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Vice President
Automated Vehicles – The Minnesota Approach

Sue Mulvihill – Chief Engineer / Deputy Commissioner
Jay Hietpas – Assistant Commissioner
Minnesota’s Vision for CAV
Why CAV?

381
Why CAV is Important

- Greater Mobility & Equity
- Workforce Impacts
- Traffic Operations
- Economic Development
- Infrastructure
- Health & Environment
What About Winter Conditions
Preparing for CAV
Three in Four Americans Remain Afraid of Fully Self-Driving Vehicles
CAV - When Will It Come?

These are possible futures. Any of these could happen. Or none.
CAV Executive Report Key Themes

- Modernize policy
- Equity
- Proactive statewide leadership
- Public education & outreach
- Funding and revenue
- Public-private partnerships
3

Engagement, Projects & Partnerships
Public Engagement

Super Bowl

Minneapolis State Fair
Engagement Efforts

- VRUs
- Freight
- Employees
- Industry
- Public
- Transit
Minnesota CAV Challenge

Innovative procurement

Industry Innovation

Ideas Submitted Anytime
Innovation - MN CAV Challenge

30+ Industry Meetings

26 Vendors

21 Proposals Submitted

9 Proposals Accepted

Three Under Contract

AECOM / WSB

Micro Systems / Kratos

Ernst and Young

First Transit

University of Minnesota

Iteris

Traffic Control Corporation

WSB

HDR
Minnesota CAV Selected Contracts

Automated Bus Consortium (ABC)

Automated Truck Mounted Attenuator (ATMA)
S.P.a.T - Signal Phase and Timing
Snow Plow Priority Video
Thank you!
Automated Bus Consortium Program
Minnesota Guidestar Update

Accelerating automated technology for transit services

Presented by Dick Wolsfeld, AECOM
September 16, 2019
Summary of Concept

• Automated small vehicle shuttle technology is proven
• Appears feasible to transfer AV shuttle technology to full-sized buses
• Vendors need a market to cost-effectively produce these buses
• Concept: Joint procurement of 75-100 buses by 12 agencies
Goal of Automated Bus Consortium Project

Deploy full-sized, full-speed accessible automated buses:

- In a variety of geographies and applications to advance the industry understanding of the technology
- Leverage the technology to improve safety, reliability, operating efficiency and customer experience
## Automation Scale

<table>
<thead>
<tr>
<th>Level</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>0</strong></td>
<td>No Automation</td>
</tr>
<tr>
<td><strong>1</strong></td>
<td>Driver Assistance</td>
</tr>
<tr>
<td><strong>2</strong></td>
<td>Partial Automation</td>
</tr>
<tr>
<td><strong>3</strong></td>
<td>Conditional Automation</td>
</tr>
<tr>
<td><strong>4</strong></td>
<td>High Automation</td>
</tr>
<tr>
<td><strong>5</strong></td>
<td>Full Automation</td>
</tr>
</tbody>
</table>

**No Automation**
Zero autonomy, the driver performs all driving tasks.

**Driver Assistance**
Vehicle is controlled by the driver, but some driving assist features may be included in the vehicle design.

**Partial Automation**
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.

**Conditional Automation**
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.

**High Automation**
The vehicle is capable of performing all driving functions under certain conditions. The driver may have the option to control the vehicle.

**Full Automation**
The vehicle is capable of performing all driving functions under all conditions. The driver may have the option to control the vehicle.

Source: Society of Automotive Engineers (SAE) / National Highway Traffic Safety Administration (NHTSA) Levels of Automation
Roughly 260 Worldwide Demos

**LAS VEGAS**
- Automated bus route on Freemont Street
- Public streets: mixed traffic, 8 intersections and 6 traffic lights
- 35,000 riders
- Providers: Navya AV and Keolis Transit (operators)

**MINNESOTA**
- Cold weather test
- Performed well on snow and ice
- Providers: Easy Mile and First Transit
MN AV Bus Pilot Summary
Bus Performed Well in Ice
Interaction with Pedestrians

More conservative with higher speeds

Front Stop Distance = 5.3 – 6.6 Ft. (Bumper to Shins)
Side of Bus = 1.6 – 1.8 Ft. (off Wheel Path)
Battery Usage Chart Sample

Dec. 18th, 2017 Battery Charge Readings
Start Temp.: 36°F; Wind: S 7 mph
## MN AV Bus Public Tours

<table>
<thead>
<tr>
<th>Event</th>
<th>Attended</th>
</tr>
</thead>
<tbody>
<tr>
<td>Media Day / MnROAD Tours</td>
<td>238</td>
</tr>
<tr>
<td>Super Bowl Demos</td>
<td>1,346</td>
</tr>
<tr>
<td>Day at State Capitol</td>
<td>216</td>
</tr>
<tr>
<td>Rochester Demos</td>
<td>267</td>
</tr>
<tr>
<td><strong>TOTALS</strong></td>
<td><strong>2,067</strong></td>
</tr>
</tbody>
</table>
• The vehicle operated well in snow, ice and slush covered roads.

• Blowing snow = a big challenge

• Public wants more experiences to learn about AV

http://www.dot.state.mn.us/automated/bus/finalreport.pdf
Scotland to Test First Autonomous Full-sized Bus Fleet in Passenger Service – 11/26/18

- Service to begin in 2020 with 5 – 42 passengers, 38 foot ADL buses between Fife and Edinburgh
- Level 4 Automation: Driver on-board during operation
- In 2019 the bus will be used in autonomous mode only within the depot environment, to carry out:
  - Parking
  - Moving to fuel station
  - Bus washing
Volvo Announces AV and AE Bus – 3/5/19

• The prototype buses are based on the Volvo 7900 electric model
• Each bus is 12 meters (39 feet) and can carry roughly 80 passengers
• The first bus will operate on the campus of Nanyang Technological University
• Volvo hopes to operate the second bus out of a depot managed by SMRT, Singapore's public transit operator
New Flyer Launches Program Focused on Self-driven Buses – 5/08/19

• St. CLOUD — New Flyer of America Inc. announced the launch of a program aimed at possibly creating self-driven buses
• In a news release, New Flyer and New Flyer Industries Canada announced the launch of their Autonomous Technology Program, which includes development and deployment of technology for advanced driver-assistance systems and automated vehicles
• The largest bus manufacturer in North America said the program will have a guiding principle focused on public safety and will adhere to the Society of Automotive Engineers’ definition and recommended practice for levels of driving automation
• New Flyer will actively participate in development of SAE related recommended practices and standards
Conclusions: Accelerating Automated Transit

- Significant investment is being made in automation
- Industry “appears able” to produce an automated bus in the 2021 – 2022 timeframe
- The technology needs a market
- Labor partnerships are important
- FTA has an interest in automated bus deployment
- Federal, state, and local regulatory framework needs to be refined
Proposed Program to Advance Full-Sized Automated Bus

Overview of Automated Bus Consortium Program
One Program to Gain Extensive Experience

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
Potential Risks

- Passenger acceptance/security
- Labor opposition
- Technology companies’ ability to deliver
- Liability insurance – not enough experience with automated buses for underwriting risk
- Research and development program costs
- Cybersecurity
- Other

Risk register is being developed
Potential Value of the Consortium

- Accelerate Technology Development and Deployment
- Reduce Planning and Procurement Costs
- Stimulate Technology Demand
- Shared Lessons Learned
Website – automatedbusconsortium.com

About the Automated Bus Consortium

With rapid advancement of driverless technologies and the urgent need to improve mobility options while safely and effectively mitigating congestion in cities across the United States, the Consortium’s collaborative effort to leverage its combined resources and launch its pilot deployment program of full-sized buses is groundbreaking. Using cost-efficient and standardized methodologies and assessment, the Consortium will lead the nation’s effort to test and evaluate driverless bus technology.
## Automated Bus Consortium Program – Phase 1

### Project Schedule: 12 Months – 4.01.19 – 3.31.20

<table>
<thead>
<tr>
<th>TASK</th>
<th>Month</th>
</tr>
</thead>
<tbody>
<tr>
<td>PDA Phase</td>
<td>1 2 3 4 5 6 7 8 9 10 11 12</td>
</tr>
<tr>
<td>1.0 - Assess Candidate Pilot Sites</td>
<td></td>
</tr>
<tr>
<td>2.0 - Risk Register</td>
<td></td>
</tr>
<tr>
<td>3.0 - Select Pilot Sites</td>
<td></td>
</tr>
<tr>
<td>4.0 - Industry Forum</td>
<td></td>
</tr>
<tr>
<td>5.0 - Regulatory Issues</td>
<td></td>
</tr>
<tr>
<td>6.0 - Draft AV Bus Specifications</td>
<td></td>
</tr>
<tr>
<td>7.0 - Final AV Bus Specifications</td>
<td></td>
</tr>
<tr>
<td>8.0 - Pilot Site Infrastructure Requirements</td>
<td></td>
</tr>
<tr>
<td>9.0 - Operations and Maintenance Plan</td>
<td></td>
</tr>
<tr>
<td>10.0 - Financial Plan</td>
<td></td>
</tr>
<tr>
<td>11.0 - Outreach Program</td>
<td></td>
</tr>
<tr>
<td>12.0 - Policy Committee Meetings</td>
<td></td>
</tr>
<tr>
<td>13.0 - Technical Committee Meetings</td>
<td></td>
</tr>
<tr>
<td>14.0 - CDA Phase Recommendation</td>
<td></td>
</tr>
</tbody>
</table>
Phased Approached from Feasibility to Implementation

1. Preliminary Development Agreement
   - Service Visioning/Pilot Projects
   - National & Local Outreach
   - Vehicle and Infrastructure Technology
   - Financial Planning
   - Regulations
   - Implementation Strategy
   - Go/No-Go

2. Comprehensive Development Agreement
   - Procurement of Buses
   - Infrastructure Design
   - Technology Testing
   - Deployment/Construction
   - Evaluation
   - Next Steps

[Diagram showing the process with GO/NO-GO decision points]
Automated Technology Overview
Automated Bus Operational Design Domain (ODD)

In what environment does the bus operate?

- Urban roadways and traffic
- Global route and path planning
- Bus stops
- Stop sign intersections
- Signalized traffic intersections
- Bike lanes
- Pedestrian crossings
Development of Candidate Pilot Projects

Overview of Automated Bus Consortium Program
Route Evaluation Criteria

**ROADWAY CHARACTERISTICS**
- % of bus route in exclusive lane
- Curb cuts/mile
- Public cross streets/mile
- Traffic signals/mile
- Stop signs/mile
- Speed limit
- Average traffic level of service
- Average daily traffic (ADT)
- On-street parking along the bus route
- Construction scheduled in next 2-3 years
- Pedestrian/bicycle/scooter presence
- Roadway grades are within -5% to +5%
- Multi-jurisdictional routes – signal interoperability

**BUS ROUTE CHARACTERISTICS**
- Bus stops with pull outs (merge required)
- Number of left-turns on the bus route
- Number of buses to provide service (3 minimum)
- Bus service headways (Peak and off-peak)
- Existing average bus passengers/day
- Current bus service or planned by 2021
- Bus connections / transfers required
- Right-side boarding
- ADA accessibility

**EXTERNAL CHARACTERISTICS**
- Adjacent land owner/community support
- Infrastructure costs or availability
- Supporting institutional partner(s)
DART - 524: Inwood/Love Field
Houston Metro - 160: Memorial City Express
THANK YOU

Please join us for lunch

5th floor AECOM