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Framework for Assessing Potential Safety Impacts of Automated Driving Systems

Quickly advancing automated driving system (ADS) technologies (typically, SAE automation Levels 3 through 5) are expected to positively affect transportation safety. ADS includes a plethora of applications that affect safety, mobility, human factors, and environmental aspects of driving. One anticipated disruption is the type of ADS-related crash (both in likelihood and severity) when compared to traditional vehicle crashes. For example, unlike human drivers, ADSs are projected to have a lower probability of certain crashes in traffic due to lower susceptibility to performance issues a human operator may face (distracted driving, drowsiness, etc.). While ADSs have the potential to improve safety, humans still have advantages in certain roadway conditions, such as operating on roads with degraded lane markings and during adverse weather (e.g., heavy rain, snow, ice), two conditions with which the ADS has challenges.

Technical Background

This section provides the technical background needed for subsequent discussions.

Dynamic Driving Task (DDT): Includes all real-time operational and tactical functions to operate a vehicle in on-road traffic, excluding the strategic functions (e.g., trip scheduling, selection of destinations and waypoints) and including the following (SAE, 2018):

A. Lateral vehicle motion control via steering.
B. Longitudinal vehicle motion control via acceleration and deceleration.
C. Monitoring the driving environment via object and event detection, recognition, classification, and response preparation.
D. Object and event response execution.
E. Maneuver planning.
F. Enhancing conspicuity via lighting, signaling, gesturing, etc.

Automated Driving System (ADS): The hardware and software that are collectively capable of performing the entire DDT on a sustained basis. This term is used specifically to describe a Level 3, 4, or 5 driving automation system (SAE, 2018). The different levels of automation are described in Figure 5 in chapter 2.

Operational Design Domain (ODD): Operating conditions under which a given driving automation system or feature is specifically designed to function, including environmental, geographical, and time-of-day restrictions, and/or the requisite presence or absence of certain traffic or roadway characteristics (SAE, 2018). ODD is typically defined by the ADS technology developer and original equipment manufacturer (OEM). More details on the ODD are provided in Chapter 3, Overview of the Framework Elements.

DDT Fallback: This occurs when the ADS is unable to continue to perform the entire DDT (i.e., under normal operating conditions). For Level 3 ADS features, the human fallback-ready user is expected to respond to a request to intervene by either resuming manual driving if the vehicle remains drivable or achieving a minimal risk condition if the vehicle is not drivable. For a Level 4 or 5 ADS, the feature or system performs the fallback by automatically achieving a minimal risk condition (SAE, 2018).

Radio Detection and Ranging (Radar): Radar is a range-finding technology that supports perception. Radars operate by transmitting a radio signal toward a region of interest and detecting the signals reflected back from objects within the field of view. Radar is a popular choice for automated vehicles (AVs) because it is relatively inexpensive and robust (Patole et al., 2017).

Light Detection and Ranging (Lidar): Lidar is a subset of radar and has been growing as a key enabling technology for AVs. Lidar allows generation of high-definition (HD), three-dimensional (3D) maps by sending and receiving high-frequency radar. Lidar works similar to radar: it transmits a wave (in this case, light) and detects the reflected light pulse from an object within the detectable region. Lidar has a much higher resolution and frequency (900–1,500-nm wavelengths) (Yole Développement, 2015).