# Automated Bus Consortium Program Overview

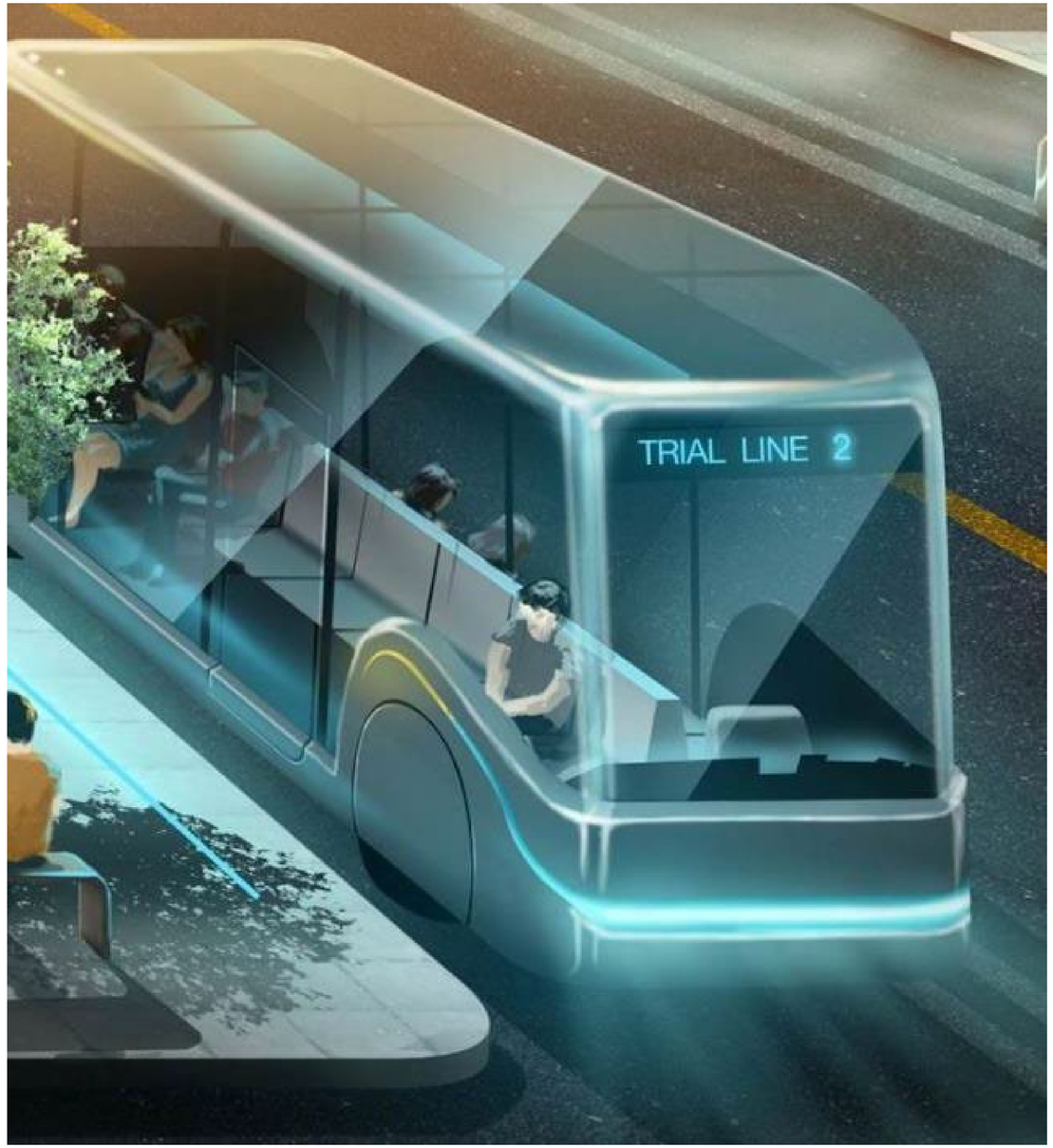
## December 2022

ACCELERATING AUTOMATED TECHNOLOGY FOR TRANSIT SERVICES

ABC Automated Bus Consortium
ACCELERATED BY AECOM

# Original Concept – Fall, 2018

- Automated small vehicle shuttle technology is proven
- Appears feasible to transfer AV shuttle technology to full-sized buses (80-85,000 US market)
- Vendors need a market to cost-effectively produce these buses
- Original Concept: Joint procurement of 75 –100 Level 4 automated buses by consortium agencies



# Why Automation?

## TRANSIT CHALLENGES

- Diminishing Safety
- Diminishing Ridership
- Reduction in Service Frequency
- Increasing Operating Costs
- Driver Shortages

## AUTOMATED TECHNOLOGY BENEFITS

- Enables Mobility on Demand
- Improves Environmental Quality
- Improves Safety of Systems through Enhanced Connectivity
- Improves Rider Experience
- Optimizes System Operations

Full Automation

| 0 |
|---|
| **No Automation**<br><br>Zero autonomy; the driver performs all driving tasks. |

| 1 |
|---|
| **Driver Assistance**<br><br>Vehicle is controlled by the driver, but some driving assist features may be included in the vehicle design. |

| 2 |
|---|
| **Partial Automation**<br><br>Vehicle has combined automated functions, like acceleration and steering, but the driver must remain engaged with the driving task and monitor the environment at all times. |

| 3 |
|---|
| **Conditional Automation**<br><br>Driver is a necessity, but is not required to monitor the environment. The driver must be ready to take control of the vehicle at all times with notice. |

| 4 |
|---|
| **High Automation**<br><br>The vehicle is capable of performing all driving functions under certain conditions. The driver may have the option to control the vehicle. |

| 5 |
|---|
| **Full Automation**<br><br>The vehicle is capable of performing all driving functions under all conditions. The driver may have the option to control the vehicle. |

# Society of Automotive Engineers (SAE) / National Highway Traffic Safety Administration (NHTSA) Levels of Automation

# ABC PROGRAM GOAL:

## Deploy Full-sized, Full-speed Accessible, Level 4 Automated Buses

### Variety of Geographies

- Cold Weather
- Desert
- Hot and Humid
- Rainy

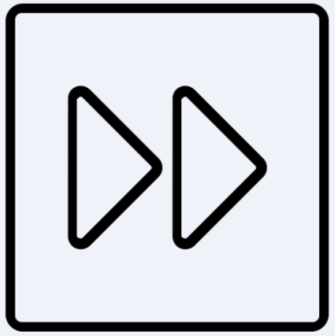
### Variety of Applications

- Bus Rapid Transit
- Shuttle Service
- Arterial Rapid Transit
- Express Service
- Fixed-Route Service
- Point-to-Point
- Maintenance Depot

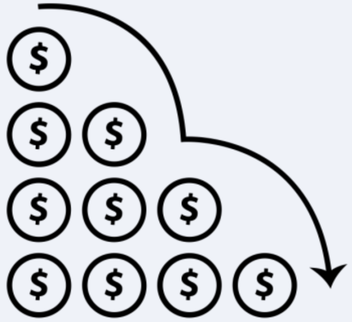
### Variety of Vehicle Options

- New Vehicles
- Retrofit Existing Vehicles
- **Electric Vehicles**
- CNG Vehicles
- Diesel Vehicles
- Hydrogen Fuel Cell

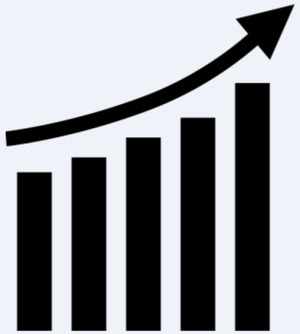
# Value of the Consortium



Accelerate Technology Development and Deployment



Reduce Planning and Procurement Costs



Stimulate Technology Demand

Shared Lessons Learned

# Agency Status for Phase 2A

| AGENCY | STATUS |
|---|---|
| Houston METRO | Work Underway |
| CATA / Michigan State University | Work Underway |
| Huron Transit/Saginaw (Michigan) | Work Underway |
| MARTA (Atlanta) | Work Underway |
| Dallas Area Rapid Transit (DART) | Work Underway |
| Sun Tran / RATP Dev (Tucson) | Work Underway |
| MetroLINK (Moline, IL) | Work Underway |
| New Jersey Transit | Work Underway |
| City of Detroit | RFP in Process |
| Other Agencies | In Conversation |

# Automated Bus Technology: Can the Vendors Produce the Desired Bus?

Overview of Automated Bus Consortium Program

# ABC Industry Forum (9.12.19)


- **Industry Forum Attendance**
  - 120 individuals (54 bus/technology companies; 23 ABC/other public agencies/academia)
  - One-on-One meetings with 21 companies
- **Input from Attendees at Industry Forum**
  - Aggressive schedule to automate all environments
  - Pilot project variety creates complexity for software development
  - Possibly limit types of pilot projects to implement
  - Need to structure study for “safety”
  - Consider grouping pilot projects for phased deployment approach

# Recent Automated Bus Announcements

## New Flyer Announces Level 4 Automated Bus – 1.29.21

- Pedestrian detection and avoidance
- Precision docking
- Vehicle-to-Vehicle communication for safe platooning.
- Vehicle-to-Infrastructure communication
- Deployment in 2023 on Hartford BRT (IMI FTA Grant)


## ADASTEC / KARSAN Level 4 Automated Bus – 2.02.21

- Speed:  Up to 40 mph by Dec 2021; up to 55 mph by 2022
- Deploying pilots in Europe
- Level 4 testing at Michigan State University
- University of Michigan testing in adverse weather

# Proposals Submitted in July

# Key Elements of ABC Specification

1. Base Bus Specification (leverage APTA White Book)

2. Bus Electrification (leverage APTA White Book)

3. Automated Driving System (ADS) (new, leverage Industry input)

NOTE: In order to participate in the procurement, the FTA requires the agency name and approximate number of buses to be purchased must be included in the procurement documents.

## Stage 1

- **Operational Design Domain (ODD)**
  - Bus service routes (local roads, arterials, freeways and highways) with speeds governed by service route speed limits, including intersections
  - Varying lighting and weather conditions
  - Maintenance yard (navigation and task execution)
- **Behaviors**
  - Acquire and navigate service routes including bus stops
  - Merge at speeds below 45mph
  - Calculate and track estimated time to arrival for bus stops
  - Track OTP *(optional)*
  - Lane navigation, lane changes
  - Detect and navigate intersections controlled by traffic signals, and 2- and 4-way stop signs, and at railroad crossings
  - Interact with bus stops - boarding, alighting passengers
  - Maintain passenger counts *(optional)*
  - *Initiate opportunity charging if available and required*
  - *Cooperative Driving Automation (Platooning) (optional)*
- **Functionality**
  - Component and critical system redundancy
  - Comfortable passenger experience
  - Manual takeover, and relinquish control to the ADS
  - Prevent unauthorized access
  - Monitoring and logging of internal systems
  - DDT Fallback and MRC
  - Perform all OEDR
  - Wireless communication (WiFi, Cellular)
  - Physical and electronic security
  - Manage deployment and verification of over-the-air updates
  - Monitor state of battery charge if battery electric propulsion
  - Event Data Recorder (SAE J1698_2017)
  - Application programming interface (API)
  - ADAS coordination

## Stage 2

- **Stage 1 plus:**
  - **Operational Design Domain (ODD)**
    - Does not require modifications to the environment
  - **Behaviors**
    - Detect and navigate intersections with flashing yellow ball, red flashing ball, all-way flashing red
    - Continue past bus stops with no waiting passengers and no requested stop *(optional)*
    - *Adjust opportunity charging time based on performance goals*
    - *Cooperative Driving Automation (Platooning) (optional)*
  - **Functionality**
    - Transit signal priority (TSP) *(optional)*
    - SCMS for DSRC (if any)

## Stage 3

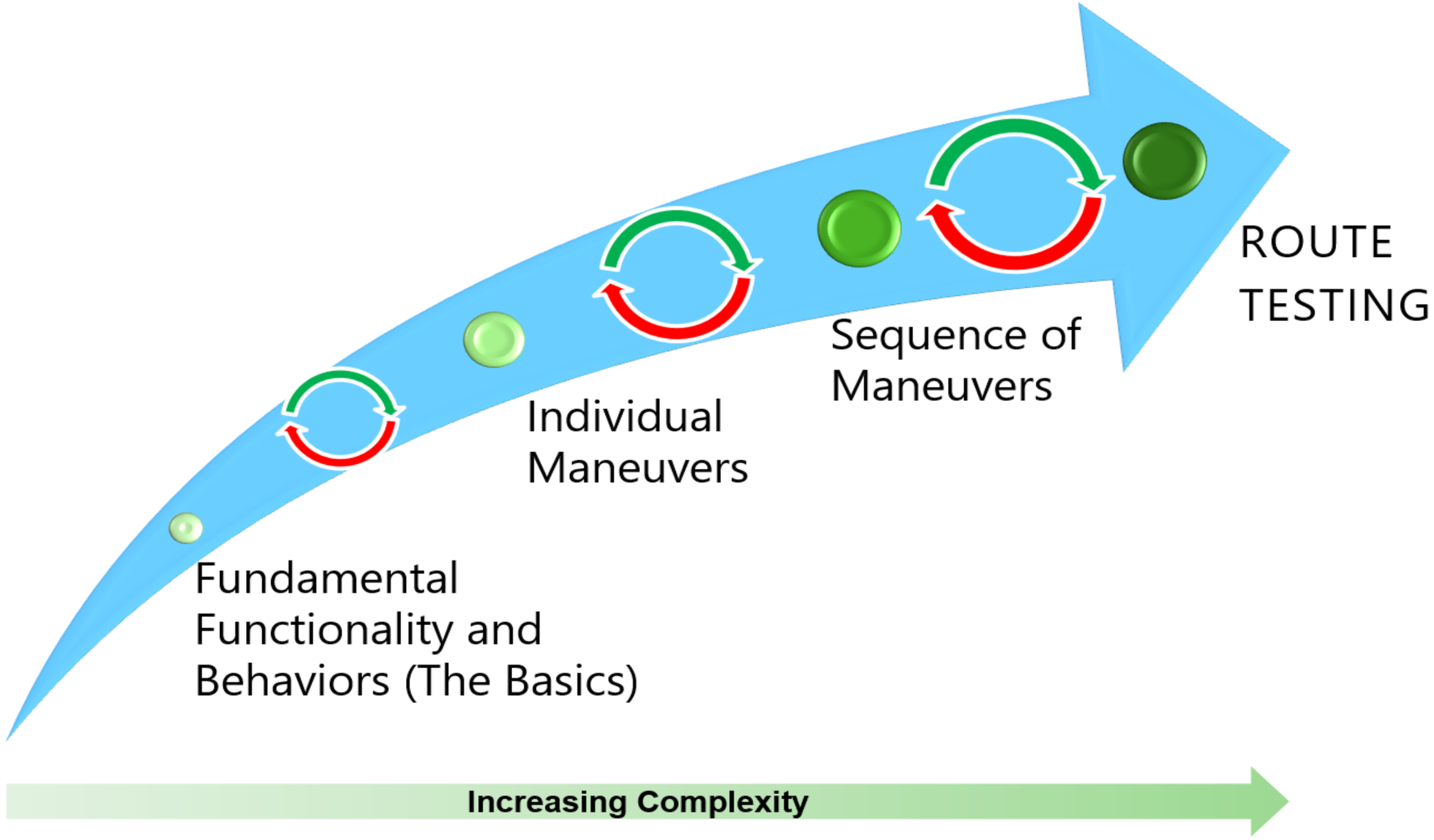
- **Stage 2 plus:**
  - **Operational Design Domain (ODD)**
    - Detect degraded pavement conditions *(optional)*
    - Detect and respond to emergency vehicles
  - **Behaviors**
    - Plan and execute a safe return route *(optional)*
    - Merge at speeds above 45mph
    - Execute an unprotected left turn
    - Detect and navigate intersections with yield signs and flashing yellow arrows
    - *Cooperative Driving Automation (Platooning) (optional)*
  - **Functionality**
    - Keep log of passenger count per stop
    - ADA: Detect and secure wheelchairs, detection and interaction with other impaired passengers *(optional)*
    - Configurable TSP
    - Unsupervised OTA Updates *(optional)*

Additions since March, 2020

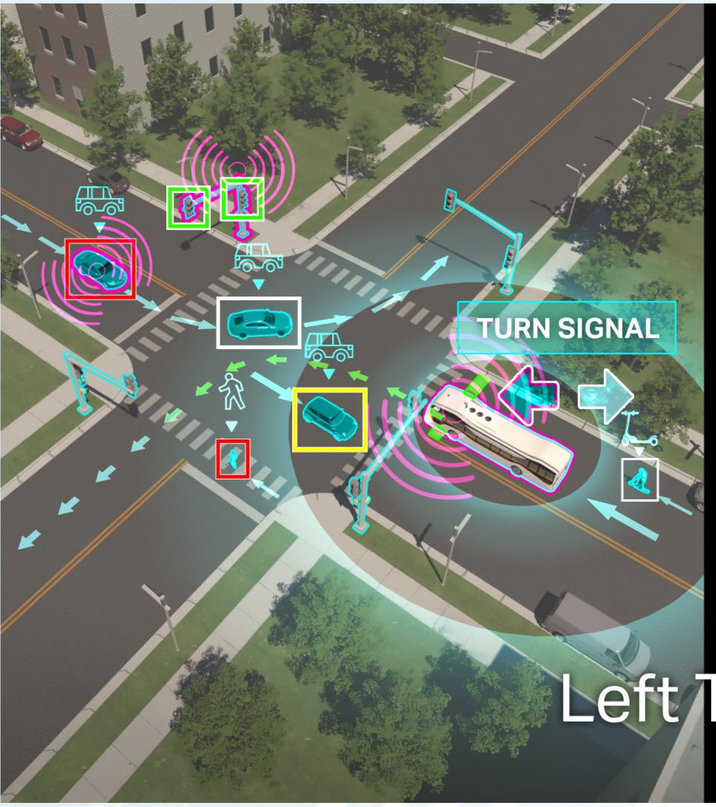
# Testing/Certification

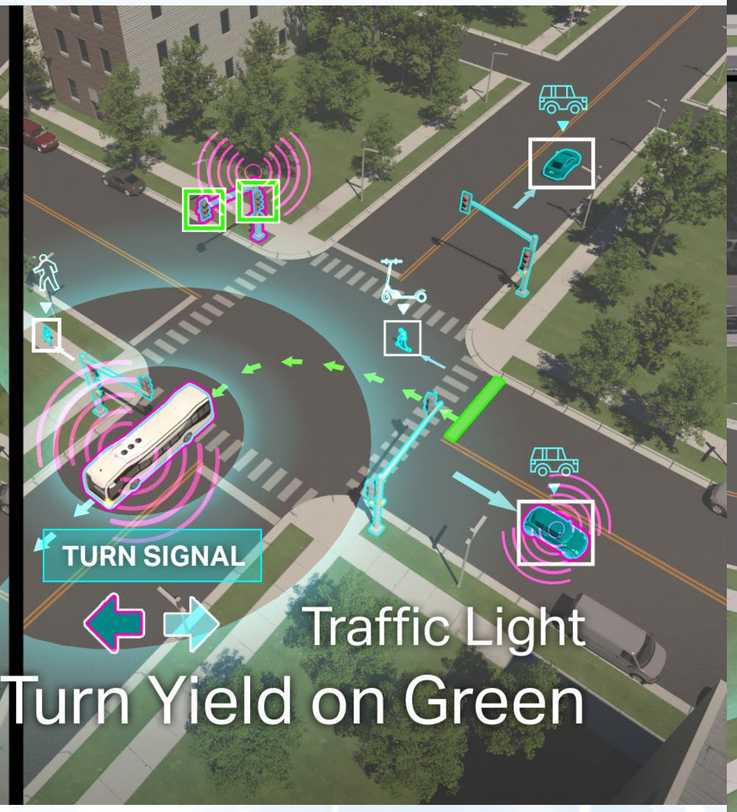
Overview of Automated Bus Consortium Program

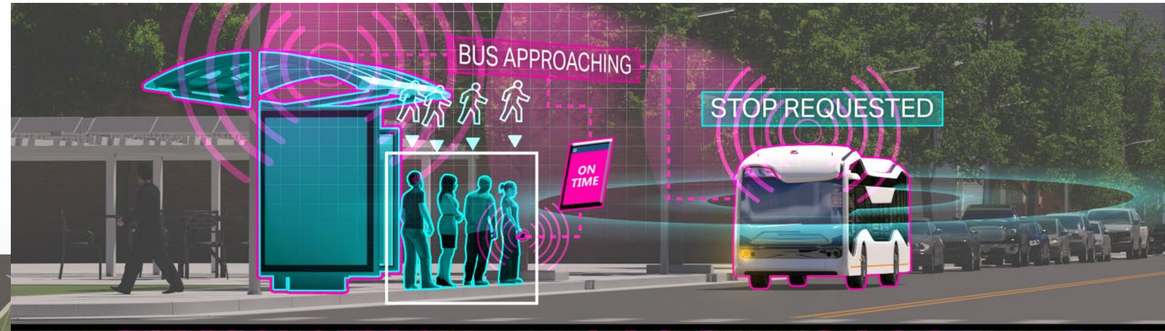
# ADS TESTING PROGRESSION AND SELF CERTIFICATION

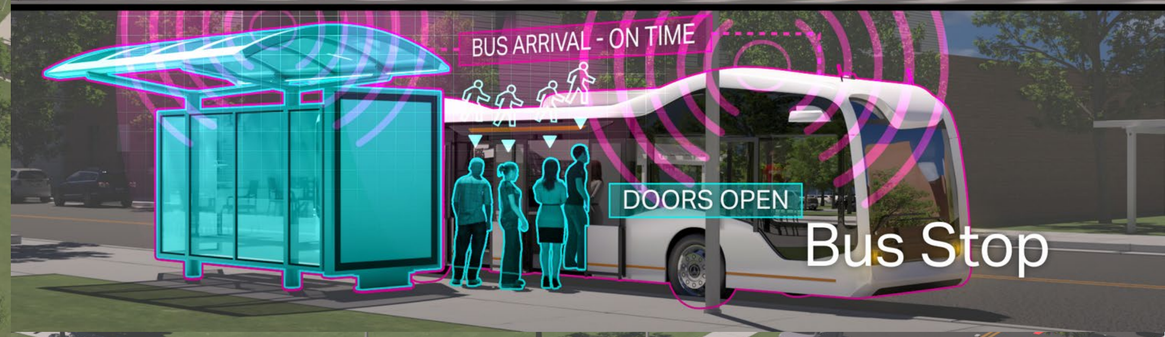


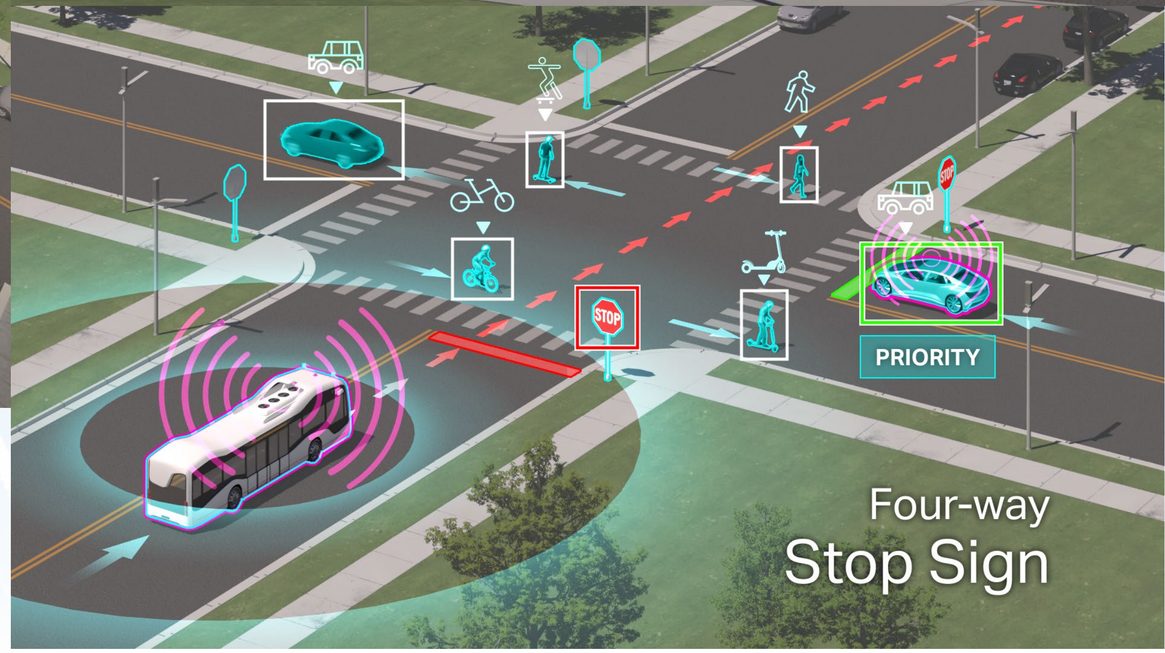
# ADS Scenarios



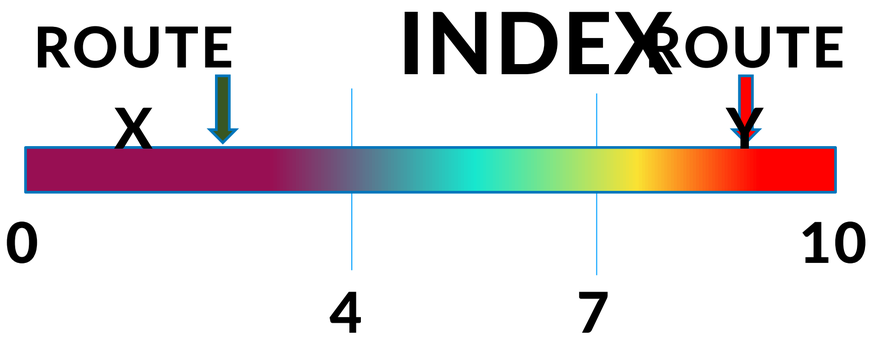



# CV/AV Route Readiness Analysis

Automated Bus Consortium
ACCELERATED BY AECOM

## ROUTE ANALYSIS COMPLEXITY INDEX

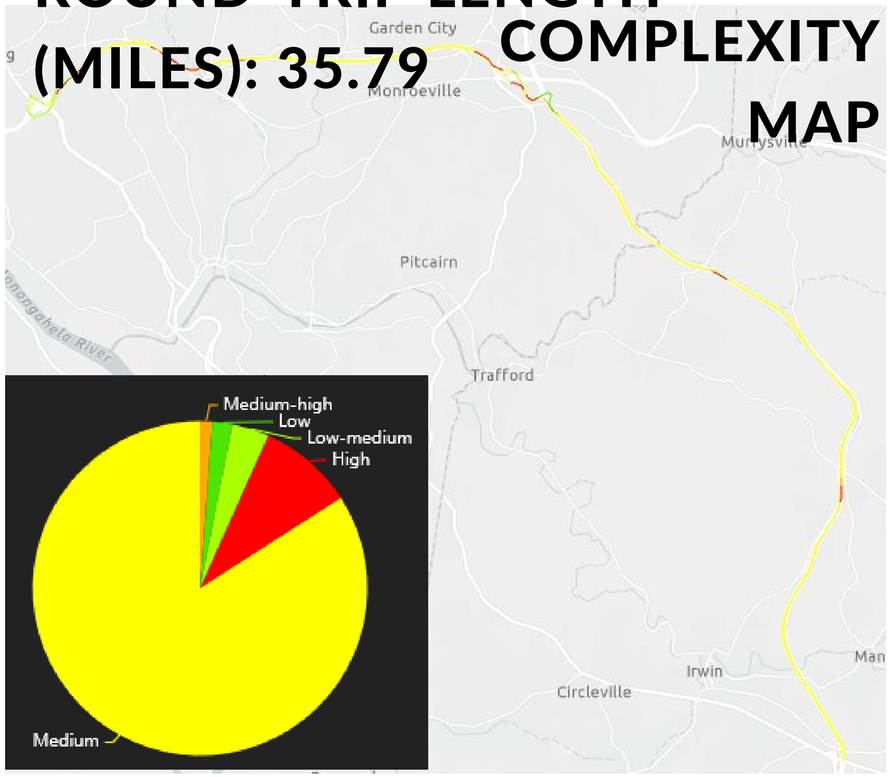


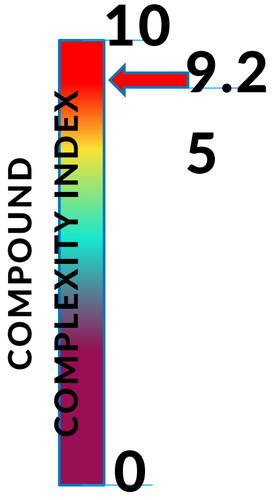

NONLINEAR SCORING SCALE

# ADS COMPLEXITY ANALYSIS AND ROADWAY READINESS: PLATOONING I-76 TO I-376

## ROUND-TRIP LENGTH (MILES): 35.79

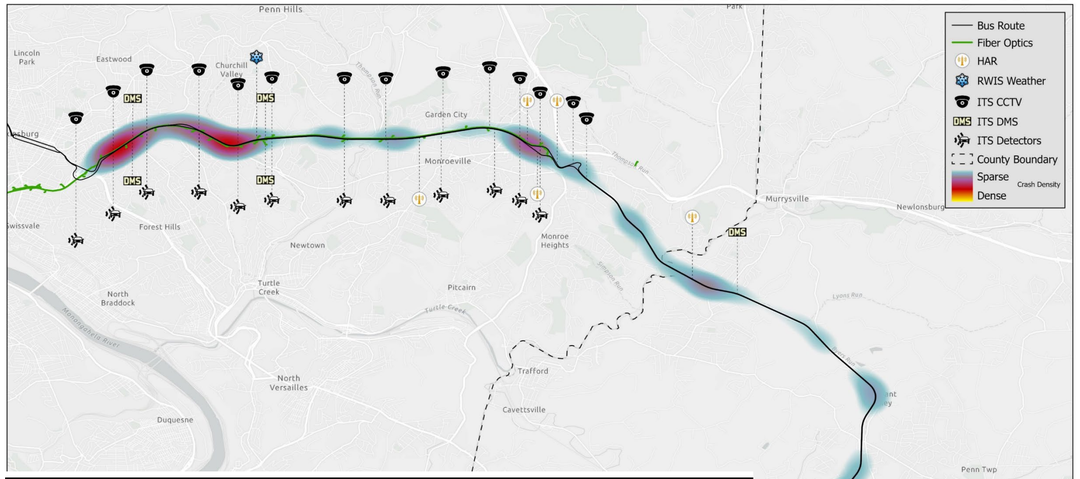
## COMPLEXITY MAP



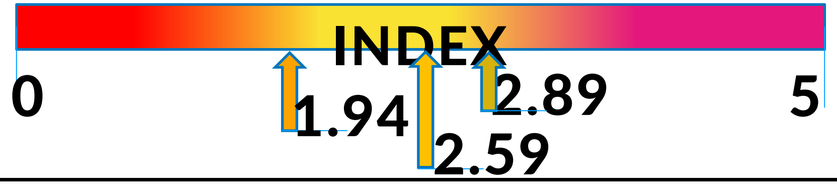

## COMPLEXITY DISTRIBUTION BY LENGTH

## READINESS MAP

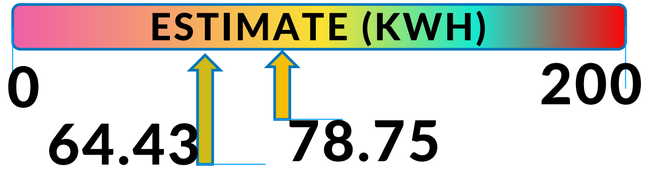



| Technology | Readiness Index (0-5) |
|---|---|
| Connected Vehicle | 1.94 |
| Machine Vision | 2.59 |
| AV Navigation | 2.89 |

## ROADWAY READINESS INDEX




## ENERGY CONSUMPTION ESTIMATE (KWH)




**Readiness Index Description**

| | |
|---|---|
| Level 0 ----> | Roadway presents serious challenges to readiness for CVs or AVs |
| Level 1 ----> | Roadway has significant restrictions on the deployment of CVs or AVs |
| Level 2 ----> | Roadway is moderately ready for CVs or AVs, but still poses significant challenges for effective deployment |
| Level 3 ----> | Roadway is moderately ready for CVs or AVs, but may still pose challenges for effective deployment |
| Level 4 ----> | Roadway is highly ready for CVs or AVs, and the remaining challenges are relatively minor |
| Level 5 ----> | Roadway is highly ready for CVs or AVs with few or no remaining challenges for deployment |

# ABC Procurement Process

# Phased Approached from Feasibility to Implementation

## 1

**Feasibility Phase (complete)**

- Service Visioning/Pilot Projects
- National & Local Outreach
- Vehicle Specification
- Electric Charging Strategy
- Financial Planning
- Regulatory Clearance
- Risk Register
- Deployment Strategy
- Go/No-Go

GO/NO-GO

GO/NO-GO

## 2

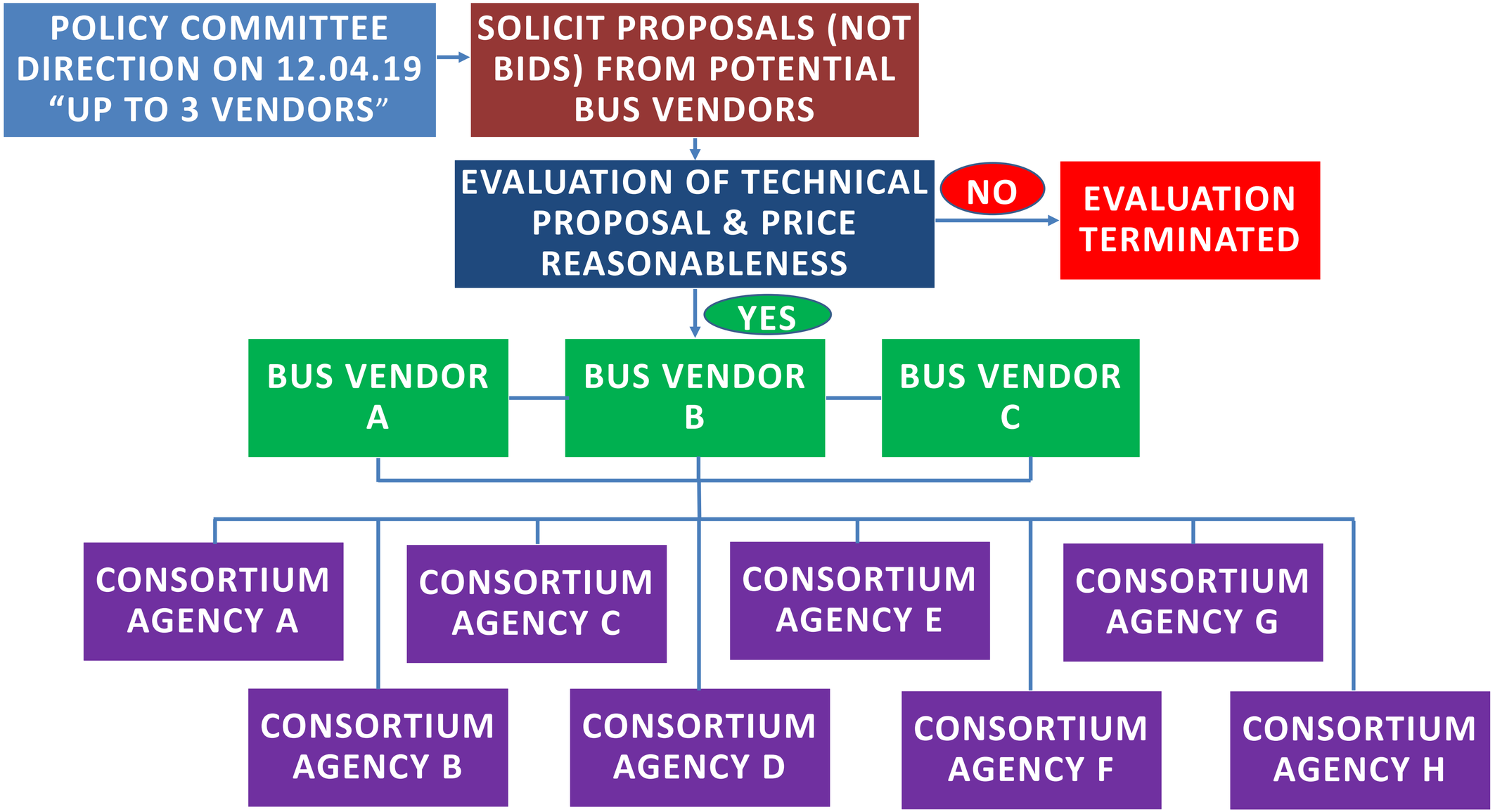
### 2A. Auto Bus Procurement (10/20 – 9/22)

- Bid, Evaluate, Negotiate, and Award
- Testing Plan
- Funding Plan
- Electric Charging Design
- Regulatory Clearance

### 2B. Deployment (10/22 – 10/24)

- Infrastructure Design
- Technology Testing
- Deployment/Construction
- Operation
- Evaluation
- Next Steps

# Approach for Selection of "Multiple Vendors": Cooperative Procurement Led by MDOT





21

# Agencies Can Still Participate in Merged Phase 1 and 2A

## Amounts Paid by Original Agencies

- $100,000 fixed price
- Fixed price due to cost sharing for many tasks
- $95,000 for Phase 2A

## Amounts to be Paid by New Agencies

- $100,000 fixed price to cover Phase 1 and Phase 2A

## Procurement Methods Vary

## Work Program and Cost by Task Available


# Discussion/Questions