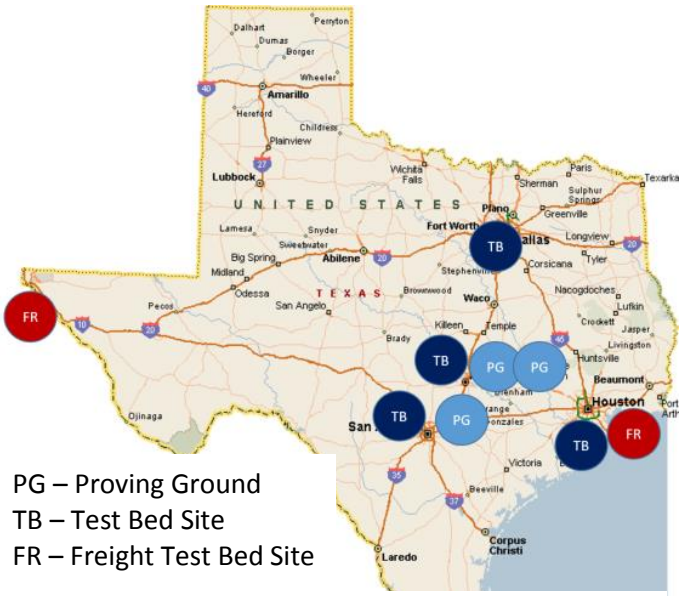
Texas Automated Vehicle Proving Ground Partnership

OVERVIEW

In response to the U.S. Department of Transportation's solicitation for Automated Vehicle (AV) Proving Grounds Designation, the Texas AV Proving Ground Partnership ("Partnership") submits this proposal for a proving grounds network and test bed sites to advance AV research, development, testing, and deployment. The Partnership includes three premier research entities: The Texas A&M University System (TAMUS), The University of Texas at Austin (UT), and Southwest Research Institute (SwRI). The Partnership also includes urban and freight test sites supported by local stakeholders in each region as shown in Figure 1.



PG – Proving Ground
TB – Test Bed Site
FR – Freight Test Bed Site

Figure 1. Texas AV Proving Grounds and Test Sites

VISION

A partnership is about leveraging combined expertise to advance mutual interests. The Partnership seeks to advance the entire AV community's interest, including USDOT, state and local agencies, academia, and the private sector. The Partnership will serve three primary purposes: 1) be a resource to USDOT on AV technology, 2) provide a network of testing sites for public and private entities interested in researching, developing, testing, and verifying AV technologies, and 3) be an AV information sharing network. The Partnership offers the USDOT multiple proving facilities with a diversity to test a range of applications and a collaborative alliance who are dedicated to openly sharing best practices.

PARTNERS

The Texas AV Proving Ground Partnership includes the following partners: research organization, urban test sites, and regional stakeholders. TAMUS, UT, and SwRI have proving grounds that have been used for decades in transportation research for public and private research sponsors. These three research organizations are supported by Prairie View A&M University, part of the TAMUS (and designated as a Historically Black College/University [HBCU]) as well as The University of Texas at Arlington and the University of Houston. The urban test sites are supported by 32 public agencies (regional stakeholders) from across the State that are interested in testing AV technologies in their communities to solve real-world mobility, economic opportunity, and safety challenges, and the active involvement of local university such as The University of Texas at Arlington and the University of Houston.

The Partnership consists of eligible entities: testing grounds, cities, academic campuses, and highway corridors

Research Organizations

Texas A&M University System / Texas A&M Transportation Institute Overview

TAMUS is one of the largest systems of higher education in the nation, with a $4.2 billion budget. System-wide, research and development expenditures exceeded $946 million in FY 2015 and helped

drive the state's economy. Since 1950, experts at the Texas A&M Transportation Institute (TTI) have developed solutions to the problems and challenges facing all modes of transportation. A member of TAMUS, TTI has a breadth and depth of programs, facilities, and capabilities unsurpassed by any other higher-education affiliated transportation research organization in the U.S. The Institute's research and development program has resulted in significant breakthroughs across all facets of transportation. TTI research is widely known as an excellent value, proven to save lives, time, and resources. TTI conducts about 600 research projects annually with over 200 public and private sponsors. In 2015, TTI research expenditures totaled $58 million.

University of Texas at Austin Overview

The University of Texas at Austin is the largest university in Texas and has a worldwide reputation as a leader in engineering education and research. The Department of Civil, Architectural, and Environmental Engineering within the Cockrell School of Engineering has consistently been ranked among the top five programs offering research and engineering education in the country. Various experimental computer systems with advanced architecture are available on campus.

The Center for Transportation Research (CTR) is a multidisciplinary transportation research and educational organization established within the Cockrell School of Engineering at UT. CTR's annual research budget exceeds $13 million, making it the second-largest university-based center in the U.S. CTR taps into an extraordinary range of expertise in multiple disciplines by collaborating with affiliated research centers across UT-Austin. CTR programs are conducted by full-time faculty members and graduate students supported by a professional research staff and a small administrative staff. Students play an integral role in research, working side by side with researchers and faculty members to gain the real-world experience they will need to succeed.

Southwest Research Institute Overview

Southwest Research Institute (SwRI) is headquartered in San Antonio, Texas and is located on a 1200-acre campus that includes a 1.2-mile test track that has restricted access and is available for use year round. Founded in 1947, SwRI is one of the oldest and largest independent, nonprofit, applied research and development organizations in the US. SwRI's 2,700 staff specializes in the creation and transfer of technology in engineering and the physical sciences. SwRI has automated a variety of vehicle platforms. SwRI's proving grounds consist of a large network of private roadways with 4 way stops, hills, curves, straightaways, typical signage and parking lots. The proving grounds also includes a 4-way signalized intersection. The campus also features an array of unmarked roadways including gravel and dirt roads as well as paved roads that are not marked.

Prairie View A&M Overview

Founded in 1876, Prairie View A&M University is the second oldest public institution of higher learning in the State. With an established reputation for producing engineers, nurses and educators, PVAMU offers baccalaureate degrees in 50 academic majors, 37 master's degrees and four doctoral degree programs through nine colleges and schools. A member of the TAMUS, the University is dedicated to fulfilling its land-grant mission to achieve excellence in teaching, research, and service. Prairie View's Roy G. Perry College of Engineering is made up of six departments: chemical engineering, civil engineering, computer science, electrical and computer engineering, engineering technology and mechanical engineering.

The Prairie View A&M brings communication network and data fusion expertise and is an Historically Black College/ University.

Prairie View A&M is designated as an HBCU. HBCUs offer all students, regardless of race, an opportunity to develop their skills and talents.

Texas Smart State Alliance

With five of the nation's 15 fastest growing cities and the population expected to more than double by the year 2050, Texas seeks to manage this disruption proactively rather than allow rapid urbanization to stifle the economy. The Texas Smart State Alliance builds upon the momentum of the USDOT Smart City Challenge, in which Austin was a finalist, and is a direct outcome of the **Texas Mobility Summit** held on December 1-2, 2016. The Texas Department of Transportation (TxDOT) is supporting the Texas Smart State Alliance. The Summit brought together 9 teams representing 10 cities to galvanize key leadership in developing innovative solutions to Texas' mobility challenges. The teams are committed to continuing the collaboration to advance AV technology and have worked together in support of this statewide proposal instead of submitting multiple individual proposals.

The agencies in each of the regions that are donating resources, staff time, and facilities as stakeholders are:

- **Austin Area** – City of Austin, Central Texas Regional Mobility Authority, Capital METRO, Capital Area MPO.
- **Bryan/College Station** – City of Bryan, City of College Station, and Brazos Valley Council of Governments.
- **Corpus Christi** – City of Corpus Christi and Corpus Christi MPO.
- **Dallas/Fort Worth/Arlington Area** – City of Arlington, City of Dallas, City of Fort Worth, City of Grand Prairie, North Central Texas Council of Governments, Tarrant County, Denton County Transit Authority, University of Texas at Arlington.
- **El Paso Area** – City of El Paso, County of El Paso, and Camino Real Regional Mobility Authority, and El Paso MPO.
- **Houston Area** – Houston METRO, City of Houston, Harris County, Port of Houston, Houston-Galveston Area Council, Texas Medical Center, University of Houston
- **San Antonio Area** – City of San Antonio, VIA Transit, Alamo Area MPO, Joint Base San Antonio.

SAFETY TEAM

PROVING GROUND POINTS OF CONTACT

The following people will serve as the points of contacts at the three research organization proving grounds. Appropriate public agency personnel are available to staff these positions at the urban test beds depending on the nature of the AV deployment.

Texas A&M Transportation Institute

- Technical Managers: Dr. Christopher Poe, P.E.; cpoe@tamu.edu; Tel: 972.994.0433 and Mike Lukuc; m-lukuc@tti.tamu.edu; (979) 845-5239.
- Safety Officer: Stuart Denner; s-denner@tamu.edu; Tel: 979.845.2257.

University of Texas

- Technical Manager: Dr. Chandra Bhat; bhat@mail.utexas.edu, Tel: 512.471.4535.
- Safety Officer: Bob Harkins, Ed.D.; Tel: 512.471.5767.

Southwest Research Institute

- Technical Manager: Michael Brown; michael.brown@swri.org; Tel: 210.522.3104.
- Safety Officer: Michael Ladika; michael.ladika@swri.org; Tel: 210.522.5912.

COMMITMENT TO SAFETY

The Partnership has safety personnel in active positions assisting with transportation and technology research currently underway at member proving grounds. The partners will build upon this wealth of demonstrated experience to develop new safety testing practices and guidance for AV technologies, conduct necessary safety training of personnel, and establish rigorous safety management plans.

TEXAS AV PROVING GROUNDS AND AV RESEARCH

Each of the research entities have proving grounds where they have historically researched, developed, tested, and demonstrated vehicle and transportation infrastructure safety.

TEXAS A&M RELLIS CAMPUS

Figure 2. Texas A&M RELLIS Proving Ground

The Texas A&M RELLIS Campus is a 2,000 acre campus being transformed into a high-tech, multi-institutional research, testing, education, and workforce development campus. The RELLIS Campus is conveniently located adjacent to State Highways 47 and 21, a 15-minute drive from Texas A&M University's main campus. These proving grounds have long been a place where Texas A&M has conducted world-class research, technology development and workforce training in a variety of areas such as vehicle safety, traffic engineering, law enforcement training, robotics, connected and automated vehicles, and unmanned aerial systems. The existing facilities at the RELLIS Campus include 6-miles of paved runway test tracks and proving grounds, 3 miles of urban grid roadways, a toll gantry test bed, a roadway safety device test bed and crash test proving ground, pavement marking proving ground, and automated pavement assessment equipment proving grounds. New improvements underway at the RELLIS Campus include seven new engineering research buildings and test beds that will provide state-of-the art research and testing capabilities, and encourage the development of additional public and private sector research facilities adjacent to the TAMUS's facilities at the RELLIS Campus. The primary research focus areas will include robotics, driverless and connected vehicles, advanced manufacturing, large-scale testing, as well as smart cities technologies in areas such as smart power grids, water systems, and parking.

Truck Platooning Research

TxDOT funded a comprehensive truck platooning demonstration in Texas, as a proactive effort to assess innovative operational strategies in automated and connected vehicles. The focus was to determine the feasibility of deploying two-vehicle truck platoons on specific corridors in Texas within 5 to 10 years. The project brought together major partners, including government agencies, national labs, truck manufacturers and equipment suppliers, all of which have

Figure 3. TTI/TxDOT Truck Platooning Project

committed significant equipment and labor resources. The current project phase focuses on transitioning the proof-of-concept system to one capable of being safely and reliably deployed on a commercial operator's fleet. The upgraded system will be tested in one or more field pilots starting at the RELLIS Campus and advancing to a Texas test bed site to demonstrate its viability in a real-world environment.

Autonomous Vehicle Safety

TAMUS has embarked on a new collaborative research Center for Autonomous and Safe Technologies (CAST) that brings together three major capabilities: the College of Engineering, TTI, and the RELLIS Campus, with a mission to research automated and connected vehicle ecosystem safety.

The RELLIS Campus will include Technology Demonstrator Platforms being developed by the faculty, students, and staff of the College of Engineering to advance safety of autonomous and connected vehicle ecosystems. These platforms include the following:

- Two heavy vehicles for truck platooning and three light-duty vehicles with automated control (Ford F-150 Pick-up, Lincoln sedan, and Kia SUV).
- TAMUS proving grounds will include a virtual simulation facility that can simulate a complete ecosystem of fully autonomous, partially autonomous, and manual vehicles, all interacting with pedestrians and other users. It will have realistic human-machine interface that will allow for human-in-the-loop evaluations. This facility will be integrated with the proving grounds, expanding the usefulness of the testing at the RELLIS Campus.

Figure 4. TAMU's Automated Vehicles

- In-between the virtual simulators and the real vehicles, RELLIS will also have an indoor, 1:10 scaled vehicle test facility. The scaled vehicles will host sensors and computing hardware comparable to real cars, providing a powerful platform for testing different types of algorithms, as well as give hands-on experience on AVs at minimal risk.

Unmanned Vehicle Systems

TAMUS is one of six Federal Aviation Administration (FAA) designated unmanned vehicle system (UAS) test sites. Lonestar UAS provides the FAA with UAS research and development and operational data to assist in the development of procedures, standards, and regulations to facilitate the transition of commercial UAS flights in the national airspace system. The Center provides an operational environment from which safe testing, demonstrations of key enabling technologies, and integration of UAS can be accomplished under FAA oversight. In addition, TAMUS is home to the Center for Autonomous Vehicle and Sensor Systems (CANVASS). CANVASS is the only center at a U.S. university that addresses all of autonomous underwater, ground, air, and space systems and their sensors. The strategic research goal of CANVASS is to establish trust in autonomous systems so that they interact with humans and their environment safely, reliably, and predictably to mutually accomplish desired missions and tasks. The center, directed by Dr. John Valasek, Professor in the Department of Aerospace Engineering, is a 17-laboratory center with 70 investigators from the engineering departments of Aerospace, Computer Science, Civil, Electrical, Mechanical, Bio and Agriculture, and Engineering Technology, together with the TTI.

UNIVERSITY OF TEXAS

UT at Austin is the flagship school of the University of Texas system, and it is located at the center of the thriving Texas State Capital. UT has over 51,000 students, making it one of the largest universities in the nation. The main campus, which is the proposed site of an AV proving ground, is 431 acres in size. This urban test bed would focus on state-of-the-art connected and AV technology, leveraging the wide-ranging expertise at UT, particularly at CTR and the Wireless Networking and Communications Group. The signalized corridors along the boundary of campus will be used to test vehicle-to-infrastructure (V2I) communications to promote the safety of not only drivers, but also the substantial populations of pedestrians, bicyclists, and transit riders. Roadways internal to the campus that operate with restricted access will be used for testing of autonomous technologies. Through a partnership with TxDOT, the UT is currently working on outfitting three test vehicles with various levels of autonomous and connected vehicle technologies. These vehicles, expected to be ready by mid-2017, will serve as the pilot vehicles of the UT fleet, and they will be used to help design and test road side infrastructure to be installed on campus in late 2017. In early 2018, UT envisions expanding use of its testbed facility to other institutions and interested private partners from the expansive Austin area technology community, including local startups and established companies already testing AVs in the city. Of particular note, UT will be seeking to experiment with mmWave communication systems, which may serve as the next generation of vehicle-to-vehicle (V2V) communication.

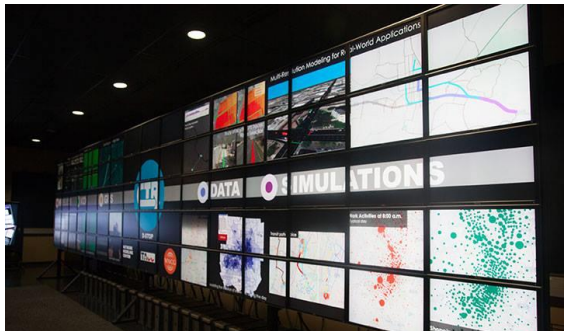


Figure 5. Texas Advanced Computing Center

SOUTHWEST RESEARCH INSTITUTE

For the past 10 years, SWRI has been testing AVs at its proving grounds in San Antonio. The institute has automated more than 15 different vehicles that have already been deployed in five countries on four continents, including vehicles outfitted for military applications that were deployed in Afghanistan.

Core Capabilities

The research and development carried out by SwRI over the past 10 years has resulted in the creation and aggregation of a diverse suite of applicable core capabilities. These capabilities include:

1. *Vehicle system integration* – partially or fully integrated actuation, sensors, computing, networking and other hardware into numerous vehicles.
2. *Vehicle control* – custom control of one or both the steering and speed.
3. *Localization* – hardware and software solutions to provide the required levels of accuracy and reliability for various automated driving applications.
4. *Perception* – perception techniques for all of the common sensors found in AVs, including cameras, LIDAR, and radar.
5. *Path Planning* – custom path planners for different applications that range from high precision and repeatable path following, to exploratory path planning in unconstrained environments.
6. *Tasking and Routing* – software to allocate and schedule tasks for cooperative vehicles. This framework allows for customization to the needs of specific applications, such as automated trailer spotting.
7. *User Interface* – User interfaces used on different kinds of devices (laptops, tablets, smart phones, etc.).

Unique Capabilities

In addition to core automated driving capabilities, SwRI has developed several technologies that are unique to SwRI and the automated driving industry as a whole.

Ranger Camera Based Localization

Since 2011, SwRI has developed its Ranger system for high-precision localization of ground vehicles. The system, which was originally prototyped for and tested on SwRI's High Mobility Multipurpose Wheeled Vehicle (HMMWV) (see Figure 6), has been adapted to passenger vehicles and has since been installed and tested on various vehicles including SwRI's Mobile Autonomous Robotics Technology Initiative (MARTI) vehicle and Acura RLX sedan. SwRI regularly uses the Ranger system as a ground-truth for the development of our own advanced driver assistance system (ADAS) and automated driving algorithms.

Figure 6. SwRI's Automated Class 8 Truck in

In 2014, a Generation 2 Ranger system was implemented on MARTI and demonstrated at the Intelligent Transportation Systems (ITS) World Congress in Detroit, MI. For this demonstration, the Ranger localization feedback was used to perform precision driving maneuvers providing lateral positioning precision of better than 2 cm. Ranger has also been demonstrated to provide suitable feedback to support vehicle control with tolerances of several centimeters.

Figure 7. SwRI's Ranger has been adapted to a variety of vehicles.
Left: SwRI HMMWV; Center: MARTI; Right: Acura RLX.

Pedestrian/Object Detection Framework

SwRI's object detection framework is a flexible, modular system for detecting objects in monocular and stereo imagery. The framework includes a library of state-of-the-art, configurable feature extraction and machine learning plugins, which function within a framework and includes tools for training the system and executing the detection. The detections from the system can have multiple uses in trailer yard environments, ranging from vehicle safety (obstacle avoidance) to yard environmental awareness (creating a map of where workers and vehicles are located or ensuring areas are clear of people and hazards). SwRI's object detection framework not only enables a vehicle to "see and understand" its environment but it can also be deployed in a distributed manner, through infrastructure mounted sensors that provide over-watch capabilities.

Figure 8. SwRI's Image-based Pedestrian Detection

URBAN AND FREIGHT TEST BEDS

Partners of the Alliance are contributing their facilities, expertise, and talents as part of a larger Texas network of proving grounds and test bed sites. Urban and freight test beds in the cities below offer real-world environments where various AV scenarios may be explored:

- **Austin Area** – Austin-Bergstrom International Airport and Riverside Drive corridor.
- **Dallas/Fort Worth/Arlington Area** – UTA Campus, Arlington streets, I-30 Corridor, including Managed Lanes.
- **El Paso Area** – Tornillo/Guadalupe Port of Entry.
- **Houston Area** – Texas Medical Center, Houston METRO high-occupancy vehicle (HOV) lanes, and Port of Houston.
- **San Antonio Area** – Fredericksburg Road/Medical Drive corridor and bus rapid transit system.

Austin

Austin proposes testing and deployment of electric, connected, and automated vehicles, both autos and buses along the East Riverside Drive Corridor and at Austin's Bergstrom International Airport. The City of Austin and Capital Metro are in discussions with private sector providers to test DSRC and autonomous technology along the corridor for both city fleets and public busses. The City is seeking to implement advanced bicycle and pedestrian detection at intersections to allow AVs and cyclists to safely coexist.

Riverside: urban arterial, ped/bike, transit, access to underserved communities
ABIA: on-property network, access to early adopters

The East Riverside corridor is currently an auto-centric stretch of roadway comprised of three lanes of fast-moving traffic in each direction, and part of a larger six-mile regional arterial. It connects downtown to suburbs in the southeast, as well as the region's international airport, and is undergoing higher-density and mixed-use redevelopment. It is one of Austin's most productive corridors in terms of transit ridership, connecting affordable and subsidized housing to education and employment opportunities within the corridor and downtown. Along Riverside Drive, there is a community college campus, an area grocery store, major employers, and a public health clinic.

While the East Riverside Drive Corridor is transforming, it still has a high poverty rate (58 percent of children in the area qualify for free/reduced lunch), is predominantly Hispanic or Latino, and its numerous older apartment complexes are popular residences for low-income individuals and families and college students. Thus, it is a prime corridor to test technology applications combined with harnessing data to test Mobility as a Service to reach residents who can benefit the most. By connecting residents to destinations within the corridor, and connecting the corridor with downtown employment opportunities, the airport and the Del Valle community farther to the east, residents will have greater access and improved mobility to work, basic needs, and education. Riverside Drive can be a technologically holistic Demonstration Connected Corridor that can be a blueprint for future smart and connected corridors in Austin, across Texas and beyond.

The Austin Bergstrom International Airport (ABIA), located at the eastern terminus of the corridor, can serve as a controlled public environment for AVs, such as an automated airport circulator. The benefits include:

1. The airport is a secured roadway network with a simplified network of urban streets. A low speed (20 mph) demonstration will allow Austin to learn how the AVs work with people driven vehicles, how it interacts with pedestrians, and introduce the technology to millions of passengers.

2. Early deployment of AVs in a service regime will provide operational experience for secondary deployment in other transit applications to address first/last-mile connectivity in neighborhoods where ladders of opportunity through accessibility can be created.

IH-30: High-speed highway, freight & light-duty, underserved communities
UTA: Campus, low-speed, access to students/faculty

Dallas-Fort Worth-Arlington

Arlington, Texas, offers a comprehensive real-world AV test environment along IH-30 in the heart of the Dallas-Fort Worth region. Arlington's population of 380,000 is socio-economically diverse and currently underserved by transportation mode choices, providing potential for AV technologies to act as ladders of opportunity and improve mobility. It is home to the University of Texas at Arlington (UTA), an R-1, designated Hispanic-Serving Institution with a student population of almost 40,000 on a 420 acre campus. Arlington also has a large Entertainment District anchored by sports stadiums and amusement parks, a GM automotive assembly plant, and demonstrated investments in connected vehicle technologies. Arlington offers three complementary test bed sites:

- *Campus*: The UTA campus offers an opportunity for deployment of AVs in a low-speed and somewhat closed environment. Given the large campus, there are many deployment opportunities, including on-road movement from remote parking areas and off-road movement within the main campus.
- *Streets*: Arlington has an extensive street system that can be utilized for AV testing at low to moderate speeds. UTA's campus is directly adjacent to the downtown urban core, providing a test environment linking campus pathways to local streets. Two long-running shuttle services operate within the Entertainment District to connect area hotels and destinations. They could be readily adapted for AV testing. Streets within the Entertainment District are good candidates for testing during light traffic periods between events, as well as moving large numbers of people during events. As AV technologies are proven, deployment along more city streets offering a wider variety of conditions will be possible.

- *Highway*: IH-30 from IH-35W in Fort Worth to IH-35E in Dallas is a modern multi-lane expressway. It includes a 10-mile, reversible, protected, managed lane facility operated by TxDOT, which can be closed during off-peak periods. Thus, AV testing on IH-30 can start in the protected environment of the closed managed lanes, followed by testing in the relatively stable conditions of the managed lanes with regular traffic, and finally, testing in the general purpose lanes.

The City of Arlington has a state-of-the-art Transportation Management Center, including 138 cameras on public roadways, 200 miles of fiber, and centralized signal software. Two connected V2I pilots are currently underway to refine signal processes and push signal data to vehicles via a smartphone app, increasing both public safety and readiness for AV deployment. The city and Tarrant County are interested in using AVs to improve mobility options for disadvantaged populations.

Houston

Houston has a number of test sites the stakeholders are interested in using for testing AV technologies.

Houston METRO's HOV lane system

METRO owns and operates more than 100 miles of (HOV) and high occupancy toll (HOT) lanes on the following five major corridors: IH-45, US 59 North, IH-45 South, US 59 South, and US 290. METRO is interested in working with the Partners to pilot autonomous and connected vehicle technologies, particularly bus platooning, on one or more of these corridors.

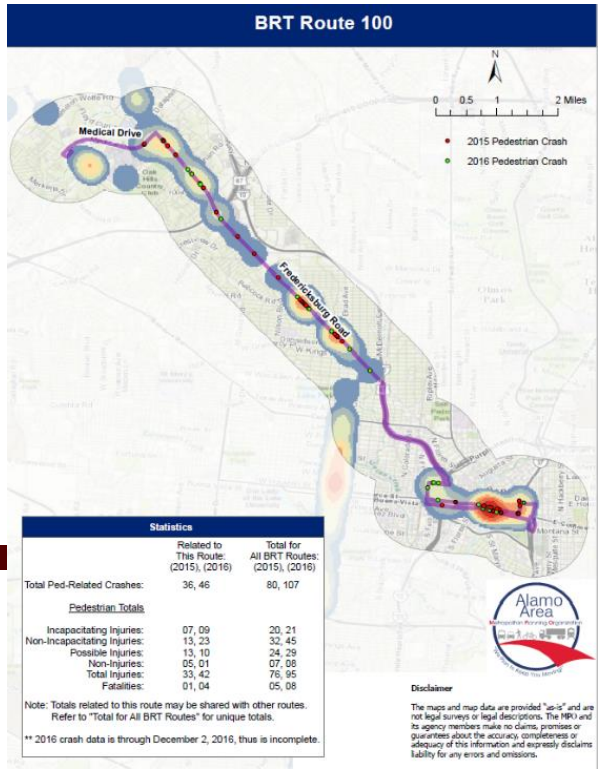
HOV system: high-speed, barrier separated HOVs, transit.
TMC: campus network.

The Texas Medical Center

The Texas Medical Center (TMC) also presents a unique space to pilot AV technologies. The TMC, spread out over 1,345 acres, is home to 106,000 jobs; its hospitals accommodate 8 million patient visits per year and provide educational opportunities to more than 50,000 students. There are 110 shuttle stops, 85 METRO bus stops, three METRORail platforms, and multiple other regional operators that provide transportation service. Due to the significant and unique movement of people in the node, the TMC is an ideal location to pilot technologies such as slow speed AVs.

Energy Corridor

Houston is the "Energy Capital of the World" and the energy footprint expands well beyond downtown Houston. The Energy Corridor is the third largest employment center in the region with more than 91,000 employees. The Energy Corridor has transit, vanpooling, car-sharing, and biking solutions and presents a unique opportunity to pilot AVs to bridge the first/last mile gap.



San Antonio

San Antonio ranked fourth in the nation in 2014 for pedestrian fatality rates per 100,000 population for cities greater than 500,000 population. In 2015, San Antonio became a Vision Zero city with the goal to achieve zero fatalities or serious injuries. The City of

San Antonio, VIA Metropolitan Transit Authority, Alamo Area Metropolitan Planning Organization, TxDOT, and multiple stakeholders worked together to identify, design, develop, and implement bus rapid transit (BRT) corridors. Primo is the brand name for the BRT system.

Fredericksburg Road Primo. VIA's Fredericksburg Road 12-mile BRT route operates from downtown San Antonio to the South Texas Medical Center with fourteen 60-foot articulated vehicles at 10-minute frequency from 6:00 am to 6:00 pm. The Fredericksburg Road corridor is the busiest transit corridor in the system, carrying over 12,000 passengers a day on all routes traveling along it. A GPS-based conditional traffic signal prioritization system is used at Fredericksburg Road's 24 signalized intersections that will grant an early green or extend a green phase if conditions for schedule adherence are met. All buses in the VIA fleet have free 4G LTE Wi-Fi.

Along Fredericksburg Road, long block lengths exist with high vehicular traffic. Between 2015 and 2016, a total of about 82 pedestrian crashes have occurred in the corridor resulting in 75 injuries and 5 fatalities. AV technology that would prevent pedestrian or vehicular conflicts is needed.

The San Antonio partnership working relationship is strong and has on-going initiatives in efforts to build two additional BRT corridors. Projected to open late 2018, Primo Zarzamora Road and Primo Military Road could be additional proving ground sites for AV technology. The San Antonio partnership continues to improve safety and mobility in the corridor by implementing technology advancements as become available. San Antonio is committed to adherence to safety of technology deployments.

BRT Corridor: urban, low-speed, arterial for transit applications with mixed traffic.

Figure 9. Fredericksburg BRT Corridor

El Paso Test Site

The nation's largest land port of entry is located approximately 17 miles east of the City of El Paso in Tornillo, Texas. The Tornillo/Guadalupe Port of Entry opened to pedestrian, private vehicle, and commercial traffic in February 2016 and was built in partnership between the United States General Services Administration and the County of El Paso. The 117-acre footprint that the Port sits on is the model layout for future ports of entry in the nation, including the capacity to conduct extensive southbound inspections. The Port's service area is home to approximately 14,500 residents in two urban census-designated places (US Census Bureau, 2010).

Land Port: freight port, on-road, pedestrians and passenger vehicles.

The Port is extensively connected to major commercial traffic corridors, including IH-10. The recently completed Aguilera International Highway (TX-FM 3380) is a spur connecting the Port to the Interstate along with Texas Highway 20. Additionally, the County of El Paso owns and operates a regional airport, Fabens (E35), located approximately 8 miles from the Port. With the recent adoption of a Ten-Year Capital Improvement Program, the Fabens Airport is poised to enhance the economic output of Eastern El Paso County, including potentially facilitating further trade of goods and services from the Port. While in a rural setting, the Port has the ability to develop, test and refine technology and other methods that could then be regionally scaled to urban environments, including other ports of entry located within the City of El Paso and Santa Teresa, New Mexico, based on its geographic size, road connectivity and proximity to urbanely populated areas.

READINESS

TAMUS, UT, and SwRI have proving grounds that are operational today to support any AV research, development, and testing. Safety policies and procedures are in place that govern the on-going research at these facilities. For example, TTI has the following safety programs in place at its proving grounds: Risk Management and Safety, Safety for Work in Public Right-of-Way, and Motor Vehicle Operations. By January 1, 2018, each of the facilities anticipates having additional equipment and functionality to support AV research, development, and testing.

Proving grounds, safety management plans, and safety officers are in place.

RESEARCH, APPLICATIONS, AND DATA SHARING

The Texas Smart State Alliance is a ready and natural outlet for disseminating information on AVs efforts and for propelling policies both at the state and national level to support the deployment of AVs. In addition to the 32 agencies participating in the consortium, TxDOT has established a Texas Technology Texas Force to provide additional national expertise and guidance.

RESEARCH DISSEMINATION AND OPEN DATA SHARING

Disruptive technologies are revolutionizing the transportation industry. This has created considerable market pull for critical knowledge about technologies, safety, human machine interfaces, societal implications, and other social, political, and economic effects of AVs. This is a time where bold social innovation could be based in part on vehicle automation. The research organizations, urban test sites, and regional stakeholders are committed to share data, publish research results, and provide training to the community.

The Partnership is committed to share data and results with the AV community.

Universities and their agencies have a rich history of publishing findings as part of their standard practice. For example, TTI has prepared well over 10,000 research reports developed by researchers addressing hundreds of transportation issues and problems. TTI maintains an extensive library of these reports, along with additional transportation publications, project summary reports, and other materials. Much of that material is accessible through an online catalog. UT's CTR maintains a multi-agency online library of over 26,000 publications.

The TTI commitment extends to all sectors of the community including over 20 years of programs ranging from K-12 science, technology, engineering and mathematics activities to the basics of how TTI researchers conduct their studies. It also includes a Teens in the Driver Seat peer-to-peer safety program for young drivers, involving teenagers who are directly developing and delivering driving safety messages.

The City of Austin maintains an Open Data Portal to encourage the use of public data to spark innovation, promote public collaboration, increase government transparency, and inform decision making. The Open Data Census gives the city a nearly perfect record on accessibility. All partners behind this application are committed to broadly disseminating information generated by their proving grounds and test beds.

IRB PROCESS AND HUMAN SUBJECTS TESTING

Technology is a tool, and people and community must be at the forefront of all solutions. The Partnership recognizes the importance of working with the communities and having procedures in place to test human factors, people's interaction with technology, and the potential for technology adoption.

The regulations governing Institutional Review Boards (IRBs) are set forth by the Office for Human Research Protections (OHRP) within the U.S. Department of Health and Human Services (HHS). OHRP provides leadership for and monitors compliance with requirements for protecting the rights, welfare, and well-being of subjects involved in research conducted or supported by HHS. The IRB reviews and oversees all research involving human participants to ensure that it meets ethical principles and complies with federal regulations, state laws, and institutional policies. In addition to IRB, other regulations may apply to research involving human subjects.

Each of the Partnership Proving Ground members has federally approved IRBs. The approvals issued by these boards can be used for off-site data collection and properly trained outside staff can be added to the research team to be covered by the IRB approval. Other compliance regulations may apply to human subjects research.

LEADERSHIP AND CONTRIBUTIONS

Each of the Partnership members have received statewide, national, and even international recognition in their own right, and each stands ready to continue their leadership roles in advanced technologies and AV efforts.

NATIONAL AND REGIONAL AV LEADERSHIP

Within the Proving Group Partnership there are many individuals that serve in leadership roles. At Texas A&M, Dr. Karl Hedrick who leads the CAST research, was awarded the Rufus Oldenburger Medal from the American Society of Mechanical Engineers in 2006 and was elected to the National Academy of Engineering in 2014. Also within Texas A&M, Dr. Ed Seymour and John Barton serve on the ITS America Leadership Circle. Dr. Seymour also guides standards development for vehicle communications through his role on the Executive Committee of the V2I Deployment Coalition. Dr. Christopher Poe serves on ITS America's Coordinating Council and has been on the planning committee for TRB's AV Symposium. Mr. Michael Lukuc, before joining TTI, was the program manager at NHTSA for V2V Safety and is experienced in running large-scale proving ground tests.

The Partnership provides leadership through testing and deployment of AV technology.

At UT, Dr. C. Michael Walton is a founding member of ITS America and a past chair of its Board of Directors. Additionally, he was a member of the inaugural class ITS America's ITS Hall of Fame. He chairs the Texas Technology Task Force and has been a driving force behind the Texas Smart State Alliance that is underpinning the state-wide collaboration described in this proposal. Dr. Chandra Bhat, Director of CTR, serves as Chair of the Travel Analysis Section of the Transportation Research Board. He has won many awards including recently being named as one of the Eno Center for Transportation's Top 10 Transportation Thought Leaders in Academia. Dr. Jen Duthie is a member of the Executive Steering Committee of the MetroLab Network, which focuses on smart city partnerships between cities and universities. She co-chairs MetroLab Network's Transportation Lab, which will be used to disseminate the proving ground's findings and lessons learned. Dr. Robert Heath, Professor in Electrical and Computing Engineering, serves as Editor for IEEE Transactions on Communications and Associate Editor

for IEEE Transactions on Vehicle Technology. He is a recognized expert in advanced communications systems and recently founded UT-SAVES, a research center focused on leveraging this expertise to solve problems related to vehicle safety.

At SwRI, Dr. Steve Dellenback serves on the ITS America Leadership Circle. Mr. Michael Brown serves on several SAE standards committees.

PROPOSED CONTRIBUTION TO THE COMMUNITY OF PRACTICE

The Partnership is committed to contributing to the AV community of practice through participation in USDOT organized meetings and events, sharing safety testing practices and procedures, participating in standards committee activities, making presentations to professional society events, and generating public outreach materials to advanced understanding of AV technologies. In addition, Texas has an existing AV Community through each of the urban test site stakeholders. The Partnership will use this network of people, agencies, and companies to share best practices from AV research, development, and testing. These agencies fully understand the near-term and long-term mobility challenges facing their communities and how AV technologies can play a role in solutions.

USDOT RESEARCH INVOLVEMENT

TTI, UT, and SwRI have long histories of involvement with the USDOT's research program. The research organizations have led or been involved with traditional USDOT research programs (e.g., Office of Operations, Office of Safety), Exploratory Advanced Research Program, grant programs (e.g., ICM and ATCMTD), and University Transportation Centers programs. Through these projects, the research organizations have gained a strong understanding of the USDOT's needs, practices, and personnel.

The Partnership proposes to participate in USDOT activities as part of the AV Proving Ground designation to support the sharing of information with USDOT and other designees. This can include participation in technical conferences (e.g., Transportation Research Board), committee activities (e.g., SAE Standards activities and V2I Deployment Coalition), and regular updates to USDOT on Texas funded research and testing activities.

DEMONSTRATED INVESTMENTS

Significant investments are being made by all of partners to advance AV technology. In addition to the existing investments described in the previous proving grounds section, Texas A&M has committed to continued growth in proving ground development. In May 2016, TAMUS announced that it would invest $250 million to expand the RELLIS Campus.

Local stakeholders are also investing in the urban test beds. For example, the North Central Texas Council of Governments, the MPO for the DFW region, has programmed over $1 billion for intelligent transportation projects such as AVs in coming years.

The Texas Legislature has demonstrated an investment in policy research by establishing the Policy Research Center at TTI to research transportation policy topics. One of those topics is transportation technology, including examination of regulation and policies related to AVs from around the country.

ADHERENCE TO LAWS, REGULATIONS, AND FEDERAL POLICY

LOCAL AND STATE LAWS AND REGULATION

The Partnership is committed to ensuring that safety is priority and that applicable laws, regulations, and policies are a part of our culture. We recognize that laws and policy will and should adapt quickly in this innovative technology arena. For example, in the last few months the states of Michigan and

California have passed new legislation concerning the development and testing of AVs. We expect others to follow and for local jurisdictions to set guidelines that could impact companies and technologies in this marketplace, such as the City of Austin's procedures for authorizing shared ride companies including Uber and Lyft.

FEDERAL POLICY

The Partnership applauds NHTSA for taking leadership for the safety of highly automated vehicles through policy guidance. As technology rapidly advances and as research and development brings products to the marketplace, this policy framework is essential. It provides a structure that ensures safety and provides an environment for innovation in the marketplace. To keep these guidelines aligned with a rapidly developing marketplace NHTSA has published the responses to its Request for Comments AV Policy. The solicitation generated 1,120 submissions each containing many comments that will help shape future iterations of NHTSA's guidance. In addition, NHTSA has recently published the Visual-Manual Distraction Guidelines for portable and aftermarket devices. The Partnership is committed to working with these guidance documents, comparing them against automotive guidelines, and providing input to USDOT as the proving grounds and test sites gain AV deployment experience.

CONCLUSION

Texas is committed to creating a platform of innovation to address community challenges. AVs have the potential to transform the lives, safety, and economic prospects of people, and the Texas Partnership offers the greatest added value to the Community of Practice. This application brings together a partnership of world-class research institutions and forward-thinking cities that are working together to host and manage proving grounds and affiliated real-world test beds that offer a wide variety of AV test environments. Our partners pledge to work with each other, with private industry, and USDOT to advance the safe and timely deployment of AVs. They are committed to sharing information and collaborating in the effort to use AVs to improve our transportation system and the lives of many who are unable to afford or operate current vehicles. Building upon the leadership and collaboration of the USDOT Smart City Challenge and the Texas Smart State Alliance, the Texas Partnership looks forward to the opportunity of joining other innovators in advancing automated vehicle technology to realize community impact.