and third parties**, and while such information is believed to be reliable for the purpose used herein, neither SIP nor any SIP Person has independently verified or assumes any responsibility for the accuracy of such information. Information contained herein relating to market trends has been determined by SIP based on external sources referenced herein. Although SIP believes that such determinations are reasonable, they are inherently subjective in nature. Other market participants may make different determinations relating to sector characterization and size based on the same underlying data. Any information relating to market trends presented herein is for illustrative purposes only and is not necessarily indicative of future results. Certain information contained in this Presentation has been obtained from published and non-published sources prepared by other parties, which in certain cases, have not been updated through the date hereof. The information provided in this Presentation will not be updated or otherwise revised to reflect information that subsequently becomes available, or circumstances existing or changes occurring after the date hereof.

•**None of the information contained herein has been filed** with the U.S. Securities and Exchange Commission, any securities administrator under any securities laws of any U.S. or non-U.S. jurisdiction or any other U.S. or non-U.S. governmental or self- regulatory authority. No such governmental or self-regulatory authority has passed or will pass on the merits of any investment or other transaction described herein or the adequacy of the information contained herein. Any representation to the contrary is unlawful.

•**The proposed terms summarized in this Presentation are preliminary, high-level, non-binding, and for discussion purposes only.** The terms summarized herein (the "Terms") relating to one or more potential negotiated transactions involving the parties or their affiliates as described herein (collectively the "Transaction") are intended as a preliminary summary and do not give rise to any legally binding obligations on the part of any party to these discussions or their affiliates, and accordingly none of the parties or their respective affiliates shall be subject to any obligation or liability with respect to any Transaction as a result of this Presentation. The Terms do not reference all of the terms, conditions (including internal approvals), representations, warranties, covenants, and other provisions that would be contained in definitive, binding, written agreements executed and delivered with respect to any Transaction ("Definitive Agreements"). The Terms are non-binding, and none of the parties to the discussions or their affiliates will be legally bound with respect to any Transaction unless and until the parties have executed and delivered Definitive Agreements in respect of any such Transaction. Nothing contained in this Presentation or the Terms constitutes an offer or commitment to engage in any Transaction, and no obligations of one party to any other (including any obligation to continue negotiations or conduct due diligence or discuss Definitive Agreements) will arise from this Presentation or the Terms. No party is relying or will be entitled to rely on the Terms, and no party will have any duty to negotiate in good faith. Either party may discontinue discussions or negotiations at any time and for any reason, without any liability. The recipient of this Presentation agrees to keep strictly confidential, and to not disclose, the Terms or the fact or status of the discussions or negotiations of the parties with respect to any Transaction.

•**The information referred to in or discussed in connection therewith** are to be treated as strictly confidential and privileged and considered exempt from any federal, state, local, or other public disclosure, freedom of information, or similar statutes or rules. The Materials constitute commercial or financial information and contain competitively sensitive or proprietary information or trade secrets, including certain research data on road and attendant infrastructure and related information about software or hardware used or created for such purposes. The Presentation is preliminary and in draft form, provided for discussion and negotiation purposes only, and are not final and do not constitute a proposal. Disclosure of the Presentation would cause substantial competitive harm to us and impair the government's ability to obtain necessary information and could risk the safety or security of the persons or property, including by providing information that could increase the potential of a cybersecurity incident. The Presentation accordingly may not be reproduced, redistributed, or disclosed, in whole or in part, without our express written approval, and, if recipient believes that any disclosure is legally required, recipient agrees to first notify us and cooperate with us and to limit disclosure to that which is legally required to be disclosed.

# SIP launched Cavnue to build the future of roads

# Initial Project Partners

SIP SIDEWALK INFRASTRUCTURE PARTNERS

cavnue

Ford

UNIVERSITY OF MICHIGAN

American Center for Mobility
CONNECTED. AUTOMATED. VALIDATED.

wsp

MILLER CANFIELD

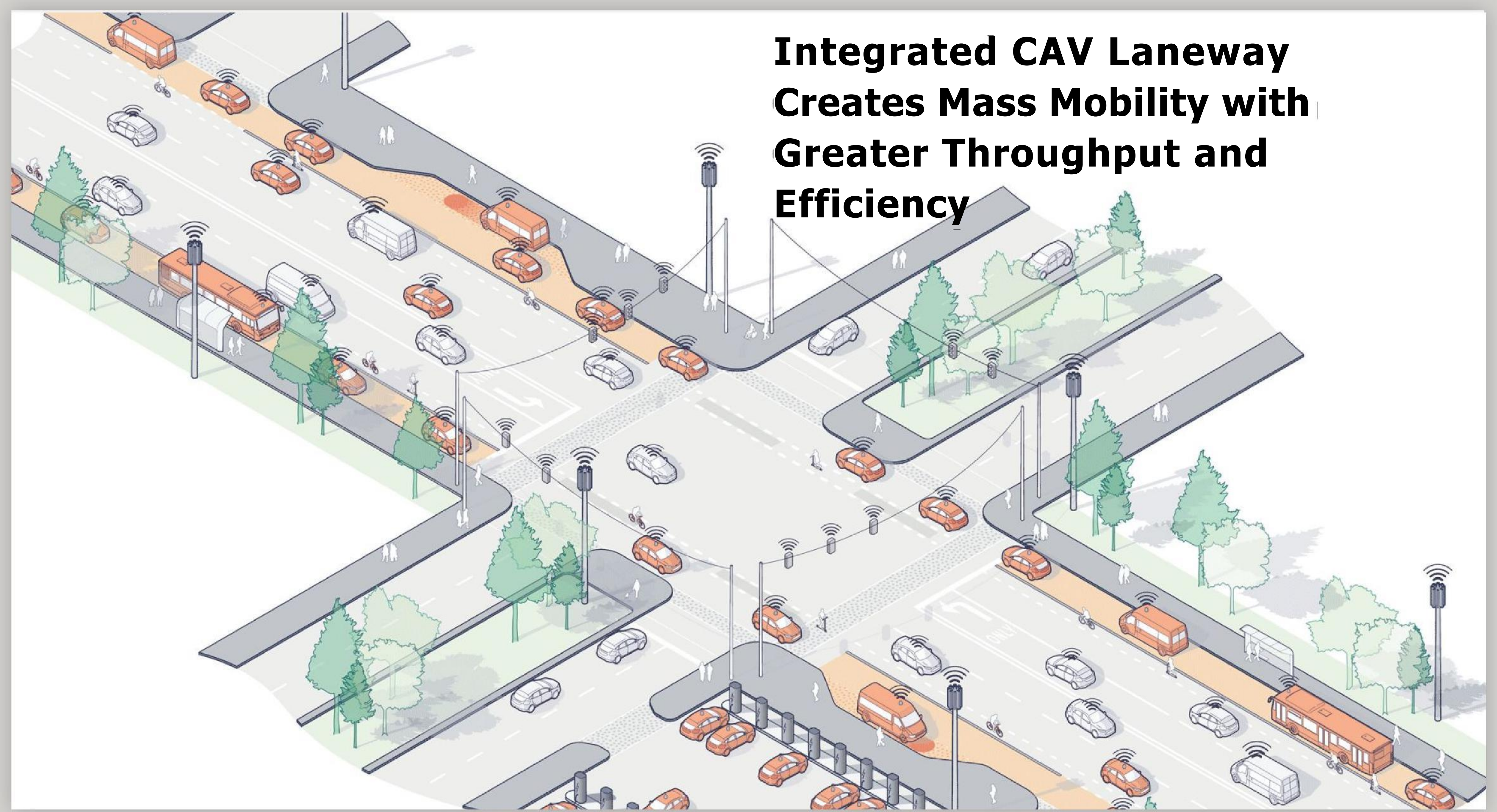
LATHAM & WATKINS LLP

1/3 middle third

# Corridor Vision

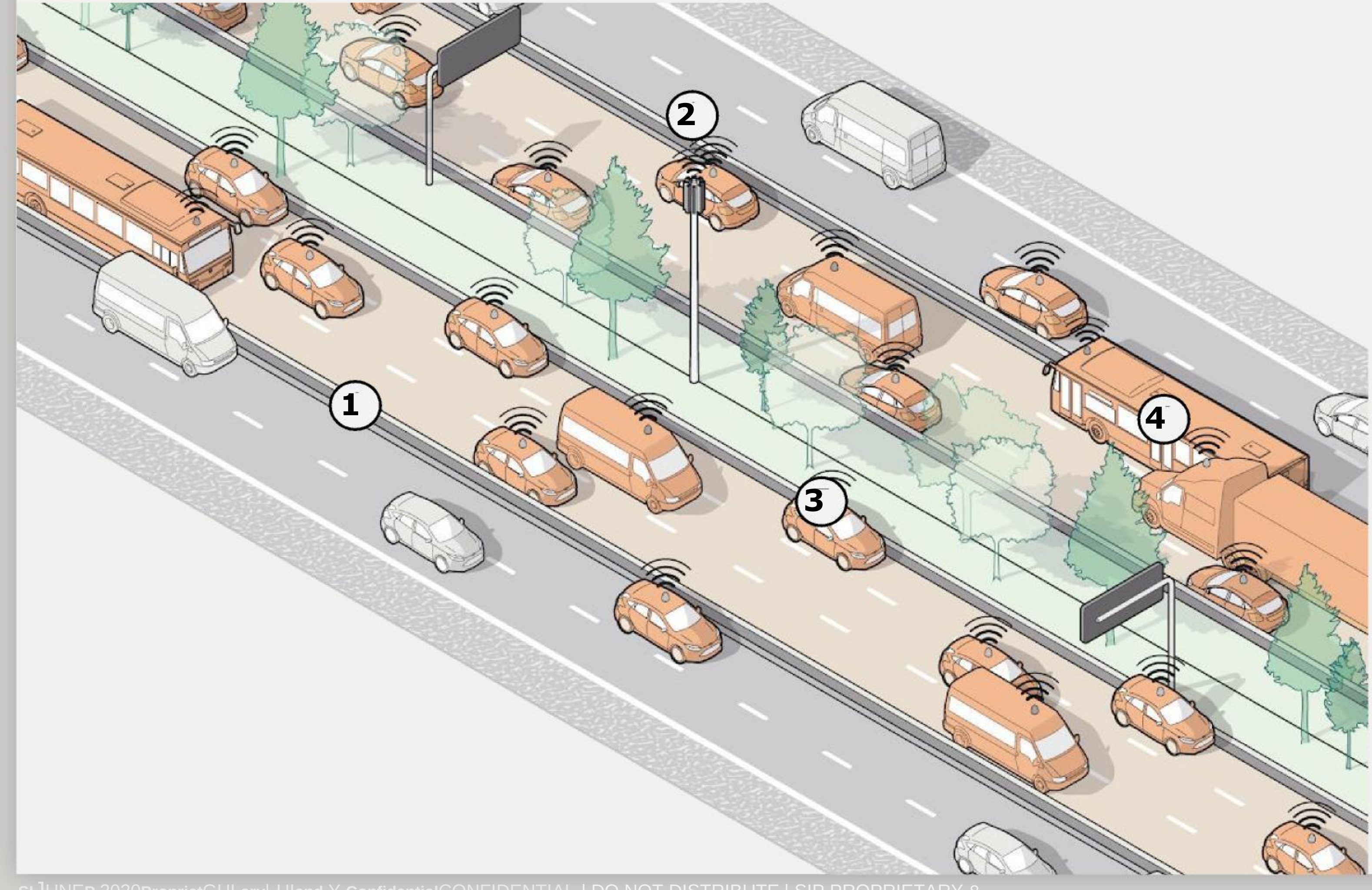
| Key Benefit | Description |
|---|---|
| **First-of-its-kind dedicated AV corridor** | Transformative project provides infrastructure to accelerate AVs drawing on resources of Detroit and Michigan |
| **Privately funded** | SIP and Cavnue provide upfront capital for infrastructure build-out |
| **Not competing with rail transit projects for passengers or financial resources** | Aligned with regional transit planning to deliver affordable, accessible transit |
| **Opportunity for innovation with OEMs and technology partners** | Leading technology companies and OEMs deliver vehicles, digital, physical, and coordination technology |
| **Mobility, transit access, and economic development** | Broaden access to shared and personal mobility for entire community with priority for fairness and equity, while spurring economic development by connecting to key anchors |

# Integrated CAV Laneway Creates Mass Mobility with Greater Throughput and Efficiency



# Anatomy of a CAV Laneway

The core infrastructure technology stack for a connected AV laneway consists of four broad buckets: physical, digital, coordination, and operational.




## 1 Physical Infrastructure

1 Well-maintained roadways

1 Separation barriers to ensure efficiency and safety

1 Enhanced, machine-readable markings, digital signage and signalling

1 Enhanced maintenance to maximize pavement life, including levels of prediction and automation

## 2 Digital Infrastructure

1 Ubiquitous, highly reliable connectivity 1 High-definition (HD) maps

1 High accuracy ground-based GPS

1 Road sensors for traffic, weather, road conditions

## 3 Coordination Infrastructure

1 System to manage vehicle coordination and interoperability

1 Ability for transportation authorities to set policy goals to maximize mobility and accessibility, and track their impact

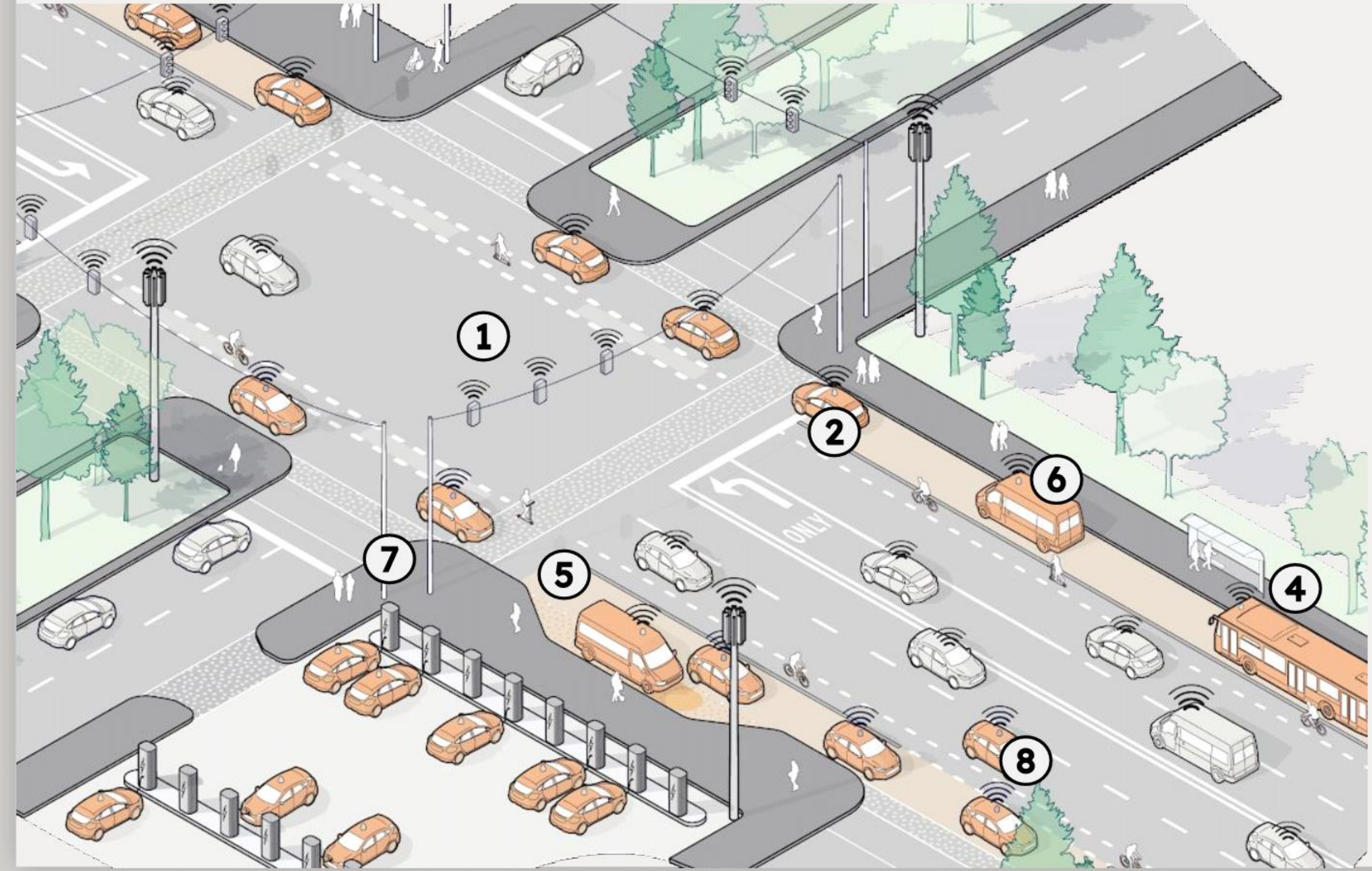
## 4 Operational Infrastructure

1 Modified or purpose-designed connected autonomous buses or shared mobility vehicles to greatly enhance the performance and passenger experience

1 Smart curbs, chargers and other supporting infrastructure

# Integrated Infrastructure Technology Framework for CAV Corridors

The infrastructure technology stack serves as part of a broader transit and mobility ecosystem.




① **Physical Infrastructure** (Cont'd)

- ↳ Adaptive traffic signals with intersection priority, particularly for transit and emergency services
- ↳ Intersection designs optimized for pedestrian safety

④ **Public Transit**

- ↳ Buses operating autonomously on loops
- ↳ Frequent stops using smart curbs and/or bus stops (see #5)

⑤ **Smart Curbs / Stops**

- ↳ Smart curbs at milestones able to identify available time/space reservations
- ↳ Consoles at smart curb locations for mobility functions
- ↳ Dynamic, digital signage

⑥ **Ride Sharing**

- ↳ Passenger app integration with superior booking and boarding experience

⑦ **Support**

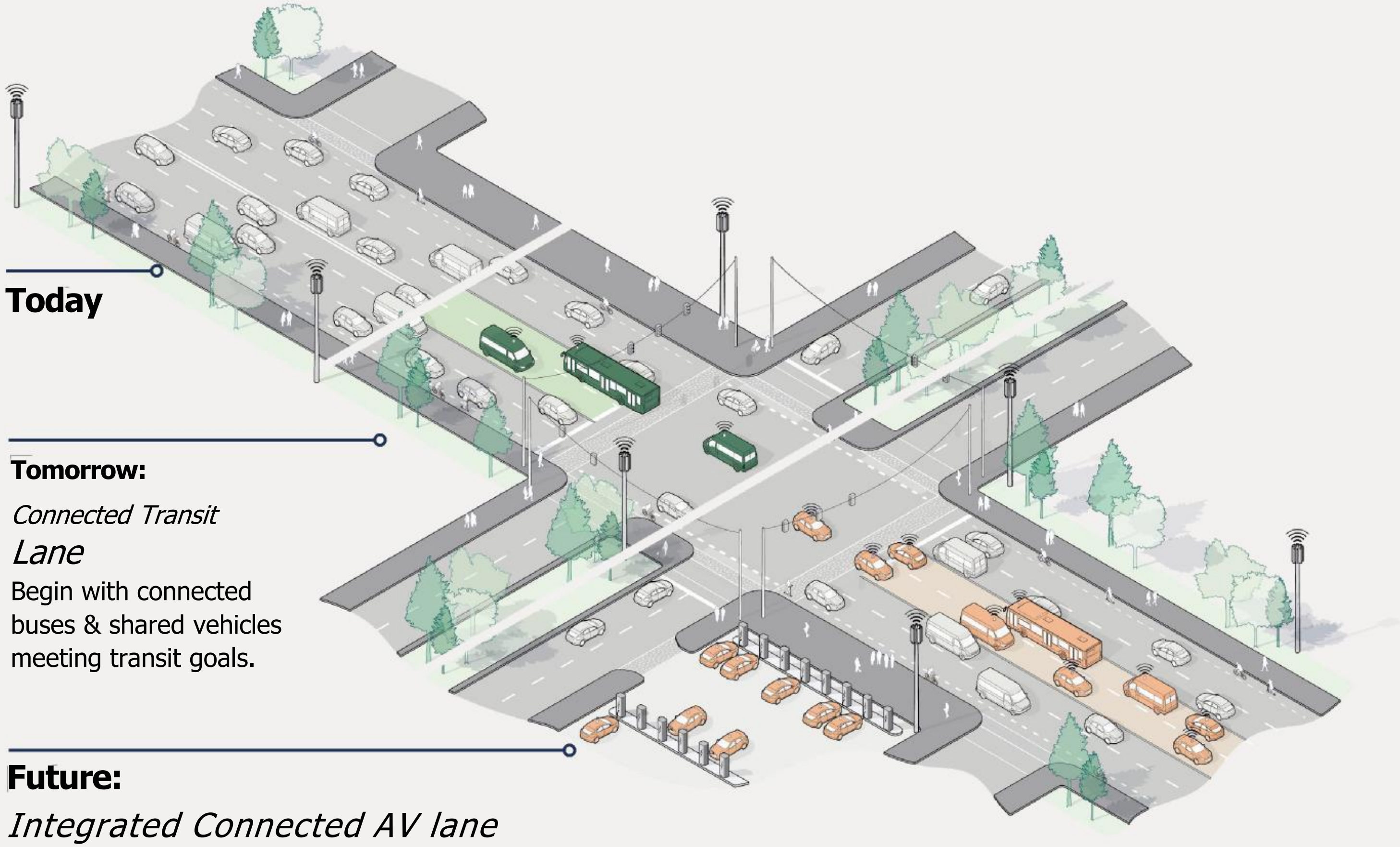
- ↳ High speed EV chargers
- ↳ High speed wireless or tether vehicle data download
- ↳ Maintenance and cleaning

⑧ **Compatible CAVs**

- ↳ Vehicles with certified AV / ADAS systems
- ↳ Ability to share information with other vehicles and infrastructure for navigation and safety

# Dedicated Laneway Can be "Future Proofed" and Evolve to Meet Transit-Oriented Goals

**TRANSITION TO CAV LANEWAY**



**Today**

**Tomorrow:**

*Connected Transit Lane*

Begin with connected buses & shared vehicles meeting transit goals.

**Future:**

*Integrated Connected AV lane*

Upgrade autonomy & expand to additional CAVs over time.

# OTHER INNOVATIVE PROJECTS

## FY20 Low/No Emissions Program Grant

**Overview:** MDOT received a $6.4 million grant to purchase electric buses and build charging infrastructure for six transit agencies around the state

**Partners**: MDOT, Benzie Transportation Authority, Clare County Transit Corporation, Capital Area Transportation Authority, Delta Area Transit Authority, Huron Transit Corporation, Macatawa Area Express, CALSTART

## WSP Technology Partnership

**Overview:** Recommend new technology for a rural and an urban system; evaluate effectiveness

**Pilots:** Bay Area Transportation Authority (BATA; Traverse City) – Vehicle Crash Avoidance; Suburban Mobility Authority for Regional Transportation (SMART; southeast Michigan) – Transit-Pedestrian Detection System

## Comprehensive Healthcare Access with Rural Transit Solutions (CHARTS)

**Overview:** MDOT and BATA will develop and demonstrate a mobility-on-demand service to meet NEMT needs of rural residents in conjunction with a larger sandbox demonstration of on-demand microtransit in Traverse City.

**Funding**: Recipient of FTA Integrated Mobility Innovation Demonstration Program grant

# Lessons learned

- Allow enough time to fully develop partnerships and projects
- Select meaningful metrics
- Monitor milestones
- Constant evaluation – change course if needed
- Public outreach/marketing

# Questions?

**Jean Ruestman**
Administrator
Office of Passenger Transportation
Michigan Department of Transportation
ruestmanj@michigan.gov
517-335-1706

# Autonomous Shuttle Demonstration Program

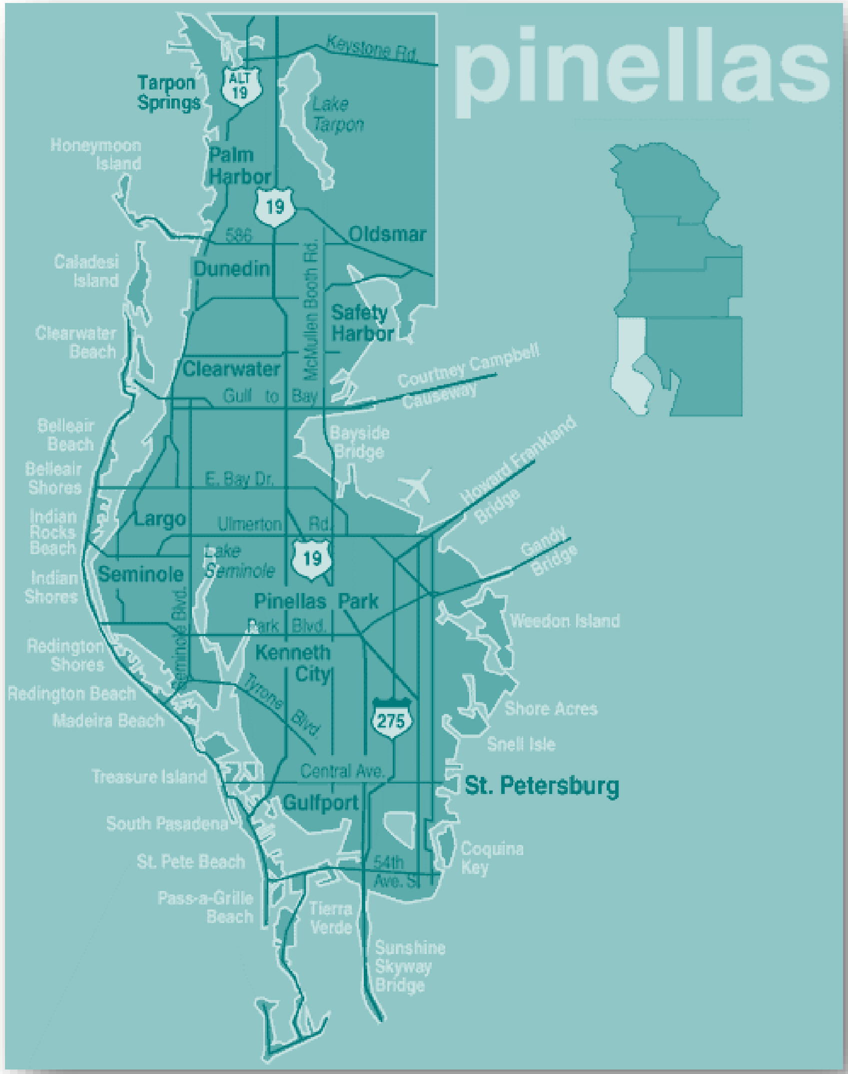
9/16/2020

Jacob Labutka

Project Planner

Pinellas Suncoast Transit Authority (PSTA)
St. Petersburg, Florida

# PSTA – Pinellas County

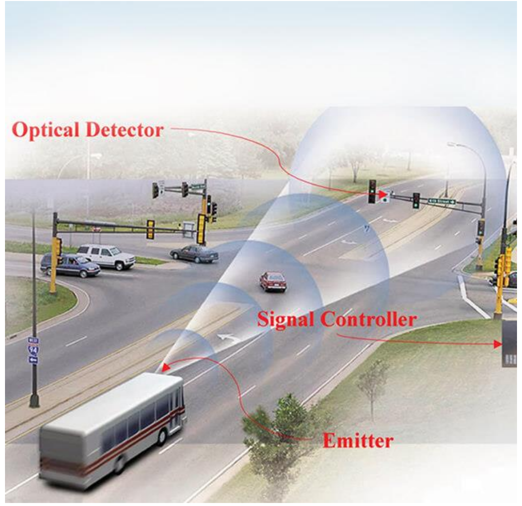



- Population of 970,637
- Median age of 48
- 24 municipalities – 22 served by PSTA
- Health, manufacturing, and financial services
- Significant tourism industry
- 44 bus routes
- 12+ million trips annually

CUSTOMER CUSTOMER FINANCIALLY SUSTAINABLE CAPITAL SERVICE VISIONARY VISIONARY

# PSTA Transportation Innovation

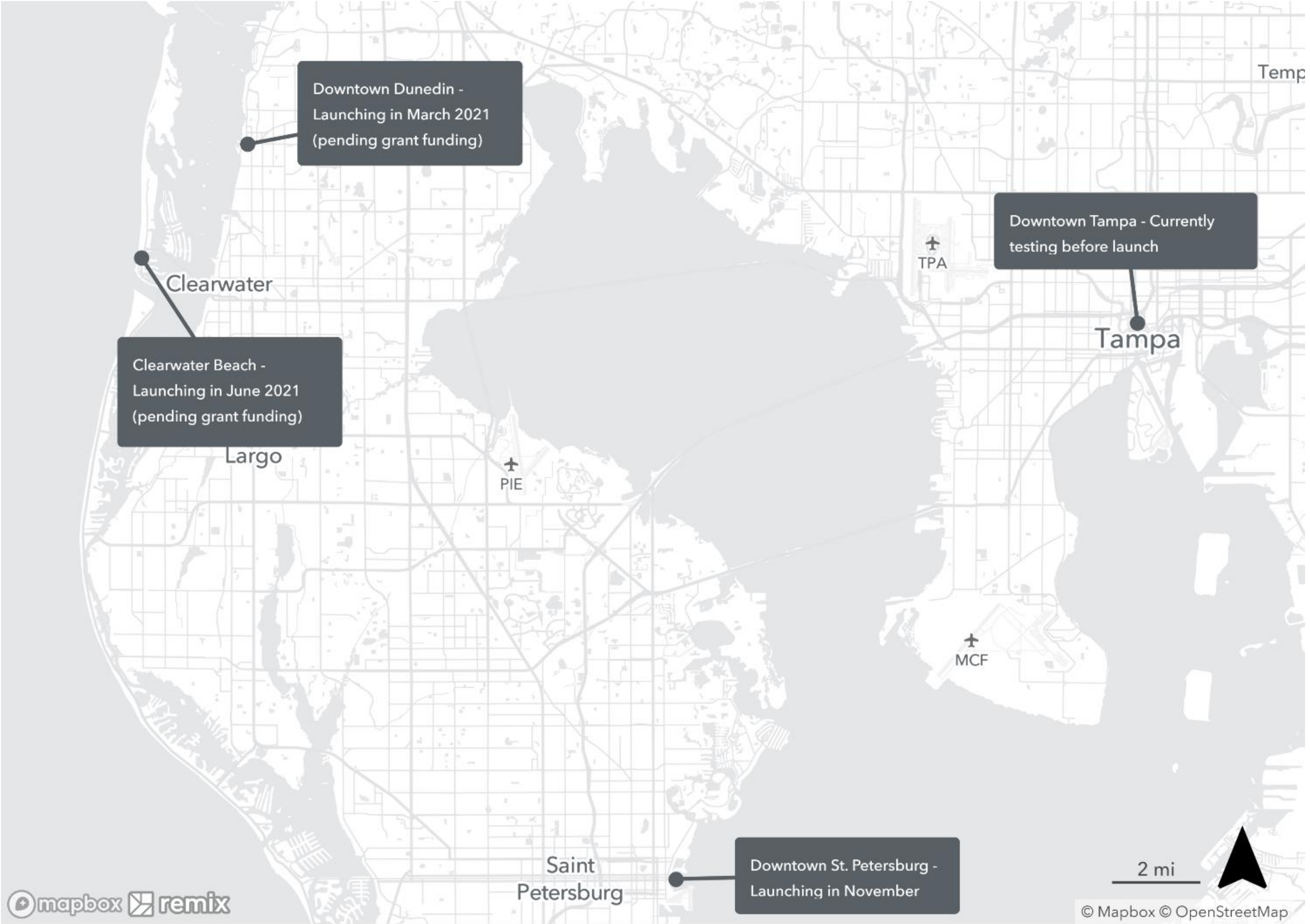
- PSTA is incorporating transportation technologies that are:
  - <u>A</u>utonomous
  - <u>C</u>onnected
  - <u>E</u>lectric
  - <u>S</u>hared
- PSTA is a nationally recognized leader in innovation





# AV Demonstration Purpose & Area Deployments

- Introduce AV technology to service area
- Educate community on driverless shuttles
- Economic development
- Inform future deployments of AV technology



# About Beep & NAVYA shuttle

Beep, an autonomous shuttle service provider based out Orlando, will operate two NAVYA shuttles at the direction of PSTA.

**Drive System**

- Motor: Electric
- Operating speed: up to 15 mph

**Energy**

- Operating time: up to 7 hours
- Charge duration up to 90%: 3-4 hours

**Sensors**

- Light Detection & Ranging (LiDAR): 8
- Cameras: 2
- Dedicated GPS Base
- Safety sensors designed to avoid collision

# Operational Details – St. Petersburg Demo

- 2 shuttles will be used with 1 attendant for customer safety and feedback per shuttle
- Shuttles serve destinations such as a hotel, art museum, restaurants, and a recently opened Pier District
- Service connects to transit services such as a seasonal ferry and local bus routes
- Fare-free service
- Project is funded through a FDOT Commuter Assistance Program (CAP) grant with matching funds from PSTA and in-kind contributions from the City
- Route has been approved by the National Highway Traffic Safety Administration (NHTSA)

# COVID-19 Precautions

- Increased cleaning and sanitizing of vehicles
- Maximum vehicle capacity reduced from 10 to 6 and designated seating arrangements
- Requiring face masks for attendants and riders
- In compliance with CDC guidelines and City requirements


# Steps Prior to NHTSA Application

1. Identify AV Shuttle Owner/Operator
2. Identify Road for deployment
   a. Low speed
   b. High visibility/Concentration of destinations within walkable area
   c. Few traffic controls
   d. Short distance
   e. On-road space for stop docking
   f. Adequate space for shuttle turning radius
3. Complete Preliminary Corridor 3D Mapping
4. Determine Operations Plan (e.g. span of service, frequency, stop locations)
5. Determine Number of Shuttles required to operate the service
6. Identify Possible Secure Storage Locations for Shuttles with access to electricity
7. Identify Secure Rooftop for GNSS (Global Navigation Satellite System) Installation
8. Operator submits NHTSA waiver


CUSTOMER CUSTOMER ...ANCE FINANCIALLY SUSTAINABLE CAPITAL SERVICE EXPA... VISIONARY VISIONARY

# Steps Following NHTSA Approval

1. Finalization of stop locations and improvements to stops:
   a. ADA accessibility
   b. Sidewalk connections
   c. Signage
2. Landscape adaptation to operate with LiDAR (Light Detection and Ranging)
3. Install 240V chargers in storage facility
4. Freight shuttles to project location
5. Conduct training with EMS on shuttle specs and operations
6. Hire and train shuttle ambassadors
7. Shuttle testing without passengers
8. Public launch


# Future

- Data collected through demonstration program will inform future deployments of autonomous vehicles
- PSTA is a member of the Automated Bus Consortium
- Potential future use cases:
  - Bus yard operations
  - Bus on shoulders
  - Bus Rapid Transit
  - Downtown circulation

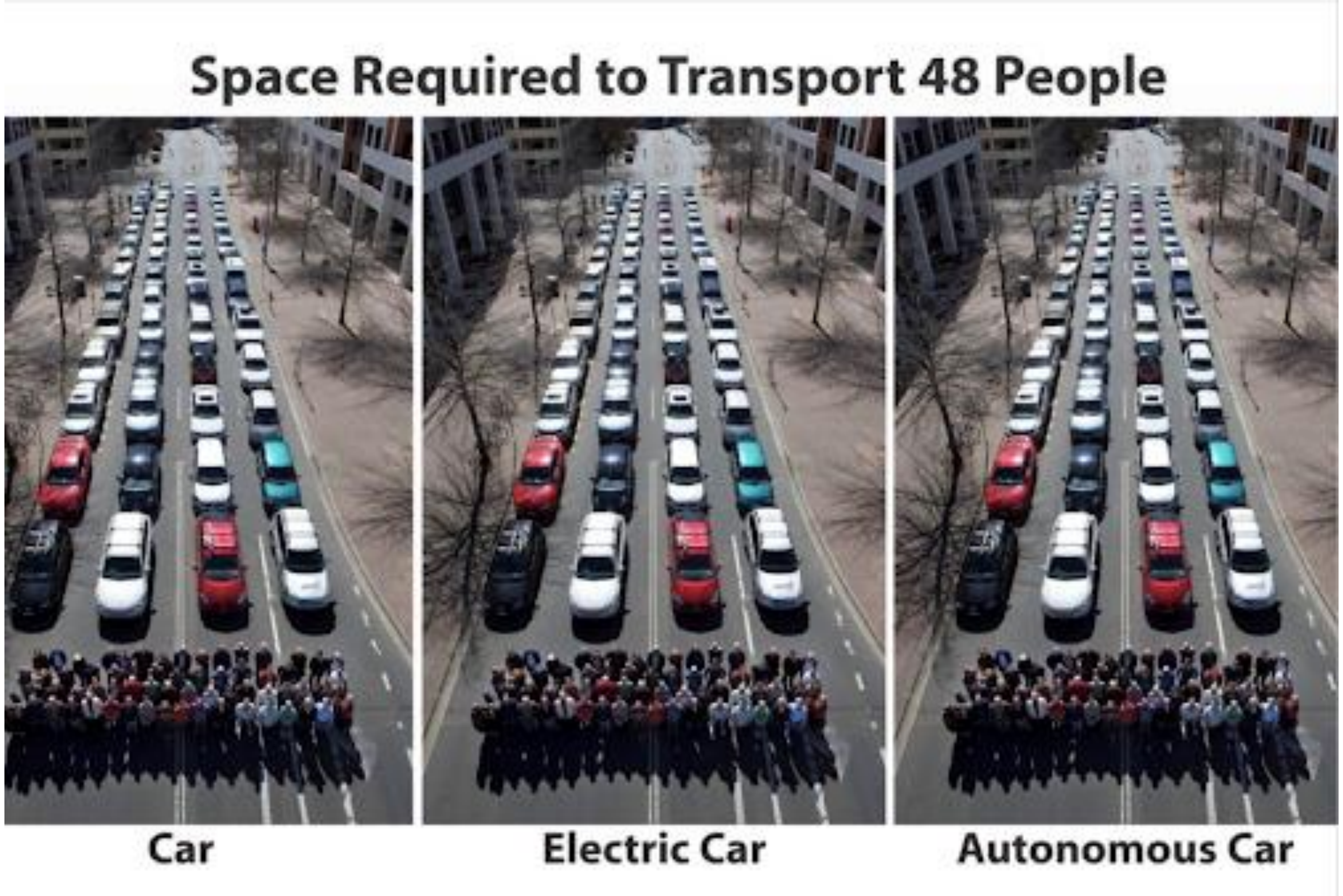
Automated Bus Consortium
ACCELERATED BY AECOM

CUSTOMER CUSTOMER ...ANCE FINANCIALLY SUSTAINABLE CAPITAL SERVICE EXPA... VISIONARY VISIONARY

# Planning for a Future, Accessible, Automated Transit System (ATS)

Matthew Lesh, AV Mobility Strategist
driverlesslesh@gmail.com

n-catt
National Center for Applied Transit Technology




# What does our automated future look like?

# So, what's my point?

"Utilize the tool of automation to enhance society, not just cars!"

# Background

- 10 years at FTA - USDOT
  - Mobility / TOD
  - Transit Access
  - Connected Vehicle / ITS
  - Automation Program Plan
- Consultant at Noblis
  - ATTRI Program
  - Smart City Challenge
- Local Motors
- Independent AV Strategist

Morgantown PRT - 2011

Uppsala, Sweden 2012

Singapore - 2014


Washington, DC 2016


Milton Keynes, UK 2018

# Discussion

- Review of documented needs
- Low-Speed Automated Vehicles (LSAVs)
- Government programs leading the way
- What a future system might look like
- Tools for planning
- Universal Design Principles
- Lessons learned & advice moving forward


Source: Federal Transit Administration

# Documented Needs: Disability & Aging

- 1 in 5 people in the U.S. has a disability (more than 57 million people)
- 25.5 million Americans have travel-limiting disabilities;
- More than 6 million have difficulty getting the transportation they need for jobs, medical appointments, and daily living
- 3.6 million Americans with travel-limiting disabilities do not leave their homes
- The number of U.S. residents aged 65+ is projected to increase to 72 million by 2030
- Nearly 16 million people aged 65+ live in communities where public transportation is poor or nonexistent

Sources: U.S. Department of Transportation, Federal Highway Administration, 2017 & National Household Travel Survey & National Aging & Disability Transportation Center

# Addressing Needs: Promise vs. Reality

- One promise of AV development is the opportunity to incorporate those populations that don't or can't drive into the transportation system.
- Accessible vehicles would begin to address the great mobility needs of disabled populations, but the form factor has not changed much.
- Paratransit operations continue to grow in expense for communities across the country and globe.
- Most OEMs have treated developing vehicles for disabled communities as an afterthought.


Source: Lyft

# Low-Speed Automated Vehicles (LSAVs)

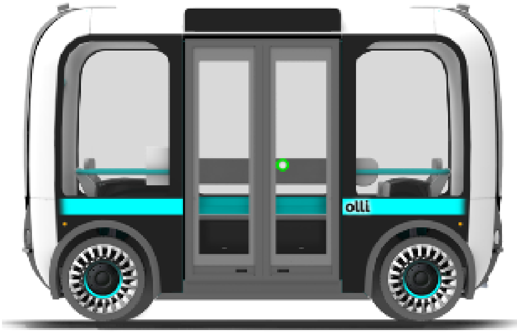
Easy Mile EZ-10

Westfield POD

Navya Arma

2getthere GRT


RDM DevPod




Local Motors Olli

# Federal Research Programs

FTA's Strategic Automation Research (STAR) Program outlines a national direction for transit automation


Source: Federal Transit Administration

# U.S. DOT BUILD Grant

**“This grant will support the county's reimagining mobility project. It’s an investment in cutting edge, multimodal transportation.”**

**-Secy. Elaine Chao, USDOT, November 2019**

Orange County, FL received a $20 million federal grant to expand its autonomous shuttle system at Lake Nona through the Better Utilizing Investments to Leverage Development (BUILD) program of USDOT.

# Orange County, FL BUILD Project Specifics

- 1st BUILD grant in Central Florida
- Create new and/or modify existing infrastructure
- 22+ miles of AV path to support a 50+ shuttle network
- Dedicated AV stops
- AV storage facility for maintenance and charging stations

Photo courtesy of Beep

# Success to Deployment - Engage Early & Often

**State & Federal Regulators**

**Community**

**ADA Community**

**First Responders**

Beep engages with external stakeholders before, during, and after a deployment to ensure the safe planning, deployment, and operation of the autonomous shuttle.

# Michigan Mobility Challenge - Accessibility Workshop

MDOT
Michigan Department of Transportation

PRATT MILLER
Transforming what's possible.

ROBOTIC RESEARCH

WESTERN MICHIGAN UNIVERSITY

UNIVERSITY OF MICHIGAN

easterseals
taking on disability together

# Michigan Mobility Challenge - 2-Week Pilot on Western Michigan University Campus - Oct 2019

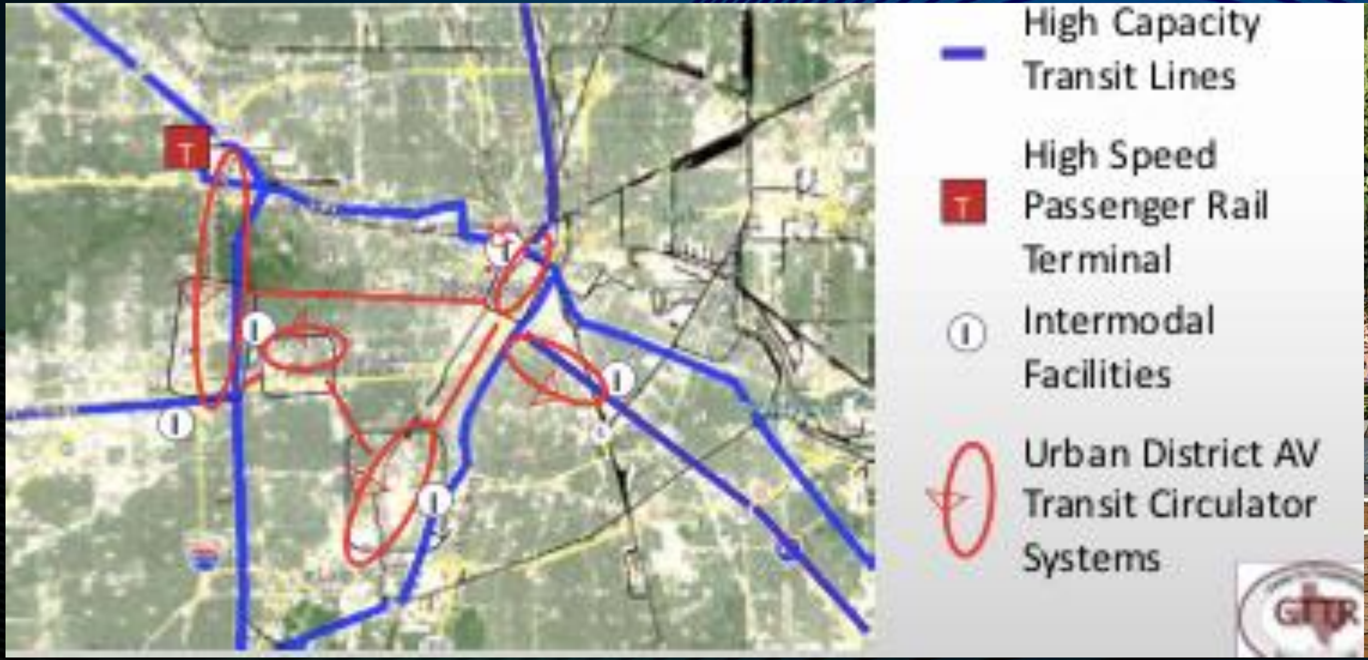

# FTA Accelerating Innovative Mobility (AIM)

- $600k Kansas City Area Transportation Authority (KCATA) for MAX BRT
- Test and develop advanced driver assistance systems (ADAS)
  - ADA-compliant level boarding
  - Reduction of dwell time
  - Object detection
  - Crash Avoidance
  - Breaking assistance


Source: https://ridekc.org/news/kcata-aim-grant

Robotic Research's technology will help operators overcome ADA-compliant gaps between platforms, which will improve accessibility, reduce dwell time and ensure a better transportation experience.

# Houston Metro's Plan: Regional High Capacity Transit System




Critically important to the Houston plan is regional access to urban core districts by a high capacity transit system. The system will strategically include ATS circulator systems to provide vital first and last mile connections.

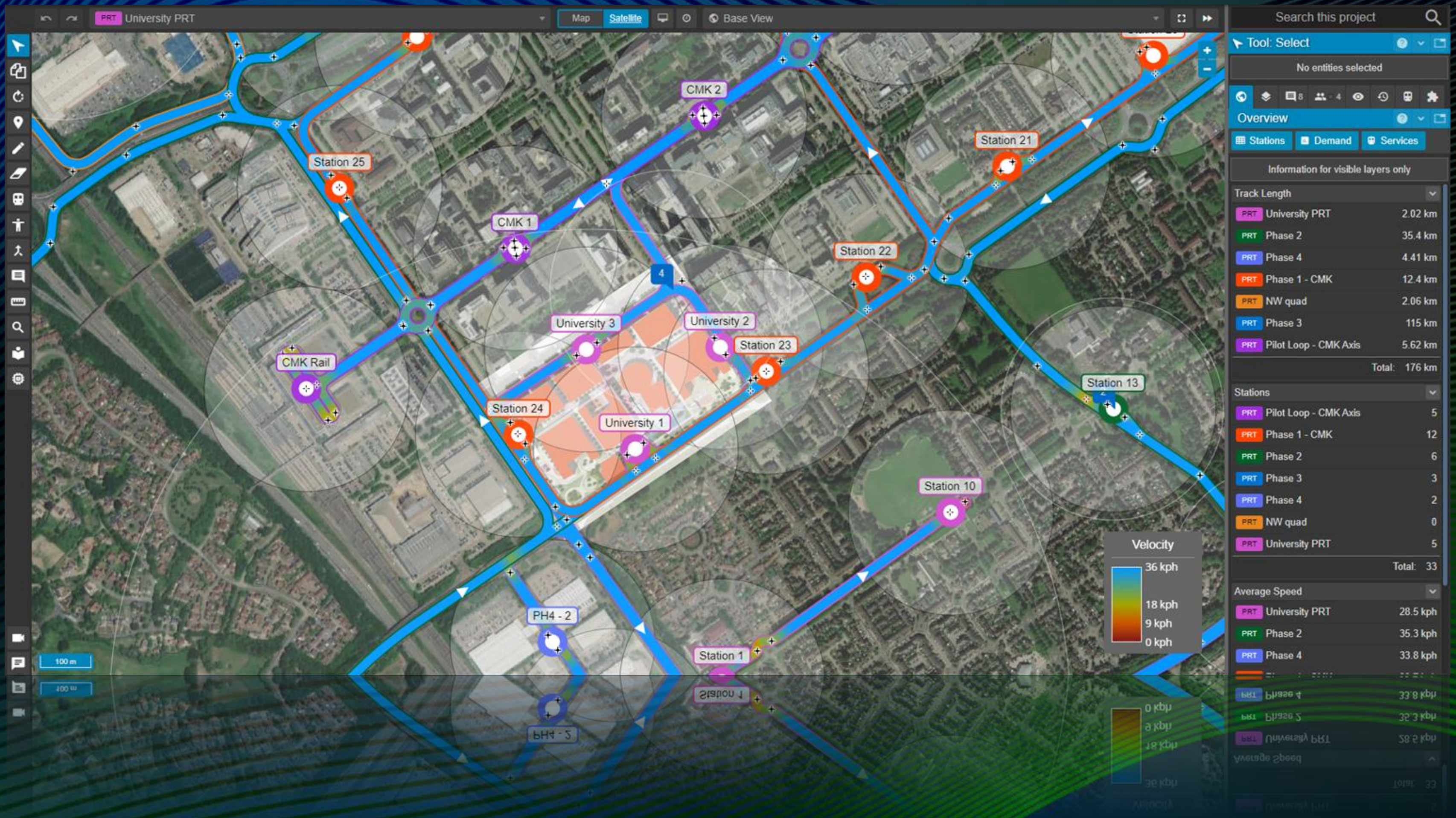
# What might the future look like?

podaris

# RAPID & ACCURATE PLANNING OF AUTOMATED TRANSIT

Podaris has its roots in PRT system design, providing high-level tools for accurate, parametric drawing of automated transit systems.

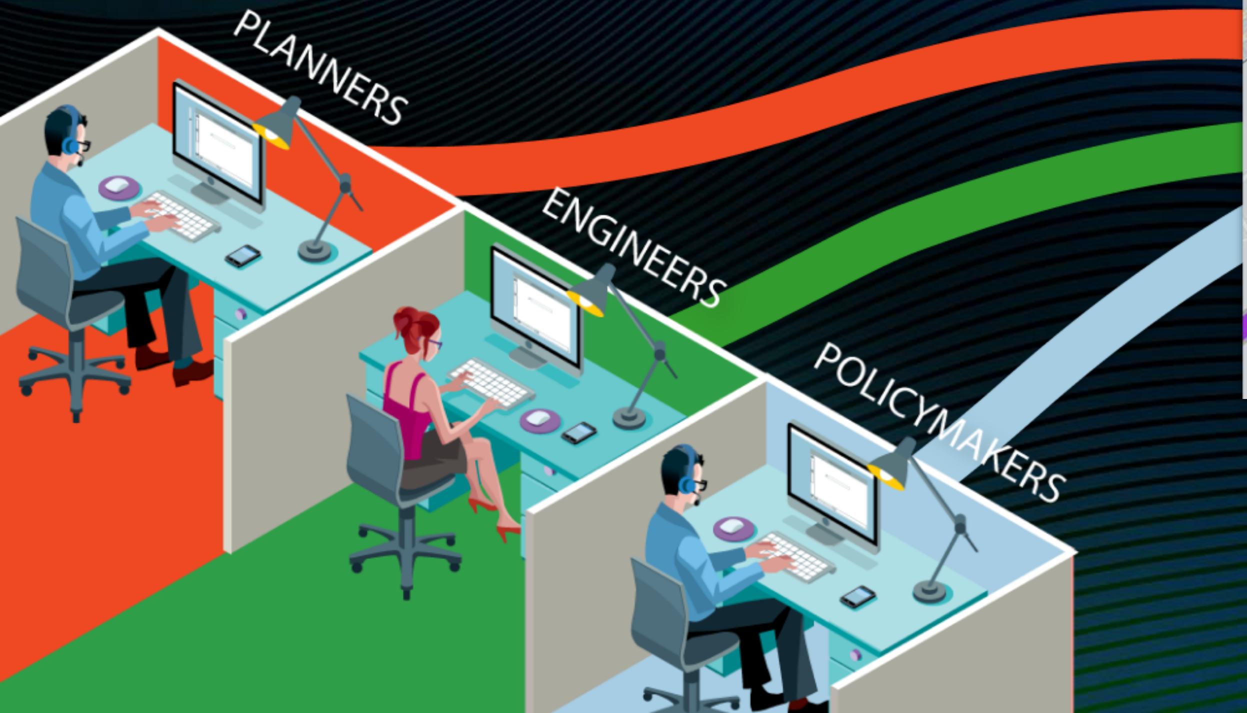
Its multi-modal nature allows you to explore the relationship between a variety of transport modes and conduct early stage feasibility studies in a fraction of the time, at a fraction of the cost.

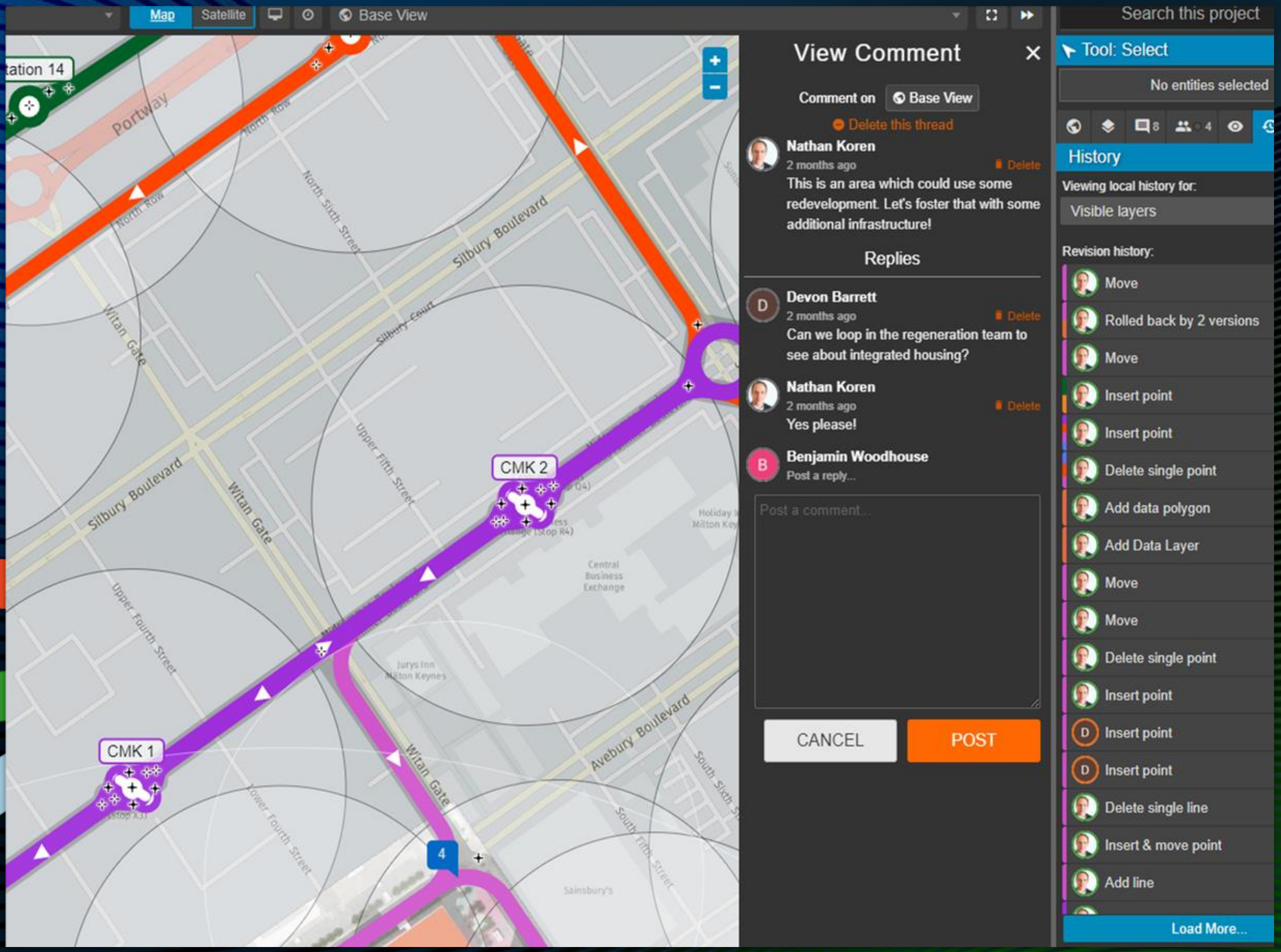


podaris

# Built for real-time collaboration

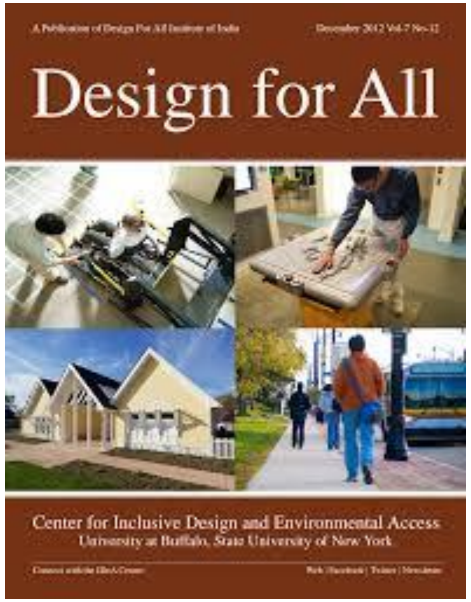
Podaris empowers interdisciplinary teams to explore concepts together, in real-time, on a shared web-based platform. It engenders dialogue, promotes transparency and reduces feedback loops from months to milliseconds.



# Principles of Universal Design

- Body Fit - accommodate a wide range
- Comfort - keep demands within limits
- Awareness - ensure information is easily understood
- Understanding - operation is clear and intuitive
- Wellness - contribute to health promotion
- Social Integration - treat all groups with respect
- Personalization - present opportunities for choice
- Cultural Appropriateness - respect cultural values



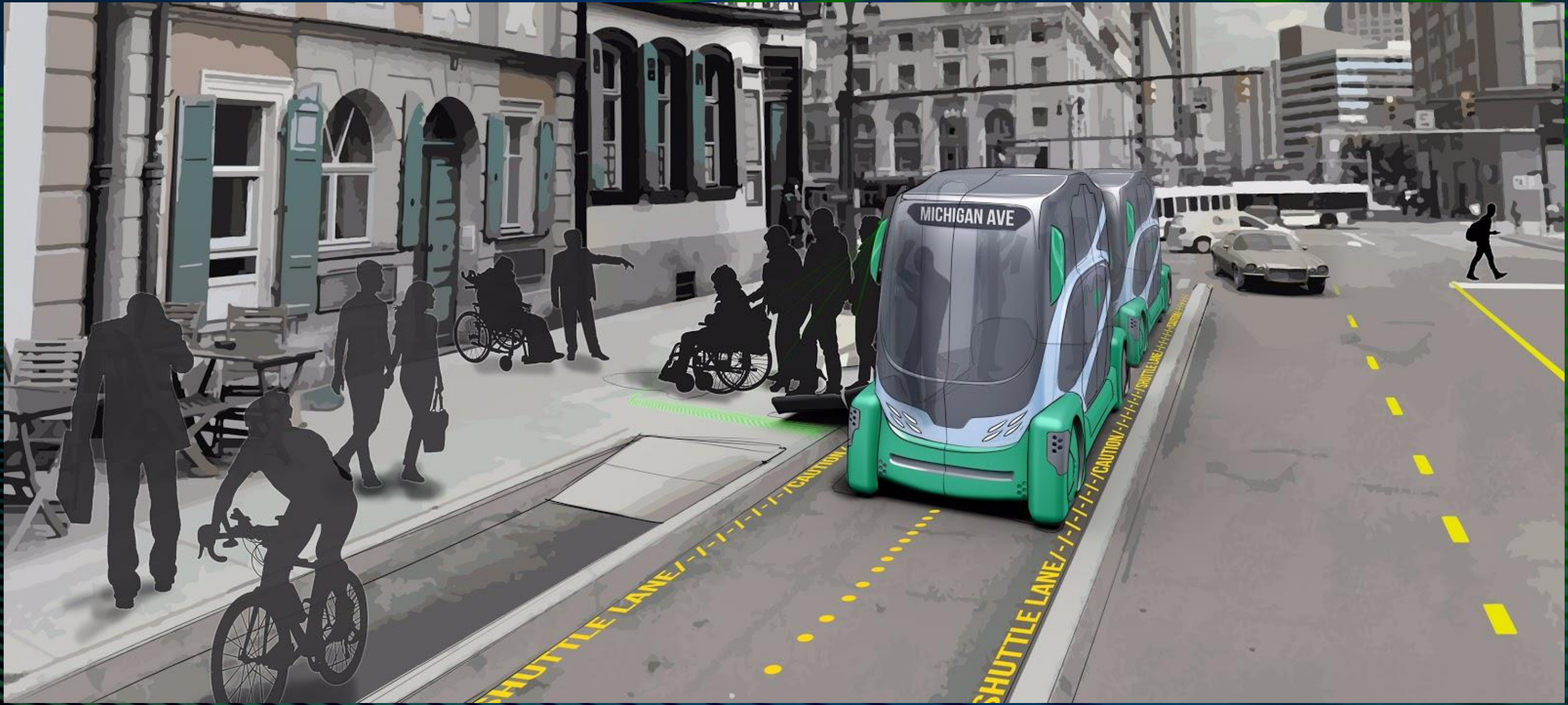

**The IDEA Center produces knowledge and innovative tools to increase equity in design for underrepresented groups.**

University at Buffalo
Center for Inclusive Design and Environmental Access
School of Architecture and Planning

# Reflections for Future Automated Mobility

- Find or be a local champion
- Plan with Universal Design Principles – Accessibility in mind
- Pedestrian Environment Supports Multimodal Mobility
- Understand Battery Capacity & Duty Cycles
- Encourage IoT, Connected Vehicle, & ADAS for greater safety
- Leverage Purpose-Built Vehicle
- Build Inclusive Strong Teams

# Thank you!




Source: Pratt & Miller Engineering

Sheryl Gross-Glaser: grossglaser@ctaa.org
Carol Schweiger: carol@tech4transit.com
Jean Ruestman: RUESTMANJ@michigan.gov
Jacob Labutka: jlabutka@psta.net
Matthew Lesh: driverlesslesh@gmail.com

**FIND US AT** https://n-catt.org/