Application to:
US Department of Transportation
Automated Driving System Demonstration Grants
NOFO Number 693JJ319NF00001

Submitted by:
Tennessee Department of Transportation
3/21/2019

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DEPARTMENT OF TRANSPORTATION
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March 21, 2019

The Honorable Elaine Chao
Secretary, U.S. Department of Transportation
1200 New Jersey Avenue, S.E.
Washington, DC 20590

Subject: Submission - TDOT ADS Demonstration Grant Proposal
Tennessee Automated Driving System I-24 Demonstration
Funding Opportunity Number: 693JJ319NF00001

Dear Secretary Chao,

Please accept the Tennessee Department of Transportation's (TDOT) proposal to NOFO Number 693jj319NF00001. The widespread adoption of highly-automated vehicles could save an estimated 32,000 lives annually. TDOT supports the ADS Demonstration program's core goal of testing the safe integration of these technologies on US roadways.

The "Tennessee Automated Driving System I-24 Demonstration" project will test the integration of ADS technologies within a section of the I-24 corridor between Nashville and Murfreesboro. This project will leverage TDOT's investment on the corridor with the I-24 Smart Corridor project, which is a multiple phase integrated corridor management deployment with and array of roadside sensors and traveler information technology. The USDOT will be provided data from both inside and external to the vehicle to help address current industry knowledge gaps on the operation of ADS technology in traffic. TDOT is strongly committed to capturing and sharing as much data as possible from this demonstration project.

Thank you for your consideration of our proposal.

Sincerely,

Phillip "Brad" Freeze
Director, TDOT Traffic Operations

Summary Table	
Project Name/Title	Tennessee Automated Driving System I-24 Demonstration
Eligible Entity to Applying to Receive Federal Funding (Prime Applicant's Legal Name and Address)	Tennessee Department of Transportation, Suite 700, James K. Polk Building, 505 Deaderick Street, Nashville, TN 37243-1402
Point of Contact	Brad Freeze, Director, Traffic Operations Division
Proposed Location (State(s) and Municipalities) for the Demonstration	Nashville Davidson County
Proposed Technologies for the Demonstration (briefly list)	• SEA Level 3 ADS Vehicle Technologies • 4K CCTV Cameras • Dedicated Short Range Communications (DSRC)
Proposed duration of the Demonstration (period of performance)	3 Years
Federal Funding Amount Requested	$ 9,773,499
Non-Federal Cost Share Amount Proposed, if applicable	$ 7,089,753
Total Project Cost (Federal Share + Non-Federal Cost Share, if applicable)	$ 16,863,252

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PART 1 - PROJECT NARRATIVE

1.1a - e - Executive Summary

As part of this project, a series of demonstrations will be conducted that will move the adoption of highly-automated vehicles forward by providing much needed information on the operation and integration of these vehicles in an Interstate and mixed environment. These demonstrations, and the resulting data, will specifically provide USDOT and others with new, and critical information that can be immediately used for both research and to develop guidance for States and Local agencies who are increasingly having to accommodate fleets of vehicles that include both manually operated and vehicles with automated driving systems. Recent announcements from most of the major automotive manufactures, as well as current advertisements on current year models, indicate that the arrival of vehicles with ADS is already being experenced on our roadways and Interstates.

As an advanced state agency, with a long history of researching and adopting leading edge technologies, TDOT understands that the conversation must continue to be driven forward. Regardless of whether agencies are ready or not, these vehicles are using and will continue to use in growing numbers our facilities. Our experience with the I-24 Smart Corridor and understanding of the local community makes us believe that commuters and commercial vehicles along the heavily traveled I-24 corridor are among the first adoptors of these technologies. With the scheduled ITS investments currently being planned for construction in the Fall of 2019 and continuing with subsequent phases in 2020 and 2021; this corridor will be one of the most heavily instrumented and ITS-centric corridors in the country. This will provide an extremely safe and low risk Environment to conduct demonstrations that can provide data on how these vehicles will operate in a complex, mixed environment.

Through this grant, we are proposing to exceed all of the goals established for this program across all of the focus ares outlined by USDOT through the execution of several demonstrations using four different types of fleets (see Figure 1). All data captured duing these demonstrations will be captured and made available to US DOT. The specific demonstrations proposed for this project are summarized in Table 1. In addition to the several major demonstrations outlined in the Table, we are proposing to supplement these demonstrations through a series of additional unstructured driving experiences where naturalistic data can be obtained. Collectively, these demonstrations will provide data on all ADS subsystems (i.e., perception, localization, navigation, and motion execution) operational on the level 3 fleet.

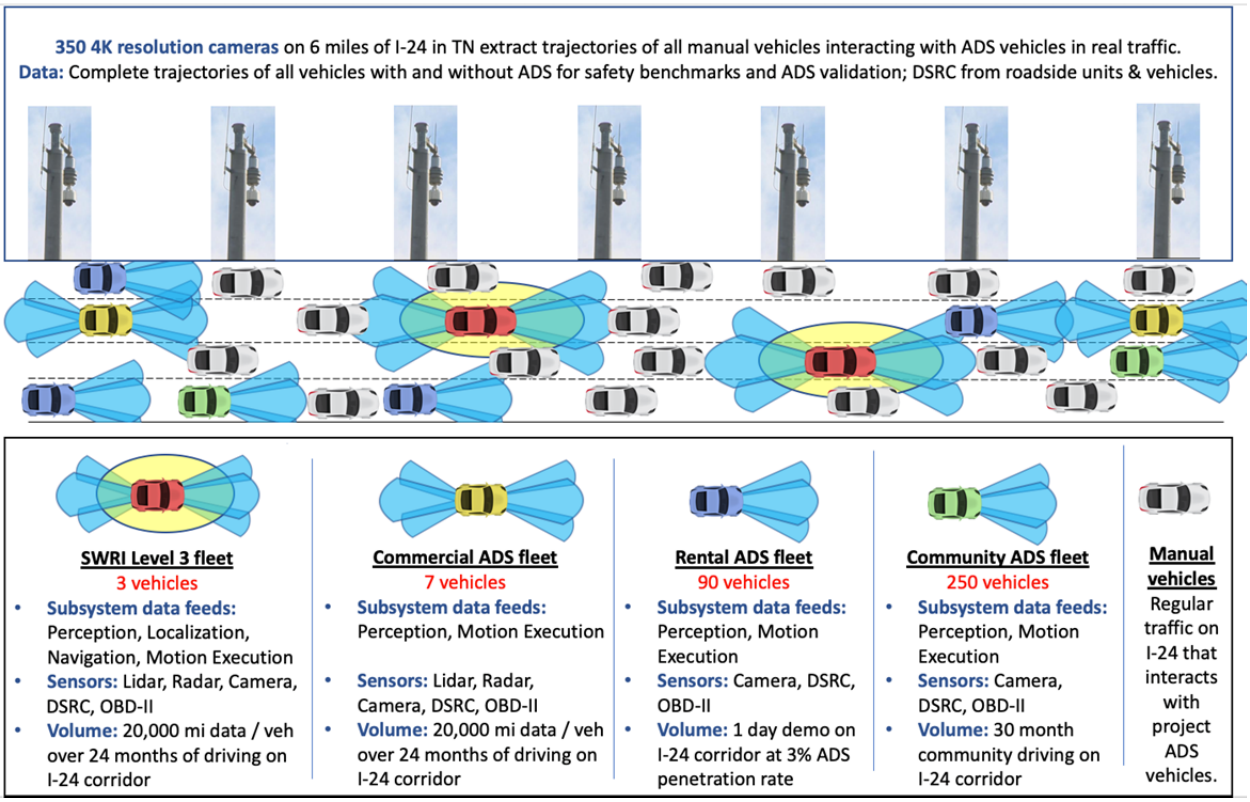

Figure 1. ADS data will be collected from multiple subsystems from multiple ADS fleets and demonstrated through deployment on I-24, as well as from 350 4K resolution cameras

It will also collect critical data on the interactions of the ADS vehicles with manual vehicles operating on I-24 near Nashville through a first-of-its-kind ultrahigh definition roadside camera network (350 4K resolution cameras) that provides continuous trajectories of all vehicles in the flow. The camera network allows safety KPI baselines for human drivers and the ADS fleets to be compared, and provides a mechanism to validate the ADS data collected on the vehicles themselves.

Table 1. Summary of Proposed Major Demonstrations

	Major Demonstrations			
	Level 3 ADS on open roads	**Commercial ADS on open roads**	**Mixed ADS-manual traffic**	**Current state of ADS via community fleet**
Fleets	SWRI Level 3	Commercial ADS	SWRI level 3, commercial ADS, & rental ADS	community ADS
Vehicles	3	7	100	250
Duration	24 months	24 months	1 day	30 months

	Major Demonstrations			
	Level 3 ADS on open roads	**Commercial ADS on open roads**	**Mixed ADS-manual traffic**	**Current state of ADS via community fleet**
Vehicle miles traveled	60,000	140,000	40,000	750,000

1.2 - Goals

This project will assist USDOT in meeting all of the goals established for this grant program as summarized in Table 2. We agree that these goals are critical for advancement of the state-of-the-art in deployment of ADS. We particularly understand the need for solid data, free of proprietary constraints that can be used for safety analysis, guidance development, and decision-making. We have specifically arranged this demonstration to maximize the data from different types of vehicles.

Table 2. Project Goals

DOT Goals	Project Delivers
1.2a -Safety	• Test the safe integration of ADS into the Nashville I-24 Smart Corridor by using (350) overlapping field of view ultrahigh definition cameras to extract and assess vehicle trajectories and calculate vehicle safety through *Key Performance Indicators* (KPIs) such as *Time to Collision* and other proximal surrogate indicators of safety. • Demonstrate the safe integration of ADS into the Interstate Highway.
1.2b -Data for Safety Analysis and Rulemaking	• Near-real time and continuous evaluation of hundreds of simultaneous vehicle trajectories assessed safety KPIs between these vehicles, vehicle DSRC Basic Safety Messages, and time-stamped post-processed data from ADS Level 3 sensor arrays from the project ADS fleet operating in this traffic. • Collaborate with the transportation community to enable access and leverage of the demonstration data and results in innovative ways across government, industry, and academia. • Quantify vehicle safety performance based on the demonstrations that provide data and information to remove governmental barriers to the safe integration of ADS technologies.
1.2c.- Collaboration	• Project team includes the fully-functioning (24) member TennSMART consortium for Intelligent Mobility that includes innovative State and local governments, universities, and private partners. • Tennessee Highway Patrol has a long history of close

	collaboration with TDOT and will be consistently engaged in the planning and execution of the ADS project. • Early and routine stakeholder communication and engagement through the TennSMART consortium and TDOT including local public agencies, industry, transportation-challenged populations, the public, and other relevant stakeholders.

1.3 - Focus Areas

1.3a - Significant Public Benefits: The overall objective of this project is to provide the basis to accelerate the safe and widespread adoption of highly-automated vehicles, and thereby cumulatively eliminating the loss of 32,000 lives from traffic accidents and recovering $64 billion of losses due to accident avoidance[1]. One of the early use-cases for the adoption of ADS is for commuters on Interstate or divided highways. Currently, options for disabled travelers and older adults along the I-24 corridor are relatively limited with only a few existing bus routes and paratransit service. However, if it can be shown that ADS, even in Level 2/3 applications, can be used safety by these drivers in a mixed and congested environment, new and significant possibilities for commuting and traveling for these segments of the population will be facilitated. Of course, the mobility and safety of all travelers will also be improved with this technology as well, but in an area of the Country where the predominant travel is by automobile, limitations associated with driving ability are significant and can dramatically reduce the quality of life of those individuals affected.

1.3b - Addressing Market Failure and Other Compelling Public Needs: The scale and scope to recreate the public highway and surrounding infrastructure of the I-24 Smart Corridor would be cost prohibitive for industry. Furthermore, if they created a privately-owned asset, the cost of populating the private asset and gathering data with the annual average daily traffic (AADT) of over a 175,000 vehicle fleet would be impossible.

1.3c - Economic Vitality: The cumulative acquisition of the assets that have been and will be purchased by TDOT for the I-24 Smart Corridor support the U.S. industrial base. The proposed project is supporting the economic vitality at the regional scale in establishing the I-24 Smart Corridor, and at the national scale by inviting the ADS OEMs to advance the domestic industry and promote domestic development of intellectual property through advanced characterization and data exchange made possible by this project.

1.3d - Complexity of Technology: This project is specifically designed to demonstrate highly-automated vehicles that demonstrate automation, with preference for

[1] Steven Underwood, "Automated, Connected, and Electric Vehicle Systems: Expert Forecast and Roadmap for Sustainable Transportation". Retrieved from http://graham.umich.edu/media/files/LC-IA-ACE-Roadmap-Expert-Forecast-Underwood.pdf on October 4, 2017.

demonstrating Level 3 or greater automation technologies. Furthermore, the project proposes to deploy a fleet of highly automated vehicles that will allow evaluation of the interplay between a substantial number of highly-automated vehicles. This will allow the general improvement in safety of traffic with increasing penetration of highly-automated vehicles.

1.3e - Diversity of Project: The scope of this project serves a variety of communities along the I-24 Smart Corridor with economic diversity between the communities, including urban, suburban, and ultimately connecting through to rural Tennessee environments. The I-24 Smart Corridor also serves a variety of transportation markets including freight, personal mobility, and public transportation. The I-24 Smart Corridor is the number eight most congestion freight corridor in the US according to the American Transportation Research Institute.

1.3f - Transportation-Challenged Populations: The overall project goals of accelerating the widespread deployment of highly-automated vehicles will benefit two primary disadvantage populations. Level 4 automated vehicles serve physically disadvantaged people by enabling travel without the need to be capable of driving or having a driver's license. Level 4 automated vehicles serve economically disadvantage people as the long-term business models of Transportation Network Companies (e.g. Lyft) are to use connected, automated, and electric vehicles to deliver transportation on a per mile basis that is less than 50% of the cost of vehicle ownership. Highly-automated vehicles serve both physically and economically disadvantaged people very effectively.

1.3g - Prototypes: This project will create and demonstrate a unique high-density camera and communications infrastructure on one of the most traffic-congested corridors in the US. This system will first be developed to evaluate the ability to assess the driving performance of highly-automated vehicles. But, the digital twin being created by this project will serve the role of near-real time situational awareness that could become the prototype system for the future of coordinated control for improve safety and energy efficiency of the US highways system based on connected and automated vehicles.

1.4 - Requirements

The project meets or exceed that demonstration requires as detailed in the USDOT solicitation (see Table 3). The following bullets explicitly align requirements with project activities.

Table 2. The Demonstration will meet all of the Demonstration Requirements

Req.	Project Compliance
1.4a	The proposed project demonstration focuses on the research and

Req.	Project Compliance
	development of automation and ADS technology Level 3 (per the SAE definitions), with a specific focus on demonstrating Level 3 or greater automation technologies through both owned and leased vehicle fleets.
1.4b	This project includes a physical demonstration ADS Level 3 vehicles on the I-24 Smart Corridor test bed. This physical demonstration will be complemented by modeling and simulation activities to analyze the vehicle performance during the physical demonstration.
1.4c	Data demonstrating safety performance will include conventional data regarding safety incidents, operational (vehicle and ecosystem data), exposure measures, and innovative measures of safety-relevant vehicle behaviors that may indicate potential safety problem. Data gathering and analysis of demonstration data will be processed and shared on an ADS Data Management System which leverages resources at Oak Ridge National Lab and Vanderbilt to achieve near real time data processing and sharing, high performance computing, and long term archival. The project will provision project data access and scientific collaboration to the project team, the USDOT, and other public stakeholders throughout the project in near real time, and assure that data remains available for five years after project period of performance. The project does not plan to have confidential business information or PII in the project data set.
1.4d	The project demonstration will include input/output user interfaces on the ADS that are accessible and allow users with varied abilities to input a new destination or communicate route information and to access information generated by the ADS. The project will include evaluation of the ability for users of varied demographics to use by developmental and commercial user interfaces. This work is detailed in Task 7.
1.4e	The project demonstrations will be conducted on the I-24 Corridor in Nashville. This is a very typical urban to suburban corridor where the results and conclusions from the demonstration can be scaled to be applicable across the Nation to many areas with similar types of road environments. The conclusions of this demonstration should be widely applicable across the U.S. The outreach task will be led by the TennSMART intelligent mobility consortium to share demonstration status, results, and lessons learned with other jurisdictions and the public, in furtherance of technical exchange and knowledge transfer.

1.5 - Approach

1.5a - Technical Approach

Task #1 - Establish an Instrumented Corridor on I-24

This task will instrument a freeway corridor for sensing and communication that enables the study of the interactions between vehicles with automated driving capabilities and vehicles that operate in manual mode. It is distinct in that it will allow continuous tracking of all vehicles on the corridor, including non-instrumented vehicles that are driven by humans that interact with the ADS vehicles. The instrumented freeway will allow data to to be collected for all experiments discussed in the proposal. The I-24 Smart Corridor Project is an ambitious project by the Tennessee Department of

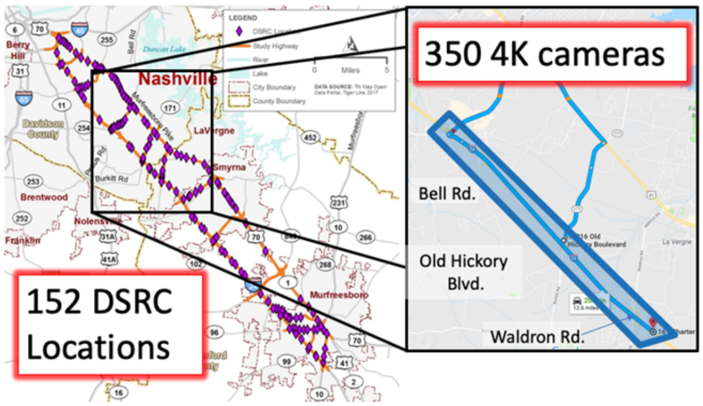

Figure 2. I-24 Smart corridor w/ 152 DSRC devices installed throughout corridor and more than 350 4K resolution cameras with overlapping fields of view on 6 mile stretch of I-24

Transportation to implement a variety of technologies to increase reliability, safety, and mobility along the I-24 corridor from I-440 in Nashville to Murfreesboro (Exit 81, SR 10/US 231). The goals are to provide drivers with real-time traffic information and to dynamically manage traffic along the corridor to reduce congestion and increase roadway efficiency. Additional technology infrastructure is proposed to supplement the planned and existing instrumentation on I-24 (Figure 2). An array of high-resolution cameras equipped with modern computer vision tracking algorithms is to be installed with sufficient frequency to provide continuous coverage throughout a multi-mile portion of I-24.

- **Subtask #1a – Design and Deploy Roadside 4K Video Detection System:**

This work will leverage the I-24 Smart Corridor as a behavioral testbed to demonstrate advanced automated driving systems operating on open roadways and in real traffic flows. A six mile stretch of I-24 will be instrumented with end-to-end coverage of 4K resolution video cameras. The cameras will be installed on 110’ tall poles spaced roughly evenly to achieve a continuous birds eye view of the roadway. It is expected more than 350 cameras will be installed on the roadway with overlapping field of views so that vehicles can be tracked from one camera to the next throughout the roadway segment. All video data will be streamed to a backend computer system that will enable computer vision algorithms to be run on the data to extract vehicle trajectories. The benefit of the camera installation is that it will allow the demonstration team to collect complete information about all surrounding vehicles near each vehicle with an automated driving system, and it allows validation of ADS vehicle fleet data.

- **Subtask #1b – Design and Deploy Dedicated Short-Range Communications (DSRC):**

As part of the I-24 smart corridor, a total of 152 DSRC units (see **Error! Reference source not found.**) will be deployed on the roadway. The roadside DSRC units will be complemented by in-vehicle DSRC devices on several ADS fleets used in this project. The DSRC units will broadcast critical information about the state of the vehicle including information regarding the state of the ADS system, e.g., if it is engaged or not, and under what settings).

- **Subtask #1c – Installation of Dynamic Message Signs:**

Dynamic message signs will be installed along the I-24 corridor in addition to existing ITS infrastructure as part of the I-24 Smart Corridor Project. The signs will be used to alert other motorists when the corridor is actively being used for experimentation. Additional portable signage from TDOT will also be used as needed during the experiments outlined in Task 3. Help Trucks will be stationed during experiments to provide emergency assistance to all motorists to reduce the congestion impacts of incidents unrelated to testing.

Task #2 - Establish a Pool of Level 3 Vehicles

This task will produce a pool of automated driving system vehicles available for testing, summarized in Table 4. The pool consists of:

- Level 3 SWRI fleet (3 vehicles). Three demonstration grade level 3 vehicles produced by SWRI, available for testing on the corridor and for which detailed in-vehicle data can be collected. These vehicles will be purchased as part of the project.
- Commercial ADS vehicle fleet (7 vehicles). Seven ADS equipped vehicles with the highest level of automation currently available for lease/sale in the US market, such as the 2019 Cadillac CT6 with Super Cruise. These vehicles will be outfitted with additional sensors and onboard data loggers to collect in-vehicle data. These vehicles will be leased as part of the project.
- Rental ADS vehicle fleet (90 vehicles). 90 ADS equipped vehicles, with the highest level of automation currently available to rent, such as the Tesla model 3 with autopilot. These vehicles will be moderately instrumented (e.g., with GPS and OBD--II scanners) for a single day experiment. These vehicles will be rented as part of the project.
- Community ADS vehicle fleet (250 vehicles). 250 community owned vehicles. These vehicles will be incentivized to participate as part of the project.

All fleets except for the community fleet will be operated by professional drivers when run on the corridor. For example, off duty police officers or similar will be trained on how to use the Level 3 SWRI vehicles. Professional drivers are budgeted at $20/hr of testing.

Table 3. Description of the various ADS vehicle fleets used for demonstrations

Fleet	SAE level of Automation	Number of Vehicles	Ownership	Duration of Availability
SWRI Level 3 fleet	Level 3	3	purchased	project duration
Commercial ADS fleet	Level 2 (3 if available)	7	leased	24 months
rental ADS fleet	Level 2 (3 if available)	90	rented	1-day demo
community ADS fleet	Level 2 and above	250	recruited	Project duration months

To construct the fleets, the following tasks will be executed.

- **Subtask #2a – Establish the Level 3 SwRI Fleet (3 Vehicles):**

The team will acquire three level 3 vehicles that will be built by project partner SWRI. These vehicles will have the capability of operating under a level 3 ADS system on the I-24 corridor. They also will be outfitted with DSRC receivers that can exchange data with the 152 DSRC devices installed on the corridor. Compared to the other fleets used for demonstrations, the Level 3 SWRI fleet vehicles allow the most data collection about the ADS system from onboard the vehicle, and they will operate at the highest level of automation on the corridor (see Figure 3). Raw sensor data used by the Perception and Localization systems (e.g., lidar, radar, camera, etc.)

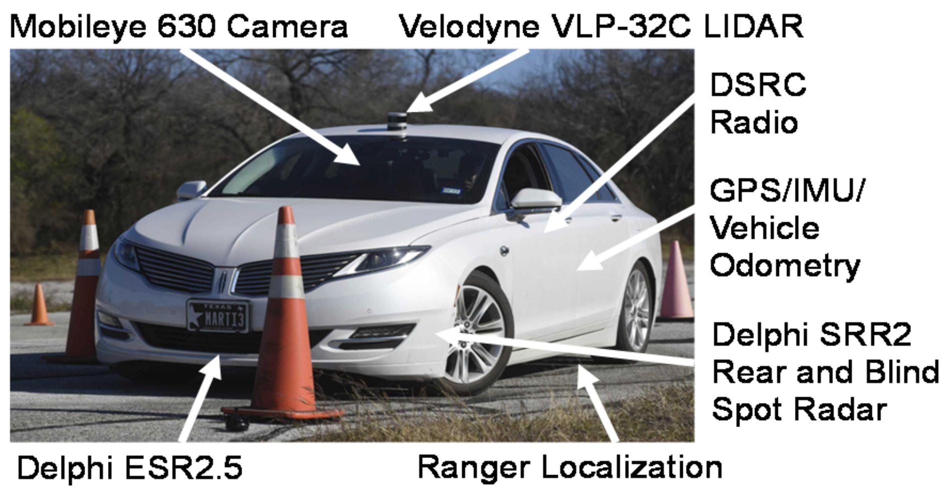

Figure 3. Proposed Sensors for Open Data Vehicles

The following data will be collected from the Level 3 SWRI fleet:

1. Processed sensor data from the Perception and Localization systems (e.g., detection and range of nearby vehicles; fused vehicle odometry)
2. ADS data (e.g., Costmap & Route data input to the Navigation system, speed and curvature setpoints fed to Motion Execution, fused vehicle odometry)
3. OBD-II data (e.g., steering angle, throttle position, brake position, engine RPM, etc.)
4. DSRC data (e.g., basic safety messages, custom messages)
5. Trajectory data from surrounding traffic (from I-24 camera network).

Many companies exist that are working to provide levels of autonomy approaching level 3 or 4, but due to concerns about company privacy and competitive advantage, data collected by these vehicles is not often available outside of the entity that has created and is testing the software. To facilitate having more data with which to evaluate what a vehicle is seeing and how it is reacting during automated operation, we propose to create a set of three vehicles that are using a software solution with internally observable components for automated driving created by SwRI and AutonomouStuff for driving on the I-24 corridor in conjunction with commonly used and available sensors to give a more detailed view of the data that is being used by automated driving systems.

Varying sensing modalities for redundant capabilities is a key component for safety and reliability of a system. With higher levels of autonomy, this redundancy is even more important as systems cannot rely on a human to be the backup system if one fails. For this set of vehicles, we propose a suite of sensors that will provide redundancy in multiple modalities to help maintain system reliability (see Table 5).

Table 4. Detailed Data with redundancy will be captured from vehicles

Object Detection	Sensor Features

• Mobileye 630 Camera
  o Visible light spectrum, camera-based detection of vehicle and people in field of view (FOV)
• Delphi ESR2.5 and SRR2 Radar
  o 76.5 GHz radar spectrum
  o Directly measures speed
• Velodyne 32C Lidar
  o Near Infrared (NIR) spectrum detection
  o Highest accuracy at ~2cm
• DSRC Radio
  o Beyond Line of Sight (BLOS) information to share vehicle data for vehicles outside of range of or occluded from vehicle sensors
Lane Line Detection
• Mobileye 630 Camera
  o Visible light spectrum
• Continuous detection of line and curvature (vs. segmented)
• Velodyne 32C Lidar
  o NIR spectrum
  o Active illumination, not dependent on ambient lighting
  o Uses intensity mapping to find line (high reflectivity returns on road surface are lines)
  o Not a continuous measure of the line
Localization
• GPS
  o Good for global position estimate
  o Lower accuracy (2.5 meters)
• IMU
  o Good for relative distance estimation over short distances
• Vehicle Odometry
  o Wheel speed, steering angle
• Ranger
  o Highest precision at 2cm
	• Mobileye 630 Camera
	  o FCW Forward Collision Warning and Alerts
	  o UFCW Urban Forward Collision Warning
	  o PCW Pedestrian Collision Warning
	  o LDW Lane Departure Warning
	  o WMW Headway Monitoring Warning
	  o IHC Intelligent High-Beam Control
	  o SLI and TSR – Speed Limit Indication and Traffic Sign Recognition
	  o LKA Lane Keeping and Guidance Assist
	• Delphi ESR2.5 Radar
	  o Simultaneous long- and mid-range functionality
	  o Dual-mode classification enhances object reliability
	  o Simultaneous Transmit and Receive Pulse Doppler
	  o Mid-Range (60m): ± 45 deg
	  o Long-Range (174m): ± 10 deg
	• Delphi SRR2 Radar
	  o Blind Spot Detection
	  o Lane Change Merge Assist
	  o Pre-Crash Sensing for Rear End Collisions
	• Velodyne 32C
	  o 32 Channels
	  o Dual Returns
	  o Up to 200m Range
	  o ~600,000 Points per Second
	  o +15° to -25° Vertical FOV
	  o 360° Horizontal FOV
	• Ranger Localization Kit
	  o Map-based localization based on unique visual features on the road surface
	  o 2cm precision at speeds over 80 mph

The sensors listed in the previous section provide the initial input into the automated driving system. As shown in **Error! Reference source not found.**4, this raw data from the sensors is then fed into the Perception and World Model pipeline to provide the vehicle with data about objects in its environment as well as to the Localization pipeline to help the vehicle accurately recognize where it is currently. Data from both of those lines is then fed into the vehicle Navigation component to create a desired path and speed for the vehicle, which is ultimately executed by the Motion Execution component. Each of the data types shown in black letters in Figure 4 connecting the various components will be available for recording, storage and playback within this system.

Some of this data, in particular, the camera image data and LIDAR point cloud data, can require a significant amount of data storage. Examples of individual sensor data rates include a Velodyne VLP16 (not proposed here) at 910KB/s, a Velodyne VLP-32C at 1.84 MB/s and a compressed video stream at 2.7 MB/s. We have found that capturing

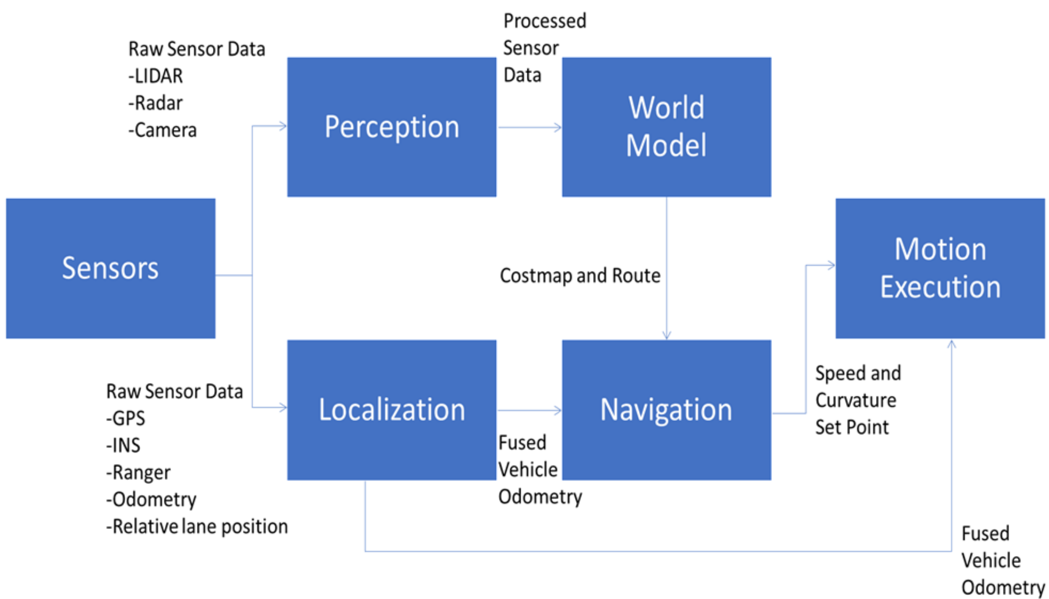

Figure 4. Automated Driving Architecture and Data Flow

all of this pertinent sensor and vehicle state data can create up to 3 GB per minute of information. It is possible to record all of this information, but typically we have found that it is more reasonable to record a subset of this information continuously and then we have a system that keeps the high bandwidth data in a circular buffer and only stores the previous 30 seconds of that high bandwidth data to disk if triggered by the user/safety driver pressing a button in the vehicle. With this method, we get continuous, basic information about the vehicle that takes up about 1.2 GB of storage per hour, but can get extremely detailed data for short durations when needed and more efficiently use our storage space. Examples of data stored continuously versus the high bandwidth data captured in the snapshot can be seen in Table 6 and Table 7, respectfully.

- **Subtask #2b – Establish the Commercial ADS Fleet (7 Vehicles):**

The team will lease 7 commercially available vehicles with the highest-grade ADS system available on the market at the time of the grant award. A current candidate vehicle is the 2019 Cadillac CT6 with super cruise. These vehicles come equipped with sensors for the ADS as well as DSRC units, and will be augmented with additional sensors to collect driver and environmental conditions (E.g., additional cameras and lidar units; on board data loggers).

Table 5. Data collected in snapshots

Component	Data Attributes
Ranger	Exposure; Camera Information
Vision	Rotated_Image; Binned Camera Info
Vehicle Interface	Transmission_Sense; Throttle_Sense; wheel_speed_report; brake_sense; dbw_sense; robotic_mode_sense
Vehicle	transmission_sense; tire_pressure_report; throttle_sense; throttle_info_report; throttle_report; surround_report; suspension_report; steering_report; steering_sense; joint_states; misc_1_report; robotic_mode_sense; sonar_cloud; gear_report; gps fix; gps time; gps; imu data_raw; fuel_level_report; brake_info_report; brake_report; brake_sense
Localization	gyro; imu_raw; gps
LiDAR	velodyne_packets; object_points; tracked_objects; pointcloud_cropped
Other	Diagnostics; Statistics

Table 6. Data collected continuously

Component	Data Attribute
Control	speed_setpoint; stop_for_transmission
LiDAR	objects_health
Localization	local_xy_origin; absolute_odom; Direction; GPS; GPS Fix, GPS Odom, GPS_Health; Direction; Gps; gps fix; gps odom; gps_health; Gyro; gyro_biases; imu compensated; imu transformed; imu_health; relative_odom; signed_speed; Speed; state_estimate; abs_health; state_estimate; rel_health; Velocity
Navigation	active_route; initial_route_position; initial_route_position_status
Path Following	route_position;route_offset; speed_setpoint; transmission_setpoint
Ranger	camera_health; Exposure; map_health; Match; match camera_odom; match vehicle_odom; Matched; matching_health
SWRI Black Box	trigger_snapshot
Vehicle	dbw_enabled; robotic_mode_sense; steering_sense; steering_setpoint; throttle_sense; throttle_setpoint; transmission_command; transmission_sense;

	turn_signal_command
Vehicle Interface	brake_sense; dbw_sense; robotic_mode_sense; throttle_sense; transmission_sense

- **Subtask #2c – Establish Rental ADS Fleets (90 Vehicles):**

The team will rent 90 commercially available vehicles with the highest-grade ADS available in the rental fleet (e.g., Tesla Model S with autopilot). These vehicles will be augmented with moderate additional onboard sensing (e.g., GPS units, OBD-II scanners, and dashcams). Some of these vehicles are expected to include DSRC devices as standard equipment from the OEM.

- **Subtask #2d – Establish a Community ADS Fleet (250 Vehicles):**

The team will identify and recruit up to 250 regular commuters on the I-24 corridor who own a vehicle with level 2 ADS systems. Participants will be given a dashcam and OBD-II scanner to install on their vehicles, such as the Waylens Horizon dashcam, GPS, and OBD-II data logger. The dashcam will allow logging of the contextual information from the video that can be used for further processing, while the OBD-II device will provide critical information about how frequently and when the ADS systems are engaged by regular human drivers. Some of these vehicles are expected to include DSRC devices as standard equipment from the OEM.

Task # 3 - Conduct ADS Demonstrations

The project will consist of 4 major demonstration activities as well as 3 smaller structured demonstrations. The major demonstrations are summarized in Table 8.

Table 7 Description of the onboard data collected from the various ADS vehicle fleets used for the major demonstrations

	Major Demonstrations			
	Level 3 ADS on open roads	**Commercial ADS on open roads**	**Mixed ADS-manual traffic**	**Current state of ADS via community fleet**
Fleets	SWRI Level 3	Commercial ADS	SWRI level 3, commercial ADS, & rental ADS	community ADS
Vehicles	3	7	100	250
Duration	24 months	24 months	1 day	30 months
Vehicle miles traveled	60,000	140,000	40,000	750,000

	Major Demonstrations			
	Level 3 ADS on open roads	Commercial ADS on open roads	Mixed ADS-manual traffic	Current state of ADS via community fleet
Onboard sensors	excellent; radar/lidar/camera/GPS	good; radar/lidar/camera/GPS	limited; camera/GPS	limited; camera/GPS
Onboard ADS data	excellent; Perception, Localization, Navigation, and Motion Execution data	good; Perception and Motion Execution data	limited; some Perception and Motion Execution data	limited; some Perception and Motion Execution data
Onboard OBD-II	Yes	Yes	Yes	Yes
Roadside 4K network	Yes	Yes	Yes	Yes
DSRC	Yes, all	Yes, all	Yes, some	Yes, some
Impacts on other vehicles	modest	modest	substantial	modest
Data quality on other vehicles	excellent; via 4K camera network	excellent; via 4K camera network	excellent; via 4K camera network	excellent; via 4K camera network
Expected benefits	comprehensive dataset on all Level 3 vehicle system components	comprehensive dataset on commercial ADS systems	first demo of ADS systems at high penetration rates	longitudinal study of real drivers using ADS systems

- **Subtask #3a – Demonstration of Level 3 ADS on Open Roads**

Using the SWRI level 3 fleet operating on the I-24 corridor operating over the course of 24 months (20,000 miles per vehicle), this demonstration will allow significant onboard data collection from all parts of the level 3 ADS system including data from the Perception, Localization, Navigation, and Motion Execution subtasks of the level 3 ADS.

Raw sensor data and processed sensor data will be logged from the three SWRI level 3 vehicles, and trajectory data for all manual vehicles on the corridor upstream and downstream from the ADS vehicles will be stored from the roadside 4K camera network. It will create a dataset to enable safety analysis of the ADS system and its interaction with manual drivers. The dataset will be valuable because it will allow data collection of the ADS systems in a variety of traffic and weather conditions.

- **Subtask #3b – Demonstration of Commercial ADS on Open Roads:**

This demonstration uses the commercially available ADS fleet (7 vehicles) operating in the same configuration of the level 3 ADS demonstration above (24 months, 20,000 miles per vehicle). It has substantial onboard data collection including from additional sensors (radar, lidar, camera) installed on the vehicle given that some components (e.g., prediction and planning subsystems) are unlikely to generate data that can be logged on a commercial vehicle. Three of the vehicles in the fleet will operate under the most conservative ADS settings, three vehicles will operate under the most aggressive ADS setting deemed safe by the project partners, and the final vehicle will switch between settings. All trajectory data needed to study the interactions of manual vehicles with the commercial ADS fleet will be logged from the roadside 4K camera network, creating a dataset to further investigate the local and nonlocal safety of ADS and manual traffic.

- **Subtask #3c – Demonstration of Mixed Annual ADS Traffic:**

This demonstration uses the SWRI level 3 fleet, the commercial ADS fleet, and the rental ADS fleet to constitute a 100 vehicle ADS pool that will be deployed on the I-24 corridor for a single day of data collection. By artificially seeding the traffic stream with 100 ADS equipped vehicles, it will be possible to experimentally demonstrate the potential benefits of commercial ADS systems improving overall traffic safety as assessed via key traffic proximal safety measures such as speed variation. The test will be operated for a single day, following a similar experimental design as the Mobile Century Experiment conducted more than a decade ago to artificially generate a 3-5% penetration rate of GPS equipped smartphones. It is expected each vehicle will be operated for approximately 8 hours, generating 400 miles of data per vehicle on the corridor. The complete effects on the traffic flow will be monitored and quantified by the roadside 4K camera network. The 5% penetration rate envisioned for this demonstration is significant because it is the rate at which ADS systems have already been experimentally shown to offer positive wave smoothing benefits in a ring setup by project partner Vanderbilt (See Figure 5). The data collected during this experiment will also enable the possibility of calibrating the digital twin (See Task 7) to accurately reflect ADS vehicles and how manual vehicles respond to the presence of ADS vehicles at scales.

- **Subtask #3d – Demonstration of Current State of ADS Vehicle Operations via Community Fleet:**

In this demonstration, a community fleet of ADS equipped vehicles will be instrumented to log contextual information and log the presence of the ADS vehicle on the I-24 corridor. It will allow daily observation of the interactions of ADS systems with manual vehicles using the roadside 4K camera network and via an onboard OBD-II scanner and dashcam. It will also provide information on the frequency at which regular commuters use ADS systems, and in which traffic and weather-related conditions.

In addition to the major demonstrations, the following structured demonstrations will also be conducted.

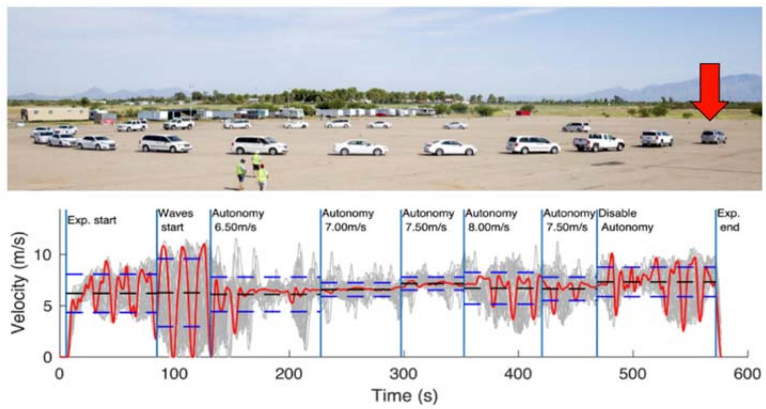

Figure 5. A single ADS vehicle (red arrow) can dissipate jams https://www.youtube.com/watch?v=2mBjYZTeaTc

- **3 vehicle SWRI Level 3 platoon.** The SWRI fleet will be driven under a variety of ADS settings in a single lane in which all vehicles initially begin in the same lane, each immediately in front of the next. For each test under the same ADS settings, events such as the number of times a manual vehicle interrupts the leader follower pair will be recorded. Figure 5 shows and recent project example lead by Vanderbilt.
- **7 vehicle commercial ADS platoons.**
  The same tests will be repeated but with the 7 vehicle commercial ADS system. In the first set of tests the corridor will be driven with all vehicles in the same lane, with only the ADS systems settings change. In the second set of tests, the multi-vehicle platoons will be constructed in two adjacent lanes to measure the impacts on the surrounding traffic flow and the response of manual piloted vehicles. The 2 lane, multi-vehicle platoons will be re-run under each of the ADS system settings to measure the influence of the settings on the overall impacts to human drivers.
- **100 vehicle dedicated ADS lane.**
  During 1 hour of the 100-vehicle major demonstration, DMS signs will be used to restrict access to a single lane of flow, creating an ADS-only lane. In this lane, the ADS penetration rate will reach 100%, allowing a demonstration of the effects of a 100% deployment rate of ADS. The demonstration will also indicate the feasibility (or lack thereof) of ADS systems to navigate to the ADS only lane.

Task #4 - Develop and Operate ADS Data Management System
The ADS Data Management System (ADS-DMS) architecture is a management system with four critical components of a successful data repository: 1) Data Collection and transfer; 2) Archival, Cataloging and Discovery; 3) Security and Cyber infrastructure; and 4) Data Stewardship and Distribution (details are located in Part III of this proposal).

- **Subtask #4a – Development of ADS Data Management System**

The ADS-DMS will be developed by effectively leveraging cyber infrastructure and processing power from the Oak Ridge Leadership Computing Facility (OLCF) high-performance computing resources including Summit supercomputer and the Compute and Data Environment for Science (CADES) at ORNL (https://cades.ornl.gov/), and Advanced Computing Center for Research and Education (AACRE) at Vanderbilt. The ADS-DMS leverages multiple resources to meet the distinct requirements of data processing and management for safe design and execution of ADS demonstrations on I-24, and as well as the high performance computing and long term archival needs of the overall project.

- **Subtask #4b – Operation of ADS Data Management System**

Within the ADS-DMS, near real-time data collection, processing, and analysis, and sharing of demonstration data necessary for successful and safe execution of the ADS demonstrations are conducted on the Experimental Management and Collaboration Platform at Vanderbilt. Curated project data streams are transmitted to the CADES system at ORNL in near-real time for development of the digital twin & alternative user interface platform and for long term archival. The project will provision project data access and scientific collaboration to the project team, the USDOT, and other public stakeholders throughout the project in near real time.

Task #5 - Data Standardization and Analytics
In this task, the data collected during each of the demonstrations will be standardized, cleaned, and processed. The tasks include the following.

- **Subtask #5a – Data Cleaning and Standardization**

For each demonstration and for each set of data from the various data streams, metadata needs to be generated, formats need to be standardized, data taxonomies need to be generated, and the quality of the data needs to be assessed. Data quality metrics will be calculated for each dataset including the data completion rate (i.e., the percentage of entries for each data type for which data was recorded), the data error rate floor (i.e., the percentage of data containing obvious errors (e.g., infeasible or impractical vehicle trajectories, lat/long coordinates corresponding to locations outside the study area etc.). It is a floor because additional errors may exist in the data but require more sophisticated techniques to identify them.

Data standardization refers to the process of unifying similar data types into a common format. For example, processed range data from a camera, a radar unit, and a lidar unit may all be recorded at different frequencies and with different units. Data also needs standardized and synchronized across a large number of devices (up to 350 vehicles each with multiple data feeds) and more than 350 4K resolution cameras. Defining the data taxonomy (including relevant metadata) and the formatting to allow reuse of demonstration data for additional analysis and updating them as the project evolves will be critical to realize the full value of the demonstration data across project partners and USDOT.

- **Subtask #5b – Video and Image Data from Roadside Cameras**:

The 4K roadside camera network will generate roughly 110 terabytes of compressed video data per day. This data will be processed to create trajectory data (x,y position and velocity information on the roadway at 30 Hz), as well as vehicle metadata assigned to each trajectory (e.g., vehicle type and length).

To transform the raw camera data into useful trajectory data supporting safety analysis of ADS interacting with human vehicles, significant data processing and data reduction is needed. Each camera on the network needs to be adjusted to have an overlapping field of view with neighboring cameras. Once the cameras are positioned, *i*) the cameras need to be calibrated, *ii*) the camera images need to be rectified into a unified world plane, *iii*) vehicles need to be detected, *iv*) tracked, and *v*) the trajectories from each camera need to be stitched together to create seamless trajectories over the full experimental site. Camera calibration and image rectification are well established modern computer vision techniques. Recent progress in detection algorithms and tracking algorithms significantly reduce the complexity and improve the quality of the trajectories that can be extracted. The use of 4K resolution cameras increase the pixel density on each vehicle to aid in tracking, and the cameras are installed to minimize the potential of vehicles being occluded in multiple cameras, facilitating easier tracking.

- **Subtask #5c – On-board AV Object Detection and Avoidance Imagery/Information:**

A core challenge of the project is to validate data collected from the ADS systems. This will be accomplished via two approaches.

In the first approach, we exploit the fact that the SWRI Level 3 fleet has multiple redundant sensing modalities that allow for comparison and consistency checks. For example, it is possible to compare the LiDAR returns with the Mobileye camera estimates to determine the level of agreement. A disagreement between two sensors is sufficient to determine that at least one of the sensors is erroneous. This approach is only possible to do on vehicles with redundant sensors and may not apply to all ADS fleets, such as the community fleet.

The second approach will leverage the unique features of the I-24 corridor 4K camera network, which provides an independent data source that localizes all vehicles on the roadway, including the non-instrumented manual vehicles, from an occlusion free overhead field of view. By fusing the roadside camera network data with the data from the ADS fleets, it will be possible to identify disagreements between perception systems on the vehicle and the positional information provided by the roadside camera network. Roadside camera imagery can be viewed to ground truth the source of the disagreement on small subsets of the data.

- **Subtask #5d – DSRC Information from Equipped Vehicles:**

Dedicated Short Range Communications or DSRC will be collected from equipped vehicles. This data is expected to largely consist of Basic Safety Message (BSM) data, including BSM Part II where available. Additionally, during the demonstrations active Traveler Information and Roadside Alerts messages will be issued to provide guidance to the ADS vehicles to determine if the vehicles can separately and collectively receive and act upon messages. The BSM data will be used in coordination with the other collected data to establish vehicle telemetry and trajectory.

Task #6. Safety Assessment
Based on the data collected in the demonstrations from the various vehicle fleets, the local and nonlocal safety impacts of ADS systems will be assessed.

- **Subtask #6a – Development and Calculation of ADS Safety KPIS**:

A key component of this project is the availability of non-local data regarding how ADS equipped vehicles and manual vehicles interact with each other to influence the collective safety of the overall traffic stream. Given the short duration of the project, classical approaches to estimate accident modification factors may not be informative indicators. Instead the project will adopt KPIs based on *proximal surrogate indicators*[2] for safety. These metrics do not directly measure reductions in crashes but provide approximate measures that are straightforward to calculate using data onboard the

[2] See the recent review article, Mahmud, S.S., Ferreira, L., Hoque, M.S. and Tavassoli, A., 2017. Application of proximal surrogate indicators for safety evaluation: A review of recent developments and research needs. *IATSS research*, *41*(4), pp.153-163.

vehicle sensors and using the roadside 4k camera network. Some of the proximal surrogate indicators for safety that can be computed from onboard vehicle sensors for ADS fleets and 4kcamer network for manually operated vehicles in the flow to be calculated are:

- Time to Collission (TTC): Time until a collision (assuming vehicles continue on current trajectory with constant speed). Only finite when leader vehicle drives slower than follower.
- Time exposed time to collision: Total time (per vehicle) TTC is below a specified threshold. The sensitive to the threshold parameter must be checked.
- Modified time to collision: Considers current vehicle accelerations when calculating time to collision. Provides a more realistic time to collision provided acceleration rates can be estimated.
- Lane change rate: Number of lane changes per mile per vehicle. Higher lane change rates increase the risk of collisions due to lane conflicts.
- Spatial velocity variation: Variability of vehicle speeds along the roadway and across the lanes. Can be quantified via standard deviations, total variation, or other metrics.

- **Subtask #6b – Establishment of Manual Vehicle Safety KPI Baseline:**

These proximal surrogate indicators will be computed when no ADS vehicles are on the roadway to determine a baseline for manual vehicles along the roadway. The baseline will be computed to determine the day to day variation, the variation in the metrics due to weather, and the variation due to time of day (e.g., rush hour, night time, etc.).

- **Subtask #6c – Safety KPI Comparison for Each ADS Demonstration:**

After the human baseline is established, the indicators can be recomputed for each of the major demonstrations.

Demonstration 1 - Level 3 ADS on open roads. The safety KPIs will be computed first for the ADS equipped vehicle to assess how the level 3 ADS system compares to the distribution of human drivers on the same segment. Next the safety KPIs in the neighborhood of the ADS vehicle will be assessed to determine if local or non-local changes occur in the KPIs for manual vehicles. For example, an increase in lane changes in the wake of a passive Level 3 ADS system might indicate a local improvement in safety to the Level 3 ADS is offset by decreases in overall safety due to the response of manual vehicles. Given more than 40,000 miles of expected travel by the level 3 SWRI fleet, significant effects should be observable if they exist.

Demonstration 2 - Commercial ADS on open roads. The analysis of the commercial ADS fleet will follow the same approach as what is done for the Level 3 ADS above, with the notable exception that the analysis will indicate the potential impacts of commercially available ADS systems.

Demonstration 3 - Mixed ADS manual traffic. Given the high penetration rate of ADS vehicles in this one-day experiment (3-5% expected, depending on flow conditions), the aggregate impacts of ADS systems on the flow will be amplified. For example, at a 5% penetration rate the ADS systems might substantially reduce speed variations depending on the details of their implementation. The data collected during this demonstration will be compared to the human baseline to quantify the aggregate safety impacts of ADS vehicles at scales that might be achieved in the near future (e.g., next several years).

Demonstration 4 - Current state of ADS via community fleet. The safety KPIs will be calculated around the active ADS vehicles similar to the approach in Demonstration 1 and 2. The notable distinction about the analysis of the community fleet is that there is expected to be a wider variation in the type of ADS system, and the ADS settings under which the community partners operate their ADS systems.

Task #7 - Develop and Deploy a Digital Twin & Alternative User Interface Platform

This task will develop and deploy a digital twin platform (virtual representation of the region) along with a *situational awareness* (SA) tool that is capable of real-time, predictive control of traffic achieved in a *High-Performance Computing* (HPC) environment. This platform is of paramount importance in providing capability to test, evaluate and safely deploy ADS vehicles and alternative user interfaces onto the real-world transportation system. Moreover, it will use data from the I-24 corridor to calibrate human responses to ADS systems that are not possible to achieve with existing simulation platforms due to the lack of appropriate data. The digital twin and the SA tool will greatly complement the Automated Driving System program from the USDOT in investigating real-time and adaptive strategies in ultimately achieving the goal of smart and efficient movements of passengers and freight through the transportation system.

- **Subtask #7a – Develop Digital Twin-Based on I-24 Demonstration Data:**

The digital twin is defined as a geospatial and temporal virtual representation of the study area as observed by means of deployed sensors sending real-time data, in which the ADS vehicles operate (under various traffic conditions). This system will also have the capability to anticipate real-world system state as well as be able to evaluate the impact of control decisions faster than real-time. The primary objective is to achieve a continuous data collection and digital twin representation of the region to enable real-time analytics and adaptive algorithm applications. For this purpose, the role of scalable computing and HPC are required in two areas:

1. **Near real-time situational awareness tool** – A regional scale digital twin will require data processing at a scale that will computing approaches that achieve near real-time situational awareness.
2. **Near real-time control of traffic infrastructure and vehicles** – Orchestration of computational resources to deliver fast algorithm decisions (machine learning and artificial intelligence), including traffic operational and related impacts from ADS vehicles operating under mixed traffic flow conditions.

The critical piece in achieving the digital twin is cataloging both existing and anticipated data collection as part of the ADS program. This includes diverse and disparate sources such existing traffic infrastructure collected from video, imagery, radar sensors, and other loggers that span a variety of spatial and temporal scales. The anticipated data sources include vehicle on-board telematics and trajectories from the program. This data cataloging will leverage from various stakeholders such as the Tennessee Department of Transportation, and other partners. These stakeholders already have existing and emerging assets such as – SmartWay information systems, ActiveITS deployment, DSRC communication systems and state and city operated ADS vehicles.

The digital twin is a virtual representation of study region by means of real-time data feed from the deployed sensors to predicting future of anticipated events in real-world, along with ability to evaluate the impact of control decisions faster than real-time. This real-time sensing of the physical world in cyber world can be replicated using the Situation Awareness (SA) tool. Essentially, SA tool will use reference data (spatial and temporal) that provides information on location and infrastructure characteristics. The intended outcome of this tool is to serve as a platform to stakeholders and policy makers in enabling informed decision making in optimizing regional mobility that enhances overall safety of ADS vehicles operating in the region.

- **Subtask #7b – Deploy Alternative User-Interface Platform:**

The digital twin will enable the emulation of alternative traveler immersion in the I-24 Smart Corridor. The digital twin will be used to demonstrate alternative input/output user interfaces on the ADS that are accessible and allow users with varied abilities to input a new destination or communicate route information and to access information generated by the ADS. The project will include evaluation of the ability for users of varied demographics to use by developmental and commercial user interfaces. A diverse population of users (ORNL visitors and staff) will be exposed to alternative user interfaces and user experience data will be gathered from the digital twin system.

Task #8 - Outreach and Reporting

Outreach and stakeholder engagement will proceed throughout the project led by TennSMART, a 24-member intelligent mobility consortium representing industry, local and state governments, public and private research organizations. Project sponsor level outreach will take in parallel with TennSMART organization meetings. The progress and future plans for the project will be disseminated to members at bi-annual membership meetings and quarterly TennSMART Board of Directors meetings. TennSmart will also lead engagement to recruit additional ADS demonstration partners from the Membership to leverage the unique features of the demonstration site on I-24. Technical findings will be disseminated through regular reporting to USDOT and scholarly articles, and a project website.

All project reports (e.g., quarterly progress reports; annual budget reports; annual budget review, program plans) will be prepared in line with USDOT requirements and guidelines.

5.B - Approach to Address Obstacles.

All ADS-Operated vehicles in the Tennessee Automated Driving System I-24 Demonstrations Project will have human drivers present behind the steering wheel. In addition, the ADS equipped vehicles deployed by the project team will meet all federal and state regulatory and legal requirements and will be compliant with the Federal Motor Vehicle Safety Standards. The Tennessee Department of Safety and Homeland Security (TDSHS) will have a key role on the project team to ensure vehicles in the establishment of the community ADS Fleet (Task 2D) meet all federal and state regulatory and legal requirements.

TDOT has developed and received federal approval of an environmental document for the installation of ITS technologies that will be utilized in the scope of the demonstrations through the I-24 Smart Corridor Project. Additional environmental approval is not expected, however if any unforeseen technology installations are needed within the existing State right-of-way that are beyond the scope of the I-24 Smart Corridor Project, the installation locations will be added for re-evaluation to the current environmental document and reviewed for impact.

The public acceptance of the ADS demonstrations along the I-24 corridor must be considered as a potential future obstacle for the project team. TDOT and the TennSMART Consortium will proactively engage the public through local mass media resources with consistent demonstration updates. This activity is included in project task 8a. The project team recognizes that this demonstration project provides an opportunity educate the public on ADS technology and will take seriously the responsibility of maintaining the public’s confidence.

5.C - Commitment to Provide Data and Participate in Evaluation

The TDOT lead project team for this proposal is committed to the data access and sharing requirements outlined in section F, subparts I. of the ADS Notice of Funding

Opportunity. This project will be in full compliance with the USDOT Public Access plan requirements for copyright license, and reporting and compliance activities.

5.D - Approach to Risk Identification, Mitigation, and Management

The project team's approach to risk management will be organized and conducted as outlined in the USDOT guidance on System Engineering for Intelligent Transportation Systems (FHWA-HOP-07-069). Time will be devoted in early project team meetings for the review and maturation of risk identification that cover all aspects of the project, which include the following sub categories: technical, institutional, schedule, funding, personnel, legal/regulatory, environmental, and public communications.

After the project team has cataloged risks, an analysis will be conducted to prioritize each based upon foreseen severity of impact. A matrix will be developed to enumerate and outline each risk, highlighting a severity of impact rating (high, medium, and low) and the probability of occurrence. The project team will utilize this matrix to develop a risk mitigation plan detailing strategies to execute for lessening the severity and probability of the identified risk. During all stages of the project, the team will reserve time during meetings to review the risk matrix and mitigation plan to determine what actions and adjustments need to be made to help insure project success.

5.E - Approach to Contribute and Manage Non-Federal Resources.

The Tennessee Department of Transportation is committed to the successful completion of the demonstrations as ascribed in this proposal. One indication of this commitment is the portion of non-federal resources designated for this project. Task 1a through 1c will be funded as part of a planned state and federal project (I-24 Smart Corridor) that includes a 20% share of matching state funds in the amount of $18.4 million dollars. In addition, TDOT facilities will be utilized during all project phases for pre-demonstration testing, vehicle maintenance, and storage. The TDOT ITS Communications office will designate storage space, one vehicle service bay, and laboratory space for the project team.

The Tennessee Department of Transportation will also coordinate the use of the Tennessee Traffic Incident Management Training Facility (Figure 6) for pre-testing and driving education for the vehicle demonstration phases. This facility provides a simulated section of Interstate and other roadway features and is designed to allow the circulation of traffic.

Figure 6. The Tennessee Incident Management Training Facility will be used for Vehicle Deployment Testing and Driver Education