The National Academies of
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TRANSPORTATION RESEARCH BOARD

Catching Up on Low-speed Automated Vehicles in Public Transit

June 8, 2021

@NASEMTRB
#TRBwebinar

Learning Objectives

1. Identify trends in vehicles, regulations, and deployments of LSAVs in public and private transit

2. Discuss how transit agencies and communities can plan scalable pilots for LSAVs

#TRBwebinar

Continuing Education Credits

- This webinar is eligible for 2 AICP credits
- Log into the APA website after the webinar to claim your credits

- This webinar is also eligible for 1.75 CLE credits.
- If you attend the entire webinar, you will be sent a link to fill out your CLE certificate.

Automated Road Transport Symposium 2021 (ARTS21)

Attend TRB's Automated Road Transport Symposium 2021, July 12-15, 2021!

#TRBwebinar
#TRBautomated

Catching up on Low Speed AVs in Transit

TRB Webinar
June 8, 2021

Introduction

Route map

- Introduction
- LSAVs in shared mobility before, during, after Covid
- Trends in vehicle types, use cases, and operating environments
- Meeting safety, access, accessibility, and mobility objectives
- A special update on how JTA is advancing AVs as part of its mobility innovation agenda

Kelley Coyner
Innovation4Mobility & Center for Regional Analysis

In 2017, a private campus owner asked for help moving hundreds of people without their cars using automated shuttles. So Kelley co-founded Mobility e3, now known as Innovation4Mobility, to bring accessible automated connected electric and shared mobility systems to communities and campuses. She helped build several emerging businesses to bring A2CES to scale. Now she forges partnerships between technology firms and cities and campuses to bring mobility to all. Recognized as one of 50 to watch in sustainability, she promotes Accessible, Automated, Connected, Electric, and Shared Mobility systems in North America and globally. Kelley has advised more than 70 nonprofit boards globally, served as Mobility Innovation Lead for Stantec; Executive Director of the Northern Virginia Transportation Commission; was confirmed as head of the Research and Special Program Administration; held appointments at MIT, Harvard, the Coast Guard Academy, the National Academy of Sciences, the Volpe Transportation Center, and George Mason University. In addition to the A2CES Framework for Hawaii, she's authored mobility innovation frameworks for a dozen cities, states, and private owners.

Shane Blackmer
Director of Operations for GenerationAV™

Shane served as the project manager for the research report, overseeing the lessons learned and case studies. Shane's experience and expertise in planning, operations, and training greatly enhanced this research team and others committed to scaling the safe deployment of autonomous vehicles. Shane authored the US Army Tank Automotive Research, Development, and Engineering Center's Ground Vehicle Autonomy and Robotics Strategy and led the US Army Ground Vehicle Robotics' Campaign of Learning to inform operational units of emerging ground vehicle robotics and autonomous capabilities. Shane also supported SAE's Autonomous Vehicle Safety Consortium before joining Stantec as the Director of Operations for GenerationAV™. Shane's passions are faith, family, and pioneering the adoption of AV technologies.

John Good, AICP
Research Lead

John is an urban and transportation planner, working at the intersection of new mobility technology and city development. He served as the Research Lead for this TCRP project, "Low-Speed Automated Vehicles in Public Transportation", where he focused on how LSAVs would be used practically in urban environments. During and before this work, John was a Consultant at the World Bank, focusing on transit-oriented development, station area design, and infrastructure finance. Previously, John worked at the Urban Redevelopment Authority (URA) of Singapore, where he first started work on autonomous vehicles and their integration within urban transportation systems. He has a Master of Environmental Management and BA in Environmental and International Studies from Yale University.

Bernard Schmidt
Vice President of Automation and Innovation, Jacksonville Transportation Authority

Bernard oversees the Ultimate Urban Circulator (U^2C) initiative and other innovative projects that will connect people and places around downtown Jacksonville through the use of Autonomous Vehicles and other technologies. He led the deployment of Amazon® Robotics fulfillment center as Amazon’s General Manager in Jacksonville, FL. Prior to that, Bernard spent 10+ years at United Technologies Corporation, serving as General Manager of UTAS Customer Service Maintenance, a Repair and Overhaul business based in Dubai, UAE. Bernard also served as the Operations Director at TEC (Turkish Engine Center) a Pratt & Whitney joint venture with Turkish Airlines and as Global Materials Manager of Pratt & Whitney Engine Centers in Connecticut, Georgia and international sites. Bernard also held positions with multiple organizations including General Dynamics Electric Boat and Dominion Nuclear Energy Company. He has a Bachelor’s degree in Chemical Engineering from University of Rochester and a Master’s in Management from Rensselaer Polytechnic Institute. He is a graduate of the Darden Business School Executive Education program and MIT Sloan School of Management’s Artificial Intelligence Certificate Program (CSAIL).He is married with 4 children, speaks 5 languages and is a recreational drone pilot.

LSAVs in shared mobility before, during, after Covid

TCRP J-11, Task 27 LSAV in Public Transportation Quick Study

OBJECTIVE: Up-to-date guide on planning, piloting, or deploying LSAVs based on expert interviews, lessons learned reviews, literature survey, and reviews of best practices in policy, insurance, safety, operations, and more.

LSAV Research Timeline

AV Shuttles to the Street, D.C. Automotive Show
January 2018

APA, AV Mobility Hub
April 2018

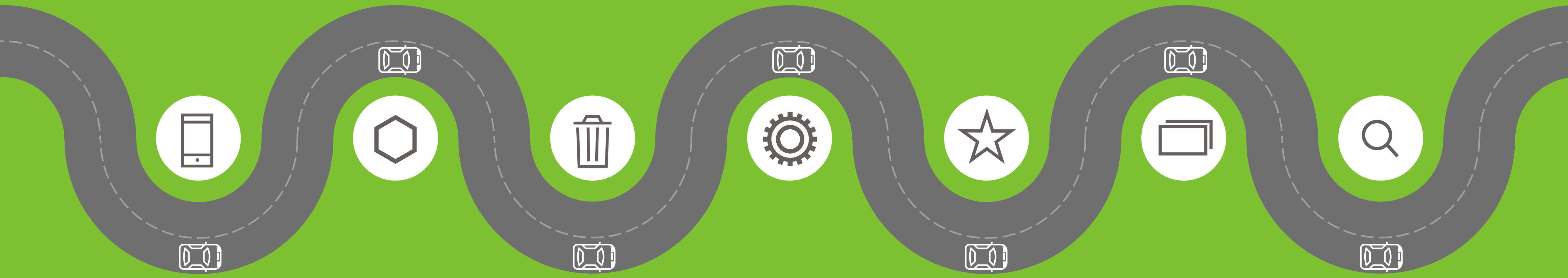
APA/FHWA Research Symposium
October 2018

Infrastructure Readiness Assessment
Oct. 2018 – March 2019

APA Smart Mobility Hub
April 2019

Hawaii Strategy
February 2020

TCRP, J-11, Task 27 Pub.
April 2020



TCRP J-11/Task 27 Table of Contents

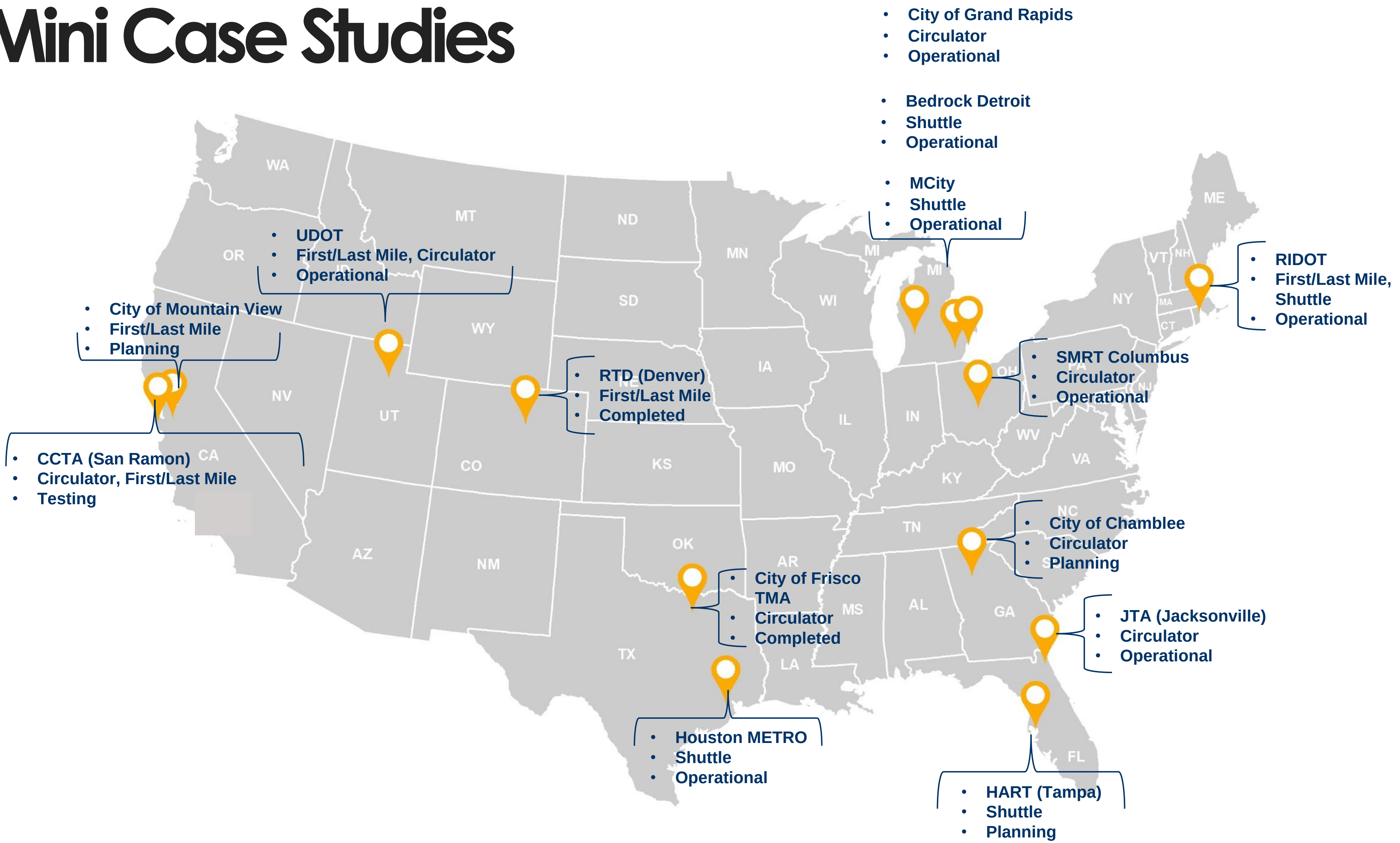
A Tale of Two Cities and a Military Base

Arlington, TX
Off Street,
Event Based

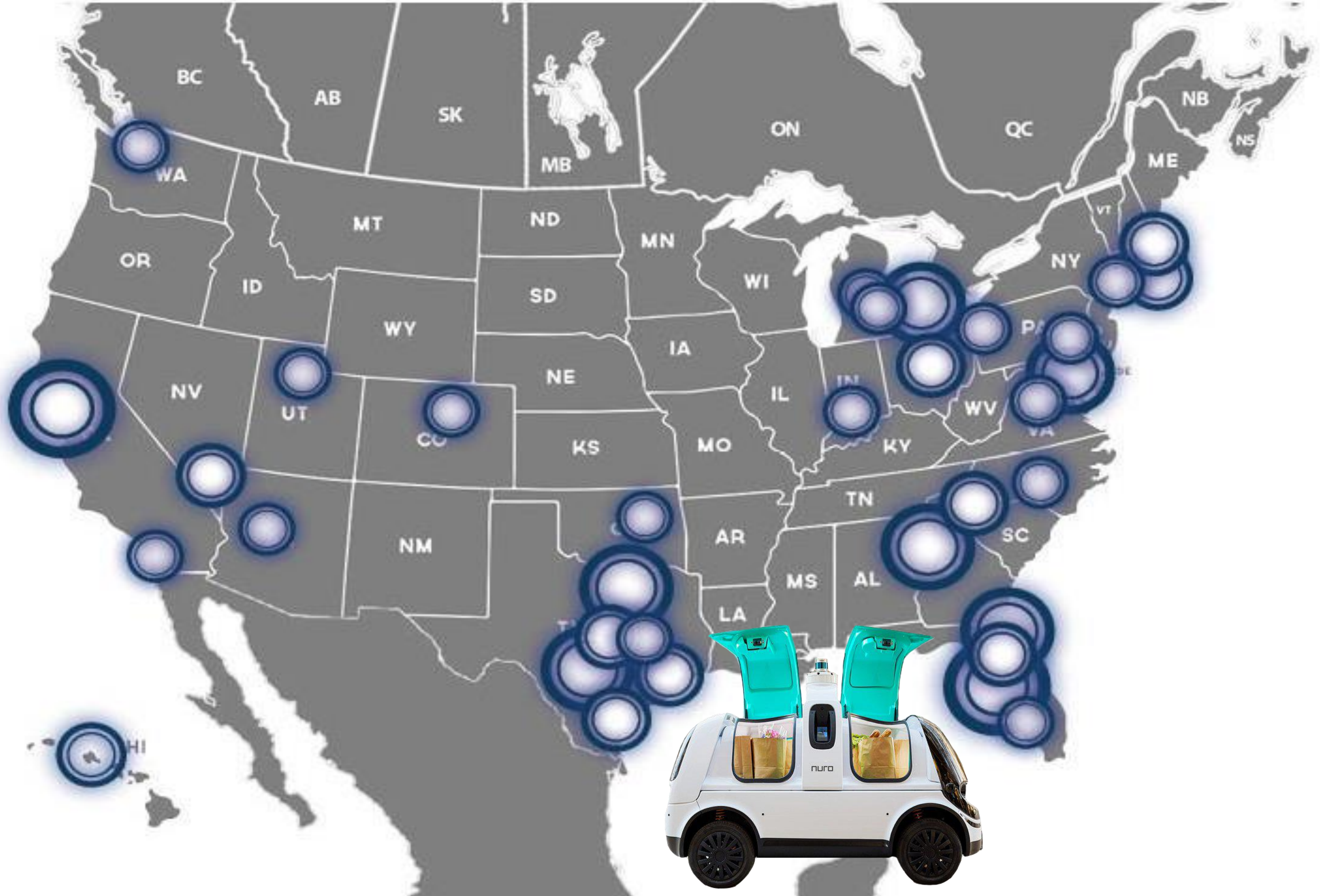
Las Vegas, NV
Mixed Traffic,
Circulator

Ft. Bragg, NC
Health Services,
Campus

Mini Case Studies



Trends (as of January 2020)



70 in active planning; 300+ identified in North America

Types of Investments

- Federal – Access for All; ADS research
- State Innovation Grants
- Private – Developers, Utilities, Energy, Financial

Demos to Deployments

Accessibility /Access

- USDOT
- Barrier Free
- Tulsa Case Study

Electrification

Freight Applications

LSAV PUBLIC TRANSPORTATION USE CASES

- **Fixed routes**
  - Set path between end points and have a number of stops along the way
- **Circulators**
  - Smaller use cases that allow people to travel between the destinations within a specific neighborhood or campus
- **Shuttles (A-B)**
  - Simplified versions of fixed routes or circulators, just travelling between 2 points
- **First-mile/last-mile**
  - Connects customers to a faster fixed-route service, effectively increasing the catchment area of a station
- **Paratransit**
  - Point-to-point on-demand service, often catering

Future Research

- Baseline Survey of Transit Agency Planning and Implementation
- Aligning LSAVs and ODDs
- Data-Sharing Mechanisms
- Accessibility, ADA Standards, Universal Design
- Sustainable LSAV Shared-Use Service Considerations
- Infrastructure and Efficacy of LSAV Applications

LSAVs in Transit – Trends During COVID

Planning Continues

RTD

WRTA/Youngstown

Athens

Tulsa

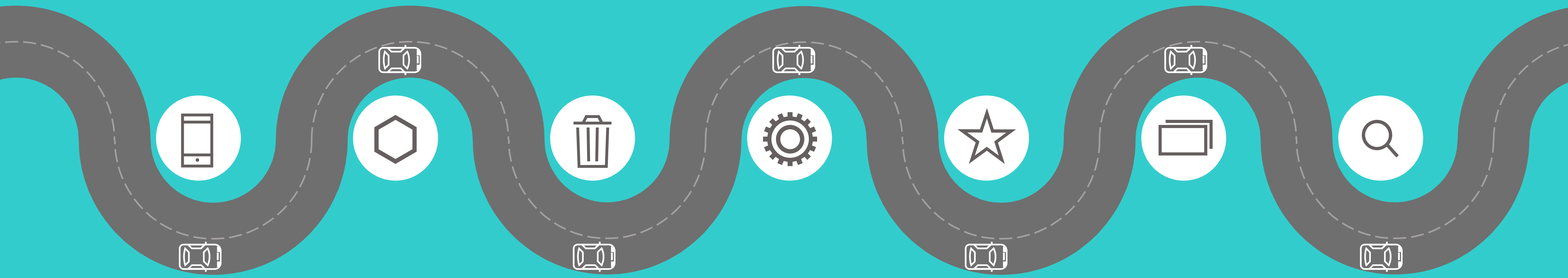
JTA

Arlington

Freight Accelerates

Moves to Larger & Smaller Vehicles

Infrastructure Readiness



Passenger Service Largely Suspended Move to Alt Uses

Planning

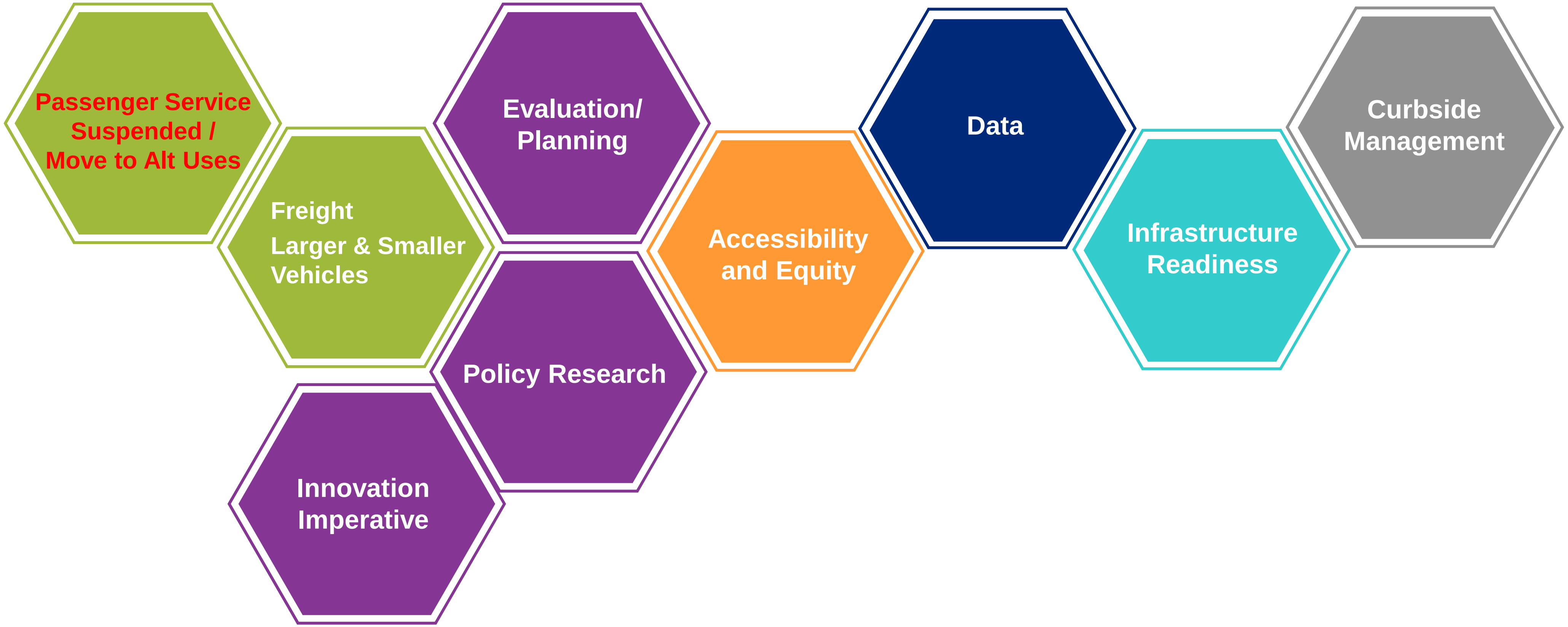
Evaluation

Vehicle Development

Industry Consolidation

Innovation Imperative

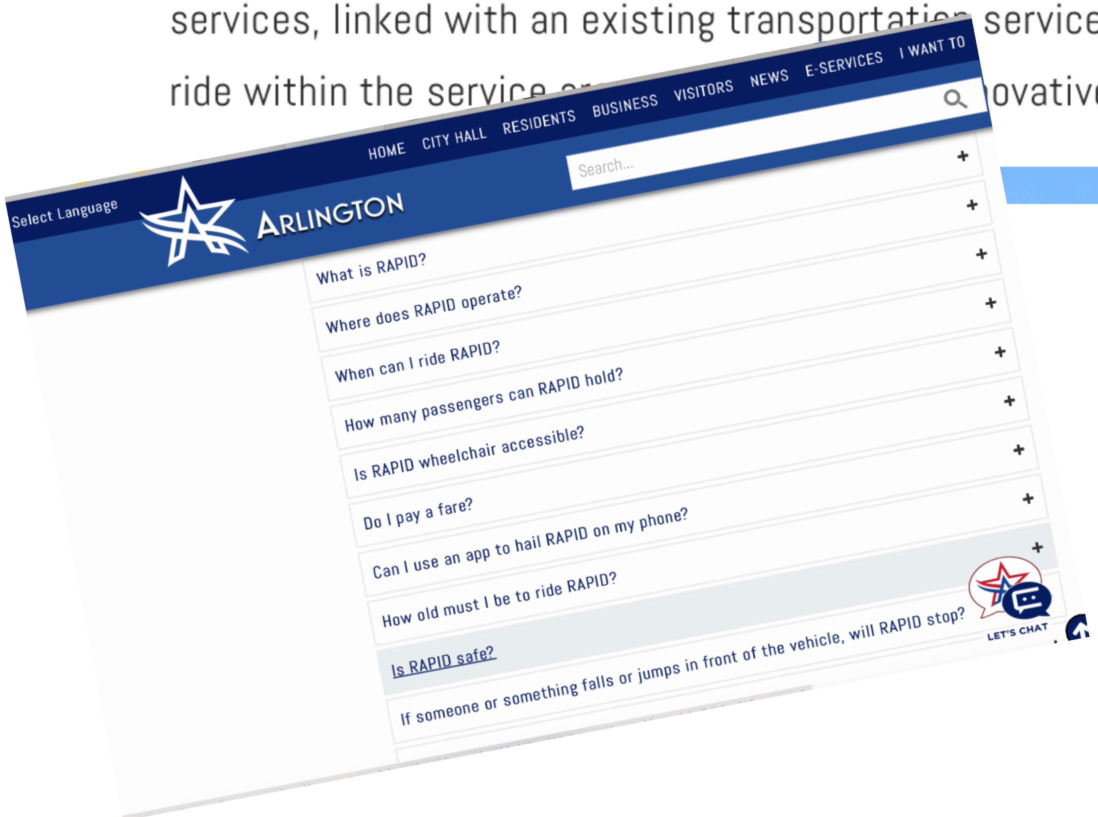
March 2020-2021 Developments



Pivots, New Pilots –California to Cambridge

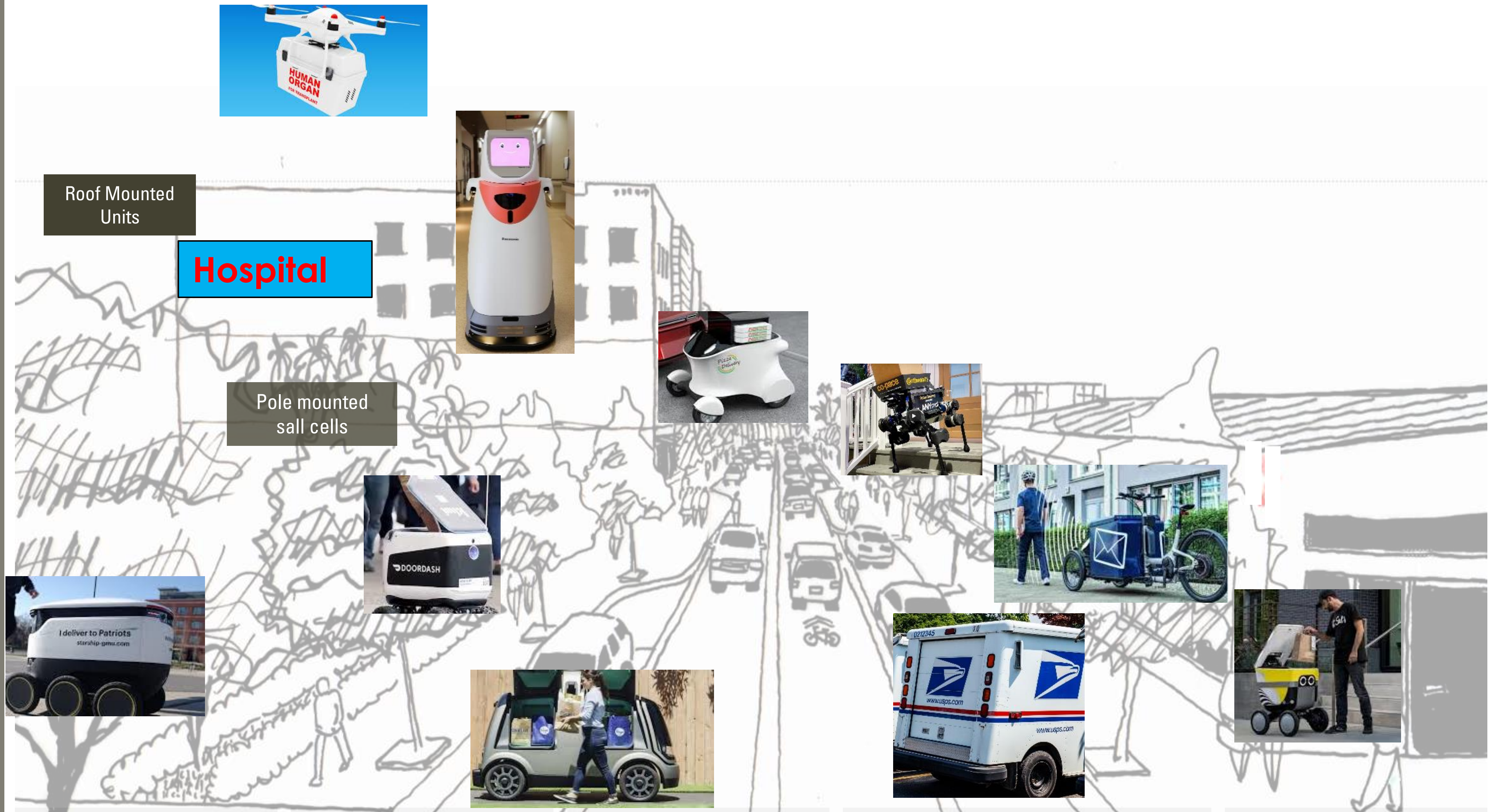
RAPID

Starting in March 2021, the City of Arlington's RAPID service provides autonomous vehicle (AV) rides i
on the University of Texas at Arlington's (UTA) campus. With grant funding from the **Federal**
partnering with **Via Transportation**, **May Mobility**, and **UTA**, the City is offering one the c
services, linked with an existing transportation service. **Using the Via app** or by calling 81
ride within the service ar... ...ovative technology!


Select Language
ARLINGTON
HOME CITY HALL RESIDENTS BUSINESS VISITORS NEWS E-SERVICES I WANT TO
Search...

- What is RAPID? +
- Where does RAPID operate? +
- When can I ride RAPID? +
- How many passengers can RAPID hold? +
- Is RAPID wheelchair accessible? +
- Do I pay a fare? +
- Can I use an app to hail RAPID on my phone? +
- How old must I be to ride RAPID? +
- Is RAPID safe?
- If someone or something falls or jumps in front of the vehicle, will RAPID stop?

LET'S CHAT



Hospital Delivery: Drones for meds/organ transplants & robots inside

From "car" to door: Door Dash

AV Wheelchair: Inside and outside

AV E-Cargo: One example of small e-utility vehicles

Bots: Pick Up

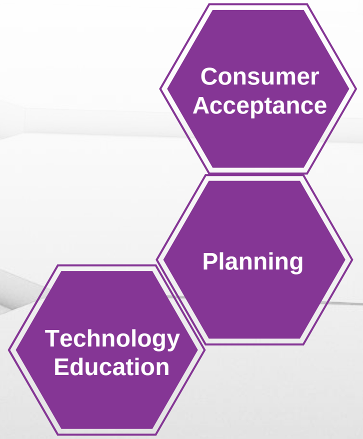
Campus: Food Delivery

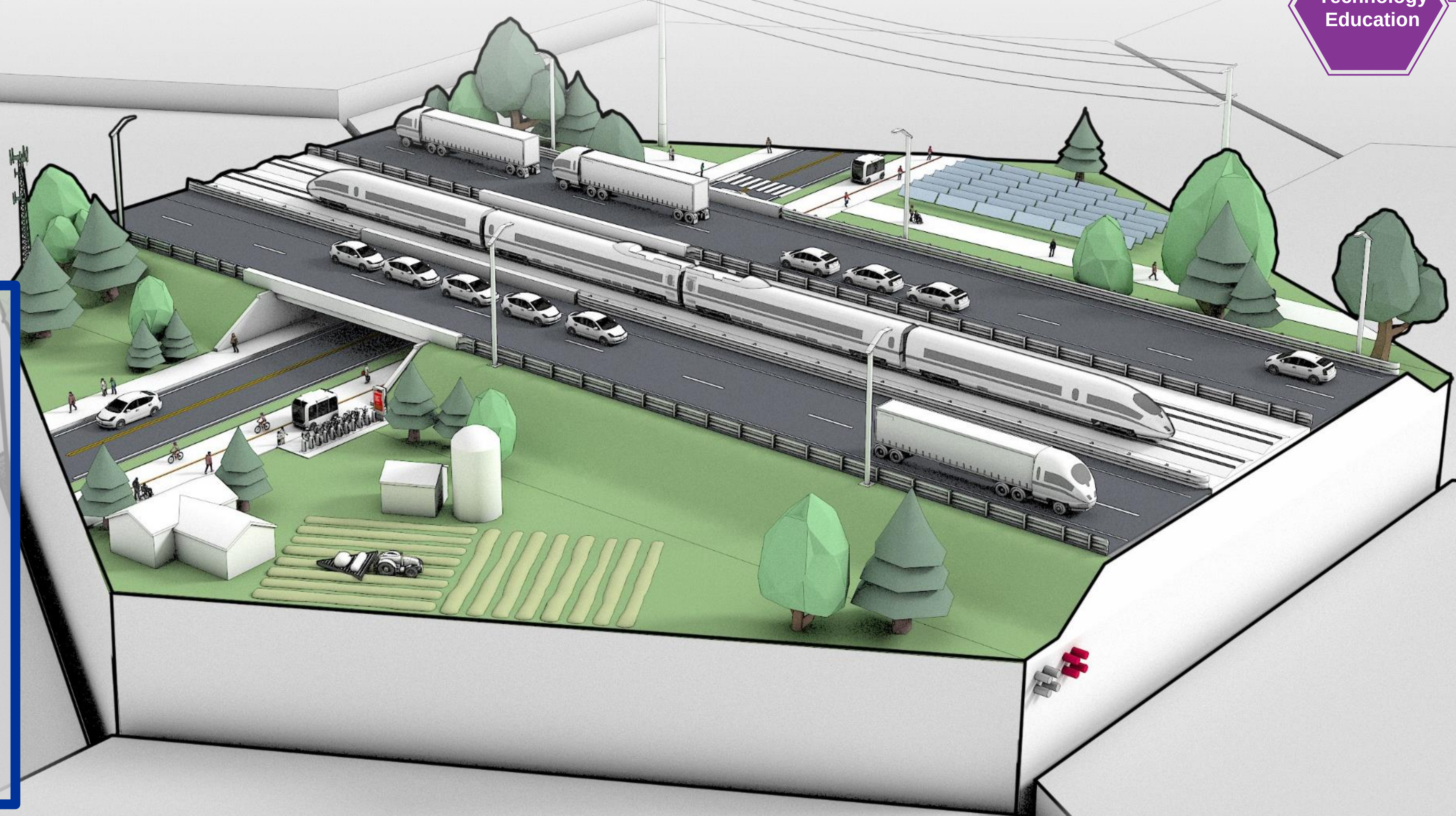
On Road : Grocery Delivery

Door to Door Delivery: Bots climb stairs

USPS : AV Delivery and Long Haul

Moving Forward





Planning Evaluation

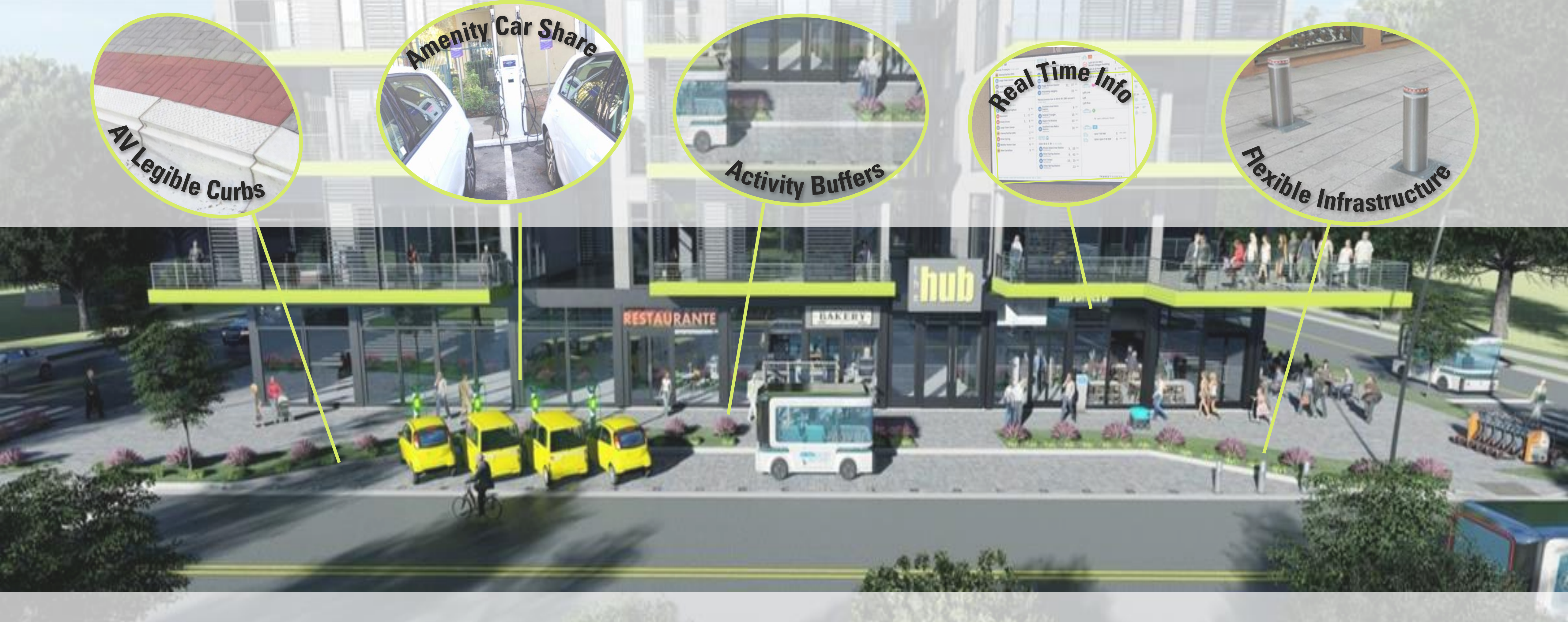
- MCORES
- NCTCOG
- HAWAI'I ACES
- Tulsa Mobility Innovation Framework
- Pinellas County

Evaluation

- Utah DOT
- Houston Metro
- Contra Costa Transportation Authority (CCTA)

Smart Infrastructure Investing

- Streets, Curbs, Lanes
- System Integration - Connected Tech - IoT
- MaaS
- Curbside Management
- Parking Tech
- Mobility Hubs – Freight & Passenger
- Electric Charging



The AV Shuttle-Ready Curb

AV Legible Curbs: Clear lines and patterns for a “machine readable resistant to alterations

Amenity Car Share: Fleets available to building residents and workers to support car-light living and value of transit

Activity Buffers: Provides a barrier that reduces shuttles’ reaction to low-risk pedestrian activity

Real Time Information: Increases transit user convenience and ability to plan travel

Flexible Infrastructure: Increases transit user convenience and ability to make the most of curb demand

WGI

A² ACCESSIBLE

Accessible vehicles and services allow for all to travel without regard to disability or socioeconomic circumstances

AUTOMATED

Vehicles that use different autonomous features can travel in narrower lanes and closer together, improving fuel economy, and effectively increasing road capacity without pouring more pavement

C CONNECTED

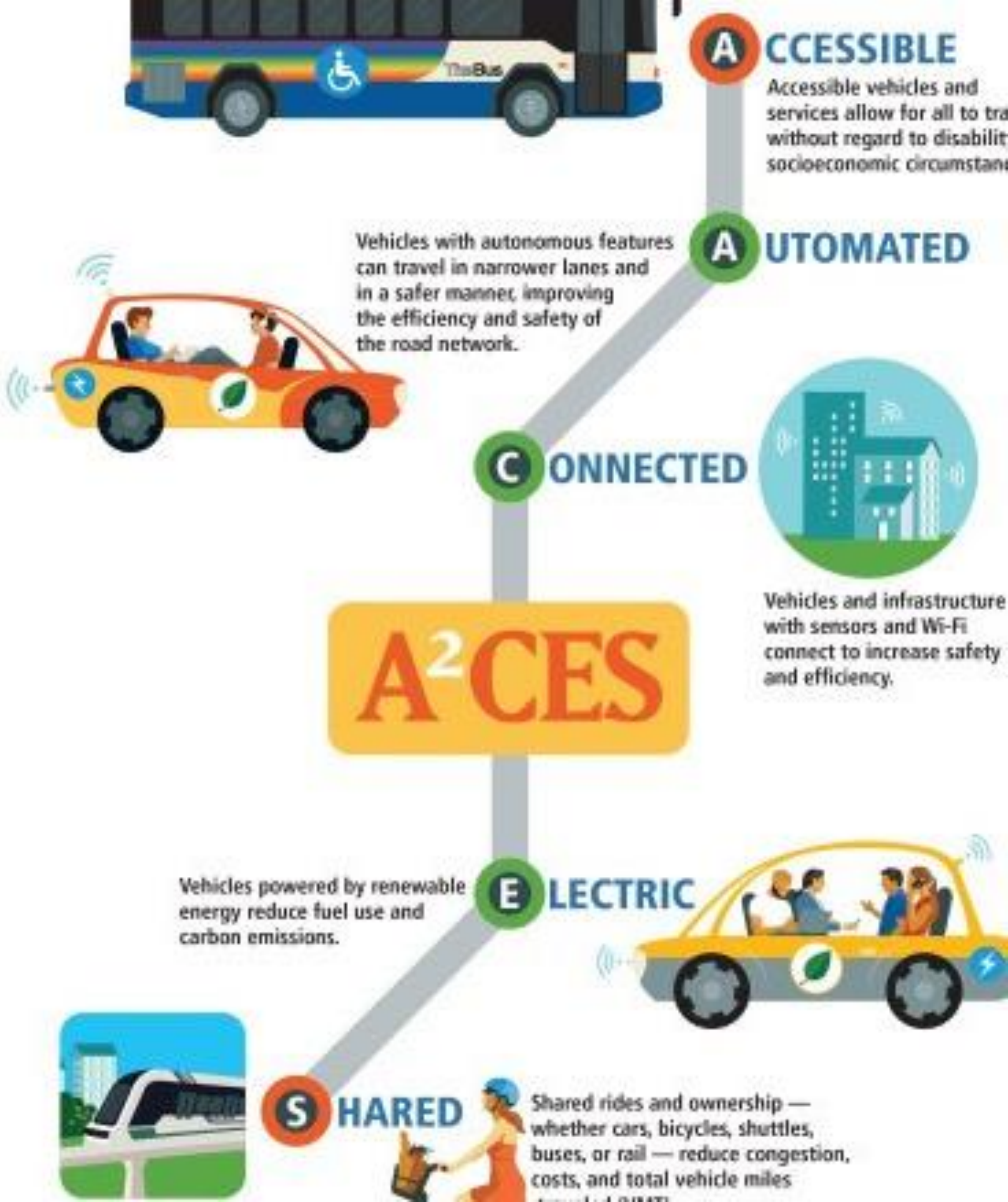
Vehicles and infrastructure with sensors and Wi-Fi or dedicated short-range communication allow vehicles and infrastructure to communicate with cyclists and walkers, other vehicles and infrastructure, increasing safety and efficiency

E ELECTRIC

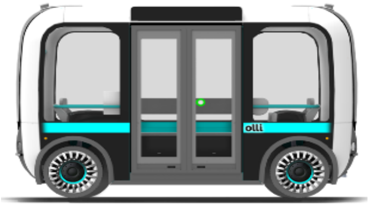
Vehicles powered by renewable energy reduce fuel use and carbon emissions

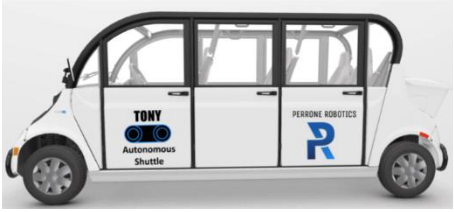
S SHARED

Vehicles—whether cars, bicycles, shuttles, buses or rail cars—where rides or ownership is shared reduce congestion, costs, and total vehicle miles travelled



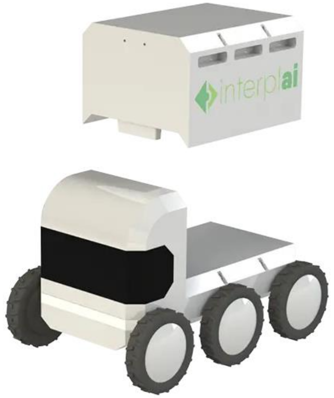
Trends in vehicle types, use cases, and operating environments



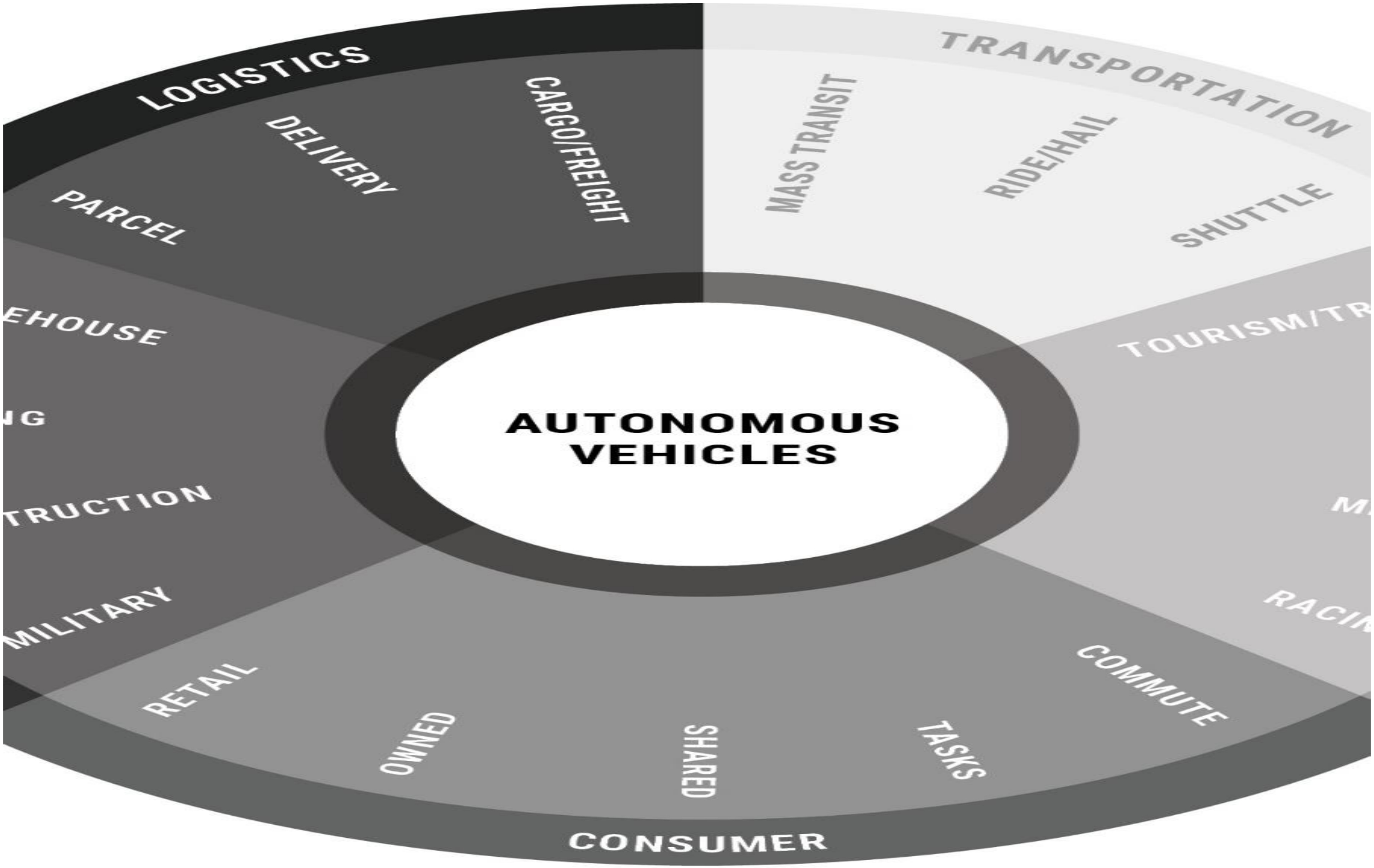


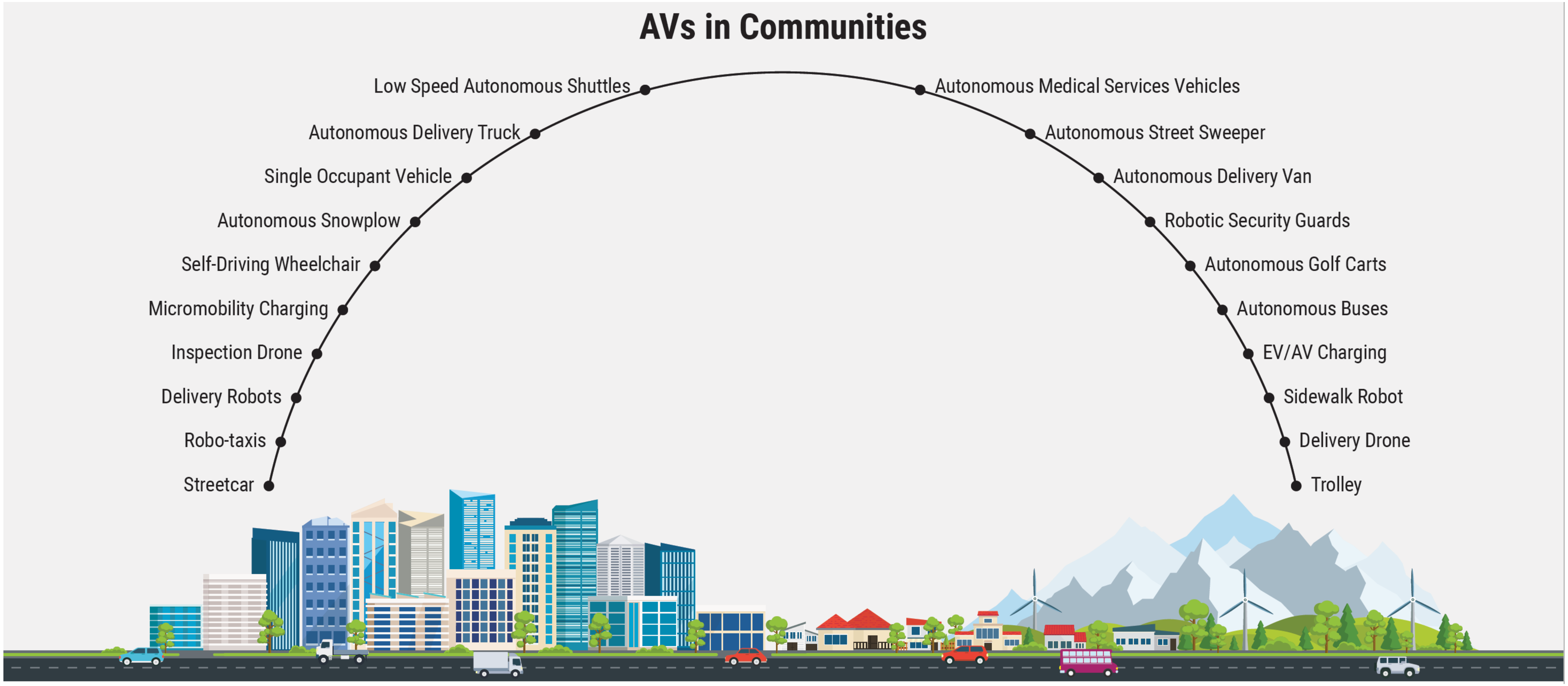
40+ Companies making automated passenger vehicles

But there is so – much – more



Use Cases


AUTONOMOUS VEHICLES
LOGISTICS
PARCEL
DELIVERY
CARGO/FREIGHT
TRANSPORTATION
MASS TRANSIT
RIDE/HAIL
SHUTTLE
MILITARY
CONSUMER
RETAIL
OWNED
SHARED
TASKS
COMMUTE


AVs in Communities
Low Speed Autonomous Shuttles
Autonomous Delivery Truck
Single Occupant Vehicle
Autonomous Snowplow
Self-Driving Wheelchair
Micromobility Charging
Inspection Drone
Delivery Robots
Robo-taxis
Streetcar
Autonomous Medical Services Vehicles
Autonomous Street Sweeper
Autonomous Delivery Van
Robotic Security Guards
Autonomous Golf Carts
Autonomous Buses
EV/AV Charging
Sidewalk Robot
Delivery Drone
Trolley

Service Models & Use Cases

Use Cases

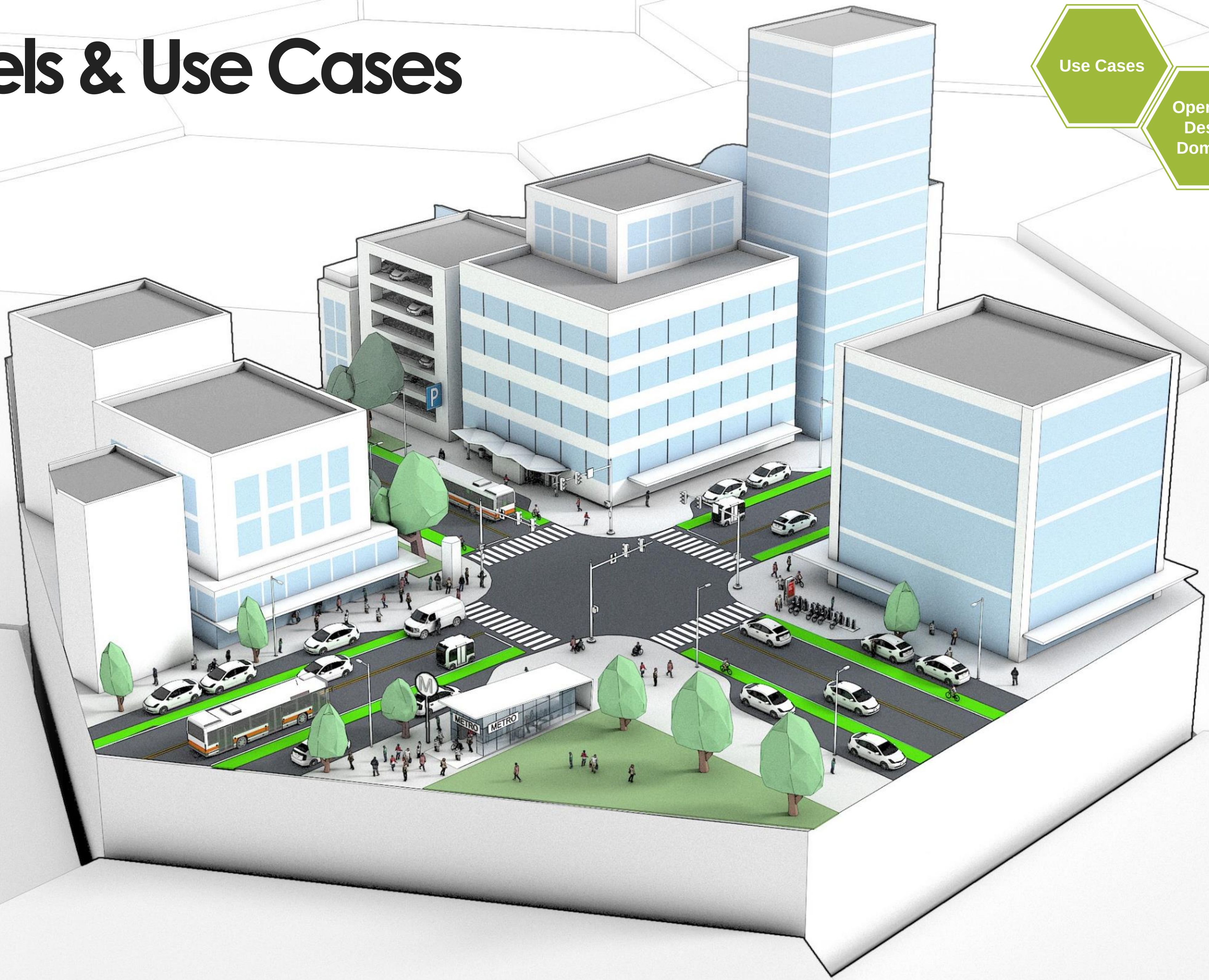
Operating Design Domains

Service Models

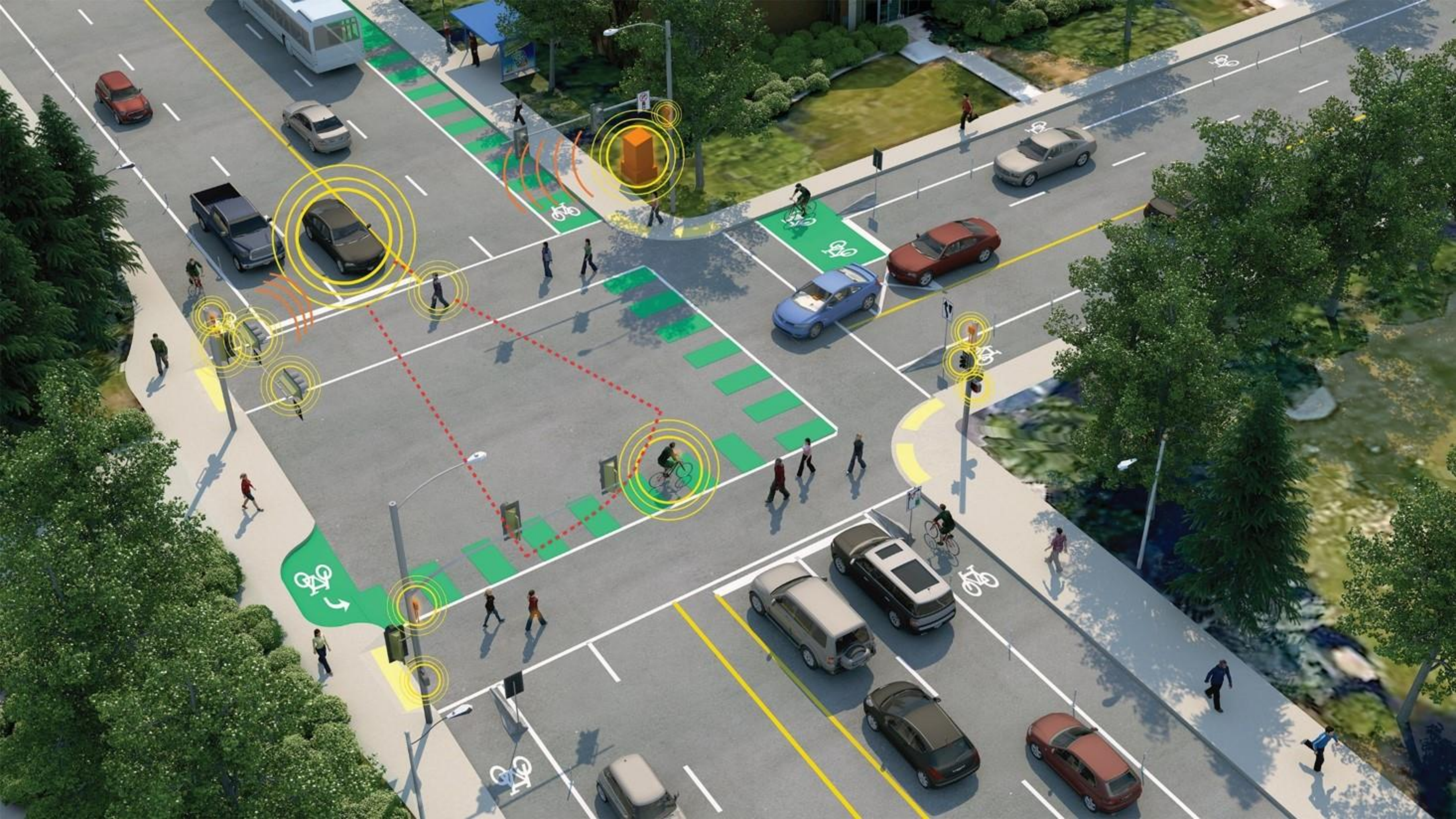
- Fixed-Route
- On-demand
- Prearranged route or zone-based
- Flexible route-based
- Private property

Use Cases for LSAVs

- Fixed-route
- Circulators
- Shuttles (A-B)
- First/Last Mile
- Paratransit
- Educational Services
- Health Care Services
- Employment
- Entertainment
- Recreation/Retail
- Parking
- Residential Developments/Senior Social Services



Managing ODDs



Operational Design Domain (ODD)

- Common terms that *may be used* by developers to describe their ODD
- Logically organized, but structurally agnostic
- Semantic labels, definitions, ranges

Weather-related environmental conditions

Operational constraints

Road Users

Roadway infrastructure

Road surface conditions

Non-static roadside objects

Connectivity

ODD Lexicon – SAE Autonomous Vehicle Safety Consortium (AVSC)

Operational Design Domain (ODD)

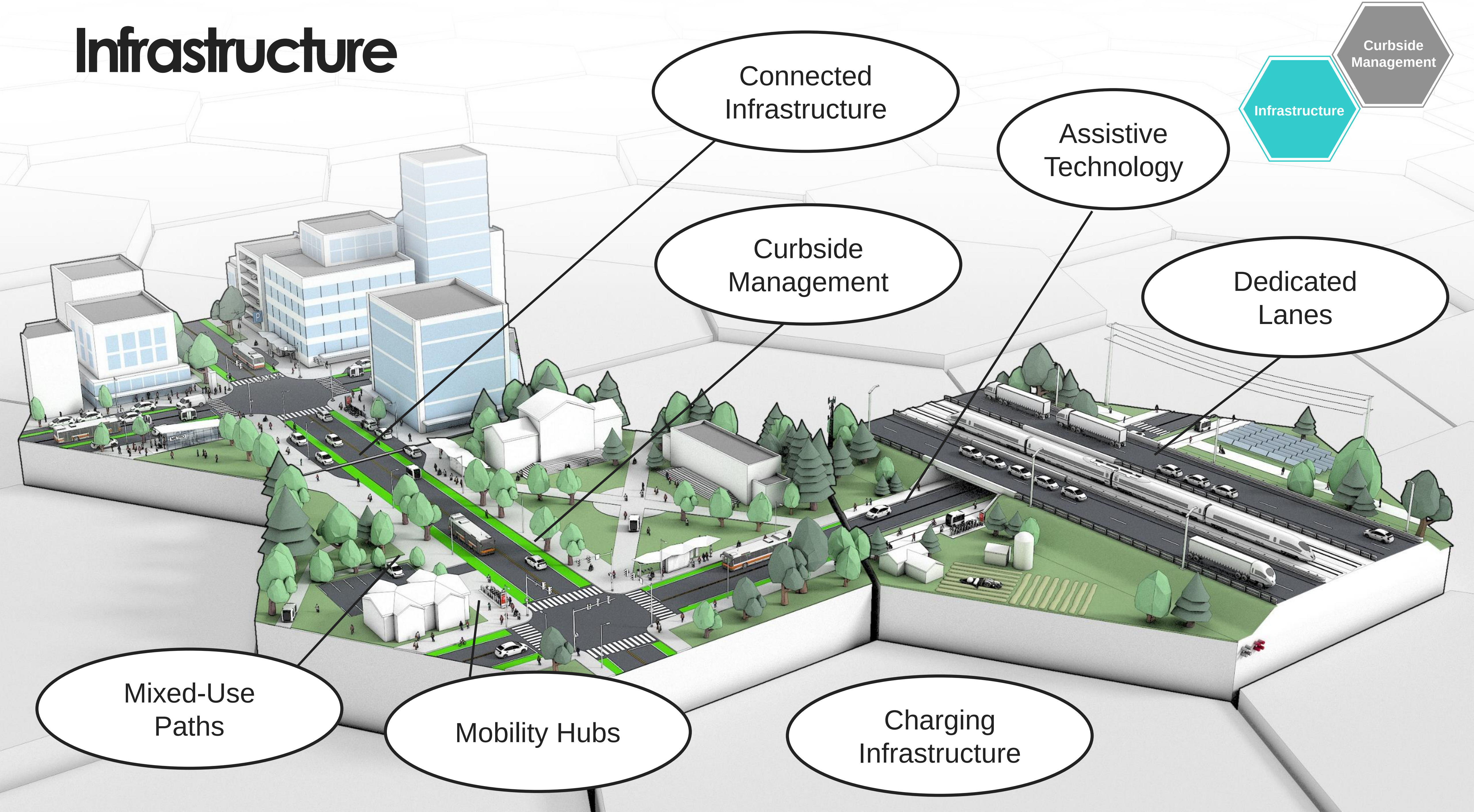
Use Cases

Operating Design Domains

Characteristics in operating environment:
Posted/operational speeds, Intersections/crossings, Road conditions

ODD	Description/significance	Example
Level of interaction with other road users (Right of Way):		
Exclusive off-street guideway	Operates in dedicated guideway or path; may be governed by geo-fencing or physical infrastructure	Jacksonville Ultimate Urban Circulator (U^2C)
Off-street multi-use pathway	No light-duty vehicle traffic; pedestrians, cyclists, scooters present	Arlington Milo shuttle
On-street pathway, dedicated lane for LSAVs	Dedicated lane with other traffic, no physical barrier	Jacksonville (JTA) Bay Street Corridor
On-street pathway, dedicated lane for LSAVs and other transit vehicles	Dedicated to specific types of vehicles and transit	Tampa downtown shuttle
On-street, mixed-traffic	ROW/street in mixed traffic	Bedrock Detroit shuttle
Crossings/Turns: This refers to how the route of the vehicle crosses the path of other vehicles.		
Unprotected left-hand turns	The vehicle must cross the pathway of other vehicles.	N/A

Infrastructure

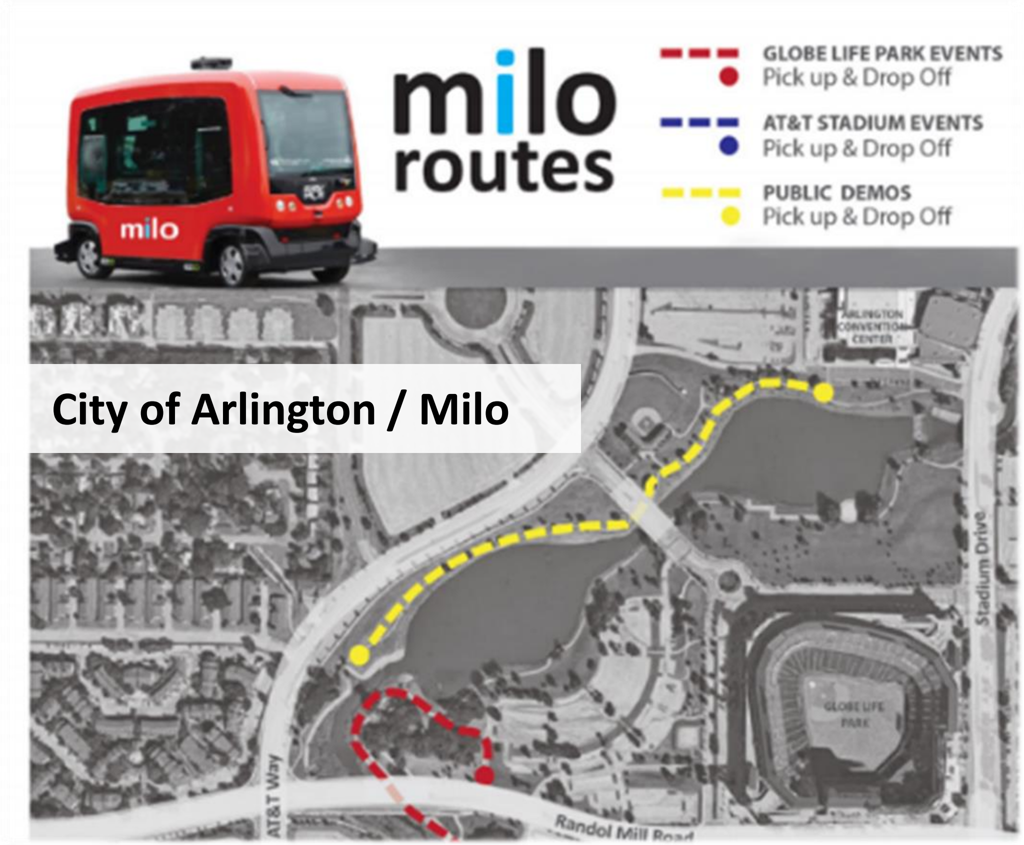


Meeting safety, access, accessibility, and mobility objectives

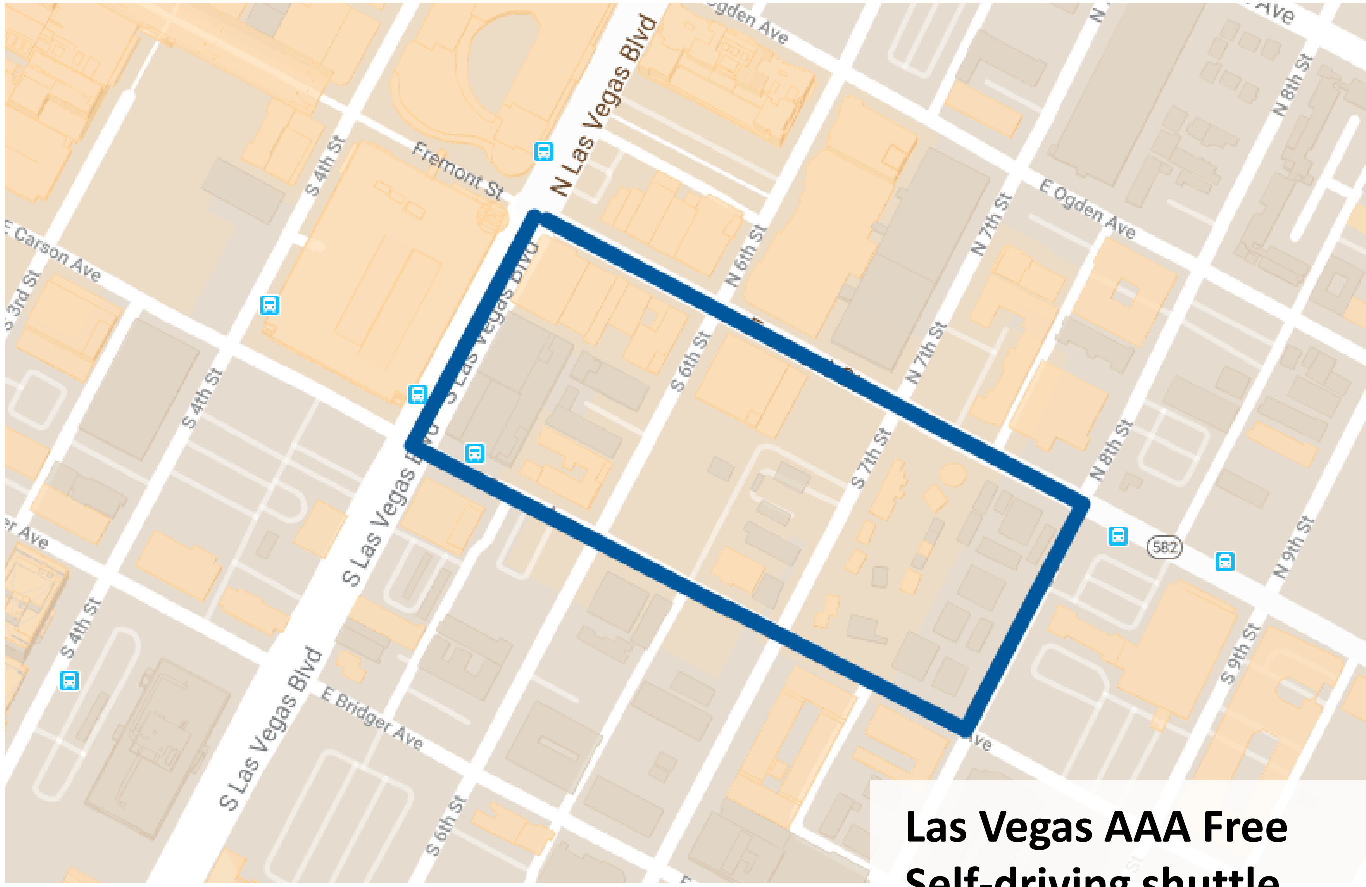

navya
navya
navya
DETROIT MOVES
navya
be fluid
#DetroitMoves
Mobile Bicycle Shop
Mobile Bicycle Shop
MAY

How have agencies thought about LSAVs thus far?

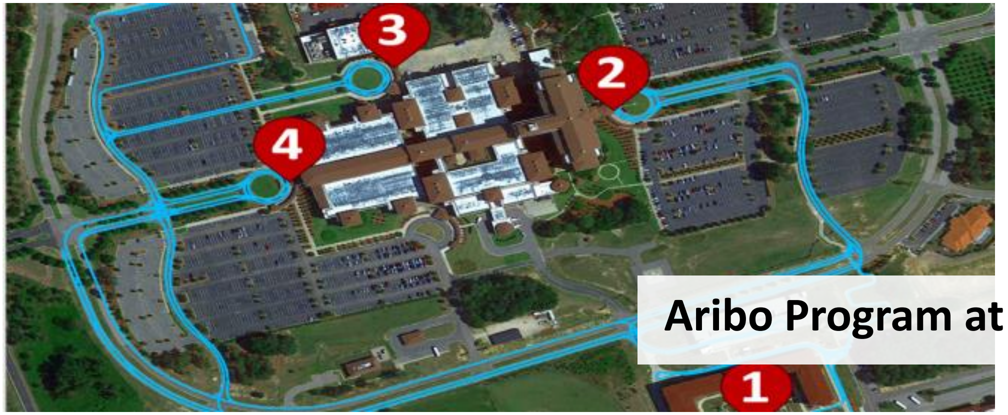
- Public transit agencies first looked to LSAVs primarily to understand the technology and its potential applications
- Agencies, cities, and private providers have tested different uses.
- Agencies are planning MOD and fixed route service; but there are no known plans to replace an existing route with LSAV service.



City of Arlington / Milo



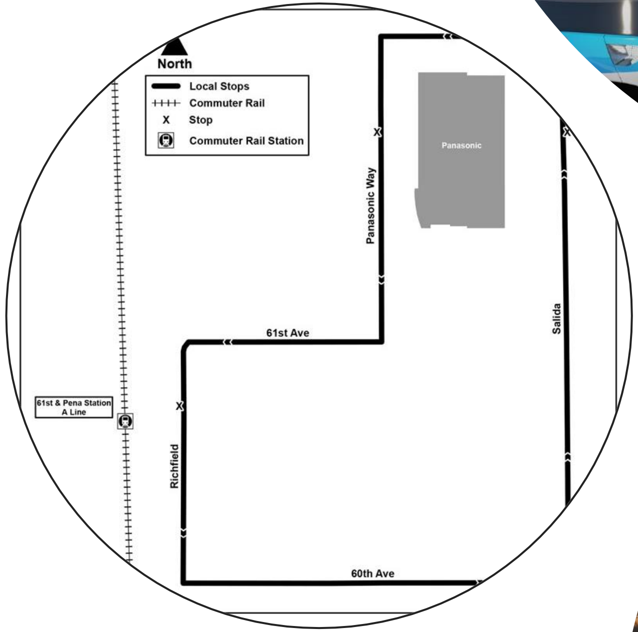
Las Vegas AAA Free Self-driving shuttle



Aribo Program at Fort Bragg

Exploring further LSAV-transit integration

- RTD (Denver)'s AV shuttle for the first-mile/last-mile from a commuter rail station was operated in 2019
- In process for a few years, Jacksonville Transit Authority (JTA)'s Ultimate Urban Circulator (U2C) LSAV project aims to replace and extend their elevated SkyTrain
- Mobility Hubs and other infrastructure efforts seek to integrate LSAVs and other AVs into the shared mobility system including transit, microtransit, shared vehicles, MaaS, and MoD



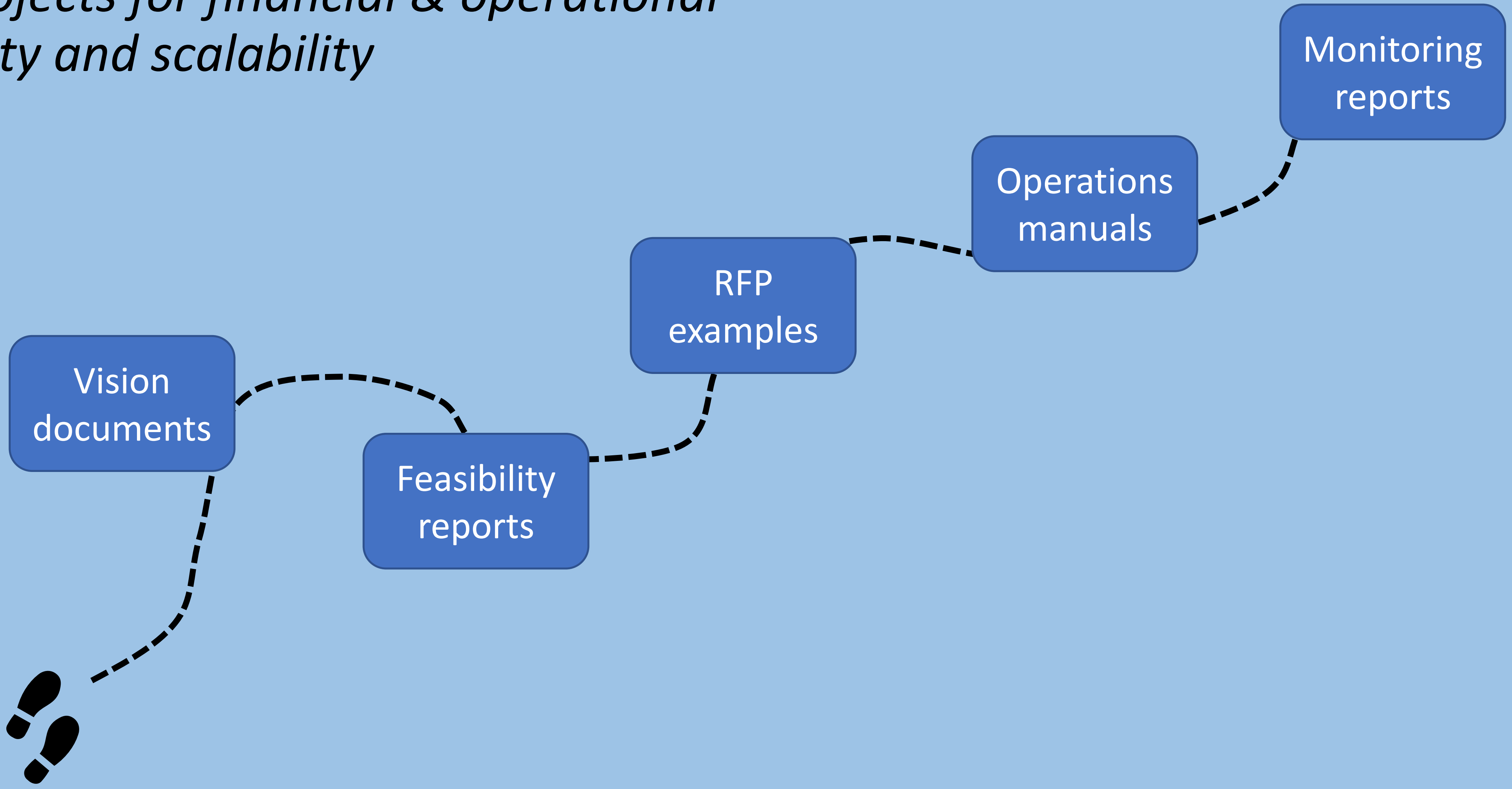
Use Case Examples

Use Cases
Operating Design Domains

Use Cases	Examples
Fixed-Route	Jacksonville, FL; Mountain View, CA
Circulators	Grand Rapids, MI; Columbus, OH; Gainesville, FL
Shuttles (A-B)	Babcock Ranch, FL; Tampa, FL
First/Last Mile	Providence, RI; Utah DOT/UTA; Weymouth, MA; Reston, VA; Denver, CO
Paratransit	Honolulu, HI
Educational Opportunity	Ann Arbor, MI (University of Michigan MCity Pilot); Gainesville, FL
Health Care Services	Ft. Bragg, NC; GoMed Shuttle, Las Vegas; and Youngstown, OH
Employment	Pawtucket, RI; and Frisco, TX
Entertainment and Recreation/Retail	City of Arlington (TX), the Assembly (GA)
Access to Parking	Bedrock Detroit; City of Arlington (TX)
Retirement Community /Senior Social Services	The Villages (FL and CA) and Grand Rapids, MI

LSAV Practitioner Guide – A Walking Tour

Building projects for financial & operational sustainability and scalability



Resources:

- Sample Contracts
- Procurement Documents
- Long Range Planning Reports
- Mobility Innovation Frameworks
- Customer Acceptance Surveys
- Info on Insurance
- Concept of Operations
- Checklist for planning & implementation
- Long term initiatives
- Monitoring and Evaluation

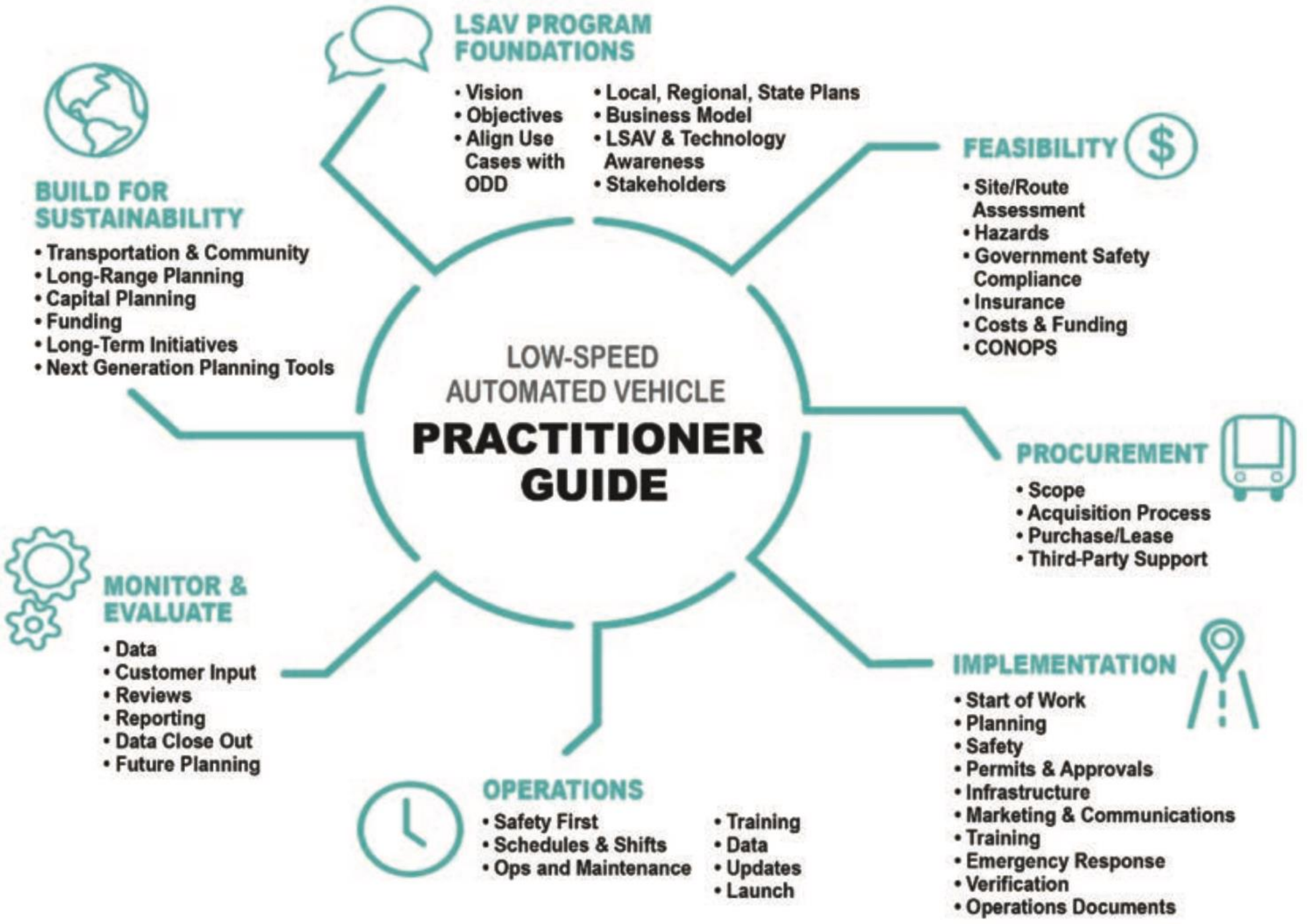


Figure 5.1. Practitioner Guide overview.

Keys to Scaling LSAVs in Transit

✔ **Long-Range Planning.** Incorporate LSAV projects into existing regional and state long-range plans and evaluate potential projects to be placed in constrained plans, such as
- Capital and operating budgets,
- Constrained LRTPs,
- Transit development plans, and
- TIPs.

✔ **Capital Planning.** Review and update state, municipal, and transit agency capital planning documents and budgets.

✔ **Funding.** Create a funding matrix of public and private grant, contract, and innovation investment funds.

✔ **Long-Term Initiatives.** Integrate the LSAV service into longer-term projects, including
- Curbside management studies,
- Digital infrastructure,
- General public transit improvement plans,
- Human services plans,
- Land-use studies,
- Lane reallocation and complete streets initiatives,
- Local and regional corridor transportation plans,
- Municipal capital planning,
- Parking studies, and
- Sign codes and signage.

✔ **Next-Generation Planning Tools.** Develop and adopt next-generation operational planning tools, including
- Capacity management through pricing, geofencing, and data from infrastructure and vehicle sensors;
- Cross-sector technology planning;
- Data-based planning and operations tools;
- Land use;
- Mobility innovation and smart city plans;
- Public–private partnerships;
- Scenario planning; and
- Simulations and visualization.

✔ **Mobility Hub Plans.** Design adaptive mobility hubs at transit stations, taking into consideration:
- Multimodal passenger and delivery services,
- Support for amenities and adaptive or future-proofed infrastructure design,
- Designated pick-up and drop-off areas,
- Bike and pedestrian infrastructure,
- Universal access through design and operation,
- Electric charging and communications facilities, and
- Strong sense of placemaking including key retail services.

✔ **Curbside Management Plans.** Develop and implement strategies to manage curbside as a terminal for AV drop-off and pick-up for passengers and goods, including
- Dynamic pricing and geofencing;
- Smart zones for loading;
- Policies relating to managing micromobility including smaller, automated electric vehicles on the sidewalk; and
- Enhanced accessibility for people with disabilities at the curb.

5.7 Sustainability Resources (Part 1)

Preparing Communities for Autonomous Vehicles, APA

APA AV Knowledge Base*

APTA Research Page on Autonomous and Electric Vehicles*

CTAA Statement of Principles for Automated Vehicles

NACTO Blueprint for Autonomous Urbanism (second edition 2019)

National League of Cities Autonomous Vehicles: A Policy Preparation Guide

National League of Cities Autonomous Vehicle Pilots Across America (2018)

NCTCOG Automated and Connected Vehicles Planning Page*

Miami-Dade TPO Connected-Autonomous Vehicle Program*

Click on the item to access the resource.

*updated periodically

Delivering Real Benefits with LSAV Technology

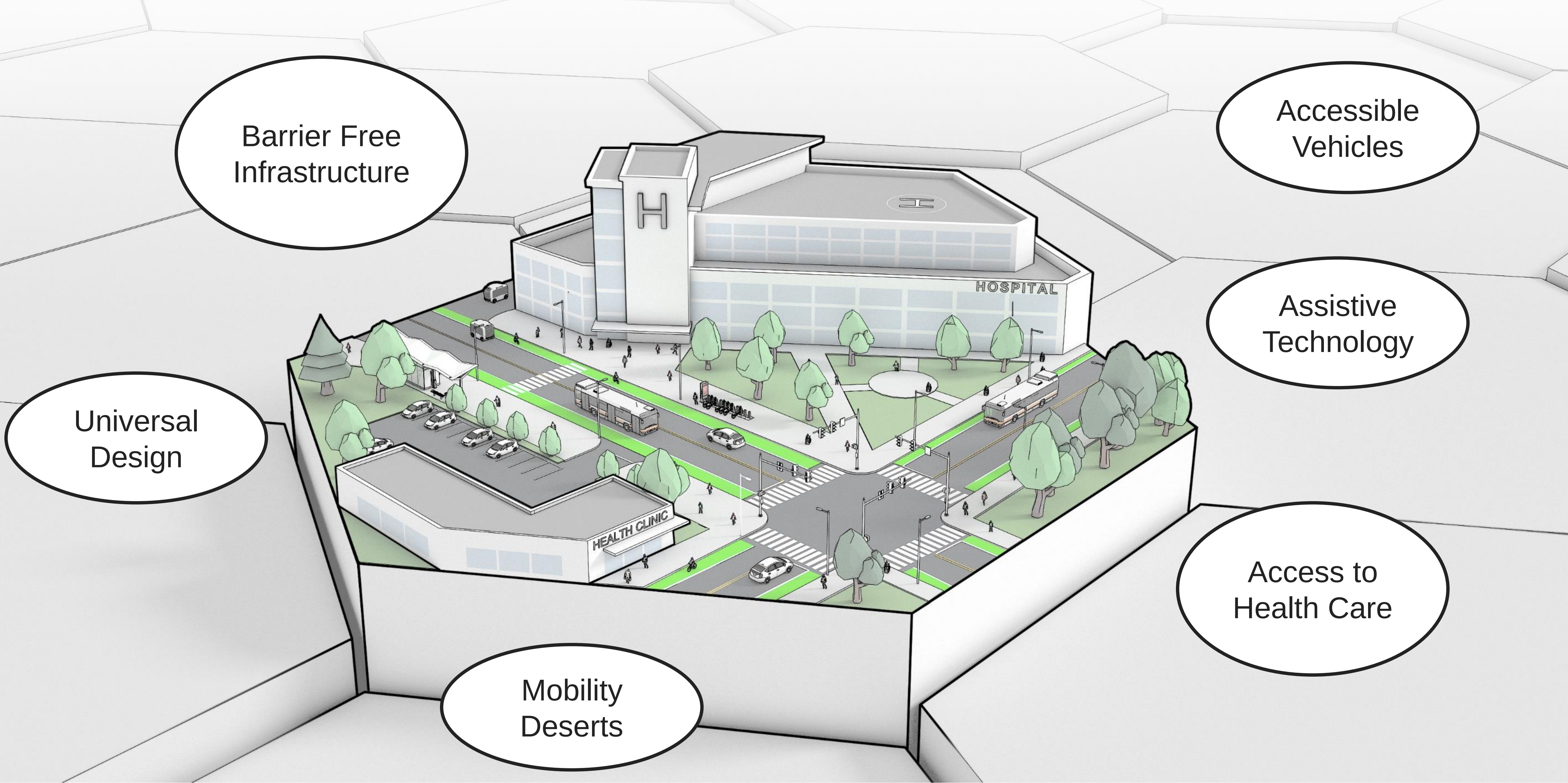
1. Mobility – *enhancing movement through the city on a network*

2. Access – *improving the ability for people to equitably reach crucial services/amenities*

3. Accessibility – *allowing all people to use new mobility services*

4. Safety – *protocols and systems that help autonomous technology to be robustly implemented to help drive trust in the technology*

Accessibility & Equity



Expanding Access & Enhancing Mobility

LSAV Planning Integration

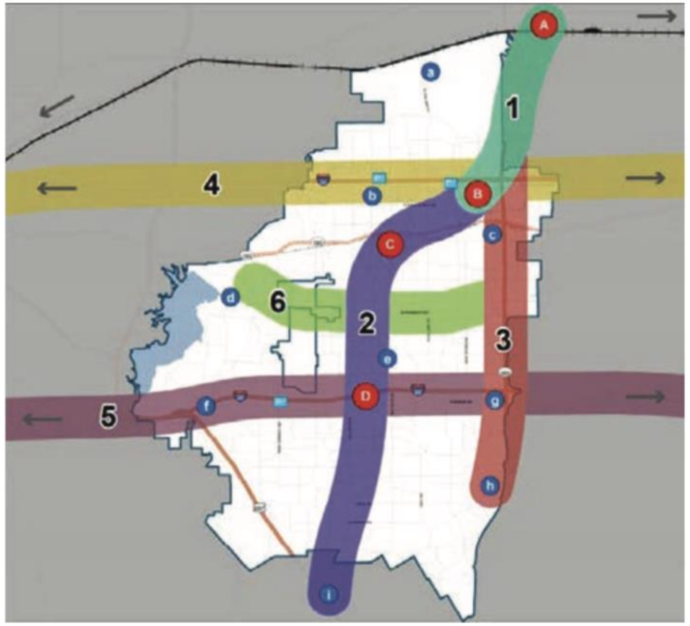


Figure D.1.3. Key new mobility corridors.

Long-Range Planning (e.g. existing regional/state long-range plans)

- Evaluate potential projects to be placed in constrained plans, such as:
  - Capital and operating budgets
  - Constrained Long-Range Transportation Plans
  - Transit development plans, Transportation Improvement Plans (TIPs)

Capital Planning

- Review and update state, municipal, and transit agency capital planning documents and budgets

Long-term initiatives

- Curbside management, digital infrastructure, land use, lane reallocation /complete streets projects, parking studies

Payment and policy integration into the larger mobility ecosystem can help improve access for all users and potentially serve regional objectives

Protocols to help ensure safety during LSAV deployments

- Hazards assessment and mitigation,
- Safety operations protocols,
- On-board diagnostics,
- Initial & refresher safety operator training plans,
- Emergency preparedness plans, and
- Continuous improvement processes to help ensure vigilance and up-to-date safety practices throughout the project

Excerpt from EasyMile Site Assessment Report (2017)

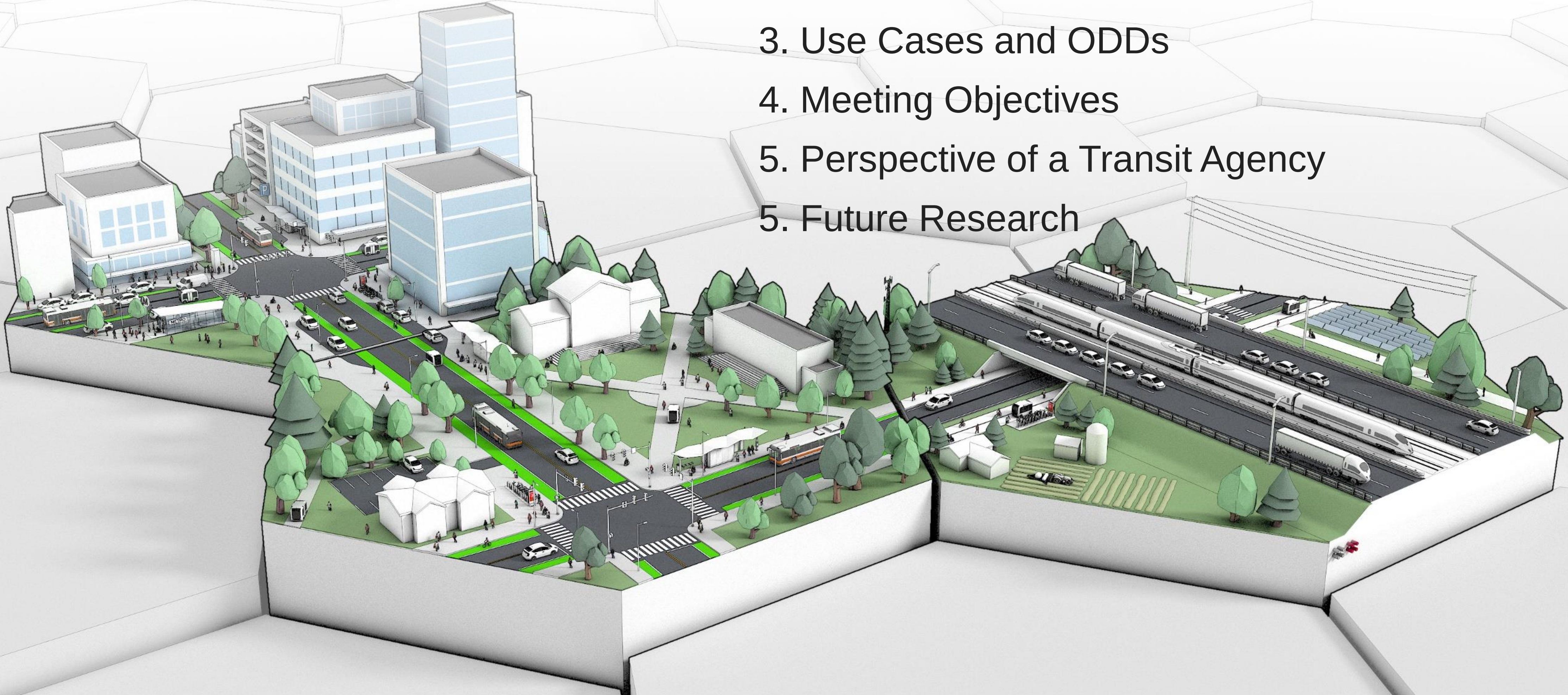
Infrastructure Changes Required	Reason
Concrete crossing turnouts	The existing multiuse pathway is not wide enough for two vehicles to pass.
Rocks along lake edge	This gave the vehicle additional reference points to minimize risk associated with localization deviation. This path followed a small lake that had insufficient reference points for the EasyMile vehicle.
Birdhouses along path	These provided fixed reference points for the vehicle to identify its location when clear edges are not available.
Tree/grass trimming	This kept the path clear for the EZ10 shuttle and ensured that grass clippings/branches would not be interpreted as obstacles that slowed the operation of the vehicle.
Signage and path marking	This is for users of the path and shuttle riders, to help them go to the right location and to share the path with the EZ10.

Well-developed training programs for operators and hazard mitigation plans help improve safety of LSAV operations

What's on your mind?

Questions

1. Nature of Research
2. Trends
3. Use Cases and ODDs
4. Meeting Objectives
5. Perspective of a Transit Agency
5. Future Research



Contact:

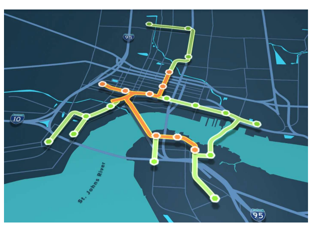
KelleyCoyner@Innovation4Mobility.com


Ultimate Urban Circulator
Impact through Automation and Innovation
ULTIMATE URBAN CIRCULATOR
WELLS FARGO
Bernard Schmidt
VP of Automation & Innovation
Jacksonville Transportation Authority

Ultimate Urban Circulator (U²C) Journey

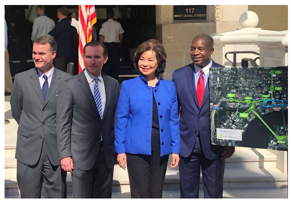
2015

Advisory Committee Approves Conversion via U²C



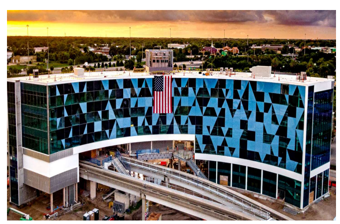
2016

JTA Board approves Advancement of U²C



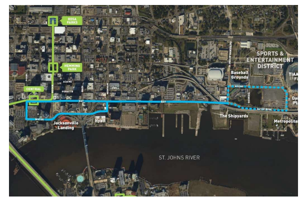
2018

JTA Awarded BUILD Grant



2020

JRTC the 1st U²C Hub Built

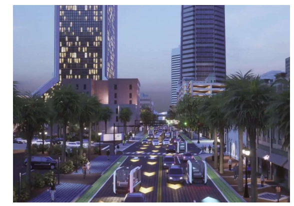


2020

Bay Street Innovation RFP Issued

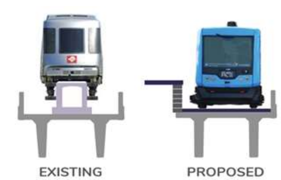
2022

U²C Skyway Station Opens



2023

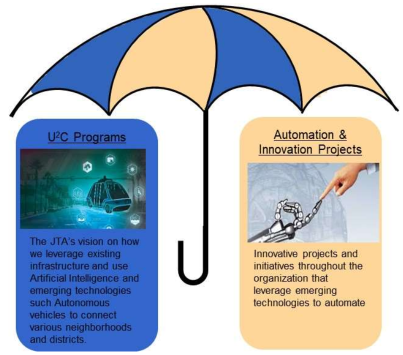
Bay Street Innovation Corridor Launch



2025

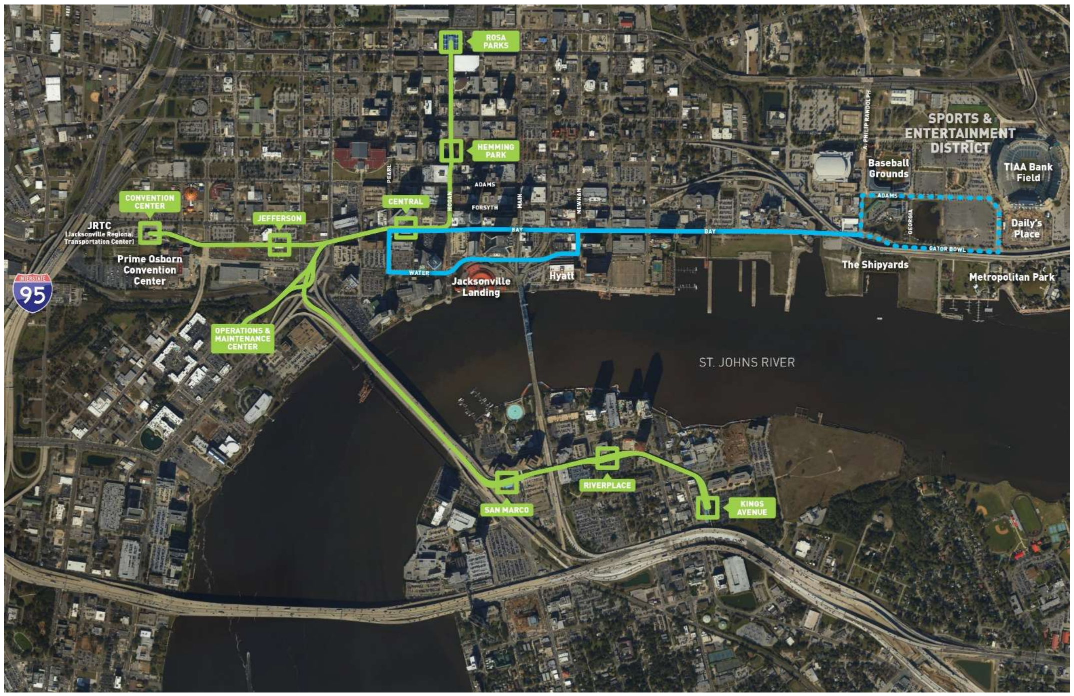
Skyway Conversion to U2C

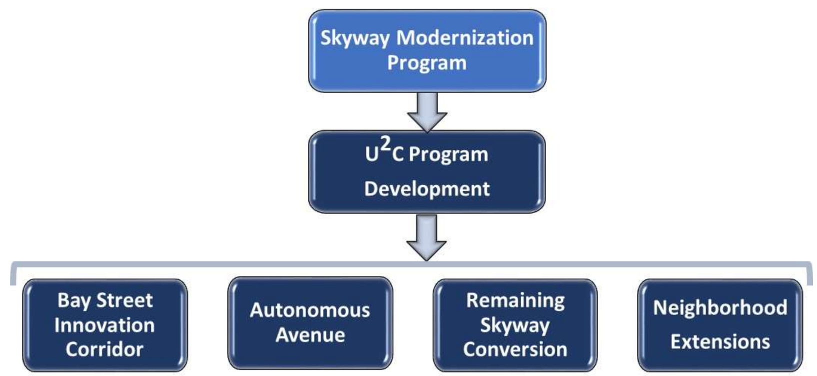
Automation & Innovation Division



Jacksonville Transportation Authority

Ultimate Urban Circulator (U^2C)





Bay Street Innovation Corridor Project

BUILD Grant Funding

Active 2 Step Procurement

Contract Award 3Q21

Implementation Strategy

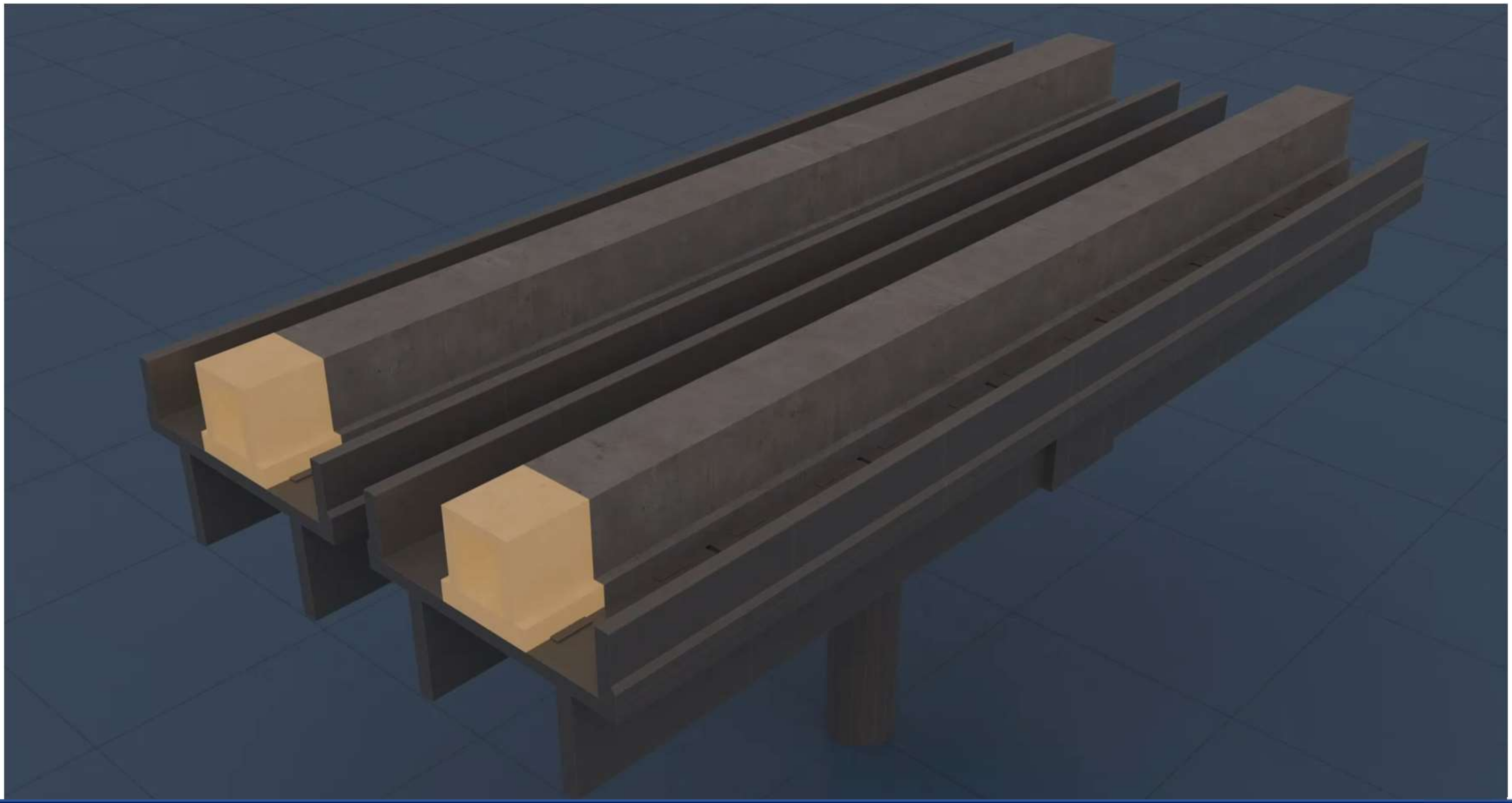
U^2C Program Development

Bay Street Innovation Corridor

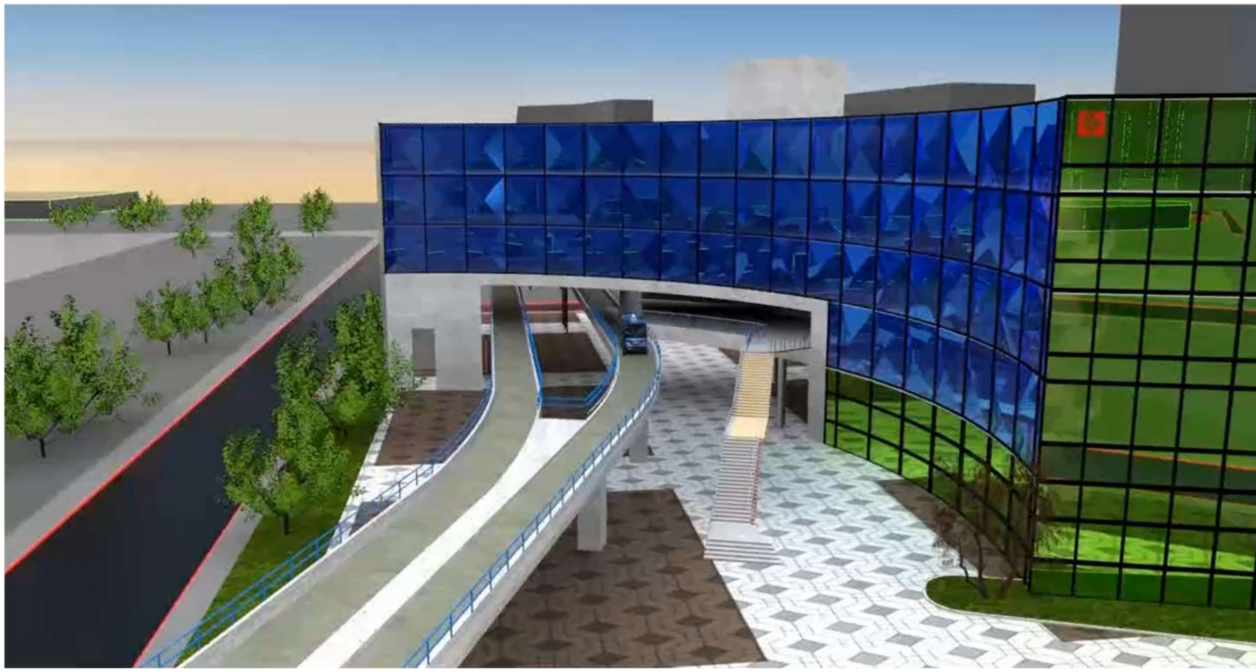
Autonomous Avenue

- Infrastructure and Miscellaneous Requirements
- Funding Strategy
- IT & Cybersecurity (Integrated Data Exchange)
- Vehicle Design & Selection (Operations & Testing)
- Policy & Regulations
- Business Development & Analysis

The Original Concept

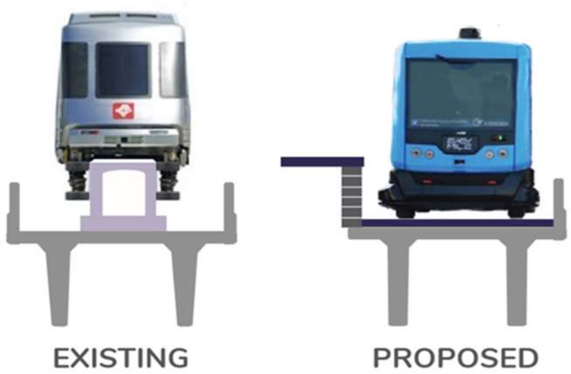


Autonomous Avenue



- Infrastructure and Miscellaneous Requirements
- Funding Strategy
- IT & Cybersecurity (Integrated Data Exchange)
- Vehicle Design & Selection (Operations & Testing)
- Policy & Regulations
- Business Development & Analysis

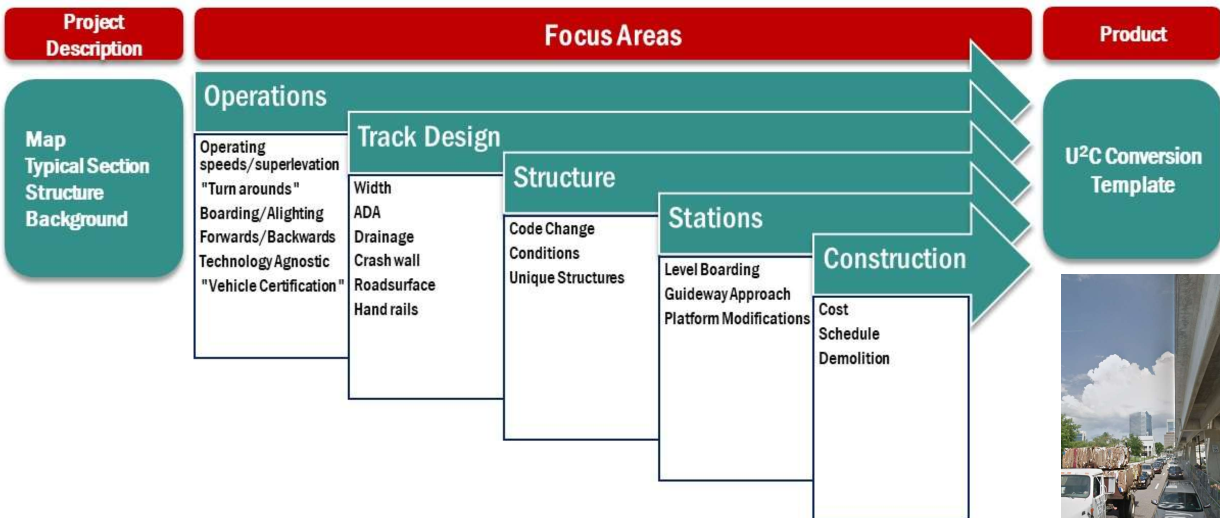
Autonomous Avenue



Autonomous Ave

Where are we today??

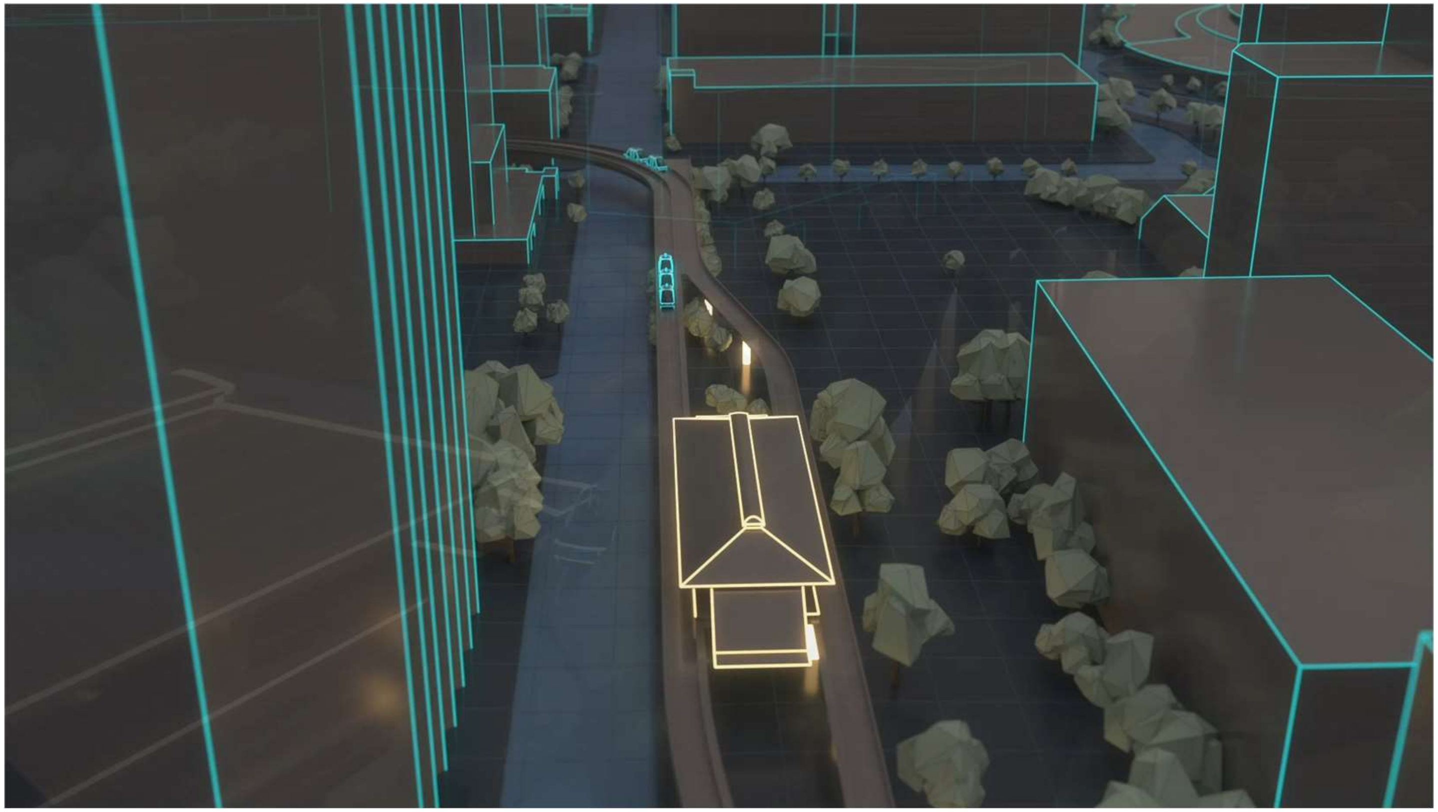
- ✓ Retrofit Concepts complete – 2 Possible Options
- ✓ Structural & Engineering evaluation (Roadway, Structure, & Stations)
- ✓ ADA analysis Complete



3 Main Issues Resolved

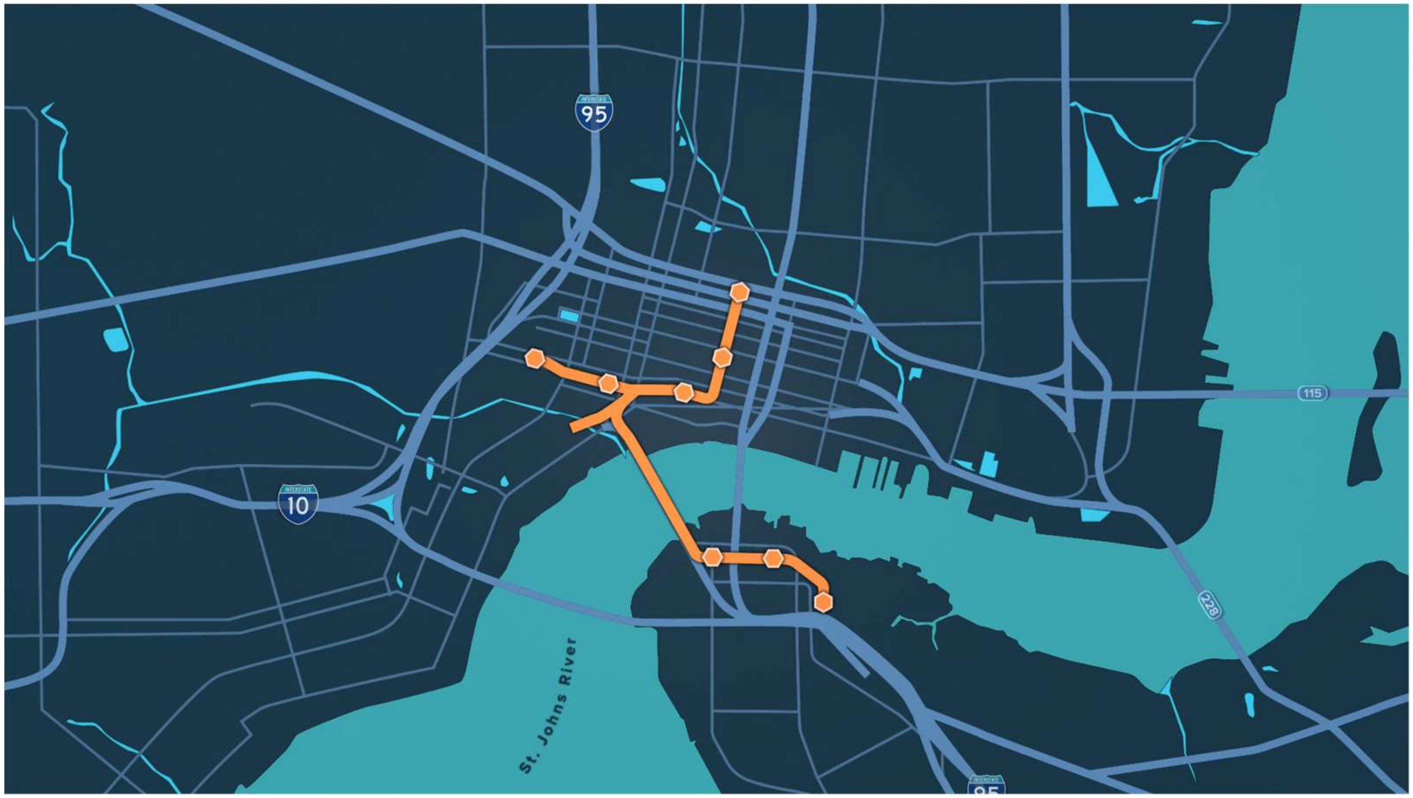
- ➢ ADA Compliance of Retrofit
- ➢ Roadway Design to Sustain Retrofit
- ➢ Existing Station Modification

U^2C – Connecting Elevated & 'At Grade'



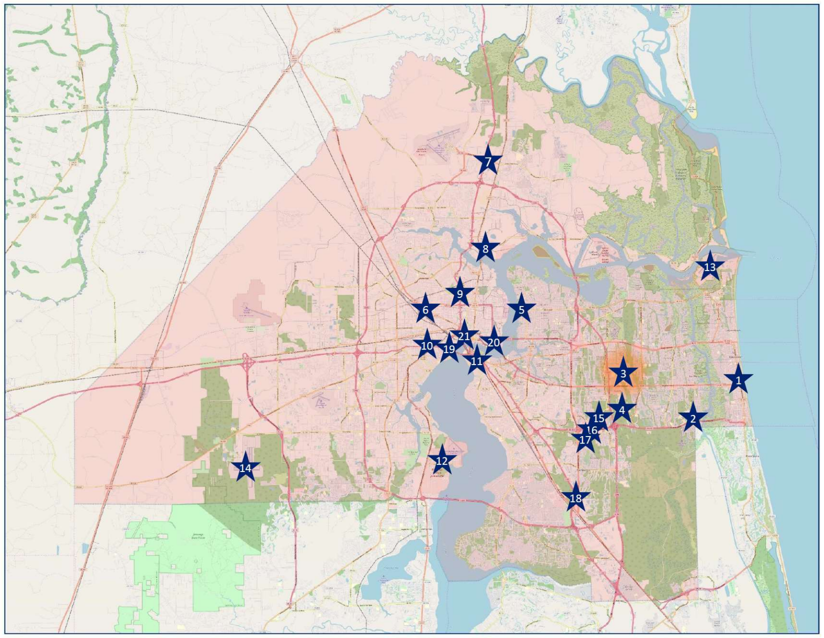
Ultimate Urban Circulator U²C

- ✓ Expands System to 10 miles
- ✓ Connects to neighborhoods and redevelopment areas
- ✓ Leverages multiple public investments
- ✓ Creates autonomous transportation network.

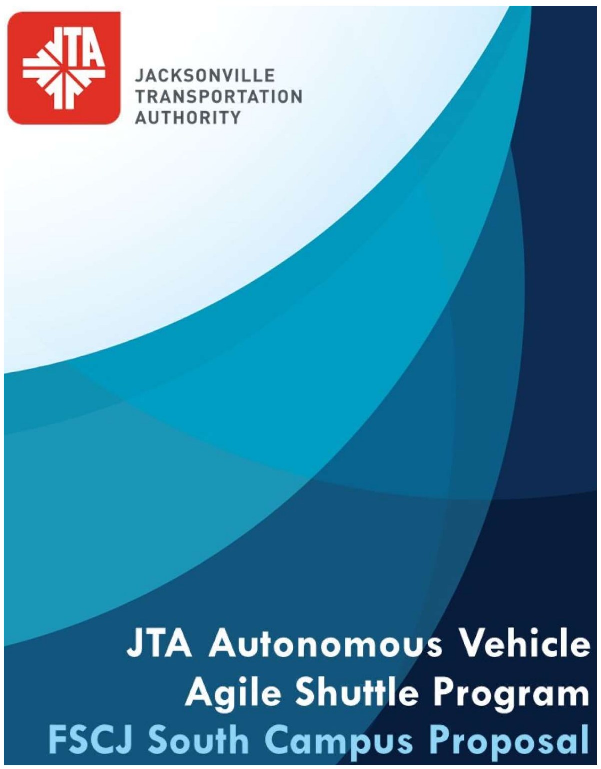


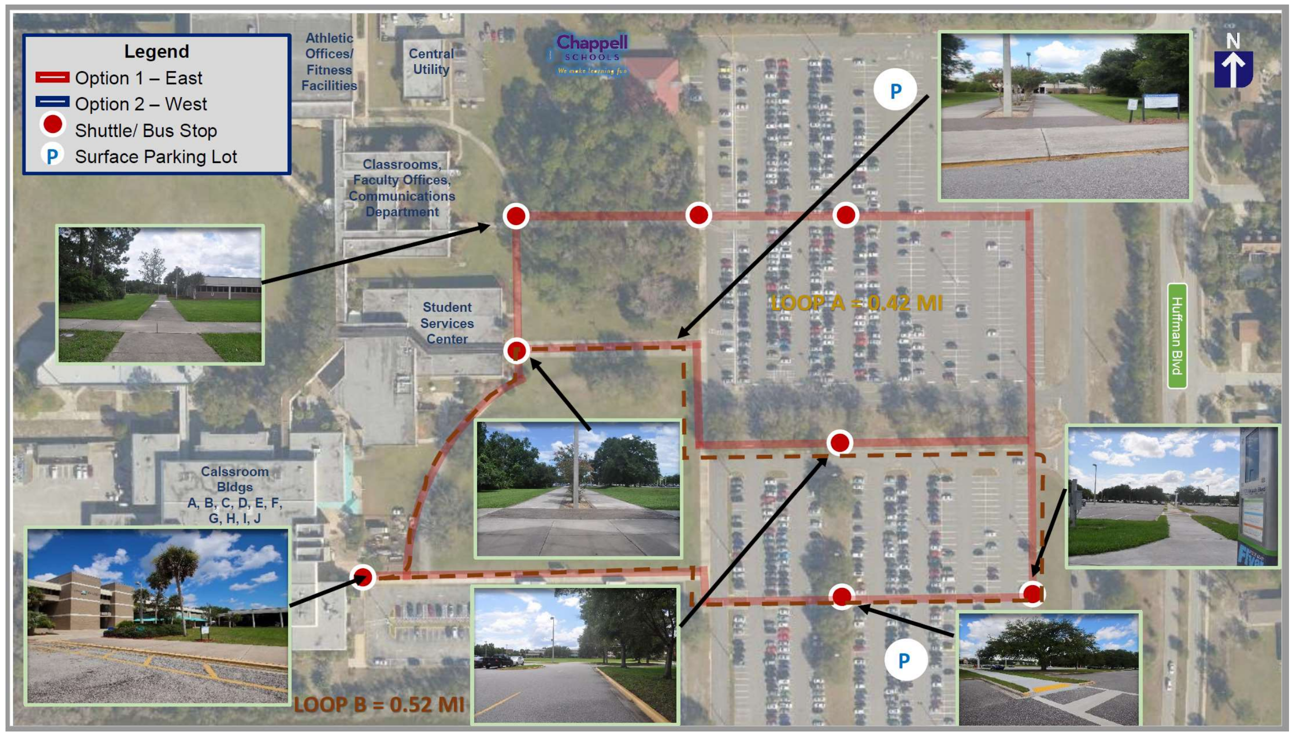
Agile Plans

- 22 Opportunities
- 5-6 Vehicles
- Private Land Operation
- High Utilization
- Widespread Visibility
- Manual Scheduling
- Low Infrastructure / Low Capital
- Supports Test & Learn Strategy
- Can be concurrent with BSIC



Agile Plan – FSCJ South Campus





Agile Plan – Jacksonville University

JTA Autonomous Vehicle – Agile Shuttle Program

Candidate Site Background/Conditions

The Jacksonville University (JU) Campus offers a full spectrum of college credit and certification classes, serving as a private non-profit institution. The main JU Campus, located riverfront to the St. Johns River, sits on 240 acres. Campus population nears 4,222 students (Fall 2017 Semester).

Jacksonville University overseeing St. Johns River

The main Campus is home several colleges as well as on-campus housing, athletic facilities, Swisher Library, student facilities, and dining options. The College of Arts and Sciences, the Davis College of Business, the Brooks Rehabilitation College of Healthcare Sciences, and the Linda Berry Stein College of Fine Arts conduct JU's traditional undergraduate and graduate academic programs. Jacksonville University offers more than 100 academic majors and programs across all disciplines and locations, including downtown Jacksonville.

Most buildings are adjacent to a pedestrian courtyard that facilitates bicycle and pedestrian movement. The campus includes more than 30 buildings, several athletic facilities, and eight residence halls or village apartments. Parking facilities are available for students and staff, with restrictions based on enrollment. Limited parking is available for visitors and alumni.

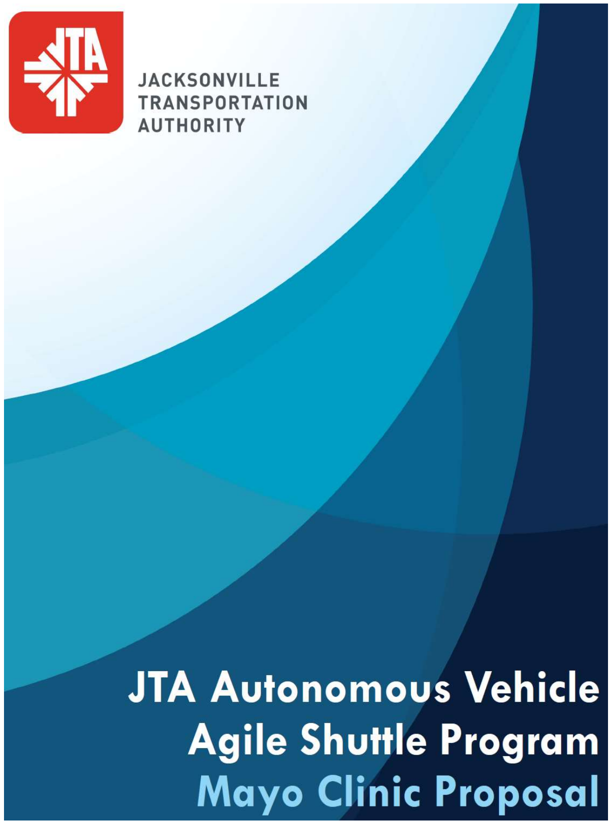
Most recent demographics show 2,877 undergraduate and 1,345 graduate students. Student population is mostly white (47%), followed by Black or African American (15%), and Hispanic (9%). Student profile includes students from 47 states, 4 districts and territories and 51 foreign countries represented. (Fall 2017 Fact Book).

Campus Buildings

Student Housing

Student Facilities

Agile Plan – Mayo Clinic



JTA Autonomous Vehicle – Agile Shuttle Program

Candidate Site Background/Conditions

The Mayo Clinic Jacksonville is a comprehensive medical center situated on 400 acres near the intersection of J T Butler Blvd. and San Pablo Rd. The center contains a mix of services, including a full hospital, outpatient care, research and a hotel. The three main buildings at the site are the Davis Building, the Mayo Building and the Cannaday Building. Excluding lodging, the center draws approximately 5,500 employees across several lots spread around the property.

Employee Shuttle Schedules

6 – 10 am 3 – 8 pm	Lot E2
6 – 10 am 3 – 8 pm	Lot E5
7 – 10 am	Lot E3
6 – 10 am 3 – 8 pm	Lot E6

Employee shuttle service is available across most lots. Service hours vary. Posted frequency is 10 minutes. Patient and visitor shuttle service is offered from 8 am to 5 pm, though parking locations are more convenient. Employee parking appears to be more of a challenge, with some lots over a 10-min walk.

Construction results in some locations being logistically challenging to walk around.


Parking Amenities

Campus Buildings


JTA Drop-off

MAYO Clinic AV Deployment – Response in Time of Crisis

JACKSONVILLE TRANSPORTATION AUTHORITY

Jacksonville Transportation Authority

ULTIMATE URBAN CIRCULATOR

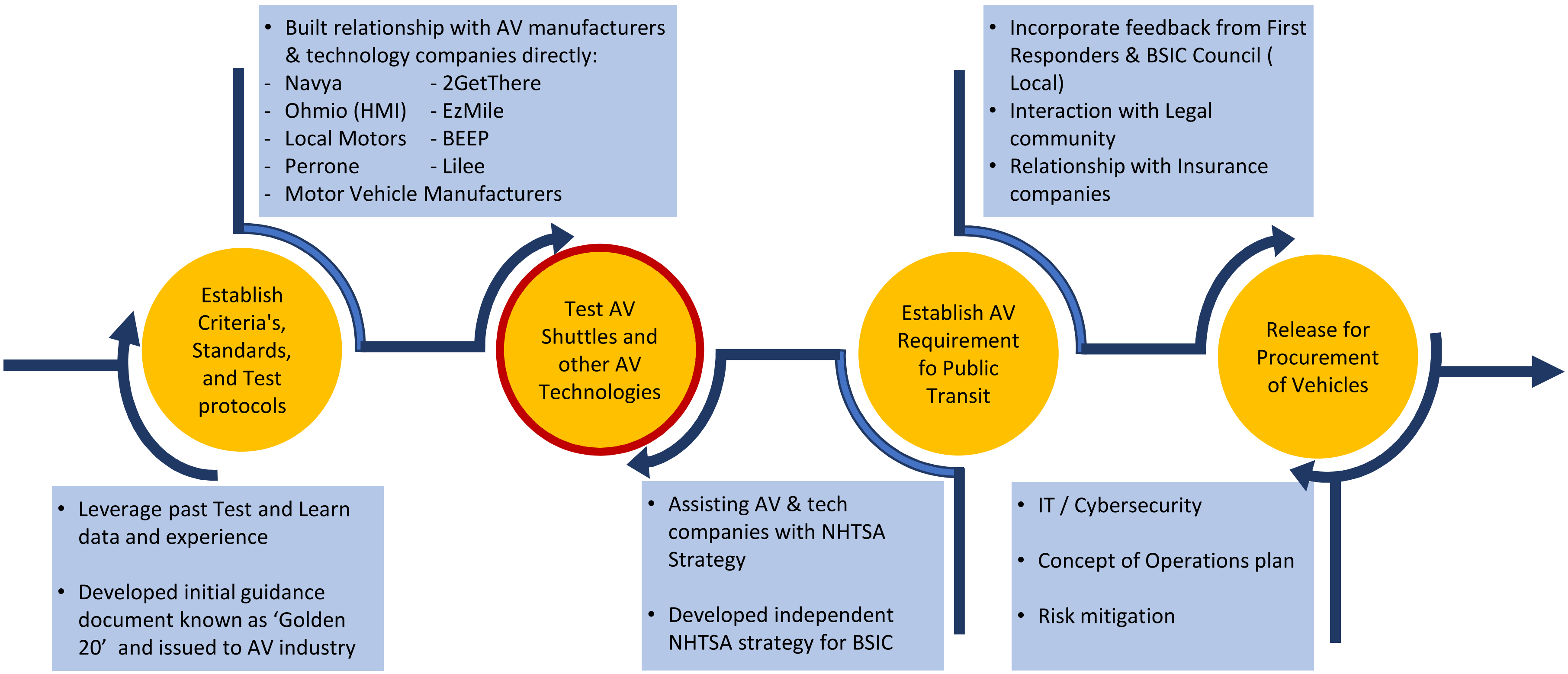
MAYO COVID-19 OPERATIONS

Friday, April 3 through Thursday, July 16

JTA – Innovating during a time of Crisis

- First Level 4 Autonomous Use Case in the US to move COVID-19 Specimens
- Approx. 30,000 COVID-19 Specimens transported with **ZERO SAFTEY INCIDENTS**.
- Benchmark Test and Learn Program for moving product in mixed-traffic conditions
- Socialization Experiment

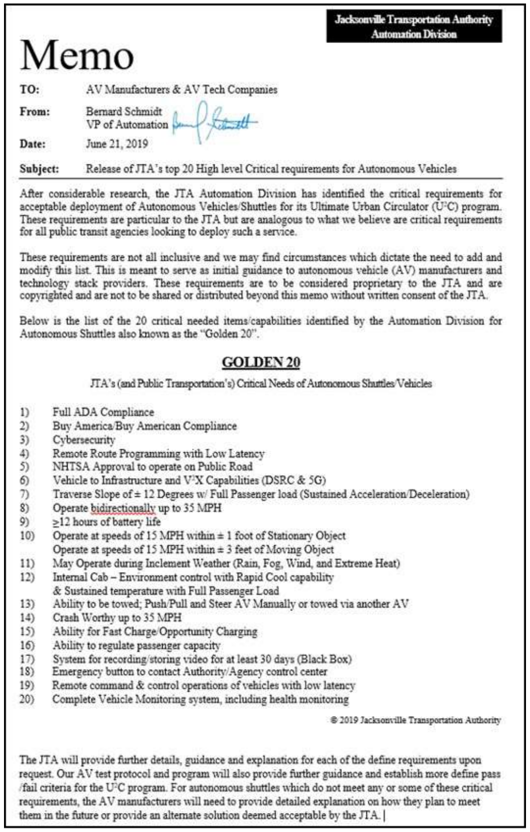
Test and Learn – Current Approach & Strategy



Jacksonville Transportation Authority

ULTIMATE URBAN CIRCULATOR

JTA – Test and Learn Program – AV Leadership & R&D – 'Golden 20'



Jacksonville Transportation Authority
Automation Division

Memo

TO: AV Manufacturers & AV Tech Companies

From: Bernard Schmidt
VP of Automation

Date: June 21, 2019

Subject: Release of JTA's top 20 High level Critical requirements for Autonomous Vehicles

After considerable research, the JTA Automation Division has identified the critical requirements for acceptable deployment of Autonomous Vehicles/Shuttles for its Ultimate Urban Circulator (U^2C) program. These requirements are particular to the JTA but are analogous to what we believe are critical requirements for all public transit agencies looking to deploy such a service.

These requirements are not all inclusive and we may find circumstances which dictate the need to add and modify this list. This is meant to serve as initial guidance to autonomous vehicle (AV) manufacturers and technology stack providers. These requirements are to be considered proprietary to the JTA and are copyrighted and are not to be shared or distributed beyond this memo without written consent of the JTA.

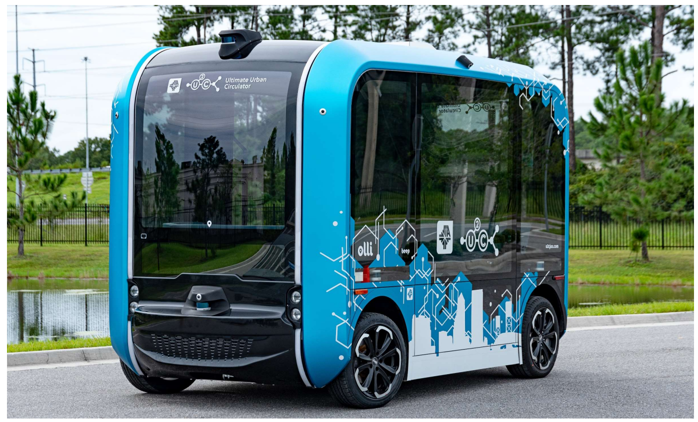
Below is the list of the 20 critical needed items/capabilities identified by the Automation Division for Autonomous Shuttles also known as the "Golden 20".

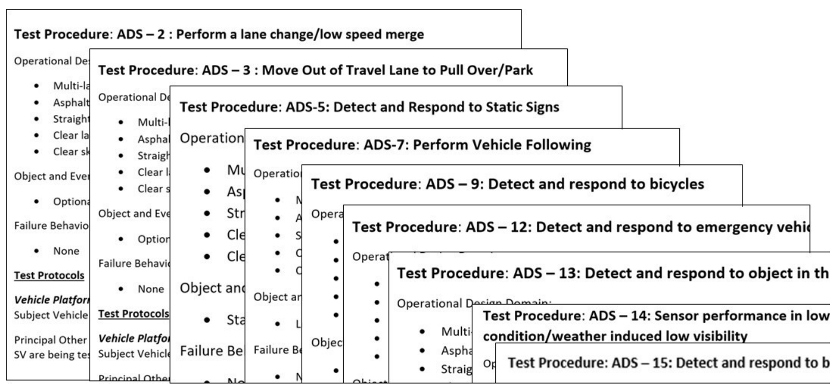
GOLDEN 20

JTA's (and Public Transportation's) Critical Needs of Autonomous Shuttles/Vehicles

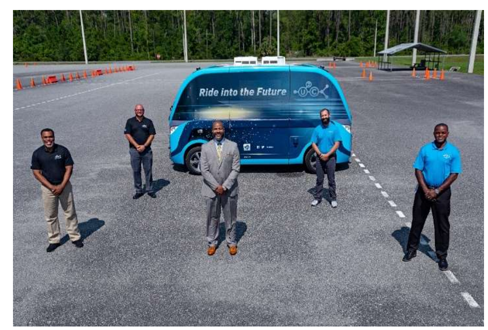
1) Full ADA Compliance
2) Buy America/Buy American Compliance
3) Cybersecurity
4) Remote Route Programming with Low Latency
5) NHTSA Approval to operate on Public Road
6) Vehicle to Infrastructure and V^2X Capabilities (DSRC & 5G)
7) Traverse Slope of ± 12 Degrees w/ Full Passenger load (Sustained Acceleration/Deceleration)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

The JTA will provide further details, guidance and explanation for each of the define requirements upon request. Our AV test protocol and program will also provide further guidance and establish more define pass /fail criteria for the U^2C program. For autonomous shuttles which do not meet any or some of these critical requirements, the AV manufacturers will need to provide detailed explanation on how they plan to meet them in the future or provide an alternate solution deemed acceptable by the JTA.





- New Test & Learn site is located in Jax. FL at the JTA Armsdale P-N-R Facility/FSCJ (AV's, CAV Technology, 3-D Ped. Cross-walks).
- Multiple vehicles across multiple platforms
- 1 ADA Prototype
- 1st Retrofit FMVSS Compliant AV



Test and Learn Expansion - FMVSS Compliant AV

1st of its Kind

- Buy America Compliant * ADA Compliant
- All Electric * FMVSS

Test and Learn Expansion - 3D mapping / Drone Technology

- 3D Mapping of Sites and JTA Assets
  - Asset Management
  - Preventative Maintenance activitites

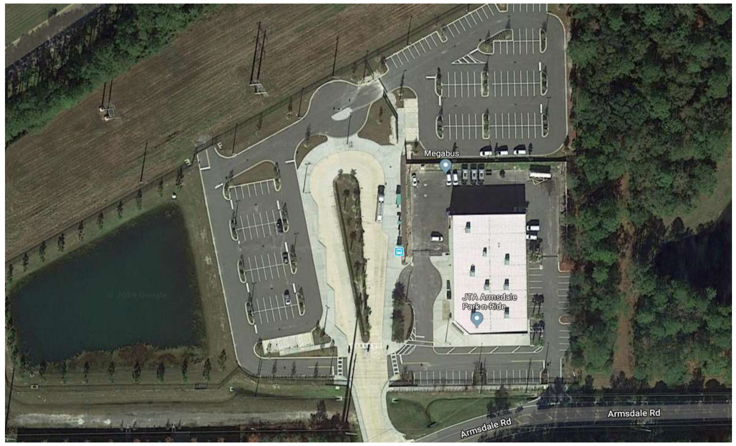
* U^2C Simulations
* Property Analysis & Surveys

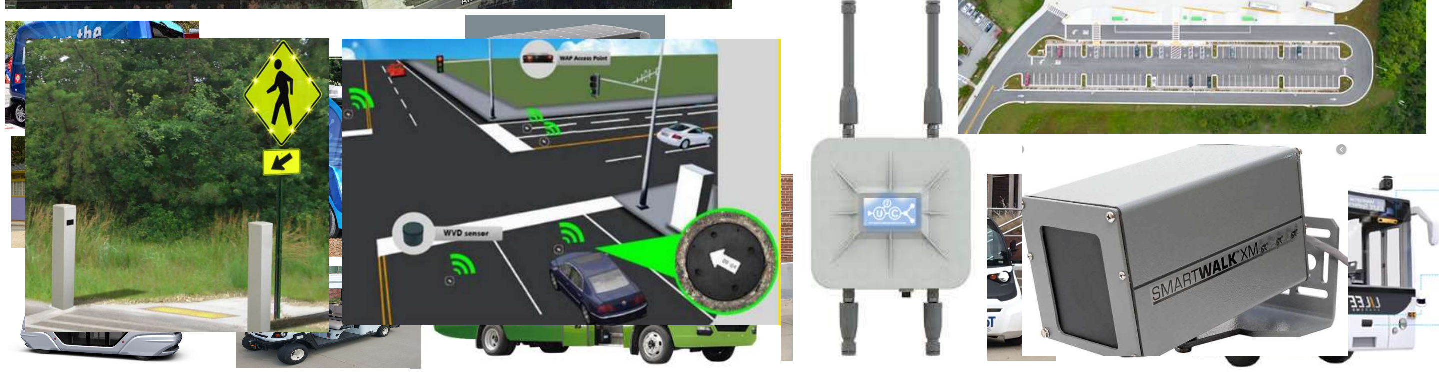
AV Down Select

Vehicle Design & Selection

Continued Expansion of Test & Learn

- Test & Learn will leverage JTA owned Facility & Properties
- Commence connected Signal & V2I Testing
- Expansion beyond AV Shuttles. JTA will test and pilot multiple AV technologies
- Incorporate and leverage Agile projects with local Universities and Businesses





Test and Learn Expansion - Armsdale Facility

- Test track buildout in progress
  - V2X/ V2I Testing
  - Remote Command & Control Operations

* U^2C Simulations
* Quality & Safety standards development

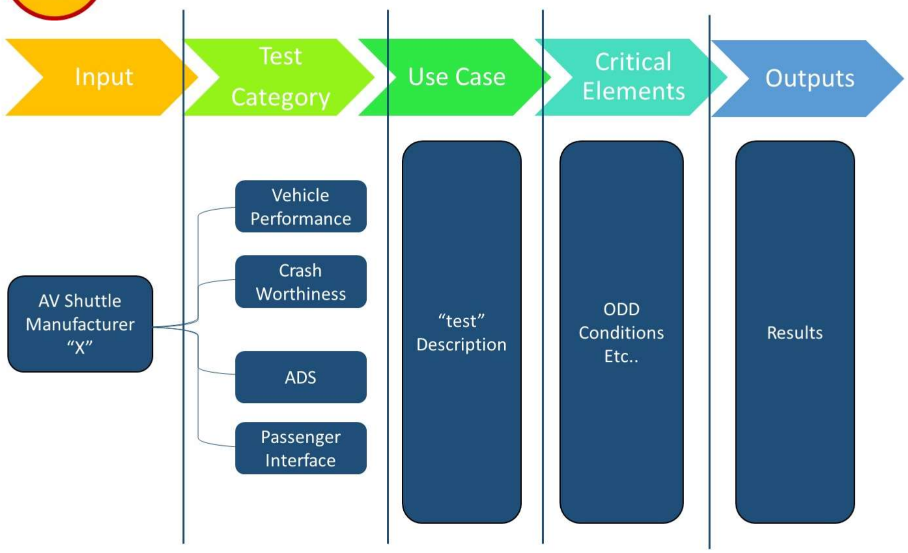
- Multiple AVs fully commissioned at this location and tests are ongoing

Test and Learn Expansion – Critical testing Elements

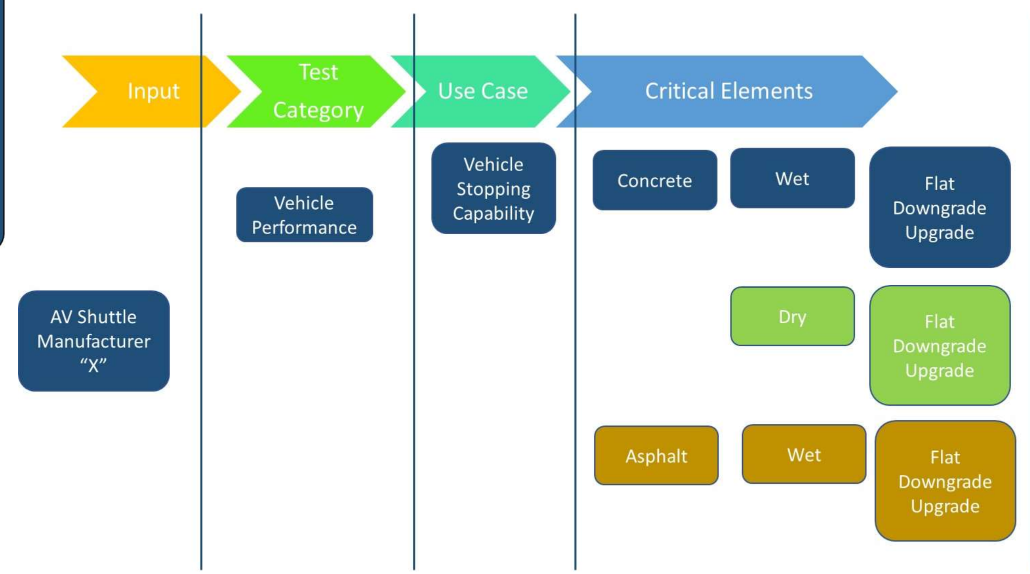
- **Vehicle Performance & Reliability**
  - Kinematics
  - Battery Efficiency
  - GNSS/ Localization
  - HVAC
- **Situational & Automated Driving System (ADS)**
  - Hardware Perception
  - Conditional Weather
  - Vehicle decisiveness
  - Traffic Conditions
  - V2X
- **Operational**
  - Route performance
  - Operators Training
  - Standard Operational Procedures
  - Customer perception / Experience
- **Qualification**
  - Applications
  - Cyber/Physical Security
  - Hardware
  - Safety/ADA
  - Quality

Test AV Shuttles and other AV Technologies

AV Test Protocol Development

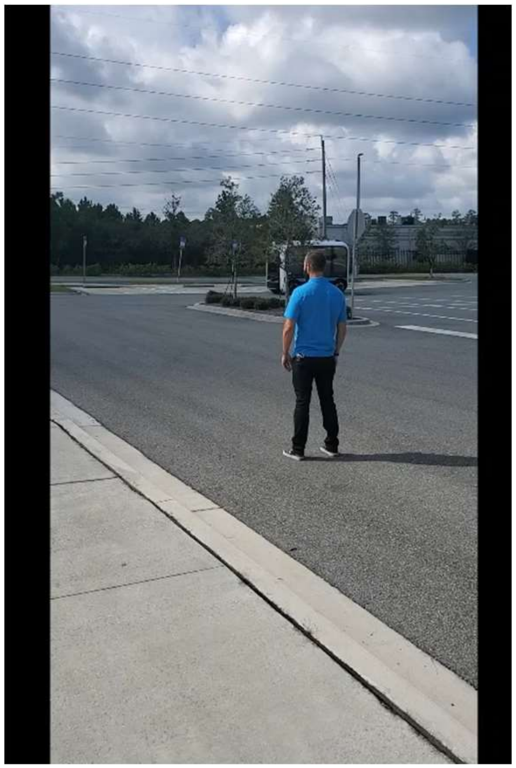


Detail Example of a Single Test Category Development



Test and Learn – Testing Activities

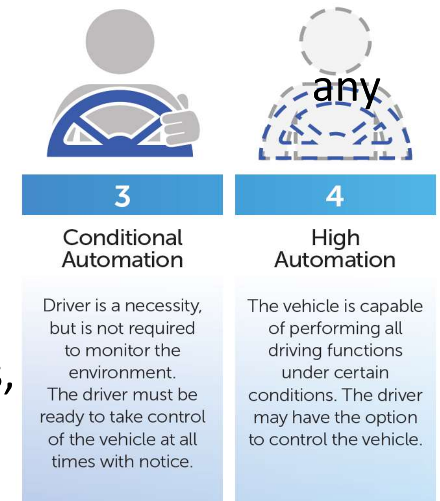
Obstacle Overtake Maneuver



JTA Strategy is to Launch AV service with L3 and transition to L4

<u>Milestones Achieved by JTA:</u>

- Most L4 Operation hrs on AV Shuttles than other transit agency
- Most certified AV operators amongst peers
- Over 350Hrs of customer interaction, events, and vehicle perception feedback.
- Most comprehensive test program

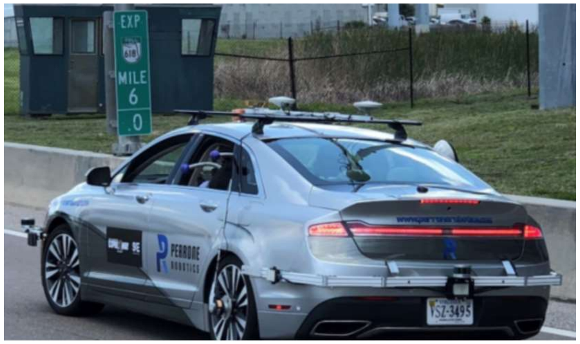


FSCJ Partnership

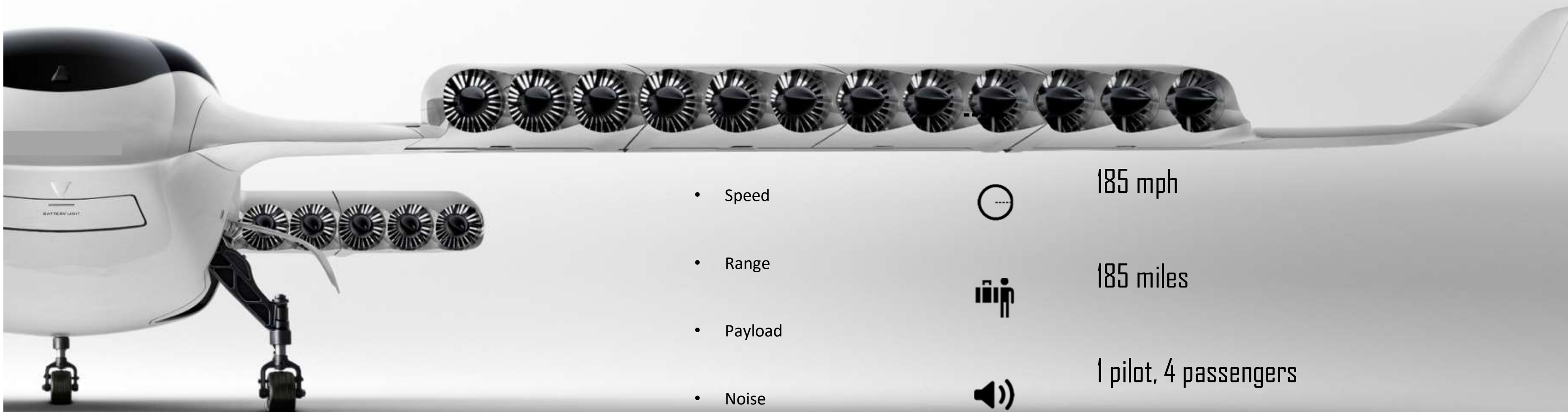
Test & Learn Expansion

- MOU is signed
  - Use of Cecil Field Test Track
  - Collaborating on curriculum and internships
  - Agile Plan/Campus Circulator Implementation
- JTA leaders are members of FSCJ ADAS Tech Advisory Team
  - A grant awarded to FSCJ by the National Science Foundation to address Advanced Driver Assistance Systems (ADAS) and autonomous vehicles (AV)
- Test track configuration in planning

Other Projects



Imagine JTA Partnership to provide: The first eVTOL air taxi service on the market



Speed	185 mph
Range	185 miles
Payload	1 pilot, 4 passengers
Noise	Inaudible in cruise flight
Simplicity	Just tiltable electric engines

What is Required??

Landing Infrastructure Components

AIRSIDE OPS:

- ATM/Flight separation
- Noise footprint (context specific)

Take Off/Landing Area:

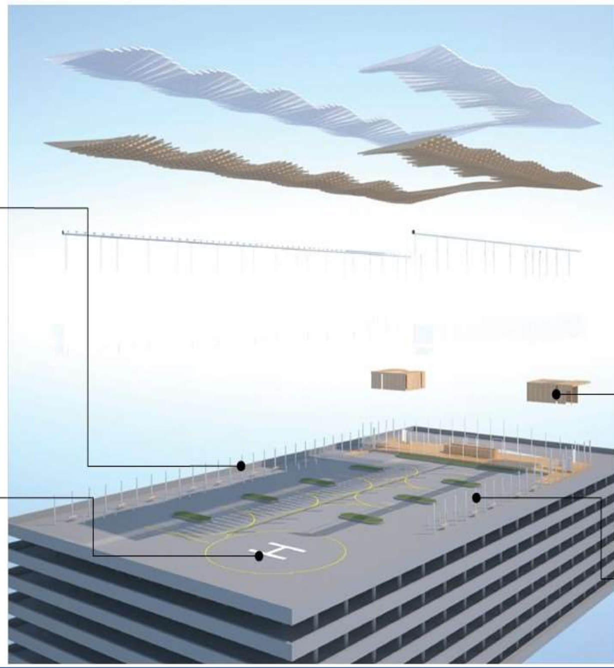
- 85 ft x 85 ft

APRON:

- 8 aircraft parking bays (49x29ft)

MRO:

- 1 dedicated parking bay and storage

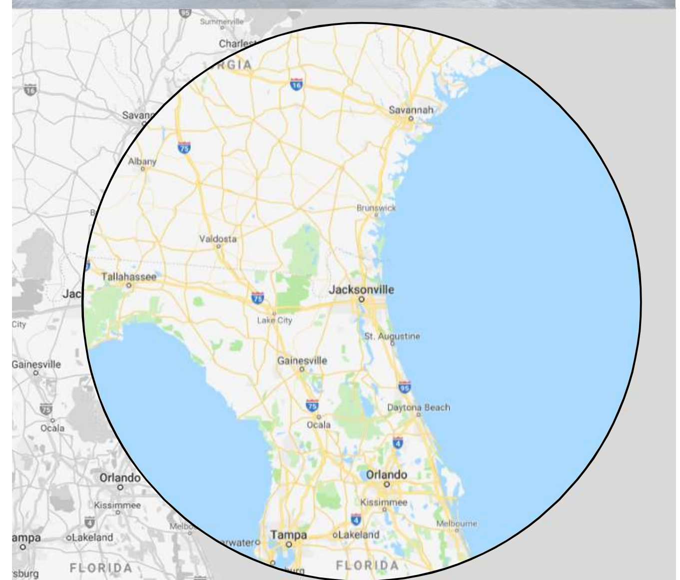


FRONT OF TERMINAL (Customer Service)

- Lounge
- Access Control (remote/adjacent)
- FIDs
- IT Backbone
- Staff/Crew Facilities

FAST CHARGING STATIONS:

- Charging Outlet
- Charge Manager
- Backbone



Thank you!

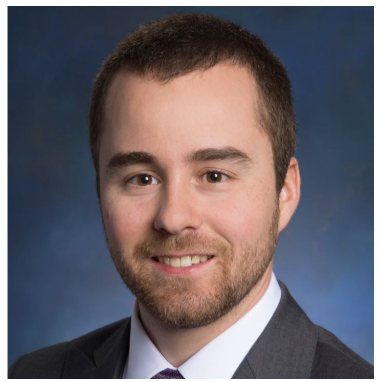
Automation Division

U2C ULTIMATE URBAN CIRCULATOR

Today’s Panelists

#TRBWebinar

Moderated by: Paul Lewis, *Eno Center for Transportation*



Kelley Coyner,
Innovation4Mobility

John Good,
Independent Consultant

Shane Blackmer,
Stantec

Bernard Schmidt,
Jacksonville Transportation Authority

ARTS21 – July 12-15

- Will provide updates on the current research and development, advanced engineering progress, and field deployment results of vehicle technologies.
- Topic areas being discussed include: Safety of Automation, Equity and Environment, Public-Private Infrastructure and Operations, Automated Freight Movement
- Will also focus on issues impacting the USDOT and State DOTs resulting from road vehicle automation advancements

https://trb.secure-platform.com/a/page/arts2021

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