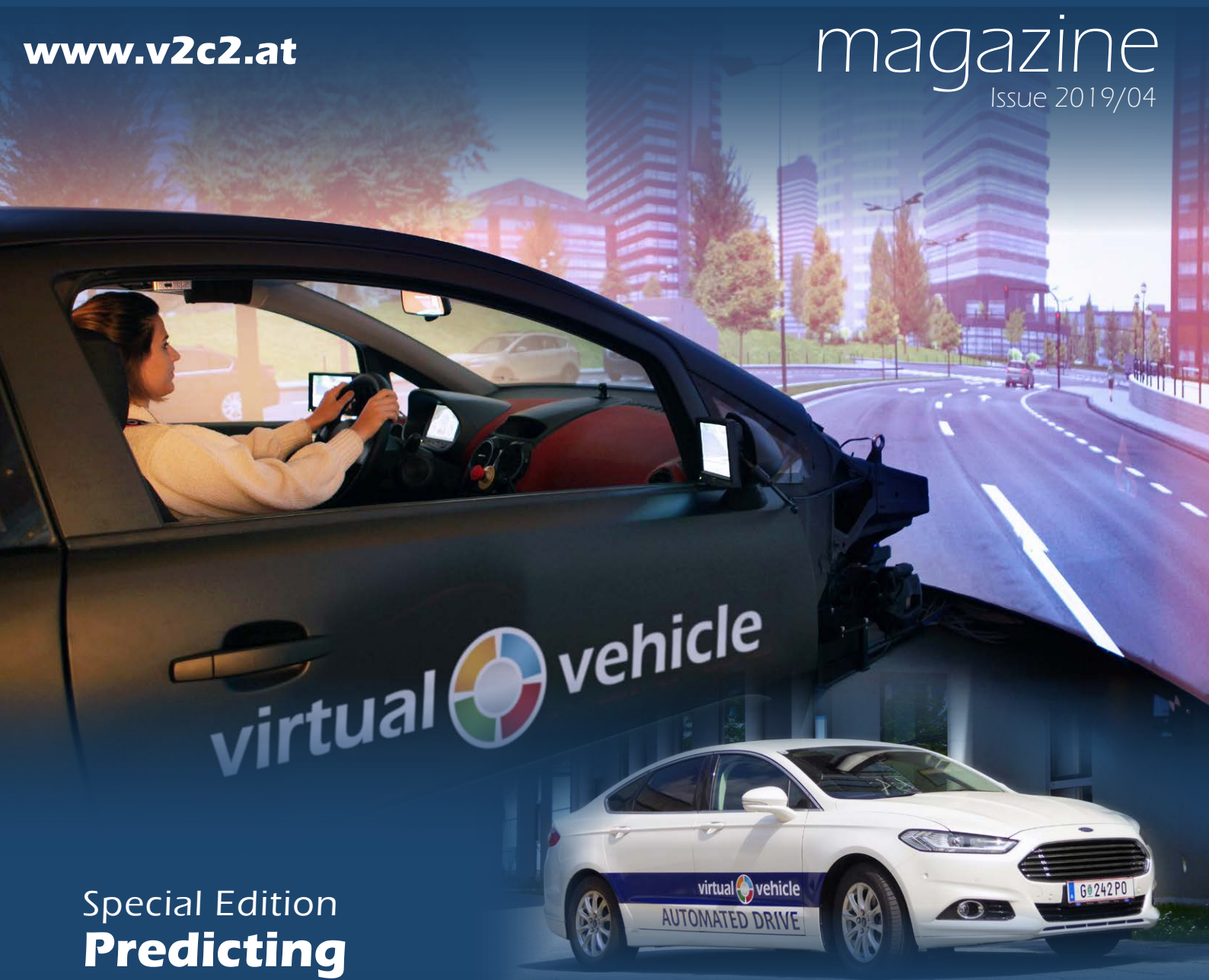
virtual vehicle magazine

www.v2c2.at

Issue 2019/04



Special Edition

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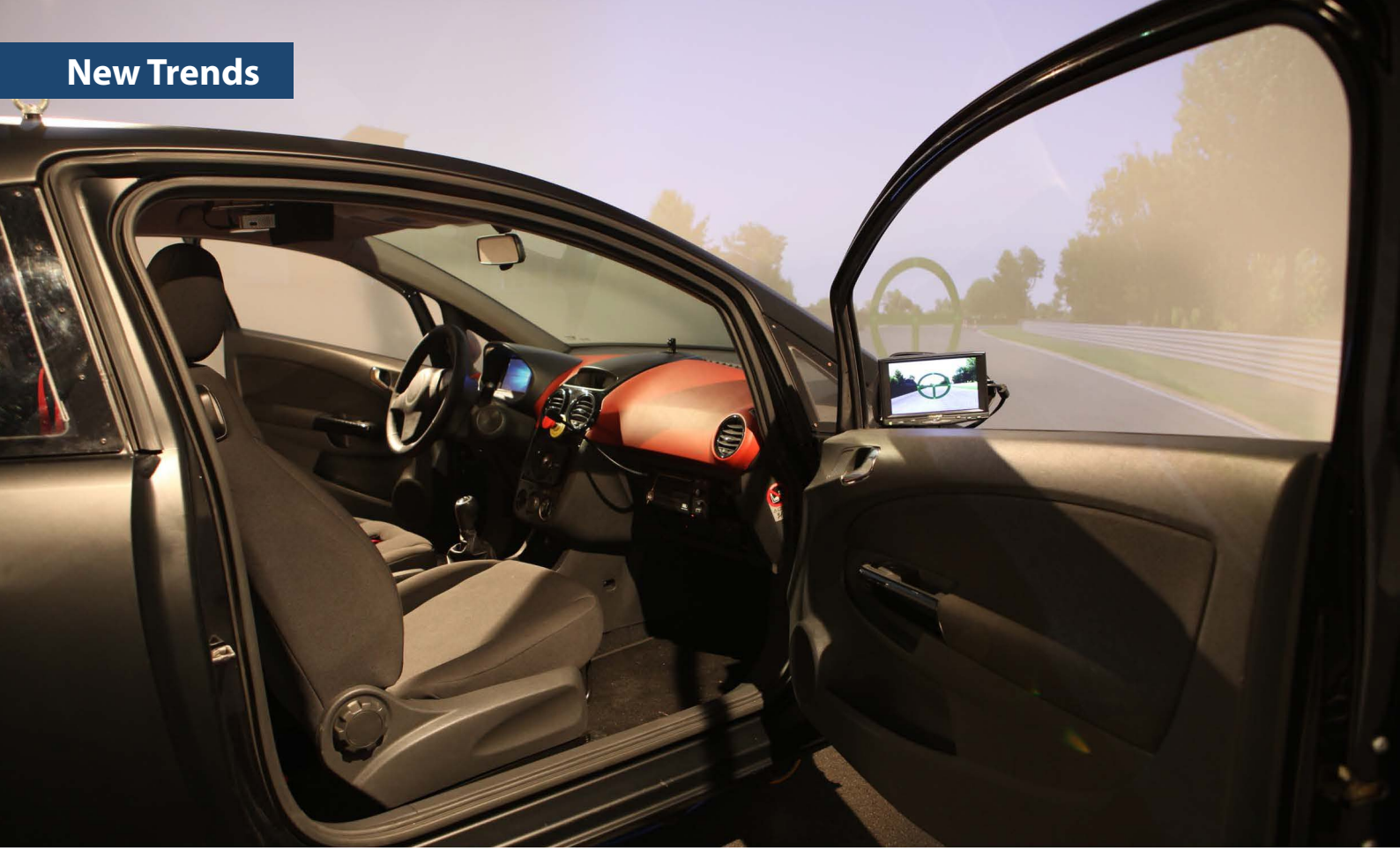

New Trends in Driving Simulators: The Out-of-the-loop Experience

PAOLO PRETTO, Key Researcher Human Factors & Driving Simulator

Driving simulators for research purposes are used in human factors research to monitor driver attention, behavior and performance, and in the automotive industry to design and evaluate new vehicles or new Advanced Driver Assistance Systems (ADAS). They are a tool that enables users to experience driving in a safe and controlled virtual environment.

Human-centered Driving Simulation

Typically, a driving simulator consists of a physical mockup, which includes the driving input commands (steering wheel and pedals), and a visualization system. The hardware configuration of these components ranges from affordable gaming-like desktop setups to complex installations consisting of, e.g., a 360-degree projection dome surrounding a real car and built on top of a moving system, often larger than a tennis court. The latter systems require dedicated IT and logistics infrastructures, with multi-million investments and high running costs. Nevertheless, this great technological investment is undertaken to provide higher fidelity, immersion and realism to the third and most important component of a driving simulator: the human driver. Indeed, the primary purpose of a driving simulator is to reproduce in a controlled virtual environment the same conditions that a driver would experience in the real world. Therefore, the simulator user is the measure of the effectiveness of the driving simulation, in which the driver's perception and behavior are met.

Nowadays, simulators have well-established roles in the vehicle design process, from early

assessment of virtual prototypes to validation of production-ready solutions. Indeed, modern driving simulators allow designers and engineers to quickly implement virtual models and test them in highly realistic environments with selected drivers. The agility of this process, the standardization of the assessment procedures and the power of integrated software/hardware tools are surely key factors that explain the wide and successful adoption of driving simulator technology in industrial research.

The massive digitalization of industrial processes and the development of human-centered systems engineering are bridging the gap towards the design of usable, understandable, and natural Human-Machine Interfaces (HMI) which can be easily implemented and tested in driving simulators. Moreover, the development of ADAS is also being successfully tackled using driving simulators. However, the topic of Automated Driving (AD) is spreading in every sector of transportation technology and a question has raised:

Do we still need driving simulators in which users should be immersed, if vehicles are going to drive autonomously?

We will use our connected infrastructure to share information about drivers and passengers state and enable predictive safety in automated vehicles.

This seems a legitimate question if one considers that the driver will soon be OUT of the loop, while driving simulators have been designed to bring the driver IN the loop. The truth is that driving simulators are now more than ever necessary to put drivers and passengers in conditions that closely resemble the real road environment to evoke, measure, model and understand the complex relationship between humans, automated vehicles and road infrastructure.

New Driver Roles and Simulator Trends

A driving simulator conceived for research and development in the field of automated driving must consider the new roles that drivers are assuming. Indeed, with increasing level of automation drivers will be able to gradually phase-out control over the driving functions and transfer it to the automated vehicle. This trend will soon enable a variety of

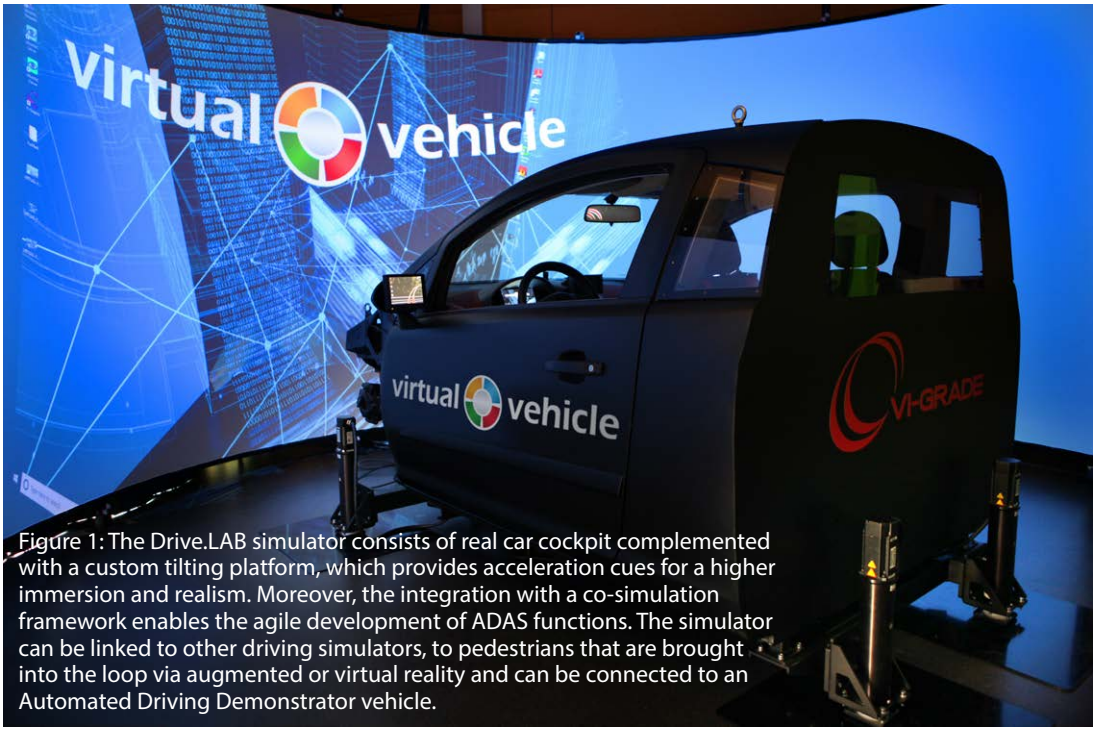

Figure 1: The Drive.LAB simulator consists of real car cockpit complemented with a custom tilting platform, which provides acceleration cues for a higher immersion and realism. Moreover, the integration with a co-simulation framework enables the agile development of ADAS functions. The simulator can be linked to other driving simulators, to pedestrians that are brought into the loop via augmented or virtual reality and can be connected to an Automated Driving Demonstrator vehicle.

non-driving tasks that until now were simply not part of the driving experience. Moreover, safety-critical issues arise in transfer-of-control scenarios, where the automated system and the human driver need to effectively communicate to each other their intensions and actions.

Therefore, a simulator must enable the study of the interactions between drivers, passengers, vehicles and road users. In line with this, it is foreseeable that the future development of driving simulators dedicated to AD research will focus more on enabling onboard connectivity, driver monitoring and interaction concepts and technologies.
Driving simulators need to be re-conceived as living spaces where humans act out-of-the-loop, in connection with each other and using different technologies, and upgraded with multi-sensory interfaces that have yet to be designed. This perspective will have profound implications in the development of future simulator technology.

VIRTUAL VEHICLE Drive.LAB

Following the above-mentioned considerations, at VIRTUAL VEHICLE we have installed a new semi-static driving simulator, equipped with a high-end visualization system and a real car cockpit. We have customized the system for research purposes with additional hardware and software components. We have integrated an eye-tracker, physiological sensors and webcams for monitoring the driver state, active belts and active seat for somatosensory stimulation to provide quick acceleration onset cues to the driver, an accurate sound reproduction system, and several mounting points for installing displays in different positions inside the cockpit. Additionally, the simulator features a first-of-its-kind integration of the car cockpit on a tilting platform, which enables the accurate reproduction of inertial cues and vibrations for drivability and comfort studies, with no need for large motion systems. Overall, our system is designed to enable and test the design and development of ADAS and Human-Machine interfaces for traditional and AD scenarios.

With this most recent addition to our simulator fleet, at VIRTUAL VEHICLE we are building Drive.LAB, a laboratory where scientists can efficiently develop and test innovative concepts and tools to address the current and far beyond state-of-the-art mobility challenges. Drive.LAB sets us apart from other research organizations, featuring a unique combination of human factors expertise, simulation facilities and access to real road and vehicles data.
Moreover, Drive.LAB connected simulators will help our scientist to investigate, understand and shape the new foreseeable driver roles in hybrid mobility scenarios, from partial to full automation. Our research focuses on improving safety in automated vehicles, while enhancing passengers' comfort and the overall acceptance of automated vehicle technology.

To these purposes, we are currently designing multi-sensory Fluid HMI, capable of driver monitoring and tutoring, seamlessly supporting the transition between automation levels in a comfortable and safe way, according to human-centered design principles. We will use our connected infrastructure to share information about drivers and passengers state and enable Predictive Safety in automated vehicles. This vision aims at designing Human-like automated systems that, like human drivers, can predict a potential hazard and prevent the triggering of a critical situation, rather than detecting a danger that is already underway. We are also contributing to an ongoing European-funded project (DOMUS) to develop an integrated acoustic and thermal comfort model for drivers of electric and automated vehicles. With our studies we are measuring the impact of different cognitive aspects on the subjective impression of sound quality in the vehicle.

All Pictures show the new driving simulator of Drive.LAB at VIRTUAL VEHICLE in Graz.
This tool was developed by VI-Grade within a strategic research cooperation. ■