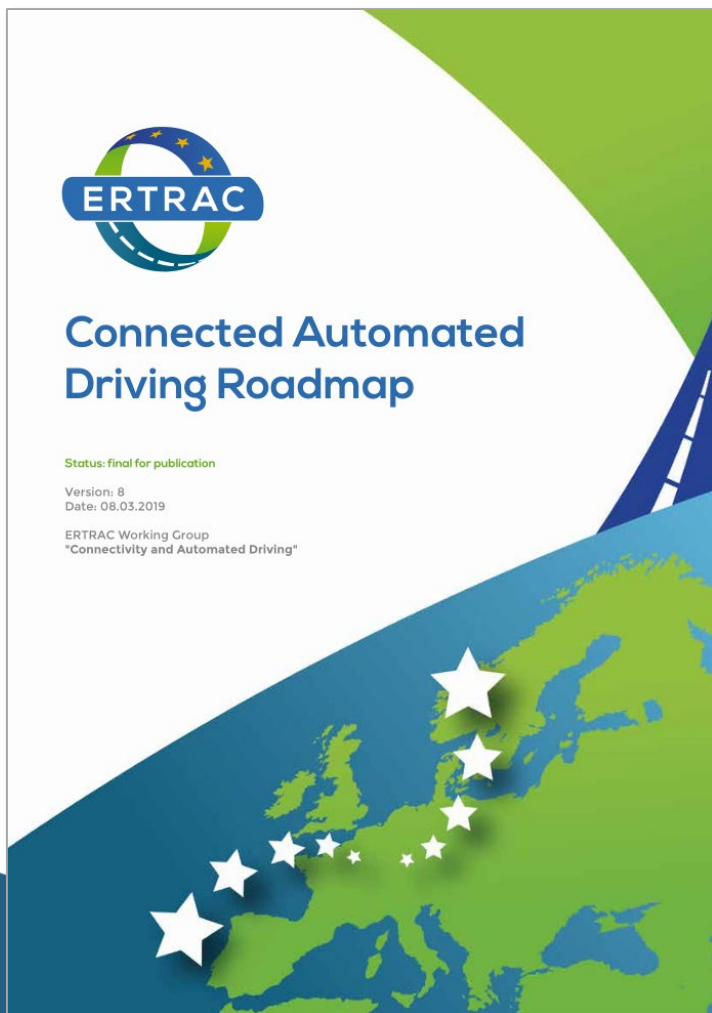




Connected Automated Driving Roadmap – 2019 update

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CAD Roadmap version 8.0 – now available!



- Increased scope to better cover **Connected Automated Driving**, including cooperative and connected vehicles.
- Strengthen the link to the **Infrastructure**, through CEDR.
- Deeper dive into three use cases including requirements on 'connected & infrastructure':
 - **Automated Passenger Cars Path**
 - **Automated Freight Vehicles Path**
 - **Urban Mobility Vehicles**
- Connect to the CARTRE (CSA) results and the ARCADE (CSA) project and provide **a EU wide overview** (and beyond).
- Incorporate the STRIA CAD actions (2018) via **Key Challenges and Objectives**.



WG Connected Automated Driving Roadmap Update 2019

1. Scope and Objectives

2. Common Definitions

- 2.1 Levels of Automation
- 2.2 Operational Design Domain
- 2.3 Vehicle and infrastructure interaction
- 2.4 Regulatory and standardisation framework for Automation
- 2.5 Connectivity as a requirement for vehicle-infrastructure interaction

3. Development paths

- 3.1 Automated Passenger Cars Path
- 3.2 Automated Freight Vehicles Path
- 3.3 Urban Mobility Vehicles

4. EU and international initiatives

- 4.1 European research projects
- 4.2 European initiatives
- 4.3 EU Member States initiatives
- 4.4 Initiatives around the world

5. Key Challenges and Objectives

- 5.1 User awareness, users and societal acceptance and ethics, driver training
- 5.2 Human Factors
- 5.3 Policy and regulatory needs, European harmonisation
- 5.4 Socio-economic assessment and sustainability
- 5.5 Safety validation and roadworthiness testing
- 5.6 New mobility services, shared economy and business models
- 5.7 Big data, artificial intelligence and their applications
- 5.8 Physical and Digital infrastructure (PDI) including Connectivity
- 5.9 In-vehicle technology enablers
- 5.10 Deployment

6. Annex: definitions of systems – Levels 0 to 2 + Parking

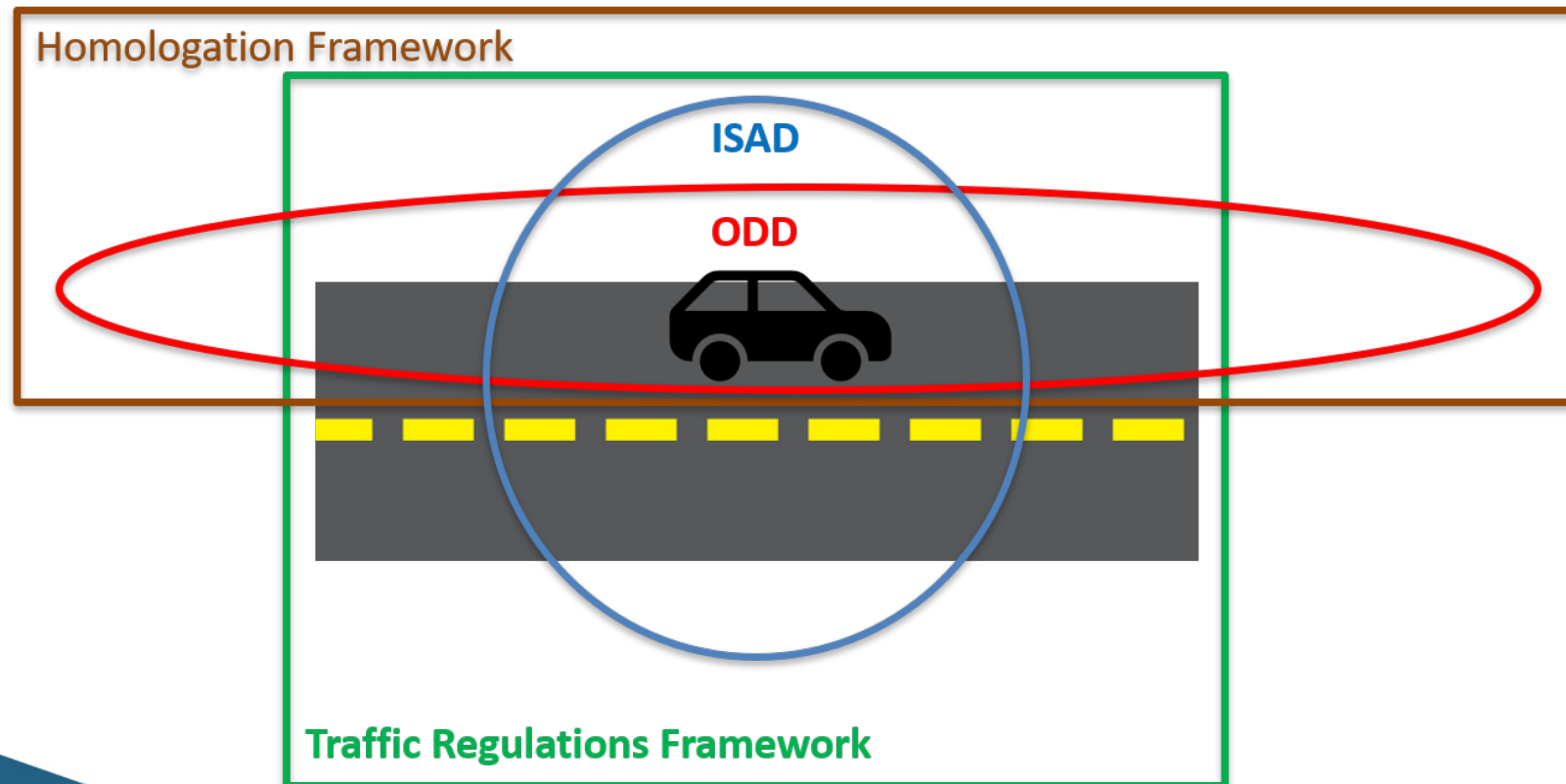
- 6.1 Current and future vehicle systems – Level 0
- 6.2 Current systems – Level 1
- 6.3 Automated Driving Assistance - Level 2
- 6.4 Automated Parking Assistance



Newest update SAE Levels

Level	Name	Narrative definition	DDT		DDT fallback	ODD
			Sustained lateral and longitudinal vehicle motion control	OEDR		
Driver performs part or all of the DDT						
0	No Driving Automation	The performance by the <i>driver</i> of the entire <i>DDT</i> , even when enhanced by <i>active safety systems</i> .	<i>Driver</i>	<i>Driver</i>	<i>Driver</i>	n/a
1	Driver Assistance	The <i>sustained</i> and <i>ODD</i> -specific execution by a <i>driving automation system</i> of either the <i>lateral</i> or the <i>longitudinal vehicle motion control</i> subtask of the <i>DDT</i> (but not both simultaneously) with the expectation that the <i>driver</i> performs the remainder of the <i>DDT</i> .	<i>Driver and System</i>	<i>Driver</i>	<i>Driver</i>	Limited
2	Partial Driving Automation	The <i>sustained</i> and <i>ODD</i> -specific execution by a <i>driving automation system</i> of both the <i>lateral</i> and <i>longitudinal vehicle motion control</i> subtasks of the <i>DDT</i> with the expectation that the <i>driver</i> completes the <i>OEDR</i> subtask and <i>supervises</i> the <i>driving automation system</i> .	System	<i>Driver</i>	<i>Driver</i>	Limited
ADS (“System”) performs the entire DDT (while engaged)			System	System	Fallback-ready user (becomes the driver during fallback)	Limited
3	Conditional Driving Automation	The <i>sustained</i> and <i>ODD</i> -specific performance by an <i>ADS</i> of the entire <i>DDT</i> with the expectation that the <i>DDT fallback-ready user</i> is <i>receptive</i> to <i>ADS</i> -issued <i>requests to intervene</i> , as well as to <i>DDT performance-relevant system failures</i> in other <i>vehicle systems</i> , and will respond appropriately.				
4	High Driving Automation	The <i>sustained</i> and <i>ODD</i> -specific performance by an <i>ADS</i> of the entire <i>DDT</i> and <i>DDT fallback</i> without any expectation that a <i>user</i> will respond to a <i>request to intervene</i> .	System	System	System	Limited
5	Full Driving Automation	The <i>sustained</i> and unconditional (i.e., not <i>ODD</i> -specific) performance by an <i>ADS</i> of the entire <i>DDT</i> and <i>DDT fallback</i> without any expectation that a <i>user</i> will respond to a <i>request to intervene</i> .	System	System	System	Unlimited

Traffic regulations, Homologation Framework ODD and ISAD



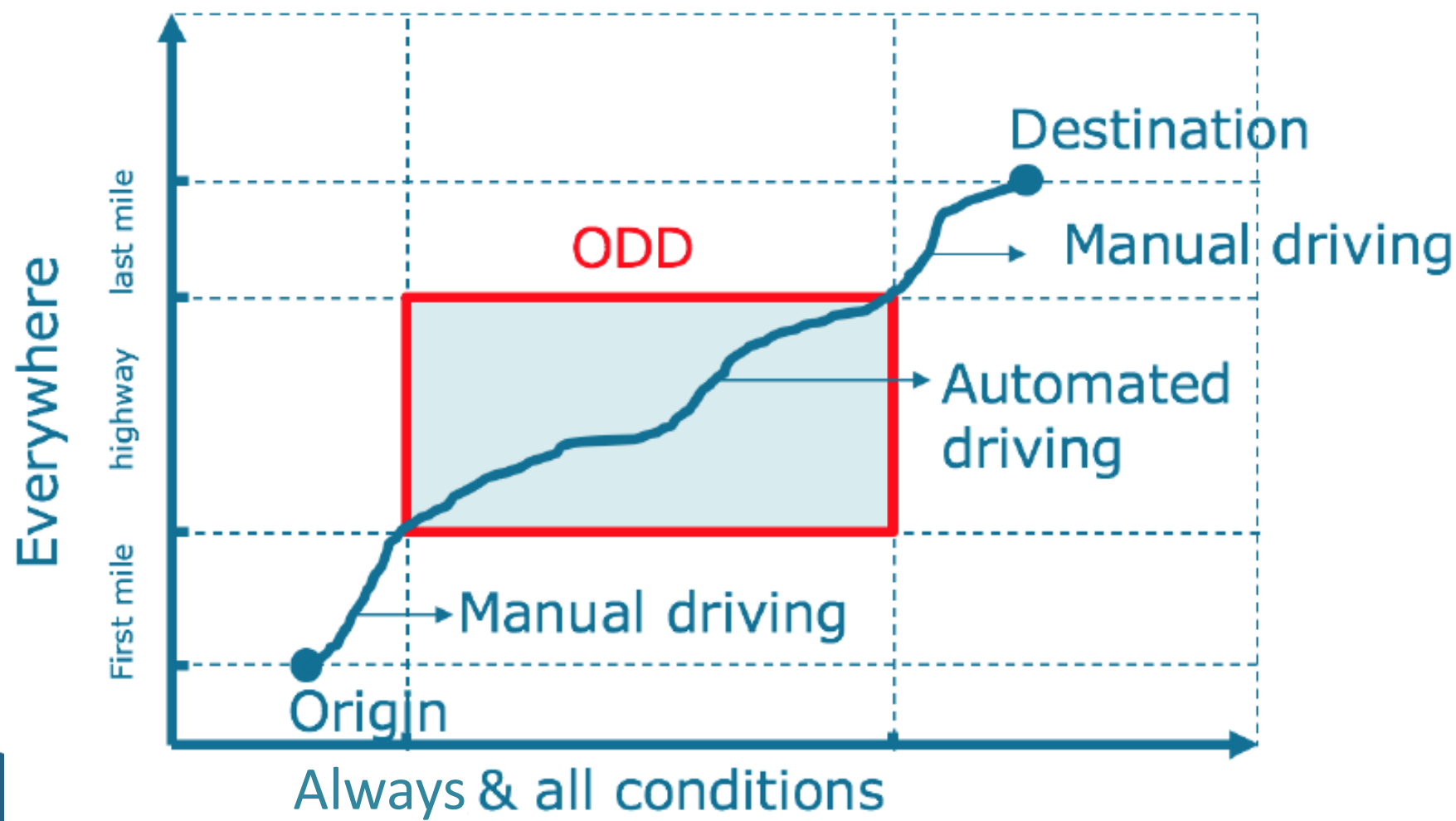
- Explanation and information on ODD
- Vehicle and Infrastructure Interaction
- Regulatory and Standardisation framework for Automation
- Connectivity as a requirement for vehicle-infrastructure interaction



ODD – Operational Design Domain

- ODD := *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 (weather, daytime/nighttime, etc.), prevailing traffic law and regulations, and other domain constraints (SAE J3016 June 2018)*
- Long term vision is to align infrastructure data with automotive safety integrity level.
- Visualize automated driving quality and availability, driving/travel experience from a user perspective
- To further provide input from CEDR CAD: What are the prerequisites towards the infrastructure from vehicle side?

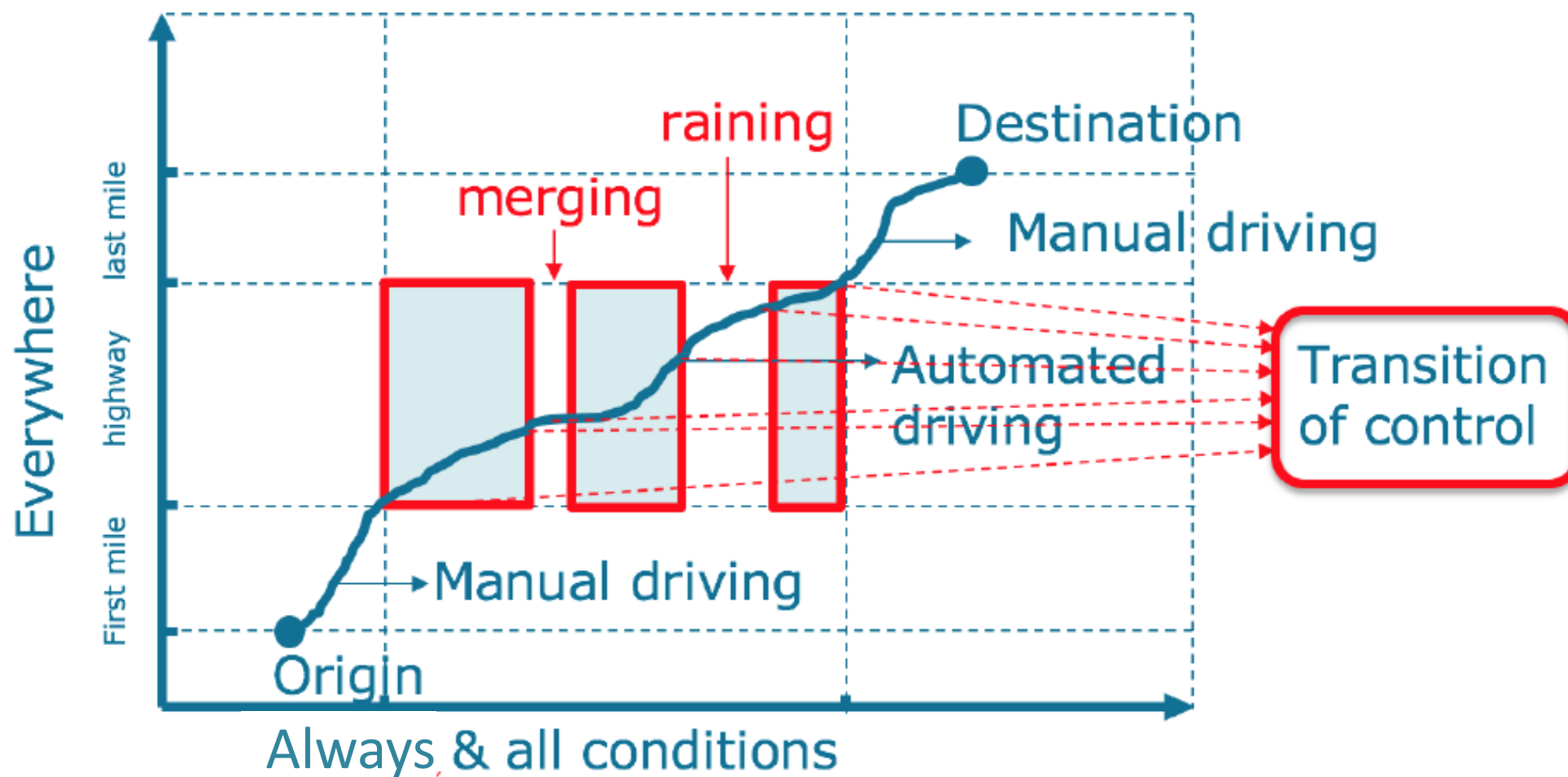
ODD – Operational Design Domain Example #1



Tom
Alkim
2017



ODD – Operational Design Domain Example #2



Tom
Alkim
2017



Input - How the infrastructure can (and should) support CAD

- Road infrastructure can provide additional information for on-board decisions of CAVs
- A classification of infrastructure support is needed:
 - Common understanding between OEMs, automotive industry and road operators is to be established
 - More use-cases have to be defined to understand the potential of ISAD in mixed traffic
 - Long transition period with mixed traffic is expected
- The workgroups' feedback was incorporated in the approach and classification of this infrastructure support levels, please find the related information on the next slides.



Infrastructure Support levels for Automated Driving (ISAD)

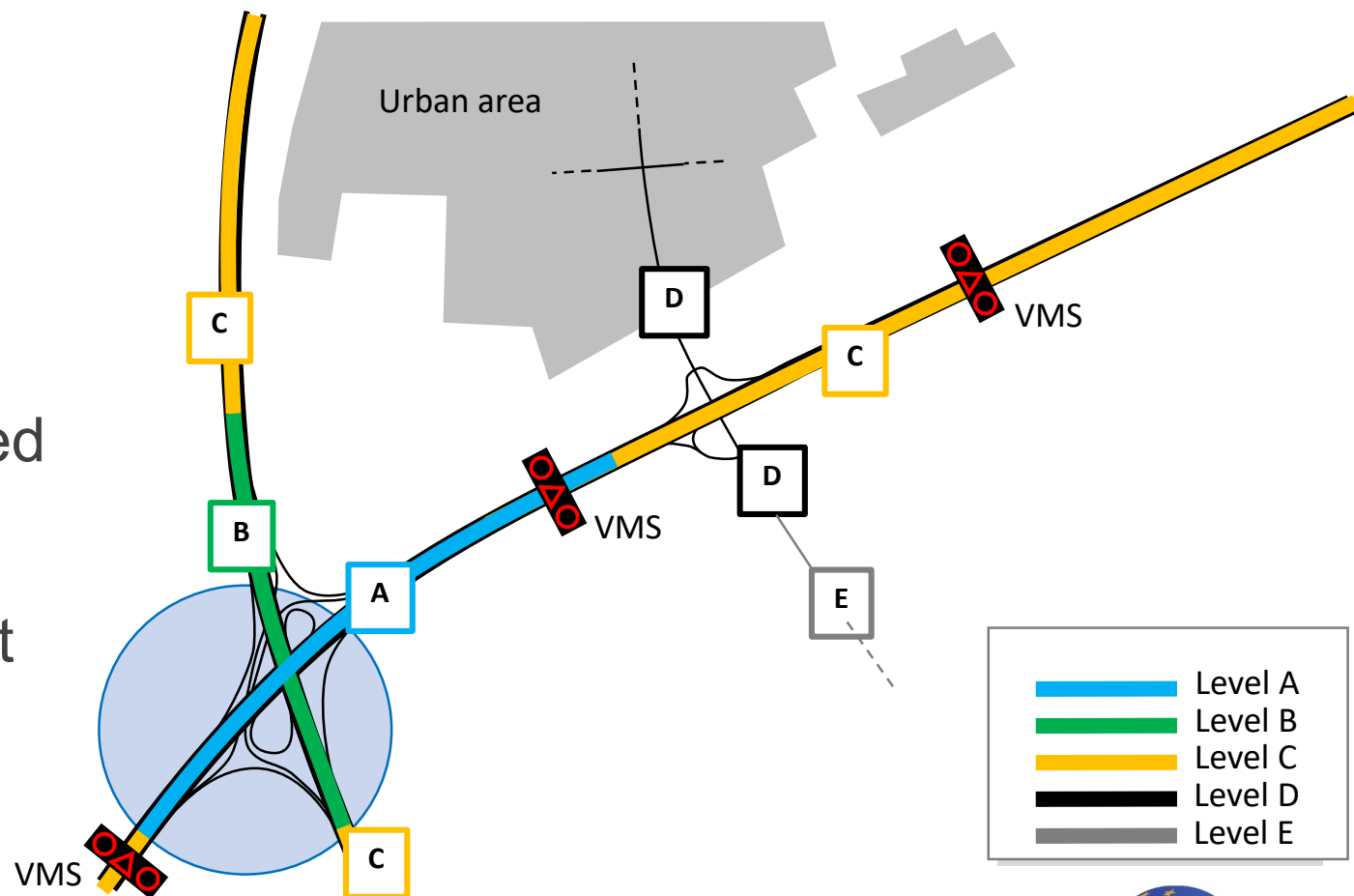
Elaborated in cooperation with INFRAMIX, see also ITS World Congress 2018 paper by AAE & ASFINAG

	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
Digital infrastructure	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
	B	Cooperative perception	Infrastructure is capable of perceiving microscopic traffic situations and providing this data to AVs in real-time	X	X	X	
	C	Dynamic digital information	All dynamic and static infrastructure information is available in digital form and can be provided to AVs.	X	X		
Conventional infrastructure	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			
	E	Conventional infrastructure / no AV support	Conventional infrastructure without digital information. AVs need to recognise road geometry and road signs.				

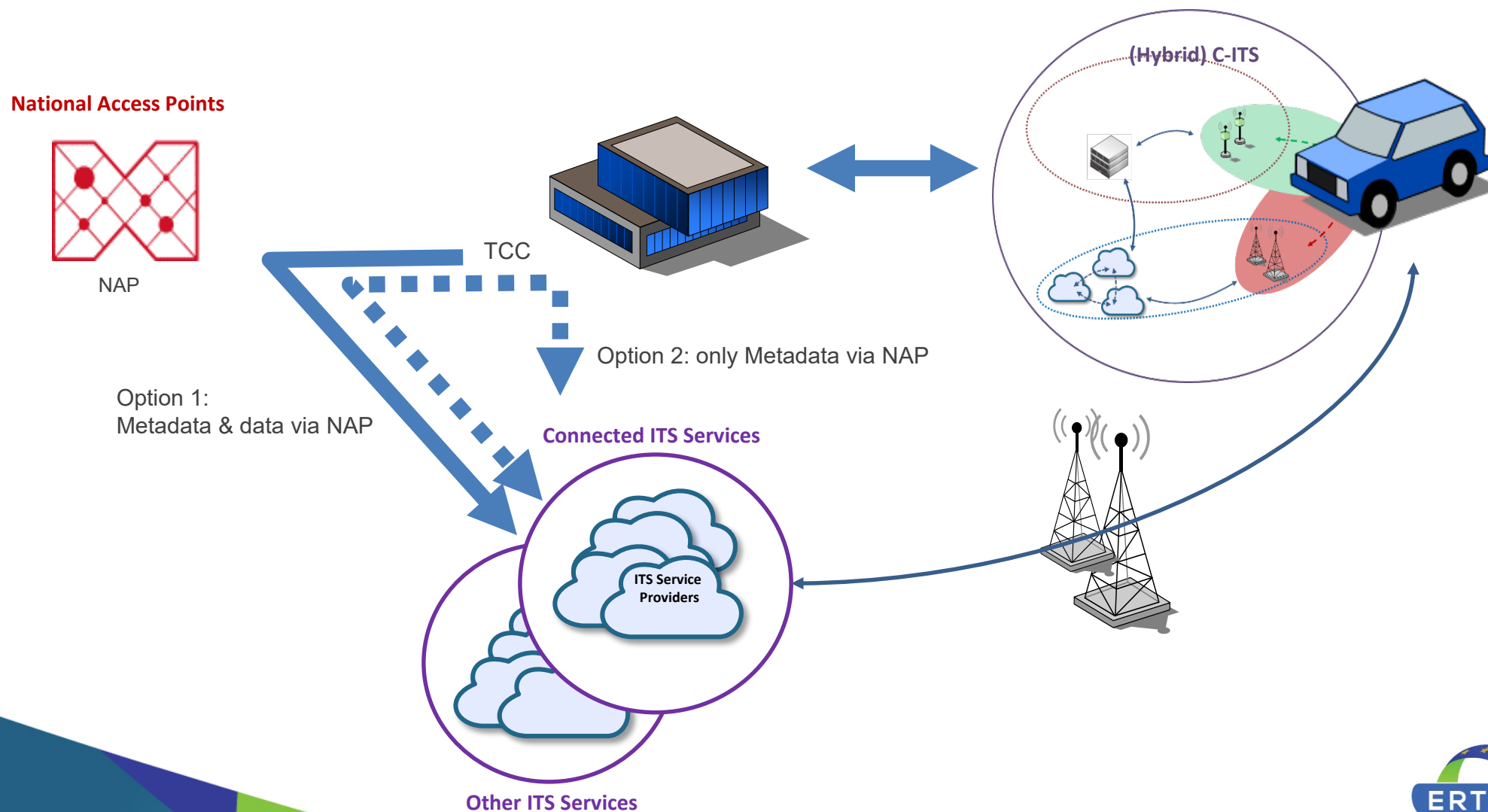


Infrastructure Support levels for Automated Driving (ISAD)

- Based on the ISAD Level of information and services different on-board vehicle decisions can be supported
- CAVs will have to be able to drive on E-level, but the additional possibilities provided by A-level sections enable a much higher customer satisfaction as well as support road safety and capacity management related goals



Connectivity as a requirement for vehicle-infrastructure interaction

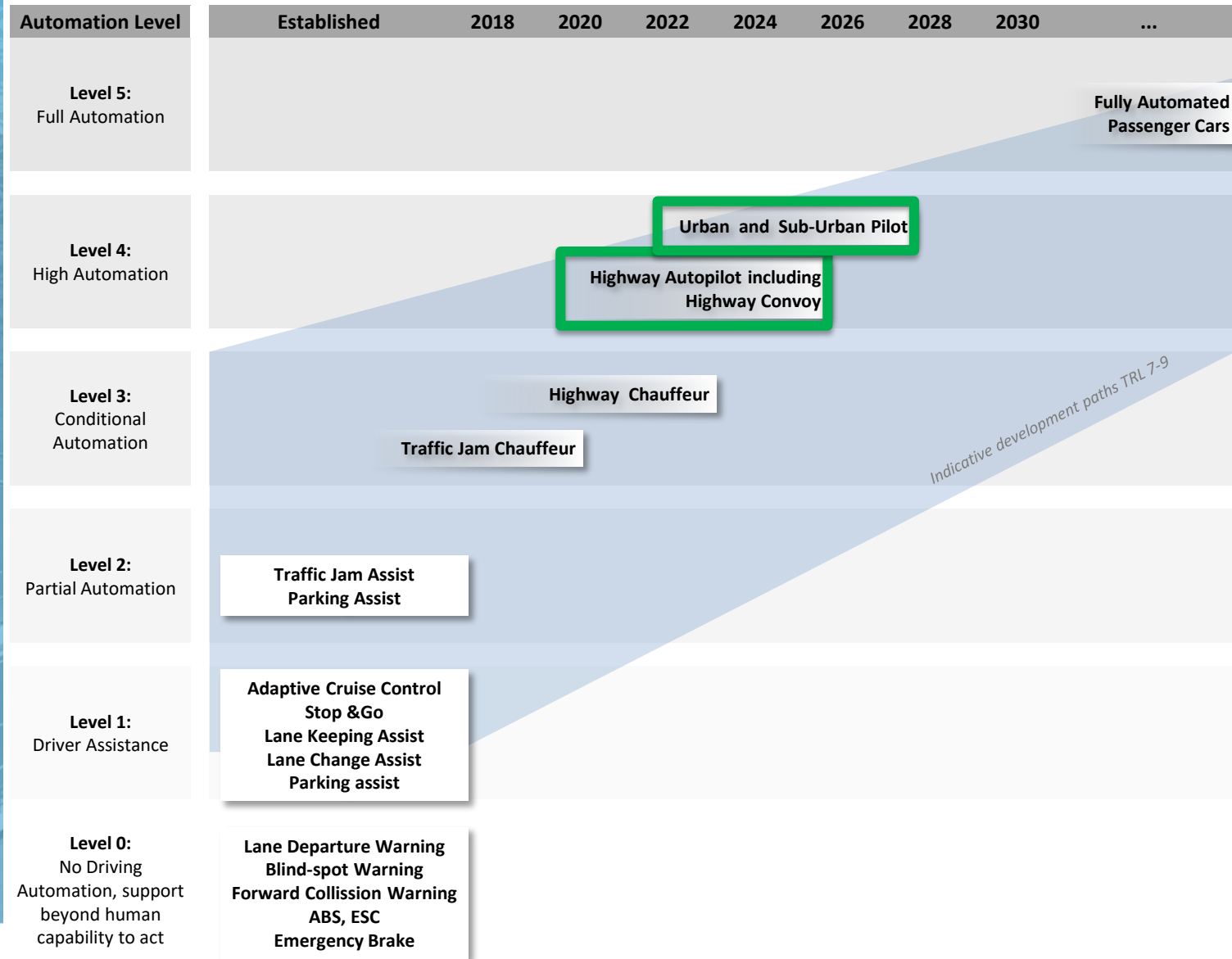


The three development path use cases

- CEDR & ERTRAC Chair meeting Vienna August 2018 provided many useful insights and new ideas on the development paths to focus on:
 - NRAs can provide valuable support through infrastructure and data provision -> this requires the NRAs to form an unified, viable approach.
 - One use case per deployment path has been deemed especially beneficial to be researched (-> green boxes), and they align well with the CEDR research project MANTRA's targeted use cases
- The use case selection was then further adapted to best fit our current focus points and still align well with other activities.
- All chapters in the roadmap include requirements on 'connected & infrastructure'



Automated Passenger Car Development Paths



Highway Autopilot (Level 4)



Highway Convoy (Level 4)



Urban and Suburban Pilot (Level 4)

e.g. 130

e.g. 70



Level 4 for passenger cars – use cases

Highway Autopilot (Level 4)

- up to 130 km/h on motorways or motorway similar roads
- from entrance to exit, on all lanes, including lane change
- sleeping is allowed
- when average human driver would try to end the journey or simply stop at the motorway (e.g. extreme weather) and the driver does not take over, the system can leave the motorway and park the vehicle safely



Highway Convoy (Level 4)

- electronically linked vehicles of all types on motorways or similar roads in the same lane with minimum distance between each other
- if V2V communication is available with realtime performance
- reduce safety distances far below today's manually driven distances
- in large urban areas, highway traffic could develop to be much more efficient (traffic space per person, energy consumption per vehicle)

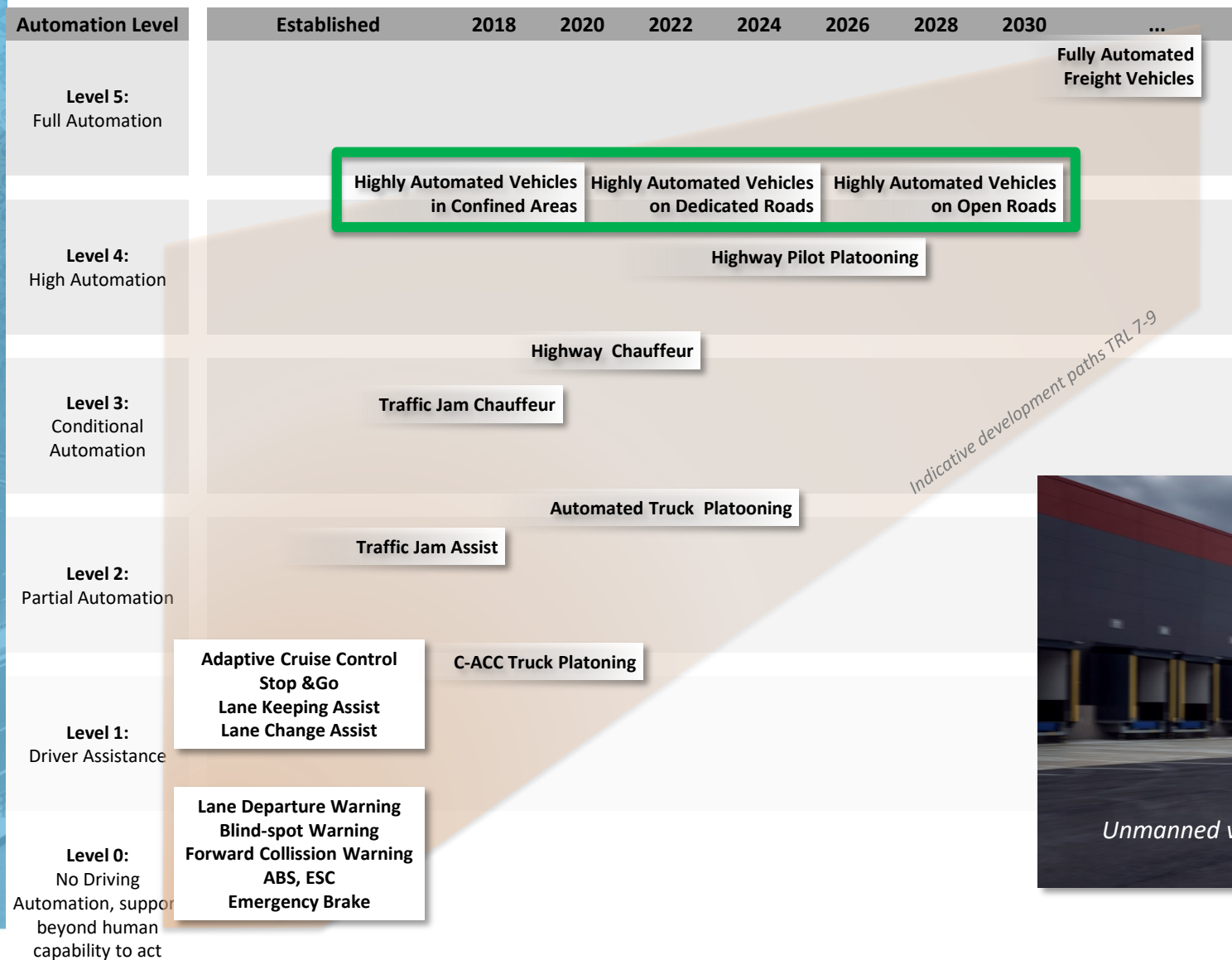


Urban and Suburban Pilot (Level 4)

- Highly Automated Driving up to limitation speed
- The system can be activated by the driver in all traffic conditions
- The driver can override or switch off the system at all time



Automated Freight Vehicle Development Paths



Truck: Freight vehicle > 3.5 tonnes categorie N2 or N3

Highway chauffeur for hub2hub and open-roads, Heavy Freight Vehicles - examples



Unmanned vehicles, confined and hub-to-hub

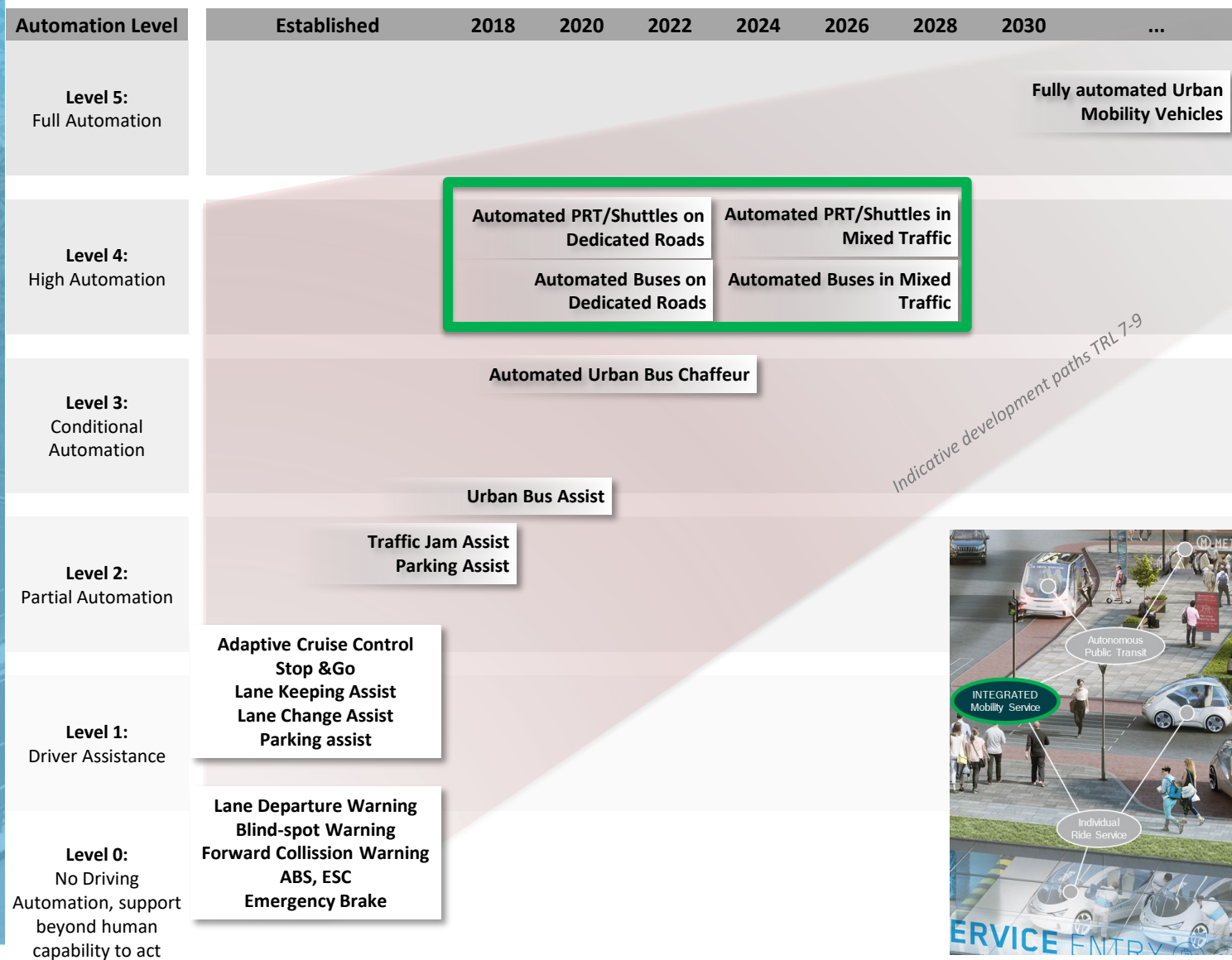
- Highly automated, un-manned connected to control and supply-chain management center
- For repetitive transport between hubs. Slow speed for energy optimized electrified operation
- Dedicated roads/lanes with infrastructure/charging support



Highway chauffeur, open roads

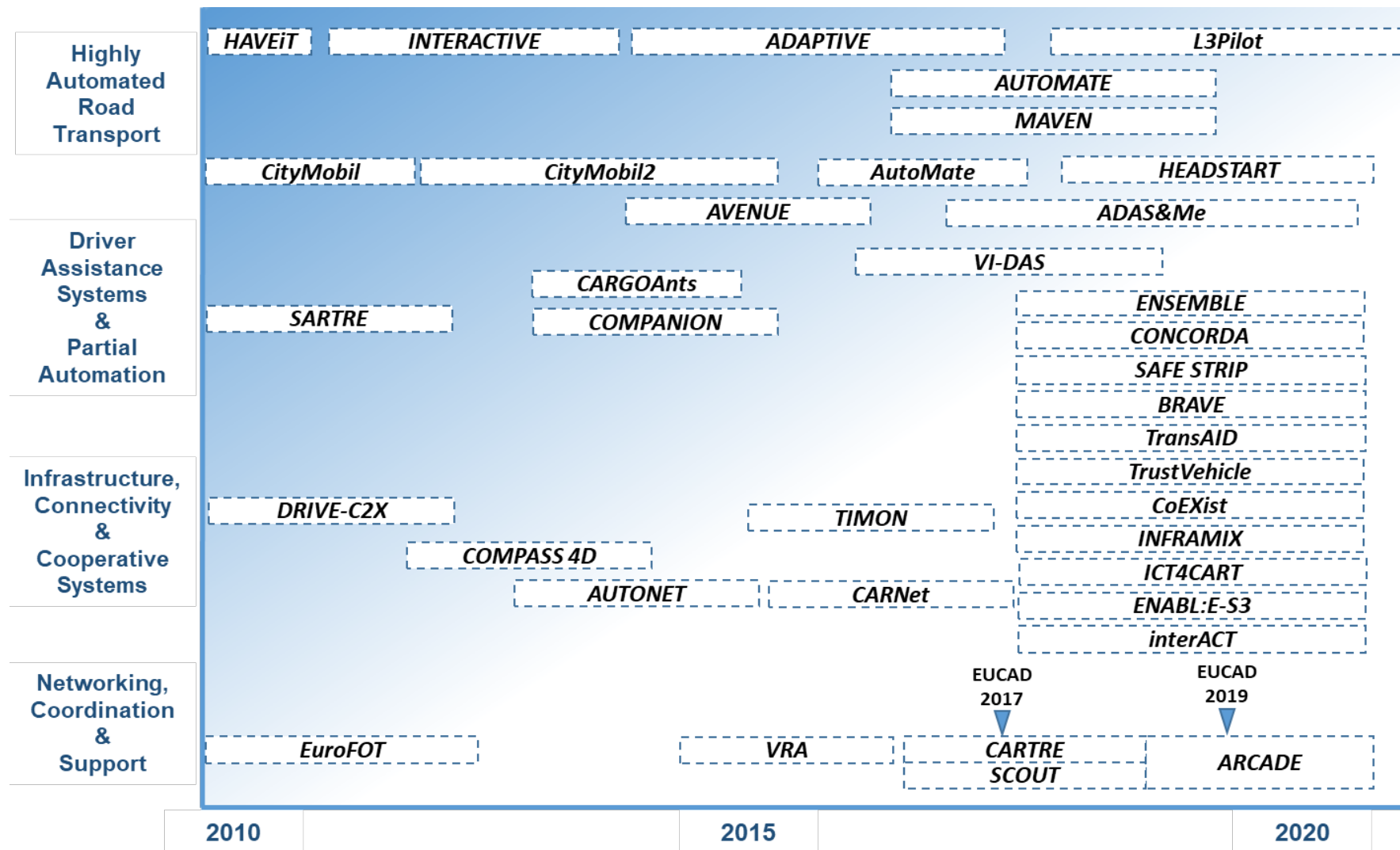
- Highly automated trucks on open roads in mixed traffic
- For flexible transport assignments with automated/manual operation
- Integrated with logistics supply chain
- Cooperative automation

Automated Urban Mobility Vehicle Development Paths

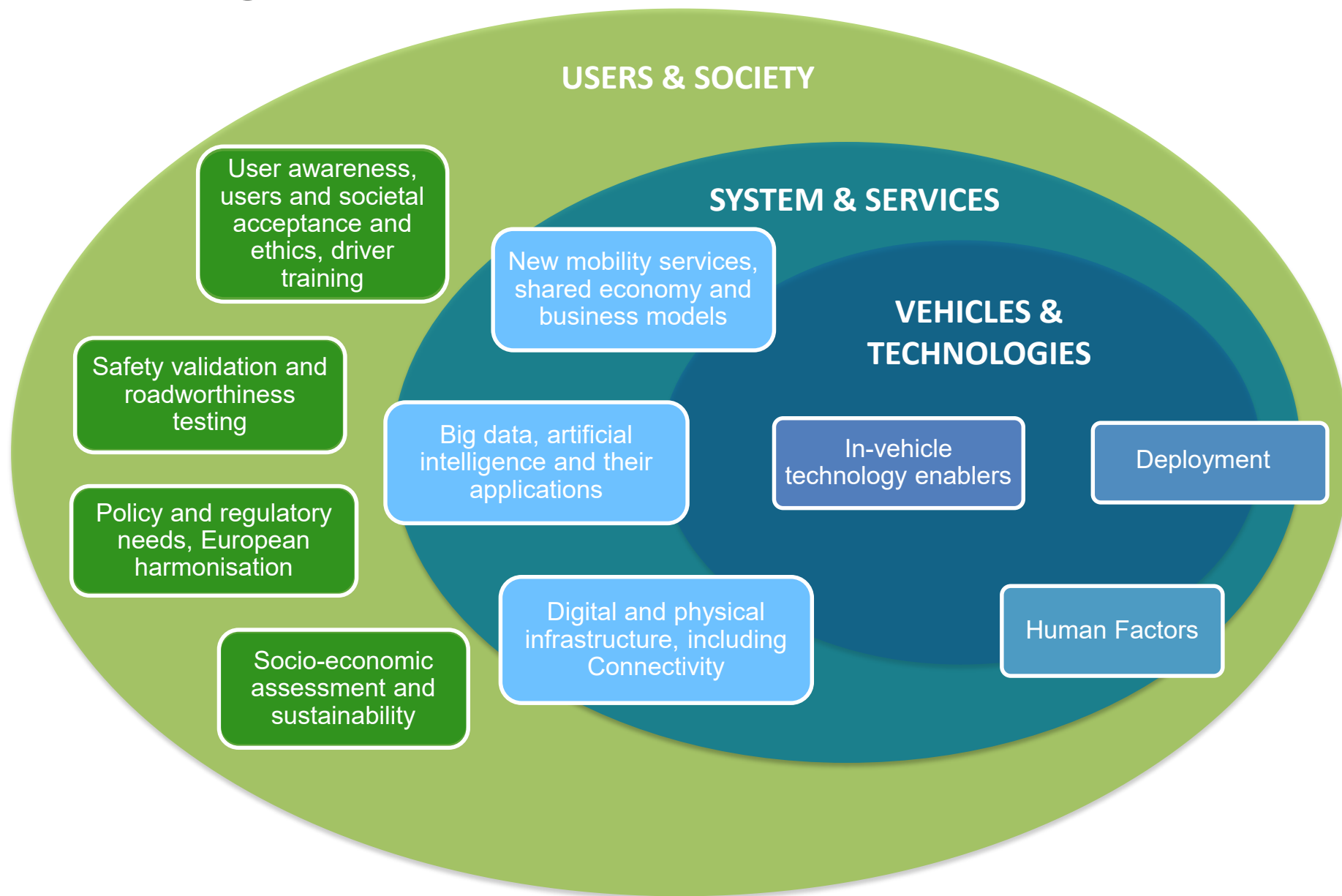


PRT (Personal Rapid Transit) incl. Urban Shuttle
City Bus/Coach: M2 < 5 tonnes < M3

Overview of EU funded projects that support the development of automated driving



Key Challenge Areas



Thank you for your work and support in updating the roadmap!