U.S. Department
of Transportation

National Highway
Traffic Safety
Administration

Administrator

1200 New Jersey Avenue, SE
Washington, DC 20590

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Ms. Jean M. Shiomoto
Director
California Department of Motor Vehicles
2415 First Avenue, M/S F-101
Sacramento, CA 95818-2606

Dear Ms. Shiomoto:

Given California's rulemaking activities on self-driving vehicles, I thought you would be interested to know what the National Highway Traffic Safety Administration (NHTSA) is doing to promote the development of vehicle automation as we pursue our mission of preventing crashes and saving lives on America's roads. NHTSA is eager to work with you and officials in other States to support the development of vehicle automation in ways that maximize the safety benefits of these emerging technologies and the exciting opportunity they represent to the American public.

Working with the Transportation Research Board, SAE International, and others, NHTSA continues to conduct research on the various levels of vehicle automation to support their rapid introduction and help provide the foundation for their future deployment. We are encouraged by the potential for significant safety benefits at all levels.

NHTSA's efforts regarding new technologies are guided by the Principles for Regulation and Oversight of Emerging Technologies issued in a 2011 memorandum from the White House Emerging Technologies Interagency Policy Coordination Committee. These principles seek to ensure that regulation and oversight fulfill legitimate objectives (such as the protection of safety, health, and the environment) while promoting innovation and encouraging technological progress and trade.

As you know, in May 2013 NHTSA issued a Preliminary Statement of Policy Concerning Automated Vehicles, which provides suggestions to the States on how they might approach some of the safety issues related to the testing of self-driving vehicles in ways that support innovation. A major element of the statement was NHTSA's research plan, which will inform our policy decisions as technology advances across all levels of automation.

Since NHTSA issued that statement, we have all witnessed continued technological progress at all levels of automated vehicle technologies. Various automakers continue to announce their intentions to bring to market different combinations of single-function and combined-function automation technologies that will likely be the building blocks for fully self-driving vehicles. Also, Google announced testing of a low-speed vehicle capable of driving itself. Helping to further support higher levels of automation, General Motors and other manufacturers have announced intentions to introduce or have showcased future products that will increase a vehicle's awareness of its surroundings by incorporating vehicle-to-vehicle (V2V) communications in the coming years. We and many others believe that vehicle awareness achieved through V2V technology will be a key enabler in realizing the full capabilities of self-driving vehicles. Because V2V offers such tremendous safety potential and its links to full self-driving automation, NHTSA and the U.S. Department of Transportation are supporting V2V communication efforts by pursuing a rulemaking that would require the technology on all new light vehicles.

NHTSA has a long history of performing collaborative research on new technologies and is working with industry to explore ways to ensure that automation technologies are implemented in ways that maximize safety benefits. For instance, we are developing classifications of vehicle automation applications that could then be used to support the development of operational safety principles and identifying best practices for the driver-vehicle interface (for those concepts requiring drivers to cycle in and out of a particular automated driving mode).

NHTSA is also researching several technologies that will likely be fundamental building blocks for fully self-driving vehicles. For single function automation, we published our research containing the latest test procedures on Automatic Emergency Braking (AEB) to mitigate and avoid crashes, and we announced our plan to incorporate AEB systems in our New Car Assessment Program. In addition, we are researching the next enhancement in automatic braking--Pedestrian Crash Avoidance and Mitigation. In other projects, our research addresses all levels of vehicle automation by (1) developing a method to systematically quantify the incremental safety benefits of each additional level of automation, (2) promoting a better understanding of hazard analysis methods (e.g., ISO 26262) that focus on electronic control system reliability and functional safety, and (3) evaluating cybersecurity issues.

To prepare for the arrival of highly automated vehicles, NHTSA expects to complete several research efforts over the next 24 months. Much of that research is outlined in an enclosure to this letter, and we are considering additional research as new areas are identified. Like California, we understand the pressure to pursue regulations in the area of highly automated vehicles; however, we believe there are complex and important issues that need resolution to continue supporting the innovation that is occurring. When and if NHTSA concludes there is a need for Federal safety standards concerning any aspect of these technologies, our research will provide important support for those standards. We look forward to additional discussions with all stakeholders, including the California Department of Motor Vehicles, on these and other issues as we all work to maximize and realize the full potential of self-driving vehicles.

I hope this information is helpful to your agency as you consider appropriate next steps in addressing the highest levels of vehicle automation.

Current Research Questions

Research Area 1: How can we retain driver's attention on the driving task for highly automated systems that are only partially self driving and thus require a driver to cycle in and out of an automated driving mode during a driving trip?

- Should drivers be required to remain fully engaged at all times? If so, will simply telling drivers to remain fully engaged in the driving task be sufficient to ensure that they remain so?
- With or without instructions, are human drivers capable of maintaining situational awareness and being available to take over vehicle controls when required due to the system transitioning back to manual control?
- What is the state of the art for driver monitoring systems (drowsiness, distraction, and health status detection), and are the systems adequate to address risks (fatigue, distraction, and detachment) associated with highly automated vehicles?

Research Area 2: For highly automated systems that envision allowing the driver to detach from the driving task, but safely resume with a reasonable lead time:

- How can we reliably bring back driver's attention to the driving task?
- Are human drivers capable of detaching from the driving task, potentially performing secondary tasks such as using a mobile phone or tablet computer to check email, but safely resume driving with a reasonable lead time?
- What is the length of "reasonable lead time" needed for a safe handoff from the automated vehicle function back to the driver in different driving conditions?
- Is it technically possible to provide a reasonable lead time in mixed traffic driving conditions?

Research Area 3: What types of driver misuse/abuse can occur?

- Identify ways in which drivers may tend to misuse or abuse the system automation beyond the capabilities of the intended design.
    - E.g., investigate whether human drivers over time may tend to treat automation levels as though they were higher than they are (e.g., treat Level 2 like a level 3 or Level 3 like a level 4).
    - Investigate whether drivers may proactively try to bypass measures put in place to keep them in the loop.
- Identify transportation system level hazards that driver abuse or misuse may cause.

Research Area 4: What are the incremental driver training needs for each level of automation?

- Identify and evaluate training requirements that may be needed for highly automated vehicles.
- Identify and evaluate potential incremental training requirements that may be needed for general public while driving in mixed traffic including surrounding vehicles with automated vehicle functions.

Research Area 5: What functionally safe design strategies can be implemented for automated vehicle functions?

- What functional safety requirements for safety-critical electronic control systems (including lateral-longitudinal control automation functions) are appropriate?
  - What safety goals/safety requirements are appropriate to address instances of electrical/electronic system failures?
  - What fail-safe, fail-operational driving concepts are appropriate for each given automation level/function?
  - Are there any appropriate extensions to ISO 26262 that can help address vehicle automation (the existing ISO 26262 assumes an average attentive driver continuously in the loop in its analysis)?
- How does one identify and mitigate hazards that may stem from human error in the context of automation? What safety requirements are appropriate to help take human error (with respect to driver role expectations of the system) into account?

Research Area 6: What level of cybersecurity is appropriate for automated vehicle functions?

- What is the capability of systems to resist cyber-attacks against remote and close proximity threats?
  - What are the incremental security needs associated with the incremental connectivity needs for automated vehicles (incremental beyond non-automated vehicles)?
  - What process is appropriate for identifying and integrating security requirements into the vehicle development life cycle?
- Can the vehicle ensure that safety-critical systems (e.g., steering, braking, throttle, and power) remain functional in case of security breach? Are there different impacts on safety if security is breached with or without a driver in the loop?
- Are there potential impacts of incorporating cybersecurity countermeasures on the performance of the automated system (e.g., potentially reduced availability, capability, etc.)?
- What methods/processes are available to ensure that safety critical vehicle subsystems such as communications are designed to resist security breaches?

Research Area 7: What is the performance of Artificial Intelligence (AI) in different driving scenarios, particularly those situations where the vehicle would have to make crash avoidance decisions with imperfect information?

- While generally accepted that Automation AI can overcome some of the weaknesses of human drivers (e.g., distraction and fatigue), what are AI capabilities during scenarios where the human driver excels (e.g., quick crash avoidance decision making under uncertainty)? Further research could help identify whether automation could introduce incremental safety concerns and whether some requirements can be developed for the minimal level of AI sophistication for various levels of automation.

Research Area 8: Are there appropriate minimum system performance requirements for automated vehicle systems?

- What are the appropriate minimum levels of safety performance?

- How should these minimum levels be set when the technology continues to evolve? Can such standards accommodate future implementations of the technology?
- What framework can help to establish system performance requirements for each automation level? Relevant steps that may help establish such requirements:
  - Develop detailed functional descriptions for emerging operational concepts.
  - Evaluate naturalistic data and crash data to determine the array of real-world scenarios (use cases) that map to the functional descriptions of emerging highly automated vehicle systems.
  - Evaluate constraints on highly automated system performance. Based on the functional descriptions of emerging system concepts and the data analysis results, evaluate the constraints on system performance that may result from various operating scenarios (traffic dynamics), driver capabilities, environmental variations (rain, snow, etc.), and roadway types/configurations.

Research Area 9: What objective tests or other certification procedures are appropriate?

- What track tests and/or simulation approaches can appropriately evaluate the performance of highly automated vehicles? This evaluation would ideally consider the real world scenarios (use cases) and how those cases map to the functional description of the automated system.
- What is the performance and operating envelope for emerging automated systems? Using testing and/or simulation efforts, can we characterize the performance envelope (i.e., appropriate operating boundaries) for each system?
- How can we evaluate and test electronic control systems to:
  - understand system failure modes for each automated system including active safety technologies installed on the vehicle; and
  - identify points of failure for each automated system (braking, steering, etc.) installed on the vehicle and determine how the systems react in various situations?
- What objective performance tests and associated performance criteria are appropriate for these systems? How comprehensively can such tests address the safety needs of these new systems, and are additional methods needed to supplement such tests?

Research Area 10: What are the potential incremental safety benefits for automated vehicle functions/concepts?

- What are the different variations with respect to the functions and concepts of these systems?
- How do the various functions and concepts impact safety?
- What safety benefits assessment framework is appropriate for identifying incremental safety impact potential of the various levels of automation (e.g., determining the appropriate target crash populations)?