National Transportation Safety Board

Office of the Chair

Washington, DC 20594

October 18, 2022

Dockets Operations
US Department of Transportation
1200 New Jersey Avenue SE
West Building Ground Floor
Room W12–140
Washington, DC 20590-0001

Re: Docket Number DOT-OST-2022–0096

Dear Sir or Madam:

The National Transportation Safety Board (NTSB) has reviewed the Department of Transportation (DOT) request for information (RFI) titled "Enhancing the Safety of Vulnerable Road Users at Intersections," published at 87 *Federal Register* 57019 on September 16, 2022. The DOT is interested in receiving comments on the feasibility of adapting existing and emerging automation technologies to accelerate the development and deployment of an intersection safety warning system for both vulnerable road users (VRUs) and drivers.[1] The intention of the RFI is to ascertain the state of the art of relevant automation technologies as well as the potential for repurposing existing and emerging technologies for intersection safety applications. The conceptual design for the intersection safety system would include the following design elements: sensing and perception, sensor fusion, image and data analysis, path planning and prediction, data handling and storage, communications and networking, and a warning system for vehicles and VRUs.

The NTSB supports this information collection effort. We believe it is important that the DOT develop a strong safety foundation for automation technologies before these systems are repurposed for intersection safety applications. The foundation should include sensible safeguards, oversight, and minimum performance standards for automated vehicles to ensure the safety of motorists and VRUs. There is also a need to provide regulatory certainty by resolving critical issues related to vehicle-to-everything (V2X) communication protocols; harmful interference from unlicensed

[1] For the purposes of the RFI, automation technologies are considered to include but are not limited to advanced driver assistance systems (ADAS), automated driving systems (ADS), and associated connected technologies (i.e., vehicle-to-everything, vehicle-to-vehicle, vehicle-to-infrastructure, and vehicle-to-pedestrian).

devices, such as those that use wi-fi; and sufficiency of the communication spectrum needed for advanced connected vehicle applications.

The RFI specifically asks for comments on 27 questions related to General Technical Considerations, System Installation and Deployment, Human Factors and Performance Measurement, and Development Costs and Time to Deployment. The NTSB's response is not specific to each question but rather focuses on the foundational safety measures needed before the conceptual intersection safety and warning system can become a reality. Our response first addresses the importance of protecting VRUs through a Safe System Approach. Next, we cover the safeguards needed for automated vehicle deployment as well as the importance of regulatory certainty for nationwide V2X deployment. Finally, we discuss intersection safety strategies that should be implemented in the short term while automated intersection safety and warning systems may not be practical.

Protecting Vulnerable Road Users Through a Safe System Approach

The NTSB actively advocates for a Safe System Approach that aims to eliminate fatal and serious injuries for all road users.[2] The approach does so through a holistic view of the road system that accepts the fact that drivers and VRUs sometimes make poor decisions and errors; this approach identifies methods to reduce or eliminate the consequences of these errors. Unlike motor vehicle users, VRUs lack an external structure to protect them when crashes occur, and they are more likely to suffer a serious injury or even death. Proven, effective countermeasures are being underused at the federal, state, and local levels to protect pedestrians, bicyclists, and motorcyclists. In 2018 and 2019, we published three reports on the risks to these vulnerable populations and issued more than 30 safety recommendations focused on reducing VRU traffic deaths. The foundational technologies and safety recommendations relevant to this RFI are described below.[3]

- **Pedestrian Safety**: In 2018, the NTSB published a special investigation report on pedestrian safety in which we determined that automated pedestrian safety systems can identify vehicle–pedestrian conflicts in a vehicle's forward path and respond by warning the driver or engaging automatic emergency braking.[4] In addition to independent systems that use camera sensors and computers to assess the driving environment, systems are under development that use heat-sensing technology to detect pedestrians who are not visible because of

[2] Refer to The Safe System Approach (ntsb.gov).

[3] Use the NTSB's CAROL Query to search for additional information on NTSB investigations and recommendations. The CAROL Query tool also provides correspondence and justification for the classification of recommendations.

[4] National Transportation Safety Board, *Pedestrian Safety,* SIR -18/03 (Washington, DC: NTSB, 2018).

obstructions. Another approach discussed in our pedestrian report involves the use of connected vehicle technology. Vehicle-to-pedestrian connected vehicle systems use wireless technology such as cell phones to alert drivers of the presence of pedestrians via dedicated communication systems. Although these systems show great promise, we determined that, for systems to be evaluated and compared, a standard set of test conditions is needed to rate their performance. Consequently, we recommended that the National Highway Traffic Safety Administration (NHTSA) develop performance test criteria for manufacturers to use in evaluating the extent to which automated pedestrian safety systems will prevent or mitigate pedestrian injury (Safety Recommendation H-18-42, currently classified "Open—Acceptable Response"). Additionally, we recommended that NHTSA incorporate such systems into the New Car Assessment Program (NCAP) to improve decision-making related to pedestrian safety (Safety Recommendation H-18-43, currently classified "Open—Unacceptable Response" due to NHTSA's inaction to upgrade the NCAP).

- **Motorcycle Safety:** In 2018, the NTSB published a safety report on risk factors associated with motorcycle crashes and determined that vehicle collision avoidance technologies could reduce the frequency of crashes involving motorcyclists.[5] Through our research, we determined that many high-risk traffic situations between motorcycles and other motor vehicles could be prevented if vehicle drivers were better able to detect and anticipate the presence of a motorcycle when entering or crossing a road, making a turn, or changing lanes. Furthermore, we found that vehicle-based crash warning and prevention systems will be most effective at preventing collisions when they can reliably detect all vehicle types, including motorcycles. Therefore, we recommended that NHTSA incorporate motorcycles in the development of performance standards for passenger vehicle crash warning and prevention systems (Safety Recommendation H-18-29, currently classified "Open—Acceptable Response"). In our examination of other technologies that could prevent motorcycle crashes, we determined that the development of connected vehicles and infrastructure technologies has been focused primarily on passenger vehicles, with limited attention to the detection of motorcyclists. Subsequently, we recommended that NHTSA incorporate motorcycles in the development of performance standards for connected vehicle-to-vehicle systems (Safety Recommendation H-18-30, currently classified "Open—Acceptable Response"). We also recommended that NHTSA work with the Federal Highway Administration (FHWA) to incorporate motorcycles in the development of performance standards for connected vehicle-to-infrastructure

[5] National Transportation Safety Board, *Select Risk Factors Associated with Causes of Motorcycle Crashes,* SR-18/01 (Washington, DC: NTSB, 2018).

systems (Safety Recommendation H-18-31, currently classified "Open—Acceptable Response").

- **Bicycle Safety:** In 2019, the NTSB published a safety study on bicyclist safety that found vehicle collision avoidance technologies could reduce the frequency of crashes with bicyclists.[6] We determined that collision avoidance technologies could be modified to detect bicycles, which would likely reduce the incidence of collisions with bicycles and mitigate injuries caused by collisions when they occur. However, many in-vehicle collision avoidance and mitigation systems do not reliably detect bicycles. As a result, we recommended that NHTSA incorporate tests into the NCAP to evaluate a car's ability to avoid crashes with bicycles (Safety Recommendation H-19-36, currently classified "Open—Unacceptable Response" due to NHTSA's inaction to upgrade the NCAP). We also determined that connected vehicle technologies could be modified to detect bicycles. We recommended that NHTSA, in collaboration with the DOT's Intelligent Transportation Systems Joint Program Office and the FHWA, expand vehicle-to-pedestrian research efforts to ensure that bicyclists and other VRUs will be incorporated into the safe deployment of connected vehicle systems (Safety Recommendation H-19-37, currently classified "Open—Acceptable Response").

In summary, improving safety for pedestrians, bicyclists, motorcyclists, and other VRUs within the roadway environment is of critical importance. Before existing and emerging automation technologies can be repurposed for the development of a robust intersection safety and warning system, the DOT should address the numerous outstanding NTSB safety recommendations that focus on the foundational building blocks needed to ensure the safety of VRUs.

Safeguards Needed for Automated Vehicle Deployment

We believe that it will be possible to adapt existing and emerging automation technologies to develop a future intersection and safety warning system. However, it is vitally important that the DOT establish adequate safeguards to ensure that automated vehicles can only operate in their intended operational design domain (ODD), establish a robust driver monitoring system to ensure the operator is adequately monitoring automation controls, and only permit testing of automation if an in-depth safety assessment is conducted prior to operation.[7] These safeguards are

[6] National Transportation Safety Board, *Bicyclist Safety on US Roadways: Crash Risks and Countermeasures*, SS-19/01 (Washington, DC: NTSB, 2019).

[7] ODD refers to the conditions in which the automation system is intended to operate. Examples of such conditions include roadway type, geographic location, clear roadway markings, weather conditions, speed range, lighting conditions, and other manufacturer-defined system performance criteria or constraints.

essential for protecting the safety of all road users, including VRUs who do not have the benefit of an external structure when crashes occur.

In the RFI, the DOT describes the considerable development efforts in vehicle automation technologies, including in the areas of machine vision, perception and sensing, V2X communications, sensor fusion, image and data analysis, artificial intelligence, path planning, and real-time decision-making on board vehicles. Although the NTSB is cautiously optimistic about the promise of these new technologies, we have identified numerous shortfalls in the testing and development of both automated driving systems (ADS) and advanced driver assistance systems (ADAS) that warrant concern. Before existing and developing automated technologies can be used in more complex operating environments, many of the safety deficiencies identified below must be resolved.

- **Safety Improvements Needed for ADAS-equipped Vehicles:** Between May 2016 and March 2019, the NTSB investigated four crashes—three resulting in fatalities—that involved ADAS-equipped vehicles operating in partial automation mode.[8] Investigations of these crashes identified numerous areas of concern. Two specific areas that require immediate attention include (1) use of automation systems outside the conditions the system was designed for and intended to be operated in, and (2) ineffective driver monitoring systems that do not ensure drivers remain engaged.

  Today's partial driving automation systems can assess a vehicle's location and the roadway type or classification, as well as determine whether the roadway is appropriate to the system's ODD. After a crash in Williston, Florida, that involved a driver operating outside the manufacturer's ODD in a vehicle with a partial automation driving system, the NTSB recommended that NHTSA develop a method to verify that manufacturers of vehicles equipped with partial vehicle automation systems incorporate system safeguards that limit the use of automated vehicle control systems to the conditions for which they were designed (Safety Recommendation H-17-38, currently classified "Open—Unacceptable Response" due to NHTSA's inaction to address this recommendation).

  Because driver attention is an integral component of lower-level automation systems, a driver monitoring system must be able to assess whether and to what degree the driver is engaged in the driving task. As highlighted by our recent investigations, drivers can disengage for prolonged periods of time without warning or intervention by the vehicle. In the United States, no minimum performance standards exist for the appropriate

[8] Refer to the NTSB's reports on crashes in Williston, Florida (HAR-17/02); Culver City, California (HAB-19/07); Delray Beach, Florida (HAB-20/01); and Mountain View, California (HAR-20/01).

timing of alerts, type of alert (visual, auditory, or haptic [touch]), or use of redundant monitoring sensors to ensure driver engagement. As a result, the NTSB recommended that NHTSA work with SAE International to develop performance standards for driver monitoring systems that will minimize driver disengagement, prevent automation complacency, and account for misuse of automation. We further recommended that NHTSA, after developing the performance standards for driver monitoring systems, require that all new passenger vehicles with Level 2 automation be equipped with a driver monitoring system that meets these standards (Safety Recommendations H-20-3 and -4, currently classified "Open—Acceptable Response").

- **Safety Improvements Needed for ADS:** The NTSB sees potential in the ability of ADS to mitigate or prevent crashes on our roadways. Unfortunately, there has been an absence of safety regulations and federal guidance on how to evaluate an ADS. Although the DOT has published multiple iterations of automated vehicle guidance, it provides insufficient instructions for how ADS developers should accomplish the safety goals of the 12 ADS safety elements—for example, training vehicle operators, ensuring oversight, or evaluating whether an ADS has reached a level of safety functionality.[9]

In our investigation of a fatal crash involving a developmental ADS vehicle in Tempe, Arizona, we found significant deficiencies in the ADS developer's management of safety risk, as well as in the federal and state oversight of ADS testing.[10] As a result, we recommended that NHTSA require the submission of voluntary safety self-assessment reports and establish an ongoing process for evaluating them in order to determine whether appropriate safeguards—such as adequate monitoring of vehicle operator engagement, if applicable—are included for testing a developmental ADS on public roads (Safety Recommendations H-19-47 and -48, currently classified "Open—Unacceptable Response" due to NHTSA's reliance on a voluntary approach to safe ADS usage rather than a mandatory safety assessment prior to beginning ADS testing).

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[9] Refer to the 2016 Federal Automated Vehicle Policy – Accelerating the Next Revolution in Roadway Safety, 2017 Automated Driving System 2.0: A Vision for Safety, and 2018 Preparing for the Future of Transportation: Automated Vehicle 3.0. The 12 safety elements described in ADS 2.0 are as follows: system safety, operational design domain, object event detection and response, fallback (minimal risk condition), validation methods, human machine interface, vehicle cybersecurity, crashworthiness, postcrash ADS behavior, data recording, consumer education and training, and federal/state/local laws.

[10] National Transportation Safety Board, *Collision Between Vehicle Controlled by Developmental Automated Driving System and Pedestrian, Tempe, Arizona, March 18, 2018*, HAR-19/03. (Washington, DC: NTSB, 2019).

In the absence of minimum federal ADS safety standards, states have begun legislating requirements for automated vehicle testing, resulting in a patchwork of laws and state-level requirements. States that have no, or only minimal, requirements related to automated vehicle testing can improve the safety of such testing by implementing a thorough application and review process before granting testing permits. Because states would benefit from adopting regulations that require a thorough review of ADS developers' safety plans, including methods of risk management, we have recommended that the American Association of Motor Vehicle Administrators encourage states to 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 establishes countermeasures to prevent crashes or mitigate crash severity within ADS testing parameters (Safety Recommendation H-19-51, classified "Closed—Acceptable Action").

Regulatory Certainty Needed for Nationwide Vehicle-to-Everything Deployment

Connected vehicle technology (V2X communications) will likely play a pivotal role in any future intersection safety and warning system where vehicles communicate with both infrastructure and VRUs.[11] V2X provides supplemental information in areas that are challenging for sensors installed on vehicles (vehicle-resident sensors). Specifically, V2X systems are not limited by line-of-sight and therefore are not affected by curves, visibility, or crash scenarios that are challenging for vehicle-resident sensors to detect. V2X communications can also provide information about a threat much earlier than radar or camera sensors can detect the threat, giving drivers more time and a better opportunity to avoid a crash. Further, V2X communications also provide a complementary source of information to vehicle-resident systems; improve the reliability, accuracy, and redundancy of data; extend the range of hazard detection; and detect crash risks that are outside a vehicle-resident sensor's field of view.

In 2013, during its investigation of a collision between a school bus and a truck with a fully loaded dump container at an intersection near Chesterfield, New Jersey, the NTSB found that connected vehicle technology could have provided an active warning to the school bus driver of the approaching truck and possibly prevented the crash.[12] As a result, the NTSB recommended that NHTSA develop minimum performance standards for connected vehicle technology for all highway vehicles, and once these are developed, require the technology to be installed on all newly manufactured highway vehicles (Safety Recommendations H-13-30 and -31, currently

[11] Refer to V2X: Preserving the Future of Connected Vehicle Technology (ntsb.gov) and Require Collision-Avoidance and Connected-Vehicle Technologies on all Vehicles (ntsb.gov)

[12] National Transportation Safety Board, *School Bus and Truck Collision at Intersection Near Chesterfield, New Jersey, February 16, 2012*, HAR-13/01 (Washington, DC: NTSB, 2013).

classified "Open—Unacceptable Response" due to NHTSA's inaction to address these recommendations). Since the NTSB issued these recommendations nearly a decade ago, NHTSA has failed to move forward and issue a rule, and industry progress in deploying the technology has been slow and hampered by regulatory uncertainty including recent regulatory actions by the Federal Communications Commission (FCC).

In May 2021, the FCC finalized a ruling that decreased the communication spectrum allocated to V2X by 60 percent and introduced potentially harmful interference by allowing unlicensed wi-fi devices to operate in surrounding communication bands.[13] In January 2022, in an effort to better understand the impact of the FCC's recent actions to reduce the spectrum available for transportation safety, the NTSB interviewed stakeholders affected by the FCC's rule change from government, industry, and academia about the safety benefits and maturity level of V2X technology and the reasons for the delayed deployment of the technology. During the in-depth discussions with experts, the following three critical hurdles were identified as preventing the broad deployment of V2X: sufficiency of spectrum for advanced V2X applications, potential for harmful interference from unlicensed devices, and regulatory uncertainty.

It is imperative that the DOT take a prominent leadership role to ensure an optimal environment for V2X deployment. Leadership is needed to establish regulatory certainty and resolve critical issues related to V2X communication protocols. In 2022, following the completion of an investigation into a multi-fatality commercial vehicle crash in Mt. Pleasant Township, Pennsylvania, we recommended that the DOT implement a plan for nationwide connected vehicle technology deployment that (1) resolves issues related to interference from unlicensed devices, such as those that use wi-fi; (2) ensures sufficient spectrum necessary for advanced connected vehicle applications; and (3) defines communication protocols to be used in future connected vehicle deployment (Safety Recommendation H-22-1, currently classified "Open—Await Response").[14]

Intersection Safety Strategies: Incorporating a Safe System Approach

The DOT has expressed interest in developing an intersection safety and warning system that will facilitate the deployment of the systems at scale. In the RFI, the DOT acknowledges that this conceptual system would likely cost hundreds of thousands of dollars per roadway intersection and states that it is "imperative to reduce the cost of providing advanced safety systems that can ensure the safety of all road users at intersections." Many of the specific questions in the RFI query

[13] *Federal Register 86* (May 3, 2021): 23281.

[14] National Transportation Safety Board, *Multivehicle Crash Near Mt. Pleasant Township, Pennsylvania, January 5, 2020*, HIR-22/01 (Washington, DC: NTSB, 2022).

stakeholders on potential cost-reduction strategies, what proportion of intersections would be suitable for such a system, and how such a system could be adapted for use in rural areas.

The NTSB has investigated numerous crashes at intersections, including those in rural areas. In July 2016, we investigated an intersection crash in St. Marks, Florida, involving a truck-tractor semitrailer combination vehicle that collided with a bus transporting agricultural workers.[15] The crash resulted in 4 fatalities and 30 injuries. In the investigation, we determined that crashes at unsignalized intersections are a national problem, with most fatal crashes occurring at intersections that are not under the control of a traffic signal. Although this was a vehicle-to-vehicle collision, it highlighted the need for a practical approach to improving intersection safety for all roadway users, including VRUs.

In the report of the investigation, we described how a Safe System Approach that incorporates the systemic application of multiple low-cost countermeasures can be effective in reducing fatalities, injuries, and crashes at intersections. This approach to intersection safety may include, for example, the placement of enhanced signage and pavement markings at multiple unsignalized intersections to increase driver awareness and recognition of potential conflicts. The systemic approach has three components: analyze systemwide data to identify the problem; look for similar risk factors in severe crashes; and deploy large-scale, low-cost countermeasures that address the risk factors. To increase the recognition of the crash problem at unsignalized intersections, we made a recommendation to nine transportation safety organizations to inform their members of the prevalence of fatal crashes and serious injuries at unsignalized intersections, encourage them to use a Safe System Approach that incorporates the systemic application of roadway engineering countermeasures, and increase their awareness of available resources to reduce intersection crashes (Safety Recommendation H-17-66, classified "Open—Await Response" overall, with three transportation safety organizations receiving a "Closed—Acceptable Action" classification).

It is unrealistic to expect that a substantial number of intersections will be outfitted with a robust intersection safety and warning system in the near term. Therefore, we encourage the DOT and the FHWA to continue to fund and support proven low-cost safety improvements at intersections using the Safe System Approach until a system is developed that leverages automation technologies. The DOT can use knowledge obtained from its decades of research on intelligent intersection systems to widely deploy existing countermeasures that can address some aspects of the intersection safety problem, such as red light running.

[15] National Transportation Safety Board, *Agricultural Labor Bus and Truck-Tractor Collision at US-98–SR-363 Intersection Near St. Marks, Florida, July 2, 2016*, HAR-17/05 (Washington, DC: NTSB, 2017).

Deployment of effective and proven countermeasures should not be delayed until a system that addresses all intersection safety issues is available.

Summary

In conclusion, the NTSB supports the DOT's initiative to develop an intersection safety system that will improve the safety of pedestrians, bicyclists, and other VRUs. In this response we have highlighted some of the foundational safety issues that require resolution before an effective intersection safety system can be widely deployed. This includes the need for performance standards for many of the underlying collision avoidance technologies and the need for improved oversight of the testing of automated vehicles. Additionally, because connected vehicle technologies will likely be needed for communications between motorists, VRUs, and infrastructure, the DOT must take a leadership role to ensure that a safe and secure communication network is available. Finally, the DOT should continue to fully support the large-scale deployment of low-cost countermeasures at intersections using the Safe System Approach until an automated system can be implemented.

Thank you for the opportunity to provide comments.

Sincerely,

Jennifer Homendy
Chair