INFRASTRUCTURE SUPPORT FOR AUTOMATED VEHICLES AND THE(IR) OPERATIONAL DESIGN DOMAIN (ODD)

SIP-ADUS WORKSHOP
BREAK-OUT REGIONAL ACTIVITIES
14 NOVEMBER 2019, TOKYO

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INTRODUCTION TO MAP™

Founded in 2010, currently 21 employees and 4 operators
Specialised in operational traffic management

- Consultancy (knowledge, studies, expertise)
- Digital services (dashboards, applications, API's)
- Operational services (monitoring, operators, assessment)
**OPERATIONAL DESIGN DOMAIN (ODD)**

**ODD** is a description of the specific operating conditions in which the automated driving system is designed to properly operate, including but not limited to roadway types, speed range, environmental conditions (including weather, daytime/night-time), prevailing traffic laws and regulations, and other domain constraints.

*SAE, Taxonomy and Definitions for Terms Related to On-Road Motor Vehicle Automated Driving Systems J3016_201401*
When, where, why?

permanent - transient
static/dynamic - highly dynamic
Why transition areas?

- Transition areas mark the boundaries of the ODD.

- What if an automated vehicle is unable to solve the situation ahead?
  - ...what if, this happens not to single vehicles only, but to several?
  - ...what if, it always happens on the same spot?
  - ...what if, this interrupts traffic flow, traffic safety, etc.

- TransAID aims to:
  - Identify potential risks
  - Recommend solutions
  - Coordinate movements
TransAID project overview

- TransAID (ART-05)
- Transition Areas for Infrastructure-Assisted Driving
- 01-09-2017 ~ 31-08-2020
- Budget: EUR 3.836.353,75
- Seven partners from 6 countries: DE, UK, BE, NL, EL, ES
- Website: www.transaid.eu
The TransAID reasoning for I2V support

Vehicle automation capabilities (A) x Scene (B) x Traffic dynamics & situational variables (C) = ODD

\[ B + C = A \quad \text{ODD: OK} \]
\[ B + C \neq A \quad \text{ODD: NOK} \]
\[ B + C = A + ? \quad \text{ODD: OK?} \]

? = digital support measures
Identifying I2V / TM support measures

- Vehicle automation systems:
  - Sense and build environmental awareness
    - Situational support: provide relevant information
  - Ability to determine action(s)
    - Operational support: provide an (alternative) action
  - Ability to perform action(s)
    - Tactical support: arrange favourable conditions
1. Provide vehicle path information

2. Provide speed, headway and/or lane advice

3. Traffic separation

4. Guidance to safe spot

5. Orchestration, distribution and scheduling
TransAID areas of recommendation

**Information services** for automated vehicles.

**Traffic control measures** for automated driving.

**Traffic regulations** for automated driving.

**Spatial planning** for automated driving, MRM-havens specifically.

Application of **V2X message sets** and proposed extensions.

Requirements for **roadside equipment and signalling**, for all vehicle modes.

**Urgency** of interventions based on market penetration (mixed traffic) forecasts.

**Priority** of interventions based on situational characteristics.

Actor **roles and interaction models** for automated driving and traffic management.
Assumptions & results require validation: questions

- What are typical *causes* of unplanned handovers when considering initial Level 3/4 AVs?
- Are the TransAID services *meaningful* services? And how will the compliance to such services be, e.g. considering *trust* issues?
- Should the ODD and/or disengagements of AVs be *reported* by OEMs?
- What will be the *lead-time* for taking over vehicle control for different levels of automation?
- Is *connectivity* a (regulated) pre-requisite for some levels of automation?
- Would automated driving require the support of some sort of *remote support* / back-end?
- Who should decide whether a specific *road section* is within the ODD of an AV?
- Will AVs be more *conservative* in terms of headway and lane change behaviour?

*And many more related to expected, assumed and revealed vehicle behaviour and capabilities.*
Stakeholder consultation workshops

- TransAID-MAVEN-CoExist Stakeholder workshop, 10 October 2017, Brussels
- TransAID-MAVEN-CoExist-INFRAMIX Expert meeting, 23 October 2018, Greenwich
- TransAID session and survey, 8 June 2019, IEEE-IV, Paris
- TransAID-U.S. CAMP expert meeting, 25 July 2019, Detroit
- EU EIP workshop on ODD, 1 October 2019, Turin
- TransAID-INFRAMIX stakeholder workshop, 9 October 2019, Graz
- International workshop on ODD, 22 October 2019, Singapore

- TransAID Deliverable 8.1 – Stakeholder consultation report (draft) will soon become available on www.transaid.eu.
**Workshop: Constructs of the ODD [Singapore, 22 Oct 2019]**

**Importance of Infrastructure**

Infrastructure can dramatically augment in-vehicle capabilities, expanding ODD and/or increasing level of automation by:
- Providing segregation from some hazards
- Providing information unavailable to vehicle sensors (beyond line of sight, around corners, or previewing planned actions)
- Reducing uncertainty about hazards
- Simplifying the driving environment to aid less sophisticated threat assessment systems
- Enhancing localization accuracy and confidence

**Shladover:** ‘Infinite variety of possibilities’, ‘N-dimensional tensor’.

**Kawashima:** ODD mngt, communication systems, orchestration.

**Erhart:** Infrastructure can support to close ODD gaps.

**Kulmala:** Cost of ODD related measures and uncertainty of evolution.

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Task: approach ODD and vehicle automation system from the infrastructure side and define categories of infrastructure support that would enable different levels of automation.

ODD continuity and coverage, minimum risk state when ODD ends.

Situations or areas where infrastructure support is considered relevant.

Kind of infrastructure features or modifications that ease automation.

Roles and responsibilities of stakeholders (who should do what).

Required redundancy of infrastructure elements.
FINDINGS

- ODD limitations must be **understandable** for the consumer.
- ODD should be defined by ADS developers (or assessment and certification institutes), based on **verifiable** technical capabilities.
- Reluctance to share needs and information due to **ODD competition**; more extensive ODDs than competitors.
- ODD attributes: **requirement** from ADS to environment that enables automation **OR conditions** that the ADS should be able to handle.
- **Interchangeability/complementarity** of attributes (technologies) as seen from the perspective of driving tasks (e.g. lateral & longitudinal control) and ADS functions (e.g. perception).
- Expectation on driving **skills and performance** of ADS must be validated.
- Focus on separate driving tasks, the underlying AD functions and their needs. Be cautious not to **overestimate** the importance of ODD attributes.
Desire to address specific conditions vs. the inability to be exhaustive in terms of ODD characteristics vs. confidentiality. **Shareable abstraction level** needed.

Roles, tasks and responsibilities of stakeholders that exist today are likely to **still exist in the future**, therefore are part of the ODD.

Infrastructure and operators perceived as **unreliable** by OEM’s.

AD bus in mixed traffic (JP): ‘infrastructure and regulation **made it possible**’.

Remote supervision and support **instead of** remote control.

Try to **limit dependence** on physical infrastructure because of cost.

**Next steps:**
- EU single platform on CCAM, WG on digital and physical infrastructure (DPI).
- TransAID ‘twinning’ expert meeting with ITS Japan – UTmobil.
- ISO work item taxonomy for classifying ODD.
BACK TO THE OPERATIONAL DESIGN DOMAIN (ODD)

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➢ Driving tasks and automation functions.
  (e.g. longitudinal control, lateral control and perception)

➢ Situations and conditions.
  (e.g. infrastructure, road user, traffic or environmental)

➢ Expected driving skills and behaviour.
  (e.g. safe, reliable, smooth)
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