March 5, 2018

Rules Docket Clerk
U.S. Department of Transportation
1200 New Jersey Avenue SE
Washington, DC 20590

RE: Federal Highway Administration Docket No.: FHWA-2017-0049; Request for Information on Automated Driving Systems posted 01/18/2018

Dear Rules Docket Clerk:

The following comments to the docket ID: FHWA-2017-0049 are submitted on behalf of the American Traffic Safety Services Association (ATSSA). The association represents the manufacturers and installers of traffic safety devices as well as roadway owners interested in traffic safety. ATSSA's Core Purpose is To Advance Roadway Safety. Our members are on the front lines in temporary traffic control zones and the invention, manufacture, sale and installation of most of the traffic control devices used on our nation's roadways.

First, ATSSA would like to thank Federal Highway Administration (FHWA) for the opportunity to comment on this rapidly changing topic of automated driving systems (ADS). We also would like to commend FHWA for asking these critical questions that will shape the industries future over the next 5, 10, 20 years and beyond and suggest that FHWA take an active leadership role by leading the national dialogue. Just like all new topics, critical thought and comments from all stakeholders are needed.

Our comments to the questions asked are as follows:

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? (For levels of automation, see https://www.nhtsa.gov/sites/nhtsa.dot.gov/files/documents/13069a-ads2.0_090617_v9a_tag.pdf, page #4)**

All traffic control devices are important for both permanent and temporary conditions, which include but are not limited to striping, signals, signing, cones, drums, and arrow boards for influencing the safety, efficiency, and performance of ADS. Lane marking characteristics that improve ADS performance may include high contrast, multi-spectral, day and night visibility and all-weather performance. Roadway signage characteristics that improve ADS performance may include greater retroreflectivity for night visibility for human readability and ADS recognition which assists the ADS signage detection and interrogation. The durability of lane markings and signage may also have a direct impact on the ADS ability to consistently detect and efficiently interpret those markings.

The challenges are inconsistent, non-uniform markings as well as application uniformity on permanent and temporary conditions (markings - intersections, ramps, lane transitions, etc., signing – horizontal curves, advisory speeds, lane control, etc., signals – position with respect to approach lane), maintenance (particularly with respect to markings), and to some extent, design (markings – contrast, width, retroreflectivity, signals - configuration).

Lower level autonomous vehicles may be fully reliant on roadway characteristics and physical infrastructure elements and as such will require human control in adverse conditions. Unfortunately, there is not a clear priority of the challenges in terms of improving the performance of Level 2-3 ADS and accelerating the safety benefits that have been promised. As far as wide-spread use of Level 4 and 5 ADS, the technology that will be used is still undetermined, therefore, there is not a good understanding of how the infrastructure assets will be impacted.

Level 4 and 5 vehicles may not be solely dependent on signs and markings but will continue to use these assets for redundancies. Infrastructure changes must be done in a way that maintains a high level of design and safety that has been established for human drivers—while improving the performance of the technologies that provide ADS. If one method of keeping the car on the road fails (i.e.: it's snowing and the car can't see the pavement markings), another technology must be able to takeover (cloud based real-time mapping, in this case).

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

Both non-uniform and "near uniform" devices may pose a significant problem. They can appear in non-approved situations where a contractor is trying to protect his work area with examples that have a wide range of non-compliance from unpainted wooden structures to battered barricades and signs. Non-uniform devices will require that ADS developers and programmers design their systems with more robust algorithms to determine the proper course of action when encountering a non-standard traffic control device. Potentially, the ADS may be strained to identify, classify and interpret the devices and act on that information. Additionally, there is currently a large variety of "uniform" devices used on the nation's roadways, including traffic cones of various sizes, drums, channelizers, stacker cones, vertical panels, and even barricade – all these devices will need to be understood by ADS when crossing state or jurisdictional lines.

"Near uniform" devices include those included in the Manual on Uniform Traffic Control Devices (MUTCD) which while standardized in the Manual are deployed with sufficient variations to pose a challenge to ADS systems. An example is overhead guide signs where the shape and positioning of directional arrows varies by state as does the placement of additional plaques such as the "Exit Only" indicator. It is possible that FHWA may need to consider *more* standardization of devices rather than providing states leeway in areas such as this.

The ADS technology must be calibrated and trained to react to a set of expected traffic control elements that incorporates traffic control devices (TCDs) into the overall system. If the TCDs vary widely, the ADS technology must be engineered to tolerate this variation. This variability increases technical challenges by requiring building extra variables into the technology or updating as variations arise and may decrease the reliability of the system. Uniform TCDs help to provide reliable identification and detection, and the efficiency of ADS to quickly and reliably classify and interpret may lead to increased safety. Simplifying the technical challenge of the ADS leads to more efficient and reliable solutions. Therefore, harmonized standards for TCDs should reduce variability, simplify the ADS solution space, and help to ensure safe operation of the ADS.

Application and maintenance of the TCDs must also be addressed. For example, placing drums (and their supports) on lane markings (or adjacent to them in such a way that they obscure the lane marking continuity) used for lane shifts may result in cameras having a difficult time tracking the markings. It also appears that cameras have a difficult time following Bott Dots markings. All lane shifts should use pavement markings in a way that they are not obscured.

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?

When the technology depends on the "eyes of the vehicle" (camera, laser. LIDAR or other tech), the quality of road markings and signs becomes vitally important, so all devices will need to be kept in usable condition to be recognized. Poor quality TCDs may impact the ability of the ADS to detect and interpret those devices, which could lower the system's ability to operate within the range of safe and efficient functioning. The vehicle must see the lane, to stay in it and having devices in good repair is the ideal situation. However, the reality is that many local jurisdictions do not have the funding to maintain roadways to current design standards and may struggle to meet any future requirements that are more stringent. ADS systems must be able to accommodate the infrastructure in actual conditions and not be designed around a best-case scenario.

Additionally, pavement marking maintenance is also important. Daytime may even be more important than nighttime. NCHRP 20-102(6) is addressing the characteristics of markings that Level 1-3 vehicles need.

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?

First and foremost, FHWA needs to take an active leadership role by generating national dialogue inclusive of the key sectors of the ADS systems to address the challenges mentioned in questions #1, #2, and #3 and work towards solutions. To do this, FHWA needs to ensure that all stakeholders are included in the outreach activities. The stakeholders to include, but are not limited to:

- Real world contractors that are setting up devices and restricting lanes on city streets, rural roads and the interstate highway system,
- Work Zone ITS providers,

- USDOT's ITS JPO,
- Associations (e.g. ATSSA, AASHTO, NACE, NACTO, ITSA) that represent roadway safety, HD map data collectors, machine vision system manufacturers, road owners, road marking industry and others,
- ADS manufacturers and providers,

Outreach would include avenues like symposiums, regional summits and/or workshops, social media, formal meetings, conferences, conference presentations and focus groups to discuss items like;

- Different methods (technologies) for communicating with infrastructure.
- Restrictions placed on development of new products, the time to roll out, and the impact to both the public and contractors who are tasked with using them on a daily basis.

Specific issues to address could include:

- Develop a roadmap for the targeted balance between roadway infrastructure and ADS capability, including a system for information sharing that provides protections for collaborator's intellectual property or business strategy.
- Develop a list of proposed or developing automated vehicle technologies and identify those with the greatest potential impact on federal aid highway systems.
- Discuss how vehicle manufacturers could assist road owners with information regarding the quality of road markings to improve maintenance cycles.
- Workable, practical, and achievable results for the state, county, city, and Indian Nation DOTs.
- Discussion on how to make changes to nationwide standards like MUTCD and HPMS that will better assist ADS technology to perform better.
- Identifying key standardization issues related to traffic control devices like uniform pavement marking edge line width, color, and contrast.
- Discussions centered on how vehicle manufacturers could assist road owners with information regarding the quality of road markings to improve maintenance cycles.
- Discussion on how highway funds are allocated and spent to include human road users as well as ADS to take advantage of these technologies to improve transportation mobility and safety.

5. What is the role of digital infrastructure and data in enabling needed information exchange between ADS and roadside infrastructure? What types of data transmission between ADS and roadside infrastructure could enhance safe and efficient ADS operations? 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? 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?

Digital data transmitted to ADS is one of several layers that can be combined to create situational awareness and important layers of replication in ADS. Physical infrastructure, such as TCDs, can also complement, confirm and enhance the security of the digital infrastructure systems. TCDs can provide trusted data that acts as a redundancy for ADS, including cyber-physical security applications. The cyber-physical security along with easily identifiable and interpretable roadway signage could enhance the safe and efficient operation of ADS by creating a digital

layer on the physical roadway infrastructure. The data collected by ADS as they drive the roadway will have value in improving safety and security. The relevant safety data could be used to create safety information that road custodians could utilize to improve the quality of roadway infrastructure and overall suitability of the roadway for ADS.

However, one of the difficulties in addressing the issue of automated driving systems is that terms are poorly defined. Even SAE and National Highway Traffic Safety Administration's (NHTSA) efforts to build out a taxonomy is so vehicle focused that infrastructure and vehicle terms continue to translate differently. Digital infrastructure is one of those terms. High definition map developers think of digital infrastructure from the perspective of relatively static to extremely dynamic. Relatively static digital infrastructure would be a digital data capture that scans a newly built roadway. The physical assets and their location are captured and adjust slowly over years. Extremely dynamic elements are digital elements that change rapidly. The location of a roadway incident, a mobile work zone (road markings), a short-term work zone (pot hole) are examples of more dynamically charged and difficult to capture data elements. FHWA should work within USDOT and NHTSA to partner with automakers and road infrastructure providers to agree on a national data exchange format. This format would allow for the exchange of data from infrastructure (traffic signals, work zones, law enforcement, emergency responders) in an open and uniform method. A central data exchange format would strengthen efforts to develop security protocols and methods, reduce latency, and create greater uniformity.

Vehicles should be moving around on a digital map with zero latency between the real world and the cloud-based digital representation of the road/city/state/etc. Everything will need to digitally mapped and/or produced in 3D using LIDAR services. Lane width, stop bars, stop signs, turning lanes, work zones, etc. will all need to be represented and considered.

Work zones will be the most common anomaly in digital maps unless we begin preparing now. Arrow boards, flagger stations, and other active work zones can be equipped to report their location and other pertinent information automatically and in real time. The same could be done for emergency responders and special events. Only by doing so can we hope to prevent crashes like the one reported January 23rd involving a Tesla running into the back of a fire truck. Safety is the driving force behind this initiative, but it will also reduce drive times, reduce air pollution, and improve the efficiency of our road networks.

The greatest and fastest return on investment for digital communication in ADS is the V2X (Vehicle-to-Vehicle or Vehicle-to-Infrastructure) system which will allow vehicles to create their own peer-to-peer networks and quickly improve safety. Having ADS communicate with infrastructure, especially traffic signals, can be beneficial but we should not let developing those protocols delay the in-vehicle networks. Auto manufacturers and especially technology companies move at much faster testing and developmental speed than DOT's and roadway agencies, and it will be challenging to develop connected infrastructure that doesn't become obsolete within a few iterations of in-vehicle software updates. However, it is imperative that any connected infrastructure is completely secure.

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?

Most of our nation's roads are governed by county and city or township jurisdictions and these agencies often do not have sufficient funding for maintenance of pavements, striping, and signage. With over 270 million vehicles in the US now, the rate of adoption is a huge unknown for state and local agencies and FHWA could provide forecasting models for the adoption rate of ADS, so that state and local jurisdictions can make informed decisions based on the design vehicle that are to be accommodated by short and long-term transportation improvement planning. Therefore, state and local agencies may be apprehensive towards investing in infrastructure technology as ADS rapidly develops. For example, expecting a rural county to implement connected infrastructure or replace signage with ADS enhanced items may not be fiscally feasible. To help get ready, FHWA could provide specific funding to improve certain road features (like signs and markings and traffic control signal controllers) that can aid both the ADS and at the same time helping upgrade current conditions that have typically suffered due to a lack of funding.

Additionally, FHWA could help mitigate the investment uncertainty and risk by enhancing collaboration and shared learnings and advancing informed standards evolution (as described in question #4) as well as providing best practices in the sharing of information, data, technology (existing and near future) to give them the tools/information they require to make smart decisions. Furthermore, by engaging with state and local partners to highlight the challenges described in question #1 and explaining how TCDs are a component of the overall ADS safety system, FHWA can enable their partners to make the most informed decisions.

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?

Several research and pilot projects assessing infrastructure and ADS interface needs are completed or underway. The National Highway Cooperative Research Program (NCHRP) 20-102 includes a series of research projects addressing the impacts of ADS on state agencies. NCHRP 20-102(6) Road Markings for Machine Vision aims to develop information on the performance characteristics of pavement markings that affect the ability of machine vision systems to recognize them. Pavement marking factors considered in the study include pavement marking presence, type of marking, recessed, or temporary, contrast between the pavement and the marking during daytime conditions, retroreflectivity of the marking during nighttime conditions and different weather conditions, pavement uniformity, vehicle speed, and the impact of other substances on the road such as snow, sand, salt, and water. The study is currently waiting for final document approval.

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?

Road owners and operators must consider how to provide a safe environment for both human and machine drivers for the foreseeable future. Traditionally, road owners and operators have provided drivers with TCDs, such as pavement markings and roadway signage, optimized for human vision. The roads of the future will include TCD that are designed for both human and the ADS that will gradually integrate into the existing vehicle fleet. FHWA leadership and guidance provided to State and local partners will be critical to enhancing the safety of roadways for this emerging dual-user paradigm.

From a manufacturing standpoint, ADS should be designed to travel the roadways as they exist today, with the assumption that the roadways are kept up to MUCTD and FHWA standards. Providing enhanced roadway devices could be beneficial but should not be a requirement for ADS to gain public acceptance. In the end, there needs to be an understanding that no one technology will enable ADS, but ADS will require many layers of replication and technologies working with one another that will allow a vehicle to drive itself safely.

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.

ADS could benefit from obtaining work zone features and data, permanent traffic signals, scheduled or emergency road closure notifications, and detour routes. With work zones as the single most frequent cause of non-recurring congestion, clearly real-time work zone data would be beneficial This data could include the precise location of the work zone, when and where lanes are closed and when they are opened again, where flagging operations are taking place, and any other important features of the traffic control including lane splits, narrow lanes, crossovers, and full closures and detours. Delay times could also be included whenever available.

However, calculating and reporting delays at various times and locations during the life of a work zone can be difficult. The calculation of these should go the vehicle/ADS managers who would take their vehicle speeds along with the defined work zone limits (perhaps reported by or as mandated by the road owner) and then calculate and report out congestion, delays, etc. The congestion and delays may extend outside of the project limits (queuing traffic upstream of a lane closure). As the industry matures, vehicles/ADS's will be able to recognize the nuances work zones traffic control like a lane closure and how traffic may queue upstream of this location. ADS's may look for and account for changes in vehicle merging, weaving, slowdowns and report this out to other ADS users so approaching vehicles can benefit from this information. Just understanding who will report locations and calculating and reporting impacts will need to be defined for consistency of all systems.

Some of this type information is already available via cellular providers (i.e. Google Maps or WAZE), but multiple communication methods can provide ADS with variable information to help with layers of replication. Infrastructure solutions, such as TCDs, can provide a trusted source of data and is more difficult to interfere with or manipulate. Information regarding road changes (such as work zones, special event routing or traffic incidents) can be programmed into

the infrastructure and delivered directly to the vehicle. The dynamic data could include information about work zone changes prior to the vehicle arriving at the location. Industry collaboration will help determine efficient and immediate solutions on necessary data elements to include in such information.

10. What issues do road owners and operators need to consider in terms of infrastructure modifications and traffic 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?

ATSSA commends FHWA for addressing the issue of the mixed vehicle fleet. We note that the median household income in 2016 was $59,039. The median vehicle age is 11.4 years. Many households below the median income level may purchase previously-owned vehicles. Therefore, it may take several turnovers of the vehicle fleet before all households own first CAVs and later HAVs (SAE Level 5). It is likely that we will have a mixed vehicle fleet for several decades to come. Furthermore, USDOT Secretary Elaine Chou noted at the AASHTO Annual Meeting last fall that in response to a department survey, some 4% of respondents indicated that they would *never* purchase a driverless car. This could result in 10-12 million level 1 – 3 cars being on the road for an unknown period of time.

We also note that some have predicted that there will be a significant shift in automobile ownership from single-household to fleet ownership that offers "mobility on demand" services. If this shift does occur, it is likely to be urban centric in order to provide a return on investment to the fleet owner(s). Yet 40% of our population lives in non-urban areas which are likely to be the last to adopt a "mobility on demand" model.

It could be valuable for FHWA to create a detailed framework and timeline to provide a structure that both ADS developers and DOT's can follow to ensure everyone is working towards the same end goal. Traffic control device manufacturers should be a key part of that structure, as vehicle manufacturers, roadway owners, and operators must consider infrastructure solutions that enhance safety for both human and ADS. Deploying separate sets of infrastructure solutions for each type of user would be costly and inefficient.

While machine vision and automated systems are seeking to replace humans as a driver, it will be increasingly important that systems that are open to automated driving do so in areas that are well-maintained from a traffic control perspective. Pedestrians, cyclists, human drivers and machines need a well-maintained and more uniform system of traffic control to ensure that all drivers know where they may safety operate. Most ADS are not capable of navigating autonomously though an active work zone. ADS need to trigger the vehicles to hand over control to the driver well in advance of the work zone as studies show drivers need a minimum of 8 to 10

seconds to regain situational awareness. Work zones, incident response, and special events will test these systems more than anything else.