USDOT,

Safety is the most significant factor of societal acceptance of AV, and by extension, a gating factor for continued sustainable investment and technology leadership in this area. It is commonly accepted by the industry that AVs must be tested for 100s millions of miles for confirming that their safety is comparable to that of human drivers. Such testing is needed after each engineering revision. When issues are discovered, additional revisions are needed, and re-testing is required. This iterative process is common in all modern engineering practices. Consequently, it is clear that bringing a **safe AV** to market would **require the equivalent of billions of miles of testing**.

There is no dispute that such testing is not practical using physical test track or road testing alone. The vast majority of these tests must be conducted virtually. Clearly, gaining driving experience through simulated accidents **is desirable**, whereas gaining such experience with physical accidents **is not**. Nevertheless, neither government nor industry are seriously committed to development of the technology, and skill sets, to render results of virtual testing reliable and certifiable.

To illustrate the major gap between perception and reality in the safety engineering industry, consider the fatal crash statistics reported by DOT HS 810 767 and DOT HS 811 731. **Less than 1% of the fatal accidents are attributed to vehicle failures currently addressed by the safety industry and standards such as ISO 26262 and FMVSS 100 series; the remaining 99% are beyond the scope of state of the art of safety engineering practices**. In other words, the safety engineering profession today has technology, and is trained, for addressing less than 1% of the AV safety challenges. **Breaking out of this quandary requires government involvement.**

There is an **urgent need** to initiate serious work on extending the safety engineering technology and profession to address the 99%. More than 70% of that gap requires testing billions of multi-vehicle and multi-agent scenarios. Thus, it is imperative to upgrade safety engineering skills, standards and regulation to focus on **statistical multi-agent testing**. This would require virtual testing and validation. It would also require augmenting the skills of traditional safety engineers with **the data science and experimental design skills required to conduct and interpret tests across billions of scenarios**.

As an example, there is **an opportunity for the government to initiate a discussion on the nature of a "Prototypical Safety Cases for Autonomous Vehicle"**. It is important to build on the vast knowledge about safety case argumentation, acquired over decades and is well understood and trusted in many safety critical industries, including aviation and industrial plants. Such prototypical safety cases must include **trustworthy statistical argumentation for the safety of systems which leverage AI (Artificial Intelligence) components, and are non-deterministic**.

To illustrate one challenge, consider the reliability gap between the components of the system and the overall system performance requirements. Whereas the individual AI components within the system have at least a 1% error rate for interpreting each sensor capture, we expect to be able to drive millions of miles between minor accidents. Considering that driving a single mile requires thousands of such sensor data captures, **we are expecting the system performance to be billions of times more reliable than its components**. Current state of the art engineering practices do not provide the technology and skills to bridge that reliability gap.

There is an immense body of data science knowledge which enables the development of statistical safety case argumentation, supported by simulation. AV developers would invest in simulation-based statistical safety case argumentation technology only if it will advance the societal acceptance of their product. Tool vendors find it hard to develop such technologies without support from paying customers. Society is therefore rightfully skeptical (at best) of the ability of the manufacturers and their vendors to provide trustworthy safe AVs.

The government has a significant impact societal acceptance of virtual testing by igniting the interest in development of a simulation-based prototypical safety cases. It can facilitate broad public education for the need and the applicable technology. It can adapt the regulatory environment to accept simulation-based argumentation, provided that the manufacturer is able to provide trustworthy proof that simulation results do correlate with physical behaviors of their product in an uncertain multi-agent environment. NHTSA and TRB can direct some of their research activities towards this area, educate the public about the results, and leverage lessons learned to inform the regulatory framework.

In summary, there is a need for the government to unlock the “fear of certification by simulation” by catalyzing activity in the area and leverage results to inform the regulatory framework.

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