Joint system as a guiding approach for driver-automation system design

Johann Kelsch

Institute of Transportation Systems
German Aerospace Center

H-CPS-I Workshop
September 2014
Paris
Overview

- **Motivation for Joint Driver-Automation System Design**

- Joint System components addressed in EU-Projects and iMobility Forum

- **Application examples** for highly automated road transport systems
Motivation for Joint System Design

- Raising number of different assistance systems used in parallel
- Raising complexity of particular assistance systems
Toward Joint Human-Machine Systems Design

Technology centered system design
- Systems Engineering

Human and user centered system design
- Human Factors
- Assistance Systems

Joint System design
- Concepts?

Diagram concept: Denis Javaux
Joint Driver-Automation System: Concepts

- Simplified **human** perception-action model
- **Machine** as a **cognitive agent**
- Human and machine **interacts** with each other

- Human and machine **compete** for vehicle control (shared control)
- **Arbitration** using
  - self-organization
  - role, task, control allocation

(*) Hollnagel & Woods, 1983
Joint Driver-Automation System: Elements

HMI

Co-driver

Mobile Devices

VRUs

‘Intelligent’ Infrastructure

Traffic Management

picture sources: http://office.microsoft.com
Human Factors Subgroup

- Supported by European Commission & ERTICO (Brussels)

- DLR, TRL, ITS LEEDS, ICCS, IFSTTAR, UNIROMA, VEDECOM, TU EINDHOVEN, UNI CHALMERS, TU DELFT, EUCAR, VALEO, HIT

- **Human Factors in Highly Automated Road Transport**
  - Automation effects on driver & other traffic participants (e.g. pedestrians)
  - HF related Joint System design issues (e.g. usability)
  - HF related **roadmaps & recommendations** for the European Commission
Joint Driver-Automation System: Taxonomy

- **Human Factors** is about human related system **problems**

- **Human Factors** is about human related system **solutions** as well

- **Interaction Design**
  - technical requirements meet Human Factors

Generic **problem** + generic **solution**
= **Design Pattern**
Joint Driver-Automation System: Design Patterns

- **Automation Levels*** and transitions
  - Problem of correct human-machine **control distribution**
  - Quantitative solution
  - How much automation is there?

- **Cooperation Modes****
  - Problem of correct human-machine **task allocation**
  - Qualitative solution
  - Who does what and how?

- Both perspectives are **compatible** to each other***

(*) Parasuraman et al. 2000,  (**) Hoc 2001,  (***) EU-Project D3CoS D3-03
Joint Driver-Automation System in EU-Projects

- Joint System
- Automation Levels
- Transitions

- Design patterns for cooperation
- Cooperation modes
- Methods & Tools

- Inform/Warn/Intervene strategies
- Joint HMI Concepts
- Arbitration

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Deliverable D3.03 | D3CoS State Inference and Adaptation

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Interative

Deliverable D3.2 | IWI Strategies | Executive Summary
Joint Driver-Automation System Design Aspects

Usability

Observability

Controllability
Join D-A System Controllability: Decoupling Concept

- Joint D-A System performance in conditions
  - no automation
  - steering intervention (coupled)
  - steering intervention (decoupled)
  - **true vs. false** decoupling

- **FASCAR II** from the German Aerospace center (DLR)
- equipped with **steer-by-wire** system
- Possibility to **decouple** the driver from vehicle control

- Obstacle covering half the lane
- Unfolds in 0.8 sec.
Controllability: Steering intervention (decoupled condition)

50 km/h

Light barrier

Obstacle

Manual driving

0.5 sec.

Driver decoupled

0.3 sec.

Driver can recouple

Manual driving

Driving

Manual driving
Controllability: Driver Decoupling Concept

- Lateral deviation (50 km/h) in ‘true’ decoupling was significantly higher than in other conditions → GOOD

- ‘True’ decoupling seemed to be well controllable for the driver

- Lateral deviation (30 km/h) in ‘false’ decoupling was significantly higher than in other conditions → BAD

- ‘False’ decoupling seemed to be badly controllable for the driver
Joint System Observability: HMI Concepts
Joint System Observability: HMI Display Concept for Cooperative Lane Change Assist
Joint System Usability: Cooperative Lane Change Assist

- Well accepted system design
- Easy to understand
Our research focus in...

- Designing a Joint System
- Ambient display
  - visual, haptic & acoustic stimuli
- **Idea:**
  - Transporting information by using peripheral signals
  - Supporting / inhibiting drivers’ actions by using affective design
- **Aim:** Improving performance in:
  - primary driving tasks
  - automation mode transitions
  - in normal & emergency situations
Conclusion

- Developing ADAS and vehicle automation, systems become complex

- Closely integrated Joint System Design is needed

- EU-Projects are addressing Joint System components, methods & tools

- Exemplary solutions show the possible developments in the future

- DLR develops Joint Systems enriched with affective HMI
References

Thank You
johann.kelsch@dlr.de

Christian Löper  Gerald Temme  Stefan Griesche  Raphael Haus  Marc Dziennus  Johann Kelsch  Anna Schieben