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Key issues for future road traffic: Human factors and automated driving

Human factors principles and procedures for automated vehicle safety – draft

Submitted by Canada

This document proposes a set of key human factors principles for the safe design of automated vehicles and provides a set of human-centred design procedures to follow when developing and evaluating automated driving systems. This document is submitted in lieu of Informal document No. 11/Rev.1 (September 2021).

1. Introduction

At the 84th Session of WP1 (Sept 2021), Canada and the WP1 chair tabled a proposal to develop a framework of key principles for automated vehicle safety and human-centred needs. The following draft principles were developed for WP1 contracting parties. The goal of the principles document is to promote human needs in the design of automated driving systems, as well as the safety policies implemented by WP1/WP29 contracting parties. This document was drafted according to input from the expert contributions in the WP.1 Human Factors Panels (2022, 2023), HF-IRADS advisory group, human factors guidelines, and industry codes of practice.

This document proposes a set of key human factors principles for the safe design of automated vehicles and provides a set of human-centred design procedures to follow when developing and evaluating automated driving systems. Following these principles and procedures will help to ensure the safety, usability, equity, and accessibility of road vehicle automation.

These principles could eventually be used to inform the development of a more formalized framework by UNECE bodies to ensure that human-centred design (HCD) is consistently applied in applicable tools and regulations developed by UNECE working parties focused on road safety and vehicle regulation.

2. Preamble

Recalling the importance of enhancing road safety and recognizing the potential impact of road vehicle automation and other innovations on global road safety,

Emphasizing that achieving global road safety targets necessitates a multifaceted strategy beyond vehicle automation and warrants a safe systems approach,

Acknowledging that while vehicle automation holds the potential to enhance road safety, the technologies will not be flawless,

Affirming that road users' well-being and safety are paramount and that safety should not be compromised for the sake of innovation,

Appreciating the necessity of evidence-based safety in the development of road transportation technologies,

Acknowledging the importance of human factors in the development of vehicle automation to advance road safety objectives and promote the safety, usability, equity, and accessibility of road transportation systems,

Reiterating that the impact of technological innovations on road safety hinges on their alignment with user needs and capabilities,

Stressing that prioritizing the human experience through human-centred design is not only conducive to safety but also supports innovation and technological advancement,

Underscoring that "human error" should be viewed as an indication of system shortcomings rather than an inherent flaw in users,

Hereby adopts this resolution to establish key human factors principles and procedures for automated vehicle safety and human-centred needs.

3. Scope and Definitions

The principles and procedures presented therein apply to vehicles (cars, vans, trucks, buses, shuttles) with SAE Level 3 – Level 5 automated driving systems.

These principles apply to vehicles that can be driven manually, by automated driving systems as well as for vehicles that users can only interact with as passengers or other road users.

Automated Driving System (ADS) - The hardware and software that are collectively capable of performing the entire dynamic driving task on a sustained basis.

Human-Centred Design (HCD) - an approach to design that focuses on the users, their needs and requirements, by applying human factors knowledge and techniques.

Human Factors - Human factors is a multidisciplinary science that applies knowledge of human abilities and limitations to the design and evaluation of technology for improved safety and usability.

4. Human Factors principles

4.1 Vehicles with automated driving systems that permit manual driving should be designed with the following principles

1. Clear and Intuitive Displays:
    a. Present information on the user interface clearly, simply, and unambiguously.
    b. Continuously display automation mode and status information when active or available.
2. User-Friendly Interaction:
    a. Ensure simple, discoverable, and easy-to-learn interaction with the ADS.
    b. Position interfaces for safe and accessible interaction.
    c. Simplify the automation mode structure, settings, and transition types to minimize confusion.
3. Communicating Urgency:
    a. Utilize combined visual, auditory or haptic cues effectively for alerts and warnings.
    b. Ensure messages convey their urgency level clearly.
4. Smooth Transition of Control:
    a. Unintentional activations and deactivations of the Automated Driving System (ADS) should not be possible.
    b. Inform fallback users of their current role, if any, and signal any changes to that role.
    c. Develop clear, simple, and direct steps for transitioning control between the ADS and human drivers.
    d. Provide fallback users with sufficient time to safely re-engage in the driving task.
    e. Monitor fallback users to verify they are available to safely resume manual driving.
    f. Use multimodal displays and escalate warnings to engage fallback users.
5. Trust and Transparency:
    a. Indicate clear user roles and responsibilities.

b. Foster appropriate trust through transparent communication of how the automation works and its limitations.

c. Ensure consistent interaction logic and driving behavior of the ADS.

d. Clearly communicate the ADS intentions and actions at all times.

6. Training and Informing about Function Limits:

a. Provide documentation and support to users for training and familiarization with safe use of the ADS.

b. Provide information to the driver about function limits that might require intervention.

c. Avoid misleading terminology and exaggerated representations of ADS capabilities.

7. Detecting Failures and Alerts:

a. Automation should detect failures and notify the user of any reduced capabilities.

b. Avoid expecting immediate user intervention during ADS driving emergencies.

c. Enable automation override or switch-off in case of automation malfunction.

d. ADS should signal when it intends to put the vehicle in a minimal risk condition.

e. Design the system to gracefully handle unexpected situations and errors.

f. Provide clear instructions for user responses during system failures or emergencies.

8. Accessibility and Equity:

a. Design the interface to accommodate a wide range of users, including those with disabilities or specific needs.

b. Avoid disadvantaging one group (e.g. non-users) over another (e.g. ADS users' safety).

4.2 Automated vehicles that do not permit manual driving should be designed with the following principles

9. Clear and Intuitive Interface:

a. The vehicle's interface, whether physical or digital, should be intuitive and user-friendly.

b. Provide clear information to the user about the vehicle's status, route, progress to destination, arrival time and any necessary actions.

10. Passenger-Controlled Stops:

a. Provide passengers with a control to request stops at their convenience.

b. Give passengers a control to command stops in emergency situations.

11. Accessibility for All Passengers:

a. Ensure that controls and displays are accessible to all passengers.

12. Effective Climate Control:

a. Implement effective climate control systems to ensure a comfortable environment inside the vehicle.

13. Prompt Human Assistance:

a. Include a "help" button for passengers to promptly obtain human assistance when necessary.

14. Transparent Information:
    a. Make information available to passengers to provide a clear understanding of vehicle activities.
    b. Communicate its safety features and guidelines for safe interaction.

4.3 Automated vehicles that interact with other road users

15. Predictability and consistency:
    a. To help other road users anticipate the actions of the automated vehicle, automation should behave predictably in various traffic situations, following established rules, norms, and conventions that other road users are familiar with.
    b. Avoid sudden or erratic behaviour that may confuse other road users and increase the risk of collisions.
16. Communication:
    a. Have an external display to signal to other road users and law enforcement when the vehicle is being driven by automation.
    b. Use standardized visual cues, signals and displays to indicate actions like turning, stopping and yielding.
    c. Create mechanisms that enable automated vehicles to respond to communication from other road users, such as hand signals from pedestrians or gestures from cyclists.
17. Share the road:
    a. Safely interact with vulnerable road users
    b. Detect and respond safely to road works, human traffic control and emergency vehicles.
18. Education and awareness
    a. Develop public awareness campaigns and educational initiatives to inform passengers, pedestrians, cyclists, and other drivers about how to interact safely with automated vehicles, including their unique capabilities and limitations.

5. Automated driving systems should be designed with the following human-centred design procedures

5.1 Specifications

19. Specify Intended Users and their Needs, Use Cases, and Interfaces:
    a. Follow established procedures to define the intended users, their needs, use cases, and interface requirements.
    b. Establish clear user roles and responsibilities.
20. Identify and Mitigate Use-Related Hazards:
    a. Identify potential use-related hazards and categorize critical tasks.
    b. Develop and implement risk mitigation or control measures to address these hazards.

21. Consult Relevant Guidelines and Standards:
    a. Consult the relevant body of knowledge, guidelines, and standards when defining, assessing, and validating the HMI concept.
22. Define Automated Driving Modes and User Interaction:
    a. Explicitly define all possible automated driving modes and settings and outline how users interact with each.
23. Effective Communication of Active Driving Modes:
    a. Describe effective modalities to communicate relevant active driving modes to users.
24. Identify Mistakes and Misuse Cases:
    a. Identify foreseeable mistakes and misuse cases related to the HMI and the Automated Driving System (ADS).
25. Explicitly Define Operating Domain:
    a. Clearly define the operating domain within which the vehicle and automation are intended to operate.
26. Design User Roles to Avoid Errors:
    a. Design roles for both users and automation to align authority with responsibilities, avoiding errors and frustration.
27. Consider User Diversity in Design:
    a. Consider and accommodate the diverse needs of different user groups during the design process.

5.2 Evaluation and testing

28. Comprehensive User Testing:
    a. Validate the HMI design by conducting user testing with real users.
    b. Assess the safety, usability, and user acceptance of the ADS through representative testing, accounting for factors like age and experience.
29. Monitor System Performance in the Field:
    c. Continuously monitor the performance of the system in real-world deployment scenarios
30. For vehicles with fallback users:
    d. Consider relevant secondary tasks and assess their impact on the time required for users to take over control.
    e. Test that the driver monitoring systems can accurately and reliability detect safety-relevant driver conditions.
    f. Test the effectiveness of warnings interventions.
31. Use Realistic Testing Environments:
    g. Conduct testing in environments that closely mirror the actual operational design domain (ODD) of the vehicle.
    h. Test user response to normal and unplanned transitions, and minimal risk manoeuvres.

i. Include other road users in this testing when safe.

32. Document the Human-Centred Development and Testing Process:

j. Thoroughly document the entire development and testing process to facilitate potential safety audits.

6. Conclusion

This list of human factors principles and procedures serves as a roadmap for designing safe and user-centred automated vehicles. Adhering to these principles and following the outlined procedures should help to effectively address the multifaceted human factors challenges presented by automated vehicles.

For automated vehicles permitting manual driving, the principles emphasize the importance of clear, observable, and intuitive interfaces that provide users with access to crucial information, mode transitions, and alerts. Additionally, the principles underscore the significance of maintaining control, ensuring smooth transitions of control, fostering trust and transparency, and accommodating a diverse user base. Through effective design, communication, and understanding of user roles, these principles aim to enhance user experience and overall safety. For automated vehicles without manual driving capabilities, the principles emphasize accessibility for all passengers and transparency of information. Passengers' needs for assistance, control over stops, and emergency situations are addressed. Principles are also provided to support the safe interaction between automated vehicles and other road users.

The human-centred design procedures further enhance the design process by providing actionable steps. These procedures cover user needs definition, risk mitigation, consultation of guidelines and standards, user testing, system monitoring, mode definition, communication strategies, mistake identification, impact assessment of secondary tasks, and documentation. Moreover, the procedures encourage comprehensive testing, diversity consideration, and the importance of clear documentation.

7. References

Informal document No. 11 (September 2021): Proposal to develop a framework document of key principles for automated vehicle safety and human-centred needs (Canada and WP.1 Chair).

WP.1 Human Factors Panels (2022, 2023). Human Factors and Automated Driving as key issues for future road traffic.

L3Pilot Driving Automation (2021) The Code of Practice for the Development of Automated Driving Functions (CoP-ADF).

Lee, John & Wickens, Christopher & Liu, Yili & Boyle, Linda. (2017). Designing for People: An introduction to human factors engineering.

Human Factors Principles to Guide the Design, Standards and Policies for Automated Driving Systems, Submitted by Human Factors in International Regulations for Automated Driving Systems" (HF-IRADS).