vti

FINDING A BETTER WAY

Hardware-in-the-loop real-time simulation in driving simulators

MODPROD 2011

Jonas Jansson

Agenda

- **Background**
  - Driving simulation at VTI, VIP
  - Challanges: MBE - HIL
  - ViP project SPASS
- **Emergency Lane Keeping Assistance - an autonomous system for the avoidance of frontal collisions**
  - Lane keeping assistance
  - Driving scenario
- **Sim IV – a realistic driving simulator for studies with advanced driver assistance systems**
  - Sim IV – the new VTI simulator in Gothenburg
  - Volvo's Mozart system
  - Integrated ADAS test facility

Shortly about me

Jonas Jansson

Ph.D. Automatic control, LIU

"Collision avoidance theory with application to automotive collision mitigation"

Before VTI

VCC – function owner, collision warning with auto brake

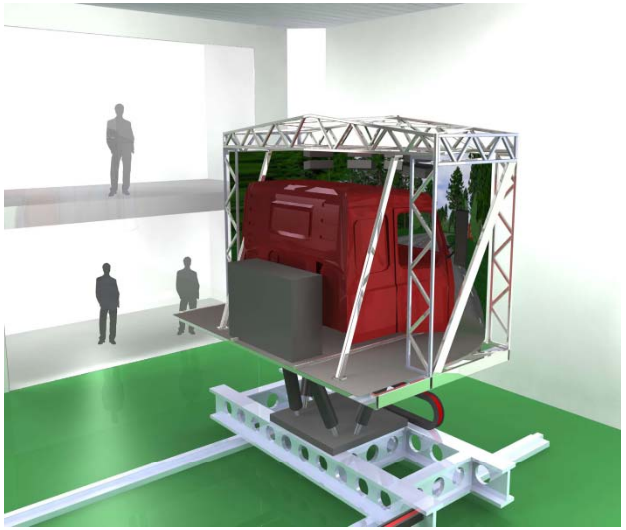
At VTI

Research director – Vehicle technology and simulation

VTI

The Swedish National Road and Transport Research Institute. 200 employes. A governmental authority under the ministry of enterprise, energy and communication

VTI Driving Simulators



Sim IV

Sim II

Train Sim

Sim 1 ('85-'02)

Sim Foerst

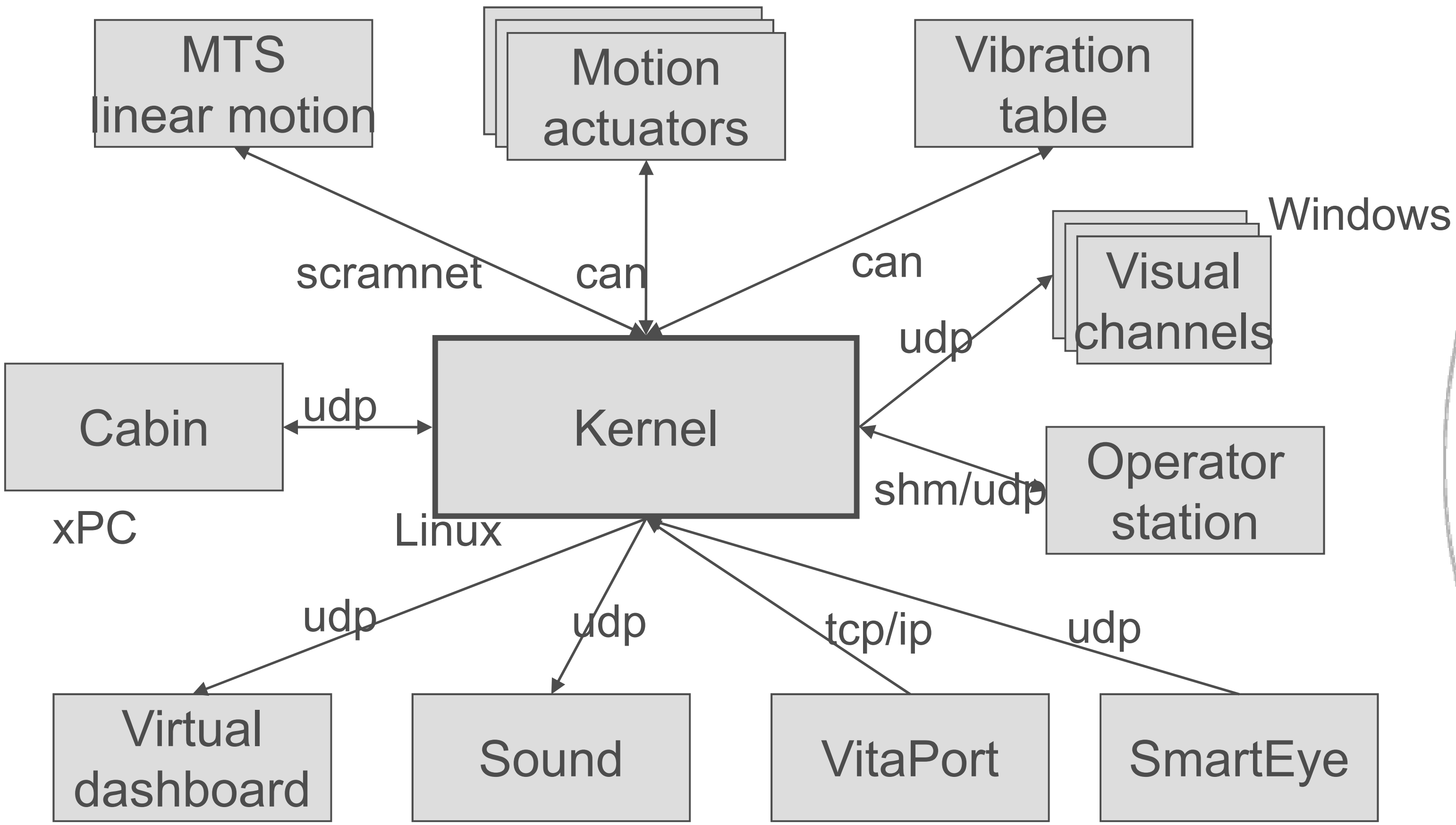
Sim III

Development strategy

- Open Source code & own development
- Consumer hardware
- Support integration of third party software

- Establish a “shared” technical platform for driving simulation
- Establish open library of vehicle/vehicle components

Simulator structure (hardware view)



Realtime constraints

Main simulation loop: 200 Hz – 5ms

Visual channels: 60 Hz

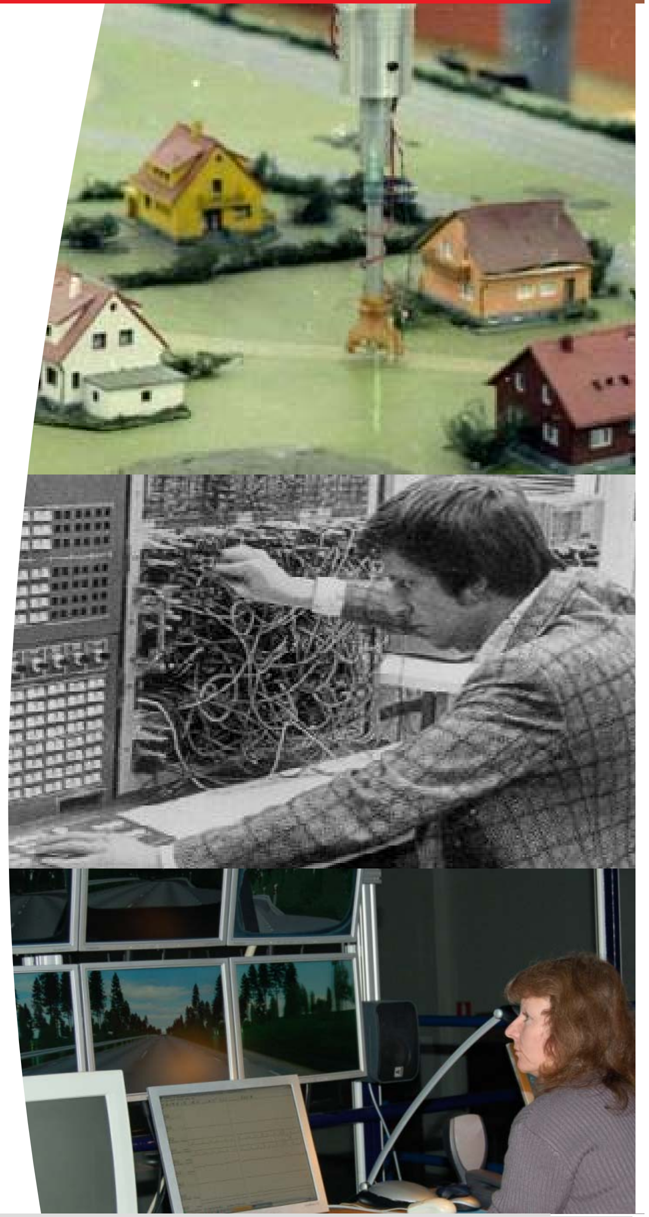
Cabincontrol: 1000 Hz

Transmission delays below 10 ms

Vehicle:

HS CAN & LS CAN: ?

Radar & Vision: 10Hz



Institute Excellence Centre at VTI

Common platform for increased and long-term co-operation, competence building and knowledge transfer

Prospective perspective - 5, 10, ….. years

Development and application of driving simulator methodology

- ✓ Instrument for developing and exploring future vehicles and traffic environment from a user's perspective
- ✓ Use of simulators in product development and evaluation
- ✓ Focus on the interaction between man and technology (HMI)

Combining 3 approaches

- ✓ Develop and co-ordinate a common technical framework for driving simulators
- ✓ Develop and use a common simulator based methodological framework
- ✓ Perform applied projects, guiding development right

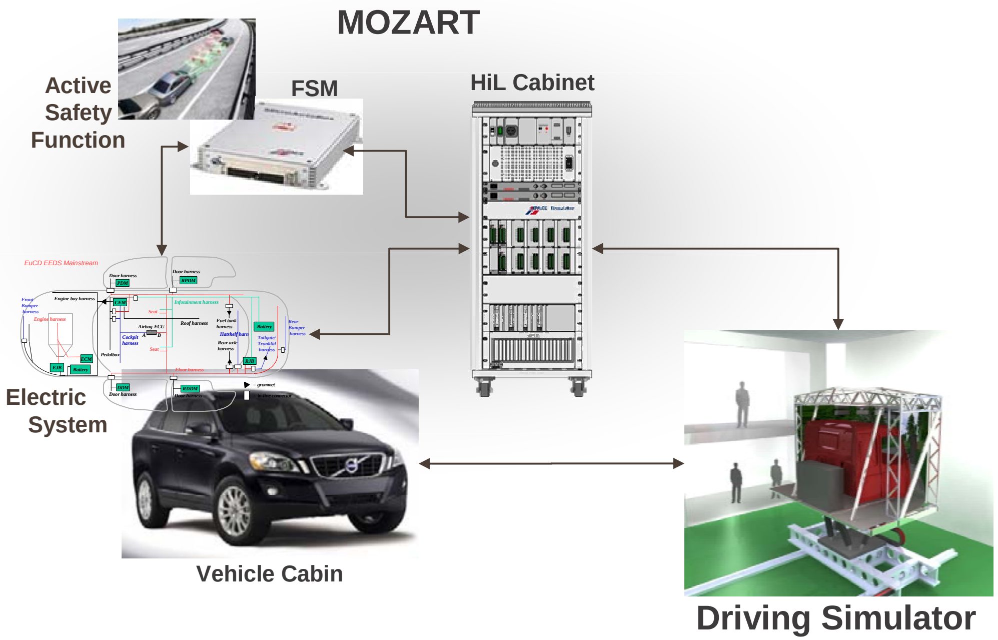
Partners: VTI, Saab, Scania, Volvo Cars, Volvo Truck, SRA, Bombardier, Dynagraph, HiQ Ace, SmartEye, Swedish Road Marking Association

Funding: Vinnova and ViP partners

www.vipsimulation.se

ViP
Virtual Prototyping and Assessment by Simulation

Challenges



AUTOSAR,

Project Facts

ViP project **SPASS**

- Focus: Active safety function demonstrator
- Duration: 01/2010 – 04/2011
- Budget: 2,27 MSEK
- Partner: VTI, VCC, Viktoria Institute

FFI project **QUADRA**

- Focus: Driver models for interactions between driver and assistance systems
- Duration: 01/2011 – 12/2014
- Budget: 22,925 MSEK
- Partner: VTEC, Volvo 3P, VTI, VCC, Chalmers

ViP SPASS – Partners

VCC	
** EESE AoV Systems Integration (Project mgmt and HIL Simulations)*	*Gunilla Karlsson, Martin Nilsson, Annica Normén*
** Safety Center (Scenarios and Data Analyze)*	*Mats Petersson, Mikael Ljung Aust*
** Active Safety Functions (Function Development)*	*Nenad Lazic*
** EESE Safety Electronics (System Development)*	*Jonas Ekström*
** EESE Vehicle HMI (Scenarios and HMI Properties)*	*Patrik Palo, Ingrid Pettersson*
** Chassies AoV Active Safety (HIL Simulations)*	*Gaspar Gil Gomez*
***	*Urban Kristiansson*
Viktoria Institute	
** HEV & EV Technology*	*Stefan Pettersson, Henrik Weiefors*
VTI	
** Vehicle Technology and Simulation*	*Martin Fischer, Jonas Jansson, Anders Andersson, Håkan Sehammar, Göran Palmkvist*

ViP SPASS – Project Description

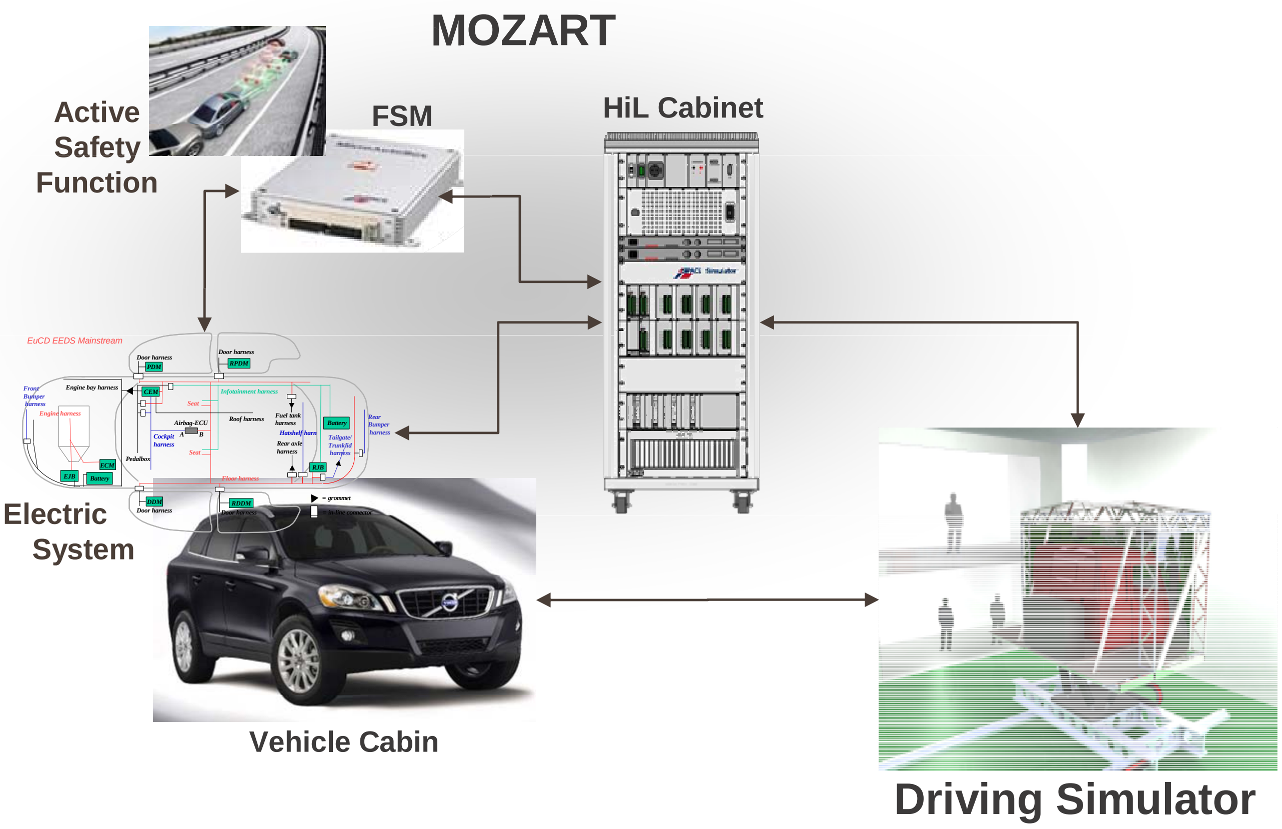
Titel

- SPASS - Strenghten Performance Active Safety Simulator.

Description

- SPASS will evaluate early development/rapid prototyping of new driver assist systems by utilizing an advanced driving simulator in combination with a vehicles electrical architecture (including sensors, actuators and HMI). As a case study, the project will demonstrate a novel active safety function which is rather well penetrated at Volvo Cars (i.e. Volvo Cars have reference vehicles up and running). SPASS primary focus is to visualize simulator performance during concept development. However, the results will also be useful for research as well as for verification of products. The project aim to use VTIs new simulator at Lindholmen; and by that pave the way to establish a simulator platform for evaluation of driver & system interaction.

Integrated Safety Function Test Facility



FINDING A BETTER WAY

Emergency Lane Keeping Assistance - an autonomous system for the avoidance of frontal collisions

Integrated Safety Function Test Facility

Active Safety Function

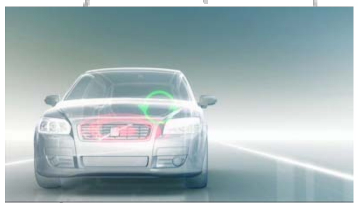
Lane Keeping Assistance (LKA)

LDW (lane departure warning)

- warns with the help of sound when you accidentally run over lane markings
- is a function that is already in production

sLKA (safety LKA)

- corrects steering angle in order to straighten up the car when you are about to unintentionally leave the lane, and (if this is not enough)
- vibrates the steering wheel while crossing the lane markings



eLKA (emergency LKA)

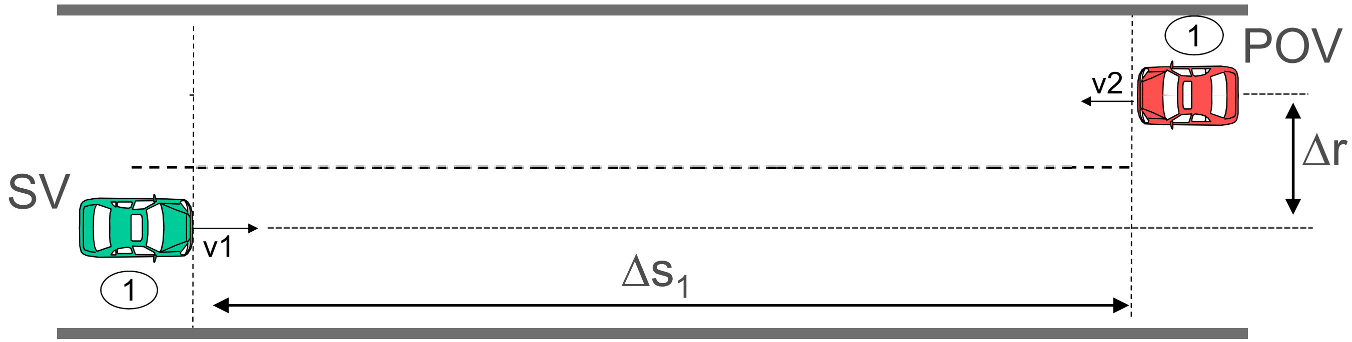
- takes care of the threat situations connected to unintended lane departures (i.e. with oncoming vehicles)
- Actively steers back into the original lane
- Steer characteristic can be smooth (similar to the sLKA) or evasive depending on assessed danger

Driving Scenario – t_1

At distance Δs_1 = 600m

- the POV's speed and
- the POV's lateral position

will be related to the SV.



$$v_1 + v_2 = v_{relative}$$

SV: Subject Vehicle
POV: Principle Other Vehicle

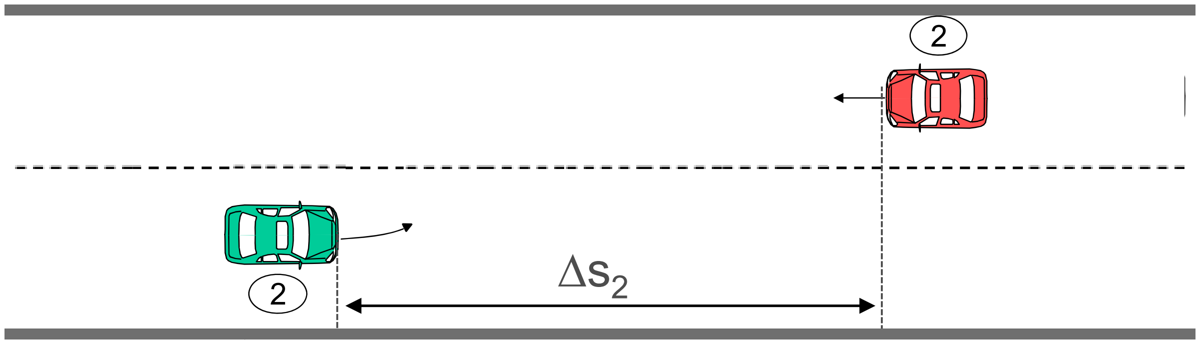
Driving Scenario – t_2

At distance Δs_2 = 250m

- both speeds will be fixed and
- the distraction task begins and
- the yaw deviation function starts.

Drivers are prompted by a pre-recorded voice to read back a sequence of 6 single digit numbers appearing on the display. Task duration approximately 2.8s.

In order to bring the SV into the opposite lane an additional heading angle is introduced to the visual system (but not to the motion system).

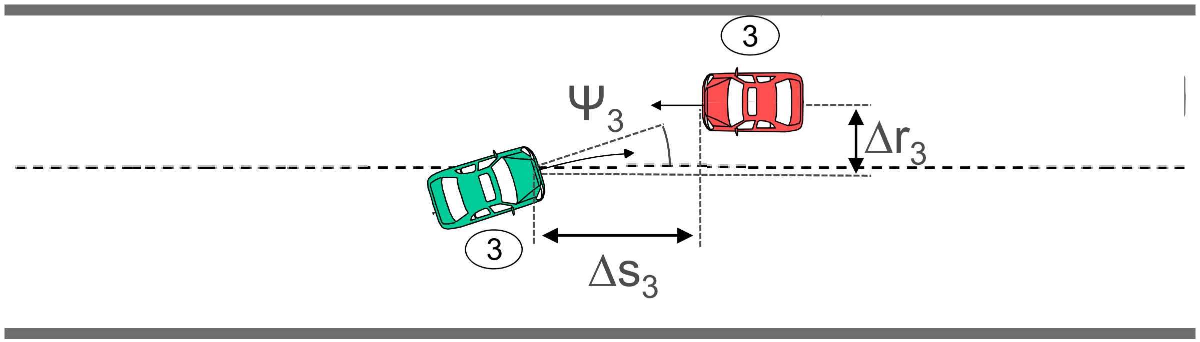


Driving Scenario – t_3

At time $t_3 = t_2 + 3s$

- heading angle (Ψ_3), as well as
- relative lateral (Δr_3) and longitudinal distances (Δs_3) between SV and POV

will be the same for all repetitions of the scenario.

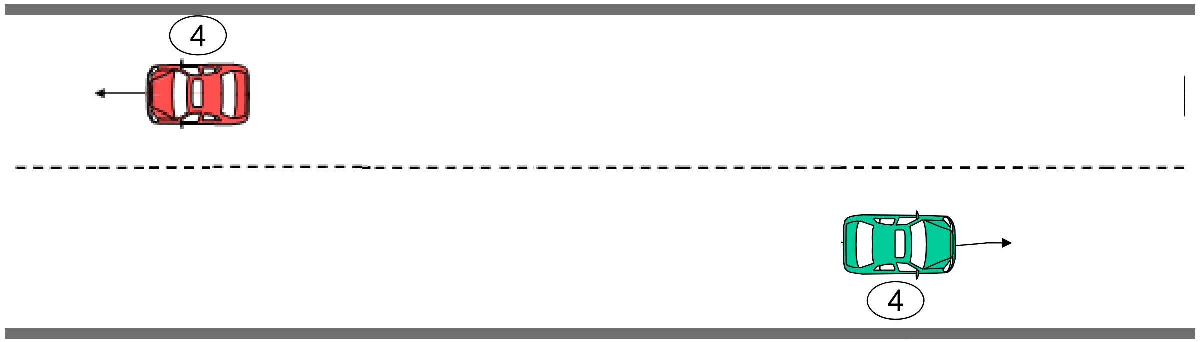


The respective values are chosen such that the eLKA function is triggered at t_3.

Driving Scenario – t_4

Between t_3 and t_4

- the eLKA function is going to steer the SV back to the own lane and
- the drivers reactions to the intervention can be studied.



Demo Set-up

3 groups of test driver

- VCC management
- ”Normal” driver with the following distribution
  - 50:50 male/female
  - 20% younger than 30
  - 20% older than 50

Demonstration

- VCC test driver/function developer

Validation

Next Step

Driver state		FCW Warning		ELA Intervention	
	Alert	True Positive	~~True Negative~~	True Positive	~~True Negative~~
		❷ False Positive	False Negative	❷ False Positive	False Negative
	Drowsy/ Distracted	❶ True Positive	~~True Negative~~	❶ True Positive	~~True Negative~~
		False Positive	False Negative	False Positive	False Negative

SPASS

QUADRA

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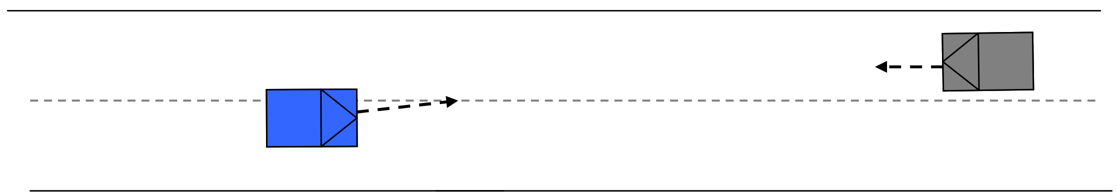

ELA & FCW - True positives for distracted drivers – pour over median with yaw deviation

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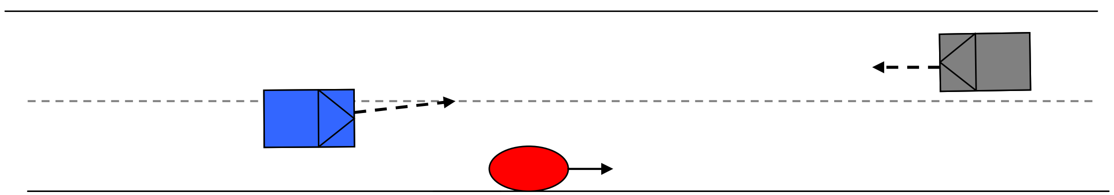

ELA & FCW - False positives for alert drivers – force over median using bicyclist

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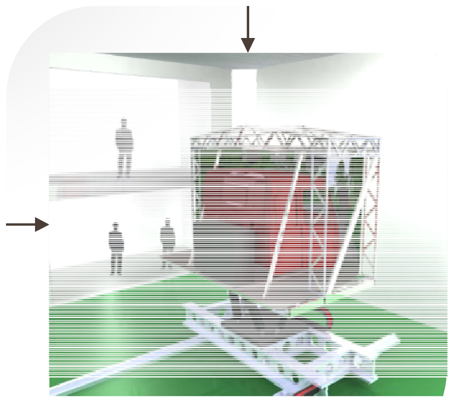
FINDING A BETTER WAY

Sim IV – a realistic driving simulator for studies with advanced driver assistance systems

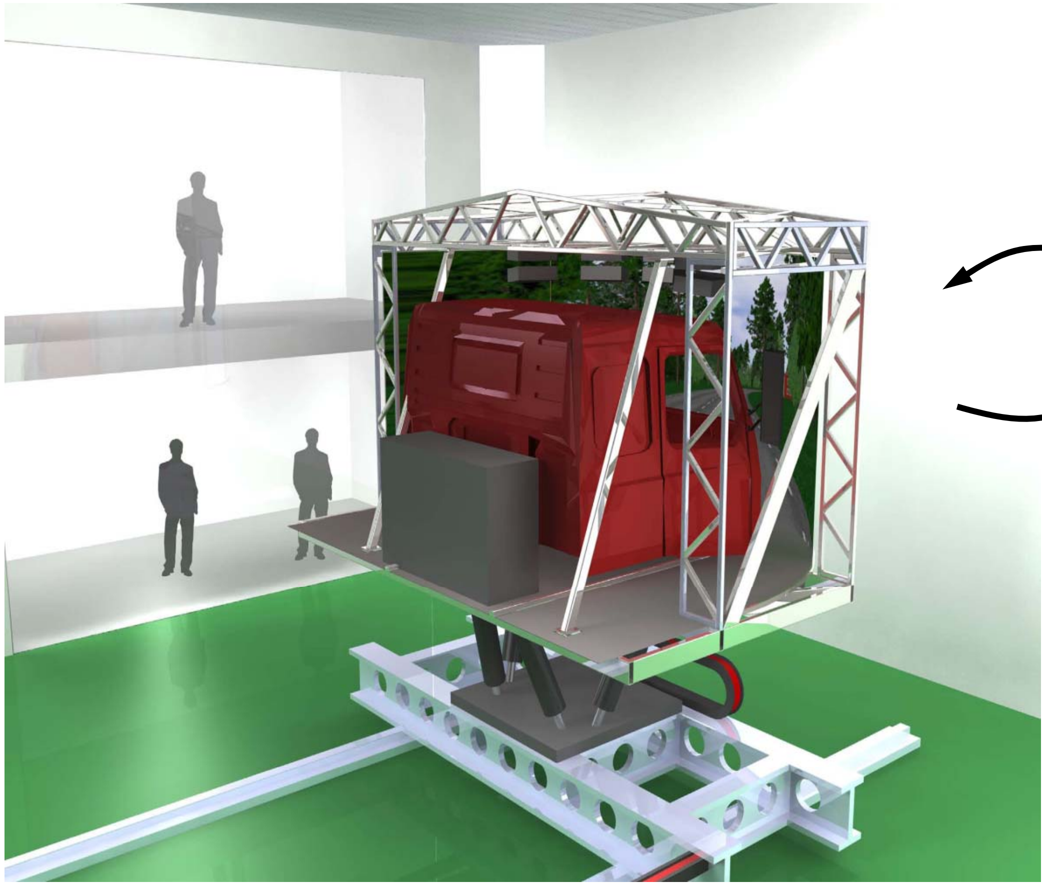
Integrated safety function test facility

Driving Simulator



Driving Simulator

VTI Simulator Sim IV – Göteborg (spring 2011)



Sim IV

Volvo XC60

Volvo FHM

Sim IV motion system

- Bosch Rexroth
  - Hexapod

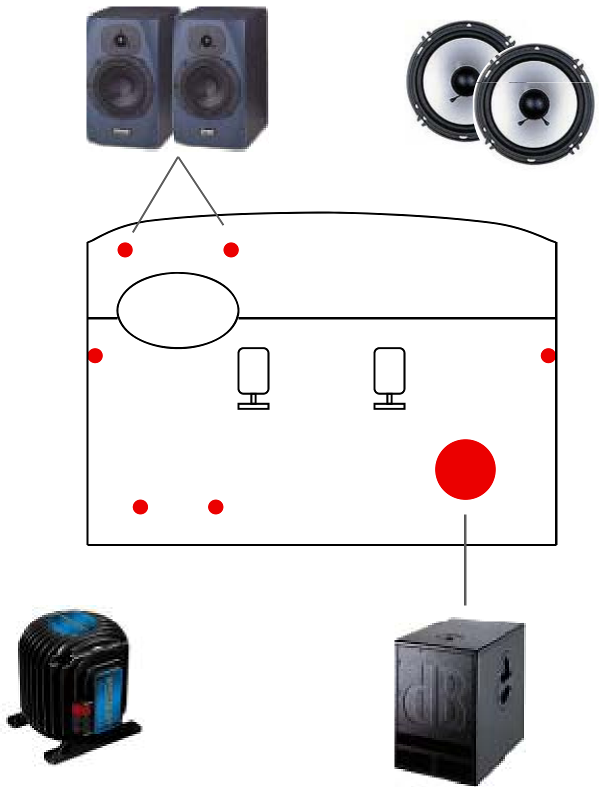
	Excursions	Velocity	acceleration
surge	- 408 / +307 mm	+/- 0,80 m/s	+/- 6,5 m/s²
sway	- 318 / +318 mm	+/- 0,80 m/s	+/- 6,0 m/s²
heave	- 261 / +240 mm	+/- 0,60 m/s	+/- 6,0 m/s²
roll	- 16.5 / +16.5 deg	+/- 40 deg/s	+/- 300 deg/s²
pitch	- 15.5 / +16.0 deg	+/- 40 deg/s	+/- 300 deg/s²
yaw	- 20.5 / +20.5 deg	+/- 50 deg/s	+/- 350 deg/s²

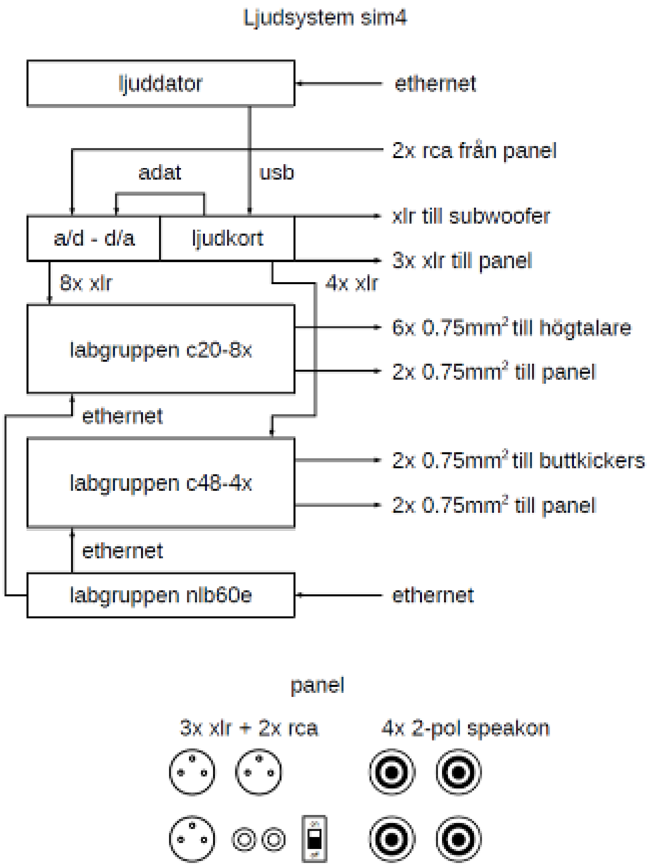
  - XY-Sled

	excursions	velocity	acceleration
Surge (X)	+/- 2500 mm*	2 m/s	+/- 5 m/s²
Sway (Y)	+/- 2500 mm*	3 m/s	+/- 5 m/s²

Sim IV sound system

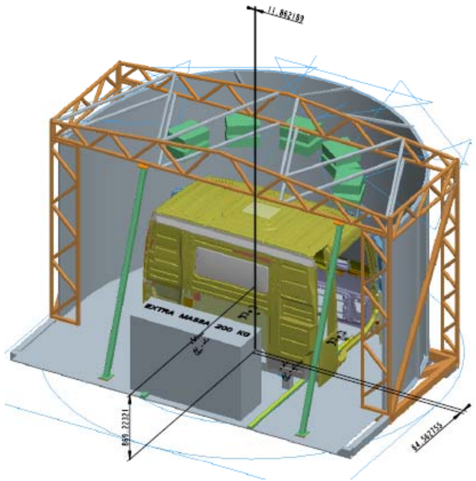
Hardware layout:





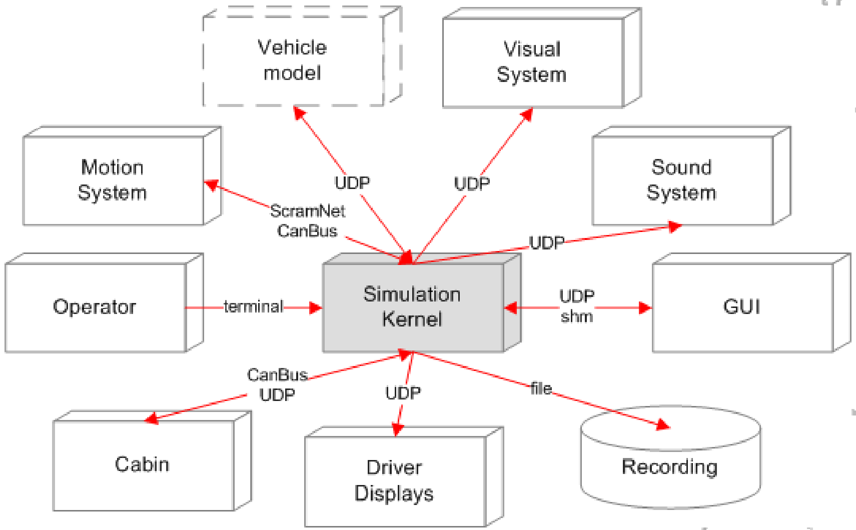
Sim IV projection system

- 9x Epson EB-410W projectors
- Mersive SOL software
  - Auto calibration
  - Edge blending
  - Color correction
- >180 degree field-of-view

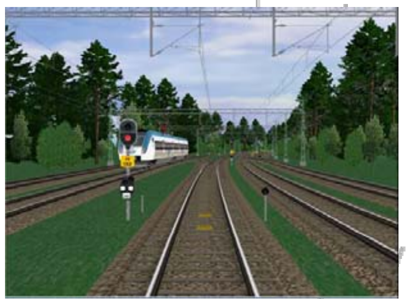


Simulation software

- VTI kernel
  - Scenario and event control
    - Traffic
    - Weather
  - Data logging
  - Communication



- VTI vehicle dynamics model
- VTI graphics engine VISIR
- VTI motion cueing



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Integrated safety function test facility

Vehicle Cabin

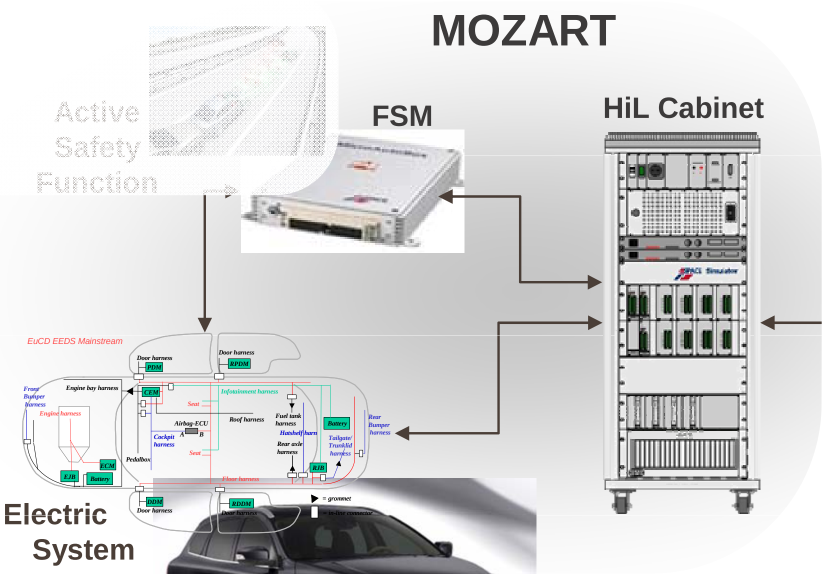
Vehicle Cabin

XC 60 cabin

Cycle time	1msec
Rated torque	7.5Nm
Maximum torque	16.5Nm
Torque resolution	0.03Nm
Angle resolution	0.009°

Integrated safety function test facility

MOZART



Mozart – Project facts

Titel: **Mozart**, Model- and Hardware In the Loop simulator for vehicles

Duration: January 2006 – August 2008

Budget: 16MSEK

Partners: None

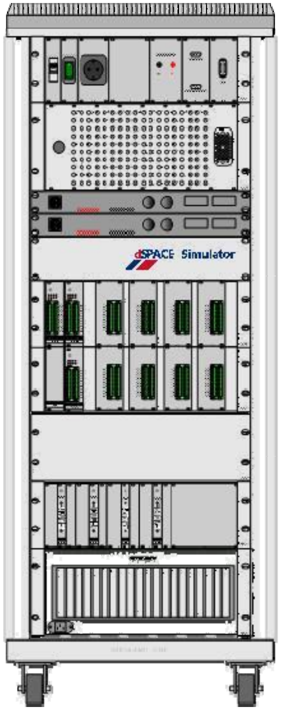
Implemented in conjunction with leading consulting firms

Background: Preparation of *Salieri* and *Mozart* were organized by Lindholmen Science Park along with Saab, Scania, AB Volvo and Volvo Car Corporation. Other scheduled participants were LSP, SP, VTI and 2-4 leading consulting firms.
Salieri was cancelled and only VCC's internal project *Mozart* was conducted.

Source: Martin Nilsson, VCC

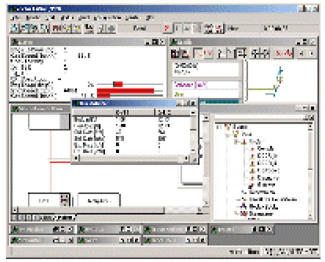
Mozart – Project goal

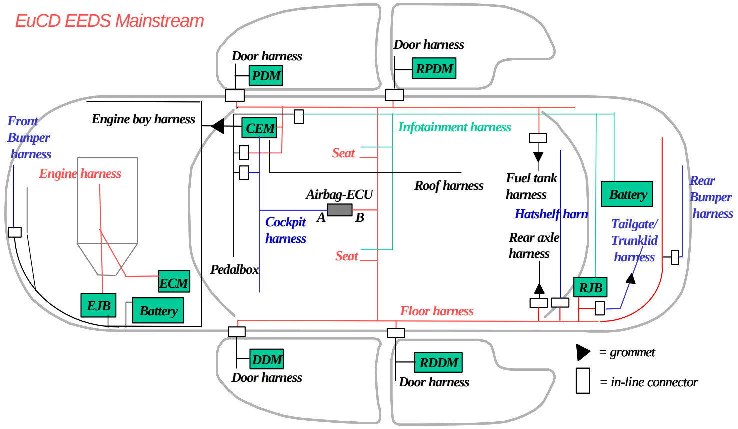
Virtual environment
engine, crankshaft, roads, obstacles, tyres, weather etc.



Virtual cockpit
Interactive/automated driver interaction

Substitute node
Model running on rapid prototype hw





System under test
A mix from models to real components

Source: Martin Nilsson, VCC

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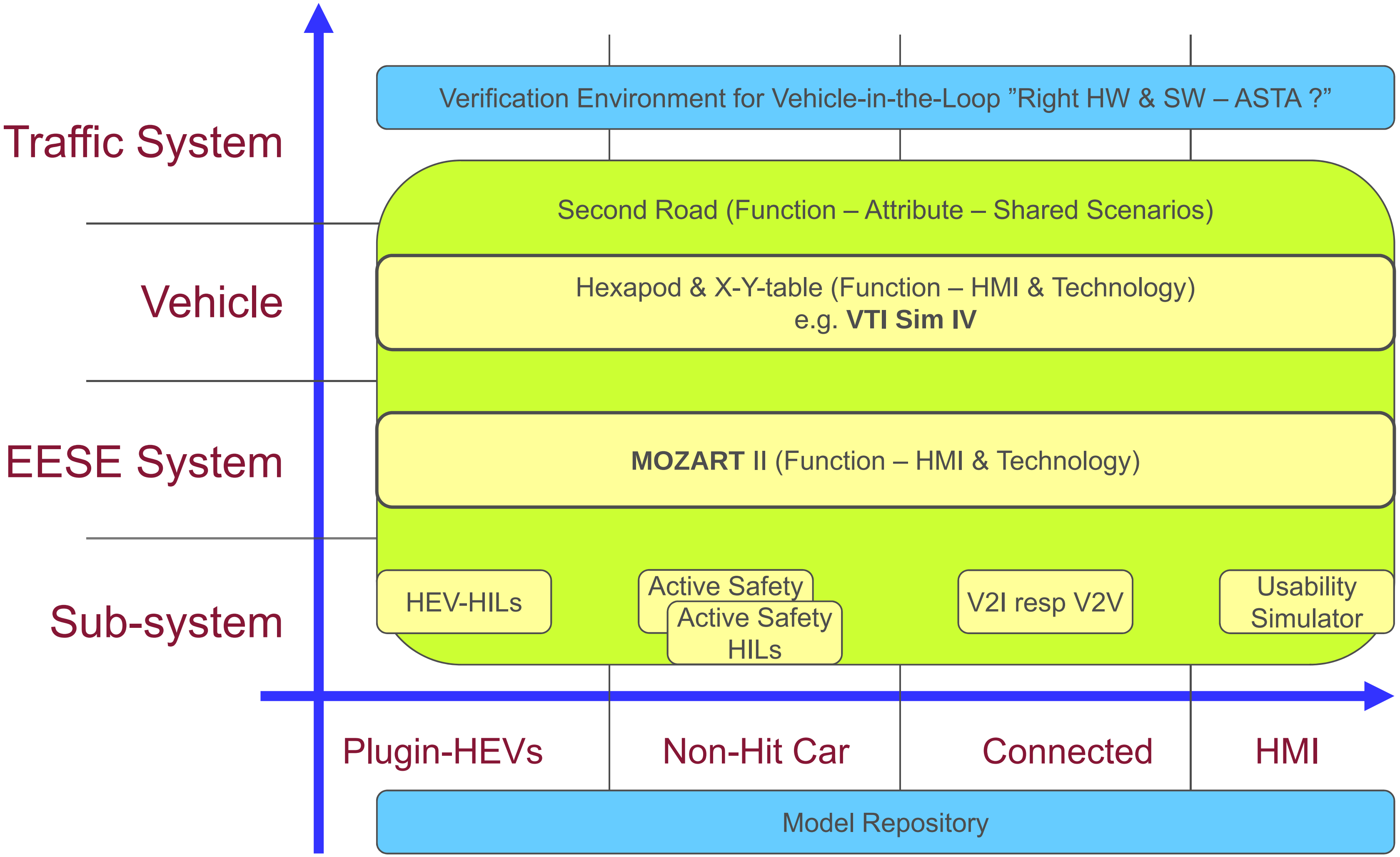
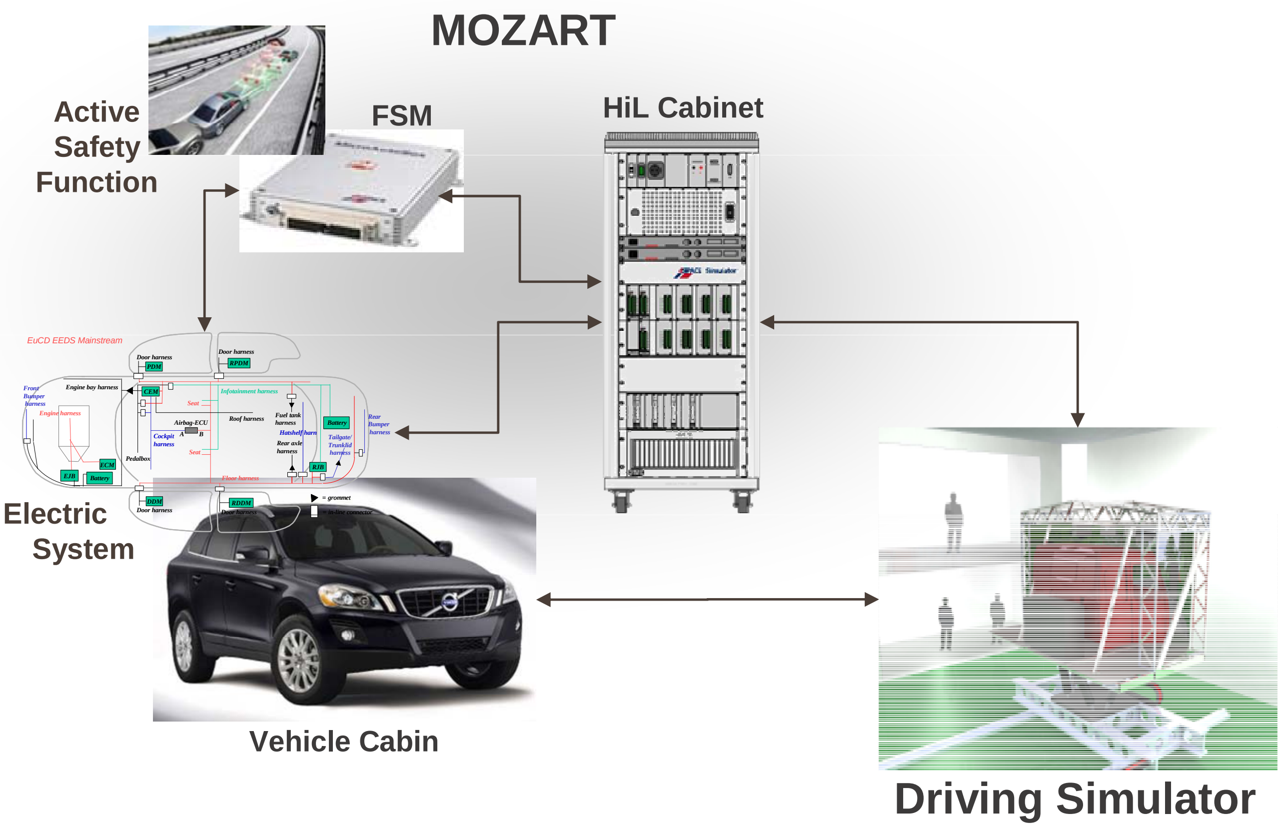
Mozart – General simulator strategy



Source: Urban Kristiansson, VCC

Integrated safety function test facility



Summary – Overall goals

Meet the challenge of interacting systems (vehicle, surrounding, driver)
Rapid prototyping (Gate -2,-1…)
System integration (complexity, functional safety, testing)
Education/competence
AUTOSAR/ Modelisar

Thank you!

www.vti.se/simulator