HUMAN FACTORS and ERGONOMICS SOCIETY

Policy Statement: Autonomous and Semi-Autonomous Vehicles (2.0)

February 2022

Automated driving technologies should be designed and tested to address human performance issues before being introduced onto public roads. The expectation that automated driving systems will necessarily enhance safety fails to consider the significant effect these systems have on human performance. Even when designed with the best intentions, automated driving technologies affect human performance in ways that could negate the potential benefits. The human performance issues that automated driving technologies could introduce include loss of driver engagement and low situation awareness, poor understanding of and overreliance on automated systems, and loss of manual skills needed for performance and decision-making. As policymakers seek to create policies and a regulatory framework for the governance of these vehicles, HFES therefore endorses the following policy positions for the development and fielding of semi-automated and automated vehicles (AV) across SAE levels 2-5 (SAE J3016).

A. Broad Integration of Human Factors in the Approval and Testing Process

1) ***Personnel identified to evaluate or research AV safety (e.g., advisory boards) should include experienced human factors, ergonomics and system safety practitioners.*** Human factors professionals should be included when legislation calls for development of committees and panels of experts. (Previous bills reference only mechanical engineering and computer science, for example.) This should include a requirement for human factors and system safety professionals who are independent from vehicle manufacturers. At a minimum, credentials should require independent experts in human-automation interaction who hold advanced degrees in human factors, engineering psychology, or a related discipline and who have a minimum of 10 years of relevant experience.

2) ***Human factors assessment should be included through all steps of design, development, and deployment***. Human factors principles should be incorporated throughout the system development lifecycle as a requirement by NHTSA. Existing DoD guidelines (e.g., Human Systems Integration assessment [DA Pam 602–2]) and FDA guidelines (e.g., FDA-2011-D-0469) provide examples of how human factors should be incorporated in the design process. Human factors assessment should be included as part of a mandatory *safety self-assessment for new AV systems*, subject to 3rd party review, based on defined performance criteria. Currently, the self-assessment report described in AV START and NHTSA's AV 1.0 and 2.0 guidance is either optional or does not affect market approval. Review personnel should include human factors professionals, specifically for system safety, human-machine interface, education and training, and the validation methods sections of the report. Minimum human-machine interface standards should include an approach for providing system transparency, (i.e., how the systems keep the driver/operator informed within a reasonable time about what the automated driving system is doing). Human factors assessments should include identification of relevant human factors issues coupled with a risk level for each, along with details on research conducted to address each issue and reduce risk. Manufacturers should provide the assessment prior to the introduction of AV technology onto public roadways, and a review of manufacturer's safety self-assessments should be a condition of approval for public use of AV technologies (which could require new NHTSA authority).

3) ***AV Readiness for human use should be evaluated and reported using the Human Readiness Level (HRL) scale.*** The HRL scale is a formal mechanism to evaluate, track, and communicate the readiness of a system for safe and effective use by its operators in a specific operational environment (ANSI/HFES 400 Standard). The HRL scale focuses on the degree to which human systems evaluation activities have been completed by the developers to demonstrate that a particular AV technology achieves the level of human readiness needed to meet desired safety and effectiveness objectives. The HRL uses a nine-level scale to evaluate, track, and communicate the readiness of a technology from early concept, through system deployment, emphasizing human-related aspects of the technology. The scale should be applied by trained and knowledgeable human systems experts to ensure that human readiness is satisfactorily addressed at each stage of the system development lifecycle. Early and proactive attention to the human element during the design process can reduce errors by drivers when AVs become operational.

4) ***Human factors guidelines for automated vehicles should be developed prior to deployment***. A collection of design guidelines for AVs should be developed in cooperation with human factors professionals. The purpose is to establish human factors design criteria that assess automated driving system performance with consideration of human capabilities and limitations to effectively and safely integrate the human driver. The guidelines would present human engineering design criteria targeting driver performance and safety and establishing design standardization across manufacturers.

5) ***Human factors testing should be required prior to deployment***. Application of human factors guidelines should be verified through testing by a 3rd party at a series of locations (e.g., existing or new "AV proving grounds"). The design, development, and testing of automated and semiautomated vehicles requires the careful assessment of human performance when operating in conjunction with such systems. Autonomous and semiautonomous driving systems must be required to pass testing that demonstrates that the combined performance of the driver and the vehicle technology is as safe as or safer than human drivers alone in a wide range of driving and weather conditions. In addition, they must be required to perform basic tasks that are currently performed by human drivers (including detection and identification of safety signage under degraded conditions, and detection and avoidance of obstacles, vehicles, cyclists, and pedestrians in a wide range of weather and visibility conditions that vehicles could reasonably encounter). For fully autonomous vehicles, testing must include at a minimum an ability to detect and safely avoid potholes, obstacles, debris, pedestrians, bicyclists, vehicles, animals, and manage other roadway conditions and hazards in both ideal and adverse weather conditions.

6) ***Automated vehicle testing on public roadways should be carefully monitored***. Manufacturers who are conducting AV development and testing on public roadways should be required to report safety events (including crashes and situations requiring driver interventions) to NHTSA for the entire period of the test. This data should be made publicly available. In the event of severe crashes, such as those resulting in injury, death, or substantial property damage, as well as collisions with emergency vehicles, safety data that could be used to reconstruct the crash event should also be provided (see section E-2). Manufacturers should be required to provide extensive driver training to "safety drivers" used for testing AVs on the capabilities of the automation, as well as instructions for remaining vigilant and for rapidly intervening. Safety drivers should be provided with displays and controls to support this role, and monitoring systems to ensure they remain vigilant and able to intervene rapidly.

7) ***"Cease and desist" authority should be granted to NHTSA*** to be enforced when AV operations create hazardous situations (as determined by NHTSA with assistance from NTSB, NASA and other agencies as needed). NHTSA requires new authority to intervene when vehicle software is found to be unsafe for advanced automation vehicles (SAE level 2 and greater).

B. Improvements to Support Consumer Understanding and Education

1) ***Manufacturers should adopt common terms*** for automated features in order to reduce consumer confusion about automation capabilities. NHTSA should publish and maintain a directory of common and consistent terms for AV capabilities.

2) ***Manufacturers should be required to provide driver training*** on the capabilities, limitations and behaviors of its automated and semi-automated systems (including the range of operational conditions the AV systems can handle) so that drivers obtain an accurate mental model required for effective oversight and interaction with them. The effectiveness of the training format and content should be evidence-based to show successful outcomes with naïve drivers. New training should be provided on any automation updates that are made over the course of the system's lifetime so that the automation's behavior remains predictable to the driver. Periodic updates to automation software (which may be provided over the internet on a frequent basis) can dramatically affect how the vehicle performs the dynamic driving task, which can affect the human operator's understanding of vehicle actions and capabilities. Steps should be taken to require follow-on training for updates that affect AV behaviors and control of the dynamic driving task.

3) ***NHTSA AV education efforts should receive increased funding***. Education and outreach about Automotive Driver Assistance Systems (ADAS) needs to reach drivers who encounter automation technologies in a variety of settings, including new and used vehicle purchases, rental companies, novice driver training, and first responders.

C. AV Design Safety Improvements

1) ***Establish AV safety requirements.*** ADAS and ADS should restrict vehicles to operations in a manner that are compliant with driving laws (except in situations that require exceptions for safety) and that is prudent for the driving conditions. This could include driving well below the speed limit, pulling over if the driving conditions are unfavorable, avoiding those who are driving erratically, and avoiding roads, merging situations, and other conditions that pose significant risk to vehicle occupants or others.

2) ***Provide driver monitoring.*** Driver monitoring systems should be required for automation that performs part of the dynamic driving task or divides control between the driver and automation (i.e., SAE Level 2 and 3). Driver monitoring systems should sense the "level of engagement" and "the awareness" of a driver and be able to provide escalating alerts to regain driver attention to the driving task. Methods for proactively maintaining driver engagement and safely managing continued driver non-compliance to engagement alerts (such as in cases where the driver is distracted or incapacitated) must be established, to include lock-out strategies and safe stop procedures (Mueller, Reagan, Cicchino, 2021).

3) ***Demonstrate safety in AV failure conditions.*** The design of semiautomated vehicles must avoid known human performance issues and provide effective mechanisms for human oversight and intervention. AV systems should be required to demonstrate equivalent or improved safety (as compared to manual driving crash rates of unimpaired drivers), across both situations where it is reliable and those where it is not (i.e., safety must be established in automation failure conditions that involve resumption of control or over-ride by human drivers). In cases of automation failure, or in situations that it cannot handle, safe transition to human control within the time available to allow accident avoidance is required. Safe transition time should take into account human decision making and maneuvering time as well as time required to overcome human vigilance

deficits that can result from the automation's reliability, robustness and co-occurrence with other automation across vehicle systems.

4) ***Establish automation reliability standards.*** Automation reliability standards and requirements for the conditions that automated vehicle systems should be able to handle should be established for each SAE level to support testing, training, and implementation approval.

5) ***Provide safe fallback states.*** Highly automated systems should include provisions for safe fallback states when the automation fails for any reason. Such fallback states should avoid stopping in a travel lane and other unsafe situations. Effective information displays and control override options for drivers should be incorporated in the design and development of fallback strategies. The vehicle should not require the human driver to perform beyond human performance limits. When the vehicle is operating with uncertainty, the vehicle should operate in a less risky manner (e.g., lower speeds). The safety of fallback states should consider the consequence of multiple vehicles seeking the same state at the same time.

D. Human-Machine Interface (HMI) Requirements

1) ***Provide safety alerts***. Automated systems introduce the need for additional information on displays and capabilities to support driver interaction and decision making. The HMI should be required to provide salient and timely alerts to drivers when manual interventions are required to maintain vehicle safety, or when transition from automated to manual driving is required.

2) ***Provide automation transparency.*** The HMI should keep the human driver or operator aware of:
    a. The automation's operating mode, intent, function and output,
    b. The automation's understanding of the environment and confidence in its assessments,
    c. Automation's projected actions,
    d. Automation reliability in current conditions,
    e. Current and imminent failures or degradation of capabilities, and
    f. If potentially unsafe modes are manually selected.

2) ***Provide automation explainability.*** Automation design should make the underlying algorithms and their behavior interpretable so that its capabilities and limits are clear to drivers, designers and policy makers.

3) ***Include the full range of drivers and other road users in automated system design and evaluation.*** Human machine interfaces should follow universal design principles that accommodate and communicate with people with disabilities (i.e., cognitive, sensory, mobility), road users across age groups (children and seniors), and diverse populations of languages, education levels and socioeconomic status both internal and external to the vehicle. External users include cyclists, pedestrians, law enforcement, and other road users.

4) ***Develop and implement requirements for remote vehicle control.*** Remote control operator interfaces for operating road vehicles should provide situation awareness of vehicle trajectories, systems and states; automation; automobile, cyclist and pedestrian traffic; and environment and road conditions equivalent to that of an in-vehicle driver, as well as the ability to avoid collisions. NHTSA should establish control, display and performance requirements for remote vehicle control.

E. Data Collection

1) ***Support law enforcement functions.*** The automation system(s) available in the vehicle should be clear to law enforcement during inspection (e.g., traffic stops, crash investigation).

2) ***Provide a 5-second data logger.*** In addition to other data elements statutorily mandated by 49 CFR 563.7, include requirements for an *automated driving system (ADS) data logger* to automatically record crash details for automated vehicles (Level 2-5) for the 5 seconds preceding a crash and made available to law enforcement via a download process that is consistent across vehicle types. Data should include:
    a. Time (in milliseconds);
    b. GPS values for the vehicle;
    c. Automation modes and mode changes;
    d. Distance to both left and right lane markings (if applicable) and confidence of those values;
    e. Track profiles (distance, vehicle type, velocity) detected by the automation for each moving and fixed object in relation to the vehicle and confidence for each measure;
    f. Video or images from all cameras;
    g. Brake signals to each wheel and accelerator signals;
    h. Ambient light sensor levels;
    i. Wiper speed if on;
    j. Ambient temperature.

About the Human Factors and Ergonomics Society (HFES)

With more than 3,500 members, HFES is the world's largest nonprofit association for human factors and ergonomics professionals. HFES members include psychologists, engineers and other professionals who have a common interest in working to develop safe, effective, and practical human use of technology, particularly in challenging settings. Members of HFES play a leading role on the development of guidelines and standards and are active in national standards organizations, such as ASTM, ANSI, NEMA, and ISO.

References

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