Traffic Management for Connected and Automated Driving (TM4CAD)

Background

- CEDR Research Call 2020 “Traffic Management”
- September 2021 – March 2023
- Consortium
  - MAP traffic management (the Netherlands)
  - Traficon (Finland)
  - Transport & Mobility Leuven (Belgium)
  - WMG, University of Warwick (UK)
  - Steve Shladover (US – PATH/retired)
  - Hironao Kawashima (Japan – Keio University)

MAP TRAFFIC MANAGEMENT

TRAFICON

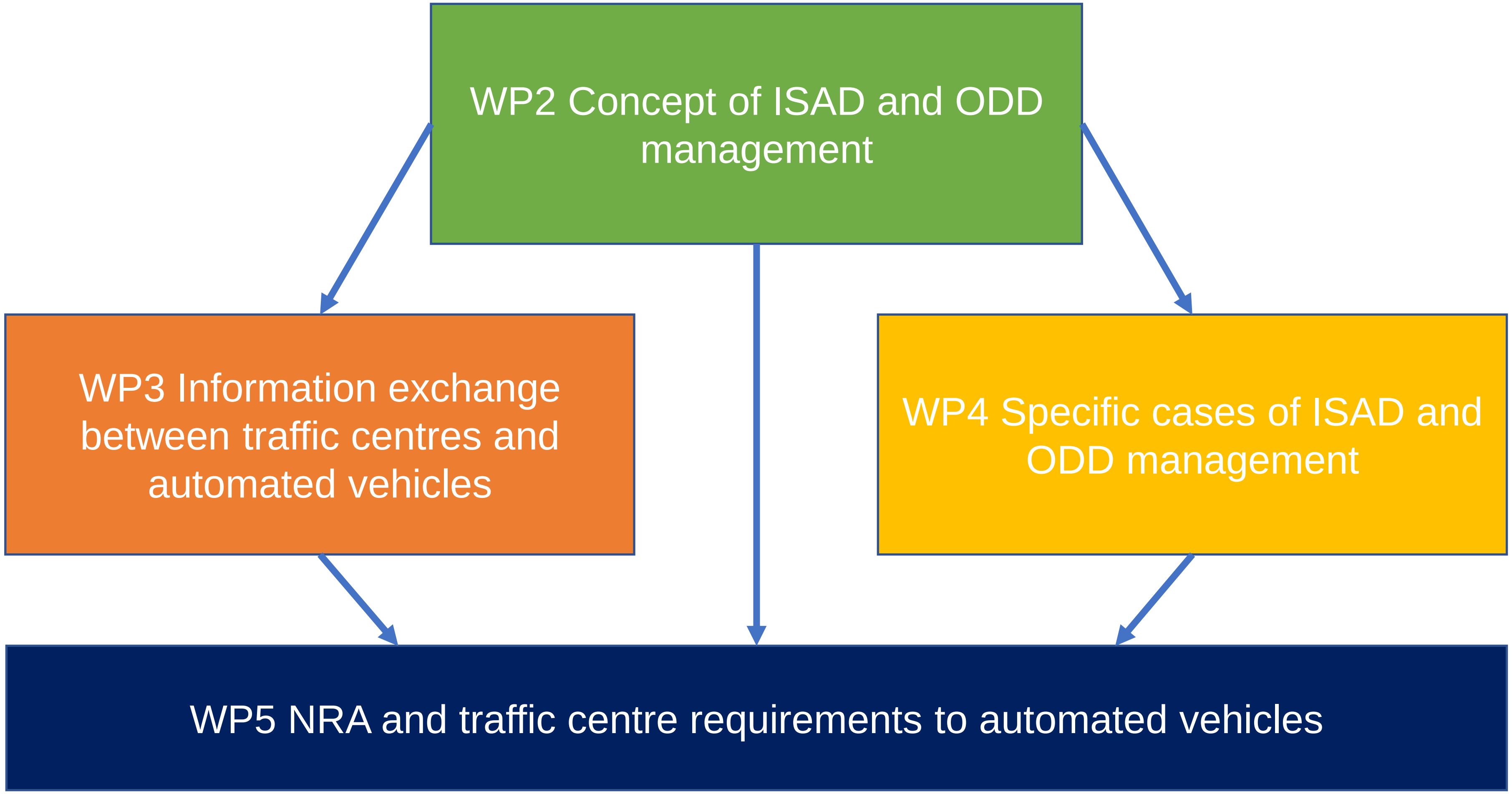
TRANSPORT & MOBILITY LEUVEN

WMG THE UNIVERSITY OF WARWICK

慶應義塾大学 Keio University

TM4CAD objectives: Answering research questions

- **RQ1**: Should NRAs set requirements on the **desired behaviour of (partly) automated vehicles** on where and how they should drive?
- **RQ2**: Do brokers between traffic management centres and vehicles/OEM back ends add value in this interaction?
- **RQ3**: **How does CCAM support** the work of traffic management centres and **how can traffic management centres support** and facilitate the deployment of CCAM?
- **RQ4**: What kind of **information is to be transmitted** in the interaction (in both directions) between a traffic management centre and vehicle?
- **RQ5**: Which information is to be provided **by the NRA/roadside** and which information can be obtained by the sensors of the moving vehicle itself?
- **RQ6**: When and how should such information be available?
- **RQ7**: How to define and measure the **quality/correctness** of such information?


WP2 Concept of ISAD and ODD management
WP3 Information exchange between traffic centres and automated vehicles
WP4 Specific cases of ISAD and ODD management
WP5 NRA and traffic centre requirements to automated vehicles

TM4CAD objectives: Results to be provided

- Identify the full range of **ODD attributes** for consideration, based on experience from working on ODD issues in standardization activities and in other related research projects;
- Integrate the very different perspectives of the CAD vehicle system developers and the road authorities and operators to **focus on the areas of intersection** between them;
- Introduce the concept of **ODD attribute awareness** and the role of infrastructure in it;
- Develop recommendations based on understanding the technical constraints on the ODD-relevant **information that can be perceived and exchanged in real time** by the NRAs and the sensing systems on the CAD-equipped vehicles;
- Provide insights on how to support CAD operation and ODD management, and **how ISAD should be refined** for traffic management use, and
- Detail how traffic management systems and CAD vehicles can **best interact** to improve traffic operations.

Distributed ODD attribute Value Awareness (DOVA) for Connected and Automated Driving

D2.1 Report on distributed ODD awareness, infrastructure support and governance structure to ensure ODD compatibility of automated driving systems

Tom Alkim (MAP), Siddartha Khastgir (WMG)

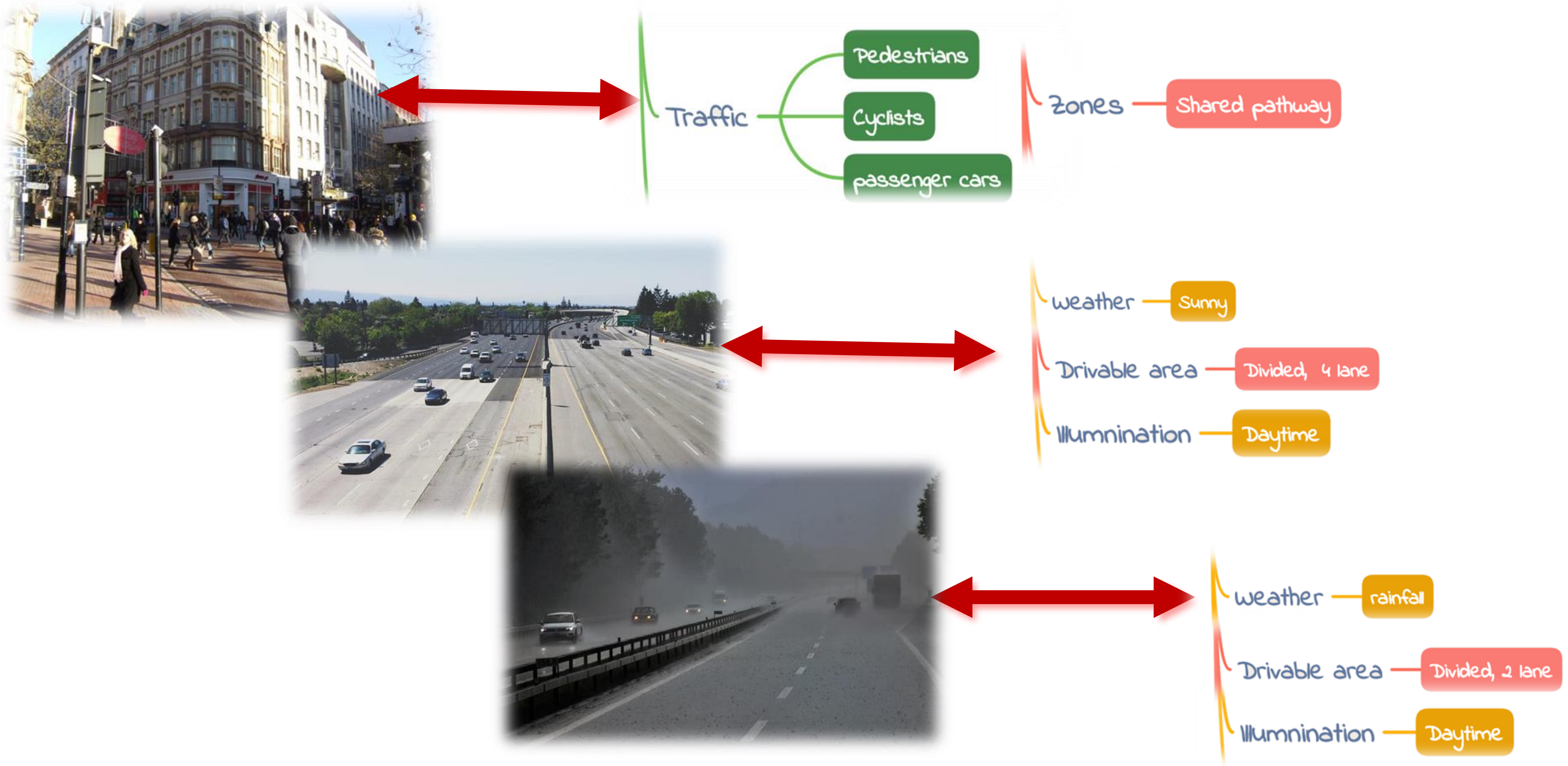
Importance of ODD

- At least as important as level of automation
- **Defined by each CAD system developer** based on their design constraints, not by any other entity
- **Different for every CAD system**, based on limitations of its technology
- To ensure safe operations, each CAD system **must remain within its ODD constraints**:
  - If ODD constraints are violated, cease automated driving
  - (Level 3) – request driver to intervene
  - (Level 4) - automatically transition to minimal risk condition (safe stop)

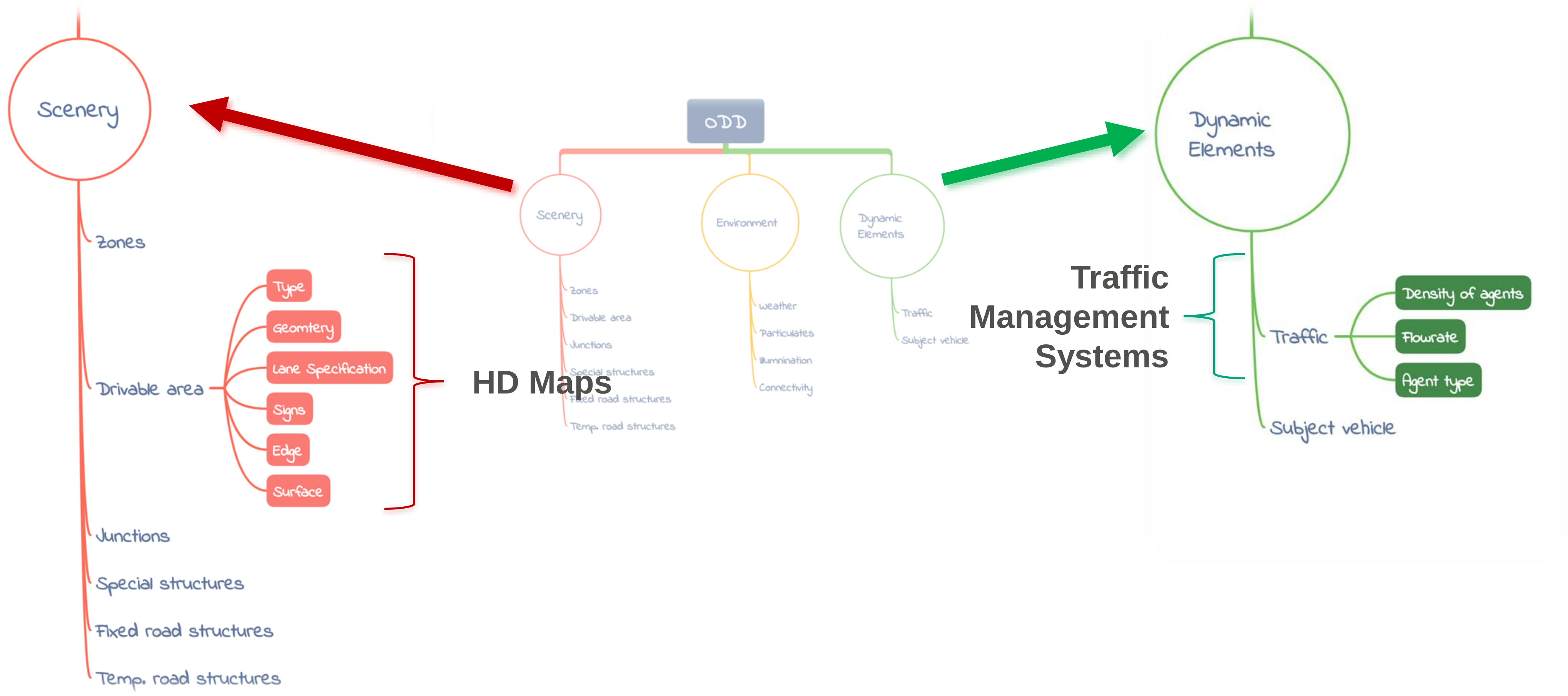
Need for real-time ODD awareness

- CAD system **continuously monitors ODD attributes** where it is operating to determine whether it can continue to operate
  - Safety cases and regulations should prohibit operations when ODD constraints are violated
- Anticipate **impending ODD constraint violations** to allow time for graceful transition to driver control (Level 3) or to minimal risk condition (Level 4)
- **Infrastructure cooperation** needed for information about attributes that CAD vehicle sensors cannot detect directly, such as:
  - Traffic incidents obstructing lanes beyond line of sight
  - Fog obstructing visibility beyond line of sight
  - Planned road works
  - Freezing pavement causing black ice

ODD Attribute Value Awareness



Distributed ODD attribute Value Awareness (DOVA)

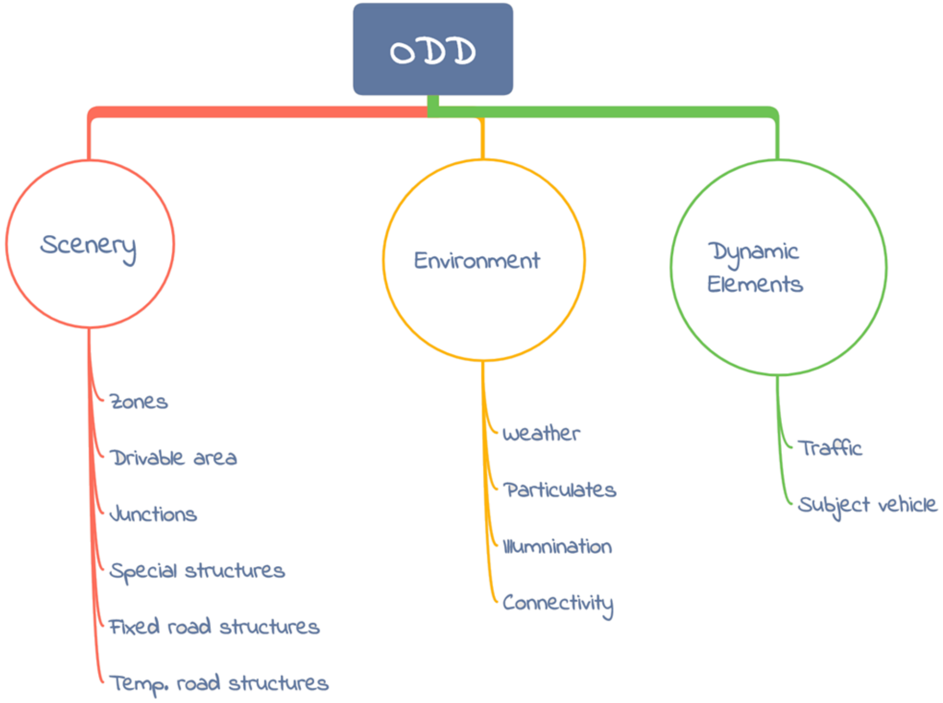


Distributed ODD attribute Value Awareness (DOVA)- Roadworks

- Roadworks (planned or unplanned)
- Road closures
- How do we address the **temporal aspects** of their existence?
- Can the CAD system measure it **via on-board sensing only?**

Distributed ODD attribute Value Awareness (DOVA)

- **Any ODD attribute value** can be measured via off-board sensing
- Every ODD attribute value **doesn't need to be** measured via off-board sensing
- Off-board measurements will require **infrastructure investment**
- **Connectivity** implicitly becomes a requirement



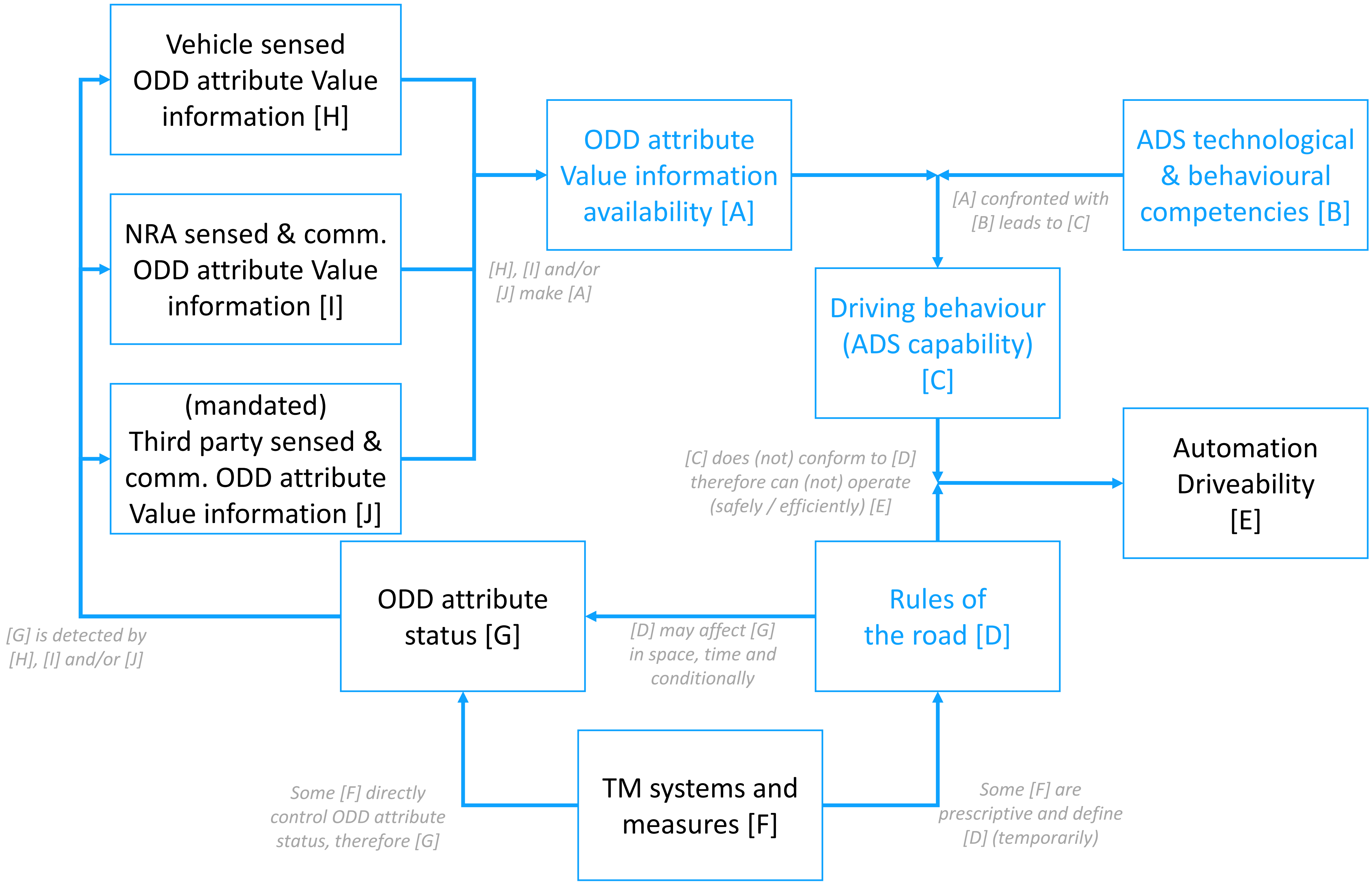
Understanding information criticality

Criticality of information refresh rate will impact infrastructure investment & connectivity requirements:

- **Category 1**: Changes very seldom (e.g. road layout, intersections etc.)
- **Category 2**: Changes every (few) days (e.g. vegetation growth)
- **Category 3**: Changes every (few) hours (e.g. wet road surface)
- **Category 4**: Changes every (few) minutes (e.g. variable message signs)
- **Category 5**: Changes every (few) seconds

Distributed ODD attribute Value Awareness: Freedom of Choice

- DOVA Framework can be implemented in multiple ways
- NRAs need to decide based on stakeholder needs and required investment
- Trade-off between the best setup and the most beneficial setup
- Potentially, use case driven



Vehicle sensed ODD attribute Value information [H]
NRA sensed & comm. ODD attribute Value information [I]
(mandated) Third party sensed & comm. ODD attribute Value information [J]
[H], [I] and/or [J] make [A]
ODD attribute Value information availability [A]
[A] confronted with [B] leads to [C]
ADS technological & behavioural competencies [B]
Driving behaviour (ADS capability) [C]
[C] does (not) conform to [D] therefore can (not) operate (safely / efficiently) [E]
Automation Driveability [E]
ODD attribute status [G]
[G] is detected by [H], [I] and/or [J]
[D] may affect [G] in space, time and conditionally
Rules of the road [D]
TM systems and measures [F]
Some [F] directly control ODD attribute status, therefore [G]
Some [F] are prescriptive and define [D] (temporarily)

Roles of Stakeholders

Role	Development	Deployment	Operation	Maintenance
ADS developer	Dev. of the framework concept	Provision as part of ADS	Use of DOVA in automated driving	Fix any problems
Vehicle fleet operator	-	Adaptation of the processes	Supervise the use of DOVA in vehicles	Report problems in use
Road authority	Input to development	Deployment in road infrastructure and related contracts with various service contractors	Monitor the use of DOVA at the infrastructure side	Report problems in use; fix problems related to own infrastructure
Traffic manager	Input to development	Deployment at TMC and roadside systems and related contracts with various service contractors	Use of DOVA in traffic management	Report problems in use; fix problems related to own services, systems, and infrastructure

DOVA: Things to consider

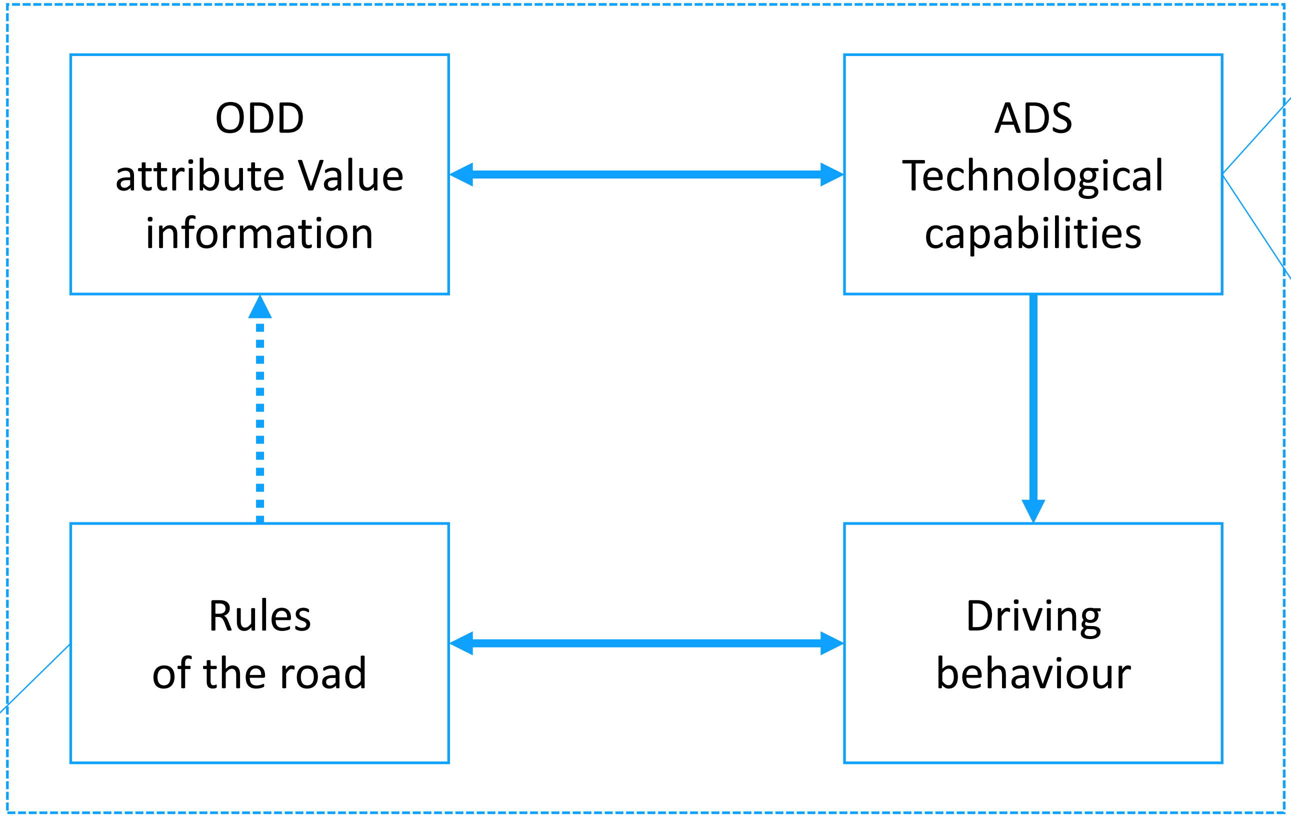
Key priorities based on workshop involving National Road Authorities :

- **Understandability**
  - Terminology and need for standardisation
- **Feasibility**
  - Understanding financial implications of the implementation
- **Completeness**
  - Systems approach and understanding the effect of MRMs

DOVA: CAD Safety Assurance

Sources of information:
- *Maps*
- *Vehicle sensors*
- *Roadside equipment*
- *Traffic centres*
- *Digital twin*
- *…*

Redundant | Exclusive



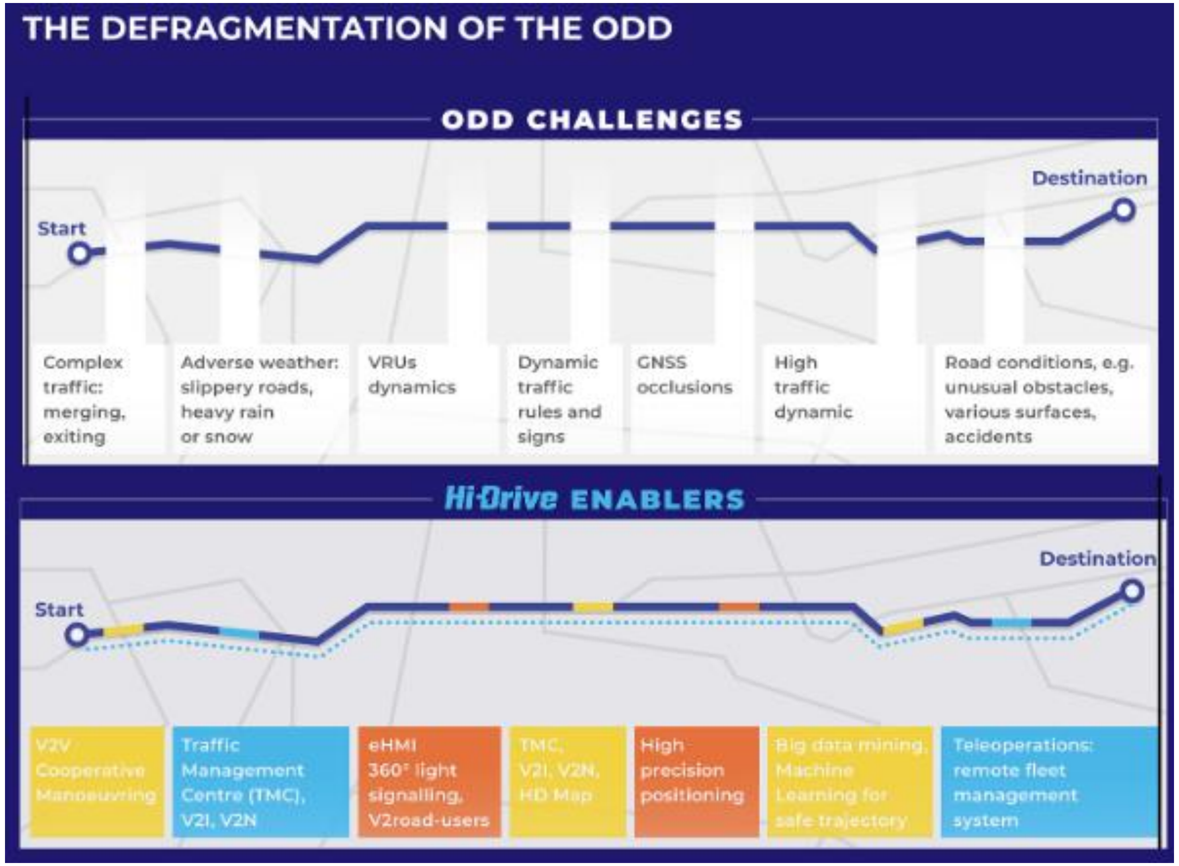
"Wide diversity"

"Behaviour competencies"

"Codified"

ADS can or cannot operate

Cooperation with Hi-Drive



Technology Enablers for vehicle automation to defragment and extend ODDs

CAD Connectivity based on direct and cellular communication

"The sixth sense beyond sensors"

- V2V VEHICLE TO VEHICLE COMMUNICATION Cooperative sensing and awareness, maneuvering, merging, coordination, overtaking.
- V2I VEHICLE TO INFRASTRUCTURE AND INFRASTRUCTURE TO VEHICLE COMMUNICATION Cooperative sensing and awareness, hazard warnings, dynamic signage at junctions, Green Light Optimal Speed Adaptation.
- VEHICLE TO CLOUD (EDGE AND CORE NETWORK) Dynamic information on ODDs, Predictive QoService.
- VEHICLE INTENTION COMMUNICATION V2Other Road Agents via lighting technology (e.g. vehicle's external display to communicate to a pedestrian «now you can cross the road»).

Hi-Drive Hi-Drive Technology Enablers / ITS European Congress 2023 – Lisbon, 24 May 2023 7

Workshop 10 June 2022, Aachen

Traffic Management for Connected and Automated Driving (TM4CAD)

D3.1 Information exchange between traffic management centres and automated vehicles – information needs, quality and governance

Risto Kulmala & Ilkka Kotilainen, Traficon

Objectives and scope

- Research questions set by CEDR:
  - *RQ4: **What kind of information is to be transmitted in the interaction** (in both directions) between a traffic management centre and vehicle?*
  - *RQ5: **Which information is to be provided by the NRA/roadside** and which information can be obtained by the sensors of the moving vehicle itself?*
  - *RQ7: **How to define and measure the quality/correctness** of such information?*
- Resources are limited, the stakeholders can not deploy everything immediately – a step-by-step approach is needed: start with the high priority easy-to-do local condition attributes first

Use cases: ADS/scenarios/actors

- ADS <u>on motorways/highways:</u>
  - ALKS (L3)
  - highway autopilot (L4)
  - automated trucks on open roads (L4)
- In three scenarios:
  - traffic jam and its dissolving
  - adverse weather
  - static/dynamic roadworks zone
- With regard to three actors:
  - roadworks or (winter) maintenance operator
  - traffic manager
  - automated driving system developer/OEM

Information Priority Evaluation Method

- Utilise the attributes of the DOVA framework from WP2
- Combined for all three use cases as the requirements were very similar
- Separately for
  - Each actor
  - Each scenario
- Overall priority level extracted by qualitative comparison (low-medium-high) between the three actors and scenarios
  - Information need, and
  - Safety criticality
- In addition, we estimated the additional cost to the actor
  - Very crude estimate
    - \- possibility cost savings; 0 no costs; + low costs; ++ medium costs; +++ high costs
  - Often the additional cost affected only one or two of the actors

Information needs

- We started with information needs for each stakeholder
  - MO = Maintenance operator
  - TM = Traffic manager
  - ADS = ADS developer/ fleet operator
- Seldom differences between scenarios for the same stakeholder
- Often differences between stakeholders

Scenario	Traffic Jam			Adverse weather area			Static/dynamic Road Work Zone		
	Actor and information need			Actor and information need			Actor and information need		
Local condition / ODD attribute	MO	TM	AV (ADS)	WMO	TM	AV (ADS)	RW or MO	TM	AV (ADS)
Variable message sign contents	***	***	***	-	***	***	-	***	***
Locations where V2I/I2V communications are available	*	***	***	*	***	***	-	***	***
Locations where GNSS differential correction signals are available	-	*	***	***	*	***	*	*	***
Locations where GNSS coverage is NOT available now, by GNSS service	-	*	***	**	*	***	-	*	***

Validation of TM4CAD expert assessments

- Investigating four ODD attribute clusters information priorities for the CAD developers:
  - Physical attributes of the roadway and its environs
  - Operational attributes of the roadway
  - Digital infrastructure support
  - Dynamically varying ambient environmental conditions
- Survey targeting OEM ADS developers
- OEM workshop
- CAD WG / PEB

Example: The most important and urgent?

Local condition / ODD attributes: Physical infrastructure	TM4CAD analysis of overall priority level	ADS dev Survey (n=8)
Locations of road boundaries	HIGH	7H 1L
Zone boundaries	HIGH	6H 2L
Roadside landmarks	HIGH	7H 1L
Special-purpose localization references	LOW	8L
Quality of pavement marking visibility	HIGH	6H 1M 1L
Load-bearing capacity of roadway or bridge structures	MEDIUM	6M 2L
Road surface damage	MEDIUM	2H 5M 1L
Game fence locations and condition	LOW	8L
Vegetation obscuring sight angles or visibility of signs	LOW	1M 7L
Road geometry constraints	HIGH	7H 1L
Road shoulder conditions on both sides	HIGH	5H 2M 1L
Notifications of locations with occluded visibility	HIGH	7H 1L

ODD attributes

- ODD attributes
  - Physical infrastructure
  - Digital infrastructure
  - Ambient environmental conditions
  - Operational infrastructure
- Identification of most important ODD attributes *(tables to the right)*
  - ADS developer / fleet operator
  - Traffic manager
  - Road works / winter maintenance operator
- No conflicts with the Hi-Drive results made available 02/2023

Physical attributes of the roadway and its environs
Geofence/geographic area
Locations of road boundaries
Zone boundaries
Roadside landmarks
Quality of pavement marking
Road geometry constraints
Road shoulder conditions on t
Notifications of locations with

Digital infrastructure support
Variable message sign contents
Locations where V2I/I2V communications are available
Locations of incidents representing traffic impediments or safety hazards
Current average traffic speed and density by lane and road section
Special events creating abnormal traffic conditions and their locations
Temporarily blocked or closed road locations
debris

Dynamically varying ambient environmental conditions
Visibility range with rain/snow/sleet/hail in visible light spectrum
Visibility range with rain/snow/sleet/hail in lidar infrared spectrum
Rainfall rate in mm/hr
Snowfall rate in qualitative ranges
Visibility range in visible light spectrum
Visibility range in lidar infrared spectrum
Predicted significant changes in key weather attributes
Electromagnetic interference
Wet pavement surface
Ice on pavement surface
Cold pavement surface (potential f
Road surface friction
Light to moderate snow/slush accu
Heavy snow/slush accumulation or
Light to moderate flooding (puddle
Heavy flooding – potentially impas

Operational attributes of the roadway
Temporary static signs
Maintenance vehicles using portions of carriageway
Work zones
Incident recovery events (crash scenes, etc.)
Availability of specific C-ITS information services
Availability of real-time merging guidance or assistance
Real-time lane-specific speed limit info availability
Obstacles or debris on road surface
Traffic rules and regulations in digital form (real-time)

Information quality

- Build on EIP, EIP+ and EU EIP quality recommendation for traffic related information
- Complement with results of Finnish study
- Compile list of quality criteria
- Study quality wishes of ADS
- Propose quality recommendation with EU EIP C-ITS as starting point
- Propose quality measurement methods

Quality criteria for DOVA and its attributes
Geographical coverage
Availability
Performance conditions
Coverage of data types
Timeliness (start)
Refreshment rate
Data transfer delay
Timeliness (update)
Latency (content side)
Location accuracy
Monitoring point density
Measurement accuracy
Reporting accuracy
Error Rate
Classification correctness (non-false positives)
Event coverage (true positives)
Missed events (false negatives)
Report coverage

Quality recommendations

- Most challenging recommendations for road operators today
  - Location accuracy
  - Geographical coverage
  - Report coverage
  - Timeliness
- For all of the above the connected automated vehicles with their advanced sensors are the solution

Excerpt for time-related indicators

Quality Criteria for Distributed ODD attribute Value Awareness Framework	Traffic jam (or its dissolving)	Adverse weather	Road works
Availability	99%	99%	99%
Timeliness (start)	< 2 min	<5 min	< 2 min
Refreshment rate	< 2 min	< 20 min	< 20 min
Data transfer delay	< 100 ms	< 100 ms	< 100 ms
Timeliness (update)	< 2 min	< 5 min	<2 min
Latency (content side)	<1 s (C-ITS) <10 s (NAP) <1 min (NAP event info)	<1 s (C-ITS) <10 s (NAP) <1 min (NAP event info)	<1 s (C-ITS) <10 s (NAP) <1 min (NAP event info)

Key finding from the ADS developer side / OEMS – **trust** is essential

- For liability reasons, ADS will only utilize external data (not provided by in-vehicle sensors) that they trust
  - Data security
  - Reliability – availability, consistency
  - Veracity

Quality monitoring and management methods

nr	Method
1	Continuous monitoring of equipment performance and availability
2	Manual verification of events or conditions
3	Reference testing of data collected
4	Time-space oriented reference test methods
5	Monitoring of data completeness and latency
6	Regular sampling of message or data content completeness and correctness
7	Verification and calibration of traffic / weather conditions prognosis
8	Surveys of perceived quality by users
9	Collection of direct user feedback
10	Monitoring of service use statistics

Data exchange

- For the “in-discussion” phase, we note:
  - Data content: ISO 34503 taxonomy for ODD definition
  - Data format: ISO 34503 a natural language format for ODD definition.
- For the “deployment” phase, we recommend:
  - Data content: same as for the “in-discussion” phase.
  - Data format: DATEX II (EN TS 16157 series) – adaptation of the data model to align to ODD taxonomy standards.
- Harmonisation targets:
  - Methodology for DOVA implementation – consistency to CAD system developers
  - ODD attribute data content
  - ODD data format

Governance

- Who is in control of the DOVA framework? Will there be a single, central point of collection, or will it be set up in a distributed fashion?
- A possible implementation of a central role would be a neutral third party, trusted by all stakeholders and mandated to act as an information and data collection and clearing house
- Public-private partnership, in which the government also commits itself to providing information and data according to pre-agreed upon specifications.
- Data for Road Safety SRTI ecosystem as an example to follow
- TM4CAD illustrations via the road works use case
- Compliance to the General Data Protection Regulation GDPR

Conclusions

- Focus on three scenarios and three stakeholder types
- The stakeholder are the key user of DOVA information in the scenarios
- Further scenarios might affect results
  - Most important ODD attributes especially
  - Some quality requirements possibly

- TM4CAD Deliverable D3.1 *Information exchange between traffic management centres and automated vehicles – information needs, quality and governance*
- Available at https://tm4cad.project.cedr.eu/

Traffic Management for Connected and Automated Driving (TM4CAD)

D4.1 Implementation aspects of Distrubuted ODD attribute Value Awareness

Sven Maerivoet, Transport & Mobility Leuven

Hironao Kawashima, Keio University

1. Introduction

TM4CAD explored the role of infrastructure systems in creating **ODD** (Operational Design Domain) **awareness** for ADS (Automated Driving Systems), so that each ADS can be forewarned by receiving in-advance information before it encounters condition in which ADS will not be capable of operating.

2. ODD awareness and DOVA (1/2)

- ✓Each ADS will be designed to perform the dynamic driving task under certain specified conditions which are represented as ODD. In addition, the ODD is defined in line with the boundaries defined by related regulations.

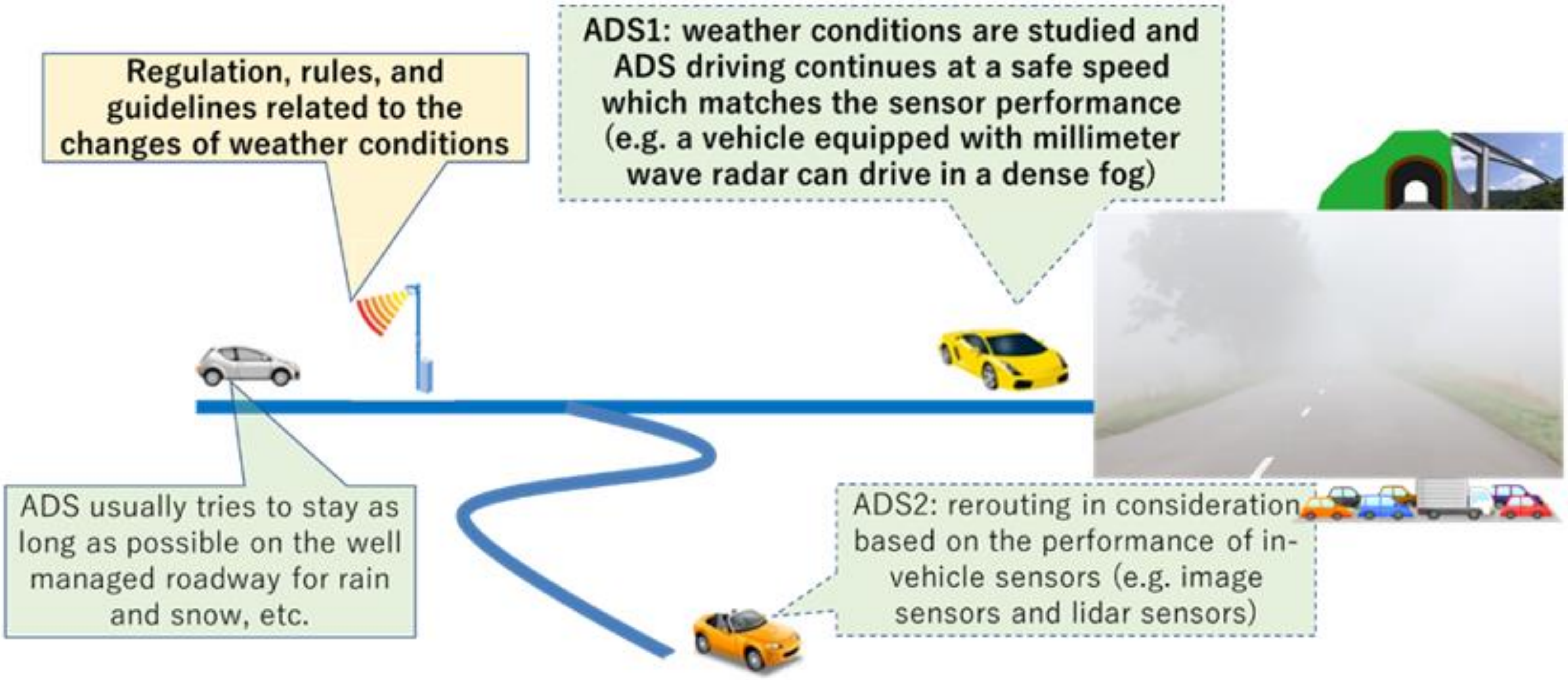
- ✓The DOVA (**Distributed ODD attribute Value Awareness**) framework introduced in TM4CAD, enables the ADS to benefit from off-board sensing infrastructure to become aware of ODD attributes values which an ADS may not be able to measure or sense by itself. In other words, an ADS might be outside of its ODD.

2. ODD awareness and DOVA (2/2)

- ✓DOVA defines a list of **ODD attributes** which can be provided from infrastructure and the **information acquisition principles** and data quality requirements are discussed for each ODD attributes. The original ODD attributes are from the BSI PAS 1883: 2020 Operational design domain (ODD) taxonomy for an automated driving system (ADS).

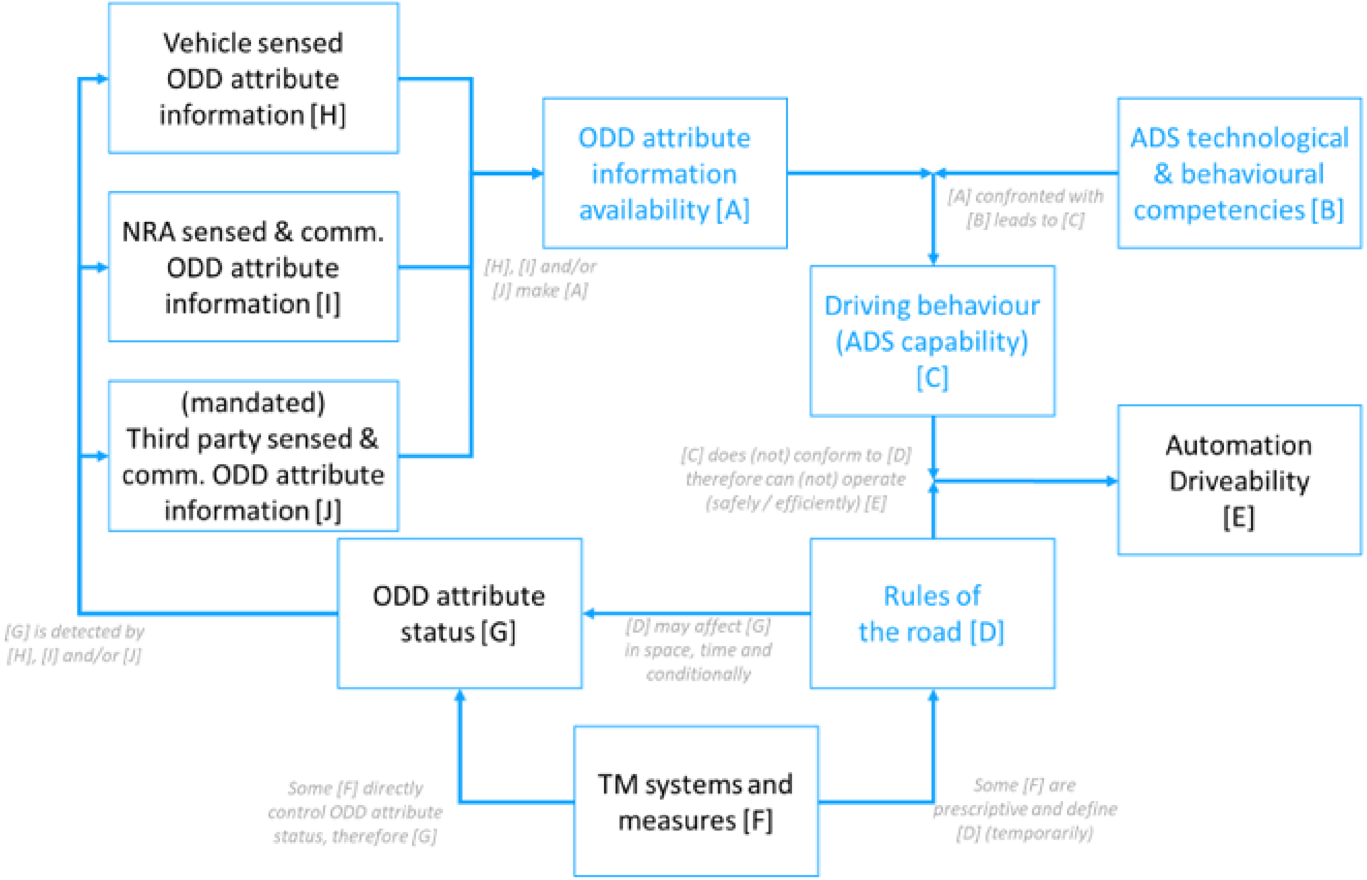
- ✓Examples of ODD attributes of DOVA are **categories** of roadway, traffic conditions (density, speed, and coexistence with other classes of road users), geographical boundaries, lighting and weather conditions, and availability of supporting physical and digital infrastructure elements.

2. Providing the ADS with in-advance information



3. DOVA Framework and the implications for NRA

Provision of ODD attributes information (provided via infrastructure) can affect ADS capability and enable safe deployment of ADS.



4. Tangible scenarios for a tunnel use case (1/3)

- ✓An ADS **approaches** a tunnel or is **driving** in a tunnel.
- ✓The ADS **detect the local conditions** at the tunnel entry or exit. When an ADS observes that the local conditions do not match the ODD of the system, then the ADS will transfer the Dynamic Driving Task to the driver in case of a Level 3 ADS. In the case of Level 4 system, the ADS will make a Minimal Risk Maneuver.
- ✓The desired behavior of the ADS is to **handle** the tunnel situation as normal, or it can **transfer the control** of the vehicle to the driver in a safe and timely manner.
- ✓The five Tunnel Passage Scenarios and corresponding different operations of ADS are shown in (2/3).

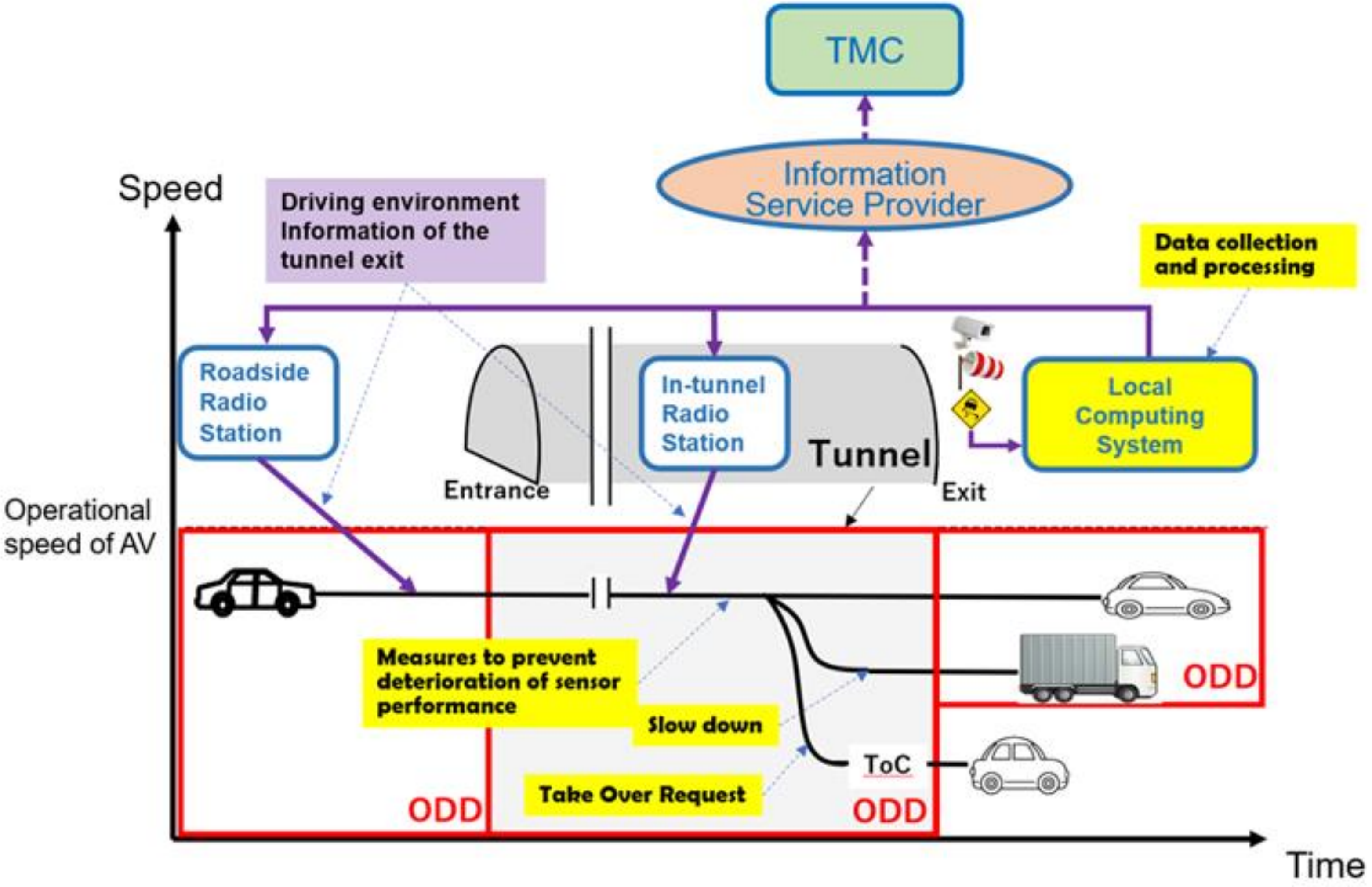
4. Tangible situations for a tunnel use case (2/3)

List of Tunnel Passage Scenarios

Scenario Type	In-advance local condition information based on DOVA and operation of ADS		
	Contents of information	Responses of ADS and the driver	Outcomes of publishing in-advance local condition information
Scenario 1 Case of closed tunnel	Temporary tunnel closures	If the ADS is not designed for this condition, ➡ Driver takes over DDT	The driver has enough time to respond and safely resume the DDT
Scenario 2 Adapting to the closed tunnel condition	Closure of tunnel and guide for active diversion via other lanes and/or tunnel tube	If the ADS assesses that it can operate in the local condition ahead, ➡ Continues DDT If not, ➡ the driver takes over DDT	Same as Scenario 1
Scenario 3 Approaching to tunnel exit	Local condition attributes at tunnel exits (e.g., weather, incidents or lighting) provided by roadside equipment	If the ADS is not designed to operate in these conditions, ➡ Driver takes over DDT If the driver fails to respond, ➡ MRM	Same as Scenario 1 ADS can use ODD attribute value with practically feasible from cost and engineering perspectives
Scenario 4 Adapting to tunnel exit condition	Same as the Scenario 3	If the ADS assesses that it can operate in the local condition ahead, ➡ Reduce driving velocity, activate in-advance to mitigate ADS capability If not, same as the Scenario 3	Same as Scenario 3
Scenario 5 Guiding through the tunnel exit condition	Same as the Scenario3 Information about activating road management (e.g., lane closure) and/or traffic calming measures (e.g., reduce speed)	If the ADS assesses that it can operate the local condition ahead, ➡ ADS continues with adapted driving behavior If not, same as Scenario3	Same as Scenario 3 Safe operation of ADS and realization of efficient traffic flow

DDT: Dynamic Driving Task   MRM: Minimal Risk Maneuver

4. Tangible scenarios for a tunnel use case (3/3)



Implications for NRA based on the analysis of the operation of the DOVA framework

- Traffic management systems will not actively manage tactical or operational decision making of an ADS (activating and de-activating automation).
- The driving rules and expected driving behaviour must be defined in regulations such as the Vehicle General Safety Regulation and UN regulations.
- Information beyond the electronic horizon of vehicle sensors is relevant for timely anticipation of the downstream conditions.

➔ This is the area where NRAs can support ADSs by providing information in advance.

Traffic Management for Connected and Automated Driving (TM4CAD)

WP5 Summary

Recommendations for the dialogue between NRAs and automated vehicles developers

Background

- **Goal: provide a complete set of realistically implementable requirements**
  - From traffic management systems and road operators
  - To CAD systems and automated vehicle manufacturers
- **Idea: on-going collection of requirements (for DOVA)**
  - First, from a technical point of view (for traffic management and CAD systems)
  - Then, highlighting the roles that both the road operators and traffic management centres and vehicle manufacturers (and Tier-1 providers, ADS developers, AV fleet managers/operators) play in this respect
- **Means**:
  - Based on the work done in WP2, WP3, and WP4, with extra inputs stemming from the MANTRA, EU EIP, and TransAID projects
  - Open stakeholder dialogues through workshops
- **Recommendation**:
  - **Publish the requirements in specific (standardisation) bodies (hire people that understand this)**
  - **Establish a codified highway code to integrate all requirements in the long term**

Acquiring requirements (workshops)

- 13/09/2021: during the kick-off meeting
- 14/02/2022: workshop with NRAs (Teams)
- 10/06/2022: workshop with OEMs (Teams)
- 23/06/2022: workshop with OEMs (Hi-Drive) (Bern, Switzerland)
- 14/11/2022: workshop with NRAs and OEMs (TRA2022, Lisbon, Portugal)

Addressing the research question

- ***"Should NRAs set requirements on the desired behaviour of (partly) automated vehicles on where and how they should drive?"***
- The answer is nuanced:
  - The desired behaviour of (partly) automated vehicles should be defined as a product of the interactions between the NRAs and the developers of the vehicle technology to produce a balance between technological feasibility and serving transportation system needs.
  - **In practice: much more interaction between NRAs and ADS developers (not just data exchanges)**
- Examples of discussion items for NRAs to be engaged in:
  - The definition of an MRM
  - What constitutes an MRC?
  - What behaviour is expected from an automated vehicle or ADS?
  - What are the consequences of any road code requirements and decisions taken by an ADS?

In conclusion

- There exists a large gap of information between both parties in the spectrum:
  - NRAs do need to understand how an ADS will react under certain conditions (**expected ADS behaviour**)
  - OEMs need to understand what is expected by the NRAs in order to finetune their ADS' behaviours
- **Recommendation: a mutual exchange of information in an open dialogue**

- A vision for these requirements will typically be created from a perspective of vehicle safety:
  - For the vehicle
  - For the passenger
  - For the environment (i.e., the other traffic participants)

- Based on a common understanding of the stakes involved, both NRAs and ADS developers can work together, and define what is realistically possible

Research questions and deliverables

Research questions	D2.1	D3.1	D4.1	D5.1
RQ1: Should NRAs set requirements on the desired behaviour of (partly) automated vehicles on where and how they should drive?	X			X
RQ2: Do brokers between traffic management centres and vehicles/OEM back ends add value in this interaction?			X	
RQ3: How does CCAM support the work of traffic management centres and how can traffic management centres support and facilitate the deployment of CCAM?	X		X	
RQ4: What kind of information is to be transmitted in the interaction (in both directions) between TMC and vehicle?	X	X		
RQ5: Which information is to be provided by the NRA/roadside and which information can be obtained by the sensors of the moving vehicle itself?	X	X		
RQ6: When and how should such information be available?		X	X	
RQ7: How to define and measure the quality/correctness of such information?		X		
RQ8: Are there any circumstances under which the traffic control centre would need to lower the ISAD level in order to stop automation taking place, or vice versa: to impose automated driving?			X	

Essential results and deliverables

Essential results	D2.1	D3.1	D4.1	D5.1
ER1: Determination of the circumstances (actual traffic conditions, status of the infrastructure, …) under which the traffic control centre would need to lower the ISAD level in order to stop automation taking place and accordingly mitigating measures if applicable;	X		X	
ER2: Determination of the circumstances under which the traffic control centre would need to upscale the ISAD level/impose more automated driving;	X		X	
ER3: Determination of the information needs and who is to provide this information in the bidirectional interaction between TMC and vehicle;		X		X
ER4: Description of the properties of this information (availability, reliability, accuracy, detail, latency, standards, …) and the required/desired reaction of the vehicles;		X		
ER5: Definition of the roles and responsibilities in the interaction between OEMs/Service Providers and NRAs on operational level.	X		X	

Optional results and deliverables

Optional results	D2.1	D3.1	D4.1	D5.1
OR1: Description of the possible added value of service providers in the interaction between NRAs and OEMs;	X		X	
OR2: Description of possible governance mechanisms for ODD management that need to be established;	X	X		
OR3: A vision on what requirements an NRA should set on the desired behaviour of (partly) automated vehicles, where and how they should drive;				X
OR4: As OEMs are publishing their requirements towards road design, establish what are the requirements from NRAs towards vehicles (e.g., on concepts like minimal risk manoeuvre / hand over request) from a safety perspective.				X

Traffic Management for Connected and Automated Driving

TM4CAD

Tom Alkim

Mail: tom.alkim@maptm.nl

Phone: +31 6 2889 4375

Project website:

https://tm4cad.project.cedr.eu/

MAP TRAFFIC MANAGEMENT

TRAFICON

TRANSPORT & MOBILITY LEUVEN

WMG THE UNIVERSITY OF WARWICK

慶應義塾大学 Keio University