



THE DESMORI MOTORCYCLE RIDING SIMULATOR FOR HUMAN FACTORS RESEARCH

POWERED TWO WHEELERS RESEARCH AT WIVW

Conference

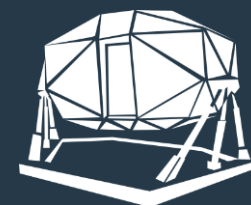
Motorcycle Industry Event at VI-Grade's Zero Prototype Summit 2024, Udine, IT

Presenters

Raphael Pleß, Sebastian Will

Date

14 May 2024





WIVW FOCUS



HUMAN FACTORS RESEARCH

R&D SERVICES

- ▶ Research & Development: interdisciplinary research on driver behavior (HMI design, usability, controllability, driver state assessment,...)
- ▶ Focus: mobility and traffic



SILAB® DRIVING SIMULATION

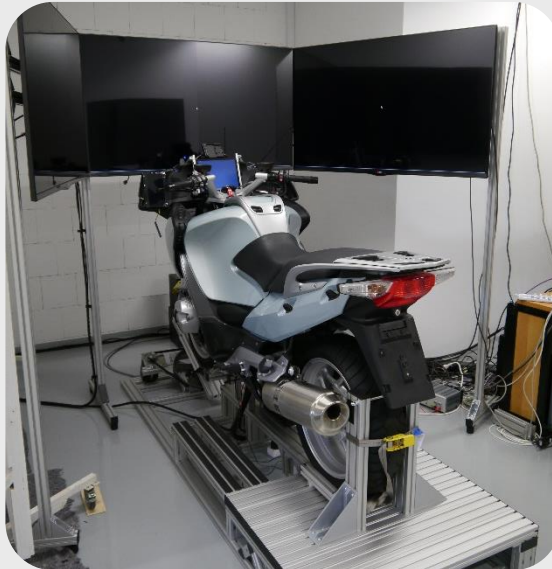
SOFTWARE DEVELOPMENT

- ▶ Simulation software for cars, trucks, powered two-wheelers, bicycles and pedestrians
- ▶ Fields of application: research & development, driver education and training



WIVW FOCUS

- ▶ From 2010: New research questions in the two-wheeler sector created the need for appropriate research tools: driving simulators, as successfully used in the automotive sector, for **human-in-the-loop** testing
- ▶ No standard motorcycle simulator available to meet the human factors research needs
- ▶ Design, construction & testing of a range of motorcycle riding simulators tailored to the different research questions



„SIM5“



„VERA“



„DESMORI“

Different prototypes and motorcycle simulators at WIVW over the course of time

wivw
FZD

BMW
MOTORRAD

DESMORI

KF3209301RP3 ZIM DESMORI

ZIM
Zentrales
Innovationsprogramm
Mittelstand

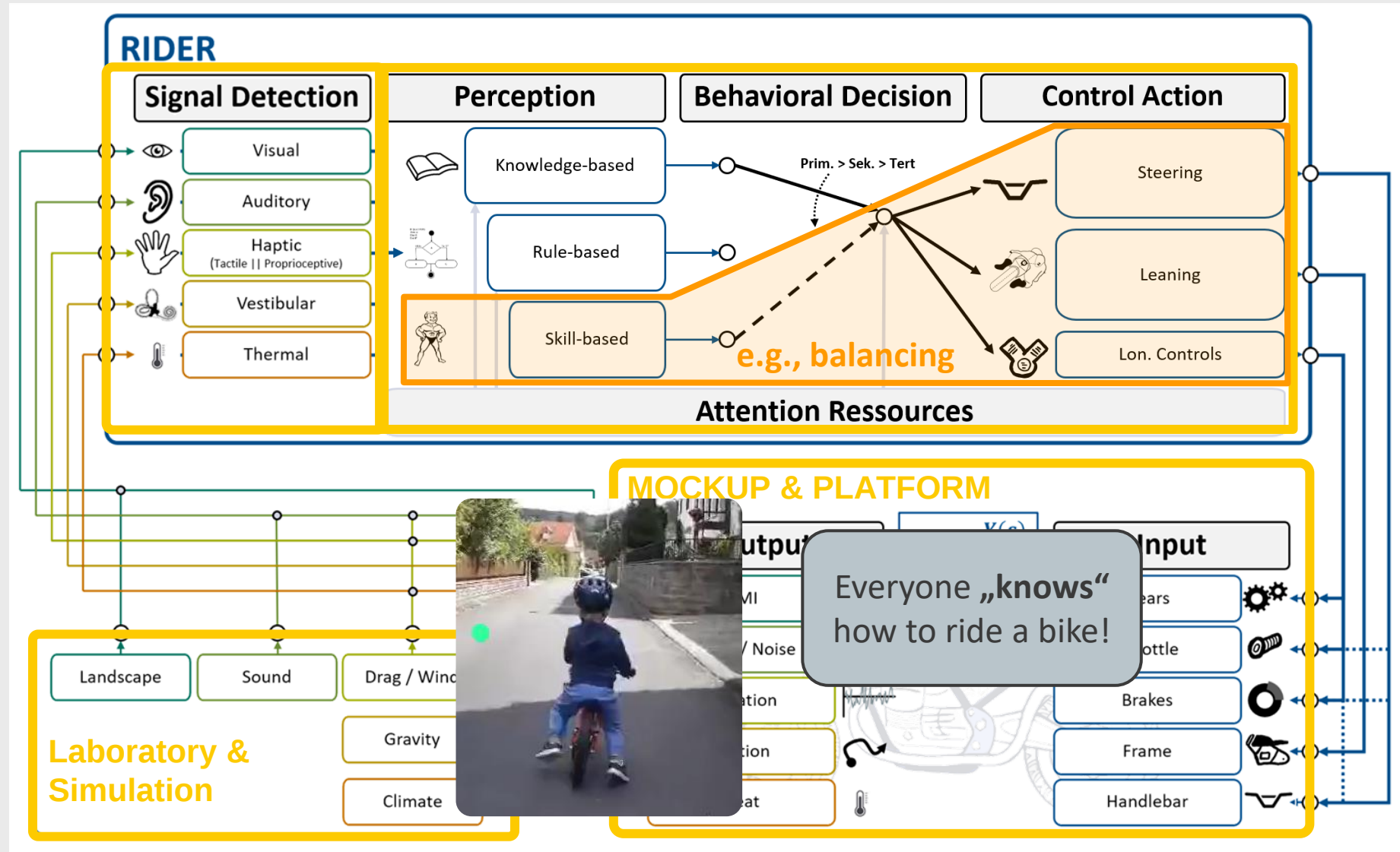
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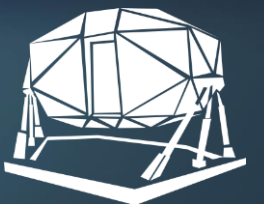
RIDING A MOTORCYCLE VS. RIDING A SIMULATOR





REQUIREMENTS & CHALLENGES

... AND HOW WE DEALT WITH THEM





MOTORCYCLE SIMULATOR EXPERIENCE

DUAL LOOP RIDER CONTROL (DLRC)

► Requirement:

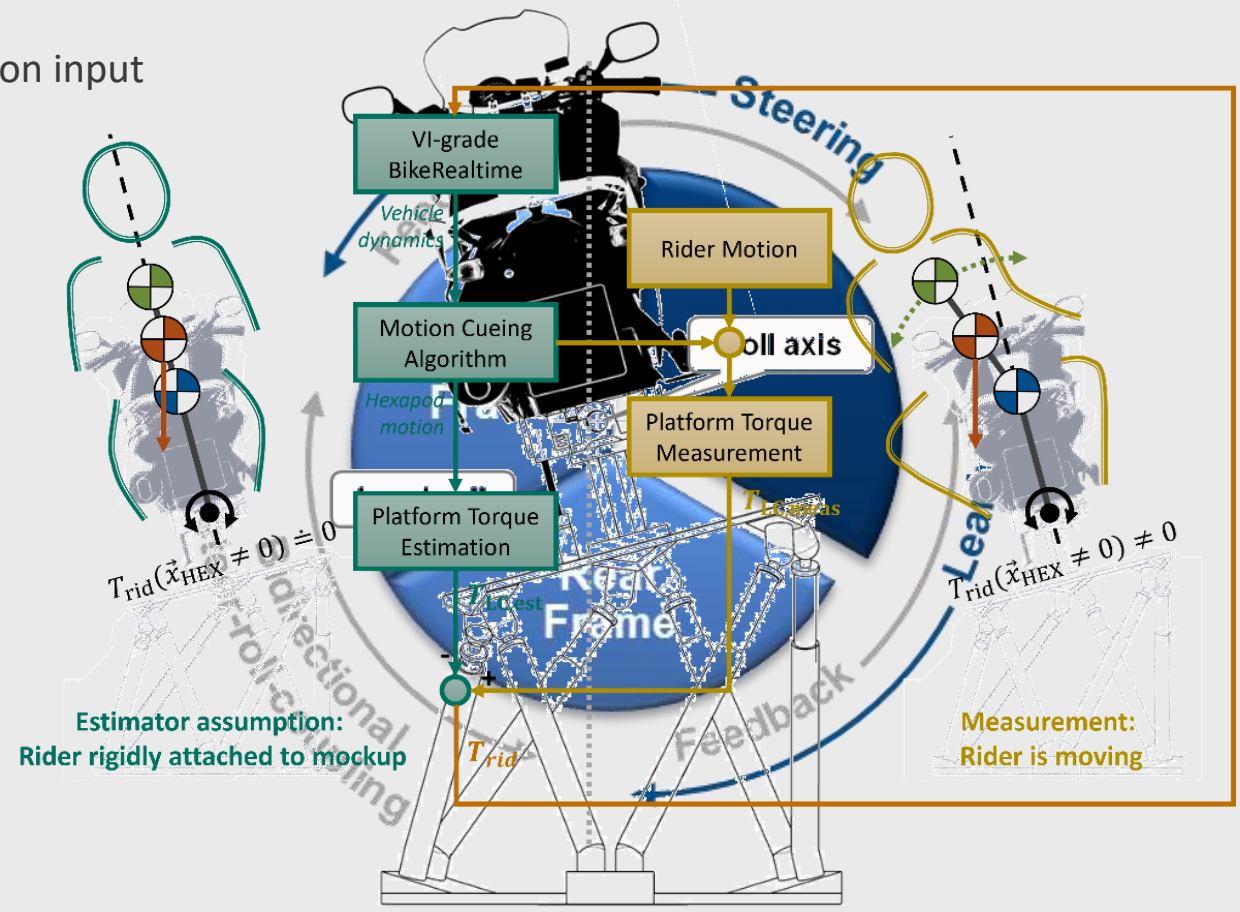
Riders must be able to steer the vehicle by a combination of handlebar input and body motion input e.g., to overcome “positive-steering”

► Solution:

Rider-induced roll torque mechanism

► Challenges:

- Compensation of platform motion
- Interpretation of rider motion w.r.t. MCA
- NVH simulation disturbs sensor





MOTORCYCLE SIMULATOR EXPERIENCE

MOTION CUEING ALGORITHM AND STEERING CONTROL

► Requirement:

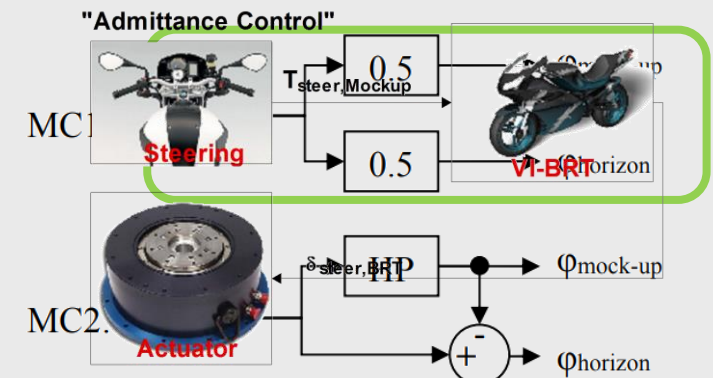
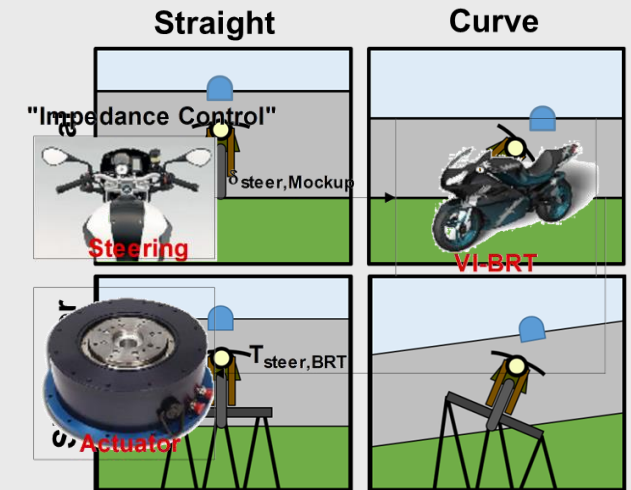
Proprioceptive and haptic feedback crucially affect the rider's control behavior. The vehicle's roll susceptibility to lateral dynamic inputs has implications on steering behavior and stability perception.

► Solution:

Utilizing a motion cueing algorithm and active steering feedback

► Challenges:

- Static platform roll angles theoretically are implausible...
- ...but studies show that they are expected in participant studies
- Steering behavior is velocity dependent
- Roll gains interact with the perception of steering torques



Motion cueing algorithm to reproduce motorcycle specific lateral dynamics on riding simulators (Guth, et al., 2015)



MOTORCYCLE SIMULATOR EXPERIENCE

VISUALIZATION AND ENVIRONMENT PERCEPTION

► Requirement:

Despite „being“ in a virtual environment, the rider will eventually relate to the real environment. Therefore, if the real (laboratory) environment can be perceived by the rider, it must provide plausible cues.

► Solution:

Floor projection screen in addition to cylindrical screen
resp. VR-glasses

► Challenges:

- With a static road platform, false cues are inevitable to a certain extent (but better than no cues)
- VR excels at road perception, but poses challenges when investigating user interfaces (HMI)





MOTORCYCLE SIMULATOR EXPERIENCE

PROPRIOCEPTIVE CUES

► Requirement:

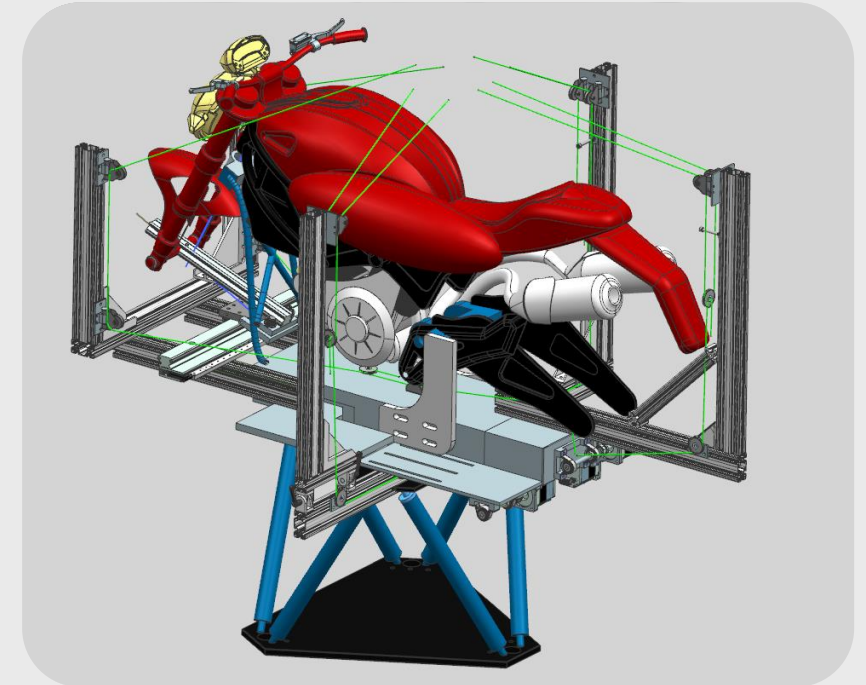
Improved velocity and acceleration/ deceleration feedback compared to state-of-the-art PTW simulators

► Solution:

Rope-towing mechanism to substitute drag & inertial forces significantly improved speed perception and presence

► Challenges:

- Applying a surface load on the rider's body
- Mechanical backlash
- Multi-directional cues





MOTORCYCLE SIMULATOR EXPERIENCE

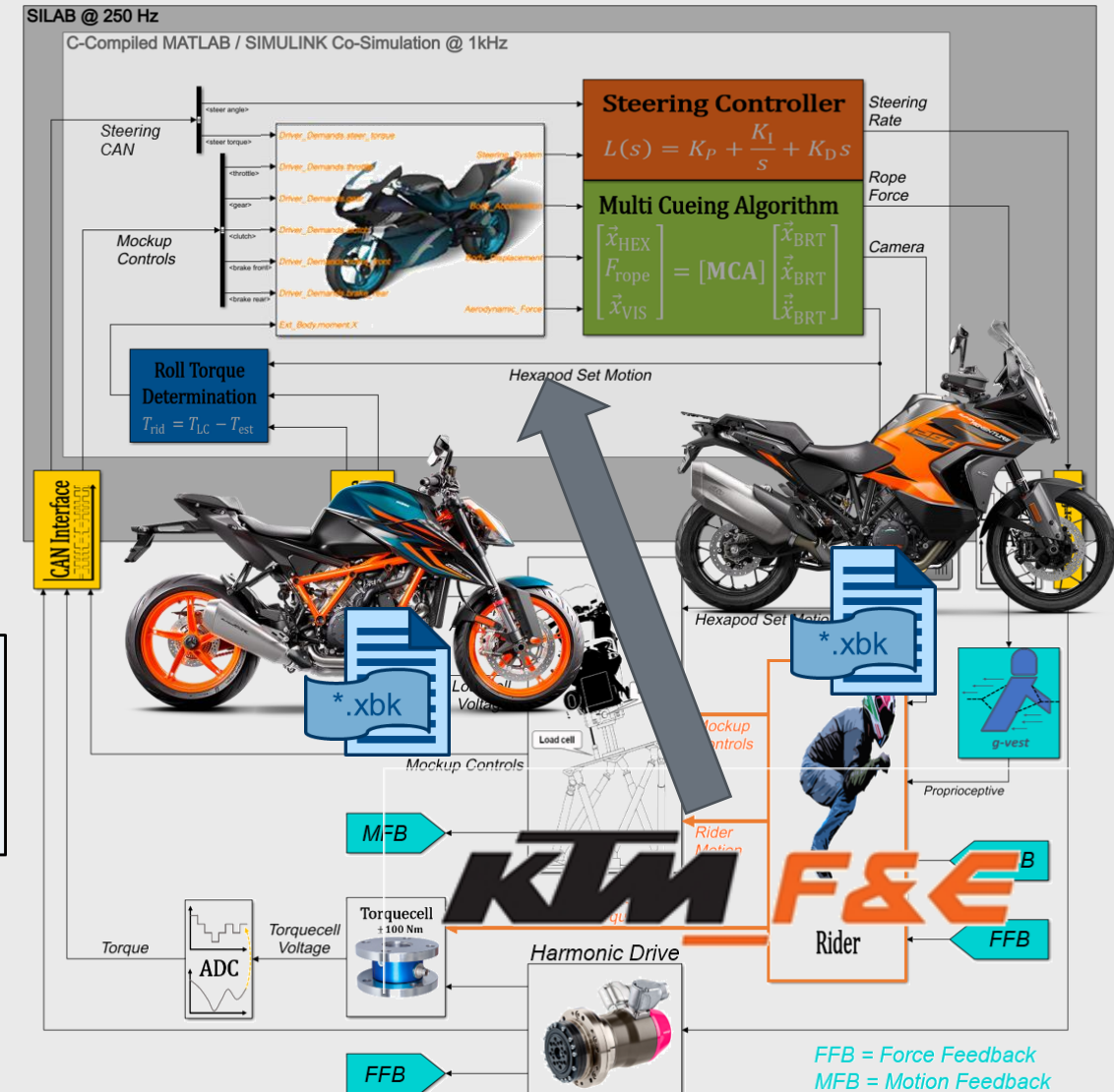
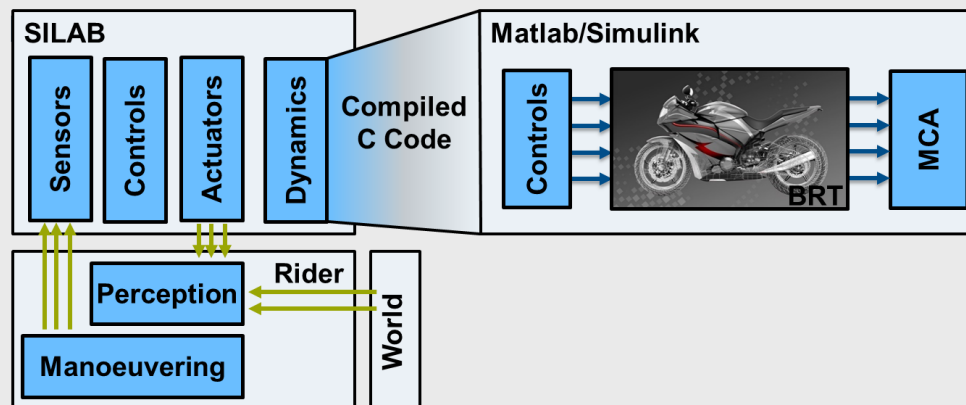
SOFTWARE & INTERFACING

► Requirement:

Integration of custom (or even black-box) motorcycle model components and peripheral systems

► Solution:

vi-BRT Co-simulation with Matlab Simulink and integration to the SILAB[®] simulation environment





CONCLUSION





THE DESMORI MOTORCYCLE RIDING SIMULATOR

WHAT LAYS BEHIND US

Various successful Human Factors research projects (industry partners & publicly funded projects):

- ▶ Distraction assessment (usability of HMIs, effects of different ergonomics etc.)
- ▶ Rider assistance system design (understanding and optimizing rider reactions towards interventions)
- ▶ Warning design
- ▶ Controllability assessment (e.g., smart glasses, HUD)
- ▶ ...

Focus on vehicle dynamics:

- ▶ Autonomous Emergency Brakes
- ▶ Naive rider study
- ▶ Effects of varied vehicle setups
- ▶ ...





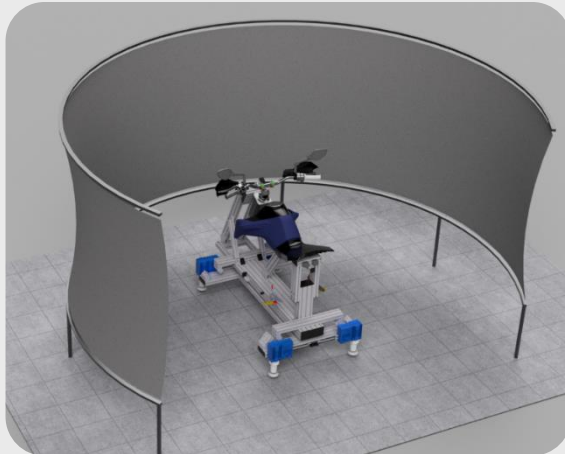
MOTORCYCLE RIDING SIMULATORS

WHAT LAYS AHEAD

Motorcycle riding simulators become increasingly important.

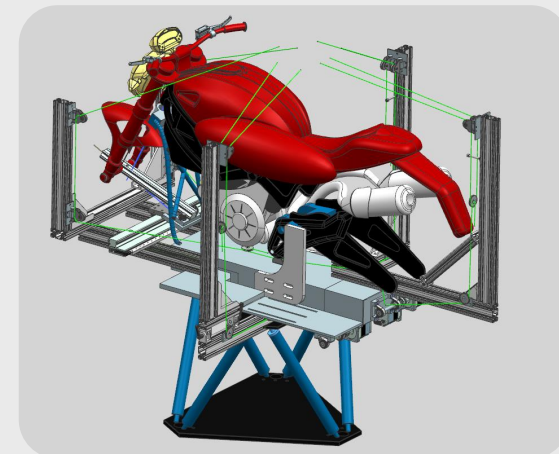
This trend confirms our approach and the development of our expertise over the last decade. Depending on the research question at hand, this motivates further upgrades and innovation.

Innovation towards simplicity



„VERA 2.0“

Innovation towards increased high-fidelity



Multidirectional vestibular feedback and rider input



THANK YOU!

wivw

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