Road operator perspective on Operational Design Domains

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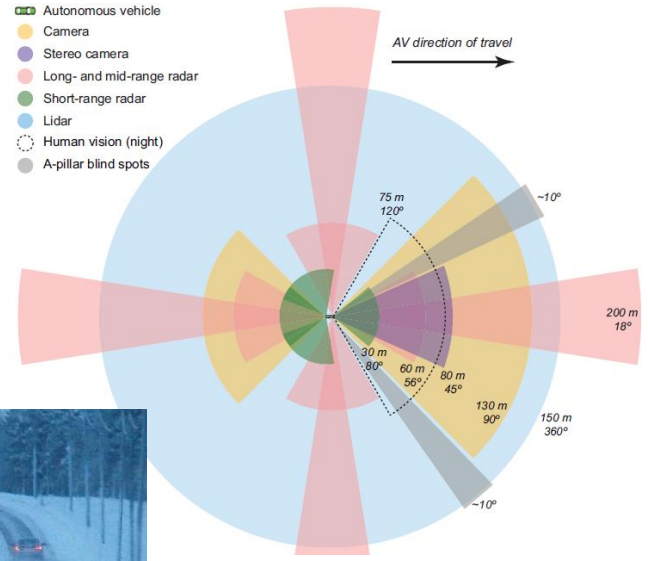
ODD evolution and road operators

- Based on work carried out in 2018-2019
  - » EU EIP 4.2
  - » MANTRA
- Operational Design Domain differs between use cases
- Also differs between vehicle manufacturers, competitive factor
  - » Depends on sensors, software incl. AI
  - » "ODD wars" forecasted
- Evolution in time: ODDs of 2040 might be very different from those in 2020 or 2030
- Evolution means added uncertainty to road authorities and operators



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Road operator understanding of ODD

- Based on research results (reports, papers), pilot area installations, NHTSA safety reports, discussions in CCAM and C-ITS platforms

ODD attribute	Physical / Digital infrastructure	Static / Dynamic
Road	Physical	Static
Speed range	Physical	Static
Shoulder or kerb	Physical	Static
Road markings	Physical	Static
Traffic signs	Physical	Static
Road furniture	Physical	Static
Traffic	-	Dynamic
Time	-	Dynamic
Weather conditions	-	Dynamic
HD map	Digital	Static
Satellite positioning	Digital	Static
Communication	Digital	Static
Information system	Digital	Static

Road operator response

- Levels of Infrastructure Support for Automated Driving

  (INFRAMIX, Carreras et al. 2018)

	Level	Name	Description	Digital information provided to AVs			
				Digital map with static road signs	VMS, warnings, incidents, weather	Microscopic traffic situation	Guidance: speed, gap, lane advice
Conventional infrastructure	E	Conventional infrastructure / no AV support	Conventional infrastructure without digital information. AVs need to recognise road geometry and road signs.				
	D	Static digital information / Map support	Digital map data is available with static road signs. Map data could be complemented by physical reference points (landmarks signs). Traffic lights, short term road works and VMS need to be recognized by AVs.	X			
Digital infrastructure	C	Dynamic digital information	All dynamic and static infrastructure information is available in digital form and can be provided to AVs.	X	X		
	B	Cooperative perception	Infrastructure is capable of perceiving microscopic traffic situations and providing this data to AVs in real-time.	X	X	X	
	A	Cooperative driving	Based on the real-time information on vehicle movements, the infrastructure is able to guide AVs (groups of vehicles or single vehicles) in order to optimize the overall traffic flow.	X	X	X	X

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Odd attribute	Detailed feature	Unit cost range estimate (deployment)	Maintenance, operation annually
Shoulder or kerb	Safe "harbours"	40-100 k€/km where needed	8 %
	Passenger pick-up/drop-off points	2-5 k€/point	10 %
Markings and signs	enhanced maintenance of road markings and traffic signs & signals	0.1-0.2 k€/km/a	included
Road furniture	Landmarks for positioning enhancement	4-6 k€/km where needed	10 %
	Signs and/or barriers for access control	15-90 k€/km where needed	8 %
Traffic management	Standardized marking and efficient management of road works zones	3-5 k€/km/a	included
	Adaptation of traffic centres & systems	10-90 k€/km	8 %
Maintenance	Enhanced snow-removal	2-2.5 k€/km /a (2-lane roads) 3-4 k€/km/a (motorways)	included
HD map - non-LIDAR	HD Maps or road areas, infra, equipm.	3-4 k€/km	8 %
	HD Maps of road structures for maint.	5-7 k€/km	8 %
	Road areas & environment	1-3 k€/km/a	included
HD map - LIDAR	Road areas & environment with LIDAR point clouds	3-6 k€/km/a	included
RTK stations	Satellite positioning land stations	0.4-2 k€/km	8 %
V2I Long Range	Base station (micro or macro)	35-40 k€/station/a (macro) 8-10 k€/station/a (micro)	included
V2I Short Range	Roadside station	15 k€/km	8%
	Connecting to trunk communication	fibre optics 20 - 100 k€/km	8 %
Problem & regulation information	High quality real-time situational picture & rules and regulations	interurban 0.4-0.8 k€/km/a urban 0.1-0.2 k€/km	included
Road works information	VMS/C-ITS warnings	0.5-0.9 k€/km/a	included

Responsibilities for ODD 1/2

ODD attribute	motorway, primary road, urban street, secondary or rural road	terminal area
shoulder or kerb	road operator	terminal operator
road markings	road operator/ maintenance. contractor	terminal operator
traffic signs	road operator/ maintenance. contractor	terminal operator
road furniture	road operator	terminal operator
traffic management	road operator/ traffic management operator	
maintenance	road operator/ maintenance. contractor	terminal operator
HD map - non-LIDAR	road operator/ other national bodies (different layers)/ digital map providers	terminal operator/ digital map providers
- LIDAR	service operator/digital map providers	service operator/digital map providers
RTK stations	land survey agency/ road operator	land survey agency/ terminal operator

Responsibilities for ODD 2/2

ODD attribute	motorway, primary road, urban street, secondary or rural road	terminal area
V2I LR	mobile network operator	mobile network operator
V2I SR	road operator	terminal operator
incident, event information	road operator/ TM operator / OEMs/ service provider	
road work information	road operator, road works contractor	
rules, regulations, geofence	regulatory agency, road operator, TM operator, service provider	regulatory agency, terminal operator, TM operator, service provider
operations centres	OEMs, fleet managers	OEMs, fleet managers

Messages on deployment (long term)

- Focus on digital infrastructure
  - » Digital information on existing widenings, lay-bys, etc. For safe harbours instead of building such
  - » Making traffic rules, static and dynamic traffic sign information, traffic management plans, road work and event information, incident information, geofencing information available in digital form
- Harmonise and aim towards consistency
  - » Harmonised and consistent road markings
  - » Harmonised marking and management of road works
- Support accurate positioning where necessary
  - » Landmarks
  - » Land stations
- Establish infrastructure communications
  - » Long-range coverage of main networks
  - » Short-range coverage of hot spots
- No enhanced maintenance due to automated vehicles

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ODD coverage?

- Road sections with safety problems
  - » Automated vehicles are expected to be much safer
  - » Accidents also major source of non-recurring congestion
  - » Awareness of problems in mixed traffic, however
- Road sections with recurring congestion problems
  - » If automated vehicles are more cautious than human drivers in terms of following headways, Avs on those sections could make matters worse
  - » If automated vehicles can use the same headways as or shorter headways than human drivers, ok
- National priorities determine priority of use cases
  - » E.g. platooning, winter maintenance vehicles, public transport, etc.
- Importance of European regulations
  - » TEN-T core network corridors or comprehensive network, for instance

Thank you for your attention!