Driving simulators in product development and assessment

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**ViP**

ViP, Virtual Prototyping and assessment by simulation

Institute Excellence Centre hosted by VTI for

- development and application of driving simulator methodology
- focusing on the interaction between humans and technology (HMI)
VTI in brief

VTI, Swedish National Road and Transport Research Institute, is an independent and internationally prominent research institute in the transport sector.

VTI is organized under the Ministry of Enterprise, Energy and Communications.

Vision
An effective, green and safe transport system.

Mission
Continuously improve knowledge of the transport sector to help create an effective and long term sustainable transport system.

www.vti.se
VTI development and use of simulators

- Long tradition
- Competence and experience
- Way of working
- International collaboration

Research unit: Vehicle Technology and Simulation (10 people, Jonas Jansson)

Internal application “clients”: Mainly from HF, behaviour, traffic analysis, environment, landscape infrastructure maintenance
VTI Simulators - Linköping

Sim 3 ('04 - )  Sim 2 ('90 - )  Sim 1 ('85-'02)
VTI Simulator – Gothenburg (under construction)
ViP: Motive

VTI interest => Swedish initiative (so far)

Sweden has strong position internationally (simulation, HMI)
Sweden has (strong) vehicle industry
Simulation and simulators are used more and more by industry & administrations

Advanced driving simulators are relatively rare
Inexpensive powerful computers (PC) and graphics (PC-based)

Facilitate and promote human-in-the-loop studies
Facilitate and promote user-centred design and assessment
ViP: Real time simulation ♥ HMI applications

Instrument for developing and exploring future vehicles and traffic environment from a user’s perspective

Simulation & test methods for vehicle industry & transport infrastructure bodies

Increased collaboration and knowledge exchange

Exchange of methods and tools for increased compatibility
Increased knowledge and “improved” transport system

Prospective – 5, 10, more years perspective – enabling studying real drivers driving future vehicles (simulator) in future traffic environments (virtual surrounding world) already today
**ViP: Goal**

Strategic *co-ordination* of competence and resources

Sustainable *common platform* for increased and long-term co-operation, competence building and knowledge transfer within the field of real time simulation of vehicles and infrastructure

Common development of technique, methodology and way of working to achieve:

- **More effective** (time, cost) innovation, product development and assessment by driving simulators (=> obvious tool)
- **Competitiveness** - industry, research, ViP environment
- Prerequisites for *keeping* research and development within Sweden
Simulator based design and assessment

Idea/Concept → Virtual prototyping → Implementation → Experimental design → Human-in-the-loop simulation → Analysis → Synthesis → Product
ViP: Strategy - combining 3 approaches

Develop and co-ordinate a common **technical framework** for driving simulators (interfaces, protocols, models; logic, graphics etc.)

Develop and use a common simulator based **methodological framework** (methods, procedures, scenarios, indicators; experimental design)

Perform concrete applications, **projects**
Knowledge flow – key issue

Methodology projects

Coordination and Development of a common simulator framework
Development of assessment methodology

Applied projects

Iterative process
ViP: Partners and funding

VTI
Saab       Dynagraph       Swedish Transport Administration
Scania     HiQ Ace         Bombardier Transportation
Volvo Cars  Pixcode        Swedish Road Marking Association
Volvo Truck SmartEye

Funded by ViP partners and Vinnova (Swedish Governmental Agency for Innovation Systems)

7 years, evaluation after 3 years
ViP: Activities

Applied projects

Technology/methodology development projects

Knowledge/technology transfer

Workshops/Seminars

Collaboration with other actors/groups (universities, institutes, competence centres, EU, international?)
Why use a driving simulator?

Experiments are performed under controllable and reproducible conditions without any potential danger for the driver, the car or the environment.

It is possible to test concepts and new technologies not in series-production and possible to control and monitor a vast amount of variables and conditions.

- The same scenario for all participants
- Real people are driving
- Quick comparisons between different alternatives
- Creating complex situations that are not possible to stage in reality not even on a closed circuit
Simulation or animation?

Driver not passenger
Perspective-correct reproduction (angles)
Driving dynamic vehicle
Time dimension - correct time relations
Sound and vibrations - information carriers
Simulator potential and credibility

Behavioural research - Product design & functionality
Use - HMI

Driving performance, driver experience and acceptance
=> Safety, comfort, environmental impact, …

Validity (correspondence) crucial
- Behavioural validity: Absolute ↔ Relative,
  Internal ↔ External,
  Construct, Realism, Statistical
- Physical validity: Simulator fidelity
Current aspects in focus

Driver’s
- perception of road, scenery, situations
- sensation of motion and forces

Needs on surrounding traffic
- Models for different road environments

Approach
- Controlled traffic
- Combining autonomous and controlled traffic
- Using semi-autonomous vehicles
## Surrounding traffic

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<th>Sense of Realism</th>
<th>Reproducibility</th>
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<td></td>
<td><strong>Vehicle</strong></td>
<td><strong>Traffic</strong></td>
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<tr>
<td>Real world</td>
<td>High</td>
<td>High</td>
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<tr>
<td>Test track</td>
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<td>Low</td>
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<tr>
<td>DS – “Fully” controlled</td>
<td>Medium - High</td>
<td>Low - Medium</td>
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<tr>
<td>DS – “Fully” autonomous</td>
<td>Medium - High</td>
<td>Medium - High</td>
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## ViP: Projects

**Tools**
- VisualEyes
- Simulator Based Design
- Sound generator
- MeMoS Motion sensation/cues
- SimHarm

**Industrial needs**

**Methods**
- FICA 2

**Methods**
- ESC
- DB2
- FCW
- Drowsiness detection and HMI
- Sound design strategies for ITS
- LDW & road marking/rumbled strips
- Driving in tunnels
- SleepEye
- SPASS
MeMoS - Methods to improve and evaluate the motion sensation in driving simulators

Enable the driver to be able to estimate the speed of own and other vehicles as in reality

Cues
- Visual
- Audible
- Haptic
- Combinations
- Weights
- Sensitivity analysis

Simulator fidelity
Road user perception/requirement of road surface conditions

Poor correlation between objective assessment of road surface conditions and road user opinions.

Effects of visual appearance, sound/noise, vibrations studied for rutted & patched road surfaces.

Even road surface as reference.

32 participants.

Visual: lateral position
Sound: speed variance (speed with visual)
Vibration: lateral position variance (speed with visual)

Contribute to negative perception of comfort and safety (separately & in combinations).

Close relation between perceived comfort and perceived safety.

**SHAKE – (rough) road data model development and implementation**

Models using road data for generating realistic road vibrations (felt by driver) and audible tire to road noise (heard) connected to the visual appearance (seen)

Road surfaces conditions/properties:
- Patched road
- Rutted road
- Rutted road with water
- Road with rough texture (red)
- Road with cracks
- Uneven road (combinations)

Comparisons between real driving and simulator driving

Simulator experiment 32 participants, mean realism ratings 5.2 – 6.0 (scale 1-7)

Validation study ongoing

Facilitated a unified way of describing the road properties => road patch definition included in augmented OpenDRIVE standard 1.3.

SHAKE => Open DRIVE 1.3

openDrive

Road

Geometry  Link  Elevation  Crossfall  Lane Section  Object  Signal

Line  Arc  Spiral

Lane

Material  Width  Link

VTI-extension

Resource  Patch

Visual  Sound  Vibration  Other
Repeated scenario exposure in active safety system (critical situation) testing

Repeated scenarios are used to study FCW. Validity - generalization to real world?

Presence of FCW system => Influence on response times to emergency braking scenario (lead vehicle)? Moderated by repeated scenario exposure?

FCW presence, two initial time headways at visual distraction task onset, repeated scenario exposure

FCW effect size:
- Saliency and timing of warning
- Transparency of the scenario for drivers who do not receive a warning.

Previous FCW experience influence driver behaviour;
- Inexperienced drivers respond only to the scenario
- Trained and trusting drivers respond primarily to FCW

Driving in tunnels

Study the impact of road and tunnel environment factors on driver performance and driver state

Actual & experienced driving behaviour => safety

4 road sections/conditions – balanced order
- 1 open road
- 3 tunnels with varying visual guidance (without, “correct”, amplified)

24 participants
- Alert
- Sleepy
VIP partner network

BOMBARDIER

TRAFFIKVERKET

DYNAGRAPH

WÖLVO

IF YOU WANT REALITY

Technology

Methods

People/competence
ViP/VTI technocal platform

State-of-the-art subsystems (moving base, HWIL-simulations)
Matlab, Simulink, CarSim, VeDyna, Industry standard
Create an open programming environment
Open Source code: OpenDrive, OpenScenGraph
PC-based computer Graphics
Embryo to simulator network in Sweden
International extension?

International

National

TRL

UoLDS

DLR

MONASH

NN

INRETS
Thank you!

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