DEPARTMENT OF TRANSPORTATION

December 19, 2016

Office of the Secretary
United States Department of Transportation
1200 New Jersey Avenue SE
Washington DC, 20590

Dear Secretary Foxx:

The United States Department of Transportation (USDOT) is requesting proposals from applicants to form an initial network of multiple proving grounds, focused on the advancement of automated vehicle technology (Docket No.: DOT-OST-2016-0233).

The Minnesota Department of Transportation (MnDOT) is pleased to propose the MnROAD research facility as a designated USDOT Automated Vehicle Proving Ground. MnDOT and the MnROAD facility offer several key strengths to support the designation as a proving ground for automated vehicles.

- **Established research facility to facilitate safe and immediate automated vehicle testing.** MnROAD has operated as a research facility for over 20 years with no serious injuries and no crashes or incidents during research related activities. It has supported testing of automated vehicle technologies dating back to the late 1990s.
- **All-weather environment to test automated vehicle performance under extreme temperature, visibility and road conditions.** Minnesota's distinct seasons provide an environment to test how automated vehicles will perform under less than ideal roadway conditions. MnDOT also guarantees the ability to produce and maintain snow at MnROAD to minimize the challenge of scheduling testing around uncertain winter weather conditions.
- **Multiple pavement and roadway types to explore automated vehicle capabilities in the real world.** In addition to nearly 10 miles of controlled access, low and high-speed roadway for testing, MnROAD offers a rare combination of both asphalt and concrete surfaces with over a dozen textures — representing the variety of roads that automated vehicles will navigate.
- **Leadership in national forums actively contributing to automated vehicle communities of practice.** MnDOT participates in several national forums designed around leadership and peer exchange, including ITS America's Leadership Circle, the Connected Vehicle Pooled Fund Study, and the V21 Deployment Coalition.
- **Partnership with 3M to explore innovative traffic safety infrastructure for automated vehicle operation.** MnDOT's longstanding relationship with Minnesota-based 3M further strengthens MnROAD as a proving ground for critical traffic safety infrastructure including pavement markings, signing and temporary traffic control.

MnROAD offers a unique environment to broaden the research of automated vehicles and MnDOT welcomes the opportunity to support automated vehicle development in this capacity. Questions regarding this proposal may be directed to Jay Hietpas, State Traffic Engineer, at 651.234.7004 or jay.hietpas@state.mn.us. Thank you for your consideration.

Sincerely,

Charles A. Zelle
Commissioner, MnDOT

3M Traffic Safety and Security Division

3M Center, Building 0225-04-N-14
St. Paul, MN 55144-1000
651 733 1100

December 13, 2016

Jay Hietpas
Minnesota Department of Transportation
State Traffic Engineer
1500 West County Road B2
Roseville, MN 55113

Dear Mr. Hietpas:

The Minnesota Department of Transportation (MnDOT) MnROAD Automated Vehicle Proving Ground Proposal represents a unique model leveraging the strengths of industry and government as partners to drive innovation in greater safety and infrastructure for automated and connected vehicles and public transportation.

3M, headquartered in St. Paul, Minnesota, is a global innovation company that never stops inventing. Over the years, our innovations have improved daily life for hundreds of millions of people all over the world. 3M technology has made driving at night easier, made buildings safer, and made consumer electronics lighter, less energy-intensive and less harmful to the environment.

In the area of ground transportation safety, 3M Traffic Safety and Security Division is a leader in providing technology solutions for "human vision" such as improving pavement markings and traffic signs on roadways and airport runways. In addition, 3M has pioneered materials technology development for the Marine, Aerospace and Specialty and Commercial Vehicle markets.

Through the rapid advancement of autonomous and connected vehicles, 3M anticipates the need for physical transportation infrastructure enhancements to support "autonomous perception." The technology in this area is quickly advancing and creating a tremendous growth area. 3M is interested in seeing this initiative advance so that industry, university, and government resources can work together and innovate safe solutions. MnDOT's proposal presents an unparalleled platform for applied research in this emerging sector to enable greater safety and the mission toward "Zero Fatalities."

If you have any questions, please feel free to contact me directly at (651) 733-6499.

Regards,

Colin Sultan
3M Company
Global Business Manager, Traffic Safety and Security Division
3M Center, BLDG 225-4N-14
St. Paul, MN 55144

Introduction

MnROAD is a research facility owned and operated by MnDOT, working with its partners. The facility is located in Albertville, Minnesota, approximately 40 miles northwest of the Minneapolis-St. Paul International Airport. The 40-acre facility features a 3.5 mile stretch of I-94 with mainline and bypass lanes and a 2.5 mile low volume, closed track roadway – all equipped with embedded electronic sensors to collect data. Short driving videos of the low volume road[1] and I-94 mainline[2] are available online.

Established Research Facility

> The University of Minnesota is proud of its contributions to the early development of automated vehicle technologies. MnROAD offered an excellent, controlled environment for testing the Driver Assist System and developing it for commercialization.
>
> *– Prof. Max Donath, Roadway Safety Institute*

As an established research facility MnROAD can support safe and immediate automated vehicle testing today. MnROAD has operated as a research facility for over 20 years with no serious injuries and no crashes or incidents during research related activities. It has supported testing of automated vehicle technologies dating back to the late 1990s when the University of Minnesota partnered with MnDOT to develop and test a Driver Assist System designed for specialty vehicles such as snowplows. Research and testing were funded by the USDOT Intelligent Vehicle Initiative with the objective to evaluate technologies that enhance a driver's ability to see the road and vehicles while performing necessary maintenance functions or responding to emergencies.

More recently, FuelMiner used the MnROAD facility to demonstrate a method for continuously estimating fuel consumption breakdown over resistive forces while a heavy-vehicle is driven on a public roadway. FuelMiner is an innovator in vehicle-to-cloud (V2C) solutions that help improve fuel economy, design more efficient vehicles and build better roads. Because the mainline lanes at MnROAD can be closed to traffic it allowed FuelMiner to test their experimental procedure under controlled conditions and use the data to benchmark their algorithm before testing in open traffic conditions.

> The 3.5 mile mainline may be the longest straight test section in the United States. Test track facilities around the country are typically oval. The straight section allows testing under quasi steady state conditions such as driving in cruise control.
>
> *– Germana Paterlini, FuelMiner*

[1] MnROAD video of low volume road, https://www.youtube.com/watch?v=zQgOqAcD6Mo&feature=youtu.be.
[2] MnROAD video of I-94 mainline, https://www.youtube.com/watch?v=O-MHaCipCBo&feature=youtu.be.

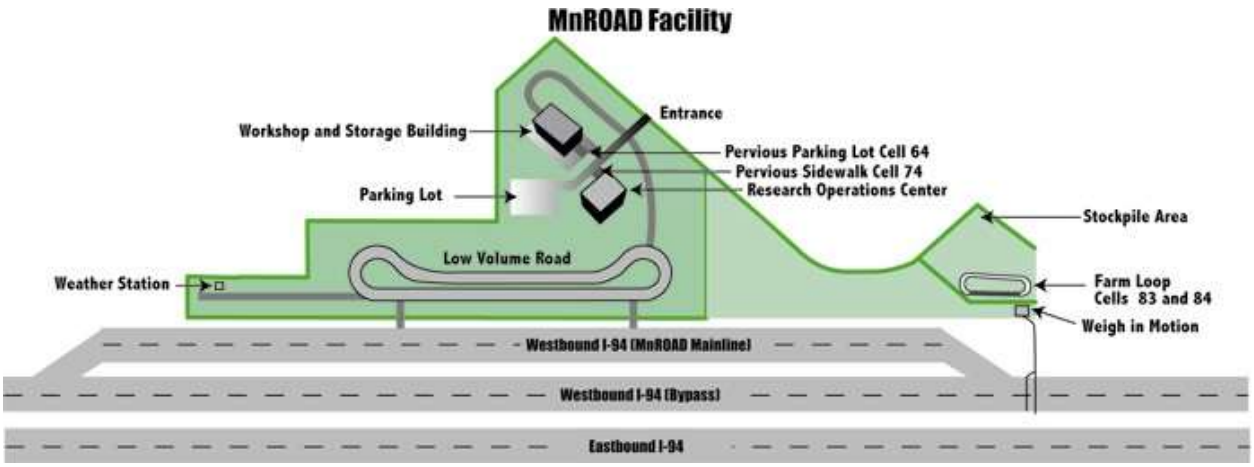

Illustration of MnROAD Property

Designed to support daily research activities, as well as guest meetings and tours, the property includes public parking, office, meeting, workshop and storage facilities. The property is surrounded by an 8' fence and includes an access-controlled security system. The secure facility allows researchers and guests to view testing away from live traffic.

MnROAD Building, Meeting Room, Pole Barn and Roadside Cabinets

Additional facility features that may be used to support automated vehicle research include:

- Utility cabinets located approximately every 750' along the mainline and low volume roadways offer easy access to power and communication.
- Traffic cameras located along I-94 within the limits of the mainline and bypass roadways allow another option for viewing traffic through the test area.
- Two weather stations, a weigh in motion scale, and a receiver for differential global positioning system (DGPS) reference correction can be used to support data collection activities.

It is significant to note that the DGPS receiver at MnROAD is part of the Minnesota Continuously Operating Reference Station (MnCORS) network. MnCORS is a cooperative effort between MnDOT, other state agencies and institutions, counties, cities and private enterprises with the goal of providing Global Navigation Satellite System (GNSS) corrections statewide. Using signals from all available GNSS satellites, and receivers at over 130 known positions, MnCORS is able to continuously provide survey grade positioning corrections. DGPS is necessary for automated vehicles to confirm vehicle positioning in relation to roadway infrastructure. Researchers can leverage the unique availability of this high-accuracy DGPS at MnROAD and along other public roads throughout the state of Minnesota.

> Minnesota offers statewide survey grade GPS corrections through MnCORS and a receiver is located at MnROAD to support automated vehicle testing.

In addition to its current robust facility features, MnROAD has 12 acres of land that could be developed in the future to provide additional research facilities. For example, a portion of land northwest of the main building could be developed into a city street setting that would be mutually beneficial for both pavement and automated vehicle research.

All-Weather Environment

> MnDOT guarantees the ability to produce and maintain snow and limited visibility conditions at MnROAD to minimize the challenge of scheduling tests around uncertain weather conditions.

MnROAD offers an all-weather environment to test automated vehicle performance under extreme temperature, visibility and road conditions. Minnesota has a continental climate with very cold winters and very hot summers. State temperature extremes range from -60 to 114 degrees Fahrenheit. The average annual snowfall for the Minneapolis/St. Paul area is 54.4 inches and snow cover of one inch or more over the state occurs on an average of 110 days annually.[3] Minnesota's distinct seasons provide an environment to test how automated vehicles will perform under less than ideal roadway conditions. MnDOT also guarantees the ability to produce snow and limited visibility conditions at MnROAD to minimize the challenge of scheduling tests around uncertain weather conditions. Artificial snow may be produced as needed during the winter months with snowmaking machines commonly used to manufacture artificial snow for ski resorts. This will provide automated vehicle researchers with more control over conditions required for testing. Furthermore, access control of the mainline lanes allows MnROAD to retain snow on the roadway for extended testing under snowy conditions, without creating unsafe driving conditions for travelers.

Real-World Roadway Conditions

Public roads are built and maintained in a wide range of physical conditions, yet automated vehicles will be expected to safely navigate them. As a pavement research facility, MnROAD offers multiple pavement and roadway types to explore automated vehicle capabilities in a real-world setting. In addition to nearly

[3] Minnesota Department of Natural Resources, Minnesota Climate Summaries and Publications: General Climate Description for Minnesota, and Normals, Means and Extremes for Major Airport Weather Stations, www.dnr.state.mn.us/climate/summaries_and_publications/index.html, accessed December 12, 2016.

10 miles of controlled access, low and high-speed roadway for testing, MnROAD offers a rare combination of both asphalt and concrete surfaces with over a dozen textures in different stages of deterioration. This represents the variety of roads that automated vehicles will be required to navigate in the real-world – all in one facility.

> MnROAD offers a rare combination of both asphalt and concrete surfaces with over a dozen different textures representing many real-world roadways – all in one facility.

Leadership in National Forums

MnDOT participates in several national forums designed around leadership and peer exchange which already demonstrates an established contribution to automated vehicle communities of practice. MnDOT is one of only five state transportation agency members in ITS America's Leadership Circle. The department has also successfully completed several multistate and federally-funded ITS-focused research studies. MnDOT actively participates in the Connected Vehicle Pooled Fund Study, V2I Deployment Coalition, and AASHTO's STSMO Connected Vehicle Working Group. The department hosts peer exchanges, conferences, and other information-sharing events to share their research experiences with transportation agencies around the world.

3M Partnership

Minnesota-based, 3M is a global innovation company that manufactures high-performance materials combined with innovative systems and services to bring the best roadway systems into reality. 3M will provide pavement marking, sign sheeting, temporary traffic control materials and DSRC testing equipment at MnROAD. MnDOT's longstanding relationship with 3M further strengthens MnROAD as a proving ground for testing critical traffic safety infrastructure. This will allow researchers to explore automated vehicle operation in a variety of traffic control environments. Some of the materials to be installed at MnROAD will include:

- 3M Stamark™ High Performance, Contrast and Removable Tapes that enhance the ability for camera or machine vision to see the presence and contrast of pavement markings on roadways in wet or dry conditions
- 3M Diamond Grade™ Reflective Sign Sheeting that enhances the ability for camera or machine vision to see signs on the roadway, the same way it enhances the ability for humans to see signs

3M Stamark™ Tape and Diamond Grade™ Sheeting

- 3M Diamond Grade™ Reflective Fluorescent Sheeting that enhances the ability for a camera or machine vision to see temporary traffic control in work zones
- 3M DSRC Multi-Channel Test Tool which is an independent multi-channel listening device, offering vehicle-to-vehicle and vehicle-to-infrastructure communications to verify DSRC standards

MnROAD – A Proving Ground for Automated Vehicle Testing

MnROAD is proposed as a unique environment for testing automated vehicles in all-weather conditions on both low and high-speed roadways. Examples of the testing that MnROAD is well-positioned to support include:

- Weather-related visibility
- Pavement marking and signing efficacy
- High-speed vehicle operation
- Temporary traffic control zones
- Transition areas between roadways
- Vehicle platooning
- Automated bus on shoulder operations
- Commercial vehicle operation

For more than 20 years, MnROAD has been a successful research facility, engaging partners from other transportation agencies, private industry and academic institutions around the world. The necessary framework is in place to extend the facility as a designated proving ground for automated vehicle research. The remainder of this proposal describes how MnROAD meets the mandatory and other selection criteria identified by USDOT in their solicitation.

Mandatory Criteria

Designated Safety Officer

As an active research facility that allows both MnDOT staff and external parties to conduct research on premise, MnROAD has an established Site Manager responsible for directing safety at the facility. The Site Manager offices at MnROAD and is on-site Monday through Friday during business hours. The Site Manager will serve as the Designated Safety Officer for automated vehicle research conducted at the facility, and will participate in the Community of Practice's regular quarterly meeting of Safety Officers.

Safety Approach

MnROAD's current safety approach includes facility access, safety guidelines and an emergency action plan that establish protocols for preventing emergencies and mitigating them if they occur. Further information regarding the current MnROAD safety protocols is provided in the section, Commitment to Safety. MnDOT agrees to share their safety approach, along with any modifications to ensure that proposed automated vehicle testing meets the guidance outlined in USDOT's Federal Automated Vehicles Policy. There are several manufacturer-oriented actions outlined in the policy that will be referenced in the modified safety approach so that MnDOT may understand how these actions have been addressed prior to approving automated vehicle research at MnROAD. For example, researchers will be asked to:

> MnDOT will share the safety approach and safety data generated through testing and operating MnROAD as an automated vehicle proving ground.

- Share their plan for physical research activities
- Identify the automated vehicle level proposed for testing
- Describe how they have ensured compliance with all applicable Federal Motor Vehicle Safety Standards (FMVSS)
- Explain how their research plan covers the key areas of automation to be addressed during testing

In addition to sharing the safety approach used at MnROAD, MnDOT also agrees to share safety data generated through testing and operating MnROAD as an automated vehicle proving ground. Such safety data will include documents exchanged with researchers demonstrating their commitment to safety protocols, documents summarizing research-related emergencies if they occur, and other safety-related experiences.

Proposed Contributions

Program Administration and Partnering

MnDOT has an established framework to administer an automated vehicle program.

MnDOT has established the framework to administer an automated vehicle program. Much of that framework is in place through the longstanding research administration practices at MnROAD. MnROAD was originally constructed in 1994 at a cost of $25 million provided by state and federal funding. The partnership between MnDOT and the Minnesota Local Road Research Board (LRRB) provided the majority of MnROAD operational funding during the first ten years. Funding for MnROAD today comes from a combination of industry, LRRB, federal and state funds, and other resources.

In addition to building on experience with the MnROAD program administration framework, MnDOT has a strong ITS Unit with staff who have administered research and testing of ITS, including automated vehicle concepts and technologies, since the 1990s. Additionally, MnDOT has used its multidisciplinary Transportation System Management and Operations (TSMO) Leadership Group to establish an internal AV/CV Steering Committee that will guide automated and connected vehicle research. MnDOT will also engage Minnesota Guidestar, a broad group of stakeholders from public agencies, private sector, industry and academia to provide external perspective on connected and automated vehicle development in Minnesota. Together, MnDOT will use these internal and external resources to solicit, develop and provide direction to automated vehicle research conducted at MnROAD.

MnDOT has worked with numerous partners including federal, state and local transportation agencies from nearly every state, industry associations, academic institutions, and private companies. Recognizing the significance of pavement markings and signing for the safe operation of automated vehicles, MnDOT has initiated a partnership with 3M to provide sign sheeting, pavement markings, and work zone signs and devices to support automated vehicle testing at the MnROAD facility. These materials may be used to test the degree to which automated vehicles can correctly recognize and interpret the critical traffic control tools under different conditions, particularly winter weather.

A Minnesota-based company, 3M is a global innovation company that never stops inventing. Over the years, their innovations have improved daily life for hundreds of millions of people all over the world. 3M is dedicated to improving traffic safety and mobility so motorists can arrive at their destinations faster and safer. Their high-performance materials combine with innovative systems and services to bring the best roadway systems into reality. 3M has been a valuable partner for over 75 years, and continues to bring innovation to the transportation safety industry. MnDOT and 3M have partnered often to test new pavement, signing and work zone products in support of both organizations' goals for improving traffic safety.

National and Regional Leadership

MnDOT has led national and regional ITS related research in areas such as Mileage Based User Fees, Cooperative Intersection Collision Avoidance Systems (CICAS), Integrated Corridor Management, and more. For example, MnDOT partnered with the University of Minnesota from 2008-2013 as one of several research projects funded through the USDOT CICAS initiative. The Minnesota project focused on warning drivers of unsafe gaps at rural thru-stop intersections. CICAS was also part of USDOT's larger Vehicle Infrastructure Integration (VII) program, a precursor to today's Connected Vehicle and Automation research programs. As such, MnDOT frequently engaged in national working team meetings, conferences and research reporting activities to share the results of their CICAS work. MnDOT has also hosted numerous peer exchanges, conferences and other demonstration events over the years to share their research in ITS.

MnDOT has led national and regional ITS related research in areas such as Mileage Based User Fees, Cooperative Intersection Collision Avoidance Systems (CICAS), and Integrated Corridor Management.

Contributions to Community of Practice

In addition to providing national and regional leadership on key transportation research efforts, MnDOT has broad experience contributing to communities of practice associated with many areas of transportation. MnROAD, for example, has been monitoring pavement performance since 1994 through laboratory testing, sensor response, and field monitoring over the life of each test cell. All data and research reports are available at no cost and are featured on the MnROAD website.[4] Implementation of Phase I MnROAD results have provided an estimated $33 million in annual savings in Minnesota, and up to $749 million nationwide.

MnDOT was honored as a 2013 White House Champion of Change for work to deploy dozens of life-saving Rural Intersection Conflict Warning Systems.

MnDOT has also made significant contributions to the ITS community of practice. During the Rural Intersection Conflict Warning Systems (ICWS) project and participation in the ENTERPRISE pooled fund program research, MnDOT contributed to the development of ICWS-related guidance and standards language for the Manual on Uniform Traffic Control Devices. The White House honored MnDOT in 2013 as a Champion of Change for its work to reduce fatal and life-changing crashes on Minnesota roadways through the Rural ICWS project.

MnDOT also routinely contributes to communities of practice through peer exchanges, conferences and other outreach activities specifically designed to share information about their experiences. If MnROAD is selected as a designated proving ground for automated vehicle research, MnDOT will continue this practice with the automated vehicle community of practice.

[4] MnROAD Data, www.dot.state.mn.us/mnroad/data/

USDOT Working Relationship

MnDOT has a strong relationship with the FHWA Division Office in St. Paul. The department also has relationships with many USDOT research program offices. The ITS Unit has long-standing relationships with the ITS Joint Program Office, Federal Highway Administration (FHWA) Office of Safety, FHWA Office of Operations, and FHWA Turner-Fairbank Highway Research Center. MnDOT expects to continue and expand these working relationships through the proposed community of practice quarterly meetings, routine quarterly progress reports, and national and regional conferences. Conferences may include but are not limited to the Transportation Research Board Annual Meeting, ITS America Annual Meeting, ITS World Congress, and Automated Vehicles Symposium.

Commitment to Safety

Safety Precautions

As mentioned under the Mandatory Criteria, a Site Manager is responsible for managing safety protocols at MnROAD to address facility access, research activities, emergencies and I-94 traffic control. MnROAD access cards are provided by the Site Manager to allow access to the site and buildings at any hour depending on research needs. The front gate to the property and main building doors are open Monday-Thursday from 7:00AM to 5:00PM and Friday from 7:00AM to 3:00PM. Card readers are located at doors in the main building, pole barn and other outbuildings. An alarm system is in place and activated outside business hours.

> MnROAD safety protocols address facility access, research activities, emergencies and I-94 traffic control.

In addition to controlling facility access to ensure safety, all researchers must use the appropriate safety equipment (including but not limited to seat belts and safety vests), observing the safety measures of the situation, and following instructions of the MnROAD Site Manager. Researchers agree to provide a work plan of physical research activities to review with the MnROAD Operations Engineer and Site Manager to determine what work is planned and how it will be coordinated with other MnROAD activities.

If an incident does occur at MnROAD, an emergency action plan is in place to guide response. Staff and guests are instructed to follow the posted emergency action plan procedures. An Injury, Illness, Incident Data Form is then completed following the emergency to provide safety data for follow up as needed.

MnROAD has a standard operating procedure to direct the safe transition of traffic between the mainline and bypass lanes on I-94. Traffic is typically transitioned between the mainline and bypass twice per month. The transition is managed by trained staff from the nearby maintenance truck station, using authorized MnDOT vehicles and a portable changeable message sign. Once the portable sign is placed upstream, MnDOT vehicles are stationed at nearby on-ramps to stop traffic while barricades are positioned at the crossover area between the mainline and bypass. Once the barricades are in place, overhead lane control signals are activated and MnDOT vehicles are then used as pilots to guide initial traffic onto the appropriate lanes. This routine transition between roadways also offers a unique opportunity to test automated vehicles under temporary traffic control conditions, especially those found in work zones.

Traffic Control for I-94 Mainline/Bypass Transition

Demonstrated Safety Record

The MnROAD safety record boasts no serious injuries and no crashes or incidents on the mainline or bypass lanes during research related activities. As automated vehicle research is conducted at the facility, MnDOT will rely on existing protocols but there is also recognition that these will need to be modified as research expands.

Research, Application and Data Sharing

Research Applicability to the Region

Minnesota exhibits the winter conditions prevalent among the northern tier of states in the US. It also exhibits a mix of both dense urban traffic and extensive rural roadways that are also prevalent in many of the northern states. These attributes have made MnROAD an ideal cold region pavement research facility with a proven record of successfully sharing its results with the transportation community. To address some of the challenges associated with snowplowing in the region, MnDOT has supported research through the University of Minnesota to develop and test GPS-based technologies and human factors implications associated with vehicle automation for snow removal operations.

Research and Extension Resources

MnROAD will utilize its existing research structure to carry out automated vehicle activities. The MnROAD Operations Engineer will work in close coordination with the Designated Point of Contact – the Traffic Research Engineer – to coordinate automated vehicle research at MnROAD. In addition, MnDOT has mechanisms in place to efficiently execute partnership agreements with external researchers to perform all types of research, including automated vehicle testing. MnDOT also maintains master agreements with academic institutions to perform research through on-call work orders that may be generated on a project by project basis. The MnDOT ITS Unit maintains a similar master agreement list of consultants to conduct ITS research, development and support services. Though these are not MnDOT's only contracting mechanisms, these provide an example of demonstrated research resources available to rapidly procure research services. MnDOT also has a variety of extension resources at its disposal to support the education of others about automated vehicles and research conducted at MnROAD.

- Full-service transportation library
- Strong Local Technical Assistance Program (LTAP) to access to city and county transportation professionals throughout Minnesota
- Active local chapters of ITS America and ITE willing to deliver educational seminars

Dissemination of Research Results

In addition to the outreach approaches outlined in the section, Proposed Contributions, Contributions to Community of Practice, MnROAD has a Communications Manager to support and enhance outreach efforts that will allow MnROAD to broadly share its research capabilities and results. MnDOT will also leverage its involvement in national and regional ITS activities to share automated research results at MnROAD. This will include but is not limited to MnDOT media contacts, electronic communication tools, and presentations at major conferences such as the Transportation Research Board Annual Meeting, ITS America Annual Meeting, ITS World Congress and Automated Vehicles Symposium.

Sharing Data and Performance Metrics

MnDOT is committed to sharing automated vehicle research data, performance metrics and results as allowed in partnership agreements negotiated with other research entities and sponsors. Current MnDOT practice includes the publication and public release of all research reports sponsored by the department. However, it is expected that much of the automated vehicle research conducted at MnROAD will be privately sponsored and as such the results may be confidential. MnDOT will publish summary reports to highlight the automated vehicle research completed at the facility within the confidentiality limitations specified in partnership agreements.

Demonstrated Investments

Capital Improvements

Because MnROAD is an existing research facility, no capital improvements are necessary to support automated vehicle research. However, to enhance the facility for expanded automated vehicle testing, 3M will provide additional pavement marking, sign sheeting and temporary traffic control materials for installation at MnROAD. Additional, minor facility upgrades could include adding other traffic control devices, expanding meeting and office facilities, adding jersey or cable median barrier between the low volume road and mainline lanes, adding further protection to roadside cabinets on the low volume road, adding sensors to the bypass lanes to expand data collection capabilities. Future capital investments could be directed toward developing available land on the MnROAD property to provide additional research facilities such as a city street setting that would support off-road testing. Such enhancements would be mutually beneficial for both pavement and automated vehicle research.

Authorization

MnROAD currently adheres to all state and local laws regarding traffic control for public roadways. The low volume road is a closed-loop section that is not classified as a public road. As such, Minnesota state law does not prohibit testing of automated vehicles on this closed road section. If MnROAD is selected as a designated automated vehicle proving ground, MnDOT will explore existing policy implications for conducting automated vehicle testing on Minnesota's public roads and consider actions to enable implementation of higher levels of automation.

Testing Underway

MnDOT has a history of conducting exploratory research, development and testing of automated vehicle concepts dating back to the late 1990s. This work, which began with testing at MnROAD and continues today, includes MnDOT's partnership with the University of Minnesota to develop and test GPS-based technologies and human factor implications associated with vehicle automation advancements such as:

> MnDOT and the University of Minnesota continue to partner in research to develop and test GPS-based technologies and human factor implications associated with vehicle automation for snow plowing.

- *Driver-Assist System for Lane Guidance in Buses and Snow Plows* – Provides lane-keeping and collision avoidance capability in low-visibility conditions using high accuracy GPS and digital maps, as opposed to vision-based approaches which are ineffective in low visibility weather conditions.
- *DGPS-Based Snow Plowing* – Facilitates driver-assist operation of snow plowing using wireless communications and DGPS-based technology that allow a snow plow to operate in white-out conditions while improving safety and productivity.
- *Testing of After Market Devices for Maintenance Operations* – Testing underway is evaluating system performance and position accuracy of commercially available onboard equipment (OBE) with DSRC for application to gang plowing.

MnDOT's research investments resulted in commercialization of the Driver-Assist System on passenger buses, and the technologies are routinely used by Alaska DOT for plowing operations in low to no visibility snow conditions.

Readiness

Open for Testing

As an active research facility, MnROAD is open for automated vehicle testing today. When MnDOT is approached by external researchers with requests to utilize MnROAD, MnDOT engages affected stakeholders to identify timeframes, site conditions, safety protocols, fees, and other parameters for testing. These items are agreed upon and documented in a partnership agreement. Overall site scheduling and coordination is managed by the MnROAD Operations Engineer. These established practices will continue with a designation as an automated vehicle proving ground.

Although automated vehicle testing could take place today at MnROAD, minor enhancements to the facility may be made and existing safety protocols will be adjusted to further accommodate an automated vehicle testing environment.

Multiple Users and Data Sharing

The structure and operation of the MnROAD facility currently supports and encourages use by multiple entities from public agencies, industry associations and academic institutions. As research is scheduled at MnROAD, consideration is given to how data from the research will be gathered and shared in the MnROAD database which allows researchers to accurately record methodology and pertinent information for research use and requests. All data and research reports are available at no cost and are featured on the MnROAD website.[5] This framework for sharing data from research conducted at the MnROAD facility will be extended to automated vehicle research.

Designated Point of Contact

The Designated Point of Contact for automated vehicle research at MnROAD will be the Traffic Research Director, Cory Johnson, coryj.johnson@state.mn.us, 651-234-7062. The Traffic Research Director will then coordinate all research reviews with the MnROAD Operations Engineer and Site Manager.

Engagement of Affected Communities

The entirety of the MnROAD facility is owned and operated by MnDOT. No other communities will be affected by the designation of MnROAD as an automated vehicle proving ground.

Adherence to Laws, Regulations, and Federal Policy

State and Local Laws and Federal Regulations

MnROAD currently adheres to all state and local laws regarding traffic control for public roadways. These laws, in addition those governing licensed drivers and vehicles on public roadways, will continue to be followed as automated vehicle research is conducted at MnROAD. MnROAD will further adhere to federal regulations regarding licensing of Digital Short-Range Communication (DSRC) and guidance outlined in USDOT's Federal Automated Vehicles Policy.

Adherence to NHTSA Policy

MnDOT will modify research and safety protocols at MnROAD to encourage manufacturers and other entities that seek use of the MnROAD facility to comply with the Framework for Vehicle Performance Guidance outlined in the Federal Automated Vehicles Policy, September 2016. This framework identifies the key areas to be addressed prior to testing or deploying vehicles with L3-L5 automation on public roadways. Because MnROAD includes a 3.5 mile section of both mainline and bypass lanes of I-94, adherence to this framework will be important to maintain safe operation of I-94 and all research oriented testing. Consistent with the framework, MnDOT will request that prospective research entities provide a copy of the Safety Assessment that is voluntarily submitted to NHTSA's Office of the Chief Counsel for automated vehicle testing.

[5] MnROAD Data, www.dot.state.mn.us/mnroad/data/

Conclusion

MnROAD is proposed as a unique environment for testing automated vehicles in all-weather conditions on both low and high-speed roadways.

- **Established research facility to facilitate safe and immediate automated vehicle testing.** MnROAD has operated as a research facility for over 20 years with no serious injuries and no crashes or incidents during research related activities. It has also supported testing of automated vehicle technologies dating back to the late 1990s.
- **All-weather environment to test automated vehicle performance under extreme temperature, visibility and road conditions.** Minnesota's distinct seasons provide an environment to test how automated vehicles will perform under less than ideal roadway conditions. MnDOT also guarantees the ability to produce and maintain snow at MnROAD to minimize the challenge of scheduling testing around uncertain winter weather conditions.
- **Multiple pavement and roadway types to explore automated vehicle capabilities in the real-world.** In addition to nearly 10 miles of controlled access, low and high-speed roadway for testing, MnROAD offers a rare combination of both asphalt and concrete surfaces with over a dozen textures – representing the variety of roads that automated vehicles will navigate.
- **Leadership in national forums actively contributing to automated vehicle communities of practice.** MnDOT participates in several national forums designed around leadership and peer exchange, including ITS America's Leadership Circle, the Connected Vehicle Pooled Fund Study, and the V2I Deployment Coalition.
- **Partnership with 3M to explore innovative traffic safety infrastructure for automated vehicle operation.** MnDOT's longstanding relationship with Minnesota-based 3M further strengthens MnROAD as a proving ground for critical traffic safety infrastructure including pavement markings, signing and temporary traffic control.

For more than 20 years, MnROAD has been successfully used as a research facility, engaging partners from other transportation agencies, private industry and academic institutions around the world. As such, a strong framework is in place to extend the facility as a designated proving ground for automated vehicle research.