Statement of

The Honorable Jennifer Homendy
Board Member
National Transportation Safety Board

Before the

Joint Committee on Transportation
Connecticut General Assembly

— On —

House Bill 6486
An Act Concerning Automated Driving System Equipped Vehicles
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An Independent Federal Agency

I appreciate the opportunity to provide comments regarding House Bill 6486 and the safe testing of Automated Driving System (ADS) equipped vehicles in the State of Connecticut.

The National Transportation Safety Board (NTSB) is an independent federal agency charged by Congress with investigating every civil aviation accident in the United States and significant accidents in other modes of transportation—railroad, highway, marine, and pipeline. We determine the probable cause of the accidents we investigate and make safety recommendations aimed at preventing future accidents and crashes. The recommendations that arise from our investigations and safety studies are our most important product.

Motor vehicle crashes are a leading cause of death and injuries in the United States. In 2019, 36,096 people lost their lives in crashes on our nation's highways; with 249 crash-related deaths occurring in the state of Connecticut.[1] The large majority of these tragedies can be directly linked to human error. The NTSB sees huge potential in the ability of ADS to mitigate or prevent crashes on our roadways in the future with the promise that such systems will be safer than a human driver. However, until that promise is realized, the testing of developmental ADS – with all its expected failures and limitations – requires appropriate safeguards when conducted on public roads.

House Bill (HB) 6486 establishes plans for a pilot program to allow autonomous vehicle developers to test fully autonomous vehicles on state highways. We are pleased that HB 6486 includes a requirement that the Commissioner of Transportation, in consultation with state stakeholders, establish state-wide guidelines and requirements prior to testing. While the bill sets forth a broad framework for establishing an ADS-equipped vehicle pilot testing program, it is vitally important that more specific safeguards be established, and that the state ensures any autonomous vehicle tester demonstrates it has a robust safety management program in place before beginning any testing.

My statement today will discuss lessons learned from our investigation of the crash of a developmental ADS-equipped vehicle that collided with, and killed, a pedestrian in Tempe, Arizona, and will outline the specific safeguards we believe will improve the safety of ADS testing programs.

On March 18, 2018, at 9:58 p.m. an automated test vehicle, based on a modified 2017 Volvo XC90 sport utility vehicle (SUV), struck a pedestrian walking midblock across N. Mill Avenue in Tempe, Arizona.[2] The SUV was operated by the Advanced Technologies Group (ATG) of Uber Technologies, Inc., which had modified the vehicle with a proprietary developmental ADS. An operator occupied the driver's seat of the SUV, which was being controlled by the ADS. As a result of the crash, the pedestrian sustained fatal-injuries.

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[1] National Highway Traffic Safety Administration (NHTSA), National Center for Statistics and Analysis, *Overview of Motor Vehicle Crashes 2019, Traffic Safety Facts*, Report No. DOT HS 813 060, (Washington, DC: NHTSA, December 2020).

[2] *Collision Between Vehicle Controlled by Developmental Automated Driving System and Pedestrian, Tempe, Arizona, March 8, 2018,* NTSB/HAR-19/03.

The NTSB determined that the probable cause of the crash was the failure of the vehicle operator to monitor the driving environment and the operation of the ADS because she was visually distracted throughout the trip by her personal cell phone. Contributing to the crash were the Uber ATG's (1) inadequate safety risk assessment procedures, (2) ineffective oversight of the vehicle operator, and (3) lack of adequate mechanisms for addressing the operator's automation complacency – all a consequence of inadequate safety culture. Further factors contributing to the crash were (1) the impaired pedestrian's crossing of N. Mill Avenue outside a crosswalk, and (2) the Arizona Department of Transportation's insufficient oversight of automated vehicle testing.

We concluded that the State of Arizona's lack of a safety-focused application-approval process for ADS testing at the time of the crash, and its inaction in developing an improved process following the crash, demonstrated the state's shortcomings in improving the safety of ADS testing and safeguarding the public. Much can be learned from this crash to help prevent a similar tragedy from occurring in Connecticut.

The Federal government has failed to provide a means to adequately evaluate an ADS. In the absence of federal safety standards or specific assessment protocols, many states have begun legislating requirements of automated vehicle testing. The development of state-based requirements can be attributed to the concerns of many states about the safety risk of introducing ADS-equipped vehicles on public roads. The requirements vary. Some states, such as Arizona, impose minimal restrictions. Other states have established requirements that include a more in-depth testing application and review process.

States that have no, or only minimal, requirements related to automated vehicle testing can improve their standards by implementing a thorough application and review process before granting testing permits. In May 2018, American Association of Motor Vehicle Administrators (AAMVA) published *Jurisdictional Guidelines for the Safe Testing and Deployment of Highly Automated Vehicles.* This guidance identified the need for state jurisdictions to identify a lead agency and establish an automated vehicle committee to develop strategies for states to address automated vehicle testing. However, the guidance does not include recommendations requiring ADS developers to submit a safety plan and for the state's automated vehicle committee to review and approve such a plan.

Since states would benefit from adopting regulations that require a thorough review of ADS developers' safety plans, including methods of risk management, the NTSB recommended AAMVA encourage states to (1) require developers to submit an application for testing ADS-equipped vehicles that, at a minimum, details a plan to manage the risk associated with crashes and operator inattentiveness and establish countermeasures to prevent crashes or mitigate crash severity within the ADS testing parameters, and (2) establish a task group of experts to evaluate the application before granting a testing permit. Consistent with this recommendation to AAMVA, the State of Connecticut should consider including the requirement for a detailed safety plan and a task group evaluation of the plan as part of any application for participation in the proposed pilot testing program.

The state can also learn a lot about the safety management controls of an AV developer by reviewing the company's safety self-assessment plan. These plans are recommended, but not required, by the National Highway Traffic Safety Administration (NHTSA). In *NHTSA 2017 Automated Driving System 2.0: A Vision for Safety*, the self-assessment is described as a means for AV developers to demonstrate to the public and States that testers are: (1) considering the safety aspects of ADSs; (2) communicating and collaborating with DOT; (3) encouraging the self-establishment of industry safety norms for ADSs; and (4) building public trust, acceptance, and confidence through transparent testing and deployment of ADSs. The NHTSA guidance describes 12 key ADS safety elements (outlined in the Appendix 1) that the NTSB believes states should examine when reviewing self-assessment plans submitted by AV testers. **These are the safeguards that should be included in HB 6486.**

A vigorous oversight program is necessary in order to ensure an ADS pilot testing program can be safely administered. This oversight should include a requirement that ADS testers submit a robust safety plan as part of the application process, a review program through which a task force of experts review the plan, and a thorough assessment of the ADS developer's ability to achieve an acceptable level of fulfillment of the 12 key ADS safety elements.

Thank you again for providing an opportunity to provide this statement on these important issues. I would be happy to provide additional information in response to any questions that the committee might have.

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Appendix 1 – State Review of 12 ADS Safety Elements

1) **System safety:** ADS developers should follow a robust design and validation process based on a systems-engineering approach with the goal of designing ADSs free of unreasonable safety risks. Design decisions should be linked to the assessed risks that could impact safety-critical system functionality. Design safety considerations should include design architecture, sensors, actuators, communication failure, potential software errors, reliability, potential inadequate control, undesirable control actions, potential collisions with environmental objects and other road users, potential collisions that could be caused by actions of an ADS, leaving the roadway, loss of traction or stability, and violation of traffic laws and deviations from normal (expected) driving practices. Additionally, all design decisions should be tested, validated, and verified as individual subsystems and as part of the entire vehicle architecture. ADS developers should document the entire process; all actions, changes, design choices, analyses, associated testing, and data should be traceable and transparent.

2) **Operational design domain (ODD):** ADS testers should define and document the ODD for each ADS available on their vehicle(s) as tested for use on public roadways, as well as document the process and procedure for assessment, testing, and validation of ADS functionality within the prescribed ODD. The ODD should describe the specific conditions under which a given ADS or feature is intended to function. The ODD is the definition of where (such as what roadway types and speeds) and when (under what conditions, such as day/night, weather limits, etc.) an ADS is designed to operate.

3) **Object event detection and response (OEDR):** OEDR refers to the detection by the driver or ADS of any circumstance that is relevant to the immediate driving task, as well as the implementation of the appropriate driver or system response to such circumstance. The ADS is responsible for performing OEDR while it is engaged and operating in its defined ODD. ADS testers should have a documented process for assessment, testing, and validation of their ADS's OEDR capabilities. When operating within its ODD, an ADS's OEDR functions are expected to be able to detect and respond to other vehicles (in and out of its travel path), pedestrians, bicyclists, animals, and objects that could affect safe operation of the vehicle. An ADS's OEDR should also include the ability to address a wide variety of foreseeable encounters, including emergency vehicles, temporary work zones, and other unusual conditions (e.g., police manually directing traffic or other first responders or construction workers controlling traffic) that may impact the safe operation of an ADS.

4) **Fallback (minimal risk condition):** ADS should have a documented process for transitioning to a minimal risk condition when a problem is encountered or the ADS cannot operate safely.[3] ADSs operating on a highway should be capable of detecting that the ADS has malfunctioned, is operating in a degraded state, or is operating outside of the ODD. Furthermore, ADSs should be able to notify the human driver of such events in a way that enables the driver to regain proper control of the vehicle or allows the ADS to return to a minimal risk condition independently. Fallback strategies should take into account that, despite laws and regulations to the contrary, human drivers may be inattentive, under the influence of alcohol or other substances, drowsy, or otherwise impaired. ADS developers should have a documented process for assessment, testing, and validation of their fallback approaches.

5) **Validation methods:** Validation methods are needed to appropriately mitigate the safety risks associated with ADS operation. Validation tests should demonstrate the behavioral competencies an ADS would be expected to perform during normal operation, the ADS's performance during crash avoidance situations, and the performance of fallback strategies relevant to the ADS's ODD. To demonstrate the expected performance of an ADS for deployment on public roads, validation test approaches may include a combination of simulation and test track testing.

6) **Human machine interface (HMI):** HMI refers to the interaction between the vehicle and the driver (operator). ADSs involve complex HMI concerns because in many instances, an operator must be receptive to a request by the ADS to take back driving responsibilities. However, an operator's ability to do so is limited by their capacity to stay alert to the automation monitoring task. ADS developers must consider incorporating driver engagement monitoring in cases where operators could be involved in the driving task. ADS testers should also have a process for assessment, testing, and validation of the vehicle's HMI design. At a minimum, the ADS should be capable of informing the human operator of the system status through various indicators that the ADS is functioning properly; currently engaged in ADS mode; currently "unavailable" for use; experiencing a malfunction; and/or requesting control transition from the ADS to the operator.

7) **Vehicle cybersecurity:** ADS developers should design their ADSs following established best practices for cyber vehicle physical systems. This includes documentation regarding how they incorporated vehicle cybersecurity considerations into ADSs, including all

[3] "Minimal risk condition" means low-risk operating condition that an ADS automatically resorts to either when a system fails or when the human driver fails to respond appropriately to a request to take over the dynamic driving task.

actions, changes, design choices, analyses, and associated testing, and ensure that data is traceable within a robust document version control environment.

8) **Crashworthiness:** Regardless of whether the ADS is operating the vehicle, or the vehicle is being driven by a human driver, the occupant protection system should maintain its intended performance level in the event of a crash. ADS developers should incorporate information from the advanced sensing technologies needed for ADS operation into new occupant protection systems that provide enhanced protection to occupants of all ages and sizes. In addition to the seating configurations evaluated in current standards, ADS testers should evaluate and consider additional countermeasures that will protect all occupants in any alternative planned seating or interior configurations during use.

9) **Post-crash ADS behavior:** ADS developers engaging in testing or deployment should consider methods of returning ADSs to a safe state immediately after being involved in a crash. Depending upon the severity of the crash, actions such as shutting off the fuel pump, removing motive power, moving the vehicle to a safe position off the roadway (or safest place available), disengaging electrical power, and other actions that would assist the ADSs should be considered. If communications with an operations center, collision notification center, or vehicle communications technology exist, relevant data should be communicated and shared to help reduce the harm resulting from the crash.

10) **Data recording:** ADS developers engaging in testing or deployment should establish a documented process for testing, validating, and collecting necessary data related to the occurrence of malfunctions, degradations, or failures in a way that can be used to establish the cause of any crash. For crash reconstruction purposes (including during testing), ADS data should be stored, maintained, and readily available for retrieval. Vehicles should record, at a minimum, all available information relevant to the crash, so that the circumstances of the crash can be reconstructed. These data should also contain the status of the ADS and whether the ADS or the human driver was in control of the vehicle leading up to, during, and immediately following a crash. ADS developers should have the technical and legal capability to share with government authorities the recorded information as necessary for crash reconstruction purposes.

11) **Consumer education and training:** Education and training from developers is important in helping the public differentiate between the use and operation of an ADS and conventional vehicles. Education programs should cover topics such as ADSs' functional intent, operational parameters, system capabilities and limitations, engagement/ disengagement methods, HMI, emergency fallback scenarios, operational design domain parameters (i.e., limitations), and mechanisms that could alter ADS behavior while in service. Education programs should include explicit information on what the ADS is capable and not capable of in an effort to minimize potential risks from user system abuse or misunderstanding.

12) **Compliance with Federal, State, and local laws:** ADS developers should document how they intend to account for all applicable Federal, State, and local laws in the design and testing of ADSs. Based on the operational design domain(s), the development of ADSs should account for all governing traffic laws when operating in automated mode for the region of operation. In certain safety-critical situations (such as having to cross double lines on the roadway to travel safely past a broken-down vehicle on the road) human drivers may temporarily violate certain State motor vehicle driving laws. It is expected that ADSs have the capability of handling such foreseeable events safely; ADS developers should have a documented process for independent assessment, testing, and validation of such plausible scenarios. Given that laws and regulations will inevitably change over time, ADS developers should have processes to update and adapt ADSs to address new or revised legal requirements.