Mediator

MEdiating between Driver and Intelligent Automated Transport systems on Our Roads

MEDIATOR final results brochure
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About the MEDIATOR project

Automated transport technology is developing rapidly for all transport modes, with huge safety potential. The transition to full automation, however, brings new risks, such as mode confusion, overreliance, reduced situational awareness and misuse. The driving task changes to a more supervisory role, reducing the task load and potentially leading to degraded human performance. Similarly, the automated system may not (yet) function in all situations.

The MEDIATOR project aimed to develop an in-vehicle system, the Mediator system, that intelligently assesses the strengths and weaknesses of both the driver and the automation and mediates between them, while also taking into account the driving context. It assists the timely take-over between driver and automation and vice versa, based on who is fittest to drive. This Mediator system optimises the safety potential of vehicle automation during the transition to full (level 5) automation. It would reduce risks, such as those caused by driver fatigue or inattention, or on the automation side by imperfect automated driving technology. MEDIATOR has facilitated market exploitation by actively involving the automotive industry during the development process.

To accomplish the development of this support system MEDIATOR integrated and enhanced existing knowledge of human factors and HMI, taking advantage of the expertise in other transport modes (aviation, rail and maritime). It further developed and adapted available technologies for real-time data collection, storage and analysis and incorporated the latest artificial intelligence techniques. MEDIATOR has developed working prototypes, and validated the system in a number of studies, including computer simulation, virtual reality, driving simulator and on-road studies .

With MEDIATOR we further paved the way towards safe and reliable future vehicle automation that takes into account who is most fit to drive: the human or the system.

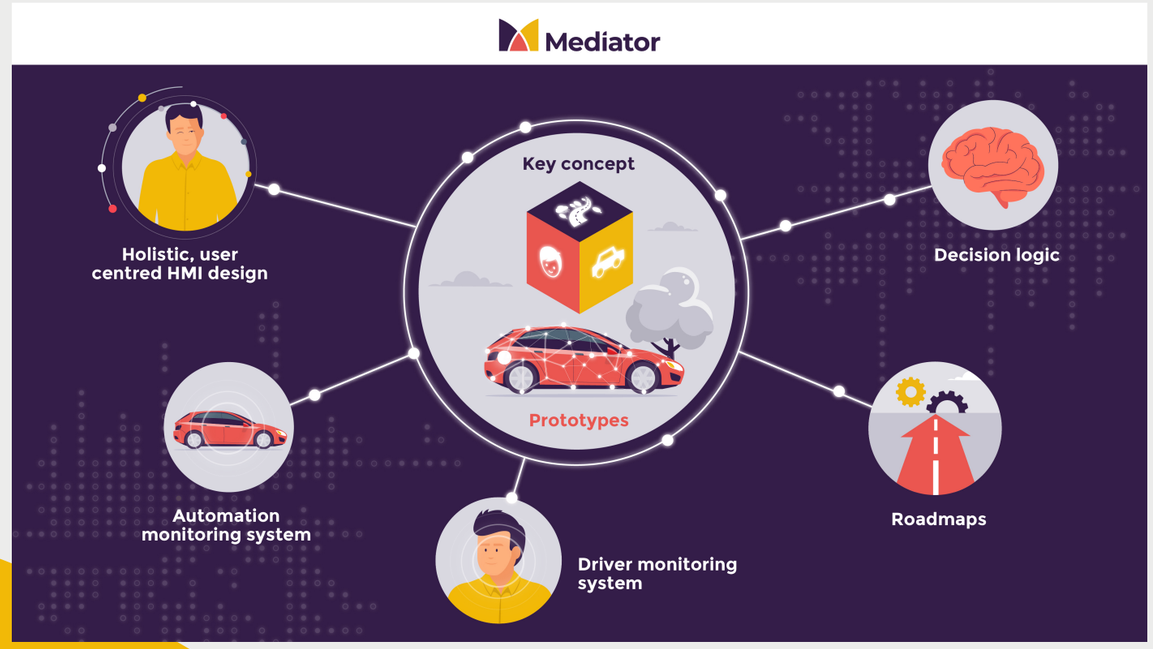
Partners

Our team

MEDIATOR, a 4-year project coordinated by SWOV Institute for Road Safety Research, has come to an end after four years of hard work.

The project has been carried out by a consortium of highly qualified research and industry experts, representing a balanced mix of top universities and research organisations as well as several OEMs and suppliers. The consortium, supported by an international Industrial Advisory Board and a Scientific Advisory Board, represented all transport modes, maximising input from, and transferring results to aviation, maritime and rail (with mode-specific adaptations).

Overview of final outputs



The Mediator system, as developed in the project, consists of four main modules: a driver monitoring system, an automation monitoring system, a human-machine interface and a decision making module.

The Mediator system was integrated in different prototype platforms and evaluated extensively. Based on the evaluation results the (safety) impact of the system was determined and guidelines were developed. Finally, roadmaps for exploitation of the system were developed.

In the first phase of the project a state-of-the-art knowledge overview was created focussing on all knowledge required to develop the Mediator system (D1.1). In addition, knowledge gaps were identified and prioritised forming the basis for the research agenda in the first phase.

DELIVERABLES

D1.1 Mediating between human driver and automation: state-of-the-art and knowledge gaps

PUBLICATIONS

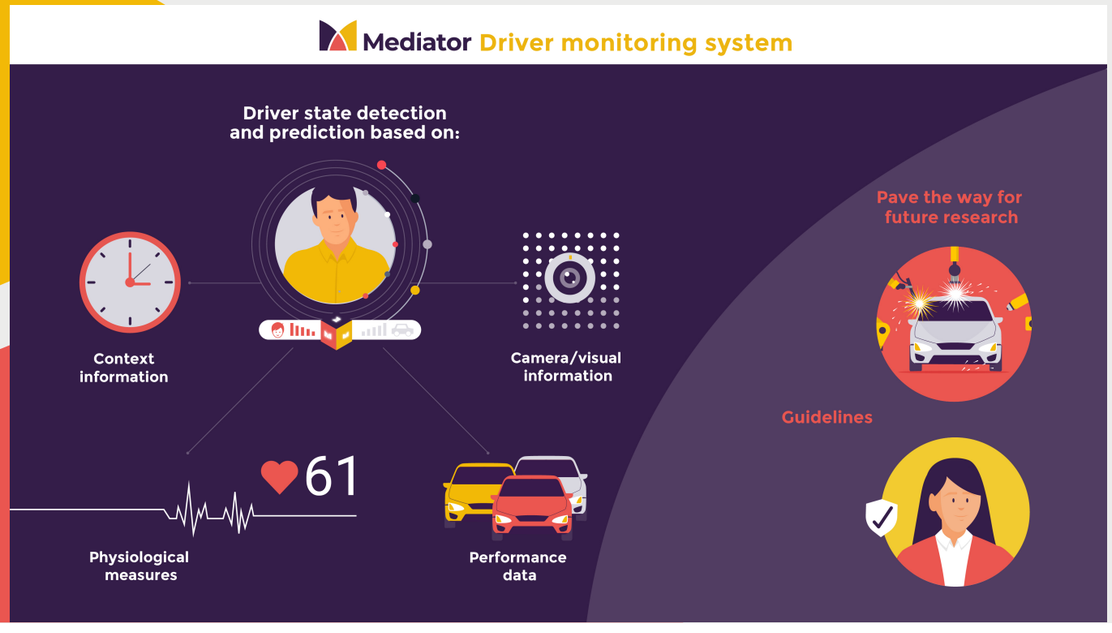
Nicole van Nes, Ingrid van Schagen, Diane Cleij, Michiel Christoph, Bram Bakker. **Towards full vehicle automation: mediating between human and technological strengths**. Proceedings of TRA2020, the 8th Transport Research Arena Rethinking transport – towards clean and inclusive mobility | Book of abstracts, page 102

Driver monitoring

With state-of-the-art knowledge and research results from within the project the functional requirements for the Mediator driver monitoring system were determined (D1.2).

The Mediator driver monitoring system was integrated in different prototypes (D2.11) that were evaluated in the project. MEDIATOR focussed on monitoring fatigue, distraction, and discomfort while taking driving context into account.

Based on state-of-the-art knowledge from the literature with knowhow from the industry and evaluation results from the project, guidelines for monitoring degraded driver performance were developed (D4.3). The guidelines focussed on fatigue, distraction, and discomfort, led by functionality constraints, technological possibilities, safety relevance and feasibility.



DELIVERABLES

D1.2 Behavioural markers for degraded human performance
D2.11 Functional and technical specifications of the Mediator system
D4.3 Guidelines monitoring degraded driver performance

PUBLICATIONS

Beggiato, M., Rauh, N., & Krems, J. (2022). **Multi-camera Face Tracking for Estimating User's Discomfort with Automated Vehicle Operations**. In: W. Karwowski, T. Ahram, M. Milicevic, D. Etinger, & K. Zubrinic (Eds.), Proceedings of the 4th International Conference on Human Systems Engineering and Design (IHSED2021), 23.-25. September 2021, doi: 10.54941/ahfe1001104 (open access).

Zangi, N., Srour-Zreik, R., Ridel, D., Chasidim H., & Borowsky, A. (2022). **Driver distraction and its effects on partially automated driving performance**. Accident Analysis & Prevention, Volume 166, March 2022, 106565. https://doi.org/10.1016/j.aap.2022.106565

Ahlström, C., Zemblys, R., Jansson, H., Forsberg, C., Karlsson, J., Anund, A. (2021). **Effects of partially automated driving on the development of driver sleepiness.** In: Accident Analysis and Prevention, doi: 10.1016/j.aap.2021.106058.

Beggiato, M., Rauh, N., & Krems, J. (2020). **Facial Expressions as Indicator for Discomfort in Automated Driving**. In T. Ahram, W. Karwowski, A. Vergnano, F. Leali, & R. Taiar (Eds.), Intelligent Human Systems Integration 2020 (pp. 932937). Cham: Springer International Publishing. doi: 10.1007/978-3-030-39512-4_142.

Van Miltenburg, M. M., Lemmers, D. J., Tinga, A., Christoph, M., & Zon, R. (2022, September). **Can EEG Measurements be Used to Estimate the Performance of Taking over Control from an Autonomous Vehicle for Different Levels of Distracted Driving? An Explorative Study**. In Adjunct Proceedings of the 14th International Conference on Automotive User Interfaces and Interactive Vehicular Applications (pp. 20-24).

Boguslavsky, D., Chassidim, H., Jiaqi, L., Borowsky, A. (2022). **Effect of engagement with a Trivia game on driver's sleepiness and behavioural adaptation in a partially automated vehicle**. Proceedings of the 8th International conference on driver distraction and inattention.

van Egmond, R., de Ridder, H., & Bakker, B. (2019). **Integration of Human Information Processing Models for Human Centered AI**. 1. Poster session presented at Human Factors and Ergonomics Society Europe Chapter, Nantes, France.

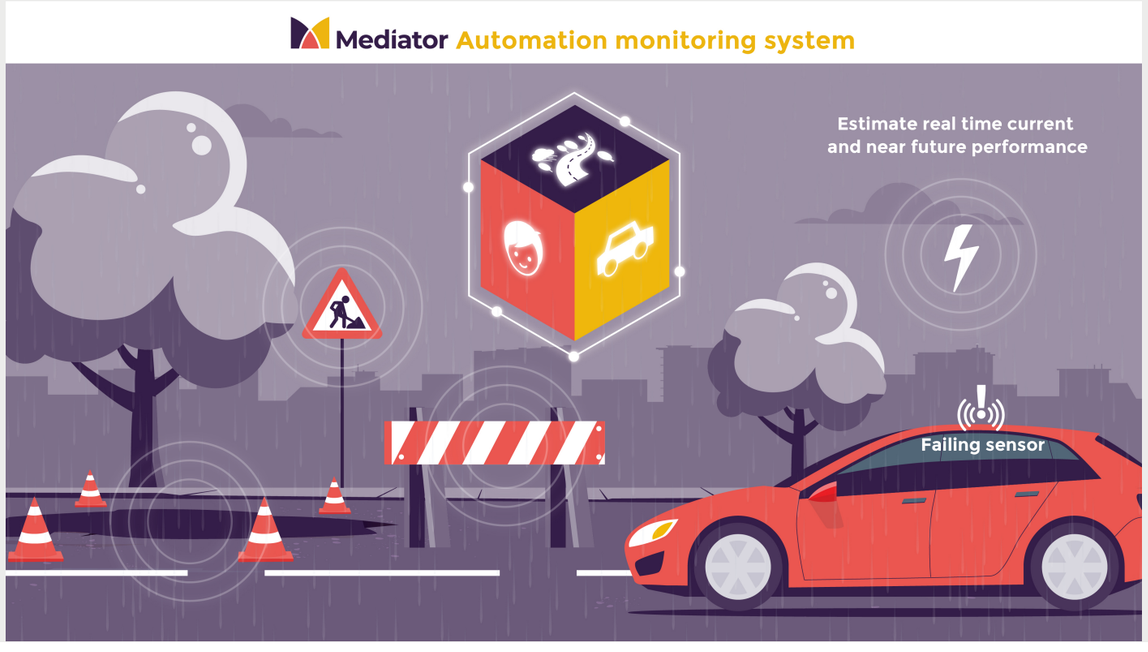
Automation monitoring

The automation state monitoring system assesses the automation “fitness”; the ability to drive in a certain automation level at the current point in time and in the near future.

In the first phase of the project the functional requirements for the automation state monitoring system were defined (D1.3).
The automation state monitoring system integrated in the prototypes (D2.11) was running in real-time. The output of the automation state monitoring, together with the output of the driver monitoring module, forms the key input for the decision making module. In addition, the output of automation state monitoring system allowed the HMI showing time budgets to the driver; the time remaining till the next change in automation level (availability).

DELIVERABLES

D1.3 Quantified markers for degraded automation performance
D2.11 Functional and technical specifications of the Mediator system

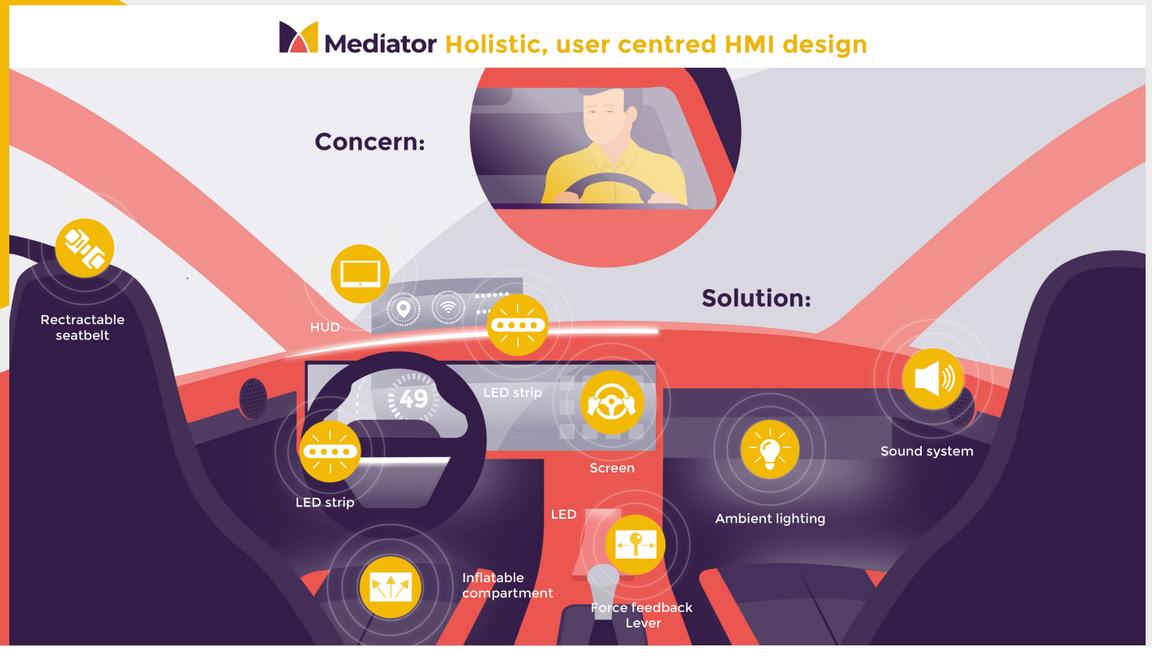


User centred HMI design

The Mediator HMI design took a user centred and holistic approach. The HMI design is framed by five principal Design Guidelines (D1.5) dealing with the following main challenges for a human interface in the transition towards automated driving:

- Transfers of control
- Transparency & information load
- Keeping the driver in the loop
- OEM design space
- Negotiating conflicts

The Mediator HMI design was integrated into several prototypes (D2.10 and D2.11). Based on the evaluation results, general HMI guidelines were defined (D4.2).



DELIVERABLES

D1.5 HMI Functional Requirements
D2.10 Final in-vehicle prototypes
D2.11 Functional and technical specifications of the Mediator system
D4.2 Guidelines safe HMI design

PUBLICATIONS

Tinga, A. M., van Zeumeren, I. M., Christoph, M., van Grondelle, E., Cleij, D., Aldea, A., & van Nes, N. (2023). **Development and evaluation of a human machine interface to support mode awareness in different automated driving modes**. Transportation research part F: traffic psychology and behaviour, 92, 238-254.

Aldea, A., Tinga, A. M., Van Zeumeren, I. M., Van Nes, N., & Aschenbrenner, D. (2022, June). **Virtual Reality Tool for Human-Machine Interface Evaluation and Development (VRHEAD)**. In 2022 IEEE Intelligent Vehicles Symposium (IV) (pp. 151-158). IEEE.

Tinga, A. M., Cleij, D., Jansen, R. J., van der Kint, S., & van Nes, N. (2022). **Human machine interface design for continuous support of mode awareness during automated driving: An online simulation**. Transportation research part F: traffic psychology and behaviour, 87, 102-119.

Kim, S., Van Grondelle, E., Van Zeumeren, I., Mirnig, A. G., & Stojmenova, K. (2022, September). **Let's Negotiate with Automation: How can Humans and HMIs Negotiate Disagreement on Automated Vehicles?**. In Adjunct Proceedings of the 14th International Conference on Automotive User Interfaces and Interactive Vehicular Applications (pp. 179-181).

Decision logic

The Mediator decision logic is really the brain of the system. With the initial functional requirements (D1.4) a prototype was developed by means of a computer simulation (D3.2). The decision logic was integrated in a vehicle prototype (D2.9, D2.11).

The central roles of the Mediator decision logic are to:

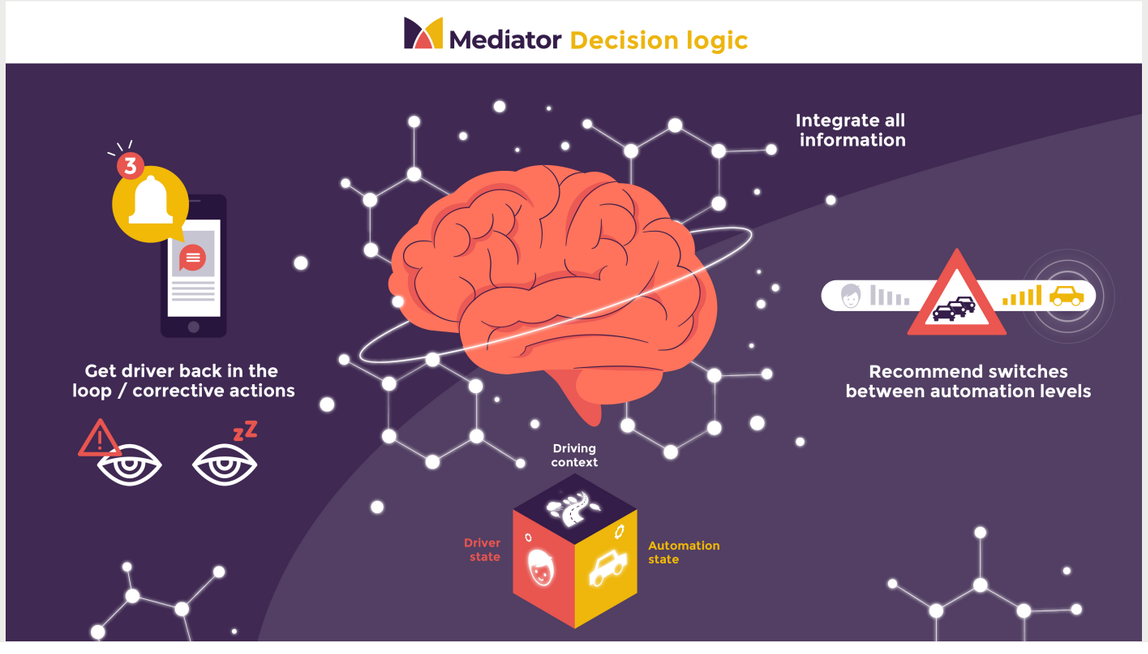
- Recommend switches between available automation levels between automation and human driver
- Trigger corrective actions
- Enforce emergency actions
- Provide supportive information to the HMI

The decision logic has multiple levels of functioning:

- An Artificial Intelligence (AI) decision making algorithm responsible for deciding whether and when an action should be executed.
- An execution & monitoring level responsible for executing the actions by the AI in close collaboration with the HMI, and monitoring whether they are successful.

DELIVERABLES

D1.4 Mediator system and functional requirements
D2.9 Development of integrated lab prototypes
D2.11 Functional and technical specifications of the Mediator system
D3.2 Simulation of decision making in the Mediator System



Prototypes

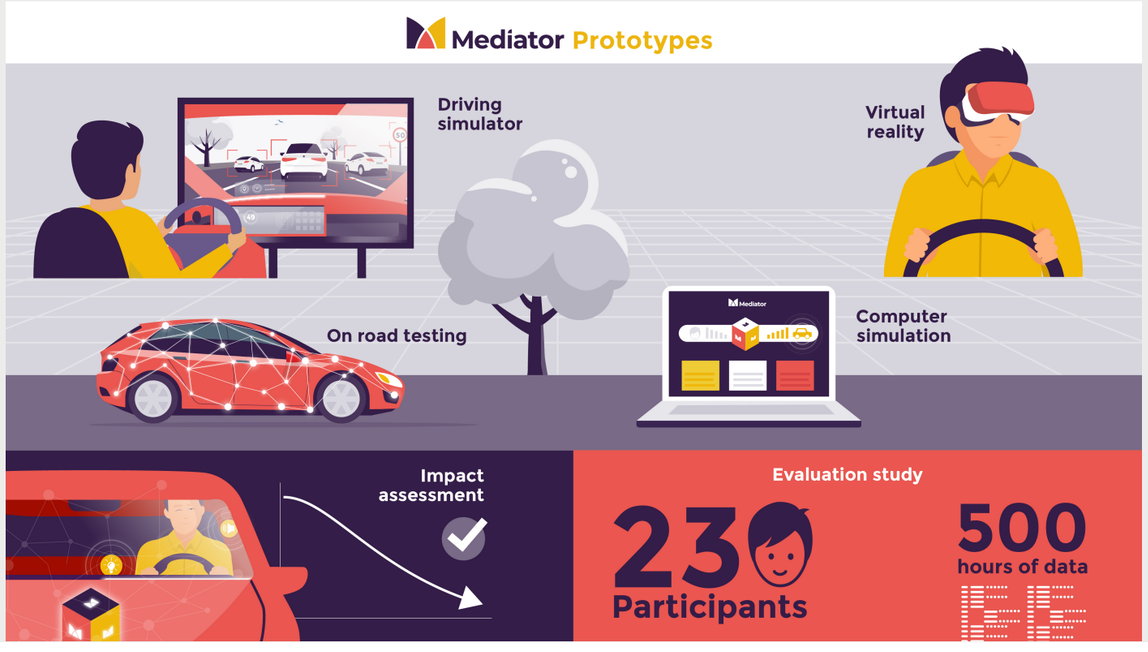
The Mediator system was integrated into six different prototypes: two driving simulators, one virtual reality, two vehicle prototypes and a computer simulation (D2.9, 2.10, 2.11) each focussing on different aspects of the system.

These prototypes were used for extensive evaluation with over 230 participants resulting in a collection of more than 500 hours of data. All evaluation results are available (D3.2, D3.3, D3.4) and integrated in a final overview of the evaluation results (D3.5).

The evaluation studies revealed good usability scores and high acceptance rates. Most importantly, several safety benefits were observed such as a reduction of distracted driving and an increase in use of the automated systems.

DELIVERABLES

D2.9	Development of integrated lab prototypes
D2.10	Final in-vehicle prototypes
D2.11	Functional and technical specifications of the Mediator system
D3.2	Results of the simulation study
D3.3	Results of the driving simulator studies
D3.4	Results of the on-road studies
D3.5	Integration of evaluation results from the MEDIATOR studies



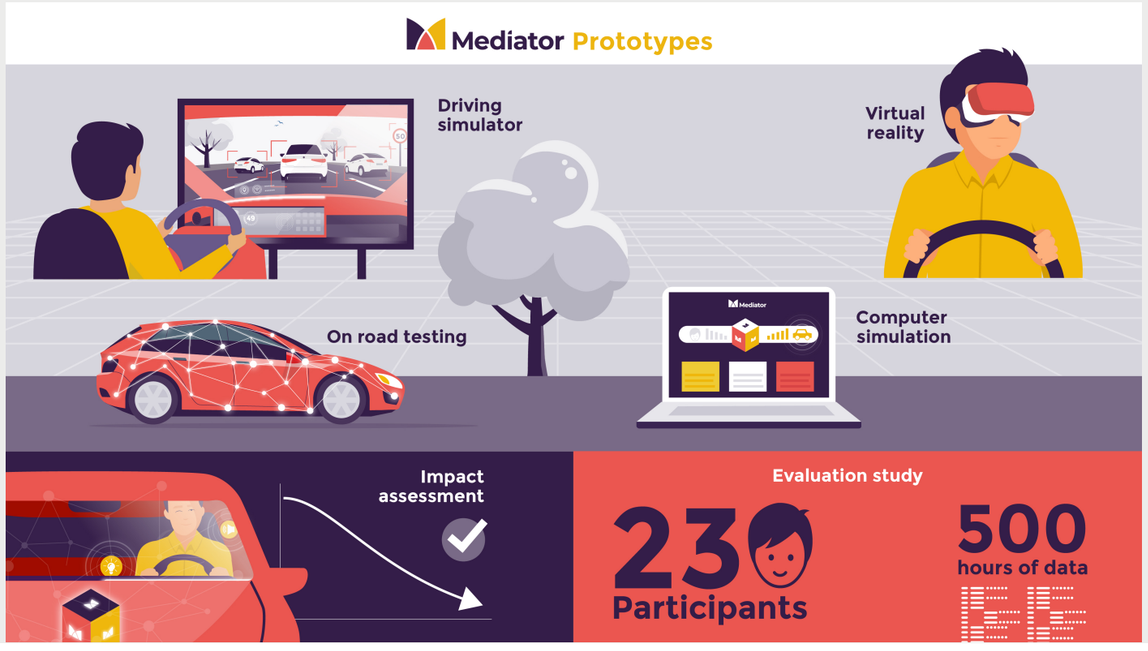
Impact and roadmaps

Based on the evaluation results, MEDIATOR estimated the potential safety benefits and related societal benefits of the system developed (D4.1). Using the experiences gained in the project, protocols for low-cost laboratory testing (D4.4) and recommendations on legal and regulatory aspects (D4.5) were defined.

In order to facilitate the uptake of the MEDIATOR results by the transport industry, a roadmap for exploitation for road transport (D5.9) and a roadmap for exploitation for aviation, maritime, rail (D5.10) were developed with the involvement of external stakeholders.

DELIVERABLES

D4.1 Assessment of safety benefits and related societal benefits
D4.4 Protocol for low-cost laboratory testing
D4.5 Recommendations legal and regulatory aspects
D5.9 Exploitation roadmap road transport
D5.10 Exploitation roadmap aviation, maritime, rail



More information

To learn more about the outputs of the MEDIATOR project, we invite you to watch our animated final results video:
https://youtu.be/gryR08lOvrg

Mediator

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