North Dakota Automated Driving System Demo Grant

Bismarck, ND

NDDOT
North Dakota Department of Transportation

VISION ZERO
Zero fatalities. Zero excuses.

FY2019 ADS Demo Grant

North Dakota Department of Transportation

Thomas K. Sorel
Director

Doug Burgum
Governor

March 18, 2019

The Honorable Elaine L. Chao
US Secretary of Transportation
US Department of Transportation
1200 New Jersey Ave, SE
Washington, DC 20590

SUBJECT: North Dakota's Automated Driving System Demonstration Grants application

The North Dakota Department of Transportation's (NDDOT) is pleased to submit this application for the Automated Driving System Demonstration Grants application.

North Dakota is currently a leader in UAS development and working in a collaborated effort to meet the UAS mission. The open landscape allows for many opportunities of development and testing. We are also a fiber enriched state which enables stronger technology for efficient usage, transmission and backhaul. In addition, NDDOT is also focused on achieving a highway safety performance target which is identified in the Highway Safety Plan. Vision Zero is a goal for our state and safety is our focus.

The Automated Driving System Demonstration Grant will give NDDOT another opportunity to collaborate with key stakeholders to prevent traffic fatalities and will help us achieve the vision zero target. NDDOT is looking at multiple areas where the grant can be used to benefit and enhance our great state. Safety can be a key rallying point for our application because it would include all 4e areas of Vision Zero: Engineering, Enforcement, Education, and Emergency Medical Services.

Technology is changing in the world today and North Dakota has a unique opportunity to work with various stakeholders across our state. Through the process of working with diverse groups such as the Upper Great Plains Training Institute, North Dakota Highway Patrol, North Dakota Commerce Department, etc. North Dakota would be a key component in shaping the Automated Driving System potential opportunities which could then be use nationally.

We understand that USDOT is seeking to collect data from several modes ranging from urban to suburban to rural. NDDOT collaborating with our key stakeholders will be able to achieve this goal.

Sincerely,

Thomas K. Sorel

THOMAS K. SOREL, DIRECTOR

01/las/slg

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Summary Table	
Project name/Title	North Dakota Automated Driving System Demo Grant
Eligible Entity Applying to Receive Federal Funding (Prime Applicant's Legal name and Address)	North Dakota Department of Transportation 608 East Boulevard Avenue Bismarck, ND 58505
Point of Contact (Name/Title; Email; Phone Number)	Linda Sitz, Strategic Innovation Manager, ldsitz@nd.gov, 701-328-1986
Proposed Locations (State(s) and Municipalities) for the Demonstration	North Dakota Interstates 29 & 94, US Highways 2, 83, and 85
Proposed Technologies for the Demonstration (briefly list)	Open source level system
Proposed duration of the Demonstration (period of performance)	36 Months
Federal Funding Amount Requested	$ 3,670,342
Non-Federal Cost Share Amount Proposed, if applicable	$ 917,586
Total Project Cost (Federal Share + Non-Federal Cost Share, if applicable)	$ 4,587,928

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EXECUTIVE SUMMARY

Vision, Goals, and Objectives

- **Vision**

The vision of this project is to develop and demonstrate the foundation to enable widespread adaptation of multi-seasonal Level 3 ADS technology across rural North Dakota highway systems leading to Vision Zero goals of eliminating fatal and serious crashes on North Dakota Highways.

- **Goals**

To reduce fatal and injury crashes on rural North Dakota highways through the increased use of effective, safe, and affordable Level 3 ADS technology.

Increase usage and demand for ADS technology by making Level 3 user benefits (such as enabling personal productivity during long commutes and reduced crashes due to distracted driving) available to the public.

Successfully demonstrate that a safe Level 3 system can be implemented for identified rural corridors within a defined Operational Design Domain in North Dakota.

Identify affordable proven technology for public application to move this technology toward standard equipment and software along with retrofit options for older vehicles.

Assessment of weather conditions adverse to Level 3 ADS technology and identification of potential communications of conditions to Level 3 systems.

Provide pathway for elimination of obstacles for industry implementation of Level 3 capable vehicles in North Dakota.

- **Objectives**

Objective 1

Test existing Level 2 vision/radar equipped vehicles on rural Interstate, State, and Local roads to develop a comprehensive list of situations where these systems either disengage on their own or where the driver must take control. The testing would be done with trained researchers on existing Level 2 Plus autonomous vehicles (vehicle is in speed and steering control, but the driver always needs to pay attention to the roadway). Examples of where disengagement may occur include:

- Inadequate striping for the vision system,
- Sharp curves and reduced speed warnings,
- Intersection control,
- Weather impacted road conditions,
- Maintenance or construction zones.

Objective 2

Compile and classify collected data for the purpose of identifying reasons for disengagements and recommending the solutions which may involve:

- Infrastructure enhancements, such as lane striping enhancements and maintenance,
- Vehicle-to-Infrastructure (V2I) communications such as stop sign locations or reduced speed warning locations via GPS coordinates or HD mapping applications,
- Vehicle sensor enhancements, such as identifying a vehicle stopped in the driving lane far enough in advance to alert the driver to take control,
- Some solutions may also involve infrastructure sensor deployment such as pedestrian or intersection vehicle detection and SPAT information.

Objective 3

Form working group involving NDDOT, Local Governments, USDOT, Vehicle Manufacturers, and HD Mapping Companies for the following activities:

- Establish methods and standards to ensure data requirements identified in Objective 2 are open source and readily available to all properly equipped vehicles.
- Provide agencies the capability to update data items in real time via cloud services available to all vehicles.
    - Specific examples include uploading locations and durations of maintenance and construction zones, roadway surface conditions, and locations of reduced speed curves, intersection control, and other situations where drivers would be required to take control or pay attention.

Objective 4

Based on solutions identified in Objectives 2 and 3 the following activities would be pursued:

- Enhancements would be developed for existing open source Level 2 system to operate as a Level 3 system where conditions allow for it.
- Development of data input and delivery systems through cloud-based data services and/or open source HD mapping services.
- Collection of necessary data and geo-fence locations including start and end of certified Level 3 road segments.

Any in-vehicle sensor enhancements identified in Objective 3 will need to be implemented or resolved by the open source autonomous system provider or vehicle manufacturers at their discretion.

Objective 5

Conduct demonstration and testing of updated systems using vehicles from the North

Dakota State Fleet or leased vehicles that can accommodate these systems. All data during this phase would be collected and submitted to USDOT in near real-time for further analysis. Drivers would have a brief training session on these systems and would always be required to pay attention to the roadway. To be considered Level 3 ready, test sections would need to have zero disengagements without proper notification from the vehicle to take control.

Objective 6

A comprehensive report would be developed with all findings and recommendations including a review of North Dakota State laws and Federal regulations regarding Level 3 autonomous vehicles and recommendations for any changes necessary to make these Level 3 autonomous systems legal under defined situations or geo-fenced certified roads.

Key partners, stakeholders and team members

NDDOT, Local Governments, USDOT, Vehicle Manufacturers, level 2 supplemental technology suppliers, and HD Mapping Companies

Issues and challenges to be addressed

Vision and radar-based technology are becoming common equipment in vehicles from most manufacturers providing Level 2 capabilities up to complete control by the vehicle, provided there is continuous driver monitoring. To move up to Level 3 and eliminate the need for continuous driver monitoring using the same vision/radar technology is possible but presents the following issues and challenges:

- Drivers must be notified well in advance when any situation will occur requiring them to take control or pay attention. This includes situations such as controlled intersections, speed warning reductions, construction zones, traffic or pedestrian conflicts, stopped vehicles or other objects in the roadway, weather conditions, and lane marking visibility. This list of situations will need to be expanded to identify all situations experienced on North Dakota highways.
- The vision/radar technology can and does identify and react to many of these situations but there are times when visibility or other limitations restrict the sensors' abilities to identify and control the vehicle based on that information. An example would be poor lane marking visibility. To address this, the study will involve Agency participation in attempting to minimize situations where this happens by updating striping standards and maintenance practices. The ADS software will also need to be updated to either verify with HD maps or provide adequate warning to drivers when lane markings are not adequate.
- In other situations, such as controlled intersections, speed warning reductions and construction activity, the ADS software will need to rely on getting that information from HD maps or directly from the Agencies'

cloud-based databases. Procedures and software will need to be developed to allow Agencies to edit and maintain this data in commercial or open source HD maps or open cloud-based relational databases which the ADS software can utilize in real-time.

- With the northern climate in North Dakota, weather conditions such as snow and ice can also provide challenges for vision-based systems. These issues can range from cruise control issues on ice to snow compacted roads covering lane markings. The likely technology to address these situations will be for Agency road weather information systems to provide that data to the HD maps or cloud-based relational databases and ADS software getting real-time updates on roadways where Level 3 is not available.
- In a situation such as a stopped vehicle obstructing the lane of a high-speed road, older radar technology may not pick up the vehicle in time to react to the situation. In these cases, newer radar and/or vision technology, which has already been developed, may need to be tested and recommended or required to be used to enable Level 3 driving.
- The last issue will involve clearing any State or Federal legal issues with operating a Level 3 vehicle on North Dakota roads.

Geographic area

The Geographic area will involve North Dakota Interstates 29 and 94, US HWY 2 and 83 excluding urban areas, and some rural 2-land state and county major collectors in Cass County ND.

Proposed period of performance

Three Years.

GOALS

As described below, North Dakota's proposal addresses the goals of the ADS Demonstration Program.

Safety

The following safety elements will be considered and addressed when developing, testing, and deploying this ADS technology on public roadways:

- System Safety – The design and validation process will be based on a systems-engineering approach with the goal of designing the system free of unreasonable risks.
- Operational Design Domain (ODD) – The ODD will describe and address the specific conditions under which the ADS features are intended to function.
- Object and Event Detection and Response - A documented process will be established for the assessment, testing, and validation of the ADS's OEDR

capabilities. When operating within its ODD the OEDR functions will be able to detect and respond to other vehicles and objects within its travel path.

- Fallback (Minimal Risk Condition) – An ADS operating on the road should be capable of detecting that the ADS has malfunctioned, is operating in a degraded state, or is operating outside of the ODD. Furthermore, an ADS should be able to notify the human driver of such events in a way that enables the driver to regain proper control of the vehicle or allows the ADS to return to a minimal risk condition independently
- Human Machine Interface - HMI design should also consider the need to communicate information regarding the ADS's state of operation relevant to the various interactions it may encounter and how this information should be communicated.
- Data Recording - A documented process will be developed for testing, validation, and collecting necessary data related to the occurrence of malfunctions, degradations, or failures in a way that can be used to establish the cause of any crash.
- Federal, State, and Local Laws will be observed and complied with at all times. North Dakota State Highway Patrol will be involved as a key partner as they are with the Vision Zero program.

Data for Safety Analysis and Rulemaking

Task 1 of this project involves real world testing of existing Level 2 ADS equipped vehicles. The purpose will be to collect the data necessary to determine when disengagements, system failures or driver intervention needs to happen. This information will help develop the safety metrics necessary for integration into the transportation system. To capture this data the test vehicles will be equipped with continuous video recording of roadway and driver along with location data and vehicle CAN bus data, including sensor and operational information. These data will be analyzed and only the data relevant to the incident will be made available via cloud services for further safety analysis. This data can be accommodated through secure servers and databases. NDSU has well-established confidentiality protocols, which are necessary within a comprehensive FOI environment.

Collaboration

The vision of this demonstration project is to help North Dakota move toward the mission to eliminate fatal and serious injury crashes, as developed by the NDDOT in the Vision Zero program. With this shared vision, this project will tap into the extensive collaboration and partnerships that have been established through the Vision Zero program.

FOCUS AREAS

Significant Public Benefit(s)

North Dakota's project will result in significant benefits across the state. It will benefit the traveling public on interstate and other arterial highways through the reduction of fatal and serious crashes. Because North Dakota has significant rural travel distances between major population centers the project will benefit the traveling public by enabling productivity in a Level 3 environment. The outcomes will benefit Native American Indian populations and growing elderly populations, providing them with safer transportation options in the future.

Addressing Market Failure and Other Compelling Public Needs

Private sector investment is focused heavily on metropolitan markets and interstate highway travel. However, much of the travel in largely rural states occurs outside of metropolitan regions on two-lane highways with minimal access control. The cost of new (fully-equipped) vehicles will limit ADS participation in the near future. North Dakota's demonstration addresses such market challenges by focusing on the extension of low-cost Level 2 features that have recently appeared in the market and expanding them to Level 3 capability. Another market failure that will be addressed is making this ADS technology available for deployments in northern states in harsh climatic zones (e.g., testing the limits of the technology). This will need to include the integration of real-time winter roadway and condition information into ADS algorithms.

Economic Vitality

The partners of the North Dakota coalition are focused on developing and advancing industries within the state to provide the technologies and services needed in the transition to Level 3 automation. The Department of Commerce offers services and technical assistance for startup businesses. The Bank of North Dakota offers financing options. NDSU's research park and business incubator offer extended support for new and potential enterprises.

NDSU and the State are promoting the development of intellectual properties with rights held by U.S. institutions and enterprises. The planned demonstrations feature U.S. automobile manufacturers and products and services provided by companies.

Complexity of Technology

The primary focus of this project will be the demonstration of advanced Level 2 ADS technology on rural North Dakota highways, leading to Level 3. To accomplish this a high level of complex technology will need to be deployed and modified for safe implementation. This will include the latest vehicle sensors and full lateral and longitudinal control along with open source ADS software. This will also need to include processes and voluntary standards for HD mapping and cloud-based data services with real time updates.

Diversity of Projects

This demonstration project will focus on the rural environments of North Dakota, serving a variety of small and medium-sized communities. With the lack of public transportation and long rural commutes, this environment provides a unique opportunity to demonstrate the benefits of the technology.

Transportation-challenged Populations

North Dakota's rural population includes a highest proportion of elderly residents. One of the social challenges facing the State is providing safe transportation options for these elderly residents that enable them to maintain active and independent life styles. Vehicles with ADS must be part of the solution. This includes deployments in areas lacking the financial and resource base of many sections of the Nation (e.g., Native American Indian Reservations, where only low-cost ADS solutions can practically be implemented).

Prototypes

The low-cost highway demonstrations conducted in the project will piggyback on existing in-the-market products that require Level 2 technologies and all baseline safety systems.

DEMONSTRATION REQUIREMENTS

North Dakota's application encompasses a physical demonstration of Level 2 ADS technology, which will be conducted to establish the Operational Design Domain of existing Level 2 technology on North Dakota's rural roads. The data gathered through the testing demonstration will be used to enhance the existing Level 2 technology. A second demonstration will be conducted to evaluate Level 3 technology under the established ODD on North Dakota's rural roadways.

The demonstrations will be conducted with ADS-capable vehicles purchased or leased through the North Dakota State fleet and equipped with open source ADS software and hardware developed with open source software. The current hardware and software attach to the vehicle's CAN bus and provide enhanced vision and control to operate the

vehicle in a high Level 2 state (but the driver must pay attention at all times). The software captures video, location, and CAN data to an open cloud service database. The software also provides driver monitoring to ensure driver attention.

In addition to the demonstrations of Level 2 and Level 3 ADS technology, there will be demonstrations of markings using contrast tape and/or paint. which enhances and expands the visibility operating design domain for vision-based ADS technology. There will also be some demonstration of infrastructure to vehicle communications as determined during Task 3 of this project.

The open source ADS software will provide a user interface to allow users with varied abilities to see and monitor the performance of the ADS software. The software will continually record all location data and video recordings that can be accessed in near real-time. All relevant sensor data will be recorded with the location data.

The open source ADS software has already been made available across the Nation to similar types of road environments. All updates and results from this project will be made available in a similar manner.

APPROACH

Task 1

Conduct testing of existing Level 2 vision/radar equipped vehicles on rural Interstate, State, and Local roads to develop a comprehensive list of situations where these systems either disengage on their own or where the driver must take control. This will be done by leasing up to six Level 2 capable vehicles with lateral and longitudinal control in the North Dakota State Motor Pool. These vehicles will be equipped with open source ADS software and hardware. This open source software allows advanced Level 2 operations, data and image recording, and rear-facing camera for driver monitoring. The testing will be done with trained researchers and staff by operating the Level 2 capable vehicles on the designated rural North Dakota roads over a 1-year period. All disengagements will be recorded, along with documentation of events requiring the operator to take control. The driver will be required to pay attention to the roadway at all times through the use of driver monitoring systems. A few examples of situations where disengagements may occur include inadequate striping for the vision system, sharp curves and reduced speed warnings, intersection control, maintenance or construction zones, etc.

Task 2

Create a decision support summary matrix based on the data collected in Task 1. This will involve compiling and classifying any situations where the driver needed to take control of the vehicle or the vehicle disengaged automatically based on sensor information. This will also involve the capture of relative sensor data, location, and

video for each type of situation. The disengagement situations will be evaluated to determine:

1. Does the vehicle sensor equipment have the capability to detect and properly respond to the situations?
2. Can the Agency responsible for the roadway provide information to the vehicle that will properly warn the driver and vehicle how to handle the situation? This information could be provided through commercial or open source HD maps, cloud-based database services, or roadside devices. Some solutions may also involve infrastructure sensor deployment, such as intersection vehicle detection and SPAT information.
3. If situations cannot be handled by vehicle sensor information or infrastructure to vehicle communications, the area in which it occurs will need to be designated as not available for Level 3 at this time. These areas will need to be enabled in the HD maps or cloud-based database services, along with identification of proper responses when they are encountered.

The following is a list of some typical situations that may be encountered. However, it is expected that many more will be identified over the 1-year testing period

- lane marking standards and visibility issues
- controlled intersections such as stop signs or signals
- reduced speed warning areas such as sharp curves or other hazards
- construction or maintenance zones
- weather impacted roads
- forward collision events such as stopped vehicles or pedestrians
- merge or other vehicle conflict areas
- other situations discovered during the Task 1 evaluation period.

Task 3

Form a working group involving NDDOT, Local Governments, USDOT, Vehicle Manufacturers, and HD Mapping Companies. This task will involve the identification of individuals within each of the participating agencies and making contact to determine participation level. Two meetings will be scheduled, which will be conducted via video conferencing or webinar format with voice call in. Following the principles identified in the USDOT's report Preparing for the Future of Transportation: Automated Vehicles 3.0 (AV 3.O), this group will work together to establish methods and voluntary technical standards to ensure the data requirements identified in Task 2 are open source and readily available to all properly equipped vehicles. There will also be a need to provide Agencies with the capability to update some of the data items in real time to cloud services that are available to all vehicles. Some examples of this would include uploading the locations and durations of maintenance and construction zones, roadway surface conditions, locations of reduced speed curves, intersection control, and other situations where drivers would be required to take control of the vehicle or be vigilant.

Task 4

Update and enhance the open source Level 2 ADS system based on solutions identified in Tasks 2 and 3. This will include all necessary updates to allow operation as a Level 3 system where conditions allow for it. Data input and delivery systems will be developed through cloud-based data services and/or open source HD mapping services. Any necessary data and geo-fence locations will be collected, including the start and end of certified Level 3 road segments. Any in-vehicle sensor enhancements identified in Objective 3 will need to be implemented or resolved by the open source autonomous system provider or vehicle manufactures at their discretion. This task will also involve the construction of several test areas across the state. Test areas will be marked using contrast tape markings and/or paint. This will be done as part of existing NDDOT construction contracts.

Task 5

Conduct demonstration and testing of updated systems using vehicles from the North Dakota State Fleet or leased vehicles that can accommodate these systems. All data during this phase will be collected and submitted to USDOT in near real-time for further analysis. Drivers will have a brief training session on these systems and will be required to pay attention to the roadway at all times. To be considered Level 3 ready, test sections will need to have zero disengagements without proper notification from the vehicle to the driver to take control.

Task 6

Complete a report with all findings and recommendations. This task will include a review of North Dakota State laws and Federal regulations regarding Level 3 autonomous vehicles and recommendations for any changes necessary to make these Level 3 autonomous systems legal under defined situations or geo-fenced certified roads.

Task 7

Provide outreach via national webinars and various conferences such as Transportation Research Board.

Demonstration Considerations

It is not anticipated that exemptions will be required from any regulatory authority in North Dakota. All testing and demonstrations of this ADS technology will require that the driver follow all regulations, pay attention, and take control of the vehicle as required by existing Level 2 equipped vehicles. It is not anticipated that exceptions will be required under the Buy American Act. This project will provide a strong commitment to providing and making all relevant data publicly available to further research and expand the safety outcomes of this project. In addition, a *risk management plan* will be developed as part of this project.

Part 2 – MANAGEMENT APPROACH, STAFFING APPROACH, AND CAPABILITIES

NDDOT has been a leader in technology deployments and traveler information systems, pioneering the 511 system. In addition to its headquarters in the state capitol (Bismarck), NDDOT has seven district offices distributed geographically throughout the state. Through its districts, NDDOT can effectively implement the project on a statewide basis.

NDDOT will contract with the Upper Great Plains Transportation Institute of North Dakota State University (NDSU) to coordinate work activities, reports, and subcontracts. UGPTI has a long history of receiving, managing, and reporting state and federal grant funds through NDDOT, Federal Highway Administration, Federal Transit Administration, and the Office of the Secretary of Transportation. In addition to its primary office in Fargo, UGPTI has an office in Bismarck, allowing UGPTI staff to meet with NDDOT staff daily (or as needed).

NDDOT is responsible for facilitating the coordination of all activities necessary for implementation of the Automated Driving System project. Upon award of the Project, NDDOT will form a Project Governing Committee with our key stakeholders, which include Governor's office, Upper Great Plains Training Institute (UGPTI), North Dakota Highway Patrol, and North Dakota Department of Commerce.

- Hold regularly scheduled meetings
- Inspect and approve work as it is completed
- Review and approve invoices as appropriate for completed work
- Coordinate with UGPTI on all project reporting requirements, including but not limited to:
    a. Status of project by task breakdown and percent complete
    b. Changes and reasons for change in projects scope, schedule and/or budget
    c. Description of unanticipated problems and any resolutions.
    d. Summary of work schedule for the next progress report
    e. Updated Project schedule

UGPTI will play a key role in this project. NDSU has long-standing arrangements for protecting confidential data used for research purposes from disclosure requests. Much of the data used for performance measurement and the estimation of project benefits will be of a proprietary nature. In addition to executing confidentiality agreements with private-sector participants, UGPTI will establish secure databases and communications systems.

The Project Governing Committee will engage automobile manufacturers, technology firms, local public agencies, and other affected stakeholders on a regular basis. As noted above, the committee will meet regularly and have conference calls or webinars to implement the demonstration.

During the project, UGPTI will utilize several of its specialized centers, including the Center for Surface Mobility Applications & Real-time Simulation Environments (SMARTSe) and the Advanced Traffic Analysis Center (ATAC). SMARTSe focuses on technology innovations in autonomous performance assessments of the multimodal transportation infrastructure (roadways, railways, pipelines) to reduce cost and enhance safety, security, and efficiency. ATAC specializes in traffic modeling, the application of advanced technologies to transportation systems, and ITS deployments. ATAC and NDDOT personnel already work together on statewide ITS deployments and other goals. UGPTI's staff are experienced in subcontracting, contract preparation, and coordinating claims-for-payments with subcontractors for state and federal projects.