

Human-Centered Design approach for Connected, Cooperative, and Automated Mobility: Insights from the CERTAIN and AIGGREGATE Projects

Authors: Turkan Hentati¹, James D. Jackson¹ & Oana Moldovan¹

¹Applus IDIADA - Spain

Abstract

Connected, Cooperative, and Automated Mobility (CCAM) systems are transforming the transportation landscape by enabling real-time communication and cooperation between vehicles, users, and infrastructure. By leveraging advanced automation and connectivity, these systems aim to improve road safety, traffic efficiency, and overall user experience. Automated vehicles (AVs), for instance, can detect and respond to hazardous situations more rapidly and consistently than human drivers, thereby reducing both the frequency and severity of traffic accidents.

Despite these significant benefits, the large-scale deployment of CCAM systems introduces major challenges related to safety, reliability, and user acceptance, all of which are closely linked to Human–Machine Interaction (HMI). The European research project CERTAIN addresses these challenges by defining and validating a framework for the iterative development and evaluation of HMI for automated driving systems, ensuring interactions that are safe, trustworthy, acceptable, and comfortable (STAC). CERTAIN adopts a user-centred design approach with iterative validation cycles spanning the full lifecycle of vehicle development and market deployment. This enables the continuous integration of evolving user needs and the progressive resolution of technical and regulatory constraints. By harmonising advanced AI technologies with stringent regulatory requirements and societal expectations, CERTAIN seeks to deliver HMI solutions that are transparent, widely accepted, and beneficial to key target user groups. A central objective is the humanisation of the regulatory approval process for Advanced Driver Assistance Systems (ADAS) through optimised HMI design.

In parallel, the AIGGREGATE project applies a human-centred design approach to AI technologies in CCAM systems. It focuses on development and approval activities around end-users through the definition of requirements and acceptance criteria supported by iterative user engagement. The project follows a robust ethical framework to ensure meaningful human control and foster public trust, particularly in complex real-world driving scenarios requiring the integration of diverse data sources.

Together, CERTAIN and AIGGREGATE exemplify an iterative, human-centred approach that strengthens user trust, acceptance, and regulatory alignment, accelerating the safe, certifiable, and transparent deployment of CCAM systems.

Keys words : Human Machine interaction (HMI), Human Centred Design, Automated Vehicles, CCAM

1. Introduction

Road traffic accidents remain a pervasive global challenge, resulting in substantial human and economic losses. The World Health Organization estimates that approximately 1.19 million people die in road traffic incidents each year, with an additional 50 million experiencing non-fatal injuries (WHO, 2023). Among the most striking observations in traffic safety research is the central role of human error, which contributes to more than ninety percent of accidents (Shinar, 2017). These errors encompass a wide range of factors, including misperception, distraction, fatigue, decision-making under uncertainty and misjudgment of dynamic traffic situations. Particularly vulnerable are older drivers, who experience reductions in cognitive processing speed, visual acuity, and attention span, all of which substantially increase the likelihood of accidents specially after the middle-old age (75–84), (Pae, 2024). Reaction times among drivers over the age of seventy are significantly slower than among younger adults, and their capacity to respond to complex, unexpected events is considerably diminished, contributing to increased accident severity.

The advent of Connected, Cooperative, and Automated Mobility (CCAM) systems promises to transform this landscape by leveraging real-time connectivity, automation, and cooperative decision-making to reduce human error and improve road safety. But until now, literature still highlights several risks linked to the use of AD(A)S like mode confusion about driving task responsibility (e.g., Carsten & Martens, 2018).

Automated vehicles (AVs) can detect hazards and execute maneuvers more rapidly than human drivers, anticipate potential collisions, and support drivers in maintaining situational awareness. However, while technology can mitigate many risk factors, human involvement remains central, whether as a supervisor, fallback driver, or passenger. The design of human–machine interfaces (HMI) and the overall human-automation interaction must therefore account for diverse user characteristics, ensuring safety, comfort, and trust for all individuals, including those who are novice drivers, elderly, or differently abled.

To achieve these objectives, a User-Centred Design (UCD) approach is essential. By iteratively involving users in the design, evaluation, and refinement of CCAM systems and considering their needs, we can address the cognitive, sensory, motor, and cultural diversity present among road users. This paper explores how the European projects CERTAIN and AIGGREGATE adopt this approach, building on the robust human factors framework developed by Souman and colleagues (2021) as a baseline, while extending it to accommodate the specific needs of distinct target groups. The following sections discuss the guidelines, their application, the limitations of generic frameworks, and the iterative human-centred design strategies employed in these projects.

2. Methods

2.1 Foundation in existing Human Factors Guidelines

The methodological foundation relies on the hierarchical human factors' framework developed by Souman et al. 2021. Human factors are critical to the design, safe deployment, and user acceptance of Automated Driving Systems (ADS) and Advanced Driver Assistance Systems (ADAS). Souman and colleagues have developed a comprehensive framework that organizes human factors guidelines to support designers in creating effective Human-Machine Interfaces (HMI) (Souman et al., 2021a). Through an extensive review of the literature, they identified sixty guidelines, structured hierarchically by functional relevance rather than by levels of automation. The framework categorizes guidelines into five main areas: basic human-machine interaction principles, information functions, warning functions, assistance functions, and automation functions (figure 1).

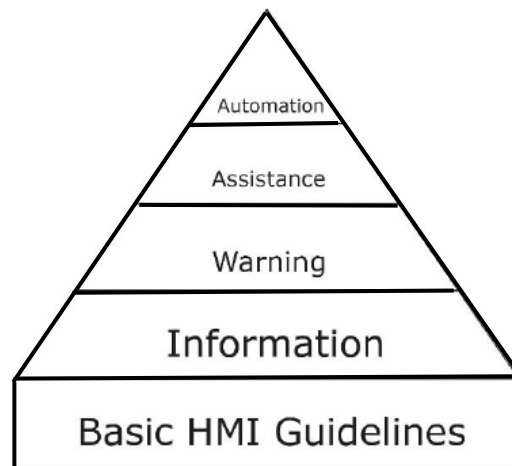


Figure 1: The hierarchical levels of ADAS and ADS functionality in system-user interactions. Source: Souman and al, reprinted with permission

- **Basic HMI guidelines** form the foundation of the hierarchy and focus on fundamental aspects of user interaction. For example, a guideline in this category recommends providing controls that allow operation with minimal mental or physical effort [ID5311]. However, minimal mental or physical effort may not be the same for an expert versus a novice driver.
- **Information functions** constitute the first level of the hierarchy and provide drivers with contextual or situational data to support decision-making. An example guideline is that information should be presented in a time window when it is relevant and allows time to respond not too late, not too early [ID5308]. Yet the definition of “too late” may differ between elderly and younger drivers.
- **Warning functions** alert drivers to system limitations or imminent hazards. For instance, a guideline may specify that urgent messages should be multimodal [ID795]. But an expert driver may not require simultaneous haptic, audio, and visual alerts in the same way as a person with disabilities, raising the risk of cognitive overload.
- **Assistance functions** support driver control, often by suggesting or initiating corrective actions. An illustrative guideline states that the use of an assistance system should not reduce the driver’s attention to driving. For example, lane-centering assistance should gently guide the steering wheel to prevent unintended lane departures while allowing the driver to override the system at any time. This ensures that assistance is helpful but does not diminish driver agency or situational awareness. However, further work is needed to specify how to ensure the driver’s situational awareness across different user groups.
- **Automation functions** relate to higher-level system autonomy, such as automated highway driving. A representative guideline suggests that the system should communicate its operational limits clearly and provide sufficient notice before transitioning control back to the driver. One guideline states that the system should always show whether the system or the user is responsible for the driving task. Again, what constitutes “sufficient notice” is not specified.

2.2 Limitations

- Ambiguity

Clear and operational human-factors guidelines are essential for automated driving, yet many current guidelines remain highly ambiguous. De Goede, Jansen, and van Grondelle (2022) note that they often lack concrete definitions, measurement methods, and threshold values posing challenges for consistent interpretation in audits or regulatory contexts. Meanwhile, research shows why such specificity is crucial: multimodal and well-designed HMIs improve takeover performance, reduce off-road glances, and support safer driver–automation interaction (Wang et al., 2024; Ma & Huang, 2022). However, these findings are seldom translated into precise design or evaluation criteria.

For example, the guideline that “*system state changes should be communicated timely and effectively*” remains too vague to guide practice. Souman et al. (2021b) illustrate how operationalisation can address this issue by defining measurable thresholds, such as requiring communication of a lane-keeping system’s transition to stand-by within 0.5 seconds of lane-marking detection failure.

More broadly, ambiguity persists because the role of the human driver in automated vehicles is still not clearly established (Kyriakidis et al., 2019). As long as responsibilities and expected behaviours remain unclear, developing harmonised and concrete human-factors criteria will remain difficult. Addressing these challenges is precisely the ambition of the CERTAIN and AIGGREGATE projects, which aim to advance the operationalisation and validation of human-factors guidelines for ADAS and automated driving.

- Individual differences not considered

Another limitation arises from human diversity. Individual differences in cognitive capacity, experience, age, and cultural background mean that a single guideline may not adequately address the needs of all users. A key principle highlighted by Souman et al. (2021a) is that “*information should be presented within a time window that ensures relevance and allows sufficient opportunity for user response: “Not too late, not too early”*” [ID5308]. While this guideline provides a solid baseline, its practical application depends heavily on the characteristics of the user. For example, a highly experienced driver may process information quickly, and presenting a warning slightly later may still allow a timely response. In contrast, a novice driver, an elderly individual, or a person with mild cognitive impairment (MCI) may require the information to appear earlier to allow sufficient time for comprehension and action. This underscores the need to adapt even well-established guidelines to the cognitive and experiential profiles of specific users, ensuring that HMI design accommodates human diversity rather than assuming a uniform response capacity.

The hierarchical human factors guidelines provide a scientifically validated foundation for ADAS and ADS HMI design. They establish best practices across information presentation, warnings, assistance, and automation functions, and their operationalization allows for measurable evaluation of system performance. Nonetheless, their generality necessitates further adaptation to address the heterogeneity of real-world users. This provides the rationale for projects such as CERTAIN and AIGGREGATE, which extend these guidelines through user-centred design approaches, tailoring interactions to target groups such as novices, experts, elderly users, users with disabilities and culturally diverse populations, thereby enhancing both safety and system acceptance.

2.3 User-Centred Design in the Automotive Domain

User-Centred Design (UCD) is essential in the development of modern automotive systems, particularly in the context of automation where the human operator’s role is transformed from active driver to supervisor or passenger. According to ISO 9241-210, UCD involves early and continuous focus on users, iterative design cycles, multidisciplinary collaboration, and systematic evaluation to ensure that systems meet user requirements (Figure 2). In the context of automated vehicles, UCD is indispensable because the consequences of misalignment between human expectations and system behavior can be critical.

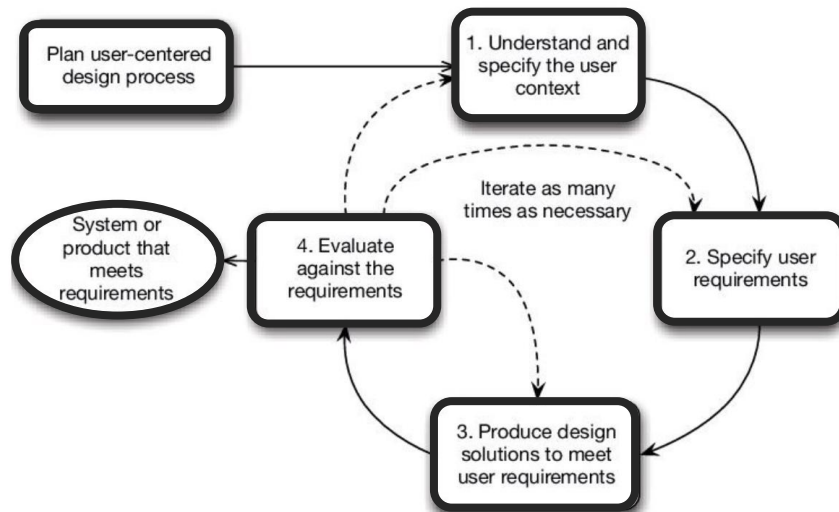


Figure 2: Illustration of the different steps of the user centred design approach ISO 9241-210:2019.

This approach explicitly considers three main component : the specific system, the user’s needs and capabilities, including diverse profiles and the task or scenario context (Figure 3). By applying UCD from the start of development, teams can identify technical constraints, anticipate varying requirements across different user profiles, and minimize costly iterative redesigns. Importantly, while UCD guides the design process and ensures user needs are met, it also aligns with broader standards and regulatory frameworks, helping translate abstract requirements into practical, usable, and inclusive solutions. This approach is inspired by the Task-Tool-User Triangle introduced by Boy (1988), which emphasizes the interdependent interactions between tasks, tools, and users. Task-tool interaction addresses information requirements (from task to tool) and technological limitations (from tool to task). In our case the tool is the system. Task-user interaction can be analyzed through task analyses (task to user) and user activity analyses (user to task), acknowledging that the task itself may be modified by the tool. User-tool interaction is mediated through the interface, which induces training requirements (tool to user) and human factors adaptations (user to tool). The triangle highlights that the three components cannot be isolated and must be considered together, particularly in dynamic systems where interdependencies are complex (Boy 1988).

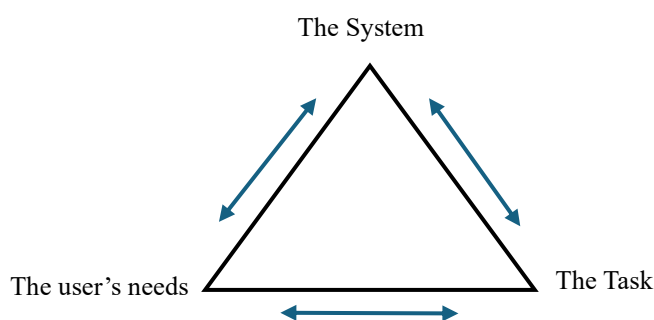


Figure 3: The triangle of interaction of the three main component

Empirical studies have shown that human factors such as cognitive load, attention management, and trust profoundly influence the acceptance and safe operation of automated systems. Correctly calibrated trust is essential, as undertrust may lead users to avoid systems that could otherwise be beneficial (Carsten and Martens, 2019). To foster appropriate trust and prevent over-reliance, Human-Machine Interfaces (HMIs) must promote transparency by ensuring observability (users understand what the vehicle senses) and predictability (users can anticipate the system’s behavior) (Carsten and Martens, 2019). Transparency provides psychological comfort and reduces “automation surprise,” enhancing user satisfaction (Carsten

and Martens, 2019). Performance metrics indicate that multimodal warning strategies improve reaction times and car-following performance through redundant channels (Ma, Li, and Huang, 2022). However, subjective evaluations reveal trade-offs: while multimodal systems score high on perceived utility, they may reduce user comfort due to warning redundancy. Multi-staged reminders further illustrate this balance, as their increased frequency, despite objective gains, can reduce trust and user satisfaction (Ma, Li, and Huang, 2022). Ensuring universal acceptability and safety also requires expanding the participant base, since current HMI validation studies predominantly involve young male participants. Inclusion of a more diverse and representative user population is essential for capturing a wide range of needs and expectations (Wang et al., 2024).

The adoption of UCD (Figure 2) in projects like CERTAIN and AIGGREGATE facilitates the translation of these human factors principles into practical, real-world interfaces. By continuously engaging with end-users from diverse backgrounds, the projects ensure that automated systems are not only technically competent but also usable, understandable, and acceptable across the full spectrum of potential users

2.4 Top-Down Design Approaches

Top-down design in CCAM involves framing system requirements in the context of broader societal and regulatory objectives. This process begins with the analysis of public policies at local, national, and supranational levels, including the European Union’s CCAM strategic research agendas, Sustainable Development Goals, Euro NCAP and UNECE regulations. These frameworks provide high-level objectives regarding safety, accessibility, environmental sustainability, and ethical AI usage. By situating automated mobility solutions within this context, designers can ensure alignment with regulatory mandates, societal expectations, and scalability across jurisdictions.

The top-down approach also facilitates the extraction of regulatory principles relevant to CCAM research and deployment from the literature review, providing designers with structured guidance on functional safety, and accessibility standards. By applying these principles early in the design process, the likelihood of fragmented or non-compliant systems is reduced, and project outputs are more easily transferable to diverse markets.

2.5 Bottom-Up Approaches

Complementing the top-down perspective, bottom-up design focuses on capturing the specific requirements of users and stakeholders in real-world scenarios. This involves detailed analysis of local use cases, mapping of user groups, and systematic collection of needs and preferences through interviews, surveys, and observation. The bottom-up approach ensures that design decisions are grounded in the lived experiences, cognitive capacities, and behavioral patterns of actual users rather than theoretical assumptions.



Figure 4: Illustration of the top-down and bottom-up approaches used in CERTAIN and AIGGREGATE

By integrating top-down and bottom-up approaches (Figure 4), projects like CERTAIN and AIGGREGATE achieve a balance between compliance with regulatory frameworks and responsiveness to user diversity, ensuring that automated systems are both legally robust and practically usable.

3. Results and discussion

3.1 Adaptation of Guidelines to User Diversity: *User Needs Across Target Groups*

A critical aspect of human-centred design in CCAM is the consideration of user-specific needs across different target groups. Novice drivers may require progressive guidance, explicit explanations, and simplified interface layouts to develop accurate mental models of system behavior, whereas expert drivers may tend to prefer concise, high-bandwidth information and configurable interfaces; excessive guidance may increase cognitive load or lead to frustration.

Elderly users generally require extended reaction times, high-contrast visual displays, larger fonts, and multimodal alerting to compensate for age-related declines in sensory and cognitive processing, including reduced visual acuity, slower processing speed, and diminished attentional resources (Salthouse, 2000; Owsley, 2011; Fisk et al., 2009).

Cultural differences further complicate HMI design. Cross-cultural studies have shown that the perceived meaning and urgency of warning colors, symbols, and icons can differ significantly between Eastern and Western user populations, potentially affecting the interpretation of automated vehicle alerts and warnings (Lesch, Horrey, & Wogalter, 2009; Rau, Li, & Li, 2014). Interface metaphors and symbol conventions may therefore require localization to ensure consistent comprehension across cultures.

Finally, people with disabilities require adapted interaction modalities, such as haptic feedback for visual impairments, auditory redundancy for hearing impairments, simplified instructions for users with cognitive limitations, and alternative input methods for motor impairments. Research in inclusive and accessible HMI design demonstrates that multimodal interaction significantly improves usability and safety in automated and semi-automated systems for users with diverse abilities (Brock et al., 2021; Stephanidis et al., 2019). Incorporating these diverse requirements is essential for safe and equitable system deployment.

3.2 Insights from the CERTAIN Project

CERTAIN is a European funded project under the Horizon Europe Framework, addressing human-centric validation of HMI for CCAM systems across different automation levels. The project focuses on ensuring safe, understandable, and trusted interaction between vehicles, occupants, and external road users.

CERTAIN operates these principles and defines three HMI use cases, comprising two internal HMI (iHMI) and one external HMI (eHMI), and applies a User-Centred Design (UCD) approach for iterative HMI development. This methodology enables inclusive design, adaptability to different users and scenarios, and consistent performance under varying conditions, with pass/fail criteria defined for both iHMI and eHMI. The project begins with a comprehensive literature review addressing cognitive, sensory, and cultural user needs. These insights are translated into personas representing diverse end-users, including variations in age, gender, driving experience, cognitive capacity, cultural background, and disability status. Design activities then combine interviews, focus groups, and simulation-based evaluations to refine HMI concepts. Iterative testing ensures that HMI designs adhere to the STAC criteria: safe, trustworthy, acceptable, and comfortable and evolve in response to actual user behavior and feedback. Through this process, CERTAIN demonstrates that foundational human factors guidelines can be adapted and extended to meet the unique needs of diverse populations, reducing residual safety risks that might otherwise persist in generalized systems.

3.3 Insights from the AIGGREGATE Project

AIGGREGATE is also a European funded project under the Horizon Europe Framework. This project applies similar Human Factors principles to AI-driven CCAM functionalities, emphasizing human

oversight, explainability, and ethical design. The project first conducts a thorough literature review and benchmarking exercise, assessing existing automated driving and ADAS interfaces for their transparency, usability, and alignment with user expectations. The next phase involves user interviews conducted with low-fidelity mockups to facilitate comprehension among participants with minimal prior experience in automated systems. These mockups allow users to interact with simplified system representations, providing valuable insights without overwhelming or confusing participants. Findings from these activities inform iterative design cycles, ensuring that AI-based functionalities are understandable, trustworthy, and responsive to user needs to ensure a collective decision making.

4. Conclusion

Connected, Cooperative, and Automated Mobility (CCAM) systems have the potential to substantially reduce road accidents and improve accessibility; however, their successful deployment is highly dependent on the quality of human–automation interaction design. While existing frameworks such as Souman’s human factors guidelines provide a strong theoretical foundation, they must be extended through iterative, user-centred design (UCD) methodologies to adequately address the diversity of real-world users, contexts, and capabilities.

The CERTAIN and AIGGREGATE projects exemplify this approach by combining comprehensive state-of-the-art reviews with persona development, stakeholder interviews, low-fidelity prototyping, and iterative user testing. This multi-layered methodology enables the development of human–machine interfaces (HMIs) that are not only safe and transparent, but also culturally sensitive, cognitively accessible, and adapted to diverse user profiles.

Importantly, guideline development must strike a balance between defining specific performance requirements and allowing flexibility for innovation. Overly prescriptive criteria can push manufacturers toward generic solutions or discourage a user-first approach, while assessing the development process itself requires significant expertise and resources. The UCD approach addresses this challenge by focusing on the system characteristics, user needs, including diverse profiles and task or scenario context. By applying UCD from the start, technical constraints can be anticipated, diverse user needs can be met, and iterative redesigns minimized. Moreover, UCD principles are generally applicable to how standards are defined, ensuring that regulatory frameworks reflect real, diverse user requirements rather than only measurable criteria.

By linking top-down regulatory requirements with bottom-up user engagement, CERTAIN and AIGGREGATE will provide detailed, practical guidance for each use case, helping manufacturers translate abstract guidelines into safe, inclusive, and context-sensitive solutions. In doing so, these projects will offer a blueprint for deploying automated mobility systems responsibly and inclusively across Europe and beyond, demonstrating how UCD can bridge the gap between high-level standards and real-world user needs

The next steps involve initiating user interviews to systematically capture user needs and expectations and integrating these insights with findings from the state of the art. Based on this combined knowledge, the HMI implementation phase will start, followed by structured usability testing to gather user feedback. This feedback will be used to iteratively refine the system, ensuring continuous alignment with both user requirements and policy objectives through a combined top-down and bottom-up UCD approach.

ACKNOWLEDGMENTS

This study was conducted within the CERTAIN and AIGGREGATE projects. CERTAIN has received funding from the European Union’s Horizon Europe research and innovation program under Grant Agreement No. 101203230, and AIGGREGATE under Grant Agreement No. 101202457.

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or CINEA. Neither the European Union nor the granting authority can be held responsible for them.

We thank all the reviewers for their useful suggestions.

REFERENCES

- Brock, Alexander M., Julie Chatain, Benoît Oriola, Delphine Picard, and Christophe Jouffrais. 2021. "Multimodal Interfaces for Accessible Human–Computer Interaction." *Foundations and Trends in Human–Computer Interaction* 14 (3): 211–329.
- Boy, Guy. 1993. "Knowledge Acquisition in Dynamic Systems: How Can Logicism and Situatedness Go Together?" In *Proceedings of EKAW '93, Lecture Notes in Artificial Intelligence*. Berlin: Springer Verlag.
- Carsten, Oliver, and Marieke H. Martens. 2019. "How Can Humans Understand Their Automated Cars? HMI Principles, Problems and Solutions." *Cognition, Technology & Work* 21 (1): 3–20.
- de Goede, M., R. J. Jansen, and E. D. van Grondelle. User-Centred Design for Type Approval of AD(A)S: Roadmap Towards a Process Audit. Report No. R-2022-16. The Hague: SWOV Institute for Road Safety Research, 2022.
- Fisk, Arthur D., Wendy A. Rogers, Neil Charness, Sara J. Czaja, and Joseph Sharit. 2009. *Designing for Older Adults: Principles and Creative Human Factors Approaches*. 2nd ed. Boca Raton, FL: CRC Press.
- Forster, Yvonne, Jörn Riener, and Josef Krems. 2020. "Compliance with Human Factors Guidelines Improves User Acceptance of Automated Driving HMIs." *Human Factors* 62 (6): 901–15.
- Janke, Mary K. 1994. "Accident Risk and Older Drivers." *Journal of Safety Research* 25 (3): 117–24.
- Kyriakidis, Miltos, J. C. F. de Winter, Neville A. Stanton, Thierry Bellet, Bart van Arem, Karel Brookhuis, Marieke H. Martens, et al. 2019. "A Human Factors Perspective on Automated Driving." *Theoretical Issues in Ergonomics Science* 20 (3): 223–49. <https://doi.org/10.1080/1463922X.2017.1293187>
- Lee, John D., and Katrina A. See. 2004. "Trust in Automation: Designing for Appropriate Reliance." *Human Factors* 46 (1): 50–80.
- Lesch, Mary F., Pei Luen Patrick Rau, Zhengxuan Zhao, and Chengyi Liu. 2009. "A Cross-Cultural Comparison of Perceived Hazard in Response to Warning Components and Configurations: US vs. China." *Applied Ergonomics* 40 (1): 140–52.
- Ma, Jun, Jiateng Li, and Hongwei Huang. 2022. "Evaluation of Multimodal and Multi-Stage Alerting Strategies for Forward Collision Warning Systems." *Sensors* 22 (3): 1189. <https://doi.org/10.3390/s22031189>
- Owsley, Cynthia. 2011. "Aging and Vision." *Vision Research* 51 (13): 1610–22.
- Pae, Gilsu, Jonathan Davis, Joseph Cavanaugh, Motao Zhu, and Cara Hamann. 2024. "Predictors of Driving Errors Contributing to Crashes in Older Adults Across Age Groups, 2010 to 2020." *Journal of Safety Research* 92: 40–47. <https://doi.org/10.1016/j.jsr.2024.11.010>
- Parasuraman, Raja, Thomas B. Sheridan, and Christopher D. Wickens. 2000. "A Model for Types and Levels of Human Interaction with Automation." *IEEE Transactions on Systems, Man, and Cybernetics—Part A* 30 (3): 286–97.
- Pires, Felipe, Pedro Lisboa, Herick Ribeiro, Pietro Campos, Marc Capdevila, and Luciana Zaina. 2025. "End Users' Perspective Matters in ADAS: Designing a Blind Spot Alert System from a User-Centered Approach." *Journal of the Brazilian Computer Society* 31 (1): 50–67. <https://doi.org/10.5753/jbcs.2025.4365>
- Rau, Pei-Ling P., Yu Li, and Dan Li. 2014. "Effects of Culture on the Usability of Icons and Symbols in Mobile Interfaces." *International Journal of Human–Computer Studies* 72 (12): 895–907.
- Salthouse, Timothy A. 2000. "A Theory of Cognitive Aging." *Developmental Review* 20 (1): 102–26.
- Santoni de Sio, Filippo, Giulio Mecacci, Simeon Calvert, Daniel Heikoop, Marjan Hagenzieker, and Bart van Arem. 2022. "Realising Meaningful Human Control Over Automated Driving Systems: A

Multidisciplinary Approach.” *Minds and Machines*: 1–25. <https://doi.org/10.1007/s11023-022-09608-8>

- Shinar, David. 2017. *Traffic Safety and Human Behavior*. 2nd ed. Bingley: Emerald Publishing.
- Souman, Jan, et al. 2021a. “A Structured Framework of Human Factors Guidelines for Automated Driving HMI.” *Transportation Research Part F: Traffic Psychology and Behaviour* 80: 1–14.
- Souman, Jan, et al. 2021b. “Operationalizing Human Factors Guidelines in ADAS Development: Empirical Thresholds and Metrics.” *Applied Ergonomics* 95: 103–12.
- Stephanidis, Constantine, Margherita Antona, Sotiris Ntoa, et al. 2019. “Inclusive Design in Human–Computer Interaction.” *Foundations and Trends in Human–Computer Interaction* 12 (1): 1–109.
- Verhaeghen, Paul, and John Cerella. 2002. “Aging, Memory, and Cognition.” *Psychology and Aging* 17 (4): 645–64.
- Wang, Meng, Jah’inaya Parker, Nicholas Wong, Shashank Mehrotra, Shannon C. Roberts, Woon Kim, Alicia Romo, and William J. Horrey. 2024. “The Effect of Human–Machine Interface Modality, Specificity, and Timing on Driver Performance and Behavior While Using Vehicle Automation.” *Accident Analysis & Prevention* 203: 107606. <https://doi.org/10.1016/j.aap.2024.107606>
- World Health Organization (WHO). 2023. *Global Status Report on Road Safety*. Geneva: World Health Organization.