Distr.: General
18 March 2024

Original: English

Economic Commission for Europe

Inland Transport Committee

Global Forum for Road Traffic Safety

Eighty-eighth session
Geneva, 18-22 March 2024
Item 4 of the provisional agenda
Assessment of the safe deployment of automated vehicles: human factors

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 consider when developing and evaluating automated driving systems. This document is submitted in lieu of Informal document No. 9 (September 2023).

1 Introduction

At the 84th Session of WP.1 (Sept 2021), Canada and the WP.1 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 to support dialogue among relevant UNECE bodies and industry stakeholders who have a role in supporting the safe operation of automated vehicles in road traffic. The goal of the principles document is to promote human needs in the design of automated driving systems (ADS), and associated safety requirements and policy instruments adopted by relevant UNECE working parties. This revised document was drafted according to feedback from industry, 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 including a set of human-centred design procedures to consider when designing, developing and evaluating automated driving systems. Following these principles and procedures will help to ensure the safety, usability, equity, and accessibility of automated driving systems that operate in road traffic.

These principles could be used to inform the development of more formalized safety requirements and policy tools adopted by relevant UNECE bodies, where appropriate, to ensure that human-centred design (HCD) is consistently applied in the development of ADS-equipped vehicles intended for use in road traffic.

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 guide 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 in this document should be considered for vehicles intended for use on public roads with SAE Level 3 – Level 5 automated driving systems.

These principles should be considered for 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 Principles for vehicles equipped with ADS that permit manual driving

1. Clear and Intuitive Displays:
    a. Consider presenting information on the user interface clearly, simply, and unambiguously;
    b. Consider continuously displaying the automation mode and status information when the ADS is active or available.

2. User-Friendly Interaction:
    a. Consider making human interactions with the ADS simple, discoverable, and easy-to-learn;
    b. Consider positioning interfaces to support safe and accessible interaction with ADS equipped vehicles;
    c. Consider simplifying the automation mode options, settings, and transitions to minimize confusion.

3. Communicating Urgency:
    a. Consider combining visual, auditory or haptic cues for higher priority ADS alerts and warnings;
    b. Consider using clear differentiation and communication of message priorities.

4. Smooth Transition of Control:
    a. Consider making it not possible to unintentionally activate and deactivate the ADS;
    b. Consider informing ADS fallback users of their current role and signal any changes to that role;
    c. Consider making clear, simple, and direct steps for transitioning control between the ADS and human drivers;
    d. Consider providing ADS Fallback users with sufficient time to safely re-engage in the driving task;

    e.   Consider monitoring ADS fallback users to verify they are available to safely resume manual driving;

    f.   Consider using multimodal displays and escalate warnings to engage Fallback users.

5.   Trust and Transparency:
    a.   Consider identifying clear user roles and responsibilities;
    b.   Consider using transparent communication about how the automation works and its limitations to develop appropriate trust;
    c.   Consider having consistent interaction logic and behavior of the ADS;
    d.   Consider clearly communicating ADS intentions and actions at all times.

6.   Training and Informing about Function Limits:
    a.   Consider providing accessible documentation and support to users for training and familiarization with safe use of the ADS:
    b.   Consider providing information to the user about their responsibilities and ADS function limits that may require intervention;
    c.   Consider avoiding misleading terminology and exaggerated representations of ADS capabilities.

7.   Detecting Failures and Alerts:
    a.   Consider having the ADS detect failures and notify the user of any reduced capabilities;
    b.   Consider not requiring users to immediately intervene during ADS driving emergencies;
    c.   Consider allowing users to override or switch-off automation in case of ADS malfunctions;
    d.   Consider signaling when the ADS intends to put the vehicle in a minimal risk condition;
    e.   Consider designing the ADS to gracefully handle unexpected situations and errors;
    f.   Consider providing clear instructions for how users should respond during system failures or emergencies.

8.   Accessibility and Equity:
    a.   Consider designing the interface to accommodate a wide range of users, including those with disabilities or specific needs;
    b.   Consider avoiding disadvantaging one group (e.g. non-users) over another (e.g. ADS users' safety).

4.2 Principles for vehicles equipped with ADS that do not permit manual driving

9.   Clear and Intuitive Interaction:
    a.   Consider making vehicle interfaces intuitive and user-friendly;
    b.   Consider providing 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.   Consider providing passengers with a mechanism to request stops at their convenience;
    b.   Consider providing passengers with a specific control to command stops in emergency situations.

11. Accessibility for All Passengers:
    – Consider having controls and displays that are accessible to all passengers.

12. Effective Climate Control:
    – Consider having effective climate control systems to ensure a comfortable environment inside the vehicle.

13. Prompt Human Assistance:
    – Consider having a mechanism for passengers to promptly obtain human assistance when necessary.

14. Transparent Information:
    a. Consider providing passengers with information to support a clear understanding of vehicle activities;
    b. Consider clearly communicating ADS safety features and providing guidelines for safe interaction.

4.3 Principles for vehicles equipped with ADS that interact with other road users

15. Predictability and Consistency:
    a. Consider having ADS behave predictably in various traffic situations, following established rules, norms, and conventions that other road users are familiar with, to help other road users anticipate the actions of the vehicle equipped with ADS;
    b. Consider limiting sudden or erratic behaviour that may confuse other road users and increase the risk of collisions.

16. Communication:
    a. Consider clearly communicating ADS intentions and actions to other road users;
    b. Consider using standardized visual cues, signals and displays to indicate actions such as turning, stopping and yielding;
    c. Consider creating mechanisms that enable an ADS-equipped vehicle to respond to communication (e.g., hand signals from pedestrians or gestures from cyclists) from other road users.

17. Share the Road:
    a. Consider having the ADS safely interact with vulnerable road users;
    b. Consider detecting and responding safely to road works, human traffic control and emergency vehicles.

18. Education and Awareness:
    – Consider developing 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 Human-centred design procedures

5.1 Specifications

19. Specify Intended Users and their Needs, Use Cases, and Interfaces:
     a. Consider following established procedures to define the intended users, their needs, use cases, and interface requirements; and,
     b. Consider establishing clear user roles and responsibilities during ADS development.

20. Identify and Mitigate Use-Related Hazards:
     a. Consider identifying potential use-related hazards and categorize critical tasks; and,
     b. Consider developing and implementing risk mitigation or control measures to address these hazards.

21. Consult Relevant Guidelines and Standards:
     – Consider consulting relevant bodies of knowledge, guidelines, and standards when defining, assessing, and validating the interaction concepts.

22. Define Automated Driving Modes, Transitions and User Interaction:
     – Consider explicitly defining all possible automated driving modes, the transitions between those modes, settings and specify how users interact with each.

23. Effective Communication of Active Driving Modes:
     – Consider identifying the most effective mechanisms to communicate relevant active driving modes to users.

24. Identify Mistakes and Misuse Cases:
     – Consider identifying foreseeable mistakes and misuse cases related to user interactions with the ADS.

25. Explicitly Define Operating Domain:
     – Consider clearly defining the operating domain within which the vehicle and automation are expected to operate.

26. Design User Roles to Avoid Errors:
     – Consider clearly defining User and ADS roles and responsibilities and providing corresponding authorities to perform them safely and effectively.

27. Consider User Diversity in Design:
     – Consider incorporating the diverse needs of different user groups into the ADS design process to ensure inclusivity and accessibility.

4.4 Evaluation and testing

28. Comprehensive User Testing:
     a. Consider validating designs by conducting iterative user testing with real users;
     b. Consider assessing the safety, usability, and user acceptance of the ADS through representative testing, accounting for relevant factors such as user age and experience.

29. Monitor System Performance in the Field:
    – Consider continuously monitoring performance of the system during real-world deployment.

30. For Vehicles with Fallback Users:
    a. Consider all relevant secondary tasks and assess their impact on the time required for users to take over control;
    b. Consider verifying the driver monitoring systems can accurately and reliability detect safety-relevant driver conditions;
    c. Consider testing the effectiveness of warning interventions.

31. Use Realistic Testing Environments:
    a. Consider conducting testing in environments that are equivalent to the actual operational domain of the vehicle;
    b. Consider testing the safety of user responses to normal and unplanned transitions, and minimal risk maneuvers;
    c. Consider including other road users in this testing when safe.

32. Document the Human-Centred Development and Testing Process:
    – Consider documenting the entire development and testing process to facilitate potential safety audits.

5 Conclusion

This list of Human Factors principles and procedures serves as a roadmap for designing safe and user-centred automated vehicles and associated safety requirements and policy instruments developed by applicable UNECE bodies. Adhering to these principles and following the outlined procedures should help to effectively address the important and multifaceted human factors challenges presented by ADS.

For vehicles equipped with ADS that provide for 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 vehicles equipped with ADS 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 vehicles equipped with ADS 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.

6 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).

Informal document No. 9 (September 2023): Human factors principles and procedures for automated vehicle safety – DRAFT (Canada).

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).

_____