AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS
AASHTO

JOHN SCHROER, PRESIDENT
COMMISSIONER, TENNESSEE DEPARTMENT OF TRANSPORTATION

BUD WRIGHT, EXECUTIVE DIRECTOR

444 NORTH CAPITOL STREET NW, SUITE 249, WASHINGTON, DC 20001
(202) 624-5800 • FAX: (202) 624-5806 • WWW.TRANSPORTATION.ORG

March 2, 2018

Brandye L. Hendrickson
Acting Administrator
Federal Highway Administration
US Department of Transportation
1200 New Jersey Avenue SE
Washington, DC 20590

Subject: "Automated Driving Systems" (Docket No. FHWA-2017-0049)

Dear Acting Administrator Hendrickson:

The American Association of State Highway and Transportation Officials (AASHTO) is pleased to provide comments on the Federal Highway Administration's (FHWA) "Automated Driving Systems" Request for Information (Docket Number FHWA-2017-0049), published in the Federal Register on January 18, 2018. Representing all 50 states, the District of Columbia, and Puerto Rico; AASHTO serves as a liaison between state departments of transportation (state DOTs) and the federal government. AASHTO's attached comments on the FHWA ADS questions are divided into two sections: general comments that were developed based upon the individual questions responses and answers to each of the ten questions listed in the Request for Information (RFI).

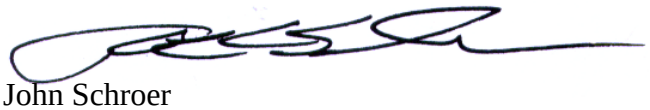
AASHTO and the state DOTs appreciate FHWA's leadership so far in supporting the research, development and deployment of connected vehicles (CV), automated vehicles (AV) and automated driving systems (ADS). While the terms and labels may change over the years, there has been, and will continue to be, a strong partnership between the state DOTs and FHWA. There is great potential that connected and automated vehicles (CAV) will have in improving safety, enhancing mobility and reducing the environmental impact of surface transportation systems. Most important to AASHTO and the state DOTs will continue to be the safety associated with the implementation of CAV. Safety has been, and will remain, at the forefront of AASHTO's policy goals as state DOTs have the primary responsibility for the safe and efficient movement of people and goods on our nation's highways and streets.

The transformative nature of CAVs is just now coming into focus. There are still many questions to be asked from both policy and technological perspectives. AASHTO's response included in this letter is but a small summary of the needs and concerns of the state DOTs. While the questions posed by FHWA cover a significant breadth of the issues, any one of these questions must be covered in significantly more depth. For example, NCHRP 20-102, Task 15, *Impacts of Connected and Automated Vehicle Technologies on the Highway Infrastructure*, will be looking at the infrastructure requirement for CAVs and this project is expected to take nearly two years

complete at a cost of $650,000. These questions are the necessary ones to be asking, but answering them will require significantly more time and resources than any one agency or organization can spend as part of this request for information.

AASHTO looks forward to continuing to work with FHWA and the rest of the US Department of Transportation's (USDOT) modal administrations in the implementation of both automated vehicles as well as connected vehicles. If you would like to discuss the issues raised in this letter, please contact Matthew Hardy, Ph.D., AASHTO's Program Director for Planning and Performance Management at (202) 624-3625 or mhardy@aashto.org.

Sincerely,



John Schroer
President, American Association of State Highway and Transportation Officials
Commissioner, Tennessee Department of Transportation

Enclosure

Section 1: General Comments

1. **State DOTs Cannot be in a Position of Chasing the Technology**—As the owners of a significant amount of the transportation infrastructure, state DOTs need to prepare our infrastructure for ADS. This includes maintaining the current infrastructure in a state of good repair such that any vehicle can operate on it in a safe and effective manner. In addition, many state DOTs are starting to plan, design, operate and maintain the technology needed for a future that includes both vehicles equipped with ADS and connected to each other and the infrastructure. The state DOTs welcome this new future where driving is safer, mobility is enhanced and the environmental impact of the transportation system is reduced. However, state DOTs are not in a position to make significant investments in technology that has a very uncertain future. State DOTs need to know that the investments they make today in technology will be used in the future rather than quickly making technology investments that are soon obsolete.

2. **Envision a Future with Both Connected and Automated Vehicles—**As infrastructure owners and operators, AASHTO's member DOTs believe that establishing a strong foundation for ADS requires ensuring robust connectedness for vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) communication. The overwhelming support for the development and deployment of connected vehicle technologies is evident in the significant commitment that the states and local agencies have made to leading, supporting, and fostering the deployment and testing of connected and automated vehicle (CAV) systems. To date, 33 locations in the US are deploying connected vehicle (CV) technologies under sponsorship of USDOT and seventeen locations are deploying the technologies without sponsorship from USDOT. Combined, this represents 72,000 vehicles on the road and 65,000 devices installed on the infrastructure.

   Many of these CV deployments involve state transportation agencies and AASHTO is working and supporting the states in many different ways. For example, AASHTO is supporting a national traffic signal phasing and timing (SPaT) program that heavily leverages V2V and similar technologies to improve traffic flow and reduce crashes. Through the SPaT Challenge, AASHTO is hoping to achieve the deployment of V2I infrastructure with SPaT broadcasts at roadway intersections in at least one corridor or network in each of the 50 states and Washington, DC by January 2020.

   AASHTO believes the transportation industry must use every tool we can—including Dedicated Short Range Communication (DSRC) to connect vehicles with each other and the infrastructure—to make our vehicles, highways and roads safer. The potential of CV technologies to save lives, enhance mobility, and serve as the platform of a new generation of transportation management systems is vast and any discussion about a future with automated vehicles must also include a path forward with connected vehicles.

3. **Technology Developers and Vehicle Manufacturers Need to Increase Their Collaboration with Federal, State and Local Agencies—**An overarching theme in AASHTO's response is the need for the public and private sector to collaborate more and for the private sector to develop some type of consensus regarding their needs of the state DOTs and the infrastructure requirements. The state DOTs look forward to reviewing the response from the technology developers in terms of what their needs are and to collaborate as equal partners to ensure the successful deployment of CAVs. While there are examples of this collaboration taking place now (e.g., Vehicle-to-Infrastructure Deployment Coalition and the Connected and Automated Vehicle Executive Leadership Team), AASHTO believes this collaboration needs to be expanded to include broader and active participation from the private sector as well as more public sector agencies.

4. **Provide State DOTs with Better Tools to Plan for an Uncertain Future—**Across the nation, state DOTs, Metropolitan Planning Organizations (MPOs), and other transportation agencies are facing increasing pressure from constituents, political leaders, and regulatory agencies to develop performance-oriented policies, plans, and investment decisions that take into account an increasingly complex transportation landscape. The advent of CAVs hold promise to further many public policy goals, but the associated uncertainty with them can be burdening to planners and decision makers alike.

   For example, the transportation planning process is designed to support decision making regarding the allocation of limited resources. Many state DOTs are concerned they will be unable to be prepared for ADS system-wide within current financial constraints since resources are limited to maintain and operate existing infrastructure. The technology industry has not provided consistent direction about what infrastructure components need to be maintained in order for ADS to be successfully deployed. Under the current state of ADS technology development, it is difficult for the state DOT to know where to focus their limited resources to help ADS be successful. A clearer picture from the industry on what infrastructure elements are important to maintain would be vitally helpful in our planning for ADS deployment.

   Currently, FHWA is engaging state DOTs and MPOs in helping to better understand a future with CAV and what future scenarios may come to reality. Several workshops have been held to develop multiple scenarios around different adoption paths and timelines in order to help agencies think through the issues that such scenarios would engender. Efforts like these are very helpful and need to be continued but not as a stand-alone project but an ongoing effort that brings not just the transportation agencies to the table, but the technology developers as well.

Section 2: FHWA Questions and Answers

1) ***What roadway characteristics are important for influencing the safety, efficiency, and performance of ADS? Are there certain physical infrastructure elements (e.g., lane markings, signage, signals, etc.) that are necessary for ADS? If so, what current challenges exist for ADS to interpret them? Are these characteristics important for all levels of automation, or only specific levels?***

Currently, state DOTs (and other infrastructure owners) can only speculate as what roadway characteristics are truly most critical to the safe and efficient operation of ADS. Aspects of ADS (e.g., Level 1, 2, and 3) have been developed in the absence of significant collaboration between the infrastructure owners and technology developers. Thus, state DOTs are not sure which roadway characteristics are important as they have received vague and mixed messages from the technology developers.

Using lane striping as an example, California has been told line striping is important, and they are going from 4-inch to 6-inch stripes to help the technology developers with their sensors and lane departure warning systems. Other states, however, are not as willing to modify their lane striping widths because this is seen as a major investment. Additionally, it is not clear how critical lane striping is to ADS as many systems are not dependent upon them and how they would work in environments that are not ideal such as construction zone or when snow or ice obscures the lines.

In order to address this lack of information and continued discourse, AASHTO would recommend that USDOT further fund and encourage a collaborative dialog between the infrastructure owners and the technology developers, like what is currently being done with the V2I Deployment Coalition and CAV Executive Leadership Group (see Question #7), to discuss and publish a list of existing data on roadway characteristics that the state DOTs can readily provide to the technology developers. This list will help the technology developers in developing near-term ADS applications and encourage them to come up with a list of additional data that they will need to completely develop the ADS. It is important that public and private sectors work together to cooperatively define the criticality of roadway characteristics and infrastructure elements to the efficient and safe deployment of ADS. The state DOTs need consensus from the technology developers about what data and information is needed and that it be consistent among all technology developers such that state DOTs are not continuing to chase the technology requirements.

2) ***What challenges do non-uniform traffic control devices present for ADS technologies and how does this affect the costs of ADS systems?***

There has been discussion about the consistent application of the FHWA Manual on Uniform Traffic Control Devices (MUTCD) and its ability to provide consistency throughout the US. While conforming to the MUTCD already takes place, there are many states and localities that provide exceptions to the MUTCD for various reasons. While strict adherence to the MUTCD may be desirable among the technology developers, the reality is that there will always be exceptions that must be accounted for. In addition to these exceptions, there will also be instances of storms or incidents knocking down and damaging signage along the roadway, and snow and debris can obscure lane stripes. State DOTs aim to repair and replace damaged signs

and striping as quickly as possible, but may not be able to do on a timeline needed by technology developers that would rely on signage and striping alone for ADS operations.

3) How does the state of good repair (e.g., pavement and road markings quality) impact ADS, including technology or safety costs, if at all?

State DOTs are committed to maintaining their assets in as good a condition as possible given the resources available to them. At this point, state DOTs do not know what, or if, minimum conditions are needed for ADS to operate effectively or what the minimum condition levels should be. The state DOTs look forward to working with other public and private sector partners in developing and defining the state of good repair needs.

4) How should FHWA engage with industry and automation technology developers to understand potential infrastructure requirements? Are there specific issues that FHWA should engage with industry directly?

There are three aspects to engaging with the industry. First, AASHTO appreciates that it is not efficient for vehicle manufacturers to have to address a patchwork of state-based policies, laws and regulations that are not consistent or coordinated with each other. FHWA needs to be actively involved in engaging the public and private sectors in developing national standards for infrastructure and ADS. There are many reasons why FHWA should play a substantial role, but first and foremost the requirements for infrastructure readiness should be the same across state boundaries so an ADS vehicle can function the same regardless of state boundaries. We need consensus from the technology developers and the infrastructure owners to develop these needed standards. While AASHTO can help to facilitate this role, FHWA has significantly more resource than AASHTO.

However, it is important that any policy, laws, regulations or guidance do not disrupt the current authority given to states to license the driver of the vehicle or the registration of vehicles. Historically, the regulation concerning the design, construction, and performance of a motor vehicle is a federal obligation that has been under the oversight of the National Highway Traffic Safety Administration (NHTSA) through the Federal Motor Vehicle Safety Standards. The licensing of motor vehicle operators, registration of vehicles, and enforcement of traffic laws has been the domain of states. The development of ADS has the potential to disrupt this separation of design versus operation whereby motor vehicles are no longer driven by a person but by the ADS and important questions about design, regulation, and certification of complex computer systems must be addressed. The state DOTs believe that these questions, and many others, will be most effectively addressed collaboratively among Federal, state, public and private stakeholders. Already, there are examples of this cooperation happening on a regional basis. For example, the I-95 Corridor Coalition, comprised of 16 states along I-95, has begun to broach this issue by bringing states together to discuss regional strategy and bridge the gap by forming a regional group to establish a regional path forward

Second, it is important that this engagement be done in partnership with state and local agencies and other private sector partners who own and operate the transportation infrastructure. There are existing structures in place—such as the Vehicle-to-Infrastructure Deployment Coalition, the Connected Vehicle Pooled Fund Study, and the Collision Avoidance Metrics Partnership—that bring together state and local DOT representatives, research partners, USDOT, auto industry,

original equipment manufacturers (OEMs), and technology vendors. AASHTO believes that FHWA should do more and to get involvement from nontraditional OEMs, such as Uber and Waymo. Thus, it is important to examine the current avenues for communications and see if they are good enough. See response to Question #7 for more information on existing engagement activities.

Finally, in addition to supporting the dialog with technology developers and asset owners, FHWA should help build new and maintain existing testbeds. FHWA should encourage industry and technology developers to test their hardware and applications on the testbeds. Then, infrastructure owner/operators and technology developers will be in a better position to understand each other's requirements and it will help create better standards.

5) Data Questions.

These four questions about data needs and information are very broad. It is difficult to cite and list detailed responses given the highly specific nature of many ADS applications. In general, the state DOTs see significant benefits from the sharing of detailed digital maps and dynamic traffic information that may be realized through alerts about nearby vehicles, pedestrians and bicyclists as well as lane availability associated with incidents and construction projects. However, the state DOTs need to know if technology developers and the auto industry are open to two-way exchange of data between the vehicles and infrastructure. Some of these data discussions are going on through the development of SAE standards, the Connected Vehicle Pooled Fund Study, and the V2I Deployment Coalition; nevertheless, a blanket question about what type of data and information is simply too broad. The state DOTs look forward to working with other public and private sector partners in developing and defining these data and information needs.

a) What is the role of digital infrastructure and data in enabling needed information exchange between ADS and roadside infrastructure?

Key to the question is the premise that there is a 'needed information exchange' between the two, and to that end, both play a critical role. Without the digital infrastructure and data, ADS operability that is reliant on information from roadside equipment (RSE) would essentially become non-functional. Thus, an important assumption to this question is that the 'needed information exchange' includes connectivity between the vehicles and the roadside infrastructure. AASHTO believes that vehicle connectivity enhances and expands the safety and mobility benefits of the ADS by providing information that the sensors cannot "see" and important redundancy of information that the sensors can "see". When dealing with life-safety issues, additional data redundancy to verify known data is essential and valuable.

Digital infrastructure at its basic level includes the hardware and software associated with applications and communications, and are typically identified as being either on-board equipment (OBE) if it's contained within the vehicle or roadside equipment (RSE) if it exists as part of the roadway network. Both applications and communications can be defined to exist in environments described as isolated (i.e., a remote roadside weather information system), local (i.e., signal system on a corridor), area wide (i.e., capturing vehicle responses in adverse driving conditions such as activating windshield wipers or having ABSs being engaged and sharing that information with other vehicles or roadside units within a designated area), regional (cellular wireless access, sharing traveler information) or even global (GPS) infrastructure. The role of the

infrastructure is the conduit by which data can be shared and consumed by the application to initiate a response for the ADS. As such, the data must be in a format by which an ADS can act upon. Standards for both are key, especially when dealing with different OEMs.

b) What types of data transmission between ADS and roadside infrastructure could enhance safe and efficient ADS operations?

Regarding V2I exchanges there are two interfaces available today for the transfer of this information, 4GLTE for non-time-critical data and dedicated short range communication (DSRC) for low-latency applications. Both should be leveraged, and both should use the same set of data definitions and standards (SAE J2735). The challenge with cellular data, to date, has been that most of the transmissions have been through corporate-specific clouds (generally not open to data sharing between various manufacturers) and are based on a fee-for-service arrangement, limiting the data to those who are willing and able to pay the fee. That is not a model that will facilitate broad increases in safety for all users. The advantage of DSRC is that it is very fast, which is essential for many safety applications, and is fee-free. We applaud the USDOT for spending considerable effort developing, testing, and proving the DSRC medium, and encouraging its use in many test beds and deployments. Because of its benefits, we encourage a continuation of support for this medium. While other mechanisms promise great advantages, such as 5G, and we are eager to see a realization of those promises through a rigorous testing process, we encourage the USDOT to require that those data transmissions be company-agnostic (available to all vehicle brands and types), free from user fees, and fully backwards compatible with current messages. If this is not the case, safety benefits will be limited, and the large investments currently being made in available technologies will be wasted. Interoperability across technologies is essential.

Regarding data transmission, it should be in a format that can be easily consumed on multiple fronts for sharing without any need for translation. In the scenario where the OBE provides information to the RSE, that information should be easily translated to other potential users or applications (i.e., traffic operations centers or advanced traffic management systems). Beyond data format, specific kinds of information that would enhance safe and efficient operations would include those associated with service packages identified in the national architecture (weather, construction, maintenance, road conditions, advisories).

c) What type of infrastructure and operations data, if available, would help accelerate safe and efficient deployment of the ADS on our Nation's public roadways?

Accelerating ADS deployment would best be determined by the system developers. However, a solid understanding of what an ADS operation design domain would consist of in advance of it being deployed would be helpful. For example, if the relationship between the algorithms and the mechanical systems controlling the dynamic driving functions has operational limits (i.e., can't assume steering control at certain speeds and/or under certain road conditions or terrain) that should be shared with other users (ADSs) so they too would know when they're approaching being beyond their respective ODD well in advance of it occurring. Again, more collaboration among public sector agencies and private sector developers is needed.

Specific to the type of operations data, there are numerous examples including roadway characteristics (pavement type, geometric design, condition), signal phasing and timing, work zone information (when, where, duration, type), incidents information, weather conditions, current traffic characteristics (speed, volume, type). Specifically, ADS could provide valuable transportation planning data, such as ridership, occupancy, origin/destination, and, potentially, roadway maintenance data (pavement/paint/sign condition). If OEMs were to provide this type of information at the individual vehicle level, state DOTs may be able to redirect significant resources for other purposes such as better maintaining the infrastructure rather than data collection.

d) How might the interface between ADS and digital infrastructure best be defined to facilitate nationwide interoperability while still maximizing flexibility and cost effectiveness for ADS technology developers and transportation agencies and minimizing threats to cybersecurity or privacy?

In general, maximizing flexibility and cost effectiveness must include a consideration for standards that are open source (allowing for improvements), as well as establishing data definitions and associated priorities of those definitions, and identifying what's needed for operational functionality and what's not needed.

6) What concerns do State and local agencies have regarding infrastructure investment and planning for ADS, given the level of uncertainty around the timing and development of this technology? How should FHWA engage with its State and local partners as they consider impacts on infrastructure, transportation funding, finance, and revenue? Are changes to any of the programs that comprise the Federal-aid Highway Program needed to enable State and local agencies to more effectively make infrastructure investments to support deployment of ADS?

The biggest concern from a transportation planning perspective is how to plan and model for future needs; specifically related to planning for the funding of technology-based infrastructure needs and understanding ADSs' impact on travel demand and mobility of people and freight. For funding, a balance needs to be struck that facilitates the understanding of the costs that potential infrastructure requirements bring to the state and local governments and how transportation agencies plan for the funding needs for assets that may have a much shorter life cycle than traditional roads and bridges as well as assets with maintenance needs that may require updating on daily basis. An example is Wyoming's testing of roadside equipment (RSE) units for truck applications along I-90. The current estimate is that the RSEs have an average life of two2 years with software and firmware updates on a much shorter cycle. The cost of maintaining these systems will create manpower and funding requirements in an era of constricted spending.

From a modeling perspective, there are reasonable assumptions about the capacity implications of the various levels of connectedness and automation may have on the transportation network, the travel demand implication is a wild card at best. The issue is further complicated by a lack of understanding about the form future travel demand will take including vehicle ownership, transit ridership, shared mobility, active transportation, VMT growth, parking, inter- and intrastate freight hauling and delivery, etc. Given these uncertainties, transportation planners need to use scenario planning as a technique to help them consider possible implications and develop

estimates around likely outcomes. However, scenario planning cannot be successful if it only includes the transportation planners, it MUST include others from with the transportation agency as well as the technology developers.

Tools such as scenario planning may help frame the problems, but they cannot help with the key unknowns. Thus, a significant challenge is how transportation agencies can ensure that today's investment decisions will remain useful in the future. How can transportation agencies position themselves to ensure future needs are met as land use, travel demand needs, and mode splits change? The continued use of scenario planning in transportation planning to explore levels of change and plausible future scenarios was emphasized as a valuable tool. Scenario planning and computer models do not show the future, but can help transportation agencies understand what might happen under various deployment scenarios, the risks associated with those scenarios, and through commonalities between scenarios and the present and future, the importance of specific technological and social developments in moving from the present to the various possible futures.

Below is a list of resources that were developed based upon the many different workshops that have been sponsored by AASHTO, the Association of Metropolitan Planning Organizations, and FHWA around the topic of CAV in general, including ADS. AASHTO encourages FHWA to review the more detailed findings available here:

- 2017 AASHTO Summer Meeting
- AMPO CAV Working Group

Resource needs to assist transportation planners as they incorporate CAV technology into their planning process and products, including:

- A better understanding of infrastructure investment needs and costs;
- A "CAV 101" template or toolkit that could be used to educate and share information with stakeholders. Several variations of the template or toolkit will probably be required to target different stakeholder groups, from board members and other decision and policy makers to members of the public, as well as for stakeholders interested in different issue such as cybersecurity or environmental justice;
- A template or framework for inclusion of CAV considerations into state DOT and MPO products and investment decisions. Suggestions have included identifying key questions and considerations to include as discussion items in the metropolitan transportation plan;
- How to incorporate risk related to CAV technology into transportation planning and investment decisions. Suggestions include identifying events, milestones, or other factors that can be used to foreshadow the course of future development, or as "triggers," or leading indicators suggesting what actions should be taken in the planning process, as well as methods to identify strategies or products to manage those risks should certain types of development start to emerge;
- The option to include a shorter horizon for long range planning since the technology is moving quickly;

- Support from the federal government to promote data sharing among the public and private sector (with reasonable safeguards against the unauthorized release of personal or proprietary information) to assist transportation agencies in accessing data for planning and operations;
- Overarching guidance at the federal level that provides flexibility and supports expansion of existing efforts across municipal and state borders and to help facilitate uniform, efficient, and effective CAV deployment and implementation nationally;
- Sharing of best practices as well as lessons learned among transportation agencies on topics including policies, partnerships, and data;
- Clarifying roles for federal, state, and local agencies and for the private sector in ensuring the safe and efficient operation of the transportation system; and
- Better venue for dialogue and coordination with technology drivers and companies.

7) Are there existing activities and research in the area of assessing infrastructure-ADS interface needs and/or associated standards? What is the current thinking on where potential revisions may be necessary? How should FHWA work with existing research partners (e.g., American Association of State Highway and Transportation Officials, Transportation Research Board, etc.) in sharing research results and information?

First, there are significant research and deployment activities underway in information interface needs and standards, including those referenced in the response above (SAE J2735 messages, new message standards, equipment deployment and interoperability, etc.). These developments are occurring in a number of places, including:

- V2I Deployment Coalition
- CAV Executive Leadership Team
- National Operations Center of Excellence
- NCHRP 20-102: *Impacts of Connected Vehicles and Automated Vehicles on State and Local Transportation Agencies*

While there is good collaboration between federal agencies and state/local agencies on many of these projects, there is always room for improvement. Federal research projects in this area should always involve representatives of infrastructure owners and operators from the very beginning of the project; we sometimes find that original scopes of work miss some key elements that road operators see as necessary and pertinent. Efforts should continue to keep the operator organizations (V2I DC, AASHTO, etc.) up to date on project progress and results so that findings can be implemented quickly and duplicate efforts can be avoided in this fast-moving field.

Of particular note concerning existing research activities is the NCHRP 20-102 task order contract administered by the Transportation Research Board. The purpose of this task order support research program are to: 1) identify critical issues associated with connected vehicles and automated vehicles that state and local transportation agencies and AASHTO will face; (2) conduct research to address those issues; and (3) conduct related technology transfer and information exchange activities. This program has been instrumental in moving forward with deployment of connected and automated vehicles. Projects have covered a wide breadth of issues ranging from impacts of regulation and policies on CV and AV introduction in transit operations

(Task 02) to the implication of AV on motor vehicle codes (Task 07) to data management strategies (Task 14). Funded through the NCHRP program, it is imperative that FHWA continue to fund and participate in these critical research projects.

Second, the transportation industry have been developing needed data standards and interface requirements. For example, the nature of the data to be shared has been well (but not completely) defined in the SAE J2735 and related standards. Definitions of the Basic Safety Message (BSM), the Traveler Information Message (TIM), the Signal Phase and Timing Message (SPaT) and the map geometry (MAP) messages, among others, include many of the needed elements. Both the automakers and the infrastructure owners and operators are currently working on a Basic Infrastructure Message (BIM) to define some of the elements of information that can be provided from the infrastructure, such as information contained on static and dynamic roadway signs, modification in roadway geometry due to construction and maintenance activities, and locations of traffic crashes and incidents. We encourage a continued collaboration through standards bodies like SAE to define and refine these elements in a way that benefits both the automakers and the infrastructure agencies. Infrastructure owners and operators will similarly make beneficial use of dynamic vehicle response information - indications of localized weather, slippery or uneven roadway surfaces, sudden vehicle movements, etc., and we encourage automakers to provide this kind of information, including data found in the BSM2 message.

Third, roadway design documents, such as the AASHTO "Green Book" and the Manual on Uniform Traffic Control Devices (MUTCD) will need to be updated to reflect the findings of ADS and connected vehicle research. Collaboration between federal research entities and operator organizations is essential to moving this process forward in a way that doesn't inhibit these technological advancements and the resulting safety benefits.

8) ***What are the priority issues that road owners and operators need to consider in terms of infrastructure requirements, modifications, investment, and planning, to accommodate integration of ADS and to derive maximum system efficiency benefits from ADS additional capabilities?***

Infrastructure owners and operators do not have clear messages from the automakers about what infrastructure elements they need in order to be successful. The advent of ADS and connected technology represents a new paradigm in the relationship between these two segments of the transportation community. We recognize that automakers work in a very competitive environment, and may be challenged to reach consensus on their needs. Similarly, road agencies range in size and capability and don't often speak with a uniform voice. However, if we are to provide infrastructure which supports these new technologies, both physical and digital infrastructure, some guidance from the automaker industry would be helpful.

We are encouraged by the recent collaboration on data communication standards. This effort needs to be continued and expanded. And, as many agencies push forward with low-latency, DSRC communication systems, some indication from the auto industry that this will, or will not, be useful to them, would be very beneficial in our planning, especially in light of the uncertainty of a communication mandate. In addition, some collaboration on systems to secure these transmissions would be helpful. A security credential management system (SCMS) has been developed for the Connected Vehicle Pilot sites, but it is not intended to be broadly available or

permanent. Data security is very important to the infrastructure owners and operators, but these new systems are different from many systems we are familiar with. Automakers are certainly dealing with these issues and are developing systems. Being involved in those discussions and collaborating on their development, would benefit the agencies and facilitate more rapid roll-out of infrastructure-ADS data sharing.

Another priority issue is the deployment of ADS, and more robust connected vehicle infrastructure, in rural environments. State DOTs own the rural state highways, which due to their longer routes may have to have different solutions, such as more reliance on cellular. However, there are still rural areas of the nation that do not have adequate cell phone service. How to ensure the communication works in rural areas is an important issue that FHWA could engage the industry on.

As automakers and other technology companies develop and test ADS systems, infrastructure owners and operators could benefit from dialogue and data sharing. There is considerable concern about mixed fleets, including vehicles with no automation interacting with vehicles that are highly automated. Dialogue about how these systems work, results of on-road testing showing how ADS systems sense and respond to non-ADS vehicles would remove misconceptions and provide infrastructure agencies with useful information about how to plan for the future.

9) ***What variable information or data would ADS benefit from obtaining and how should that data be best obtained? Examples might include information about zone locations, incidents, special event routing, bottleneck locations, weather conditions, and speed recommendations.***

There is a significant amount of variable information and data that could be provided to ADS by the state DOTs. The examples included in the question cover the basic types but the level of detail is likely much more extensive. For example:

- Is it enough to know the beginning and end of work zone location or does it also need to include the modified roadway geometry due to construction or maintenance activities? For example, work zone configuration can change multiple times of day and when they are operational can be affected by weather conditions. How much information is needed and to what level of detail?
- How granular of information would an ADS need for weather-related roadway impacts such as standing water, snow, wind impacts, etc.?
- Vertical or horizontal limitations such as low bridges, temporary wire crossings, etc.?

The state DOTs are providers of a lot of information and it is important that the state be involved in this discussion about needs. State DOTs need to understand the demand for this data and how to provide in in a consistent format, frequency and reliability that meets the needs of ADS. However, with hundreds of thousands of lane miles to cover, providing fast, up-to-date data can be a technical challenge that is expensive to address.

10) What issues do road owners and operators need to consider in terms of operations as they encounter a mixed vehicle fleet (e.g., fully-automated, partially-automated, and non-automated; cooperative and unconnected) during the transition period to a potentially fully automated fleet? What are likely the most significant impacts of ADS on other motorized and non-motorized users of public roadways? What plans do stakeholders have to address these impacts, and are there possible roles for road owners and operators to support the interaction of ADS with those users through infrastructure changes or operational strategies?

The primary concern of state DOTs in transition to an ADS-equipped fleet of vehicles is safety; safety of the occupants in the car, safety of our maintenance workers, safety of construction workers, safety of bicyclist, and safety of pedestrians. There are many questions that must still be asked and answered such as:

- How will an ADS navigate a temporary work zone?
- How will it handle variable speed limits (speed limits are frequently reduced in construction zones)?
- How will it know that a school zone speed reduction is in effect?
- How will it handle a hand signal from a bicyclist that is turning left?
- How will vehicle/pedestrian communication work?
- What will the impacts be to mode shift, travel patterns, and land use?

Clearly, there are considerable concern about fleets with mixed automation capabilities. A more open dialogue about how these systems work, and the results of on-road testing showing how ADS sense and respond to non-ADS vehicles would remove misconceptions and provide infrastructure agencies with useful information about how to plan for the future. State DOTs are ready and willing to work with the technology developers in addressing these safety issues since the industry is evolving rapidly and has not clarified their collective needs.