# EMMA Learns to Drive – Dynamic Human Model for Autonomous Vehicles

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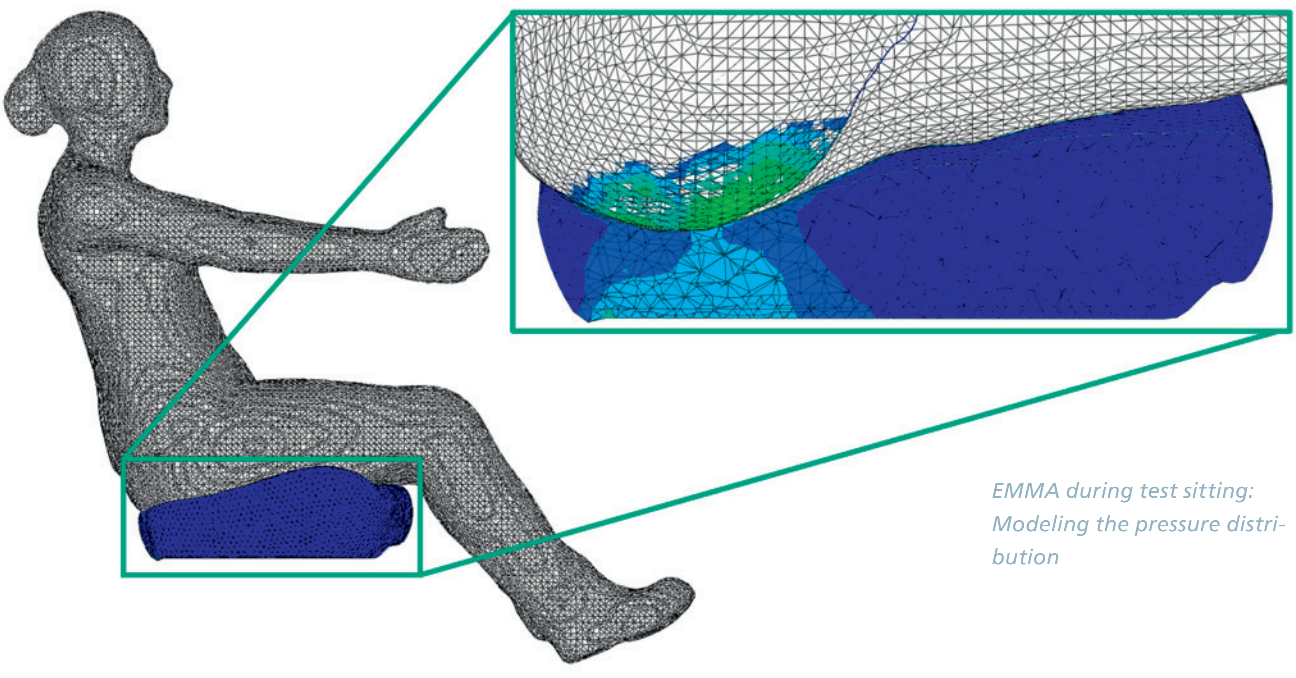
Five disciplines combined in EMMA4Drive: mechatronics, ergonomics, psychology, automotive engineering and techno-mathematics

In order to understand the expectations of customers of autonomous vehicles, to strengthen their trust and to prove safety, new digital tools are needed for research, development and validation of the technology. With the EMMA4Drive project, researchers in the division of "Mathematics for Vehicle Engineering" are further developing the dynamic human model EMMA-CC for use in fully or partially autonomous driving vehicles.

EMMA-CC stands for "Ergo-dynamic Moving Manikin with Cognitive Control" and is an old acquaintance: In the MAVO project of the same name, six Fraunhofer institutes had collaborated on digital human modeling for the simulation-based ergonomic design of workplaces. The further development EMMA4Drive now virtually takes a seat in the car and dynamically simulates the interaction of human body parts and the vehicle seat during driving maneuvers. The resulting software prototype will serve as a digital twin of the occupants, helping to analyze and evaluate new seating concepts in the passenger compartment in terms of safety and ergonomics during driving maneuvers.

## Motion sequences instead of quasi-static tests

So far, human models have mostly been used in crash simulations to estimate the risk of injury. However, detailed, computationally time-intensive models for calculations in the millisecond range are used here, which are not suitable for the simulation of dynamic driving maneuvers, since longer processes have to be simulated here. Another field of application for digital human models are ergonomics analyses in assembly planning. The models used for this purpose often only represent postures of the human body or quasi-static motion sequences by means of highly simpli-



*EMMA during test sitting: Modeling the pressure distribution*

*Precision work during the cabin change: For the next test cycle, a car chassis is lowered into the projection dome of the RODOS.*

fied multi-body kinematics. Such models do not take dynamic effects into account and the analysis of physical loads is hardly possible, since pure kinematics models can provide little information about biomechanics..

## Sit better, operate more comfortably

"Our human model, on the other hand, uses an optimization algorithm to automatically calculate new body postures and entire motion sequences over a longer time window with the associated muscle activities," explains project manager Dr. Marius Obentheuer. "This means that the simulation model can also be used to investigate the effect of dynamic driving maneuvers on humans and their (reaction) behavior – for example, in the design of assistance systems or control algorithms for (partially) autonomous driving." EMMA4Drive thus enables comparatively simple implementation of new movement patterns and efficient virtual investigation of safety, comfort and ergonomics in (partially) autonomous driving.

## EMMA on RODOS®

And before EMMA is allowed on the road, she must of course pass her driving test – virtually in our interactive driving simulator RODOS® (RObot based Driving and Operation Simulator). But first, a real human takes a seat there to collect physical measurement data and provide input for the simulation software. The interaction between the driver and the seat is investigated, for example the pressure distribution. This data should help to better answer fundamental questions about autonomous or semi-autonomous driving: How quickly should the tilted backrest of a seat be raised again with the integrated electric motor system? Does the turned seat return to its original position? How long does it take for the human to take the wheel again when the vehicle signals "Danger from the right, please take over!" in semi-autonomous mode?

The driving simulator is a central component of the technical center in the division "Mathematics for Vehicle Development" and allows the use of different production cabs and real car bodies mounted on a strong robot arm. Currently, the researchers are working on a combined biomechanical-mechatronic model of the coupled seat system, which can be used to parameterize and calibrate the simulation software developed in the EMMA4Drive project.

## Fewer hardware conversions required

This means that in the future, certain tests that are primarily aimed at physically stressing the occupants can also be carried out purely virtually, in addition to individual RODOS® simulator studies in a real driving cabin. When testing new concepts or comparative investigations of alternative variants, this saves time-consuming hardware modifications. However, for studies in which psychological aspects of the driving behavior are in the foreground, the simulation with RODOS® in a realistic cabin environment remains indispensable, since it is crucial for achieving a perfect immersion of the human being into the driving situation.

**Further information can be found at www.itwm.fraunhofer.de/emma4drive_en**

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