

Enhancing Immersion in Virtual Test-Driving: Integrating Varjo XR technology with DiM250

Martin Heiderich, M.Sc.

Vehicle Dynamics Technology Research
Honda R&D Europe (Deutschland) GmbH
E-Mail: martin_heiderich@de.hrdeu.com

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Honda Americas



Ohio

Honda Development and Manufacturing of America

Honda Europe

Honda R&D Europe (UK) Ltd



Reading

Offenbach

Honda R&D Europe (Deutschland) GmbH
(global pathfinders for new technologies and methods)

Honda Asia



Honda Japan



Tochigi

Honda Motor Co., Ltd &
Honda R&D Co., Ltd

Main R&D centres



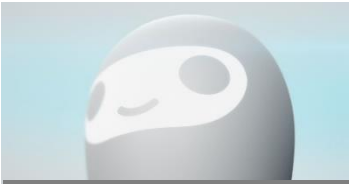
AUTOMOBILE



MOTORCYCLE



Solution System



HONDA RESEARCH
INSTITUTE

2014-2018

Preliminary Simulator evaluations

- Vehicle Dynamics
- Ride comfort
- AD/ADAS
- Steering Feel
- Biometrics Measurements

2020 → Compact Simulator



2014

2016

2018

2020

2022

2024



2018 → 1st DIM250 worldwide at
Honda R&D Europe

Enhancement of driving simulator technology and virtual development methods



2023 → 1st DIM300 worldwide at
Honda Japan

Use of simulator technology for vehicle
development and research

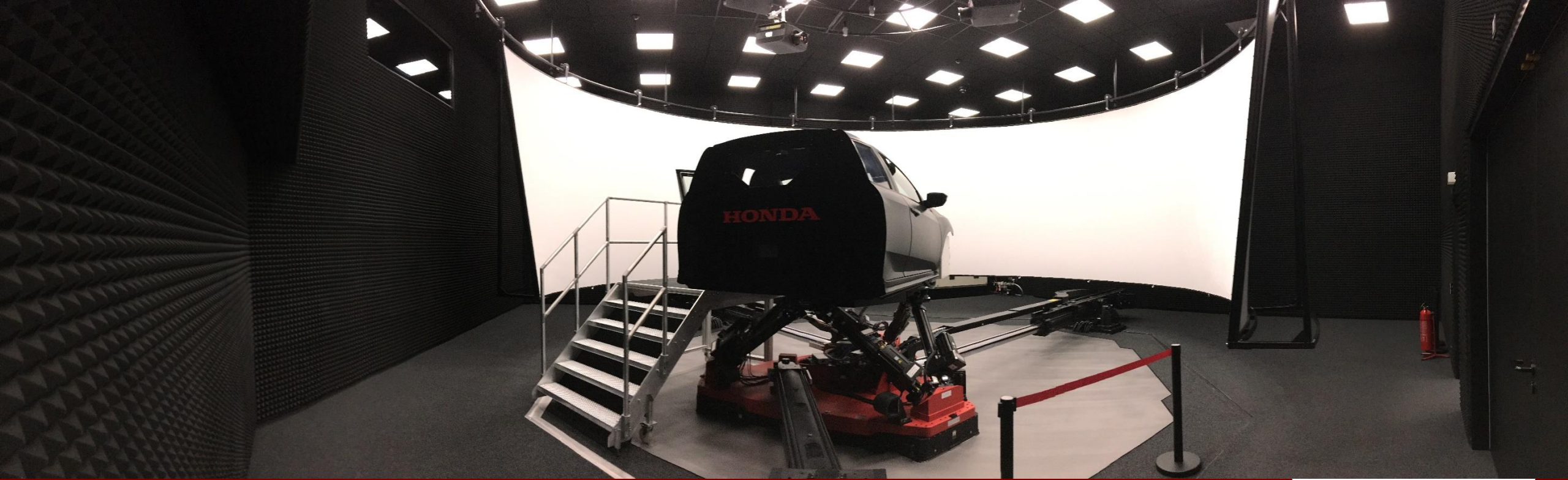
Established Virtual Test Center at Honda R&D Europe

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Actuator-based DiM250 dynamic Driving Simulator
customized Honda Cockpit

Clean soundproofed environment to reduce actuator noise
(sound-absorbing pyramids, carpet and acoustic absorbent ceiling)

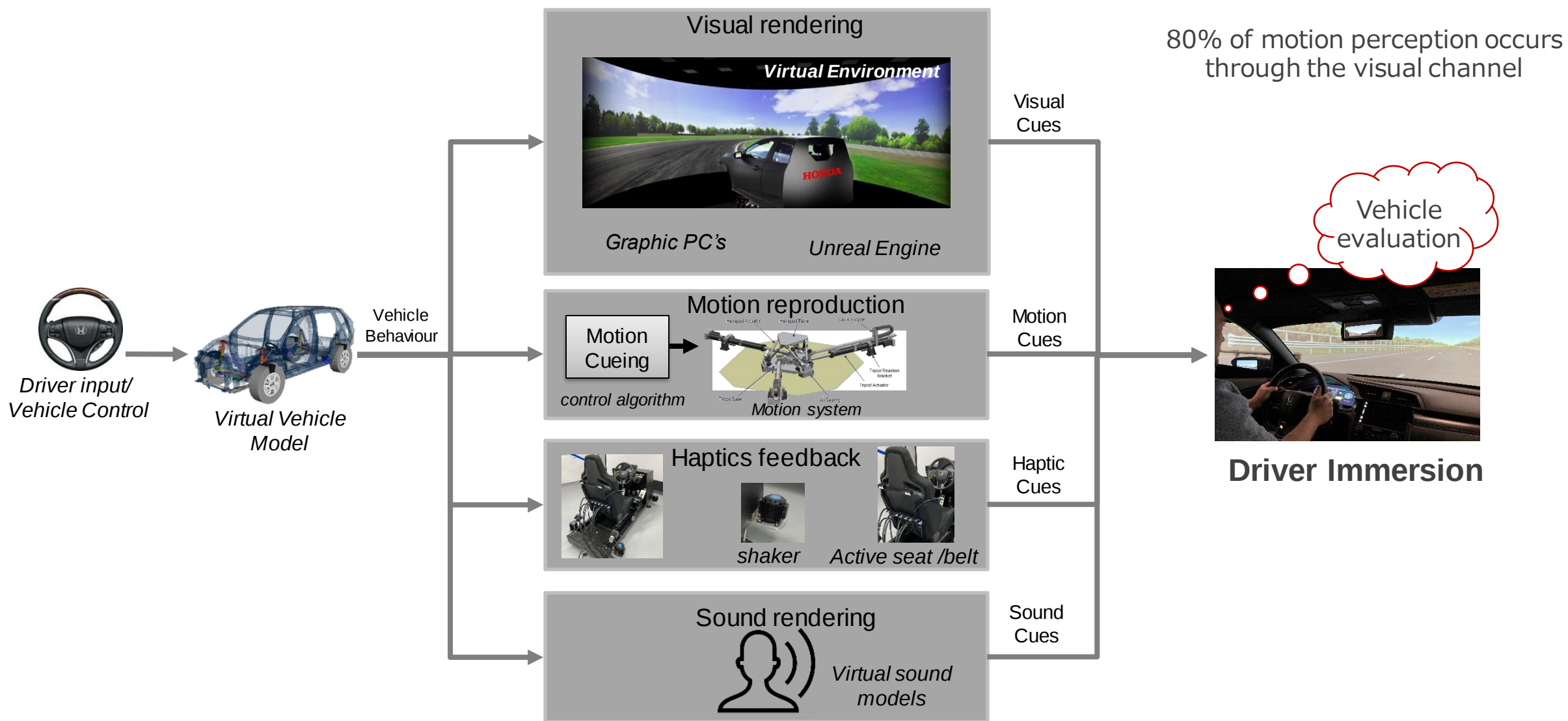


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DIM250



5x Laser Projector (Barco F70-4K6)
2560x1600 @120Hz, ~40 PPD
Conical Screen (average d=8.5m, FOV 260deg)
GPU Nvidia RTX 3090/ Graphic PC Latency of ~ 25ms

Compact Simulator



1x Laser Projector (Barco F80-Q7)
2560x1600 @120Hz, ~36 PPD
Cylindrical Screen (d=4m, FOV 70deg)
GPU Nvidia RTX 4090/ Graphic PC Latency of ~15ms

Projector limitations:

- System latency (PC Latency + Display latency)
- Illumination and brightness
- Retinal resolution demand (60 PPD)
- Static screen size is limited
- two-dimensional images

Speed perception

→ Underestimation Lead to ~ 20% faster driving

Distance judgement

→ 80% overestimate the distance to the vehicle in front



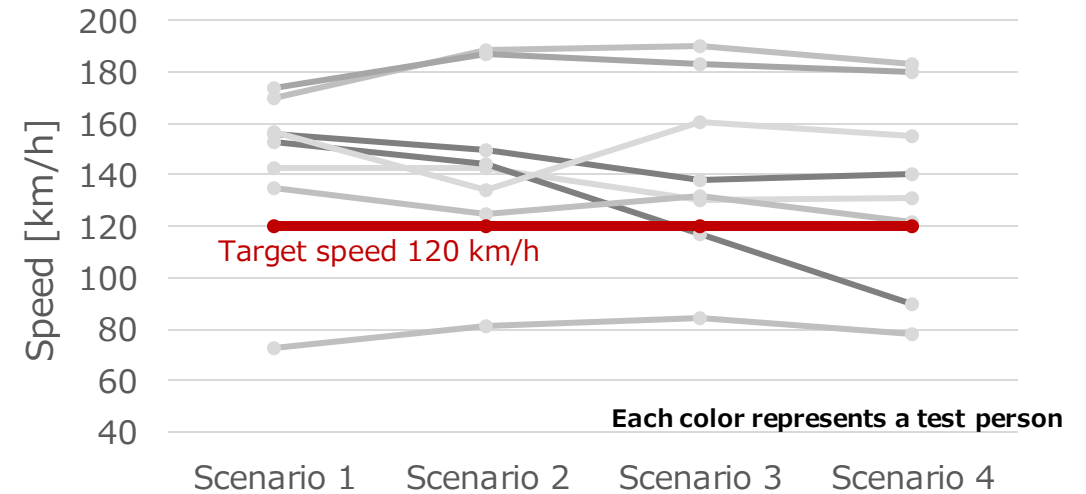
e.g. during following traffic vehicles on Highway

Sense of presence / Immersion

- Influenced by lighting, shadowing, contrast
- 88% preferred physical based rendering
- Disadvantage of projectors (reflecting the light source; LED walls / HMD are their own light source with more colorful pictures with high contrast)

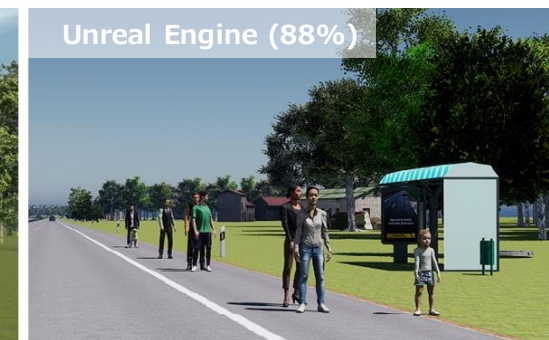
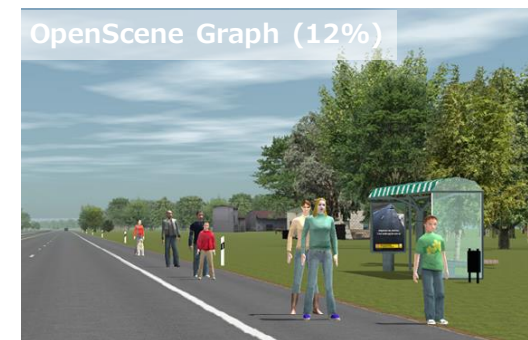
Influence of scenario design on speed perception

(Internal study with 8 participants, straight Highway Scenario)



Rendering engine and visualization preferences

(Internal study with 10 participants, Compact Sim projection system)



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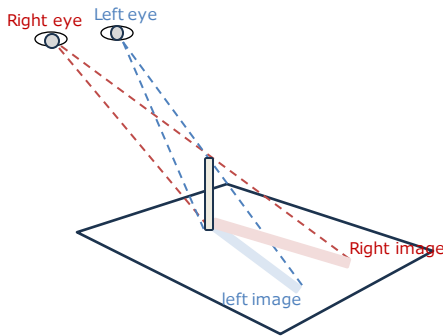
4. Challenges and Outlook

Strong performance enhancements in the last years

- Reduced display latency
- Increased resolution and PPD
- Ergonomic comfort

Stereoscopic vision

- Two images, one for each human eye create depth cues
- corresponds to the way we see the real world



Cost aspects

- only < 5% of a conventional projection system

HMD	Bigscreen Beyond	HTC Vive XR Elite	Pimax Crystal QLED	Varjo XR-3	Varjo XR-4 Focal Edition	VRgineers XTAL 3 Neo
						
Display resolution per eye	2560x2560	1920x1920	2880*2880	2880x2720	3840 x 3744	3840x2160
Resolution	32 PPD	20 PPD	35 PPD	69 PPD	51 PPD	-
Refresh Rate	90 Hz	90 Hz	160 Hz	90 Hz	90 Hz	75 Hz @ 4K 120 Hz @ QHD
Field of View	VFOV: 90° HFOV: 102°	VFOV: 91.27° HFOV: 102.13°	VFOV: 110° HFOV: 120°	VFOV: 90° HFOV: 115°	VFOV: 105° HFOV: 120°	VFOV: 90° HFOV: 180°
features	-	Hand tracking	Eyetracking (Hand tracking)	Eyetracking Hand tracking	Eyetracking Hand tracking	Eyetracking Hand tracking
weight	157g	625 g	845 g	980 g	1021 g	1035 g

Hypothesis

- Class leading HMD combined with latest Rendering Engine have the potential to enhance immersion and sense of presence

Proof of Concept Setup

AVSimulation SCANeR Studio
(based on Unreal Engine 4.27)



Varjo XR-3



Steering and hand visualization to enhance controllability

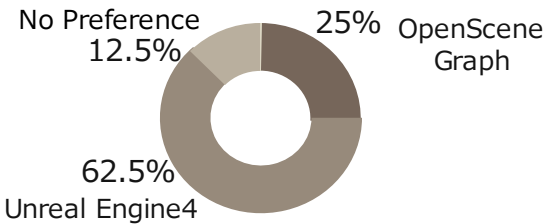


- Compact Simulator
- Tracking: Lighthouse 2.0 for SteamVR

- Depth occlusion (using LIDAR with a range from 0.1m up to 0.7m)
- Varjo Masking (Video pass-through with 20ms latency, 2x 12 MP cameras)

Results

Preferred VR Rendering engine (OSG vs. UE)

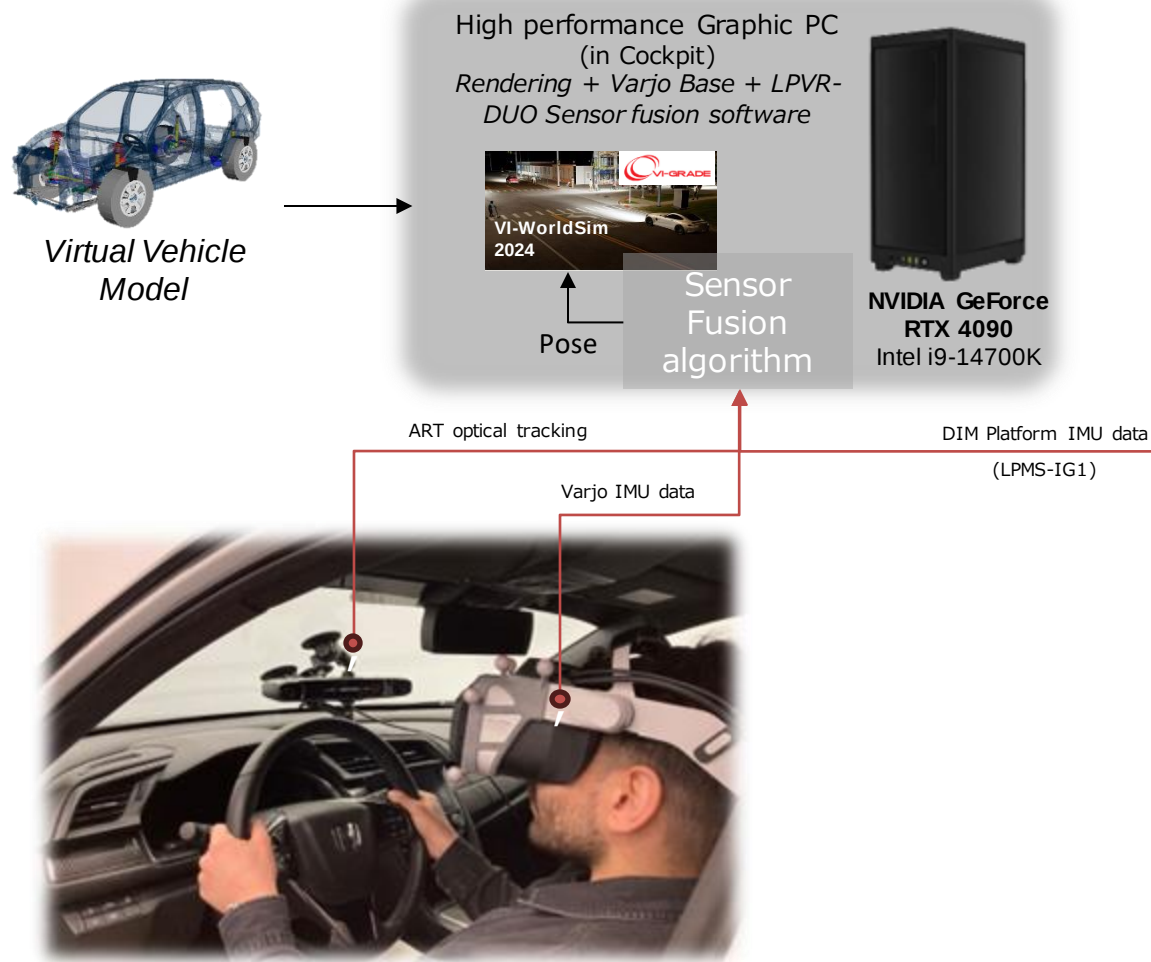


(enhanced level of details, better lighting conditions and shading, and more realistically rendered textures.)

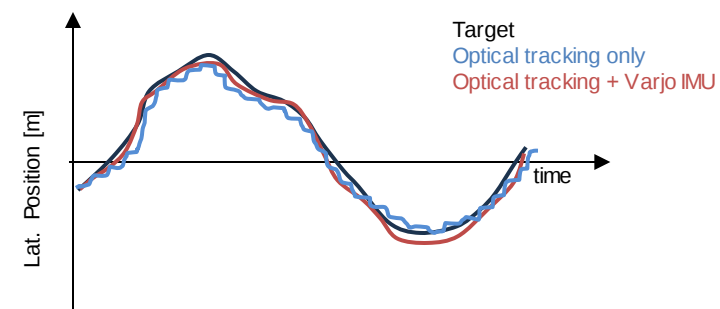
Subjective Evaluation aspects
(projection vs. HMD)

	Projection	HMD
Speed perception		
Distance judgement		
Vehicle speed controllability		
Sense of realism		
Increased sensory conflict (due to lack of motion perception)		
Display latency		
Rendering performance		

DIM250 Challenge: stable Headtracking and Motion compensation



Tracking performance



→ IMU supported sensor fusion tracking shows improved and smoother results

Projection (260deg FOV) vs. HMD evaluation scenarios

Straight driving (for speed perception)



Speed perception

- projection system: still underestimated and speed seems slower than in reality
- Varjo with a much better depth and speed perception
 - much closer to reality

Subjective Evaluation at DIM250 (projection vs. HMD)

	Projection	HMD
Speed perception		
Distance judgement		
Vehicle speed controllability		
Sense of realism		
Display latency		
Rendering performance		

Cornering track



Distance judgment and cornering

- difficult distance estimation with projection system causes problems with trajectory guidance
- HMD stereoscopy offers significant advantages in terms of more accurate trajectory guidance



Required technical improvements:

- Display latency
- FPS stability

Ride comfort track



Comfort perception

- Big excitations on a ride comfort track require a strong fixation of the HMD (discomfort)
- additional HMD mass acting on the driver's head is a bit annoying

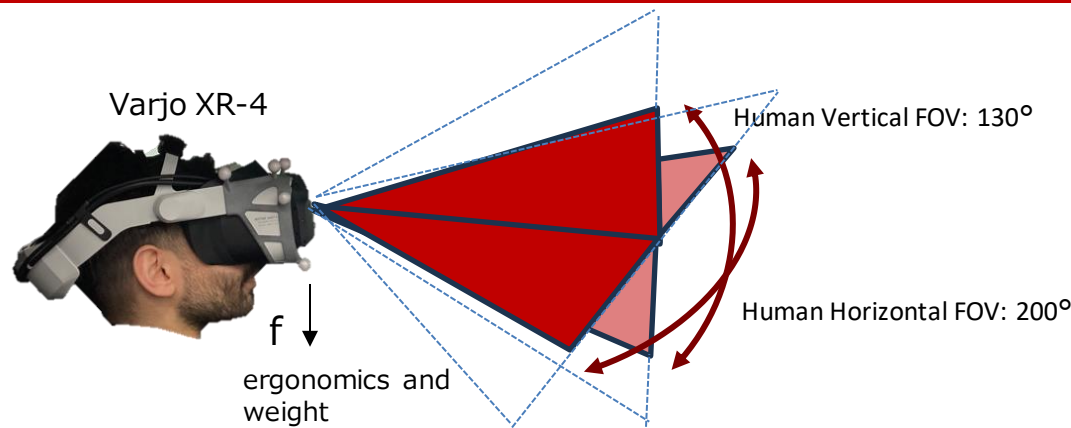
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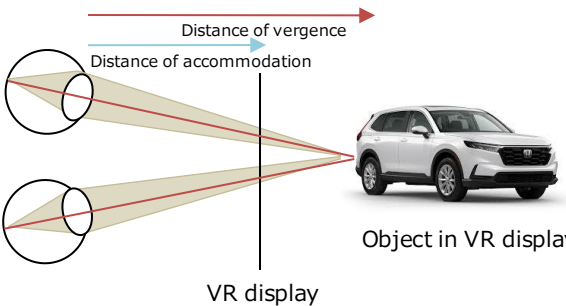
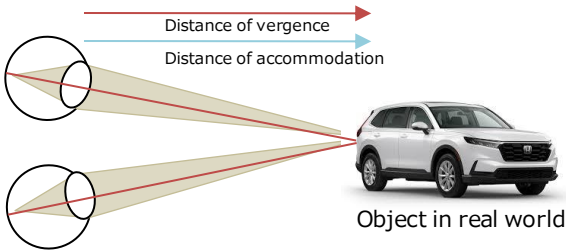
4. Challenges and Outlook

- Discomfort during ride evaluations
- Limited HMD Field-of-View



HMD	Varjo XR-3	Varjo XR-4 Focal Edition
		
Display resolution per eye	2880x2720	3840 x 3744
Resolution	69 PPD	51 PPD
Refresh Rate	90 Hz	90 Hz
Field of View	VFOV: 90° HFOV: 115°	VFOV: 105° HFOV: 120°

- Latency of current HMD
(Low latency important for cognitive functions such as sense of presence, spatial cognition and awareness)
- Vergence-accommodation conflict
(sensory conflict lead to eye strain, blurred vision, and headache)
- Motion sickness/ Virtual reality sickness risk
(due to enhanced visual demand and immersion, but limited motion reproduction)



- Continue Investigations with Varjo XR-3 and XR-4 in official release WorldSim 2024.1
- Virtual reality sickness investigation during longer test drives
- Derive requirements for a next Honda Cockpit and visualization system



HONDA

Martin Heiderich, M.Sc.

Vehicle Dynamics Technology
Honda R&D Europe (Deutschland) GmbH
E-Mail: martin_heiderich@de.hrdeu.com