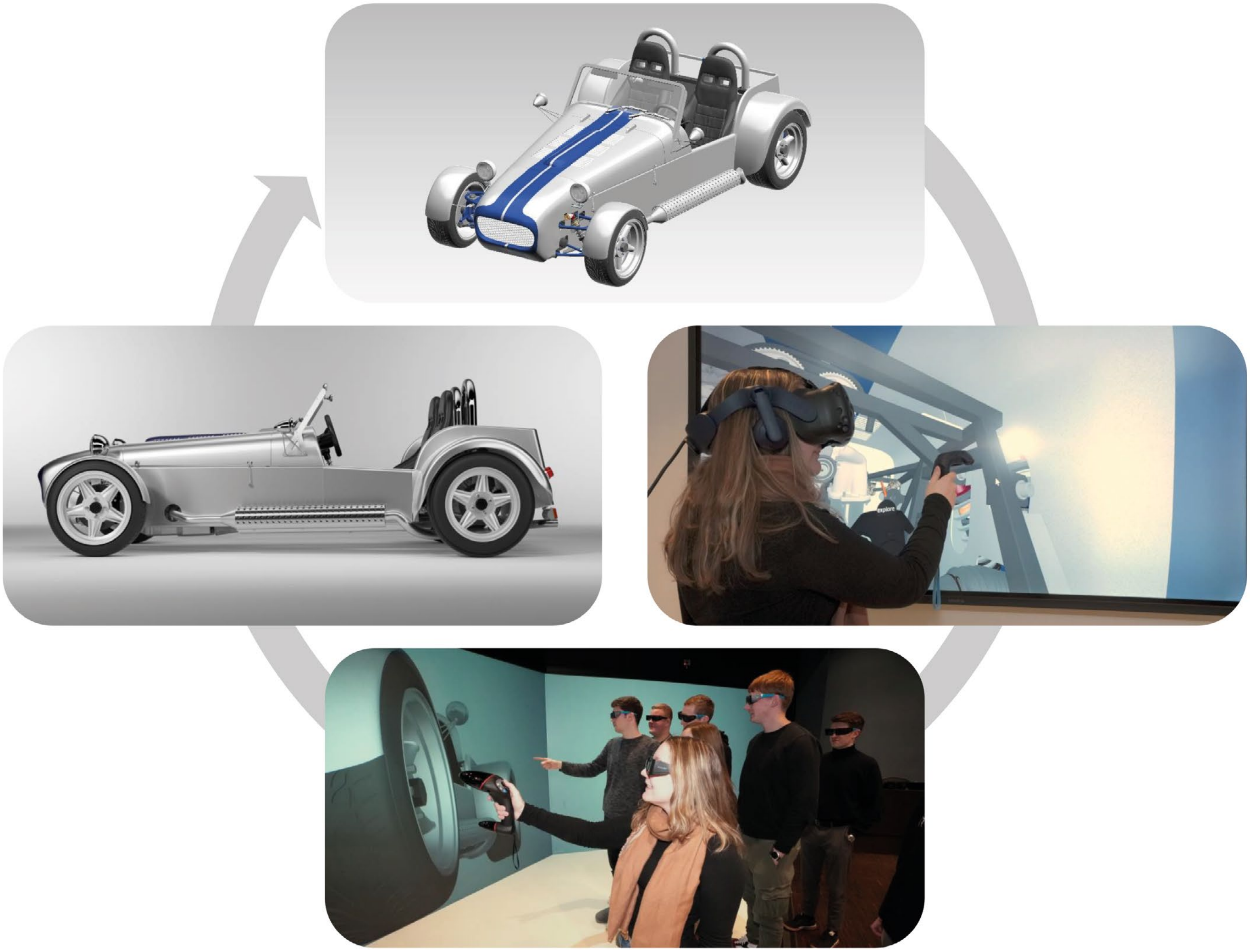

Innovative Training Methods in Automotive Engineering Using Virtual Reality

The use of virtual reality methods in vehicle development leads to higher quality products that can be developed more time-efficiently and cost-effectively. In addition to the head-mounted displays currently in use, a future-oriented virtual reality laboratory has been set up at the South Westphalia University of Applied Sciences in Iserlohn, where up to ten people can simultaneously immerse themselves in the virtual world on a big projection screen.

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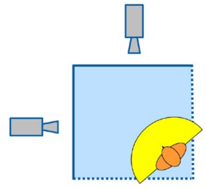
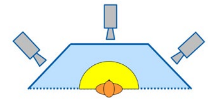
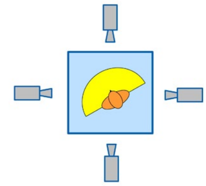
Since the 1980s, vehicle development has been carried out in three-dimensional space using 3-D Computer-Aided Design (CAD) software solutions. Today, these tools enable intuitive operation and the creation of stable geometry models. Computer simulations can use these models using suitable interfaces to enable virtual product development that is time-saving and cost-effective. With the introduction of Virtual Reality (VR) in vehicle development, processes can be further optimized, leading to high-quality results.

Only a small number of people have a very good spatial imagination, as studies have shown [1]. With the possibilities of VR, this ability to imagine is promoted and processes are presented more transparently for all project members. Immersion in the virtual world is so realistic that even complex geometries and processes can be understood more easily, even with the aforementioned restrictions.

In addition to Head-Mounted Displays (HMD), so-called Cave Automatic Virtual Environments (CAVEs) are used as VR technologies in industry and research. A CAVE is a projection room in which a three-dimensional geometry can be displayed virtually.

	Three-sided CAVE	Four-sided CAVE	Five-sided CAVE
Configuration			
Level of immersion	o	+	++
Group suitability	o	++	o
Multifunctionality	–	+	–

++ Very good   + Good   o Average   – Bad

TABLE 1 Comparison of different CAVE concepts [2] (© FH SWF)

CONCEPTION OF THE XR LABORATORY

Extended Reality (XR) is a generic term for various immersive technologies in which digital models are developed to represent the real world. The newly designed XR laboratory at South Westphalia University of Applied Sciences (FH SWF) focuses on VR teaching and research activities. Before a decision was made on the technology to be installed, there was a one-year concept phase in which the software and hardware solutions available on the market were evaluated. The priority for the concept selection was CAVE use, in which up to ten people can immerse themselves in VR models at the same time. Compared to the familiar HMD glasses, with which only one person at a time experiences virtuality, a large-scale CAVE projection offers multi-layered perspectives for training and project presentations.

TABLE 1 schematically shows various CAVE solutions known in practice. In this case, the solution of a four-sided CAVE with a matt glass projection surface of approximately 10.5×2.5 m that is opened up on three sides was used. The fourth side of the projection is the floor area in front of the three glass screens. Five three-chip laser projectors are used in summa. Three projectors shine onto the rear walls of the glass panes and two projectors are used for the floor projection (not shown in **TABLE 1**) which project the geometries onto the floor via mirrors. The immersion achieved with this concept does not quite come close to that of a five-sided CAVE solution, **TABLE 1** (right), as used at TU Dresden or RWTH Aachen University. This is a closed CAVE room with an additional projection from below onto the floor, whereby the CAVE room can only be used by a small number of people. In the solution at the FH SWF, an additional lecture hall has been set up to the open area of the projection screen, whereby additional people can follow the presentations from three tiered rows of seats [3].

With this implemented concept, it is possible to use the glass panels as normal projection surfaces for presentations, videos or video conferences in addition to pure CAVE operation. It is also possible to combine different image sources so that, for example, simulation software can be displayed simultaneously with a on-screen presentation. This makes it possible to impart knowledge in such a way that CAVE mode can be used only temporarily in a lecture if required. Another option is the use of HMD glasses, which can also be used to communicate with the CAVE. For example, data generated by an external

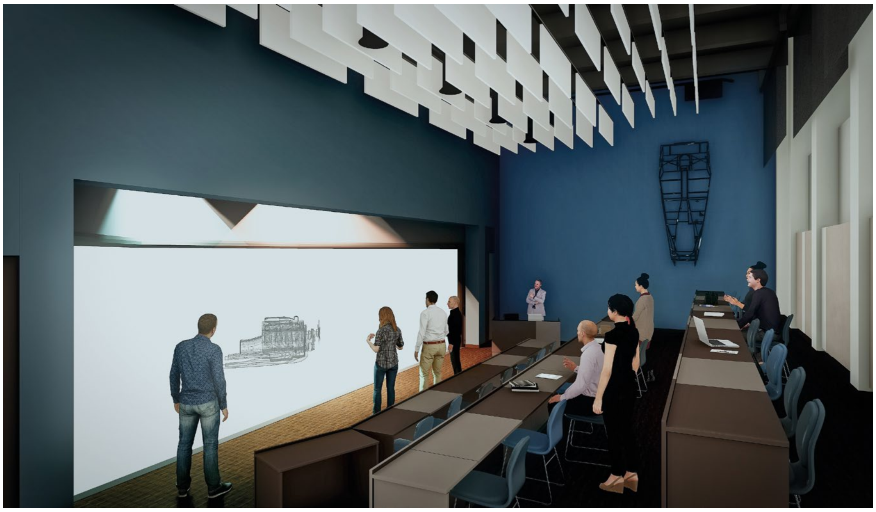


FIGURE 1 3-D architectural model of the XR lab during the planning phase (© FH SWF)

HMD workstation can be exchanged with the CAVE and people in the CAVE environment can immerse themselves in the externally presented geometries.

IMPLEMENTATION OF THE CONSTRUCTION WORKS

The new laboratory could be integrated almost perfectly into the existing premises. There was a partition wall between the technical room for the projectors and computers and the lecture hall, which was provided with a corresponding opening. The entire rough planning for the implementation was carried out using the Siemens NX CAD software used in mechanical engineering on the basis of detailed scan data of all the shell laboratory rooms in the building, which dates back to the 1960s. The entire interior architecture was visualized for the first-time using HMD glasses to ensure that the technical equipment could be integrated into the building and that good visibility was provided from all seats. The rough geometry was then transferred to architectural software in order to define all the details on this basis, **FIGURE 1**.

SOFTWARE FOR CAVE MODE

When selecting VR software, it was crucial that it was also suitable for use with HMD glasses. Furthermore, it should be used in the automotive industry so that technology transfer is possible and data can be easily exchanged with standard CAD software. The ability to create sectional models, carry out collision analyses, perform assembly tests and use existing kinematic motion simulations led to the selection of the IC.IDO software from the ESI Group.

USE OF A VEHICLE MODEL IN CAVE MODE FOR TRAINING PURPOSES

In recent years, a Lotus Super Seven from Vielhauer/Irmscher in Stuttgart has been reconstructed as part of

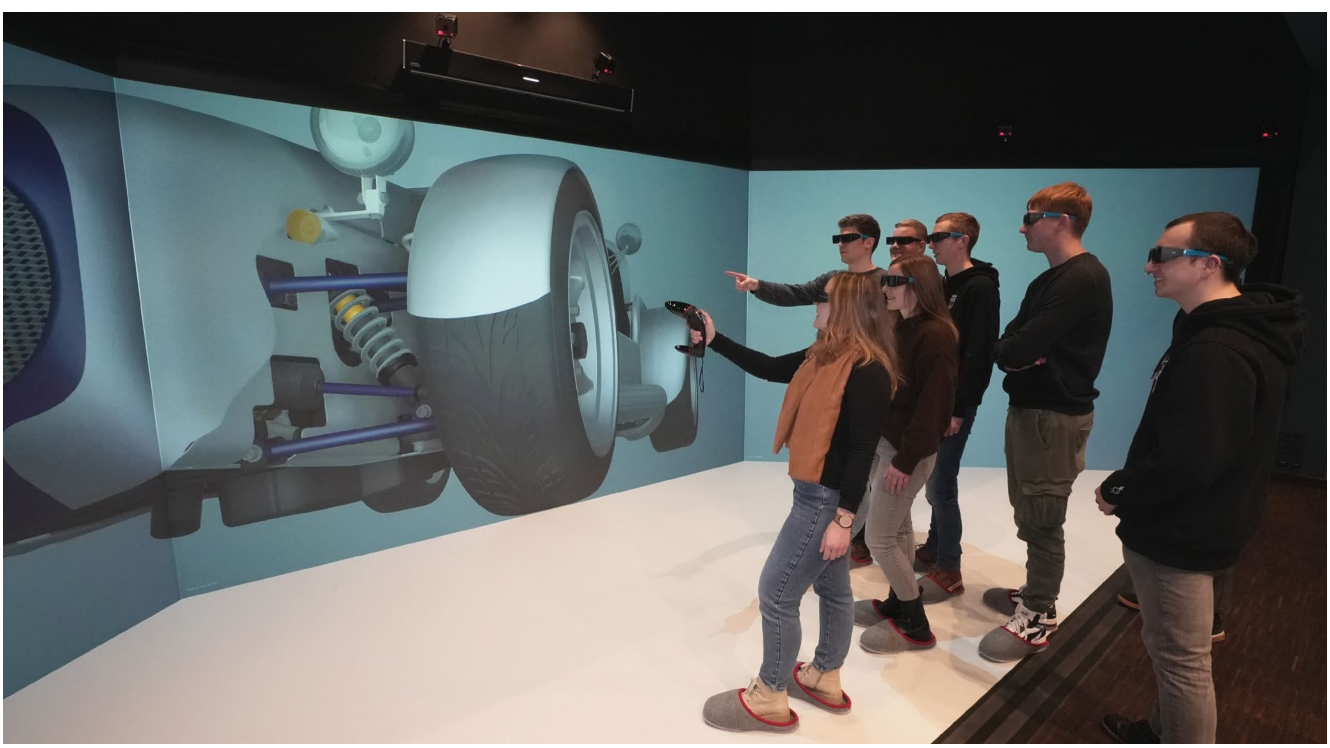


FIGURE 2 VR model of a Lotus Super Seven replica in the CAVE (© FH SWF)

One drives all.

Our **Integrated Drive Module** simplifies the electrification of all kinds of vehicles.

Charging forward

to accelerate the world's transition to eMobility

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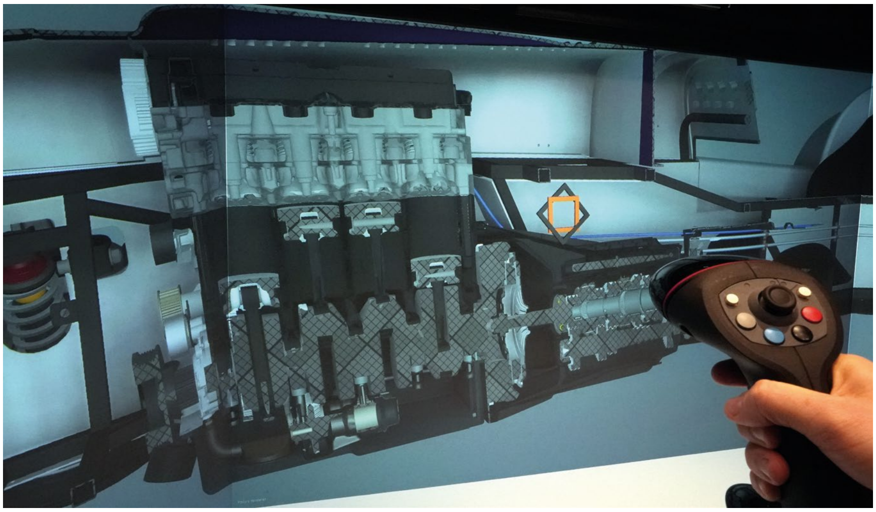

FIGURE 3 VR cutaway model of the combustion engine and gearbox of the Lotus Super Seven replica (© FH SWF)

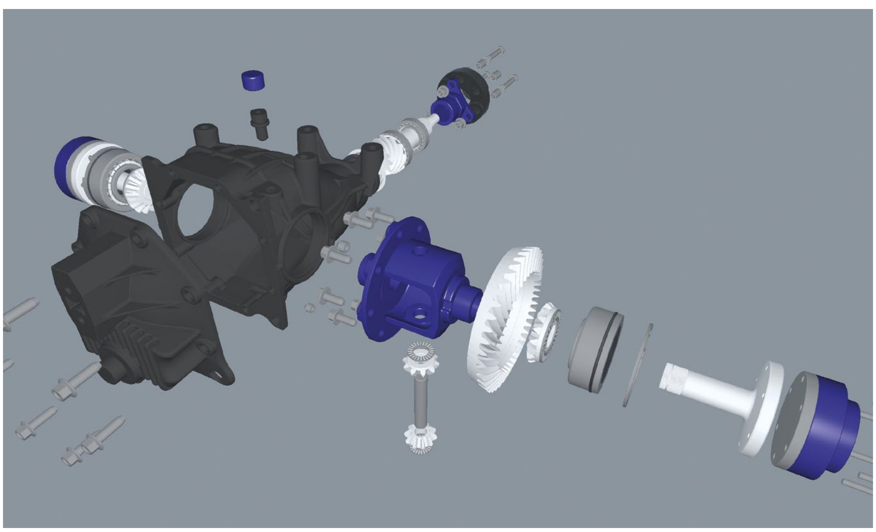

FIGURE 4 Exploded view of the individual parts of a differential gearbox (© FH SWF)

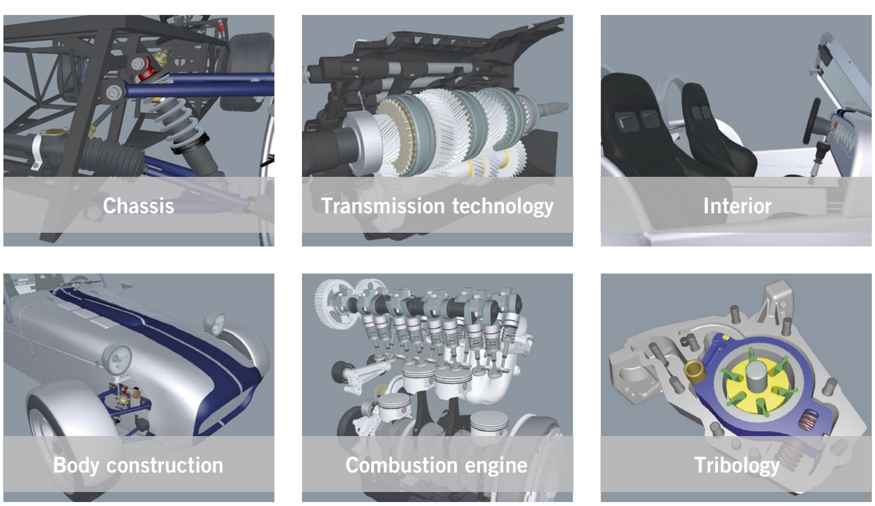

FIGURE 5 Example of the application of individual submodels of the vehicle (© FH SWF)

project work and final theses. The aim was to enable a later visualization of the data in the VR world for various teaching modules in the automotive engineering course. **FIGURE 2** shows the reconstructed vehicle in the CAVE and **FIGURE 3** shows a longitudinal section through the model. 3-D data from various CAD systems was used for the vehicle model. Scan data from a computer tomograph was used for the cylinder head and scan data from an optical 3-D scanner for the cylinder block.

No geometries can be created or changed in the VR software. This is done on the CAD workstation available in the XR laboratory. Various geometry analyses can then be carried out in the VR software. For example, any number of sections can be created through complex geometries, components can be removed from assemblies or exploded views can be created to provide a better overview of the components used, **FIGURE 4**. In addition, installation or removal tests can be carried out, which also take component collisions into account.

The CAVE or XR laboratory can be used by all teaching staff at the FH SWF. A laboratory engineer is responsible for operating the entire system with all application scenarios. The presentation of the VR models is very simple, so that lecturers can guide students through the VR models after a short briefing. **FIGURE 5** shows example components of the reconstructed VR vehicle model for courses in different semesters.

Another area of application for the use of CAVE is factory planning, in which component manufacturing processes can be simulated. Companies already have many 3-D CAD models of production facilities and/or machine tools that can be used and made available for a virtual production process. This allows entire factory plans to be created virtually, saving costs and avoiding planning errors. With avatars that depict people in the production facility, ergonomics studies can be created in advance, allowing the movement sequences of people to be sensibly predetermined.

An additional CAVE scenario is the possibility of displaying a three-dimensional structure on three sides of the projection surfaces in so-called 3-D mixed mode and, for example, displaying the workflow of assembly instructions in parallel on the free projection surface. This is important for training courses, where up to 30 people can follow this process in the connected auditorium.

Kinematic simulations can be easily displayed by either generating them in IC.IDO or importing them directly from Siemens NX. There is currently no experience in the laboratory with VR applications from simulation technology such as finite element calculations in strength of materials, vehicle crash simulations or, for example, flow simulations.

SUMMARY AND OUTLOOK

With the new XR Lab at FH SWF, development processes in mechanical engineering and especially in vehicle development can be made more transparent for the entire project team. Different file formats from various CAD systems used in automotive development can be successfully integrated into the VR software [4]. This made it possible to create a self-constructed vehicle model for the students' training. The spontaneous switch between the VR visualization options and the normal presentation tools leads to more efficient and higher quality teaching. Furthermore, all those involved in project work – regardless of their training – can participate in the decision-making process for new products.

It is to be expected that software tools for augmented and virtual reality applications will be further developed and become more widespread. The degree of immersion of HMD glasses is very high and will become even higher in line with the performance of PCs. Furthermore, HMD workstations are inexpensive compared to large CAVE solutions and are therefore attractive for companies. Unfortunately, wearing HMD glasses can easily cause dizziness (motion sickness) in older people, which restricts the use of VR technology for individuals or groups of people due to the system. As part of the technology transfer between industry and the university, the FH SWF has decided to rent out the XR lab. Own VR models, for example also created with HMD glasses, can be used there for presentations in groups.

THANKS

The authors would like to thank the project manager Dirk Schluck (FH SWF) and the project partners Imsys GmbH & Co. KG, Project:Syntropy GmbH, ESI Group and Architectural Office Walter Ebeling for their cooperation during the development of the XR laboratory.

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