MOTORIST Simulator

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Realize innovation.

MOTOrcycle Rider Integrated SafeTy
MOTORIST

SIEMENS

Enhance Motorcycle Rider Safety

Motorcycles are an efficient and flexible transport system in the congested European cities. But the risk for the riders is still higher that for other vehicles.

→ **Reduce number of accidents and consequent injuries**

WP1: Rider Training	Improving rider's skills with training strategies both in real and virtual environment

ESR1.2: Maria Di Gesu

WP2: Integrated Safety	Developing advanced safety systems modelling the rider and the interaction with the motorcycle

ESR2.1: Marco Grottoli
ESR2.3a: Francesco Celiberti

WP3: Protective Equipment	Developing personal protective equipment

Consortium: UNIVERSITÀ DEGLI STUDI FIRENZE · TU Delft · SIEMENS · Università degli Studi di Padova · UWS UNIVERSITY OF WEST OF SCOTLAND · UNIVERSITY OF LUXEMBOURG · LMU Ludwig Maximilians Universität München · DAINESE

Associated Partners: TNO innovation for life

Supervisory Board: acem · FEMA · esi get it right · MOOG · SWOV

Website: www.motorist-ptw.eu

Siemens PLM Software

MOTORIST simulator: overview

- 8 Simulator manager
- 6 Virtual-reality
- 7 Safety
- 2 Sensors-actuators
- 3 Vehicle dynamics
- 4 Haptic feedback
- 1 Mechanical design
- 5 Motion cueing

MOTORIST simulator: overview

1 Mechanical design

Mechanical Design

Preliminary design

↓

Tentative design
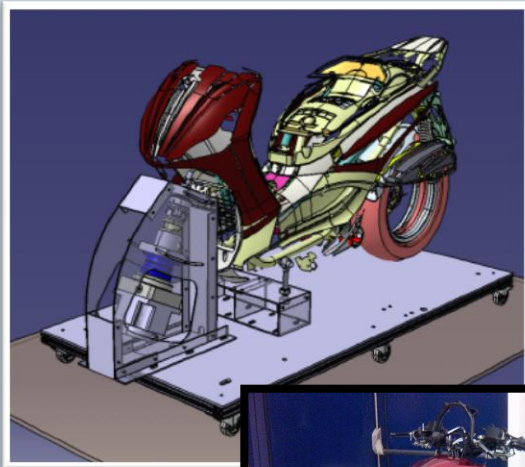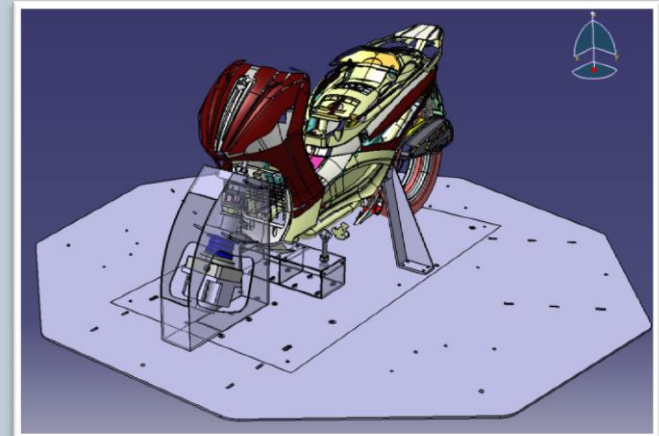
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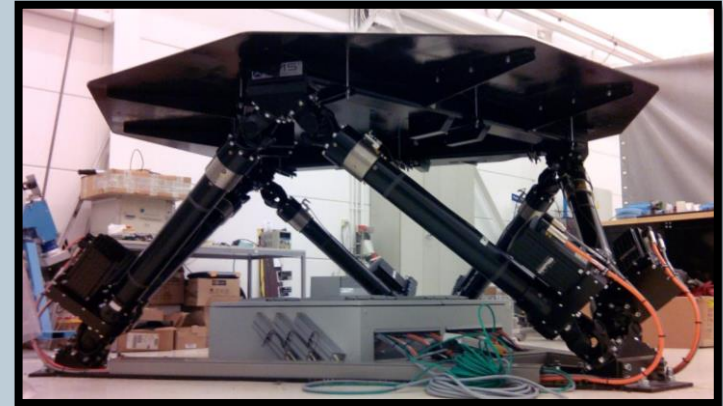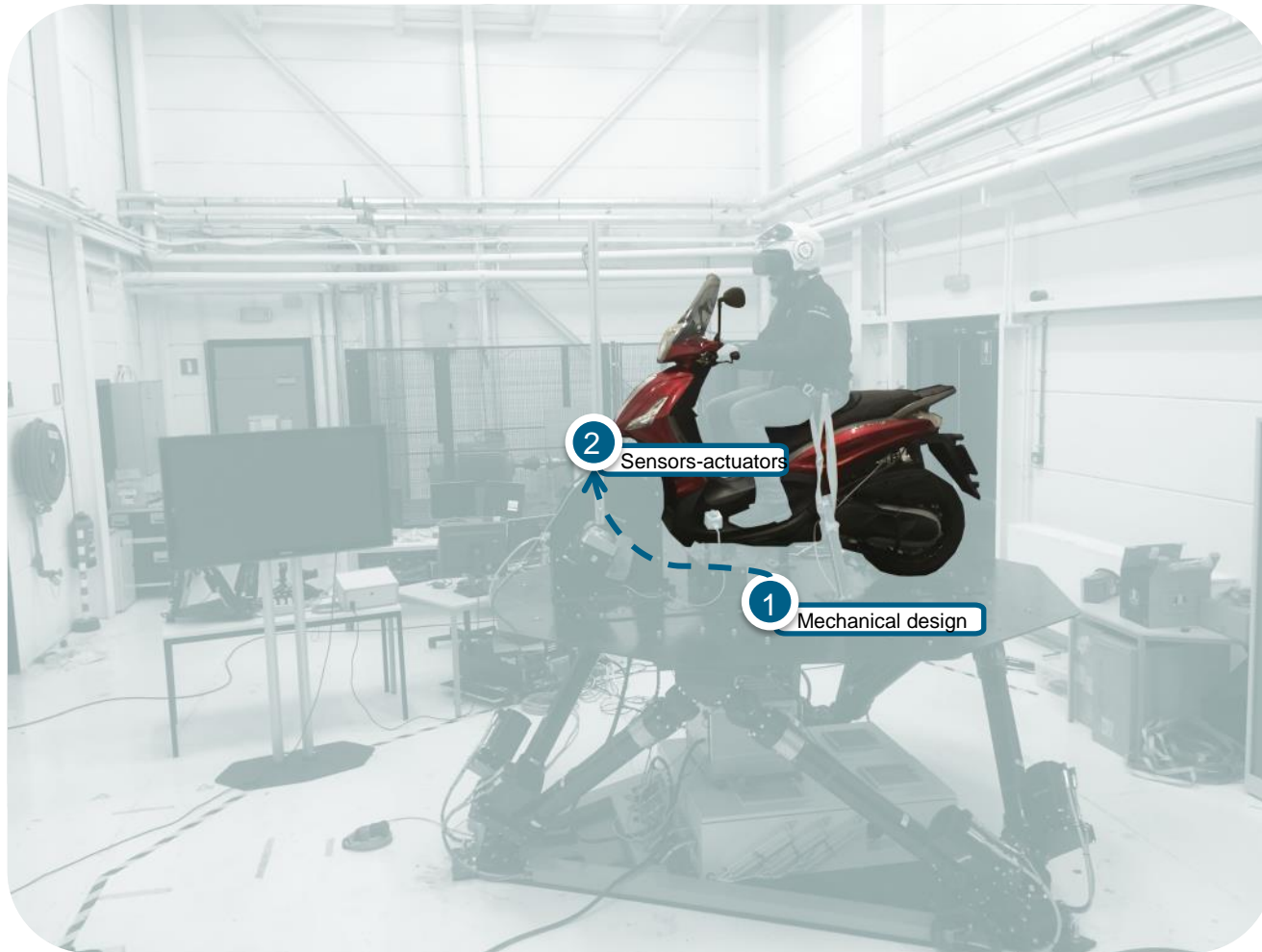**Static & Dynamic analysis**

↓

Verified

No

Yes
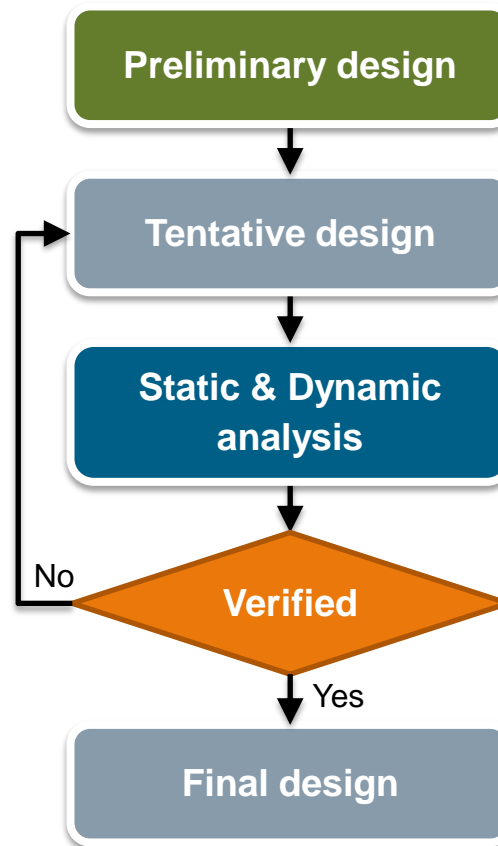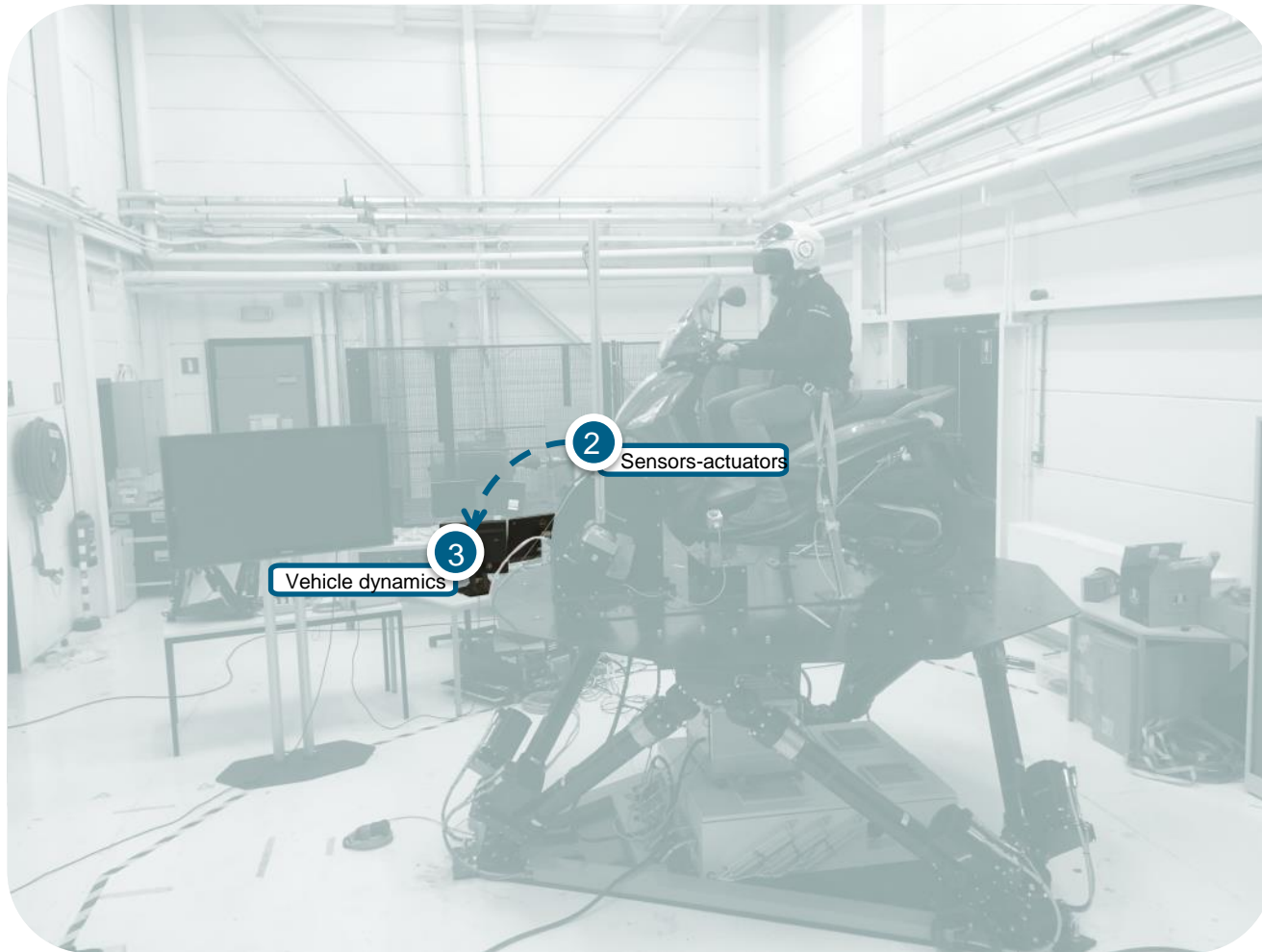
Final design

Mechanical Design

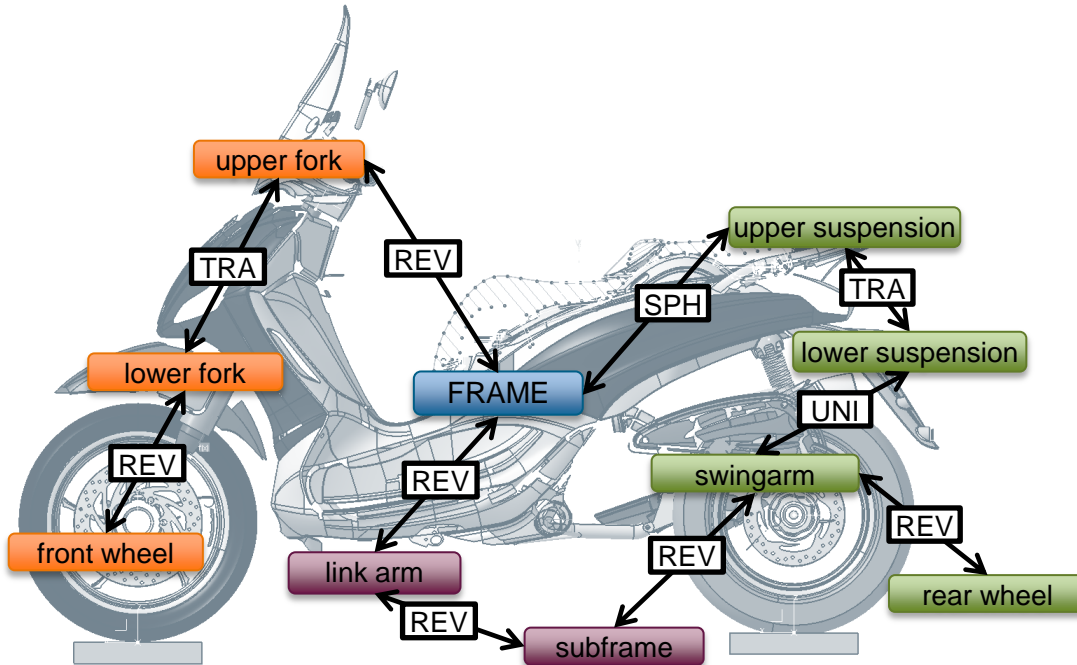## Static setup

Dynamic setup

MOTORIST simulator: overview

2 Sensors-actuators

1 Mechanical design

Instrumentation

ENCODER

THROTTLE

BRAKES ENCODER

STEERING ANGLE ENCODER
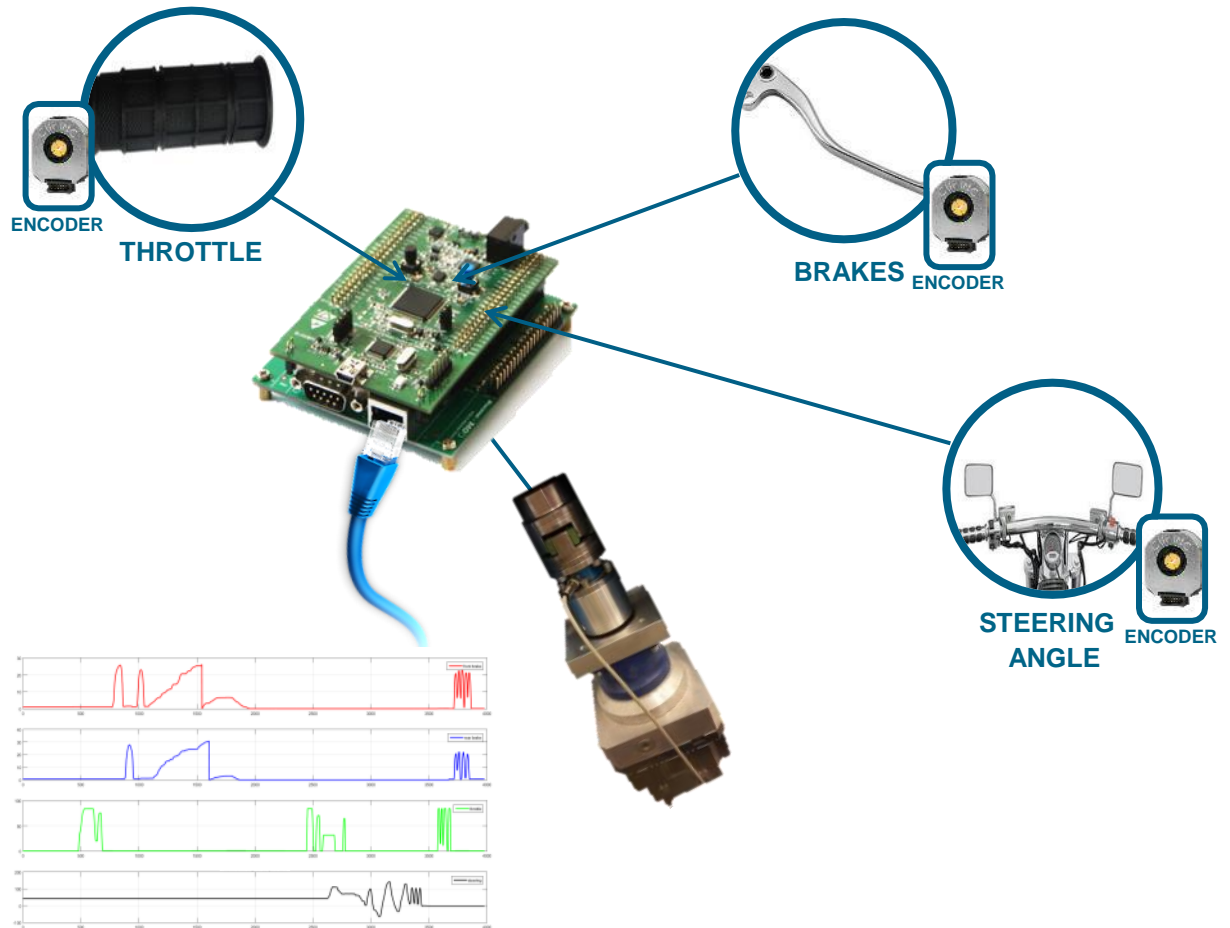
MOTORIST simulator: overview

Multibody Model

upper fork
TRA
REV
lower fork
REV
front wheel
FRAME
REV
link arm
REV
subframe
upper suspension
TRA
SPH
lower suspension
UNI
swingarm
REV
REV
rear wheel

- • Rigid bodies connected with ideal joints

- • Nonlinear stiffness and damping curves

- • Estimated tires parameters

- • Model realized in **LMS Virtual.Lab Motion**

- • In collaboration with **Piaggio**

Previous project

4DOF **9DOF** **11DOF**

17 bodies & 18 joints

➢ **13 DOF**

Increasing complexity

MOTORIST project

Real-time

Siemens PLM Software
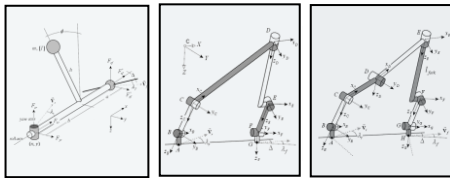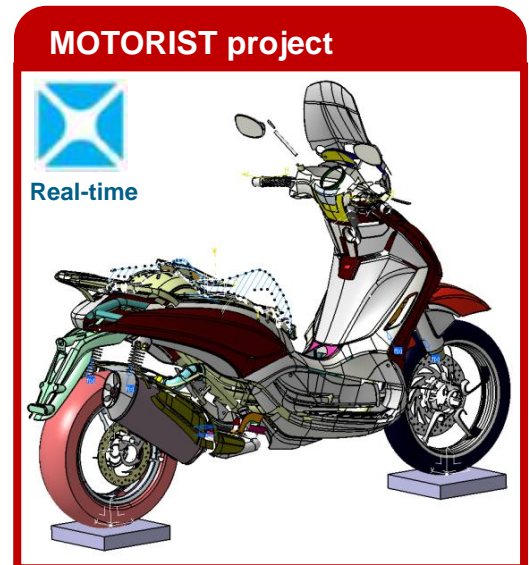
Multibody Model Simulation
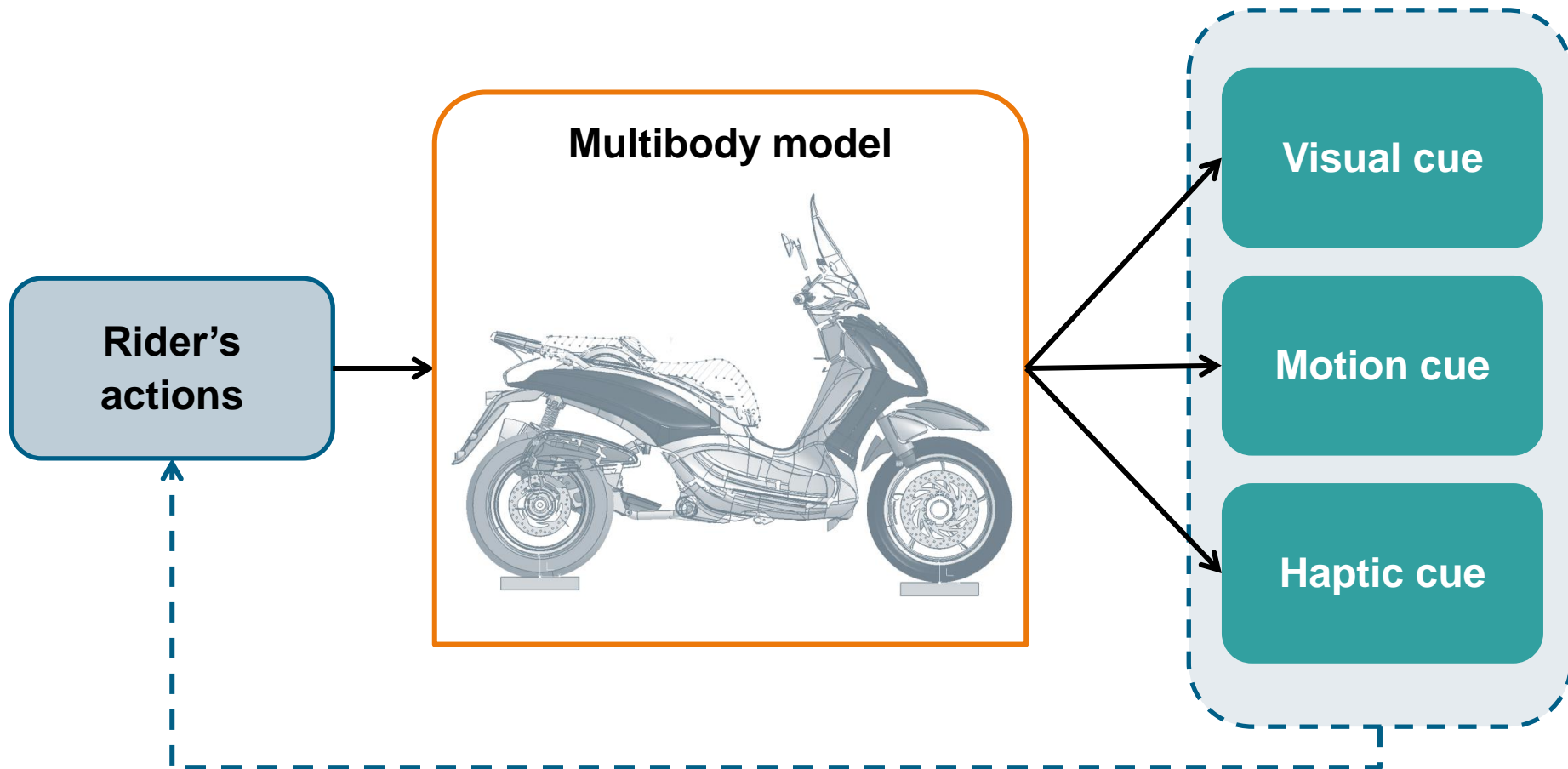
Rider's actions → **Multibody model** → **Visual cue** / **Motion cue** / **Haptic cue**

MOTORIST simulator: overview

Siemens PLM Software

Haptic Feedback

VEHICLE DYNAMICS

SIMULATOR

τ_r

τ_{ref}

MOTOR
CONTROLLER

τ_m

RIDER TORQUE ESTIMATION

τ_m

$\hat{\tau}_r$

τ_{ts}

Disturbance Observer

DISTURBANCE OBSERVER
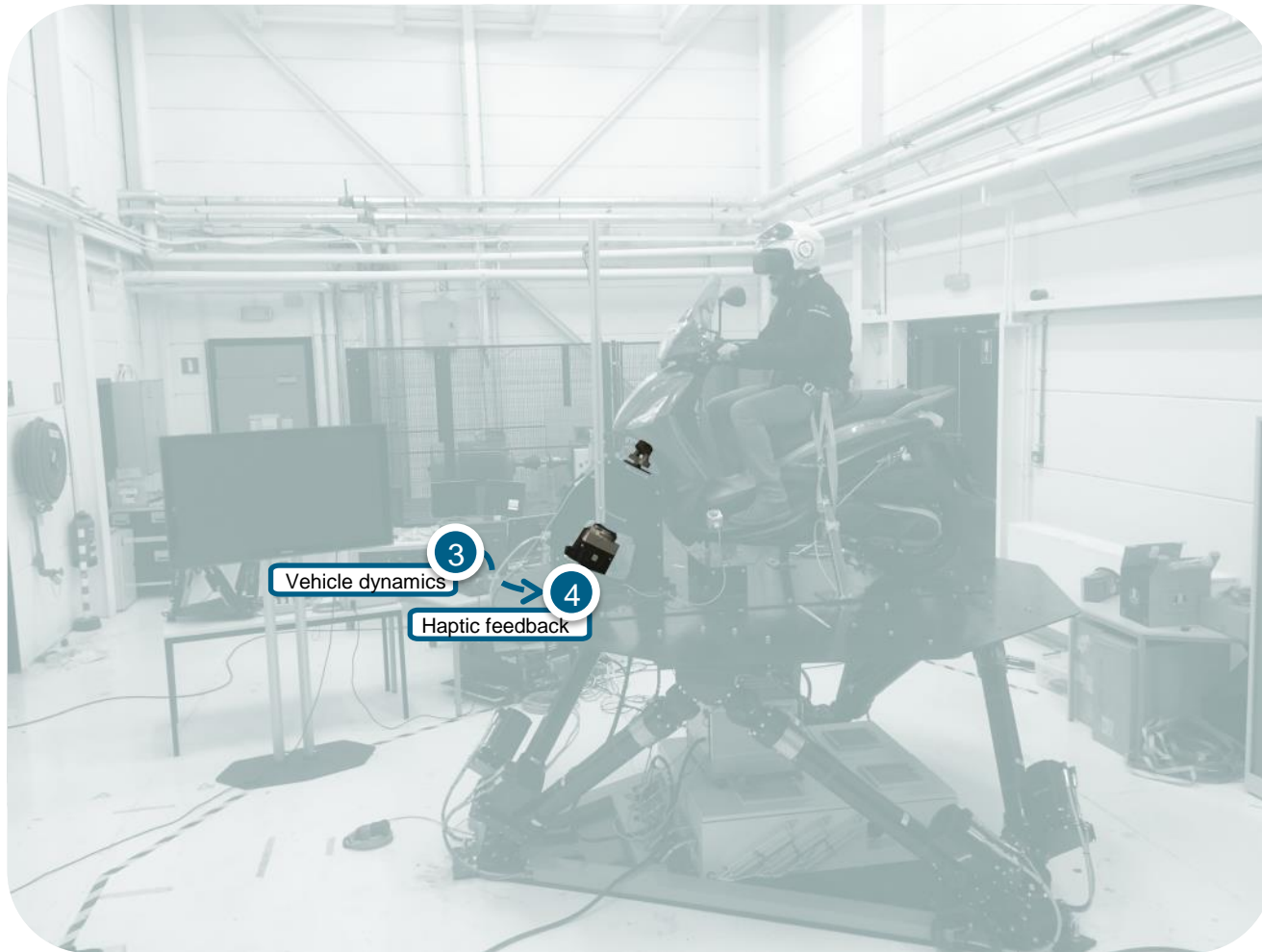
MOTORIST simulator: overview

4 Haptic feedback
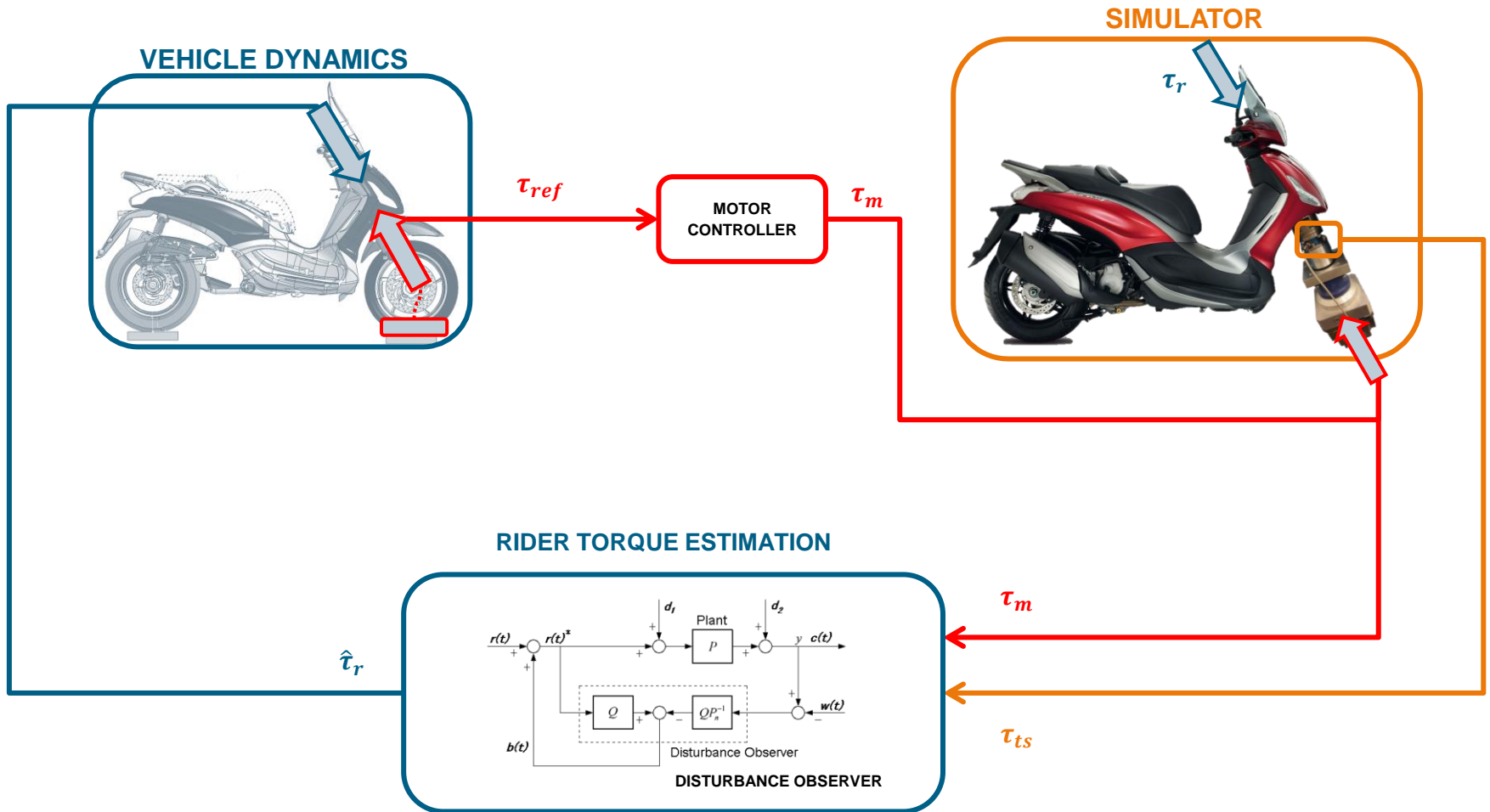
5 Motion cueing

Classical cueing algorithm

Linear accelerations →

Angular velocities →

scale / limit
- Gains
- Gains

filtering
- High-pass filter
- Low-pass filter
- High-pass filter

to positions /angles
- Double integrator
- Tilt coordination
- Single integrator

washout
- High-pass filter
- High-pass filter

→ Platform position

→ Platform orientation
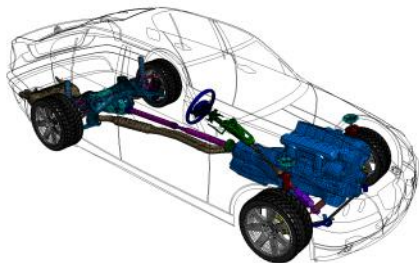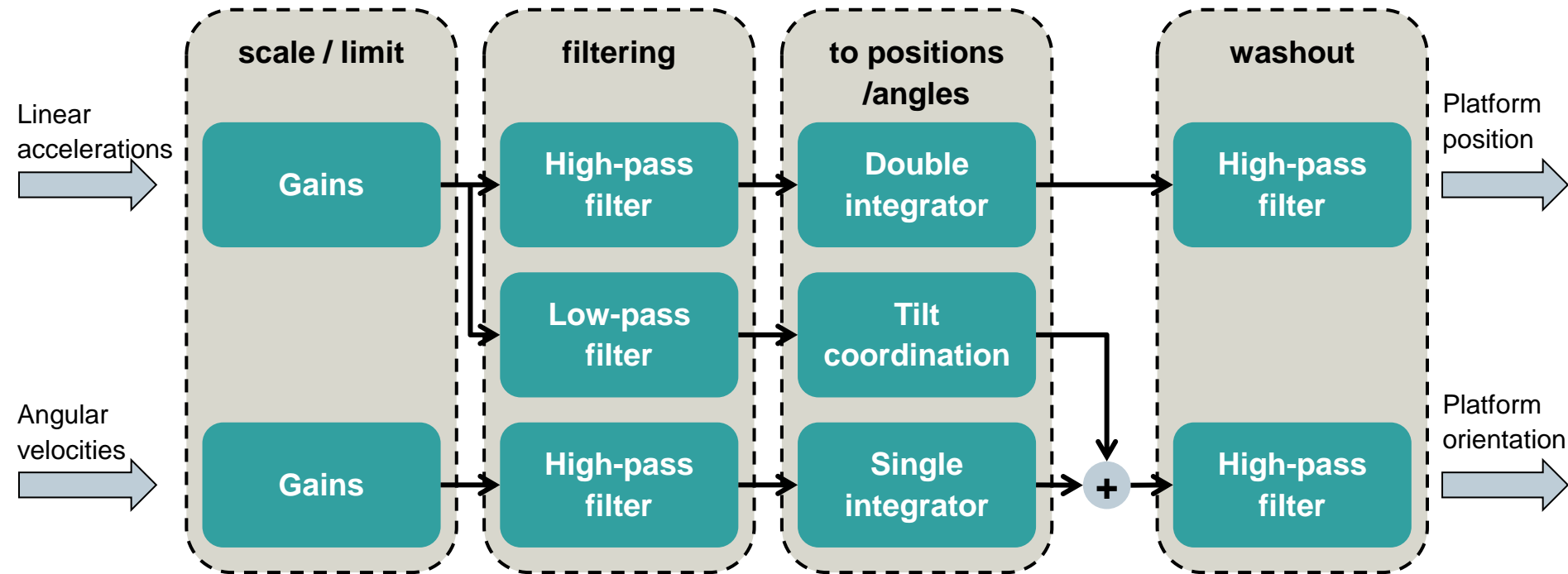
+ Easy to tune
+ Parameters with physical meaning
+ Simple implementation
− Independent from driving scenario
− No advantages of full motion envelope

Conceptual MPC algorithm
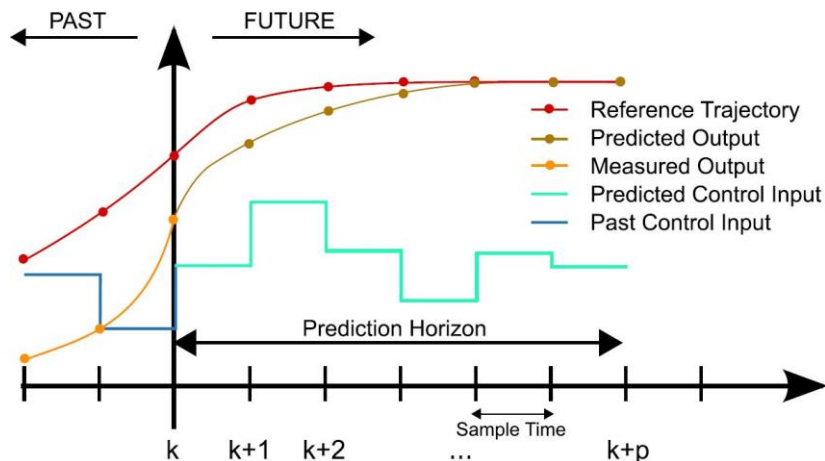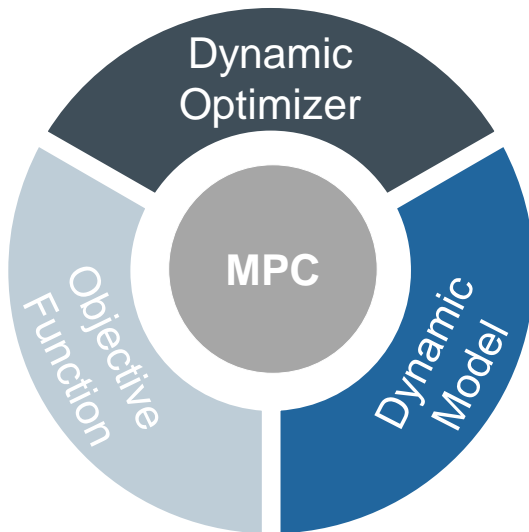
MPC Controller needs to know:

1. Which system it is working on
   → **Dynamic Model**

2. What goal it has to achieve
   → **Objective Function**

3. How to calculate the controls
   → **Dynamic Optimizer**

Possibility to consider the constraints in the optimization problem
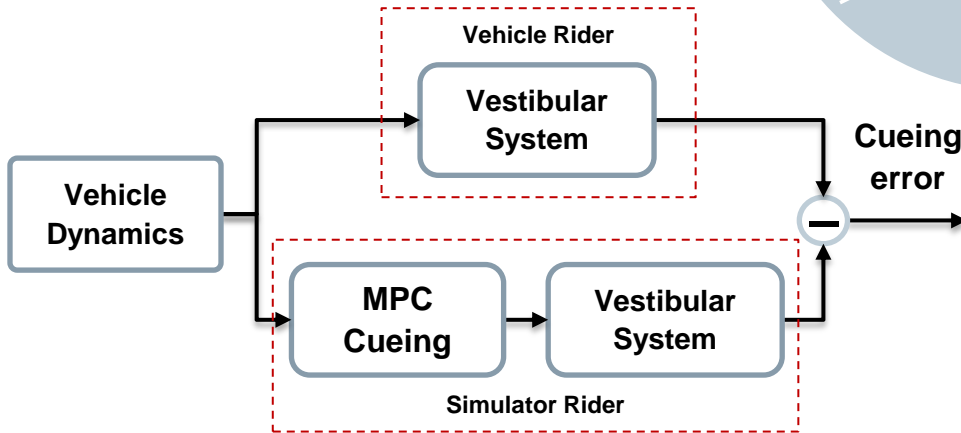
MPC cueing

ACADO toolkit

Dynamic Optimizer

MPC

Objective Function

Dynamic Model
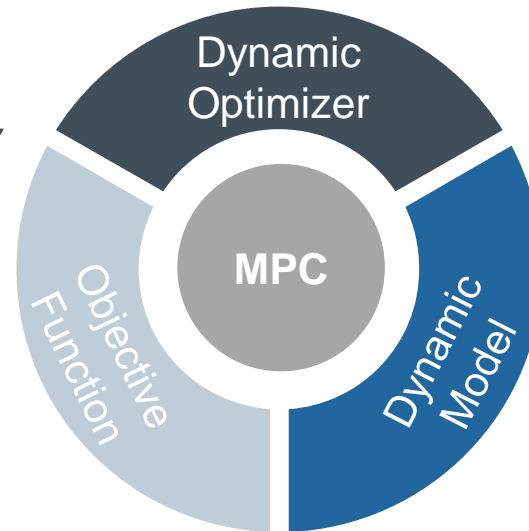
Minimize Cueing error

$$\Phi = \int_0^T L(t, x, u, p)\,dt + L_F(T, x(T), p(T))$$

Vehicle Rider

Vestibular System

Vehicle Dynamics

MPC Cueing

Vestibular System

Simulator Rider

Cueing error

Vestibular System

$$\dot{x}_{vest} = A_{vest}x_{vest} + B_{vest}u$$
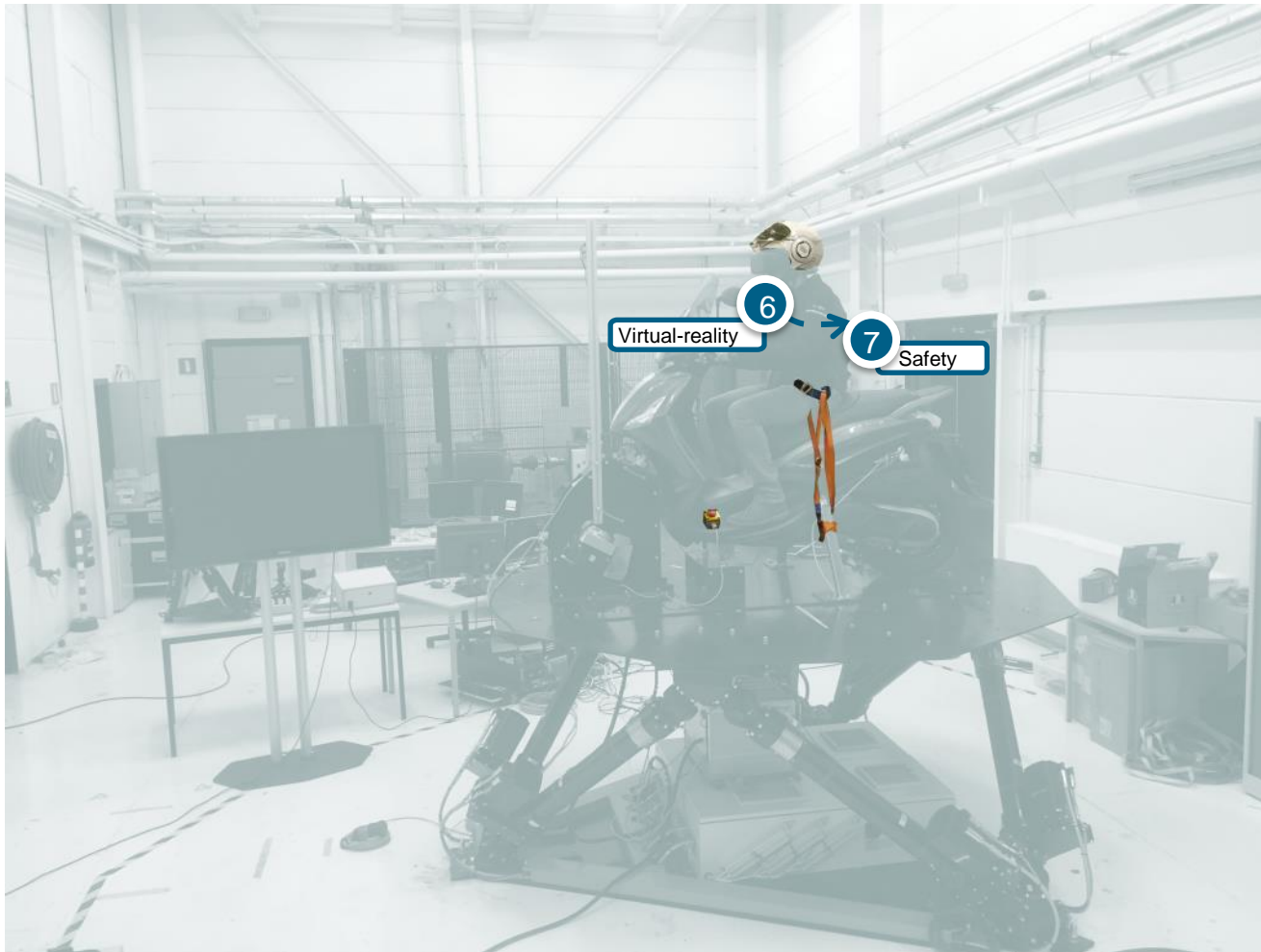
$$Y_{vest} = C_{vest}x_{vest} + D_{vest}u$$

Inner Ear
Ear Canal
Pinna
Eardrum
Middle Ear
Eustachian Tube

MOTORIST simulator: overview

6 Virtual-reality

5 Motion cueing

Visual/audio cues

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Virtual Scenario

Siemens PLM Software

MOTORIST simulator: overview

Virtual-reality (6)
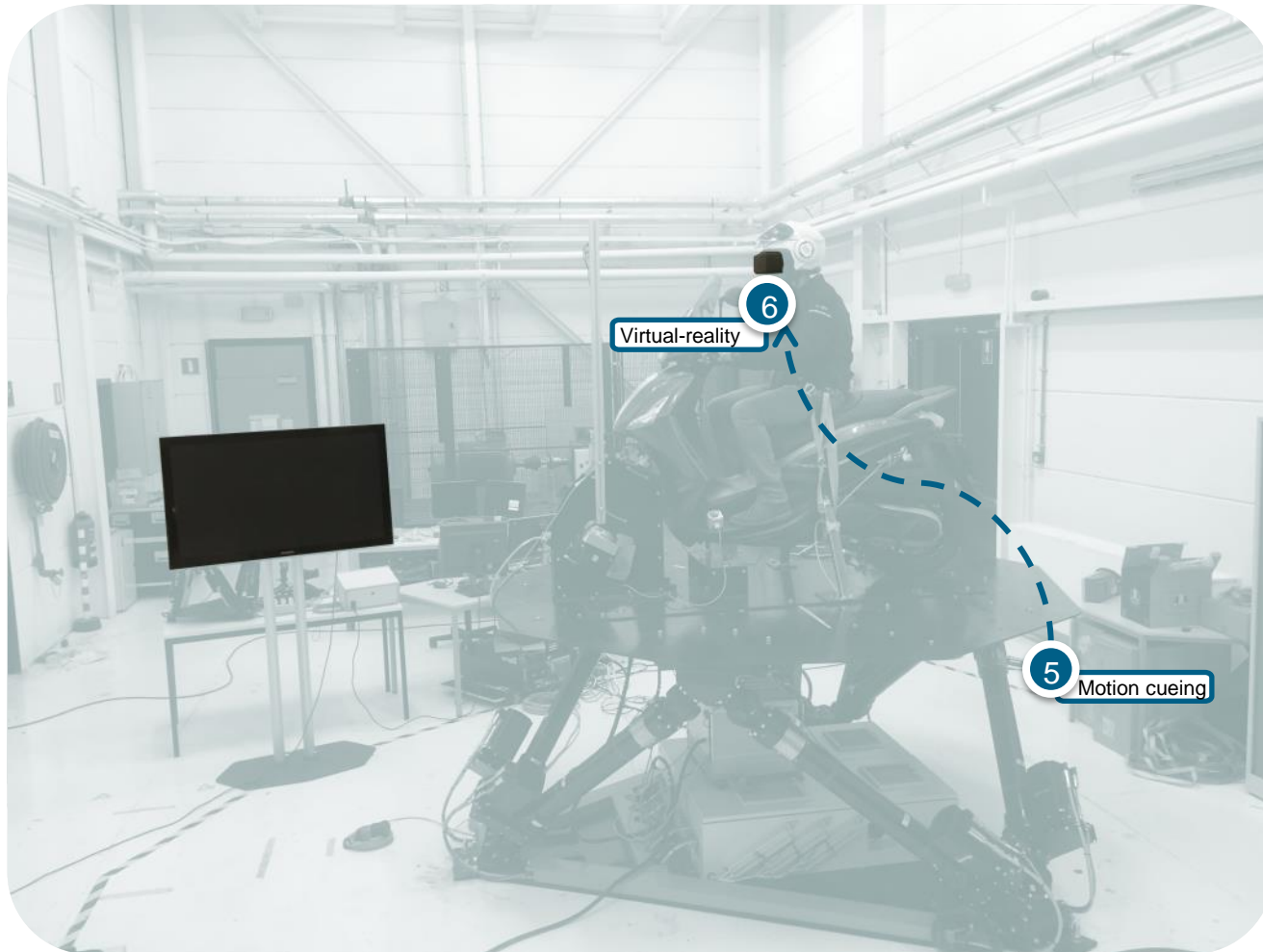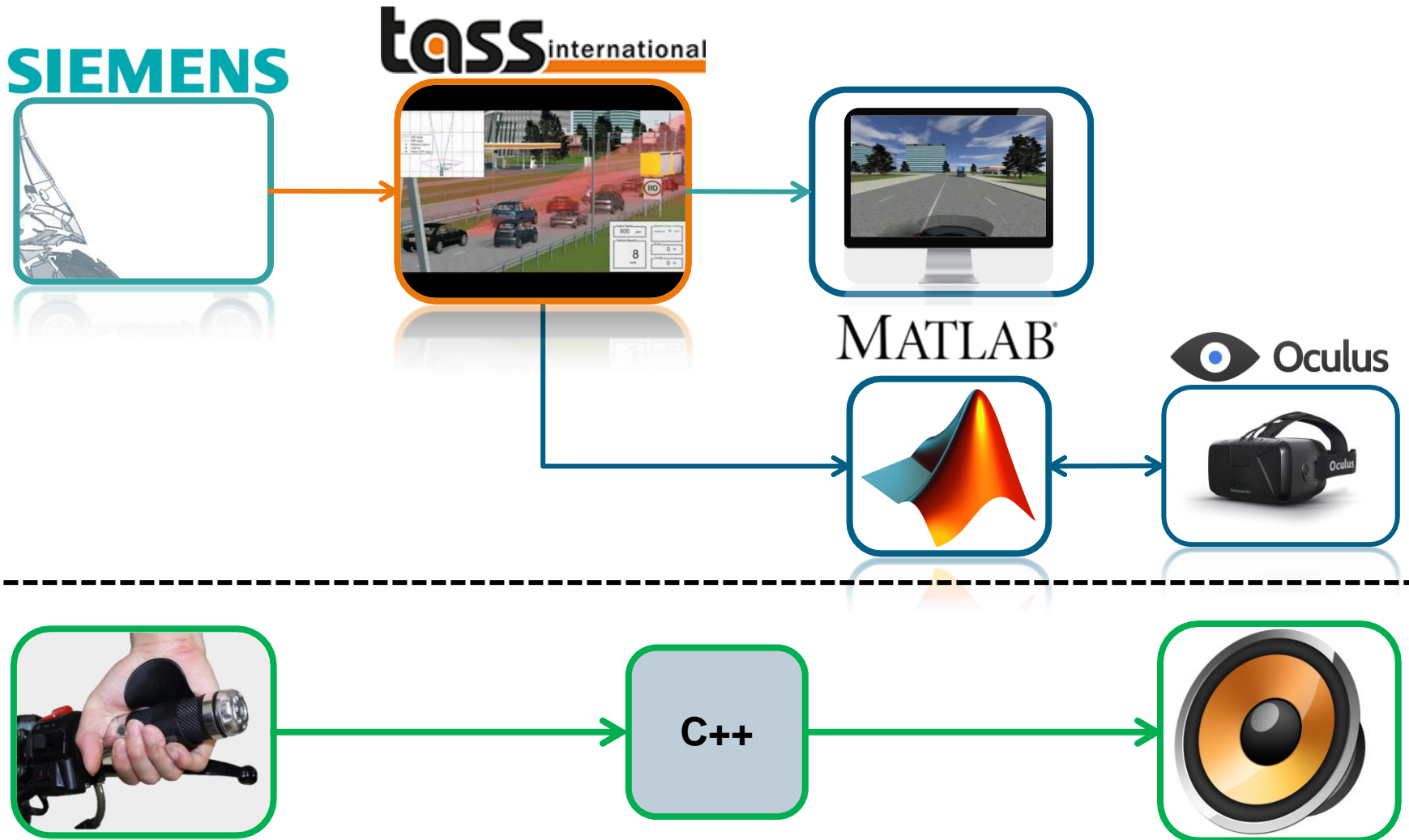
Safety (7)

Safety

HELMET
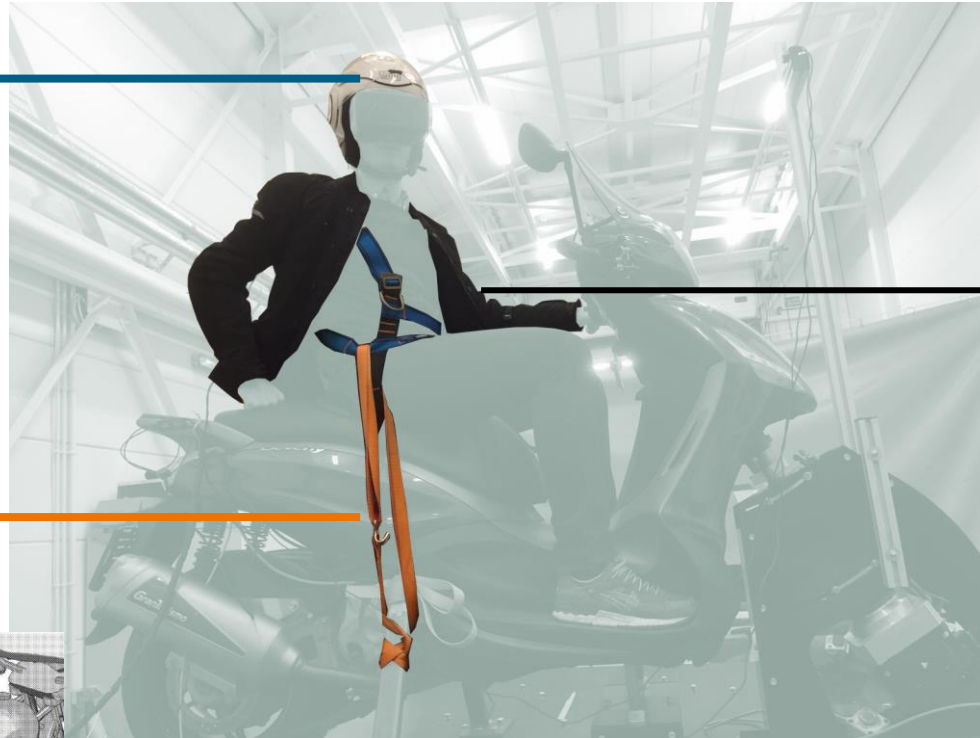
PROTECTIVE
JACKET

HARNESS

MOTORIST simulator: overview

8 Simulator manager

7 Safety

Siemens PLM Software

SIEMENS
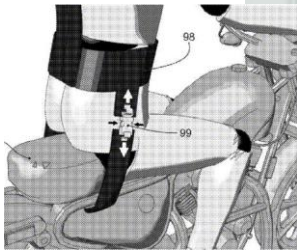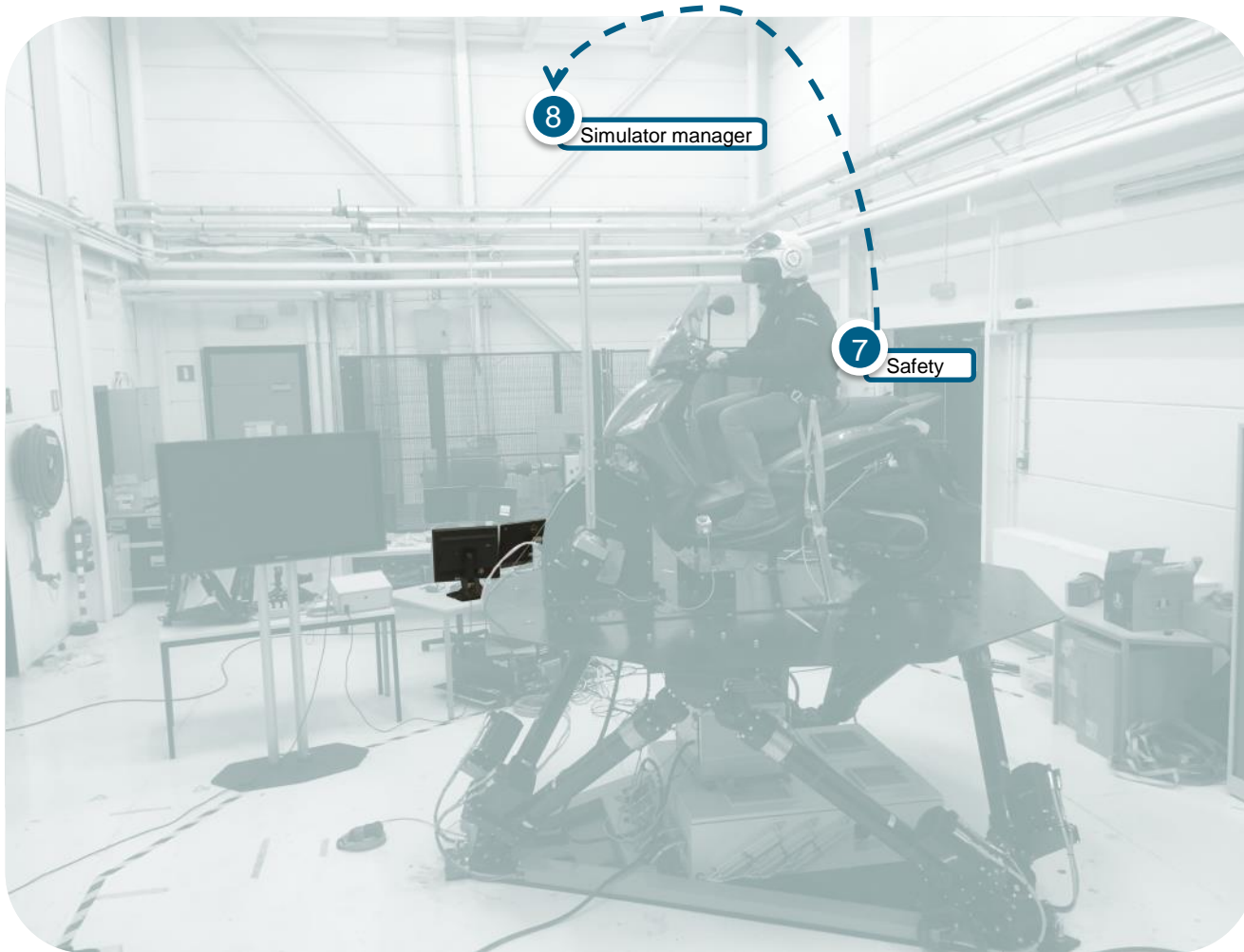
Simulator manager
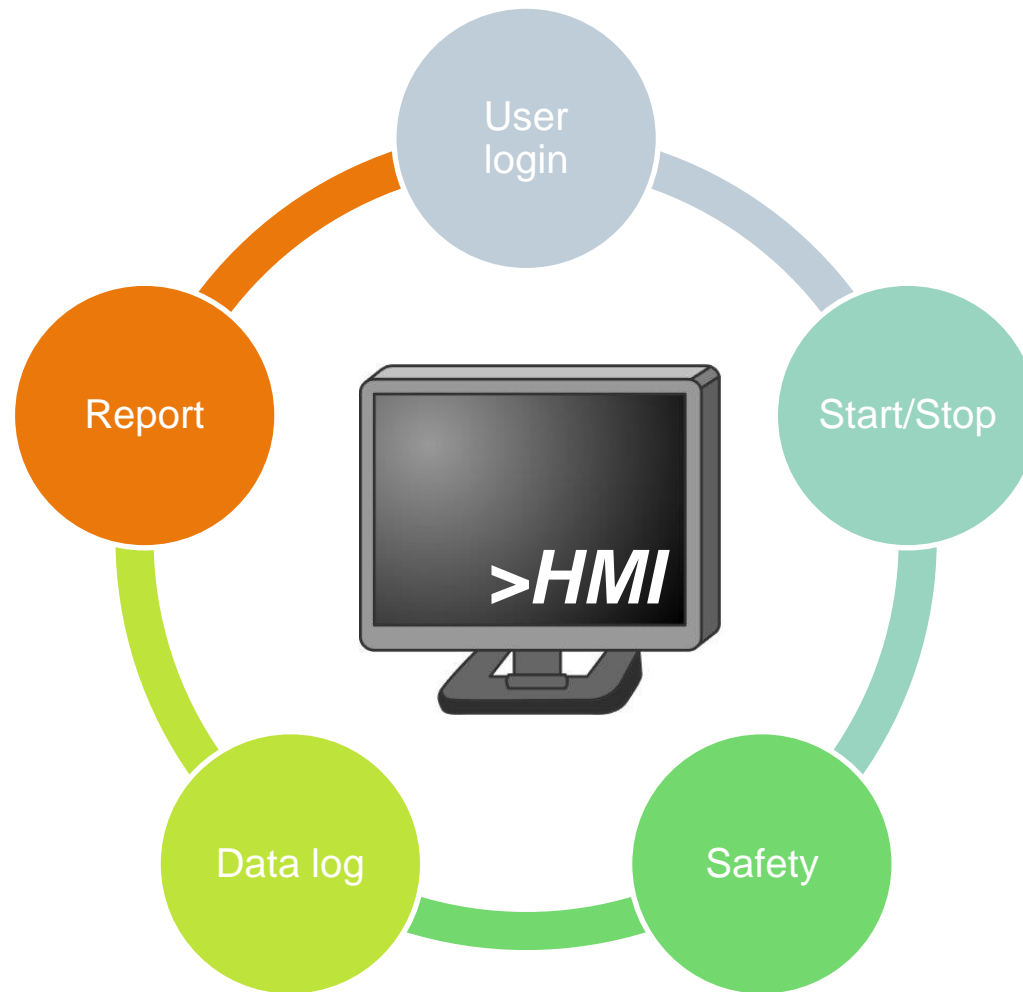
Data Logging Interface

Loading data file from remote machine

Rider personal data

Relevant data for training purposes

Generate report

Automatic reporting
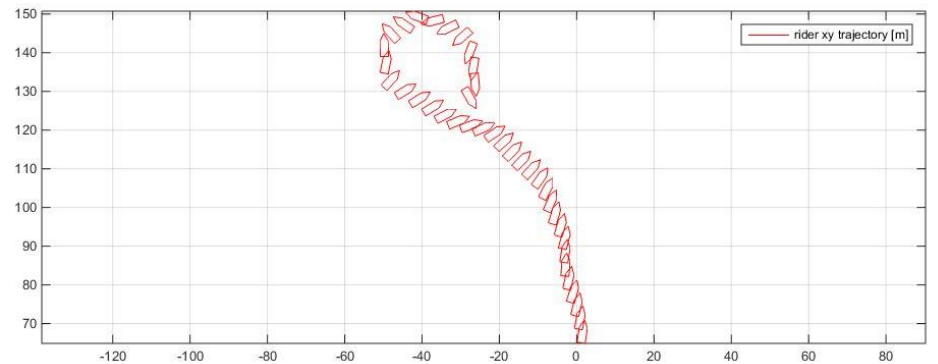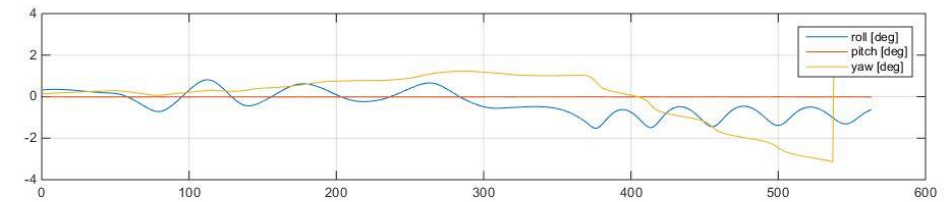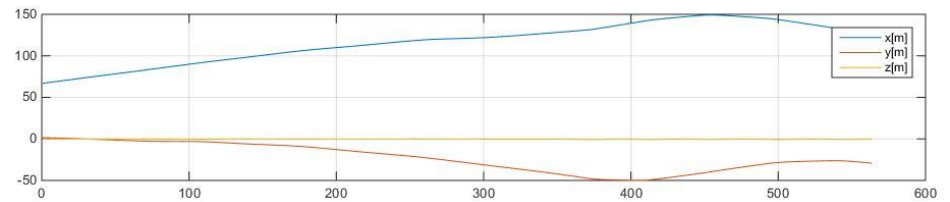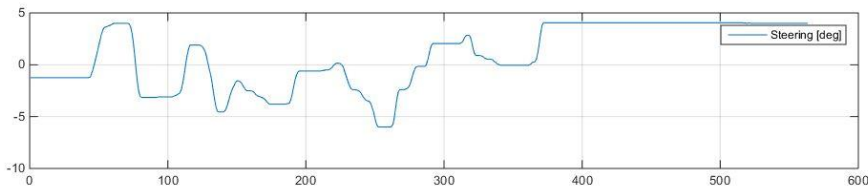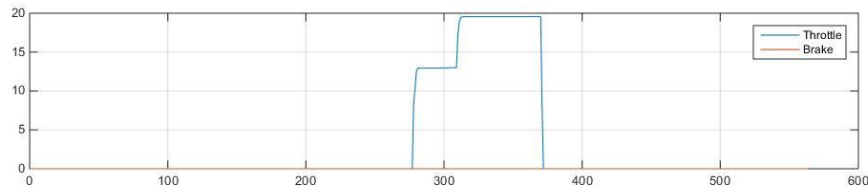
Thank you for the attention!

8 Simulator manager

6 Virtual-reality

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2 Sensors-actuators

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…questions?
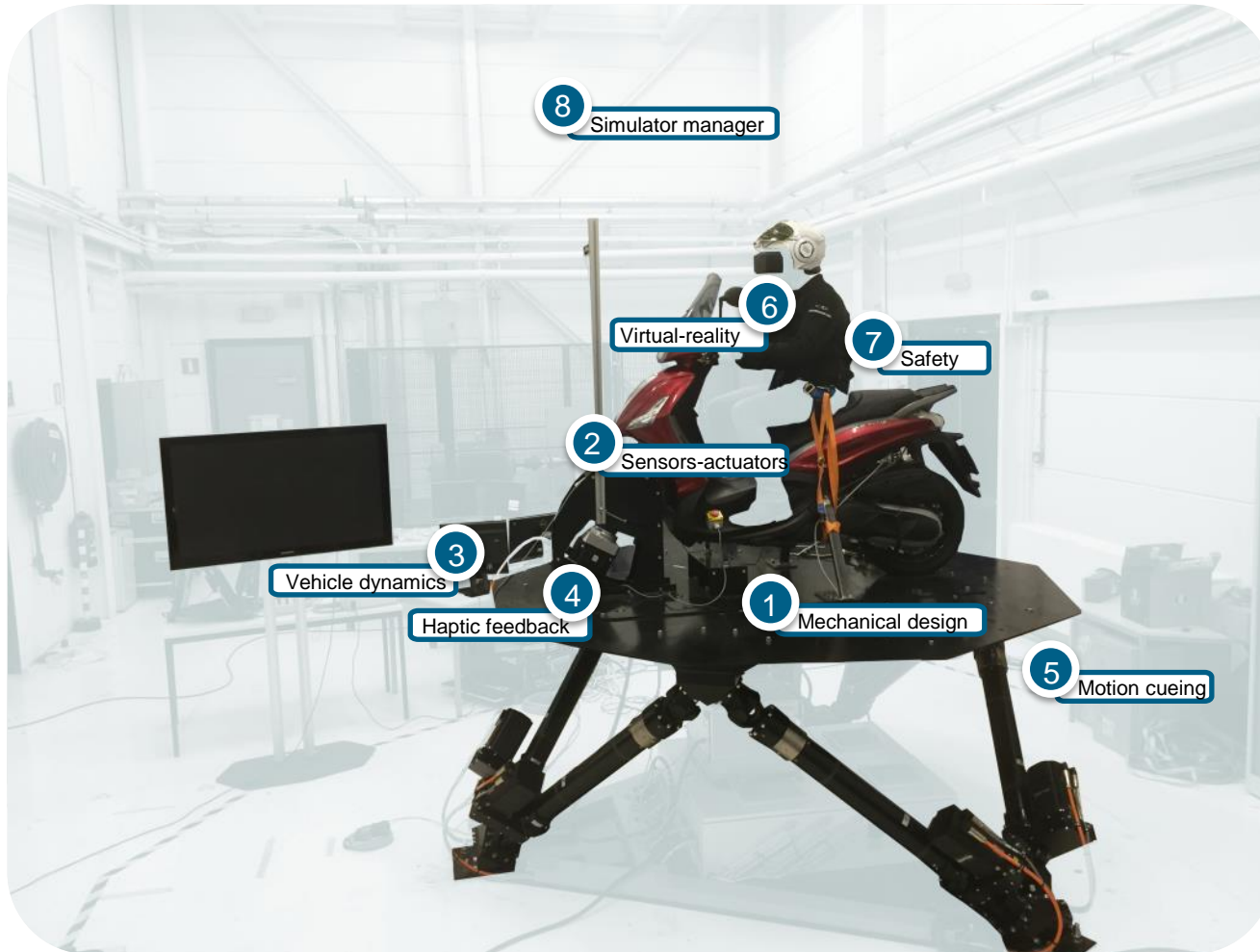
Thank you!

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