This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 723390

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

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

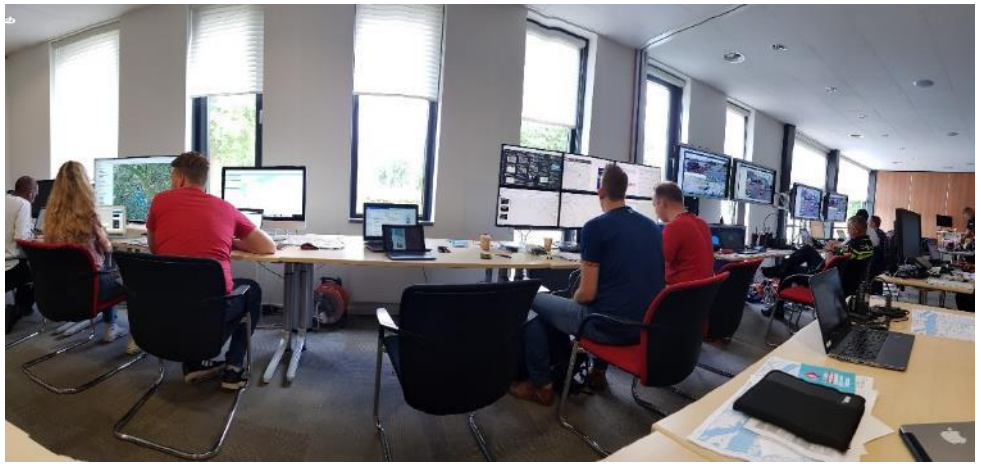
Dr. Jaap Vreeswijk
Traffic Architect CAD

INTRODUCTION TO MAPTM

Founded in 2010, currently 21 employees and 4 operators

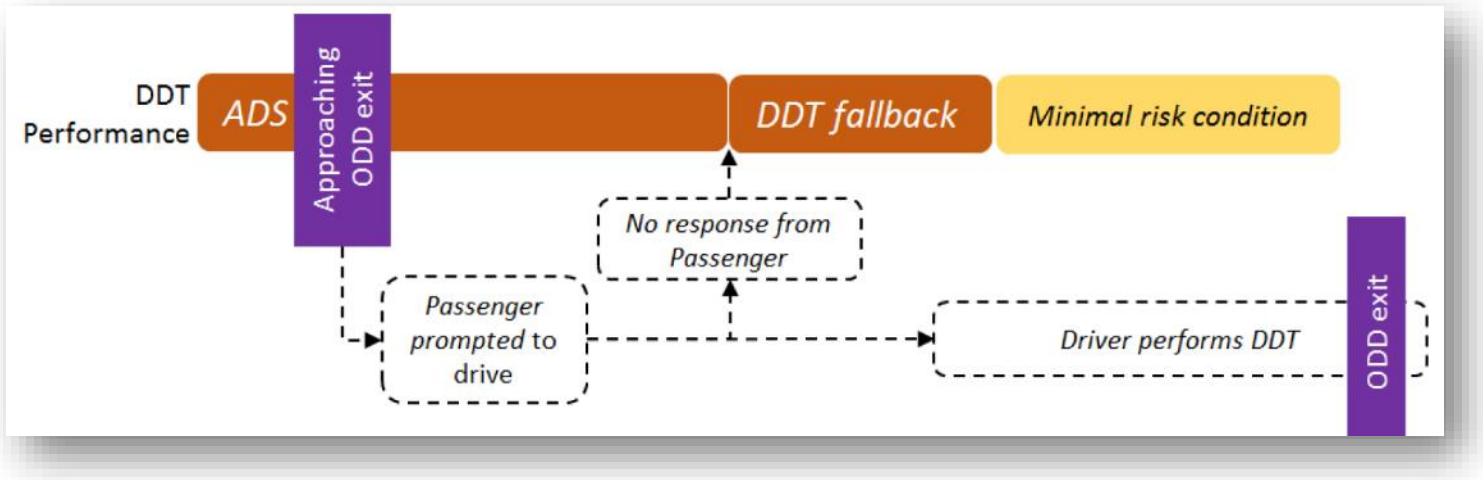
Specialised in operational traffic management

- 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?

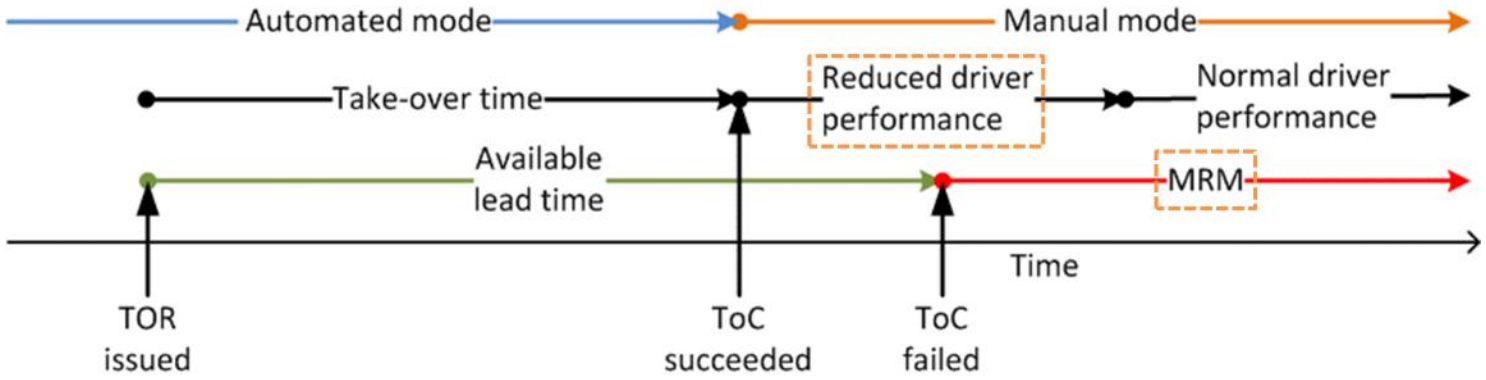
permanent - transient
static/dynamic - highly dynamic

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.

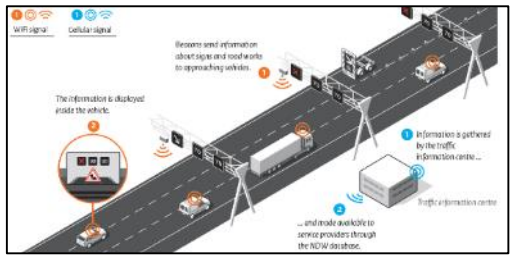
- TransAID aims to:
  - ✓ Identify potential risks
  - ✓ Recommend solutions
  - ✓ Coordinate movements



SAE INTERNATIONAL

SAE J3016™ LEVELS OF DRIVING AUTOMATION

Operational Design Domain



MAP

SAE INTERNATIONAL

SAE J3016™ LEVELS OF DRIVING AUTOMATION

Vehice automation capabilities

(not) Geofenced areas/roads

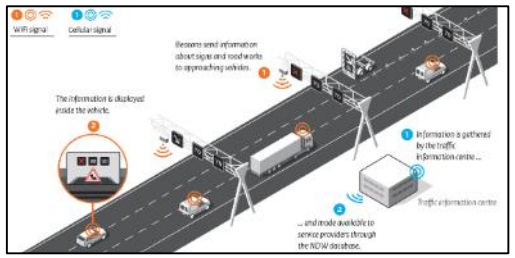
Scene (access, intersections, behaviour)

Vehicle / System operational performance

Situational / environmental conditions

Physical infrastructure measures

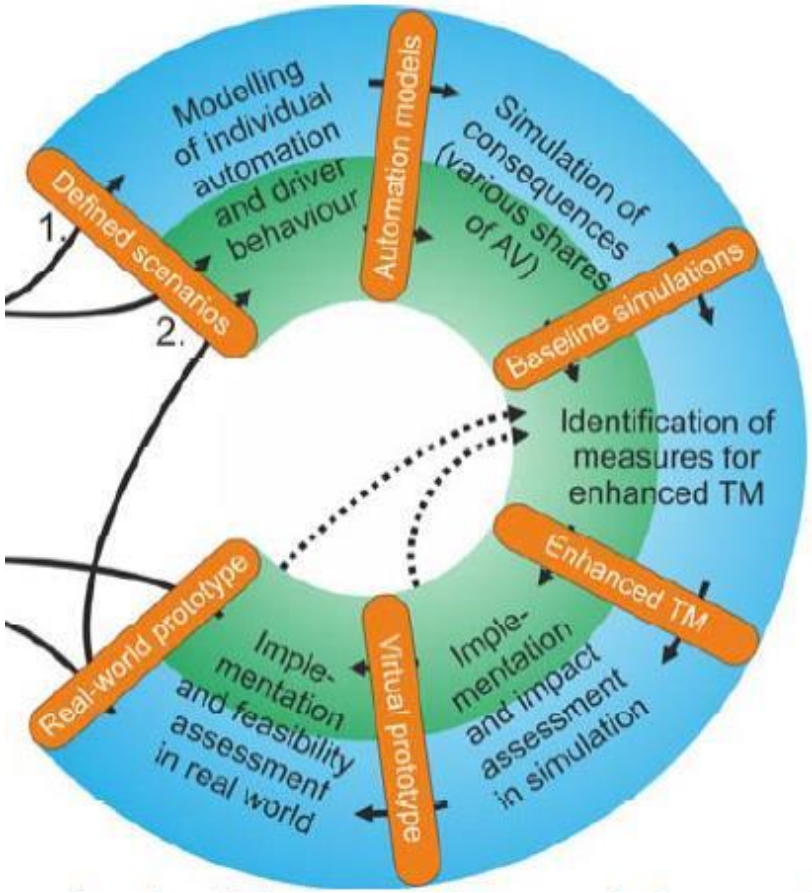
Digital infrastructure measures



MAP

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 ODD: OK

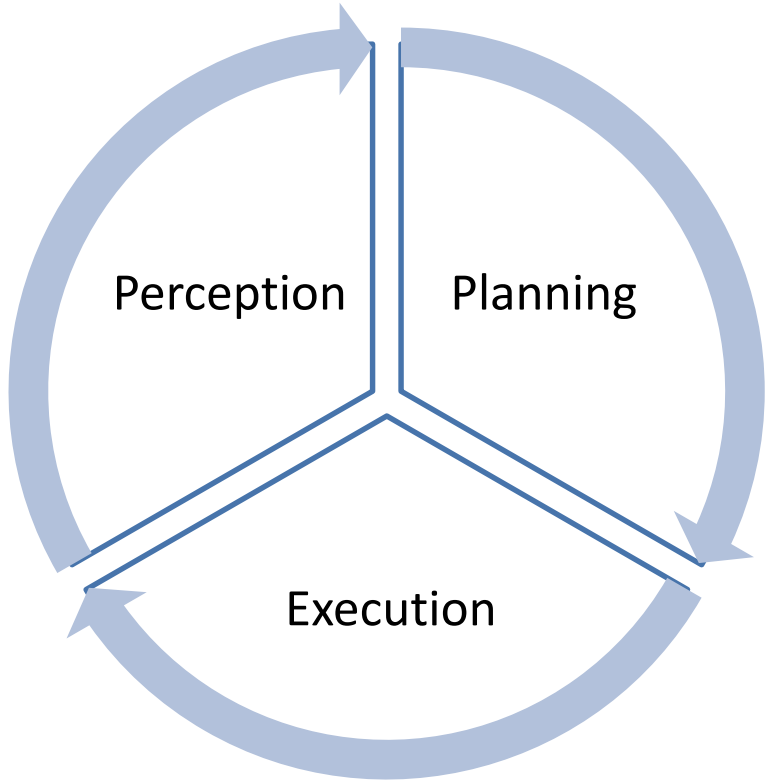
B + C ≠ A ODD: NOK

B + C = A + ? ODD: OK?

? = digital support measures

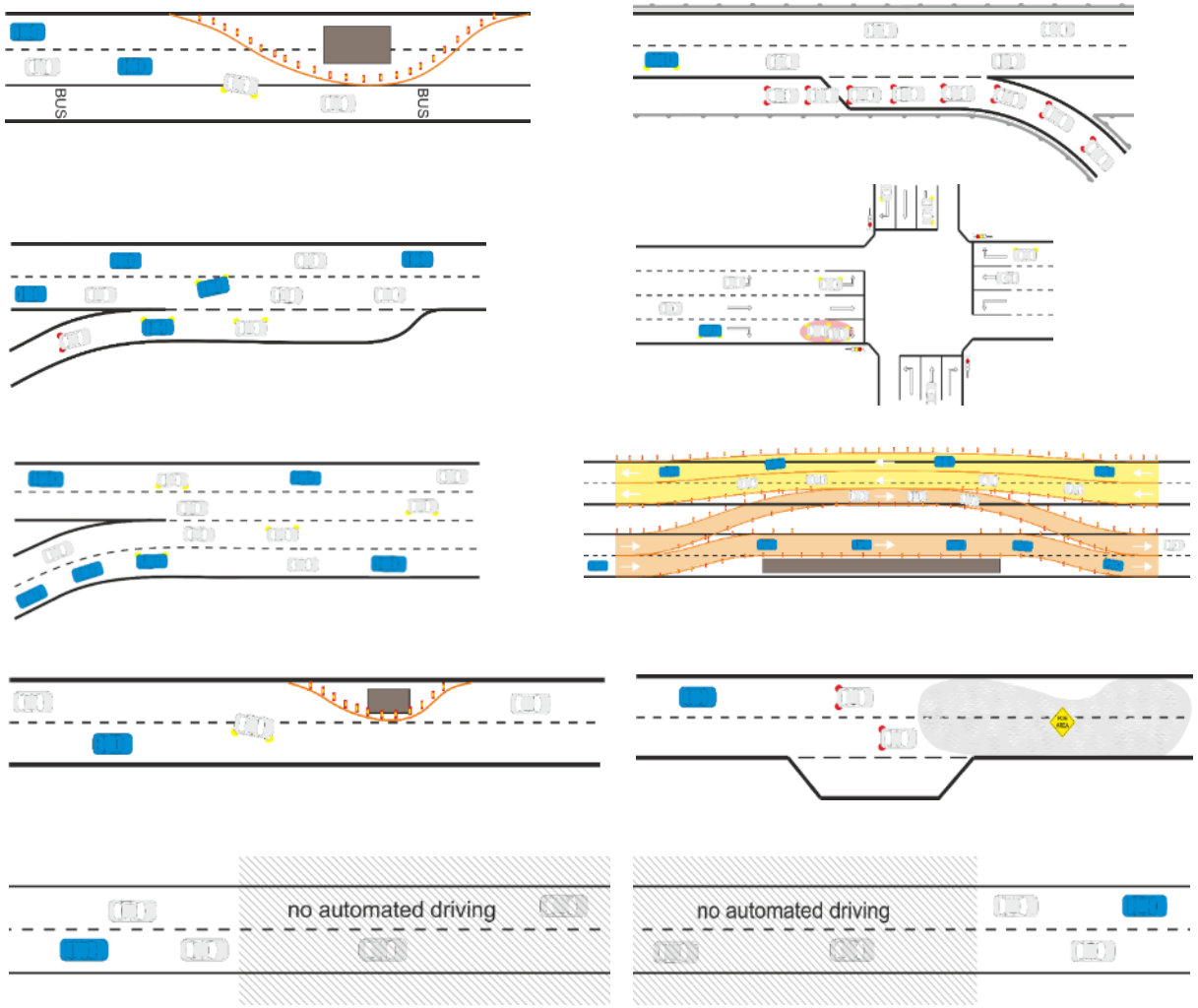
Identifying I2V / TM support measures

- 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



TransAID I2V / TM services and use cases

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?

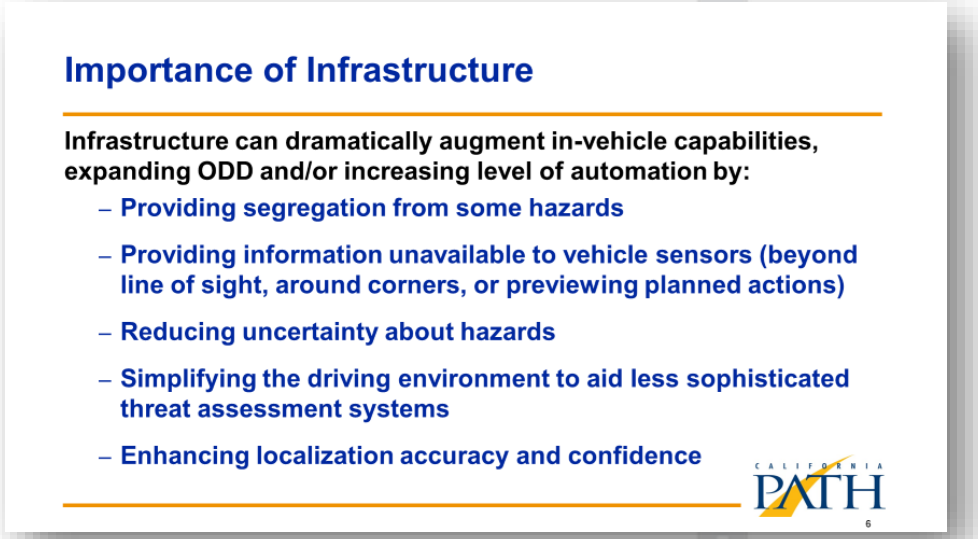
And many more related to expected, assumed and revealed vehicle behaviour and capabilities.

Stakeholder consultation workshops

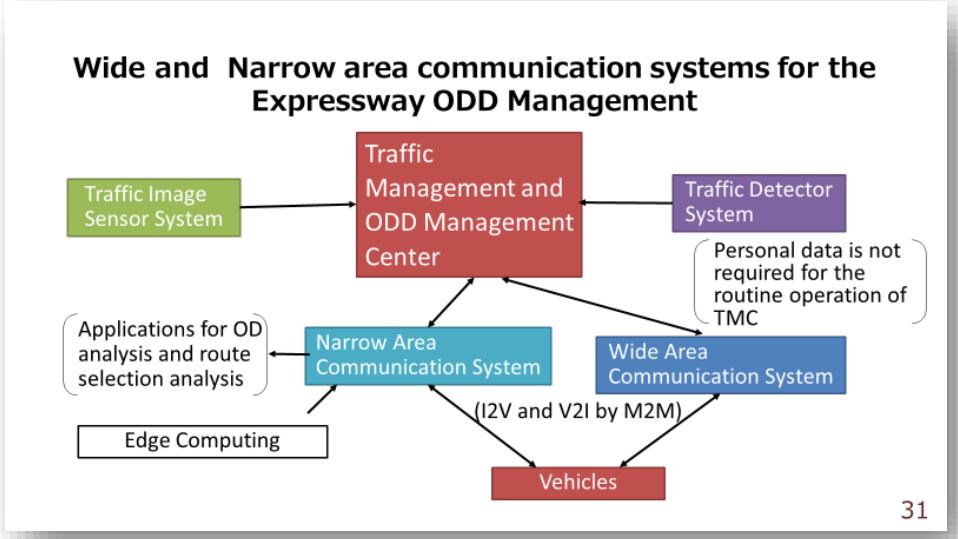
- TransAID-MAVEN-CoExist Stakeholder workshop, 10 October 2017, Brussels
- TransAID-MAVEN-CoExist-INFRAMIX Expert meeting, 23 October 2018, Greenwich
- TransAID session and survey, 8 June 2019, IEEE-IV, Paris
- TransAID-U.S. CAMP expert meeting, 25 July 2019, Detroit
- EU EIP workshop on ODD, 1 October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

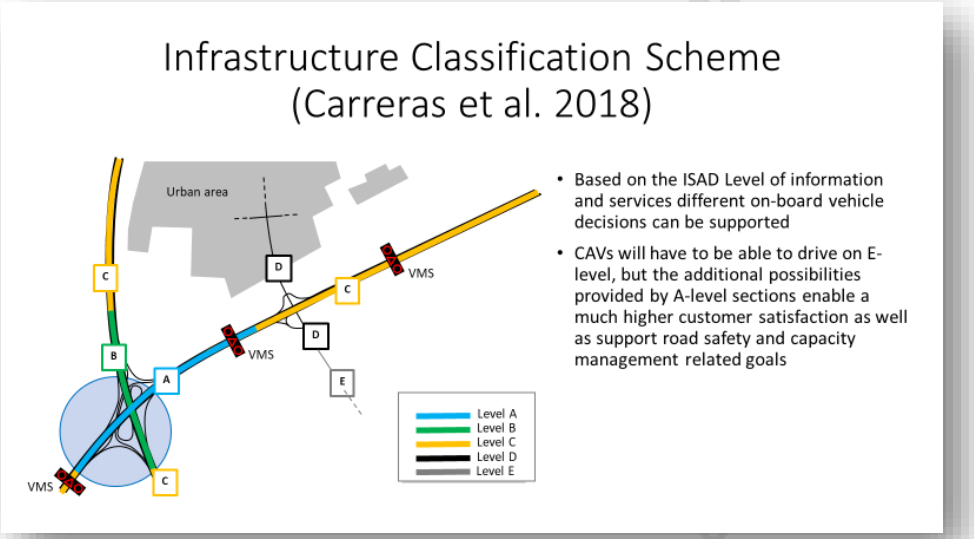
WORKSHOP: CONSTRUCTS OF THE ODD [SINGAPORE, 22 OCT 2019]



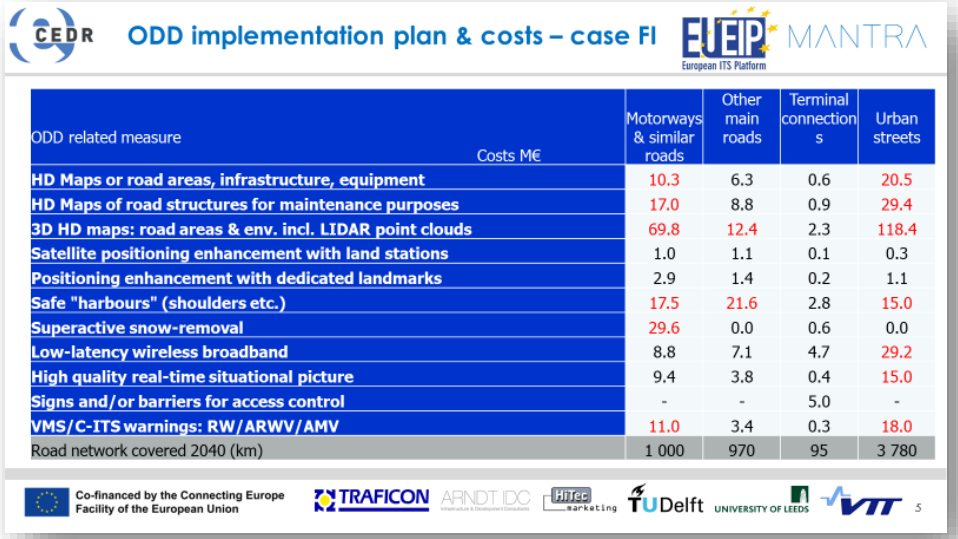
Shladover: 'Infinite variety of possibilities', 'N-dimensional tensor'.



Kawashima: ODD mngt, communication systems, orchestration.



Erhart: Infrastructure can support to close ODD gaps.



ODD related measure Costs M€	Motorways & similar roads	Other main roads	Terminal connections	Urban streets
HD Maps or road areas, infrastructure, equipment	10.3	6.3	0.6	20.5
HD Maps of road structures for maintenance purposes	17.0	8.8	0.9	29.4
3D HD maps: road areas & env. incl. LIDAR point clouds	69.8	12.4	2.3	118.4
Satellite positioning enhancement with land stations	1.0	1.1	0.1	0.3
Positioning enhancement with dedicated landmarks	2.9	1.4	0.2	1.1
Safe "harbours" (shoulders etc.)	17.5	21.6	2.8	15.0
Superactive snow-removal	29.6	0.0	0.6	0.0
Low-latency wireless broadband	8.8	7.1	4.7	29.2
High quality real-time situational picture	9.4	3.8	0.4	15.0
Signs and/or barriers for access control	-	-	5.0	-
VMS/C-ITS warnings: RW/ARWV/AMV	11.0	3.4	0.3	18.0
Road network covered 2040 (km)	1 000	970	95	3 780

Kulmala: cost of ODD related measures and uncertainty of evolution.

WORKSHOP BREAKOUTS

- 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.

FINDINGS

- 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 o**f 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 – UTmobI.
  - ISO work item taxonomy for classifying ODD.
  - Workshop at Automated Vehicle Symposium 2020 (US).

BACK TO THE 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 .

- *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)

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 723390

Dr. Jaap Vreeswijk

MAP traffic management

jaap.vreeswijk@maptm.nl
+31 6 4164 7985

www.transaid.eu