WiscAV Shuttle

A Comprehensive Safety and Rulemaking Demonstration

Part 1: Project Narrative and Technical Approach

Application for
USDOT Automated Driving System Demonstration Grant
NOFO # 693JJ319NF00001

Submitted by

University of Wisconsin-Madison

March 15, 2019

The Honorable Secretary Elaine Chao
Secretary of U.S. Department of Transportation
Washington, DC 20590

Dear Secretary Chao:

I am pleased to submit the University of Wisconsin-Madison's application for the United States Department of Transportation's Automated Driving System Demonstration Grant. We have built a multidisciplinary team that includes private, public, academic, and non-profit groups to demonstrate how to make autonomous vehicle systems practical for use by a wide and diverse group of the population.

The Wisconsin Automated Vehicle Proving Grounds was officially designated by the USDOT in January 2017 with partners across the state. Over the year and a half of official designation, the team expanded and initiated a number of research projects with our primary partners at MGA Research, Road America, and the City of Madison. Post official designation, our proving grounds remain one of the most robust and collaborative regional teams in the nation. Our team is committed to the success of this project.

- UW-Madison researchers along with public and private partners will ensure data collection on this project is managed efficiently and responsive to USDOT needs
- The City of Madison will be an integral partner with UW-Madison and will support infrastructure development along the living laboratory route and in many other logistical aspects of the project
- The Lac De Flambeau Tribe will support the deployment of the shuttle on their lands to address how automated vehicles can address rural/tribal needs, and the opportunities and obstacles to their wider deployment
- MGA will provide it's private testing facility, testing knowledge, and rigor to understand the limits of automated shuttle technology
- The Wisconsin Department of Transportation and the Wisconsin State Patrol will support the project at a state level
- Wisconsin Rural Partners, Greater Wisconsin Agency for Aging Resources, Dane County and others across the state will support demonstrations specifically to address transportation-challenged populations and their access to and input in AV technology

- Transportation for America, Community Transportation Association of America, and State Smart Transportation Initiative enable national outreach and knowledge transfer
- Local partners including MGE, Schmitt's Towing, UW Transportation Services, and the City of Madison provide for logistical support including charging, parking, and towing

American Family Insurance has committed to funding the purchase of an automated shuttle. The shuttle will be in Madison in 2019 and ready to perform for this demonstration. We have worked through all channels to ensure there are no barriers inhibiting the shuttle from operating on campus or on public roads in the City of Madison. Prior to this grant proposal, we have worked with the City of Madison and successfully demonstrated an AV shuttle twice, in November 2017 and April 2018. During the later demo, we provided more than 750 rides to members of the public in an effort to build public trust in this technology. Research team leaders have also worked with our Joint Research Institute on Internet of Mobility (JRIIM) partnership with Southeast University in Nanjing, China. We have collaboratively designed, implemented, operated, and managed AV shuttle operations in public roadway facilities.

UW-Madison, as the state's flagship university, will provide all facilities required for the successful deployment of this automated shuttle. This is not just one college or department, but a commitment from the entire campus, spanning multiple colleges, with a transdisciplinary approach to provide the diverse expertise needed to ensure the success of this project.

Thank you for initiating the ADS Demonstration Grant. In developing our proposal, we have strengthened partnerships and advanced our understanding of the impact that our automated shuttle will have on the citizens of our state. We will be a model for data collection, data analytics, rulemaking, and eventual deployment of this technology across the United States.

This large-scale automated shuttle demonstration will only succeed with a full, uncompromising commitment from myself; our engineering faculty, staff, and students; and my colleagues across campus. If selected for a grant award, I will support Professor David A. Noyce, principal investigator on the project, to ensure our team has the support they need to succeed.

I believe we have built the type of interdisciplinary team that is required to resolve the challenges facing wide-scale implantation of autonomous transportation systems. I look forward to receiving your comments and decision on the UW-Madison application for an Automated Driving System Demonstration Grant.

Sincerely,

Ian M Robertson

Ian Robertson,
Dean, College of Engineering

SUMMARY TABLE

Project Name/Title	WiscAV Shuttle: A Comprehensive Safety and Rulemaking Demonstration
Eligible Entity Applying to Receive Federal Funding (Prime Applicant's Legal Name and Address)	The Board of Regents of the University of Wisconsin System
Point of Contact (Name/Title; Email; Phone Number)	David A. Noyce Arthur F. Hawnn Professor & Chair, Department of Civil & Environmental Engineering danoyce@wisc.edu (608) 265-1882
Proposed Location (State(s) and Municipalities) for the Demonstration	Madison, WI Walworth County, WI Lac De Flambeau, WI Marshfield, WI Elkhart Lake, WI Chippewa Falls, WI
Proposed Technologies for the Demonstration (briefly list)	SAE Level 4 Autonomous Shuttle with support hardware / sensors
Proposed duration of the Demonstration (period of performance)	3 years
Federal Funding Amount Requested	$ 2,972,348
Non-Federal Cost Share Amount Proposed, if applicable	$ 469,891
Total Project Cost (Federal Share + Non-Federal Cost Share, if applicable)	$ 3,442,239

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Part 1 – Project Narrative and Technical Approach

1 EXECUTIVE SUMMARY

1.1 Vision, Goals, and Objectives

1.1.1 Vision

The University of Wisconsin-Madison (UW-Madison) team proposes safety and operational testing and demonstration of a their SAE Level 4, low-speed autonomous shuttle vehicle (ASV) under a wide range of scenarios to obtain, analyze, and share data for enabling rulemaking and knowledge transfer while bolstering trust and acceptance of automated driving systems (ADS) among all stakeholders. This comprehensive demonstration will evaluate the ASV in a closed-course, multiple on-road, and simulation environments.

1.1.2 Goals

1. **Comprehensive data collection** on safety and operational performance of an ASV in a variety of traffic, weather, illumination conditions, and scenarios through testing in closed-course, public road with live traffic, and simulated environments.
2. **Analysis and sharing of the data** and findings with the USDOT and federal, state, local, and tribal agencies for enabling data-driven rulemaking regarding safe deployment of AVs.
3. **Engaging, informing, and educating** a broad range of stakeholders including elderly, disabled, and transportation-disadvantaged groups about ADS and involving them in the experiencing and testing of an ASV.

1.1.3 Objectives

1. Compute performance measures for **safe ASV** operation
2. Study ASV interaction with **vulnerable road users** and **manually driven vehicles**
3. Assess the role that **connected vehicle technology** will play in ASV operation
4. Use **simulation** for AV safety and operational characterization
5. Test safe and efficient vehicle operation in **congested environments** and **adverse weather conditions**
6. Understand **law enforcement** data needs
7. Determine **roadway maintenance** standards for ASVs
8. Integrate ASVs into **transit service** planning and operations
9. Understand **user trust** in technology
10. Serve **transportation challenged** populations by enabling equitable access in rural/tribal areas and for persons with disabilities
11. Disseminate **lessons learned** to public agencies for rulemaking

1.2 Key Partners, Stakeholders, and Team Members

UW-Madison has assembled a strong, multidisciplinary team of partners and stakeholders to successfully execute this project. The team includes public, private, academic, and non-profit organizations, all with clear objectives for supporting the project and a shared vision for success of this demonstration.

Living Lab: At the core of the project demonstration is the development of a living laboratory for public road vehicle demonstration and data collection. American Family Insurance have already provided full funding for the ASV purchase and initial route creation for the living lab route. In addition, the City of Madison will enable the demonstrations on public roads, and Madison Metro Transit will provide usage of their facilities.

Simulation Environment: The Simulation Based Engineering Lab and the Department of Mechanical Engineering at UW-Madison will support development and simulations using their connected automated vehicle emulator (CAVE).

Closed-Course Testing: MGA Research, a founding partner of the Wisconsin Automated Vehicle Proving Grounds, will conduct closed-course testing at their facility in Burlington, Wisconsin.

Data for Safety and Rulemaking: The living lab route will be instrumented with infrastructure technology. Arista Networks will support the instrumentation of wireless access points for road user localization. Traffic and Parking Control Company (TAPCO) will serve as the systems integrator for connected vehicle (CV) applications, including instrumenting the intersections on the route with Siemens roadside dedicated short-range communications (DSRC) radios for V2X applications.

Transportation Challenged Populations: Greater Wisconsin Agency for Aging Resources (GWAAR) along with their partners in Dane County will facilitate the participation of senior, disabled, and disadvantaged and underserved populations from the counties surrounding Madison. The Lac De Flambeau Tribe will serve as the demonstration site for the tribal route. Wisconsin Rural Partners (WRP) will support ASV demonstrations at their annual summits in Marshfield, Elkhart Lake, and Chippewa Falls. Madison Metro Transit will support the first/last mile connectivity with the existing transit system for a transportation-challenged neighborhood.

Outreach and Knowledge Transfer: The State Smart Transportation Initiative (SSTI) along with Transportation for America (T4A) will facilitate the knowledge transfer and outreach to state DOTs and cities across the country. Community Transportation Association of America (CTAA) will support the outreach to rural and transportation-disadvantaged communities across the nation. Wisconsin State Patrol will support and participate in understanding law enforcement needs as related to ADS.

Logistical Support: Many groups will be involved with logistical support for the project. UW-Madison Transportation Services will provide support for vehicle maintenance and campus operations. Madison Gas and Electric (MGE), Madison's energy provider, will provide charging resources. Wisconsin Department of Transportation (WisDOT) will provide support with operations on state routes. Schmidt's Towing will continue to support the project team in towing the vehicle locally and to statewide destinations, as they have done for prior vehicle demonstrations in November 2017 and April 2018. The City of Madison will also be a primary logistical resource for citywide operations including parking, signal system and backhaul access, and outreach efforts.

Safety Analyses and Rulemaking: Multi-disciplinary research teams from several departments of UW-Madison will carry out innovative research harnessing foundational scientific principles and emergent data science tools to evaluate safety performance of ASV integration and provide data for rulemaking in a variety of domains for federal, state, local, tribal agencies.

1.3 Issues, Challenges, and Performance Improvements

User Trust: The primary challenge associated with widespread adoption of ADS is gaining user acceptance and trust. As illustrated by a recent survey conducted by the American Automobile Association (AAA), 73% of drivers are "too afraid" to ride in a self-driving vehicle. Through the extensive and extended ASV demonstrations for public including disabled, blind, elderly and tribal citizens, we propose to engage, inform, educate and bolster user trust and acceptance of ADS.

Rulemaking and Certification: In addition to experiencing the benefits of automation, the key to gaining user acceptance is the development of standards or rules along with their certified compliance by independent agencies. The data and resultant analyses by transdisciplinary experts will provide vital information for rulemaking in a variety of domains including: safety performance measures, ADS performance requirements, law enforcement needs, transit planning and operation, tribal/rural/local requirements, equitable access for disabled and other transportation challenged populations, roadway pavement markings, and simulation for testing.

Infrastructure Applications: Statistics show that 25% to 45% of all traffic crashes occur at intersections. As part of this project, a Cooperative Vehicle Intersection Control System (CVICS) will be developed on the living lab route. DSRC/LTE-V2X based CV units will be deployed to interact with the ASV. The team will also demonstrate how an infrastructure-free, mobile ad-hoc network-based framework can be harnessed to improve vulnerable road user (VRU) safety and provide preparation for 5G technologies. The system will collect key data elements from both the vehicle and infrastructure and provide quantitative performance measures to allow for rulemaking ensuring that AVs traverse signalized intersections without incident.

Rural/Tribal Areas: Historically, rural and tribal areas have lagged in adoption of technologies that would have immensely improved the quality of life and opportunities for those communities. Along with our demonstrations, we will develop and disseminate information on identifying impediments and opportunities for AV adoption as well as lay the groundwork for AV deployments in those areas.

Open Data and Simulation Framework: Most ADS research, development and testing have been proprietary and opaque to the public, contributing to diminished trust in ADS. Open simulation framework along with sharing of most data resulting from these demonstrations (see data management plan) will enable transparency as well as independent testing of ADS including recommended performance improvements to ASV technology.

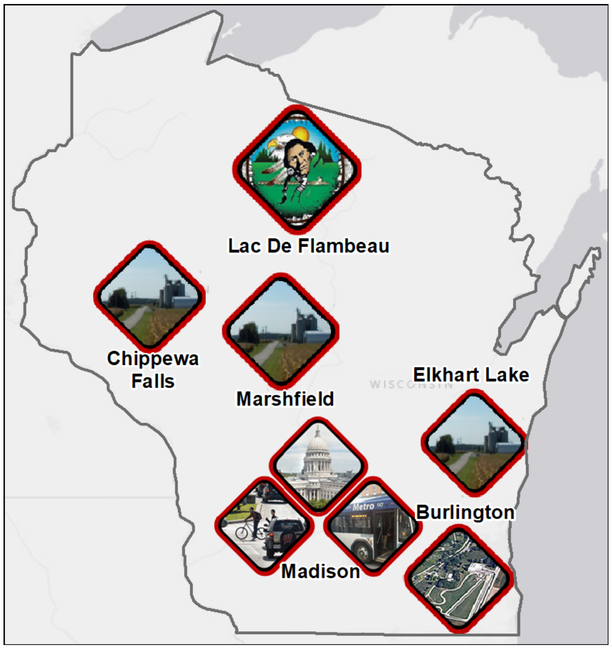
1.4 Geographic Area of Demonstrations

City of Madison, Wisconsin: The majority of on-road demonstrations including the living lab, campus route, and first-mile/last-mile route will take place in Madison. The living lab is an urban core route, the campus route is an urban route, and the first-mile/last-mile route is a suburban route.

Walworth County, Wisconsin: Closed-course testing will take place at the MGA Research facility outside of Burlington, Wisconsin in a rural area of the county.

Lac du Flambeau Reservation: A rural town demonstration route will connect community services on the Lac du Flambeau reservation in Northern Wisconsin.

Rural Demonstrations: Demonstrations will be conducted at the sites of WRP Annual Summits in Marshfield (2020), Elkhart Lake (tentative 2021) and Chippewa Falls (tentative 2022).



1.5 Period of Performance and Demonstration Schedule

The table below shows the planned project timeline based on a start date of October 1, 2019 and a period of performance of three years.

Task	'19	'20				'21				'22		
	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3
1. Project Management	■	■	■	■	■	■	■	■	■	■	■	■
2. Demonstrations	■	■	■	■	■	■	■	■	■	■	■	■
3. Safety Performance Measures				■	■	■	■	■	■	■	■	
4. Operational Impacts						■	■	■	■	■		
5. Transportation Agency Needs						■	■	■	■	■		
6. Transit Integration Planning and Operation							■	■	■	■		
7. Equitable Access and User Trust			■	■	■	■	■	■	■	■	■	
8. Data Sharing	■	■	■	■	■	■	■	■	■	■	■	■
9. Knowledge Transfer and Outreach		■	■	■	■	■	■	■	■	■	■	■
10. Final Report										■	■	■

The table below shows the planned location of the ASV throughout the project period. Note that for vehicle may not spend the whole month at the location shown.

'19			'20												'21												'22								
O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S
W						M	L							W				E	T	L			U				W			C	T	F			

W = Closed Course, Walworth Co.
L = Living Lab, Madison
M = WRP, Marshfield
T = Tribal Route, Lac du Flambeau
U = University Route, Madison
F = First/Last Mile, Madison
E = WRP, Elkhart Lake
C = WRP, Chippewa Falls

2 GOALS

The UW-Madison proposal addresses all the three goals of this NOFO, in word and in spirit as elaborated in the following sections.

2.1 Safety

Most of the testing of autonomous vehicles (AVs) has been rather opaque to the public and government agencies in general. There is acute need for public (as opposed to private) safety testing of AVs using closed course, simulation, and on-road testing environments. To contribute towards this goal, the UW-Madison team proposes to **demonstrate and test a SAE Level 4 ASV** for understanding its safety performance and operational consequences. Our proposed demonstrations address a **wide-spectrum of scenarios** ranging from closed-course testing, urban living laboratory with multimodal traffic, campus route with heavy pedestrian and bicyclist traffic, tribal route with low traffic volume, and simulation testing. Testing and demonstration will occur under a **combination of traffic, weather, road, and illumination conditions** over extended periods of time throughout of the project. We will leverage our combined extensive experience and expertise in traffic safety and operations modeling, human factors, user trust in and acceptance of automation, vehicle testing, simulation modeling, law enforcement needs, and state/local agency needs to achieve this goal.

2.2 Data for Safety Analysis and Rulemaking

One of the alluring features of autonomous vehicles (AVs) is their potential to drastically reduce, if not eliminate traffic fatalities on our roadways which have exceeded 40,000 in 2016. Furthermore, **AVs have the potential to enable efficient, equitable, healthy, and sustainable transportation systems and communities.** However, the fundamental challenge for a wider and quicker adoption of AVs is user trust and acceptance. A recent survey conducted by the American Automobile Association (AAA) reported that 73% of drivers are **too afraid** to ride in a self-driving vehicle. Public enthusiasm for and trust in AVs has been significantly impacted following multiple fatal crashes involving vehicles with varying levels of automation. Unfortunately, the fact that several of these crashes have occurred in rather “routine” situations including a pedestrian crossing the road (outside the crosswalk), tractor semitrailer turning left across a high speed roadway, and encountering a concrete barrier at a fork in the highway has not been helpful.

One of the keys to gaining user acceptance is the development of standards or rules along with certification of compliance by independent agencies. In addition to sharing the raw data obtained from the demonstrations, the UW-Madison team will harness our combined expertise to sift through vast amounts of data generated from these demonstrations to characterize, quantify, analyze and obtain useful datasets and information enabling rulemaking as well as future research and development of ADS for any and all interested parties. We expect to provide vital information for rulemaking in a variety of domains including safety performance measures, ADS performance requirements, law enforcement needs, transit planning and operations, tribal/rural/local requirements, equitable access for disabled and other

/transportation-disadvantaged challenged populations, roadway pavement markings, and simulation for testing.

UW-Madison's Traffic Operations and Safety **(TOPS) Lab has extensive experience in developing systems to host and communicate data** across a variety of applications including incident alerts, crash data, and winter maintenance in near real-time. Our team will build on our vast experience in this area to make the varied data sources available to USDOT and the public throughout the project. While some data streams will be shared in near real time, other data streams will be made available through periodic batch updates. The data section in Task 8 of the technical approach illustrates the various data sources and the expected timeline for sharing them. We propose to use the **USDOT secure data system** to host and share the data, details of which are presented in the Data Management Plan, Part 3 of this proposal.

2.3 Collaboration

UW-Madison has assembled a strong, multidisciplinary team of partners and stakeholders all with clear objectives for supporting the project and a shared vision for success of this demonstration. The team led by UW-Madison (**academic organization**) includes **public agencies**: City of Madison, Wisconsin Department of Transportation, Wisconsin State Patrol, Nation of Lac De Flambeau, Madison Metro; **private partners:** American Family Insurance, MGA Research, Traffic and Parking Control Company; and **non-profit organizations:** Greater Wisconsin Agency for Aging Resources, Community Transportation Association of America, Wisconsin Rural Partners.

The functional roles of each of the team members have been elaborated in the Executive Summary on Page 2 and are not being repeated here.

3 FOCUS AREAS

3.1 Significant Public Benefits

Communities across the United States have been part of ASV demonstrations, including two demos at UW-Madison. These demos typically have been limited in duration and/or environments for the deployments. Larger scale tests of AVs in general have provided limited public data on crashes and disengagements. The proposed project builds on these demonstrations and spans a vast spectrum of scenarios for ASV operation (as described above) over extended duration. Comprehensive data sharing will enable public rulemaking.

3.2 Addressing Market Failure and Public Needs

The private sector rapidly integrating advanced machine and deep learning algorithms to advance AV technology to the point where it is viable at SAE Level 4. It is likely industry will keep pushing this envelope. Current industry AV business models include operating AVs in large cities as transportation network companies (TNCs) and developing freeway driving ADS systems. The market has not yet incentivized development in rural areas nor for transportation-challenged populations. Even with manually driven TNCs in large cities, focus is on high-profit routes, often leaving behind transportation-challenged populations including older citizens, people with low incomes, and people with disabilities. Rural counties, rural municipalities, and Native American tribes have also been traditionally left behind with technological evolutions and this trend could continue.

This project will address these concerns by demonstrating routes and researching possible business models for this large population of Americans. The first/last-mile route will demonstrate providing transit to low-income households who live in food deserts who have traditionally not been served by larger transit buses. The living lab demonstration will provide focus groups of older citizens and people with disabilities the chance to ride and have input on the AV shuttle. Residents of rural counties and municipalities will be able to do the same at the three Wisconsin Rural Partners summits across the state. The Lab du Flambeau tribe will experience the shuttle first-hand on their tribal lands on a route designed to support their community.

3.3 Economic Vitality

Open sharing of the demonstration data and resultant analyses will democratize the field and spur the further development of safe AVs domestically by not only big companies, but also more importantly by startups and other entrepreneurs. Currently, the exemption process from building vehicles in the United States and selling them domestically limits ASV providers. A path to US production of ASVs must be pursed including decoupling ASV waivers from the importation process. This will involve rulemaking based on the data this project will collect and support.

3.4 Complexity of Technology

Rather than demonstrate a breath of vehicle technologies, the project team decided it would be more valuable to provide an in-depth set of demonstration environments and data for one particular vehicle. Through a partnership with American Family, UW-Madison will deploy an SAE Level 4 shuttle in this demonstration. This vehicle will interact with a variety of technologies at intersections to better understand connected vehicle applications, detection abilities, and interaction with VRUs and manually driven vehicles.

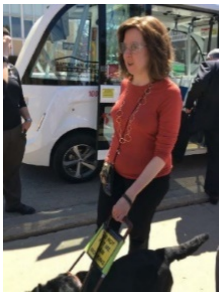
3.5 Diversity of Projects

Our demonstrations cover a variety of use cases of ASV in urban core, urban area, suburban area, rural area, rural town area, and tribal environments including first/last mile connectivity for public transit access, campus routes for student usage, as well as access to downtown areas.

Personal mobility and public transportation are being explored on various routes; however, freight is not addressed directly.

3.6 Transportation-Challenged Populations

UW-Madison's ASV is accessible and usable for disabled individuals and our demonstrations include serving older adults and disabled populations in the downtown Madison area through the Living Lab route. Additionally, several focus groups of older and disabled individuals will be conducted to understand the needs and challenges faced by these groups in effectively using the ASV as well as ADS technologies in general.



UW-Madison has an extensive history of supporting inclusive transportation.

3.7 Prototypes

UW-Madison's ASV is SAE Level 4. Both Navya and EasyMile shuttles have been used in deployments across the world, including Navya demonstrations in Madison, WI. Currently the State of Wisconsin and the City of Madison have no statutes limiting the demonstration of automated vehicles. Because the ASV does not satisfy the Federal Motor Vehicle Safety Standards (FMVSS), an exemption from National Highway Traffic Safety Administration (NHTSA) for operating it on public roads is required. Our team has obtained NHTSA exemption for the two previous demonstrations conducted in Madison, WI in November 2017 and April 2018. Prior to on-road demonstrations, we will again obtain a NHTSA exemption.

An on-board attendant will be on the vehicle at all times and is included in the budget of this project.

4 REQUIREMENTS

UW-Madison's proposed demonstration satisfies all the five requirements of this NOFO. Specifically, a **SAE Level 4 ASV**, purchased prior to the period of performance of this project, will be deployed over the period of performance at **multiple physical demonstration sites**. These include a living lab on public roads, on a campus route, a first/last mile connector to a transit system, a tribal route in a rural town setting, three short routes in rural areas, and an extensive closed-course track test. ASV simulation will also be performed. UW-Madison's ASV is **wheelchair accessible and with accessible interfaces** that allow users with varied abilities to access and communicate information to the ASV. Data sharing and outreach/knowledge transfer tasks will occur practically throughout the duration of the demonstration. UW-Madison will leverage its **extensive data sharing** experience to share raw data (including sensor data, camera data, and location data, use data), processed/derived data (conflicts, near misses, crashes, disengagements, and other innovative data measures), and linked data (crashes, traffic volumes/speeds, and weather) with USDOT. Complete details of data sharing are presented in the Data Management Plan in Part 3. Our demonstrations cover a vast majority of use cases for ASVs; therefore, the lessons learned will be practical and useful for broader deployments across the nation.

Through our partners at State Smart Transportation Initiative (SSTI), Transport for America (T4A), Community Transportation Association of America (CTAA), and Wisconsin Rural Partners (WRP) we enable **knowledge transfer and outreach** to state DOTs, cities and rural agencies across the country. Our team confirms a commitment to negotiate and sign a mutually agreeable data sharing agreement with USDOT as a requirement for award.

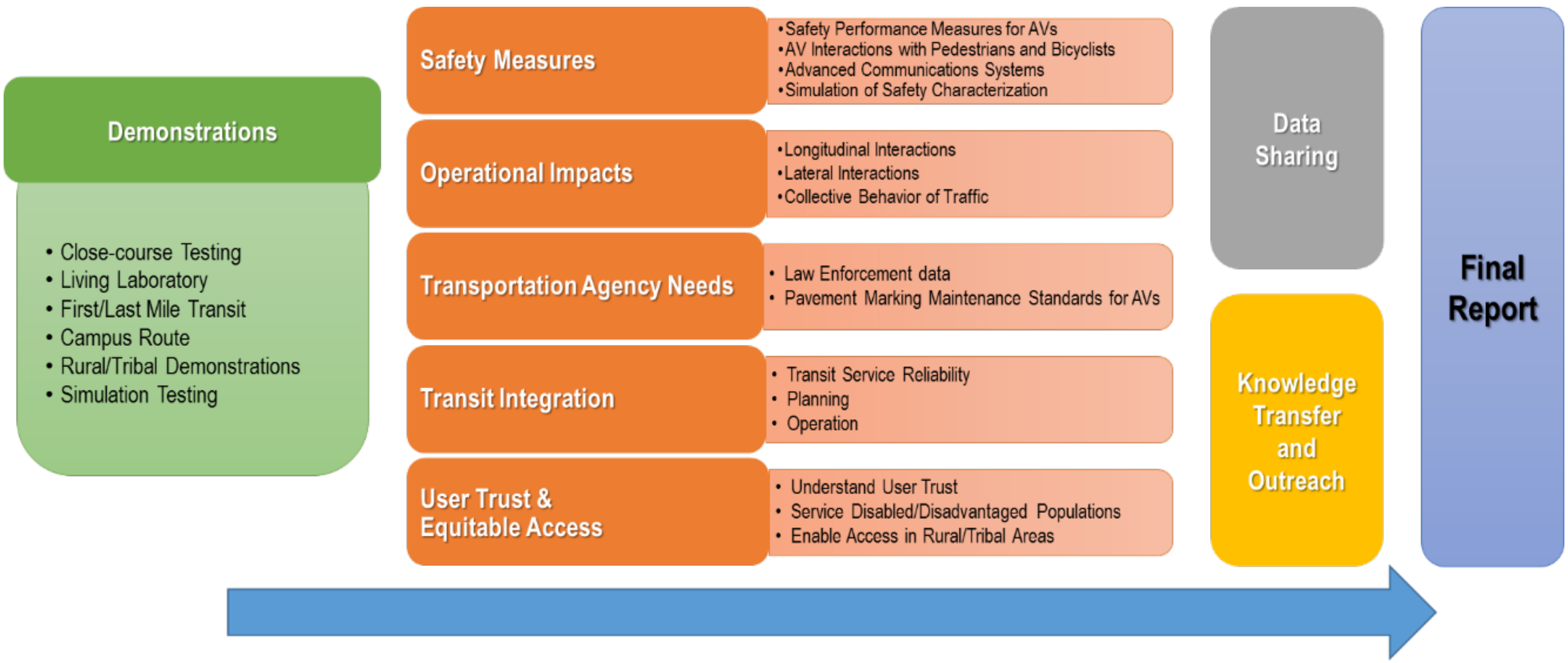
Requirements

- ✓ L3 or Greater
- ✓ Physical Demonstration
- ✓ Data Sharing
- ✓ Accessible I/O Interface
- ✓ Outreach/Knowledge Transfer

5 APPROACH

5.1 Technical Approach

This section outlines the project team's technical approach to the project. The purpose of the demonstration project is to collect data surrounding the usage of an ASV on the routes being demonstrated. This data falls into categories ranging from highly technical data to user survey data. The following data diagram shows the range of data types being collected for this project. More information is discussed in each task of the technical approach as appropriate as well as in Part 3 of this submission.



Task 1. Project Management

The objective of Task 1 is for the UW-Madison team and USDOT to institute processes for managing the demonstrations effectively so we satisfy all the goals and objectives within budget and in a timely manner. Some of the major project management activities include the kick-off meeting, development of a Project Management Plan, Data Management Plan, Project Evaluation Plan, Quarterly Progress Reports, Annual Budget Review and Program Plan/Meeting. Details of the team structure and management are presented in Volume 2 of this proposal application.

Task 2. Demonstrations

The ASV will be demonstrated across seven diverse sites to explore appropriate use cases for these vehicles. This section outlines the technical approach to ensure success at every stage of the project.

2.1 Closed-Course Testing

MGA Research offers a 400-acre private testing environment with over 20 miles of roadway including eight unique tracks with varied grades, pavement conditions, and surface types. MGA Research is a leader in crash testing for the federal motor vehicle safety standards (FMVSS) including crash testing with the most advanced human dummies.

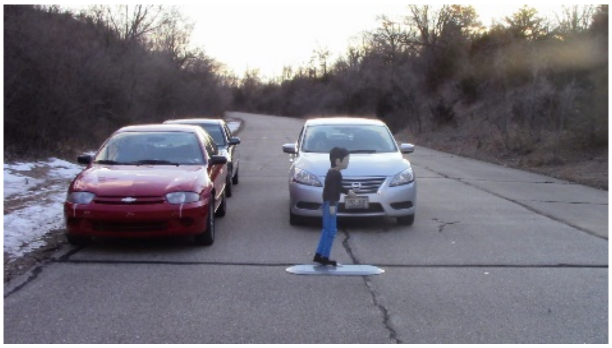
The objective of closed-course testing is to validate expected vehicle functionality as well as explore the limitations of state-of-the-art ASV technology. Understanding response to extreme weather, difficult terrain and pavement conditions, VRUs, and manually driven vehicles is critical to operating the vehicle safely in mixed traffic and determining rules allowing such usage.

The ASV will be evaluated through a variety of replicated real-world conditions prior to integration on public roads. These evaluations will focus on developing new safety protocols and utilizing current consumer safety rating test protocols.

ADS Operational Design Domain (ODD) Testing: MGA will develop tests and test the shuttle for the conditions described below. These tests are a basis to develop repeatable, closed-course evaluation procedures to support ADS deployments.

1. ODD – Vehicle Performance
   a. Rear automated emergency braking and pedestrian detection
   b. Driving up/down on grades including start/stop on grade – 12%-30%
   c. Varied environmental factors including snow/ice/flooding/glare
   d. Varied ballast conditions including lightly loaded to fully loaded
   e. Parking – Entry and exit from marked stalls, charging stations

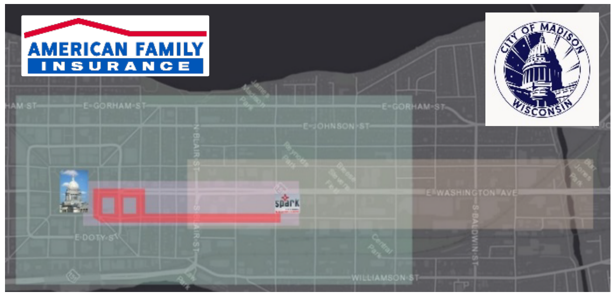
2. ODD – Traffic/Obstacle Performance
   a. Lead vehicle accelerating, braking, or stopped
   b. Oncoming traffic and cross traffic
   c. Driving through a tunnel
   d. Parked car door opens into traveled way
   e. Interacting with emergency service vehicles
   f. Roadway obstructions – people, wheelchairs, animals, potholes, barriers, and debris



Current Consumer Safety Rating Test Protocols: MGA will conduct the following pedestrian and bicycle interaction standard tests developed for automated emergency braking by the Insurance Institute for Highway Safety (IIHS) and EuroNCAP.

1. IIHS Pedestrian Autonomous Emergency Braking Test Protocol (Version 1) December 2018 including scenarios similar to CPNA-25, CPMC-50, CPLA, and using obstruction vehicles
2. IIHS Autonomous Emergency Braking Test Protocol (Version 1) October 2013 including approaching target vehicle at different test speeds
3. EuroNCAP Autonomous Emergency Braking Vulnerable Road User Test Protocol (Version 2.0.4) February 2019 including pedestrian and bicycle scenarios: CPFA-50, CPNA-25 and -75, CPNC-50, CPLA, CBNA, and CBLA.

2.2 Living Lab



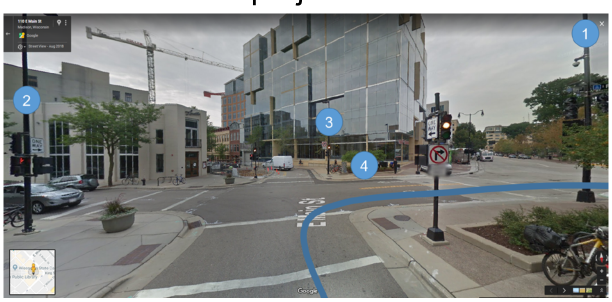
The living laboratory is the primary on-road, mixed traffic study area for the ASV. This route is a 1.5-mile return route operating from the Capitol East district in Madison to the Capitol Square. The project team has worked with the City of Madison as well as other stakeholders on the precise route. The City and MGE will provide parking and charging near the route.

The route consists of two main components making it a living lab, the vehicle data management system and the infrastructure detection and control system. Infrastructure is connected back to the TOPS Lab through Madison's fiber network, as described in Part 3 of this proposal.

Corridor Description: The living lab corridor consists of travel on city streets with a maximum speed limit of 25 mph. Main Street is the primary straight route, with other side streets used to reverse the vehicle on the route. Main Street is a two-lane collector route with relatively low AADT compared to parallel routes on Madison's isthmus. This route provides enough traffic to allow for a variety of vehicle, bicycle, and pedestrian traffic interactions, but low enough traffic to ensure safe and jam-free operations. The primary route consists of five signalized intersections and Metro bus transit integration. The ASV will navigate the signalized intersections using DSRC technology, which has been demonstrated effectively on a Navya ASV in Las Vegas.

Vehicle Data Management System: The ASV will be collecting data constantly while driving on the route. To better allow for collection of the data, a secondary computer system will be installed on the vehicle with the primary purpose of comprehensive data collection. Inputs to this system will be the vehicle's primary computer system including data from vehicles sensors as well as additional hardware installed by the project team. Sensors include cameras, LiDAR, radar, ultrasonic, temperature, speed, odometer, and differential GPS/GNSS.

Infrastructure Detection and Control System: The infrastructure along the living lab corridor will be instrumented with a variety of technologies to support vehicle operations and data collection. Statistics show that 25% to 45% of all traffic collisions occur at intersections, and are thus the location of the majority of off-vehicle data collection for this project.



The intersection safety system is shown in the image above with the blue line being the shuttle route. This system will be installed at one busy intersection on the route. The system includes the following components (Number corresponds to location in diagram):

- A combined DSRC/LTE-V2X roadside unit (RSU) and necessary hardware to integrate the device into the controller – To communicate SPaT and other messages to the vehicle (1, 2)
- Wireless access points – for vehicle and VRU localization (1, 2, 3)
- LiDAR sensors – to validate detection of VRUs (2, 3)
- A 360 degree video camera – to validate detection of VRUs (1)
- Edge computer – to process data and communicate with the data center (4)
- Other controller hardware (4)

All other signalized intersections will include only RSUs and APs. Each of these systems are described in the next sections.

Connected Vehicle Technology (DSRC / LTE-V2X): Madison, in collaboration with the Wisconsin Automated Vehicle Proving Grounds and Traffic & Parking Control Co., Inc. (TAPCO), is one of a handful of cities that is planning to meet the goals of AASHTO's SPaT Challenge. Madison's Park Street Connected Corridor's University/Park intersection has already been instrumented and tested with a combined DSRC/LTE-V2X roadside unit (RSU) and intersection controller.

The team involved in planning and testing this corridor are part of the ASV demonstration grant team.

TAPCO will support this project on the infrastructure side and the vehicle side in the following ways:

- Source RSUs and OBUs compatible with Madison's traffic controllers
- Provide hardware to connect the RSUs to the controllers
- Configure MAP messages to describe the signalized intersections

- Configuring RSUs to send out MAP and SPaT messages
- Configure OBUs to receive and display intersection light status and time to change, using messages sent by RSUs
- Work with the ASV provider to configure OBUs to output SPaT to the ASV system

VRU and Other Vehicle Observation: The Electrical and Computer Systems Engineering team members will integrate information to observe and log the trajectories of different road users (AV, other vehicles, and pedestrians) providing data to answer key macroscopic and microscopic traffic engineering questions. The following three sensing modalities will be used.

Wireless APs: We will purchase and deploy a network of wireless access points (APs), connected to the Madison's fiber network. Access points with these capabilities are available from vendors such as Arista Networks. The network of wireless APs will have the potential to sense the traffic behaviors almost anywhere in the deployed area. To enable this, we will deploy APs that have an Open Network Install Environment (ONIE) interface and suitable drivers from the OpenWrt framework.

AV Mounted Sensors: Using the AV-mounted sensors, the team will observe the activities around the AV. These observations include the driving behaviors of vehicles immediately behind, immediately to the left and right, and the vehicle/pedestrians in the front of the AV. These observations will allow us to partially observe the trajectories of nearby vehicles.

Mobile Apps in Willing Participants: We will develop an app and make it freely available to Android and iOS users. The app will collect GPS and IMU (Inertial Measurement Unit) sensor readings of willing participants in privacy-preserving fashion. The GPS data enables localization of users and identification of their speed. IMU sensory data allows for identifying the transportation mode along with more fine-grained aspects of user mobility.

2.3a College Campus Route

The college campus route will run during the Fall 2021 semester on the UW-Madison campus. The location of the route will be in the vicinity of Observatory Drive and Linden Drive, and will run in a roughly 2-mile loop. The precise route will be determined with university stakeholders including Transportation Services in order to serve a student population that has a transit demand between student housing and classrooms and other facilities.

A student cohort of 40 students will be given access to the shuttle as the primary focus group for the study. The shuttle will also be open for general public use throughout the demonstration period. The cohort will provide general feedback throughout the semester and more directed feedback centered on route effectiveness, ASV operations, and safety.

This route will also provide for additional data collection including interactions with heavy and unstructured bicycle, scooter, and pedestrian traffic.

This route will only run during class hours; however, the team is aware of a need for overnight transportation and will work with the focus group of students to determine future routes to serve these demands.

UW Transportation Services has agreed to assist with parking / charging on this route.

2.3b First/Last Mile Route

The first/last mile route will run from June through September 2022 in South Madison, where there is a known need for additional transit services.

The Allied Drive neighborhood has well-documented transportation challenges including limited access to Metro transit buses.

Transit challenges in many South Madison neighborhoods include very large transit headways and no transit during late night and weekends preventing people in this neighborhood from working second and third shift jobs. Many neighborhoods in this area are also in food deserts.

The route will run a return route from the identified neighborhood to the South Transfer Point, Metro's southern hub station. The current plan is for a fixed route with the ability for riders to hail the shuttle to stop at a designated stop, although a dynamic route will be considered.

Community members will be engaged in route design. This route will serve as a trial operation for Madison Metro Transit to understand the dynamics of ASV feeder routes into their larger network. Dynamic road network mapping will not be integrated, but will be explored as part of this demonstration route.

2.4a Tribal Demos

There will be two one-week demos operating on the Lac du Flambeau tribal lands in Northern Wisconsin. These will occur in the spring of 2021 and 2022. This is an ideal community setting to show shuttle usage in a rural town. The graphic above shows the proposed route, which is a 1-mile fixed route. The route includes access to areas important to the community including the downtown, library, post office, dentist's office, casino, and tribal offices. The Lac du Flambeau Tribal Council will collaborate with the project team to finalize the precise route.

The route will be open to the public. The tribal council will help select members for a focus group to ride the shuttle and provide feedback. Emphasis in interviewing focus groups will be placed on future use cases for AVs including low-speed ASVs for the downtown areas and high-speed vehicles for regional transit. This demo will provide good insight into public perception of AVs.

2.4b Rural Demos

As part of access to automated vehicle demonstrations, Wisconsin Rural Partners will assist in locating a short, 100-yard demonstration area for the ASV at each of their three annual conferences during the project performance period. These routes will be relatively straight and separated from live traffic. The 2020 summit in Marshfield is confirmed, with the 2021 and 2022 summits tentatively planned for Elkhart Lake and Chippewa Falls, respectively. For the Elkhart Lake location, the team will work with Road America, a Wisconsin AV Proving Grounds partner, to determine a location for the route.

The demos will be open to registered participants of the WRP summits and team members will be on site to query riders throughout their experience.

2.5 Simulation Testing

Members of the Systems Based Engineering Lab in the Department of Mechanical Engineering at UW-Madison will implement this portion of the project.

The simulation component of the project will further establish and validate a framework for testing and evaluating autonomous shuttle transportation in a virtual environment. This allows for billions of miles of virtual data collection that is orders of magnitude faster to collect than in the real world. The purpose of the framework is to assess vehicle behavior in safety critical scenarios (e.g., inclement weather scenarios), imminent crash scenarios, etc. This group is currently developing simulation platform called Chrono Connected and Autonomous Vehicle (CAV) that allows the analysis of autonomous vehicles in complex scenarios through computer simulation. This infrastructure is the outcome of a research and development technical effort that spans five thrusts: (i) vehicle dynamics; (ii) sensing and perception; (iii) communication; (iv) virtual environments; and (v) control and path planning.

In the vehicle dynamics thrust (i), the team has established a platform called Chrono::Vehicle that allows one to simulate the dynamics of a variety of vehicles – from sedans to SUVs and buses. These are high-fidelity, nonlinear models that combine sub-models that capture the response of vehicle sub-systems such as tires, suspension, powertrain, driveline, etc. The dynamics of these vehicles is critical as it comes into play in the control and path planning thrust (v) that emulates the decision making process that goes on continuously in each AV. In making these decisions, the AV will require information pertaining other vehicles and the environment in which the vehicle operates.

This is the topic of the sensing and perception thrust (ii) in which the emphasis is on synthetically generating sensor data for software-in-the-loop testing. The synthetic sensor data will be physically realistic such that actual limitations in real-world sensing can be explored insofar as their impact on AV control is concerned. For example, scenarios involving rain, snow, or fog may result in limited sight from a camera and the virtual camera sensor will mimic this distortion and limited sight.

This simulation platform component is envisioned to work in tandem with other communication protocols supported by tools such as Cooperative Automation Research Mobility Applications (CARMA).

Task 3. Safety Performance

During shuttle demonstrations, data collection and research will be performed focusing on safety and operational performance of the ASV. These projects are described below. Data collection will focus on providing data that will support rulemaking to define operational and safety parameters for ASVs as well other AVs.

3.1 Performance Measures for Safe Operation of AVs

The performance measures to be used include conflicts, near misses, crashes and events. Furthermore, data will be used to categorize and characterize these under varied typologies of road users, weather, illumination and roadway features. The extensive field-testing described above will allow us to explore these performance measures in a systematic manner. Specifically, we anticipate that the Campus Route will be better suited to study how the shuttle negotiates unexpected instances of random pedestrian crossing and bicycle maneuvers. Thus, this route is ideal to observe interactions between the shuttle and pedestrians and bicyclists.

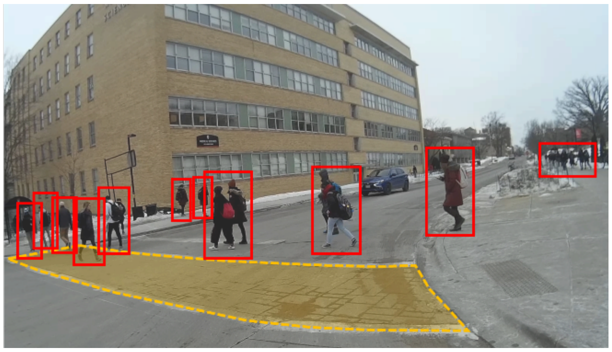
The Living Lab route will be ideal to observe how the autonomous shuttle interacts with other surrounding vehicles, traffic control (e.g., signalized intersections), and VRUs in a more structured manner (i.e., through designated crosswalks and bike lanes).

We anticipate that the autonomous shuttle will be able to travel at higher speeds for longer periods due to more organized interactions with other modes. This is required to operate safely on roads with 25 mph speed limits. For instance, the 2018 demo shuttle operated at 10 mph and was involved in risky passing maneuvers by vehicles traveling the speed limit.

We expect that the response of the autonomous shuttle may be affected by various environmental and road conditions including snow and ice, large grades, rough pavements, gravel and unpaved roads, and cold and hot temperatures. The closed-course testing will provide a safe environment to test the behavior of the autonomous shuttle to shed light on operational and safety implications of the interactions under adverse conditions.

Particularly, the deployments will generate a large high-resolution (~0.1 s) dataset of vehicle and pedestrian trajectories with high accuracy achieved by novel fusion of data from the vehicle data management system and the infrastructure detection and control system. These rich datasets will enable us to meaningfully characterize the interactions and quantify the conflicts, near misses, and other ASV interaction events.

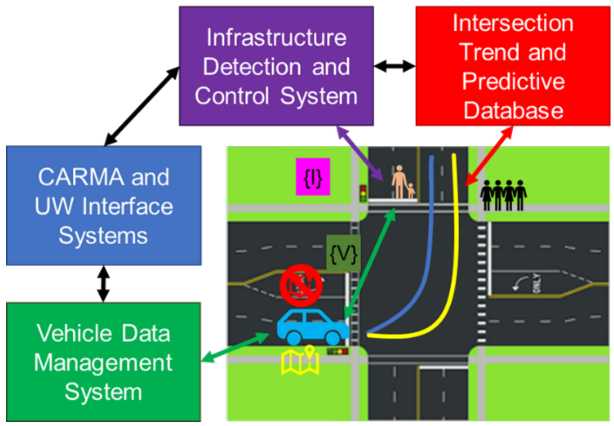
3.2 AV Interaction with Pedestrians and Bicyclists



The interactions between pedestrians and AVs during permissive movements such as left and right turns as well as mid-block crosswalks are complex due to the number of factors that could be involved in the decision. Decisions by drivers about yielding to pedestrians are not always based on traffic laws; these decisions could be influenced by non-verbal cues, a-priori knowledge of site behaviors, the position of the pedestrian along the crossing path, the type of pedestrian, weather conditions, and traffic conditions, among others. Understanding these interactions at a microscopic level is key to the safe operation of AVs. For trust and acceptance of AVs to increase, AVs need models of these complex vehicle-VRU interactions to better resemble the behavior of human drivers. This includes minimizing potential for rear-end crashes resulting from a human driver misjudging the next step of an AV, for example an AV completing a permissive left or right turn maneuver and yielding to pedestrians or bicyclist.

The research team will study the interactions of AVs with pedestrians from two perspectives: that of the AV and that of the infrastructure. From the AV perspective, research efforts will be focused on analyzing data about AV-pedestrian interactions to understand how built-in safety thresholds increase "jitter" (confusion or system halts) during these interactions with pedestrians and thus reducing trust from users of the transportation system. From the infrastructure perspective, research efforts will be focused on understanding how AV-pedestrian interactions influence the safety of other interactions such as those in which the AV is leading vehicle and unexpected behavior increases near misses with other vehicles or negatively influences the operations efficiency of the transportation system. UW-Madison researchers have developed a framework to study these interactions and AV manufacturers can use the improved AV-pedestrian interaction models developed by the research team to have their systems more closely resemble human drivers' behavior and increase trust and acceptance of AV technology.

3.3 Advanced Communication Systems



The team will develop the Safe Access to Future Exchanges System (SAFES). SAFES is a Cooperative Vehicle Intersection Control System (CVICS) designed by to: 1) safely guide AVs through signalized intersections and, 2) provide a mechanism for capturing innovative data sources that allow authorities to measure safety and support future rulemaking.

The cornerstone of SAFES is data: in order for SAFES to deliver on the promise of safe signalized intersection navigation, the system will collect key data elements from both the vehicle and infrastructure systems to develop strategies to allow AVs to traverse signalized intersections without incident.

The SAFES system will compile VRU data from both the vehicle and intersection systems and compare the data looking for situations when both detect correctly, only one detects correctly, or neither detect correctly. This data will provide direct input into rulemaking strategies for AVs navigating intersections. The platform will be developed to work with protocols supported by tools such as CARMA.

3.4 Simulation for Safety Characterization of AVs

This task will focus on validating the Chrono CAV open source simulation platform using data collected from the ASV and studying the interactions of other vehicles with the ASV. During this focused validation effort, we will

- produce a simulation environment that replicates the ASV operating experience on the Living Lab by generating a virtual world replica of the 3 by 2 mile area,
- improve and validate the synthetic sensor simulation process both for camera and LiDAR sensing,
- carry out a systematic safety assessment study in two adverse weather conditions: (a) torrential rain (low friction coefficient at the tire/road interface and poor sensing ability); and (b) icy and snow-road conditions, and
- release and support the Chrono CAV platform as a tool for physics-based simulation of CAVs.

This project will continue to evolve the Chrono CAV platform towards a scalable, high-throughput virtual proving ground that enables cost-effective, safe, and comprehensive testing, exploration, and development of connected and autonomous vehicle technologies.

Task 4. Operational Impacts

The field deployment of the autonomous shuttle system envisioned in this project presents a unique, unparalleled opportunity to bridge a major gap in research and provide a first-hand understanding of AV interactions. These include AV interactions with pedestrians, bicyclists, and human-driven passenger and transit vehicles, as well as how these interactions influence traffic operations.

To understand the operational impact, this task will characterize the key features of AV-induced disturbances, including magnitude (e.g., speed reduction) and duration that would result in marked, persistent disruption to traffic flow. The analysis will shed light on how AV-induced disturbances might undermine traffic throughput. Furthermore, the rich data will enable us to develop (analytical and deep learning based) models that can be rigorously calibrated and validated.

Two types of AV-vehicle interactions will be investigated in this task: (i) longitudinal interactions characterized by car-following behavior (CF), and (ii) lateral interactions characterized by lane-changing (LC) behavior and the influence of autonomous shuttle presence on (human-driven) vehicles in the adjacent lanes. We will also analyze pedestrian “freezing” of the shuttle, where heavy pedestrian traffic could freeze the shuttle for an extended period.

We will analyze the behavior of the AV itself to better understand how it compares to other human-driven vehicles and study how that translates to the behavior of surrounding vehicles. For the longitudinal interactions, the CF behavior of the ASV and its immediate follower will be analyzed.

We expect interesting features during deceleration and acceleration near signalized intersections. This research will reveal what features of the AV are desirable and how the control can be improved to minimize disturbance propagation in traffic flow. The team will also investigate the lateral interactions around the autonomous shuttle.

For the shuttle behavior in adverse conditions, this research will largely focus on the CF behavior of the shuttle; more specifically, the responses of the shuttle under high-collision-risk situations such as hard braking of the lead vehicle, oscillatory driving condition, short initial spacing, etc.

We will compare the responses to those under 'normal' conditions to observe any differences in response. These responses will have operational and safety implications which will be analyzed.

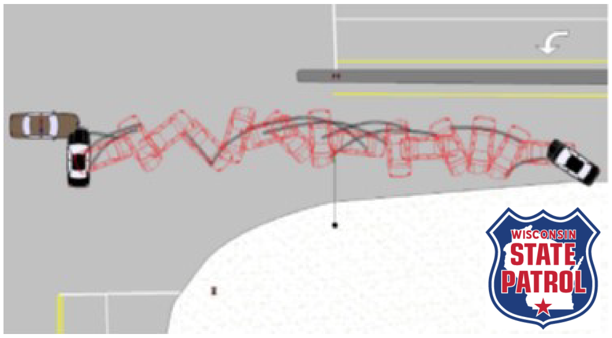
Scaling up from microscopic interactions, we will study the impact of these interactions on the collective behavior of traffic flow, namely disturbance evolution and traffic capacity in various conditions.

While we will investigate the impact of a single AV, our vision is to investigate the impact of AVs in mixed traffic in relation to AV penetration rate. Integrating the effects of CF and LC would not be analytically tractable, and thus, we will develop a simulation platform to investigate the combined effect.

Task 5. Agency Needs

Many agencies will be involved with the safe operation of AVs on our public roads. The project team has engaged several agencies at the state level to focus on enforcement, traffic operations, and registration. These are discussed below.

5.1 Law Enforcement and Traffic Records Data Needs

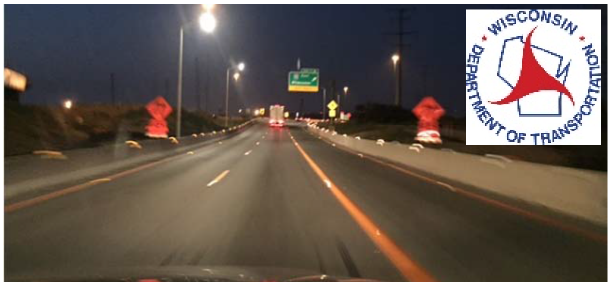


Law enforcement agencies need access to certain information to be able to do their duties in the event of a crash or incident on roadways. Law enforcement agencies will need direct and timely access information about the operation of the vehicle and the circumstances at the time of crash.

In this task, we will enhance our relationship with Wisconsin State Patrol (WSP) to identify the data needs from a traffic records coordinating perspective. Minimum data requirements will be developed analogous to FHWA's Model Minimum Uniform Crash Criteria.

The team will define the minimum amount of data that needs to be accessible to law enforcement to execute their duties. We will collaborate to address questions about the need for event data recorders (EDRs) and law enforcement access to them. We will also validate using EDR data to reconstruct crashes.

5.2 Pavement Marking Maintenance Standards



While state Departments of Transportation are very excited about the potential safety improvements and long-term societal benefits of AVs, they are concerned about preparing the transportation network to enable safe integration of ADS. A chief concern is maintenance of pavement markings, especially in parts of the country affected by snow/ice.

WisDOT pavement marking engineers will help in developing research questions on this topic and in performing tests at the closed course as well as on public roads.

Specific questions to be addressed include retro reflectivity and wet-reflectivity requirements, the role of raised and six-inch pavement markers, and pavement marking impacts on AV operations.

5.3 Registering, Licensing, and Insuring AVs

The team has engaged the Wisconsin Department of Motor Vehicles (DMV) regarding the registration of AVs in Wisconsin. The task force is studying best practices from across the United States and Europe. Licensing questions are being addressed through scenario assessment on the closed course and with the DMV.

American Family Insurance is interested in how AVs will are insured and will work with the team on potential models. The data collected from the ASV will feed into data models that the insurance industry uses for pricing insurance, particular operational, disengagement, and near miss data.

Task 6. Transit Integration

Integrating AVs with transit services can improve ridership, level of service, customer and operator safety at the same or smaller operating cost. A data-driven, scientific approach to develop policies and rules for integrating AVs into transit systems is required. Some of the questions that need to be addressed for successful transit operations involving AVs include:

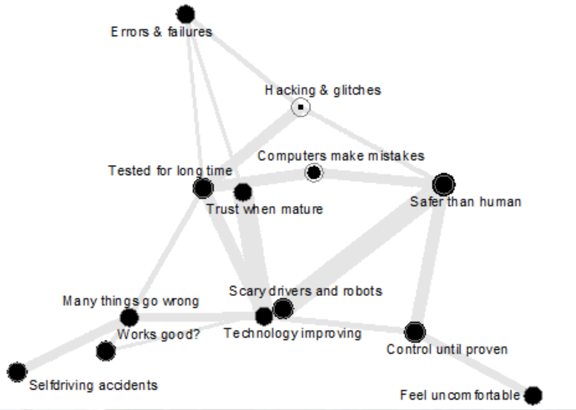
- What is required for enabling universal access to riders of all abilities? Are these beyond current ADA requirements?
- Should there be rules governing AV acceleration/deceleration rates to not cause injuries/falls to riders?
- Impact of weather on shuttle stops
- When should the ASV move after passengers have alighted the vehicle?

In addition, the research team will address questions about operational reliability planning of AVs using data and lessons learned from these demonstrations. Questions of interest include impact of weather (e.g., extreme temperatures, snow storms, flooding events) on operations reliability and remediation measures for unanticipated breakdown or failure in AV operation due to dynamic and temporal changes in ODD, such as a brief, heavy thunderstorm or blizzard conditions.

Task 7. User Acceptance

Public perception is seen as a large barrier to the advancement and integration of AVs into the transportation network. As AVs are quickly coming, we will provide citizens with the ability to understand the technology to be involved in shaping future AV usage.

Task 7.1 User Trust



Trust has emerged as a critical variable mediating the relationship between people and technology across domains that include process control automation, human-robot interaction, and decision aids. For automated vehicles, the complexity, risk, and limited opportunity for control make trust particularly important. Lack of trust may leave both riders and other road users susceptible to dread risk—a heightened feeling of risk when the risk is uncontrollable, not understandable, and has dire consequences.

Without people's trust and acceptance, ADS will fail to produce the promised benefits. Surveys provide a valuable method to assess initial trust and estimate how people might respond to automated vehicles during their initial deployment. Surveys frequently include quantitative data, such as Likert ratings, along with qualitative data, such as open-ended comments. Ratings can be analyzed with traditional statistical methods to assess attitudes, but such analysis fails to explain the basis for those attitudes. Text analysis provides quantitative methods to analyze open-ended survey data and might reveal what factors underlie trust in automated vehicles. Techniques such as topic modeling treat words as data and make it possible to extract insights from hundreds, or hundreds of thousands of comments, with the efficiency and transparency that traditional statistical techniques provide for ratings data. Using this text analysis approach to understanding what lies behind rider attitudes towards AVs will provide critical input into AV deployment.

Task 7.2 Equitable Access

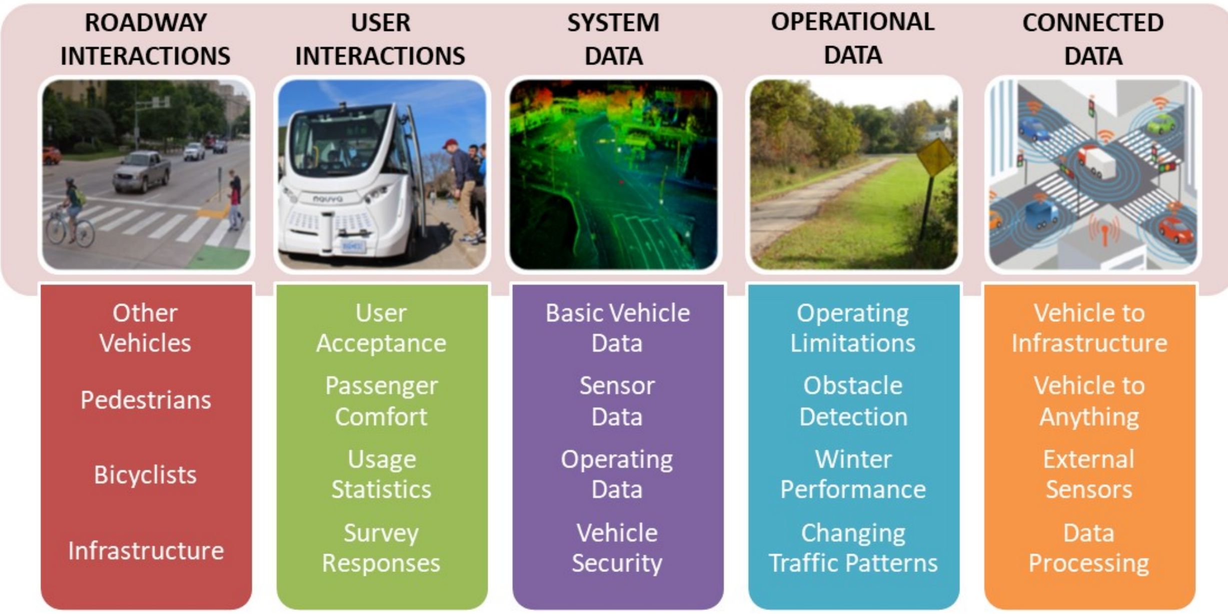
GWAAR's Transportation Specialist will work with Dane County's Mobility Manager to host 5 focus groups to engage, inform and educate a broad range of public stakeholders including elderly, disabled, and transportation disadvantaged groups about automated driving systems, and involving them in experiencing an ASV.

GWAAR and Dane County anticipate engaging groups of seniors who still drive, as well as those who use public transportation services, individuals who are blind or visually impaired, people with physical and cognitive disabilities, low income workers including seasonal workers in high tourism areas such as Wisconsin Dells, non-English speakers includling Hmong and Bhutanese refugees, and tribal members.

The team will engage our network partners from the disability community, tribal governments, and the Retired and Senior Volunteer Program (RSVP) to bring their constituents to the table for learning about automated vehicle systems; what it is, how it works, experience an automated shuttle ride and provide feedback on concerns and cultural considerations moving forward.

The focus groups will be conducted using principles of design thinking to plot customer journeys, collect ethnographic information and understand attitudes, behaviors and impressions from the ride. The agenda will include education about AVs, information regarding the ASV ride and safety, experience of a ride in ASV, and interviews and observations.

The collection of insights gathered from these focus groups will help the pilots go beyond just mobility, how we move, to understand accessibility, why we move. The result will be thoughtful integration of ADS technology deployment in a way that is inclusive and collaborative. The impact of these focus groups will be the deployment of equitable, person-centered, culturally competent ADS into the transportation ecosystem.



Task 8. Data Sharing

The ADS project is expected to generate large, multi-faceted datasets over the course of the demonstration project, consisting of roadway interactions, user interactions, system data, operational data, and connected data. In particular, video, LiDAR, ADS sensor, and other ecosystem data is very large in raw form. External operational, safety, and traffic network datasets will also be integrated for purposes of data analysis.

The UW TOPS Lab project team will build on existing large-scale data management capabilities to collect data from the field, process that data locally, and transmit resulting datasets to USDOT provided servers in near real-time for automated data sets and in a timely maner for highly processed and manually derived data. Particular empasis will be placed on public distribution and long term retention of data.

This will be accomplished through the development of an ADS "staging hub" as an extension to existing capabilities on the UW TOPS Lab WisTransPortal system, more fully described in the Data Management Plan, Part 3 of this proposal.

Task 9. Outreach

Outreach is a very critical task in providing support for citizens to help shape the AV future. The three primary outreach tasks for this project are discussed below.

9.1 State DOT and City

State Smart Transportation Initiative along with their partner Transportation for America will do the outreach to state DOTs and Cities. SSTI's annual Community of Practice meetings typically include the top officials from upwards of 20 state DOTs and their partners at Transportation for America maintain the Smart Cities Collaborative, which includes upwards of 30 municipal agencies including Madison.

9.2 Wisconsin Rural

Wisconsin Rural Partners will support the team in bringing the automated shuttle to WRP's statewide rural summits from 2020 to 2022. WRP will help design the routes, market the route to the organization, organize rider groups, and interview groups before and after rides.

9.3 National Rural

Most of the attention related to AVs has focused on large urban areas. These include AV demonstrations, transit and land use planning, and public/private shared-use partnerships for passenger transportation investment and trials.

Rural counties, municipalities, and planning organizations, as well as Native American tribes, lack the capacity to concentrate on how to approach the AV passenger transportation revolution. Rural and tribal communities need resources and technical assistance tailored to their lives.

CTAA has been actively educating our members about AV developments and we are exploring business models that will work to keep Rural America economically vibrant with the advent of AVs.

To disseminate the knowledge learned and data collected in the UW-Madison AV demonstration project, CTAA will host a one-day summit in Madison to allow transit and transportation leaders to experience the AV shuttle at the University of Wisconsin-Madison, and receive a basic education about AV technology, and legislative, regulatory and planning issues that influence how to AV demonstrations

CTAA will host two national webinars to share the lessons from the UW-Madison AV demonstration and to share details about ways rural and tribal planning, transportation and transit staff can work to lay the groundwork for AVs to become a part of their transportation networks.

CTAA will prepare and distribute three fact sheets with links to in-depth resources about the opportunities that AVs create for rural and tribal areas, the lessons learned for these areas from the UW-Madison AV demonstration project, and the legal and regulatory environment that will influence AV planning outside of major metro areas.

Task 10. Final Report

Research team will compile a final report summarizing the demonstrations, data obtained and shared, specifically include information on conflicts, near misses, crashes and events, results of the data analyses, understanding of user trust and acceptance of ADS. Finally, the report will include recommendations for federal, state, local, tribal agencies' rulemaking or policymaking based on the analyzed data. A 508-compliant final report will be submitted 90 days prior to the end of period of performance.

5.2 Legal, Regulatory, and Environmental Obstacles

Currently the State of Wisconsin and the City of Madison have no statutes limiting the demonstration of automated vehicles. Because the ASV does not satisfy the FMVSS, an exemption from NHTSA is required for operating on public roads.

Our team has obtained NHTSA exemption for the two previous demonstrations conducted in Madison, WI in November 2017 and April 2018. Prior to on-road demonstrations, we will obtain the NHTSA exemption through working with NHTSA and the ASV provider. This will be done as part of the shuttle procurement that is ongoing and will be completed before the performance period for this grant.

Two shuttle manufacturers have been involved in planning and vetting for the Living Lab Route and have stated that they are consistent with other approved routes.

The project team has already held a stakeholder summit for the Living Lab route in February 2019 including various stakeholders from public and private entities. The project management team has several meetings planned with citizen groups and additional stakeholders to support the project goals and objectives.

5.3 Data and Participation Commitments

The UW-Madison research team is clearly committed to sharing data, participating in the evaluation of safety (Task 3), operational (Task 4), and policy impacts (Tasks 5, 6, 7) of integrating AVs into our transportation system, as illustrated in the technical approach. Part 3 of the proposal outlines the Data Management Plan.

5.4 Approach to Risk Management

Large integrated research and demonstration project such as the propose one inherently have an overarching risk of ensuring coordination between multiple deployments and stakeholders. To mitigate this risk, we have an overall project manager whose responsibility will be to coordinate activities and manage risks to program schedule and project delivery. Additionally, three types of risks that may arise in these projects: technical, policy, institutional, risk to the public, injury risk, and failure risk. UW-Madison's risk management team has been and will continue to be involved in risk assessment and management for AV operations.

Technical risk is inherent with the experimental nature of many of the proposed elements. Security and interoperability between devices, vehicles, and the backend control systems will be one of the biggest technical risks and challenges for the various deployments. However, our team partners have extensive technology integration experience and we do not anticipate this to be a high risk. Given the commitment of the City of Madison, Wisconsin Department of Transportation and the State of Wisconsin, we do not anticipate any policy risks to this project. The University of Wisconsin-Madison has assembled a large group of public and private sector partners in a synergistic manner with a unified vision. We do not anticipate any significant institutional risks at this time.

5.5 Approach to Non-Federal Resources (Cost Share)

The UW-Madison team brings several non-federal resources to this project. Total committed non-federal resources exceed $469,000. The following are the details of the cost share:

1. Several University of Wisconsin-Madison faculty have committed a month of their research time over the course of the project, amounting to $203,377.
2. American Family Insurance has committed $ 180,000 to support data collection and analysis.
3. Private partners cost sharing include TAPCO ($24,514) and MGA Research Corporation ($ 62,000)

In addition to the non-federal match budget, partner in-kind contributions are also offered and estimated at over $500,000 based on collaboration letters provided and described below:

1. One autonomous shuttle vehicle system will be purchased in 2019 through a gift from American Family Insurance as described in the Letters of Collaboration. The anticipated gift value is $410,000.
2. The City of Madison, Wisconsin State Patrol, and WisDOT are cost sharing their resources for this demonstration and evaluation.
3. Madison Gas and Electric (MGE) will provide up to $10,000 for charging costs.