< Day 1 >

< Human Factors & User awareness >

SIP-adus Human Factors & HMI Research for Automated Driving

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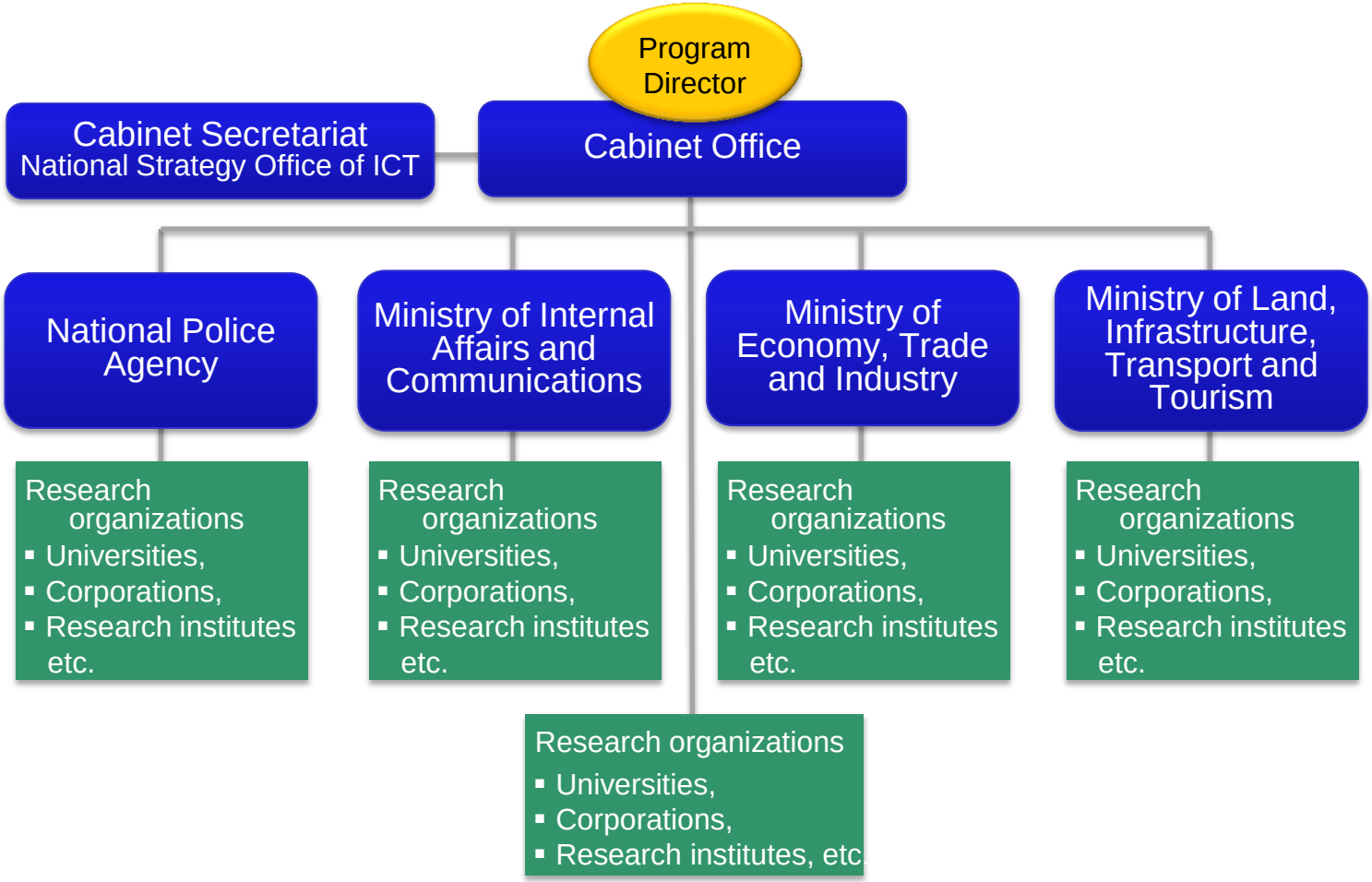
European Commission

Cross-Ministerial Strategic Innovation Promotion Program
SIP Automated Driving for Universal Services (SIP-adus)



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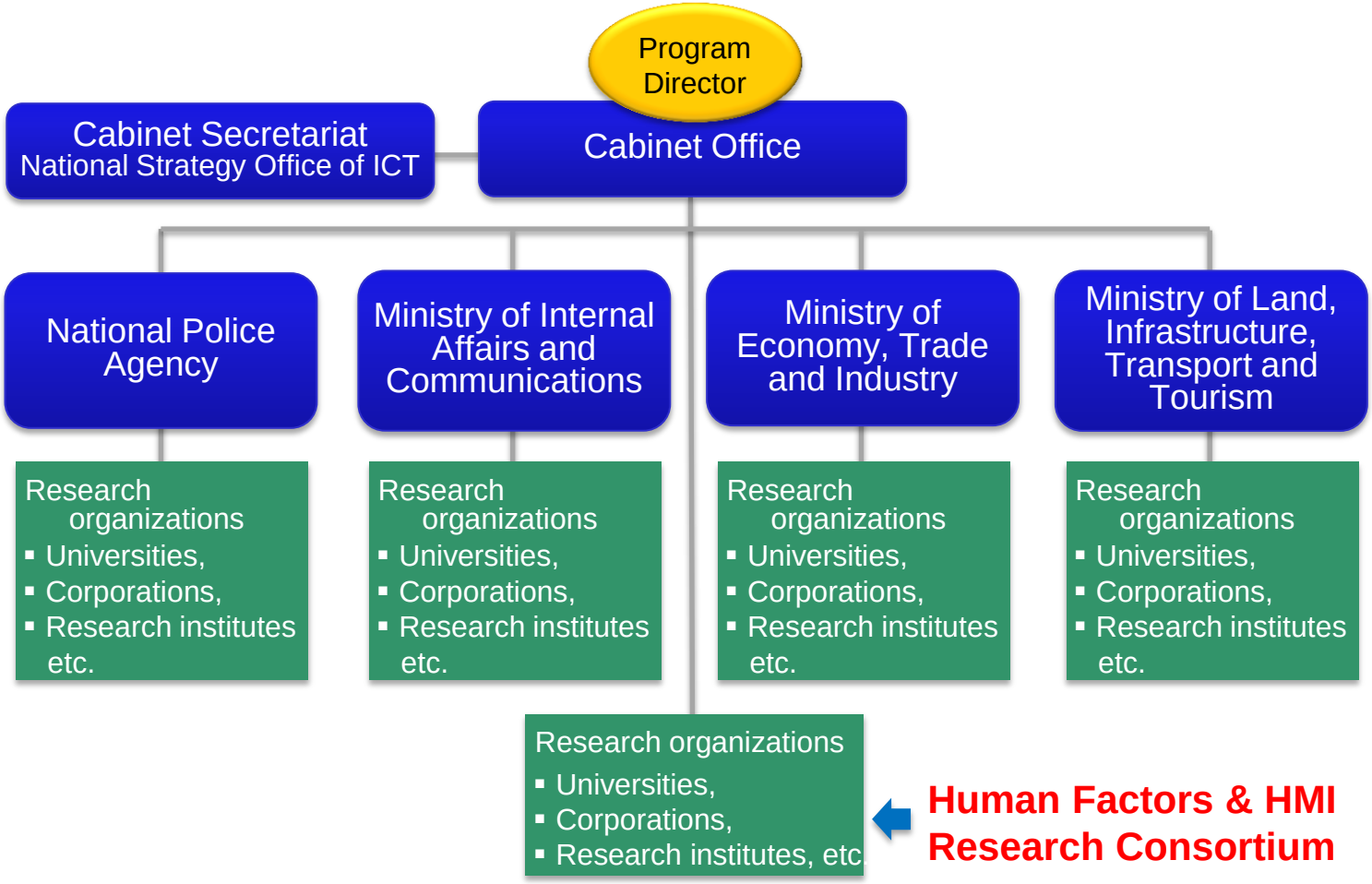

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Tasks with high priority

Task A

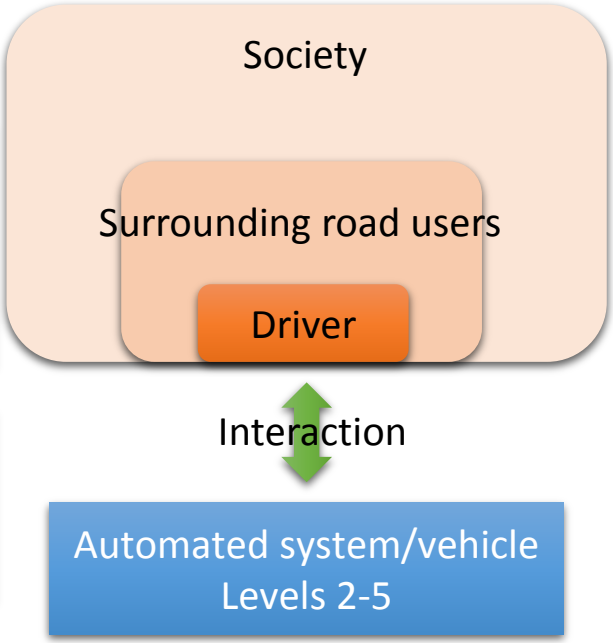
Task A investigates effects of system information (static and dynamic) on drivers' behavior in transition from Levels 2 and 3 to manual.

Task B

Task B investigates effects of driver state (readiness) with Levels 2 and 3 on his/her behavior in transition to manual.

Task C

Task C studies non-verbal communication between drivers and other road users, and investigates effective ways to functionalize the automated vehicle (Level3+) to be communicative.



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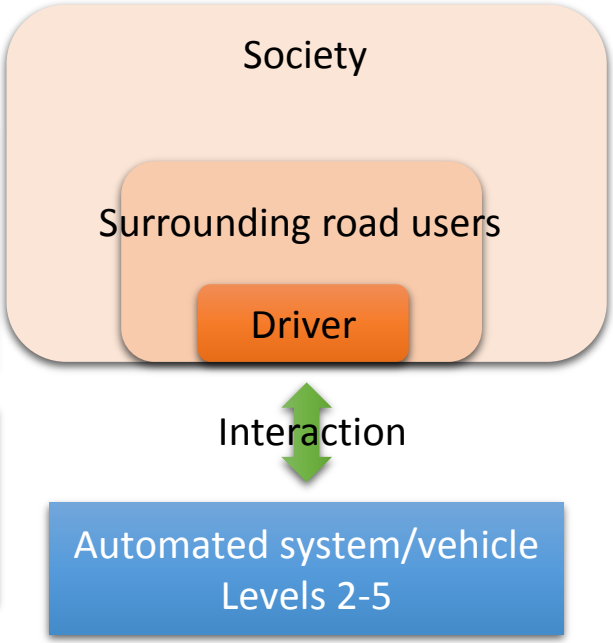
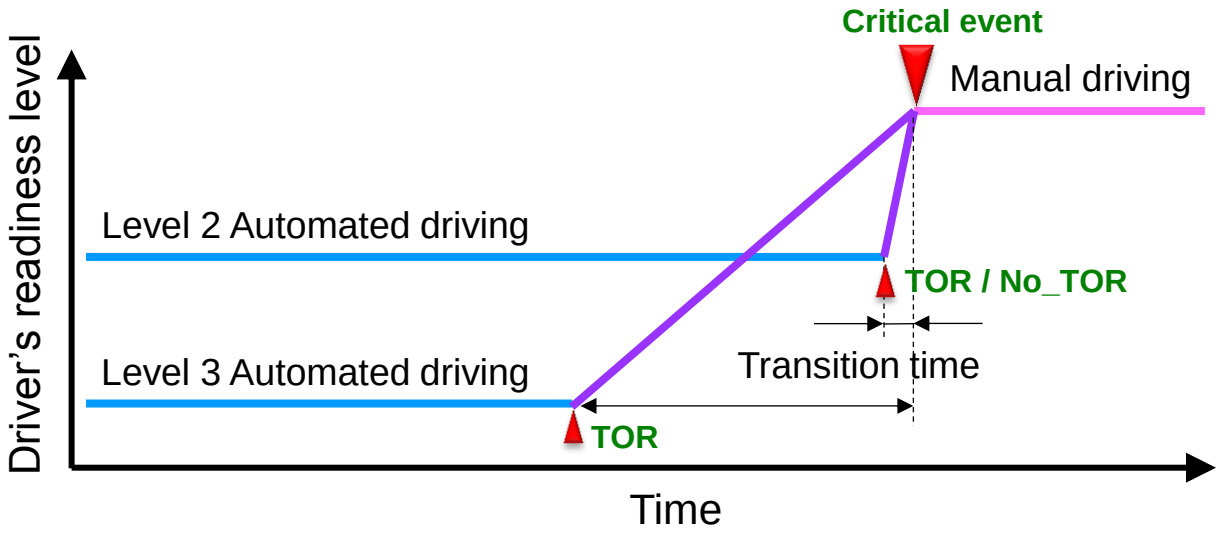


Goals

1. To investigate effects of driver state (readiness) with Levels 2 and 3 on his/her behavior in transition to manual and extract metrics of readiness for the driver monitoring system. ← Year 1
2. To define the transition time as a function of readiness.
3. To identify fundamental requirements of the HMIs for supporting the driver to stay with the appropriate readiness and to take-over the driving task smoothly (prototyping included).



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Experiential method

Subjects drove Level 2 and 3 systems with cognitive and physical additional tasks in the driving simulator. The scenario included several events with low criticality. Subjects' physiological metrics were measured to extract those correlated with degraded performance in the events.

Driver state
- Cognitively loaded by N-back tasks
- Physically (visually & manually) loaded by SuRT※
- Low arousal
- (Shortage of SA)
- (Out of position)

Controlled

Physiological metrics
- EEG (ERP)
- Visual behavior
- Saccadic movements
- Pupil diameter
- Blinking behavior
- Perclos
- Heart rate
- Blood pressure

etc.

Correlation

Performance at the event
- Longitudinal and lateral control of the vehicle
- Minimum distance and minimum TTC to the hazard
- Time spent to regain control

etc.

System terminates
→ Leading vehicle changes lane
→ Stationary vehicle appears

※SuRT: Surrogate Reference Task (see ISO/TS14198)

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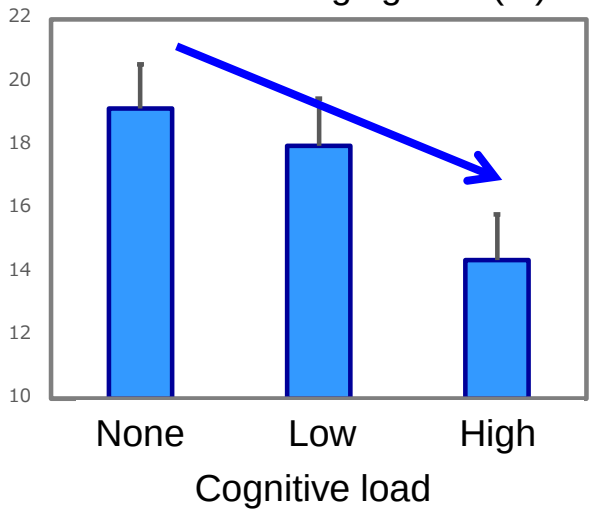
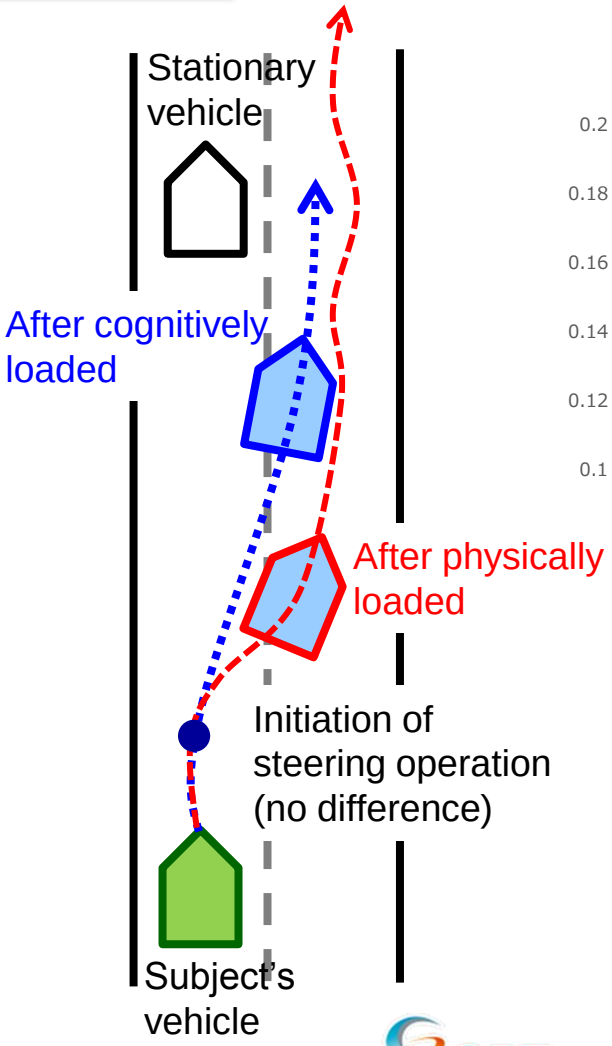
Results: Performance at the event

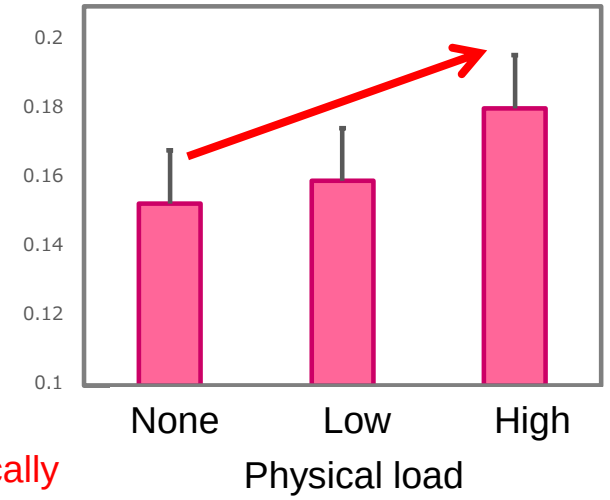
Minimum distance to the stationary vehicle while changing lane (m)



Cognitive load slowed down the cognitive process resulting in degradation of driver's performance to avoid collision with the obstacle.



Steering angle variability in 5s after lane change



Physical load degraded the situation awareness resulting in abrupt steering that led to increase in unstable steering operation and increase in time to stabilize the vehicle laterally.

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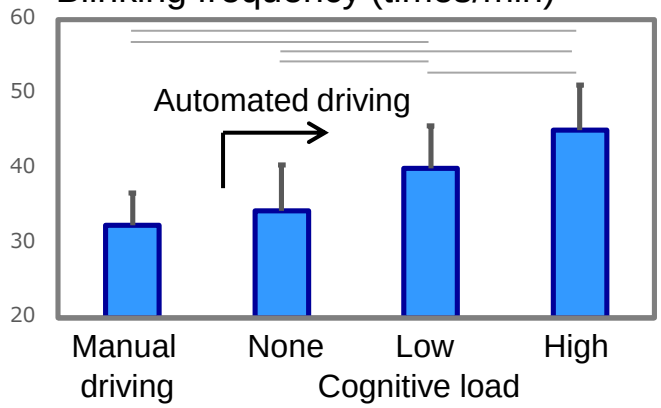
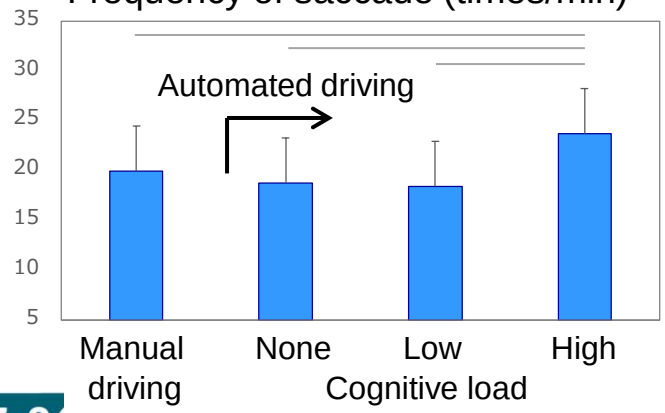
Results: Physiological metrics

Cognitive load

Blinking frequency (times/min)

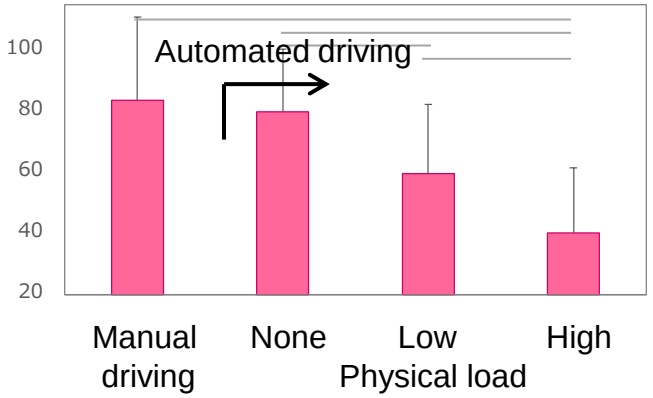


Frequency of saccade (times/min)



Physical load

Percent time of forward looking (%)



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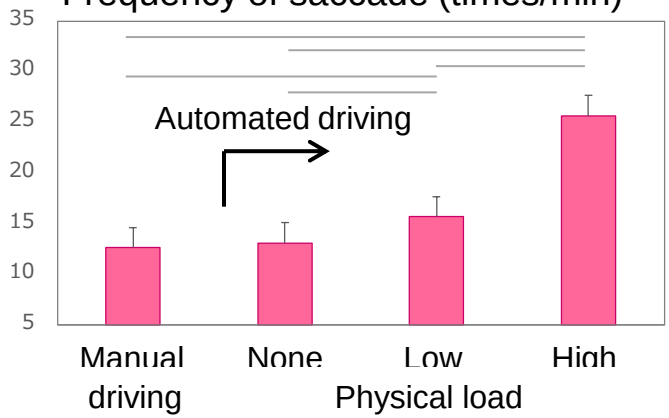

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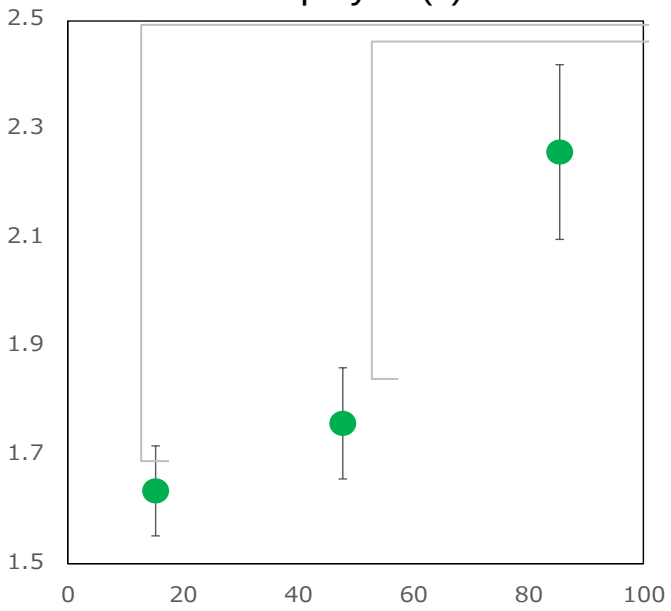
Results: Physiological metrics

Arousal level

The time to initiate steering operation after TOR is displayed (s).



High ← Arousal level → Low

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Conclusions

1. Driver state while driving with the system influences his/her behavior in transition from automated to manual after TOR. The behavioral changes in transition varies depending on the type of driver state such as cognitively loaded, physically (visually and manually) loaded, and low arousal.

2. Physiological metrics of driver state that degrades driver performance in transition have been extracted. Metrics measurable in a vehicle in real time are amplitude/frequency of the saccadic movements of the eyes, frequency of blinking, percent time of forward looking, and Perclos.