

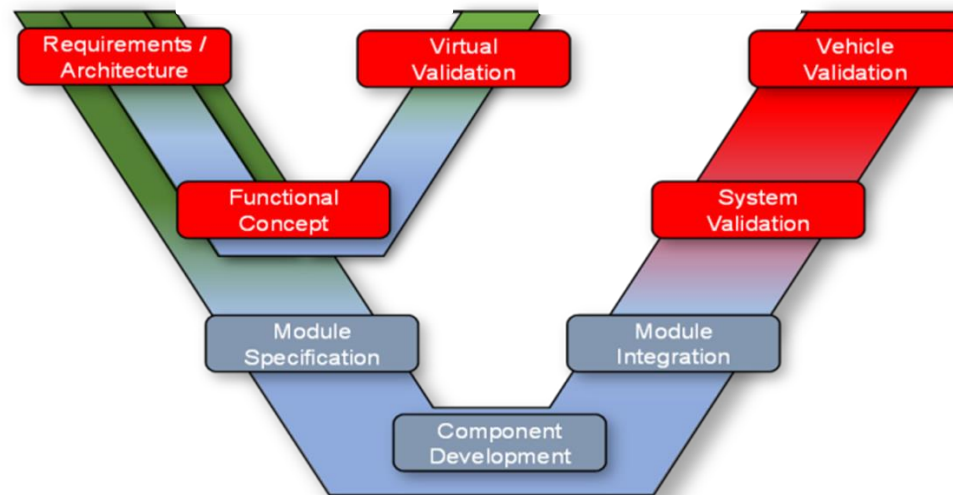


A Novel Approach to Integrate Human-in-the-Loop Testing in the Development Chain of Automated Driving on the Example of Automated Lane Change

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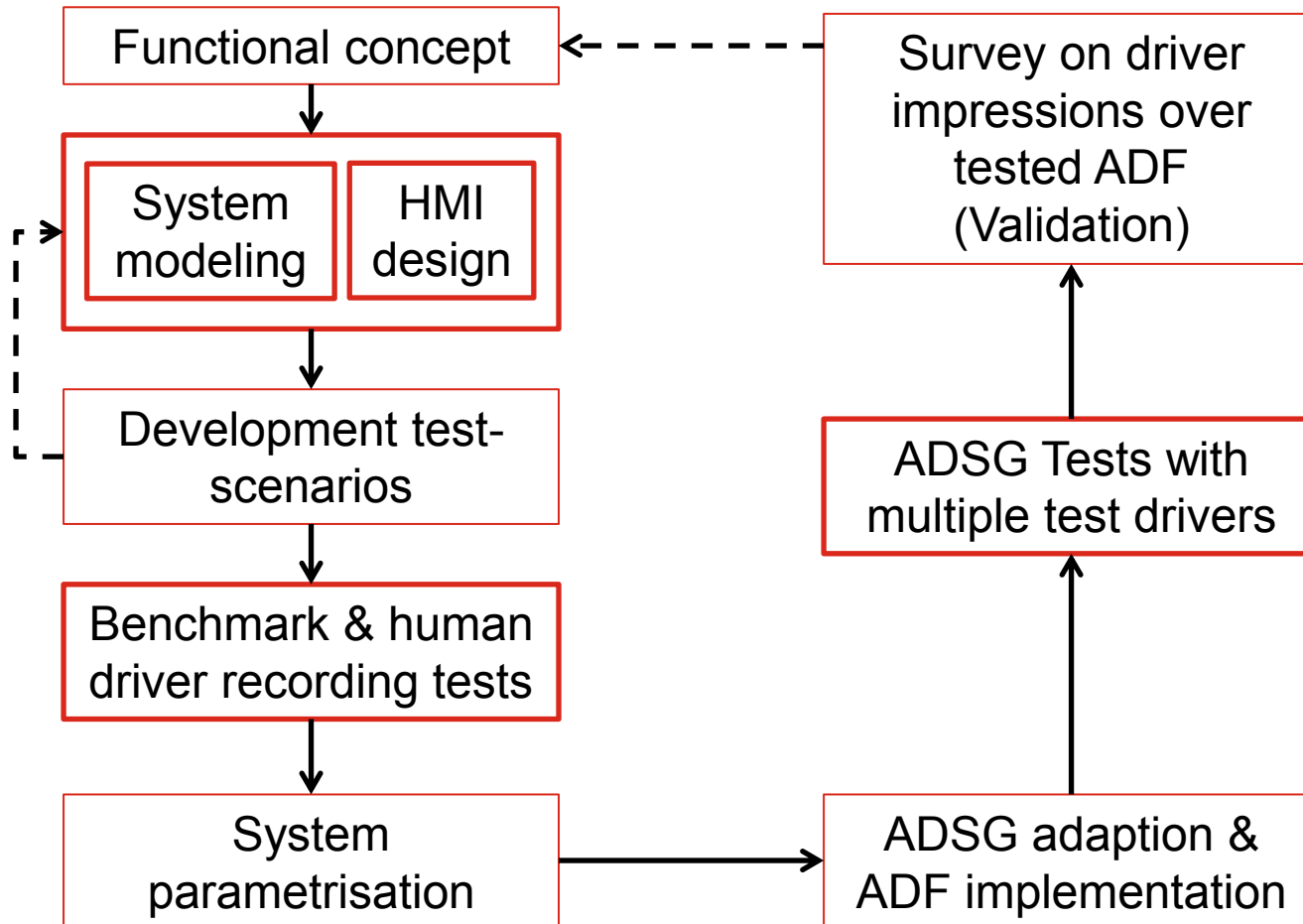
- Project Introduction
- Automated Driving System Development Chain
- Automated Lane Change Function & HMI Concept
- Human-in-the-Loop Testing with Driving Simulator
- Results & Discussion

- **Project goal:** implementation of virtual tools in the development process of automated driving systems
- The automated lane change (LC) function is used for demonstration purposes as system under test
- Industrial project in cooperation with Magna Steyr



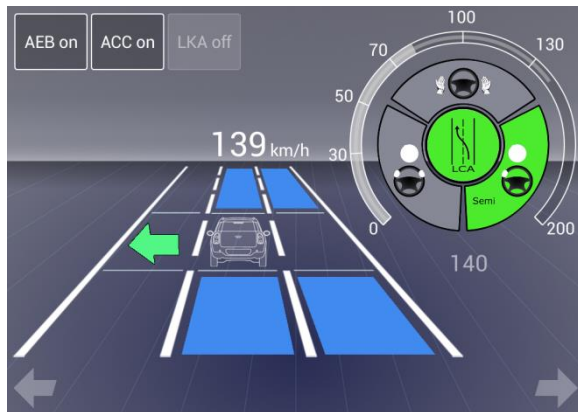
Double V-Model for the development of
Advanced Driver Assistance Systems (ADAS)

Automated Driving Function (ADF) Development Chain

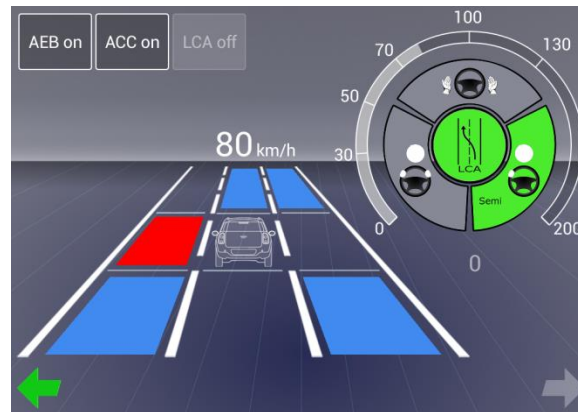


Automated Lane Change Function & HMI Concept

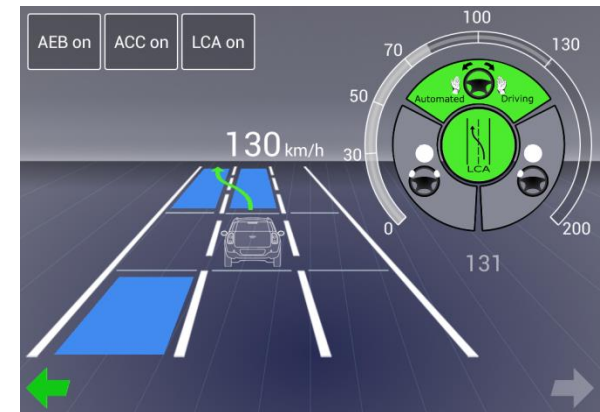
- Lane change algorithm for decision making and trajectory planning based on dynamic traffic (Samiee, 2016)
- Parametrisation based on recorded natural test drives with multiple drivers
- HMI concept (Quinz, 2017)



Manual mode



Semi Automated mode



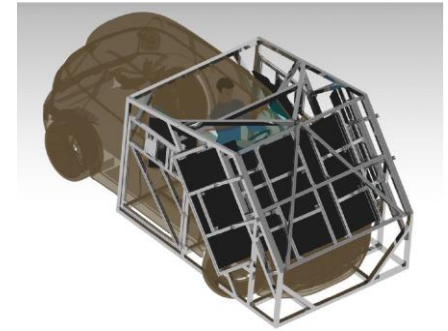
Automated mode

Driving Simulator Study

- Stationary driving simulator with full vehicle body, 360° surrounding view, acoustic and force-feedback simulation
- 20 test persons

Method

- Two-way test concepts: *fixed manoeuvres* and *traffic flow scenario*
 - The fixed maneuvers evaluate driver acceptance with respect to the lane change *starting point* and its *duration* (focus function)
 - The traffic flow test concept gives feedback about overall driver impression regarding usability and user friendliness (focus HMI)



Front view

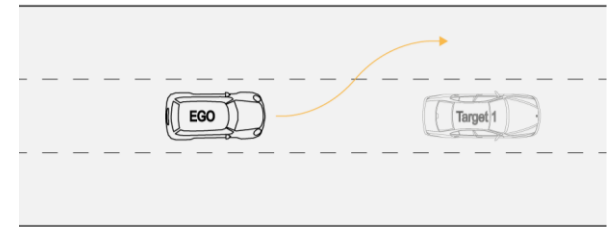


Side view

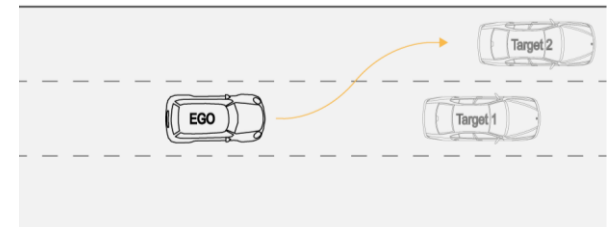


Rear view

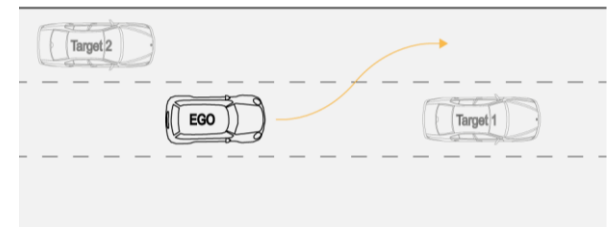
- Four repeatable standard manoeuvres with fixed kinematic for all vehicles
- Every manoeuvre was driven three times by each test person:
 - Manual
 - Automated variant 1
 - Automated variant 2
- Questionnaire after each automated drive regarding:
 - Overall performance impression
 - LC initiation timing
 - LC duration



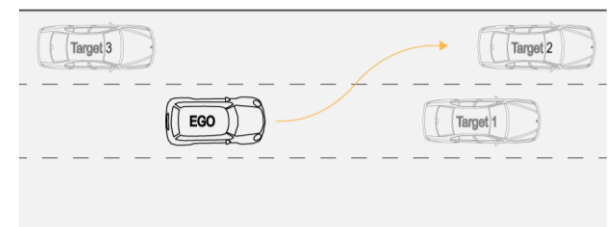
Manoeuvre 1



Manoeuvre 2



Manoeuvre 3



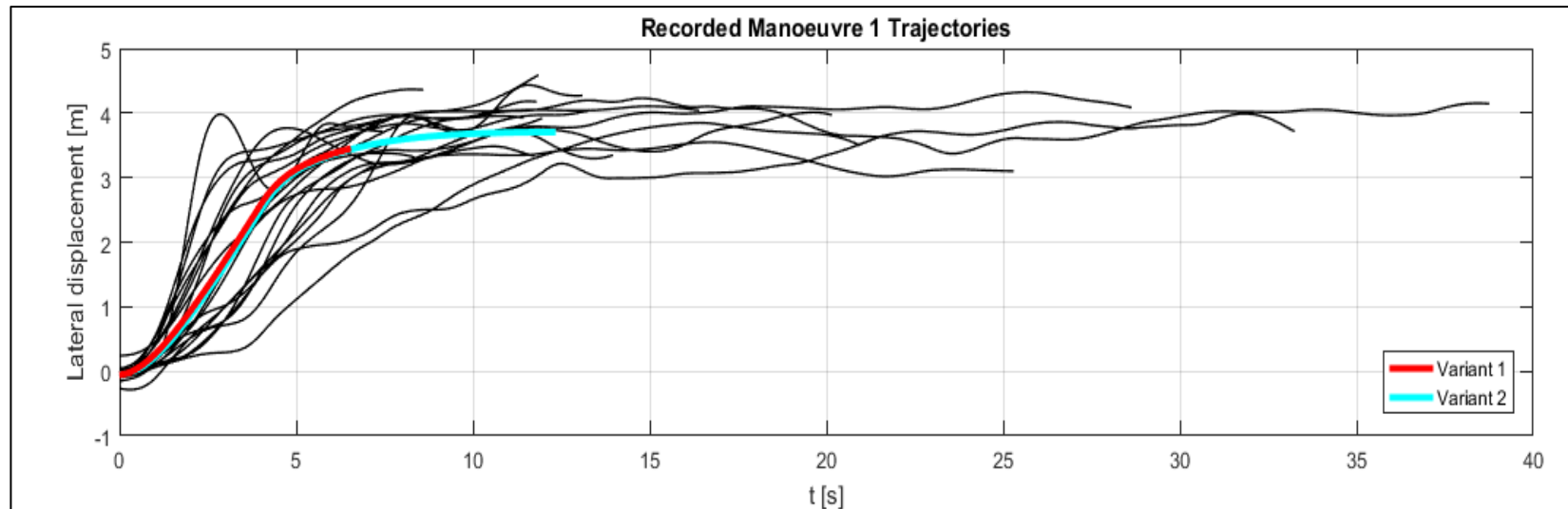
Manoeuvre 4



- Microscopic traffic flow simulation of a three-way highway with calibrated parameters from road measurements (PTV VISSIM)
- Simulated driving in “naturalistic” highway traffic
- Feedback about the overall driver impression of the LCA system
- Focus on HMI
- Three LCA modes:
 - Manual
 - Semi Automated
 - Automated
- Two-way questionnaire:
 - NASA Task Load Index
 - Specific questions regarding system understanding, safety and complexity and driving comfort



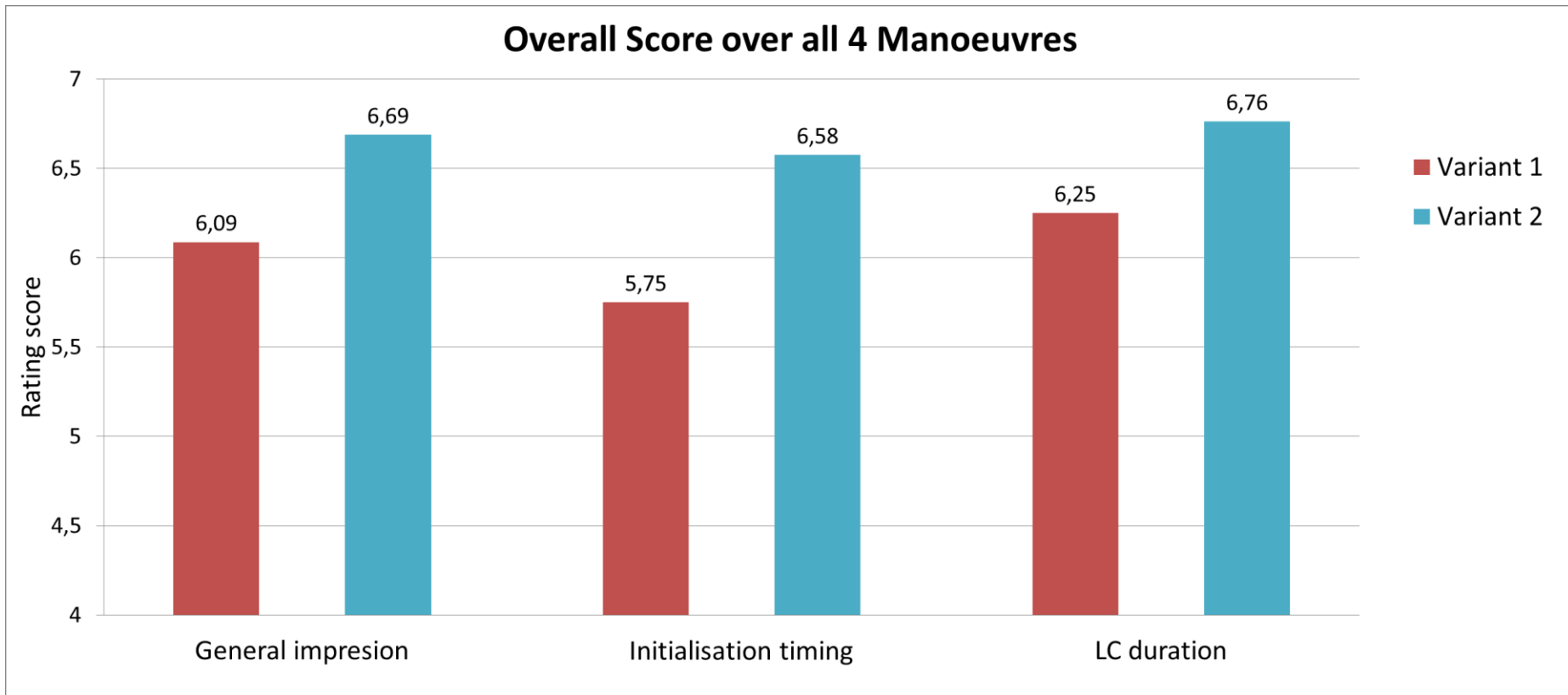
Fixed Manoeuvre Study Results



	Initialisation timing [s]	LC duration [s]
Mean value +/- standard deviation (N=20)	16,1 +/- 9,0	8,3 +/- 4,1
Mean value excl. outliers +/- standard deviation	11,1 +/- 2,8 (N=14, <15s)	6,7 +/- 1,9 (N=15, <9s)

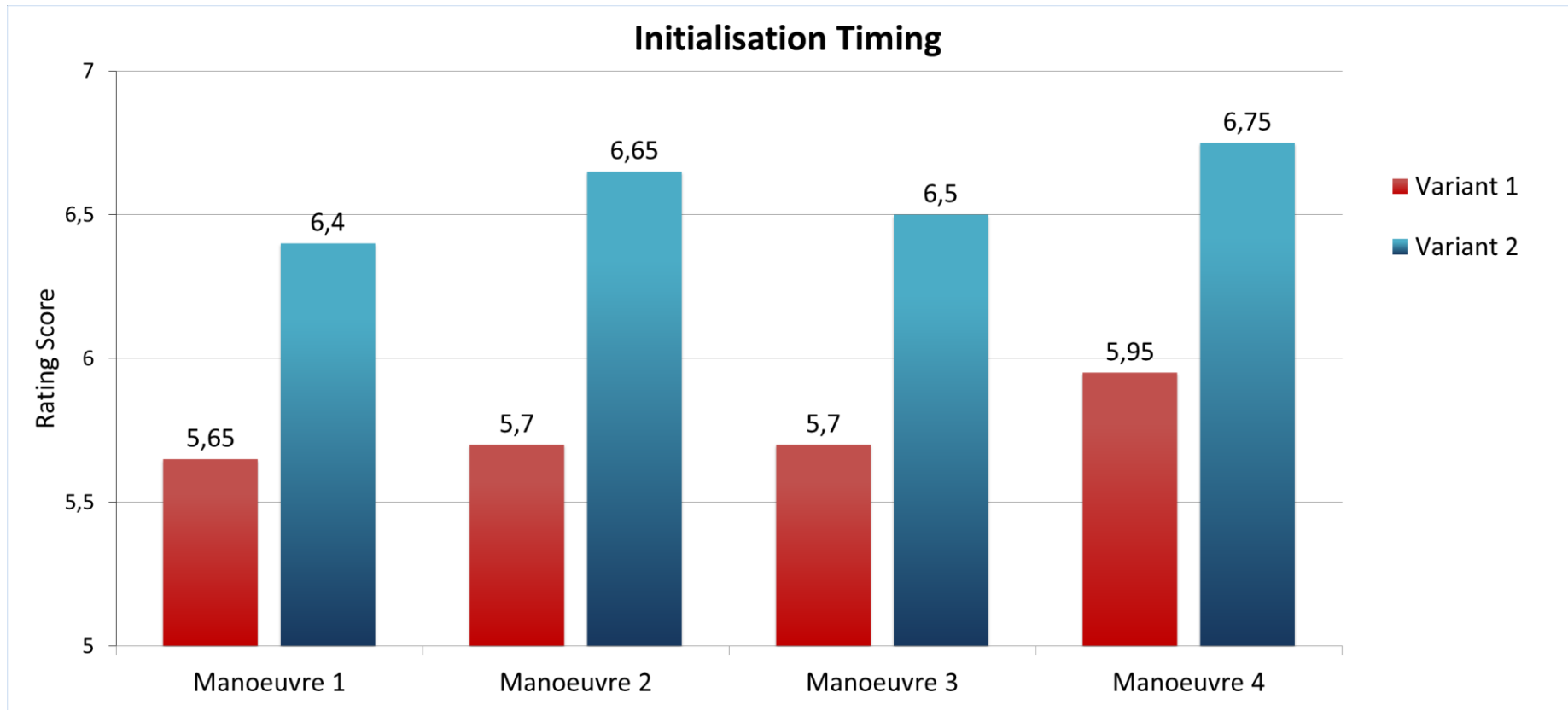
- Initiation timing (calculated over TTC) for most drivers under 15 s
- LC duration normally under 9 s
- No correlation between manual driving behaviour and rating of automated driving performance → “Driver vs. Passenger”

Fixed Manoeuvre Study Results



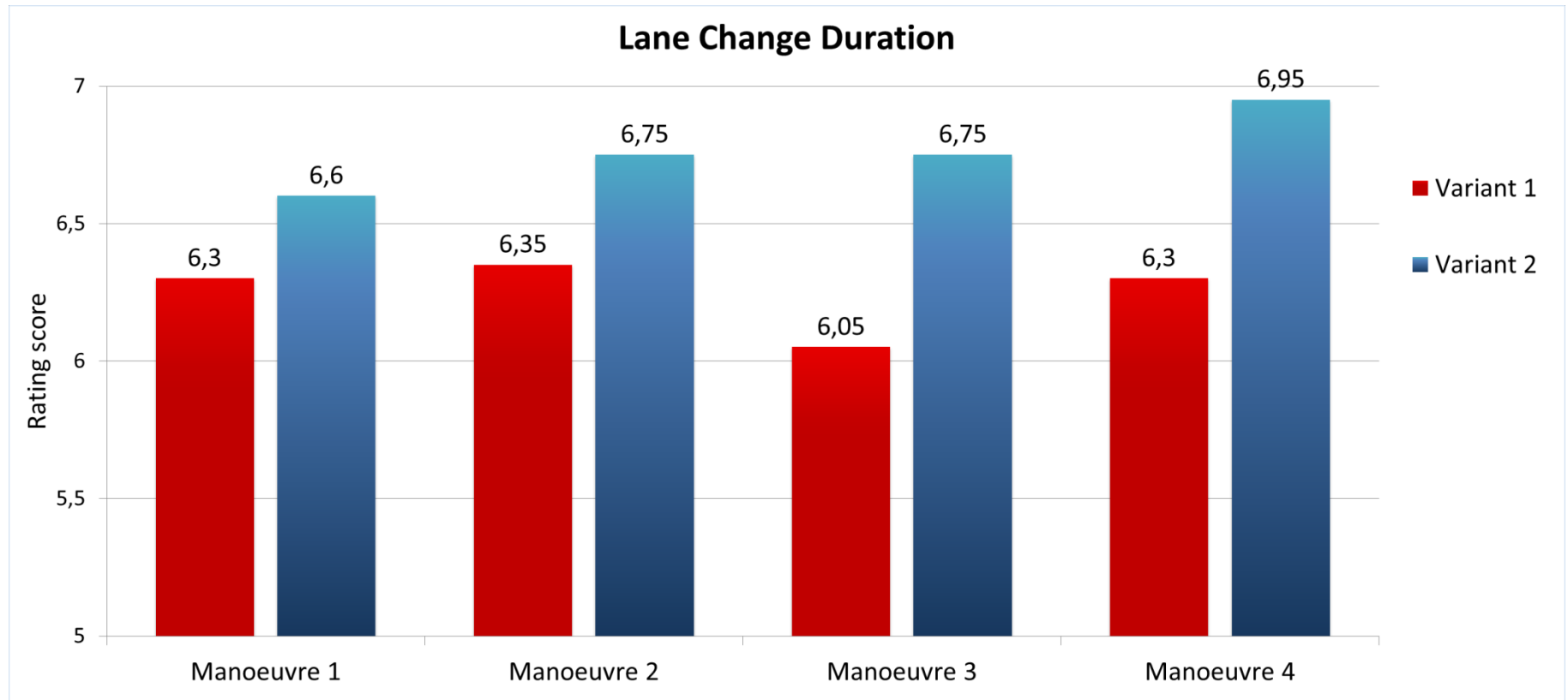
best rate 7
worst rate 1

Fixed Manoeuvre Study Results



best rate 7
worst rate 1

Fixed Manoeuvre Study Results

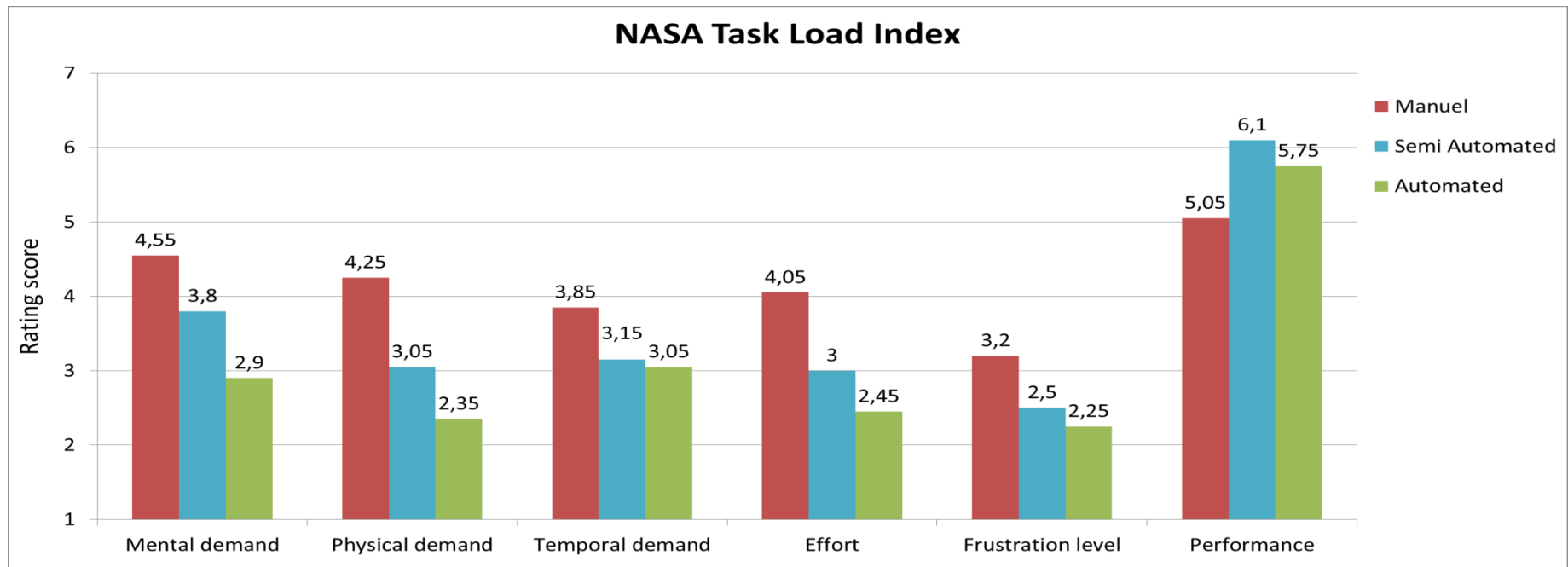


best rate 7
worst rate 1

NASA Task Load Index (TLX)

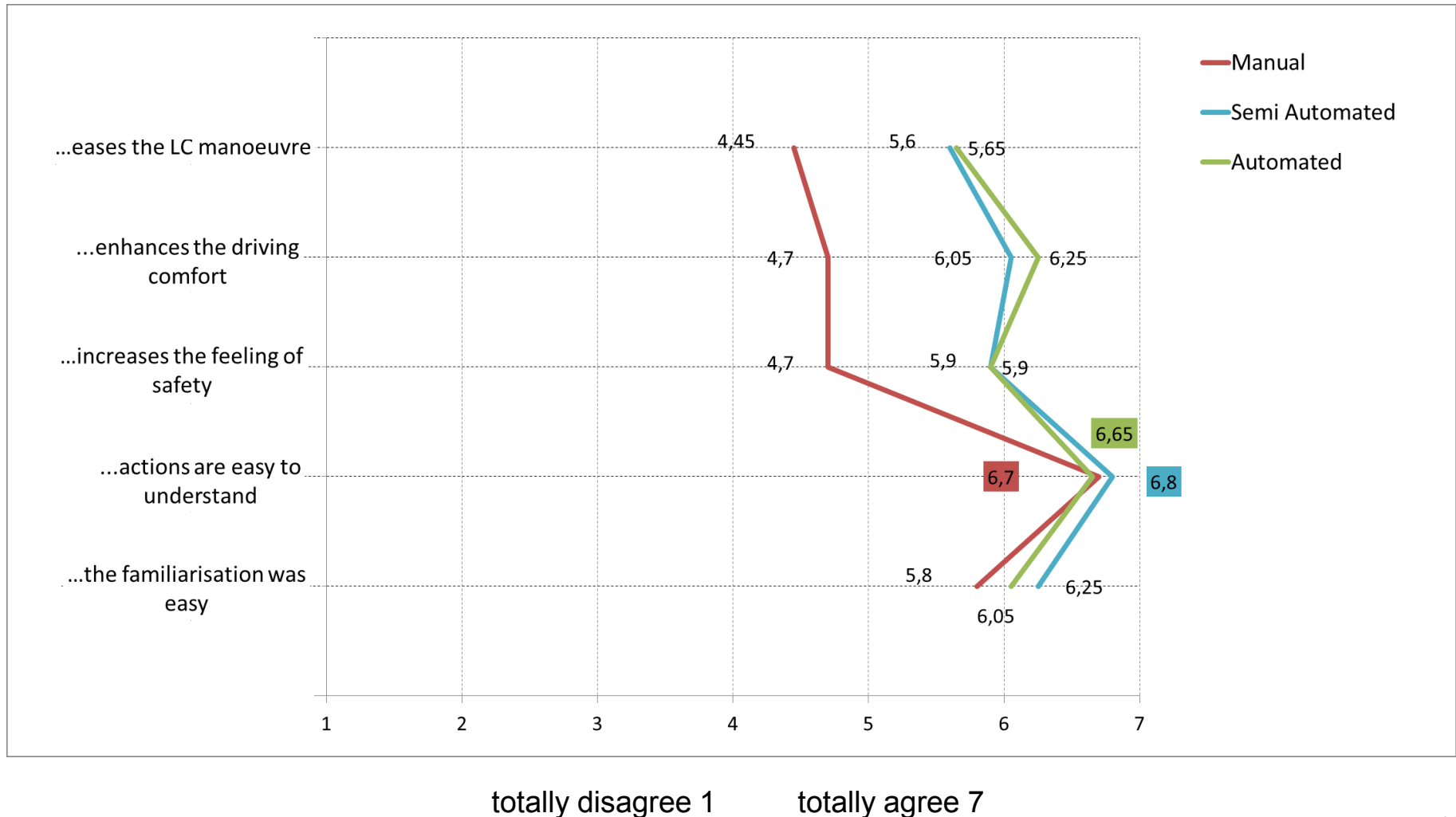
“...subjective, multidimensional assessment tool that rates perceived workload in order to assess a task or other aspects of performance” [Wikipedia]

- The questions were adjusted according to the driving task and different LCA modes in highway traffic



Traffic Flow Scenario Results

- Specific questions regarding system understanding, safety and complexity and driving comfort



Thank you for your
attention

S. Samiee, A. Shahram, K. Reza and A. Eichberger, "Towards a Decision Making Algorithm for Automatic Lane Change Maneuver Considering Traffic Dynamics", *Promet - Traffic and Transportation*, vol. 28, 2016.