European collaborative research in connected automated driving since Prometheus ...

The Eureka PROMETHEUS Project (PROgraMme for a European Traffic of Highest Efficiency and Unprecedented Safety, 1987-1995) was the largest R&D project ever in the field of driverless cars.

The project received €749M in funding from the EUREKA member states and defined the state of the art of autonomous vehicles

Industrial research

- *PRO-CAR : Driver assistance by computer systems*
- *PRO-NET : Vehicle-to-vehicle communication*
- *PRO-ROAD : Vehicle-to-environment communication*

Basic Research

- *PRO-ART : Methods and systems of artificial intelligence*
- *PRO-CHIP: Custom hardware for intelligent processing in vehicles*
- *PRO-COM : Methods and standards for communication*
- *PRO-GEN : Traffic scenario for new assessment and introduction of new systems*

EU PROJECT CONTRIBUTIONS EXAMPLES: **CONNECTED AUTOMATED DRIVING & ADAS**

Connected Cooperative Automated Driving
Collaboration, Network, Demonstration, Pilots
Field Operational Tests (FOT), Test verification and validation, Platooning, V2x, Cooperative Driving, …

EUROFOT | VRA | CARTRE | ARCADE
SAFESPOT | CVIS | DRIVE-C2X | HeadStart
SARTRE | ENSEMBLE

Advanced Driver Assistance Systems
Advanced systems for Lane Change Support, Lane Keeping Support and Adaptive Cruise Control. Drowsiness detection. Driver Interaction. Emergency Brake, Distance Alert, …

AIDE | PReVent | ADAPTIVE
HAVEit | XCYCLE

Results brought into products e.g. Volvo FH

European Road Transport Research Advisory Council

Reminder:
- ERTRAC is a European Technology Platform (ETP)
- About 60 members, representing all the actors of the Road Transport System: industry, research, academic, European associations, EU Member States, local authorities, European Commission services.

Working groups & Task forces
- Urban Mobility
- Long Distance Freight Transport
- Energy & Environment
- Road Transport Safety & Security
- Global Competitiveness
- **Connectivity and Automated Driving**
- Electrification task force

Connected Automated Driving Roadmap – 2019 update

FFI TSAF Conference September 17, 2019

CAD Roadmap version 8.0 - now available!


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Connected Automated Driving Roadmap

Status: final for publication

Version: 8
Date: 08.03.2019

ERTRAC Working Group
"Connectivity and Automated Driving"

- 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

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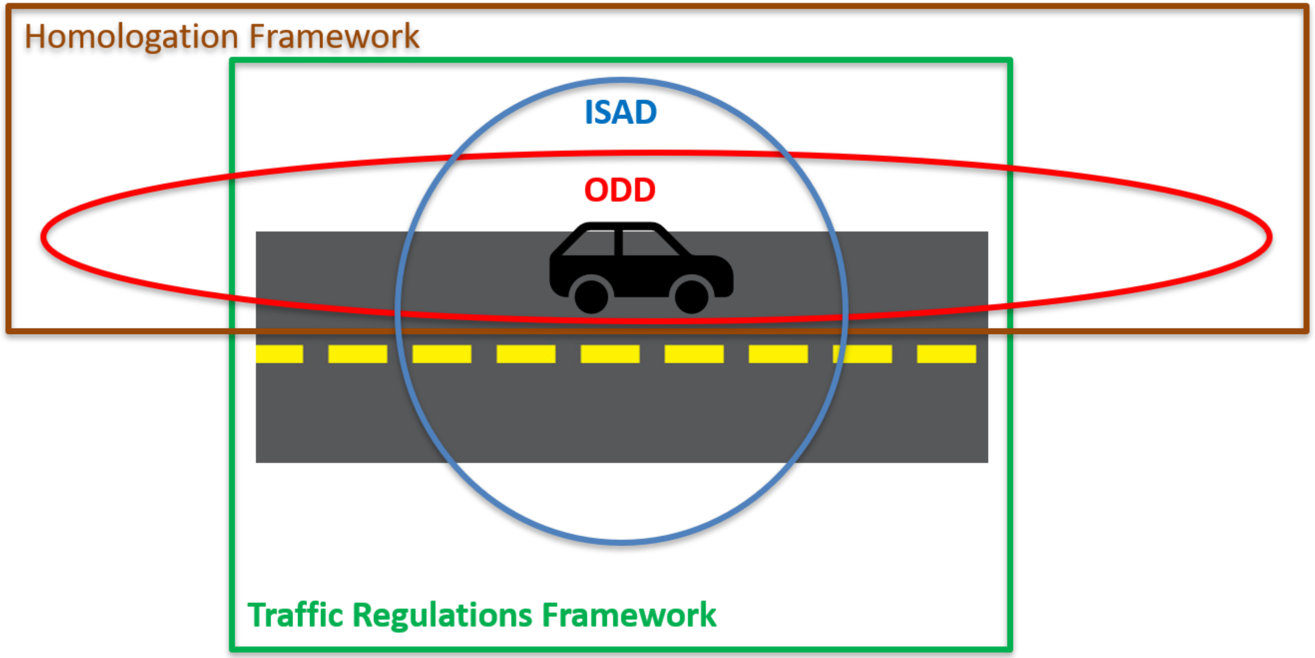
ODD / ISAD / Traffic regulations and Homologation Framework



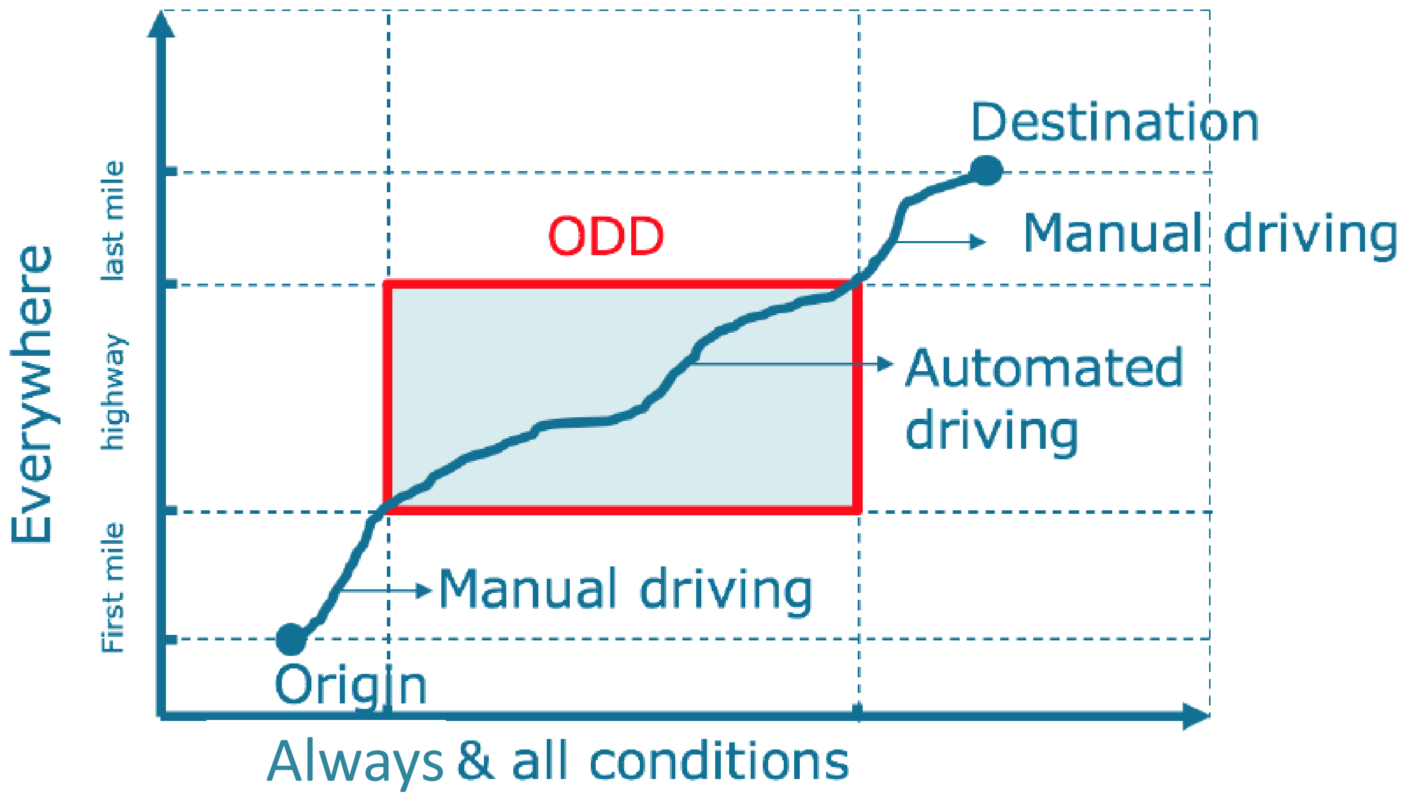
- Explanation and information on ODD
- Vehicle and Infrastructure Interaction
- Regulatory and standardisation framework for Automation
- Connectivity as a requirement for vehicle-infrastructure interaction

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)*

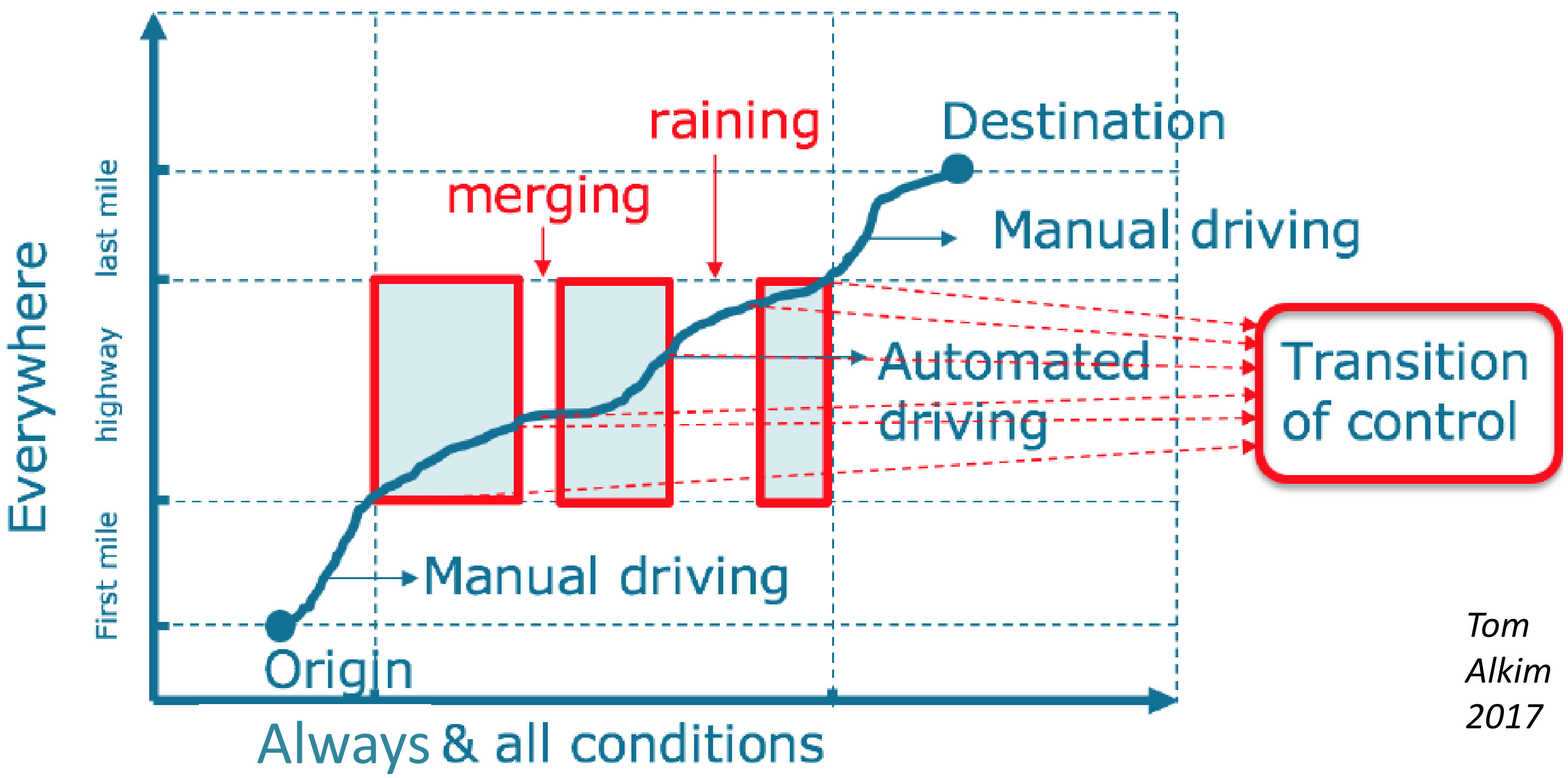
- Long term vision is to align infrastructure data with automotive safety integrity level.
- Visualize automated driving quality and availability, driving/travel experience from a user perspective
- To further provide input from CEDR CAD: what are the prerequisites towards the infrastructure from vehicle 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.

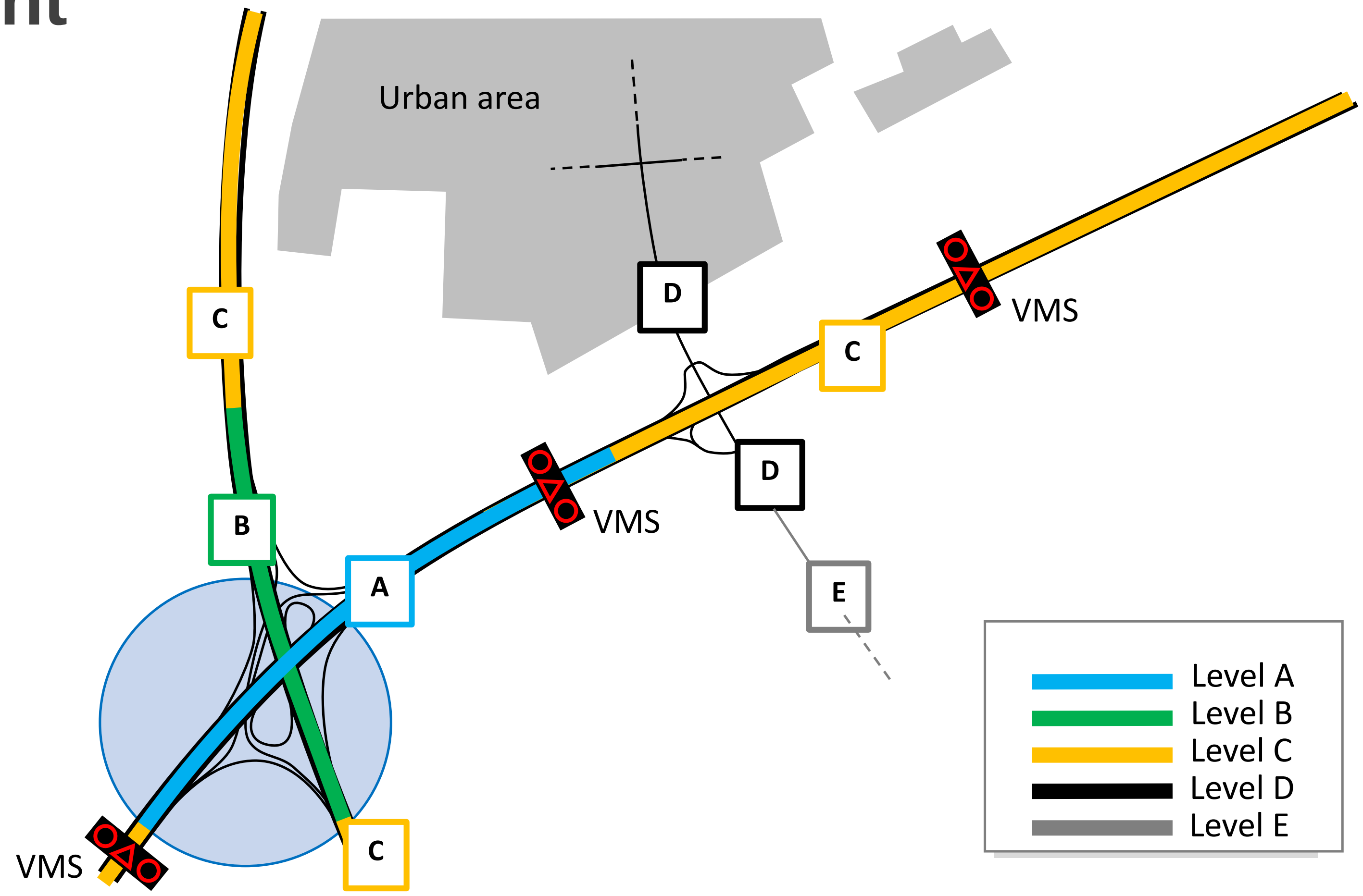
Infrastructure Support levels for Automated Driving (ISAD)

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

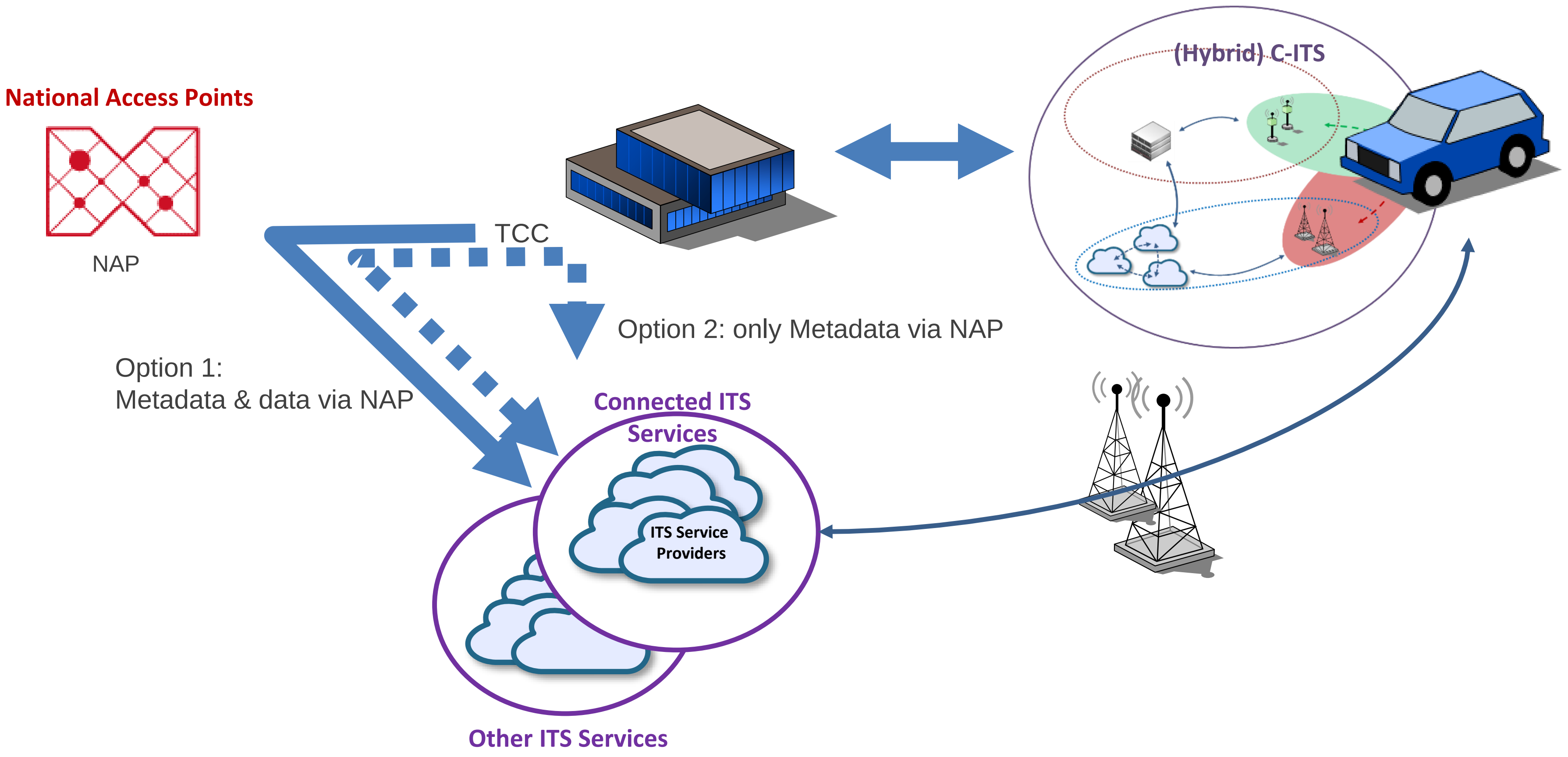
	Level	Name	Description	Digital information provided to AVs			
				Digital map with static road signs	VMS, warnings, incidents, weather	Microscopic traffic situation	Guidance: speed, gap, lane advice
Digital infrastructure	A	Cooperative driving	Based on the real-time information on vehicle movements, 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
Digital infrastructure	B	Cooperative perception	Infrastructure is capable of perceiving microscopic traffic situations and providing this data to AVs in real-time	X	X	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		
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			
Conventional infrastructure	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) - on schematic road segment

- 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



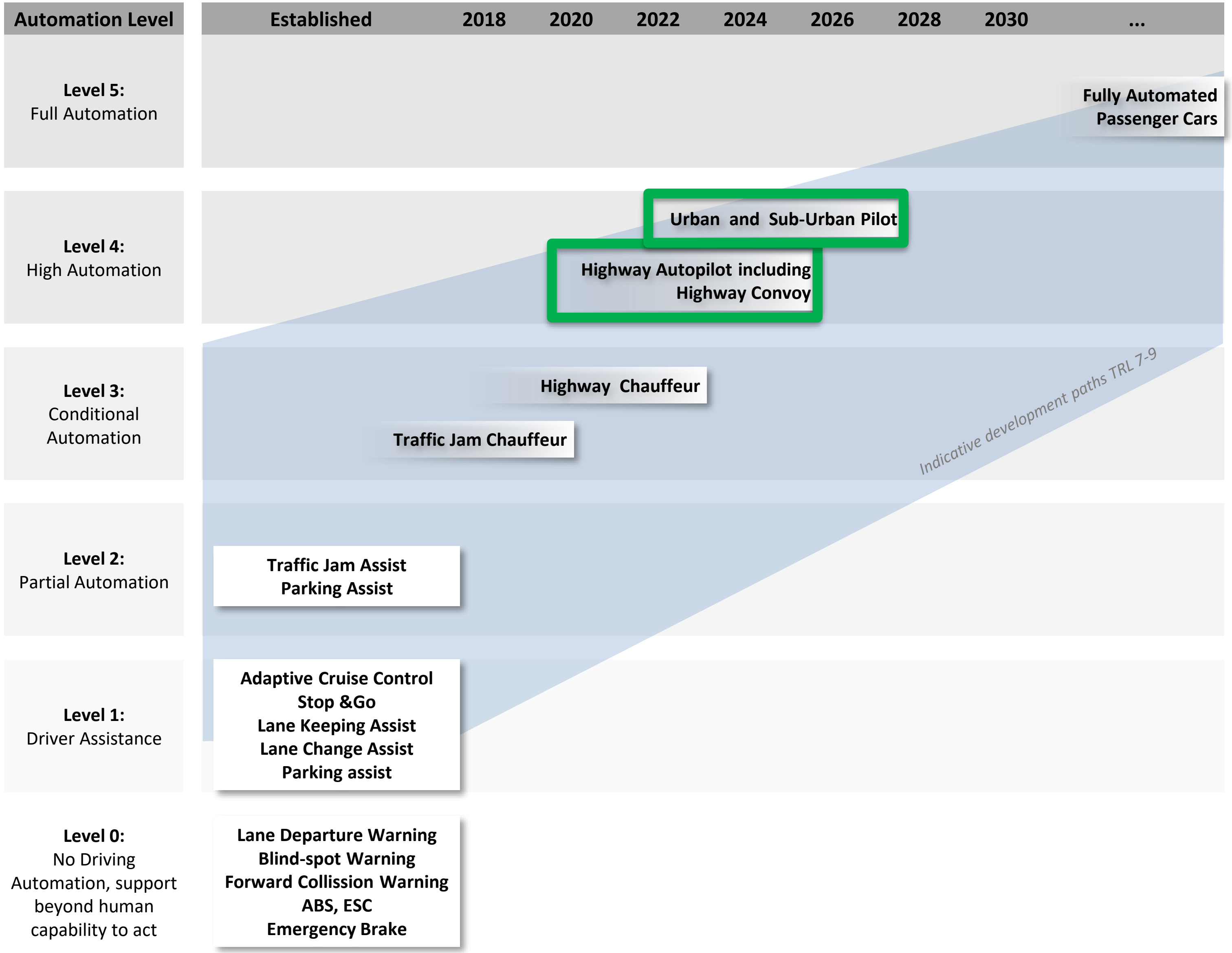
Connectivity as a requirement for vehicle-infrastructure interaction



The three development path use cases

- 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



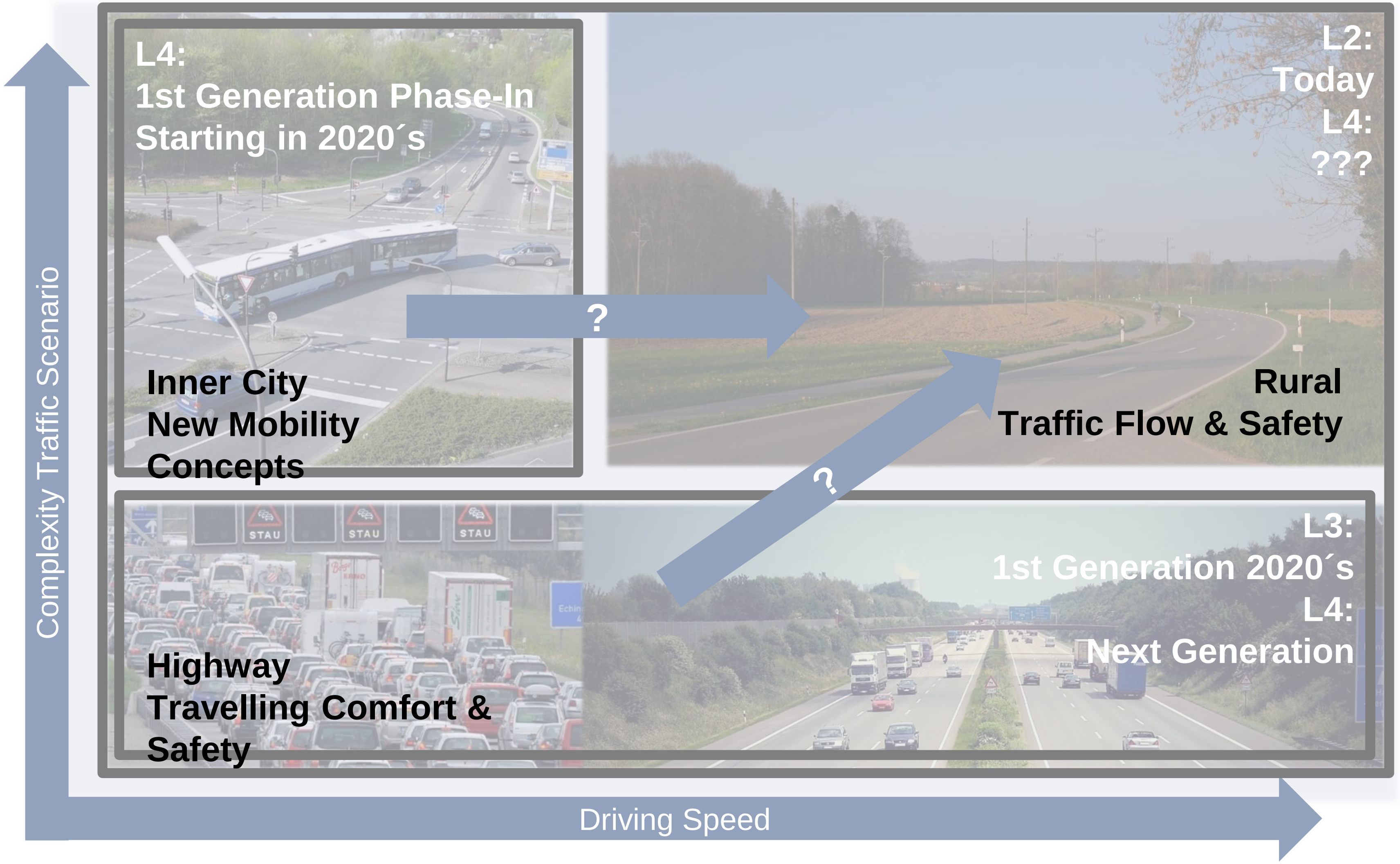
Highway Autopilot (Level 4)

Highway Convoy (Level 4)

Urban and Suburban Pilot (Level 4)

Passenger Cars: M1 category

Level 4 for passenger cars – what drives technology?
Rollout limited by scenario complexity and driving speed.



Automated Freight Vehicle Development Paths

Automation Level	Established – 2018 – 2020 – 2022 – 2024 – 2026 – 2028 – 2030 – ...
Level 5: Full Automation	Fully Automated Freight Vehicles
Level 4: High Automation	Highly Automated Vehicles in Confined Areas; Highly Automated Vehicles on Dedicated Roads; Highly Automated Vehicles on Open Roads; Highway Pilot Platooning
Level 3: Conditional Automation	Highway Chauffeur; Traffic Jam Chauffeur
Level 2: Partial Automation	Automated Truck Platooning; Traffic Jam Assist
Level 1: Driver Assistance	Adaptive Cruise Control, Stop &Go, Lane Keeping Assist, Lane Change Assist; C-ACC Truck Platoning
Level 0: No Driving Automation, support beyond human capability to act	Lane Departure Warning, Blind-spot Warning, Forward Collision Warning, ABS, ESC, Emergency Brake

Indicative development paths TRL 7-9

Truck: Freight vehicle > 3.5 tonnes categorie N2 or N3

Highway chauffeur, open roads

Unmanned vehicles, confined and hub-to-hub

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

Unmanned vehicles, confined and hub-to-hub

- Highly automated, <u>un-manned</u> 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

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Automated Urban Mobility Vehicle Development Paths

Automation Level	Established / 2018 / 2020 / 2022 / 2024 / 2026 / 2028 / 2030 / ...
Level 5: Full Automation	**Fully automated Urban Mobility Vehicles**
Level 4: High Automation	**Automated PRT/Shuttles on Dedicated Roads**; **Automated PRT/Shuttles in Mixed Traffic**; **Automated Buses on Dedicated Roads**; **Automated Buses in Mixed Traffic**
Level 3: Conditional Automation	**Automated Urban Bus Chaffeur**
Level 2: Partial Automation	**Urban Bus Assist**; **Traffic Jam Assist**; **Parking Assist**
Level 1: Driver Assistance	**Adaptive Cruise Control**; **Stop &Go**; **Lane Keeping Assist**; **Lane Change Assist**; **Parking assist**
Level 0: No Driving Automation, support beyond human capability to act	**Lane Departure Warning**; **Blind-spot Warning**; **Forward Collision Warning**; **ABS, ESC**; **Emergency Brake**

Indicative development paths TRL 7-9

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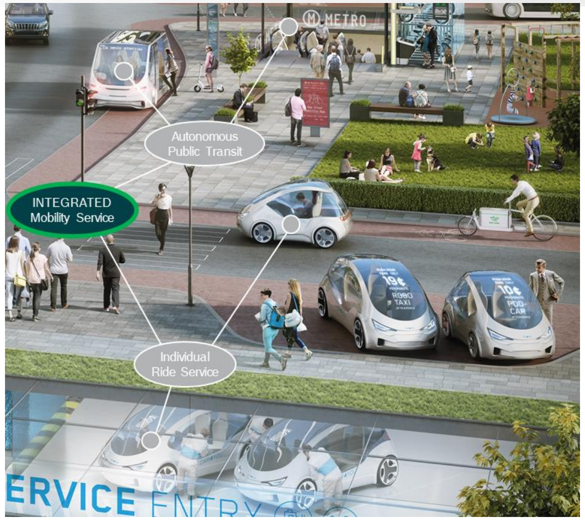


PRT (Personal Rapid Transit) incl. Urban Shuttle
City Bus/Coach: M2 < 5 tonnes < M3

Urban Mobility and Automation

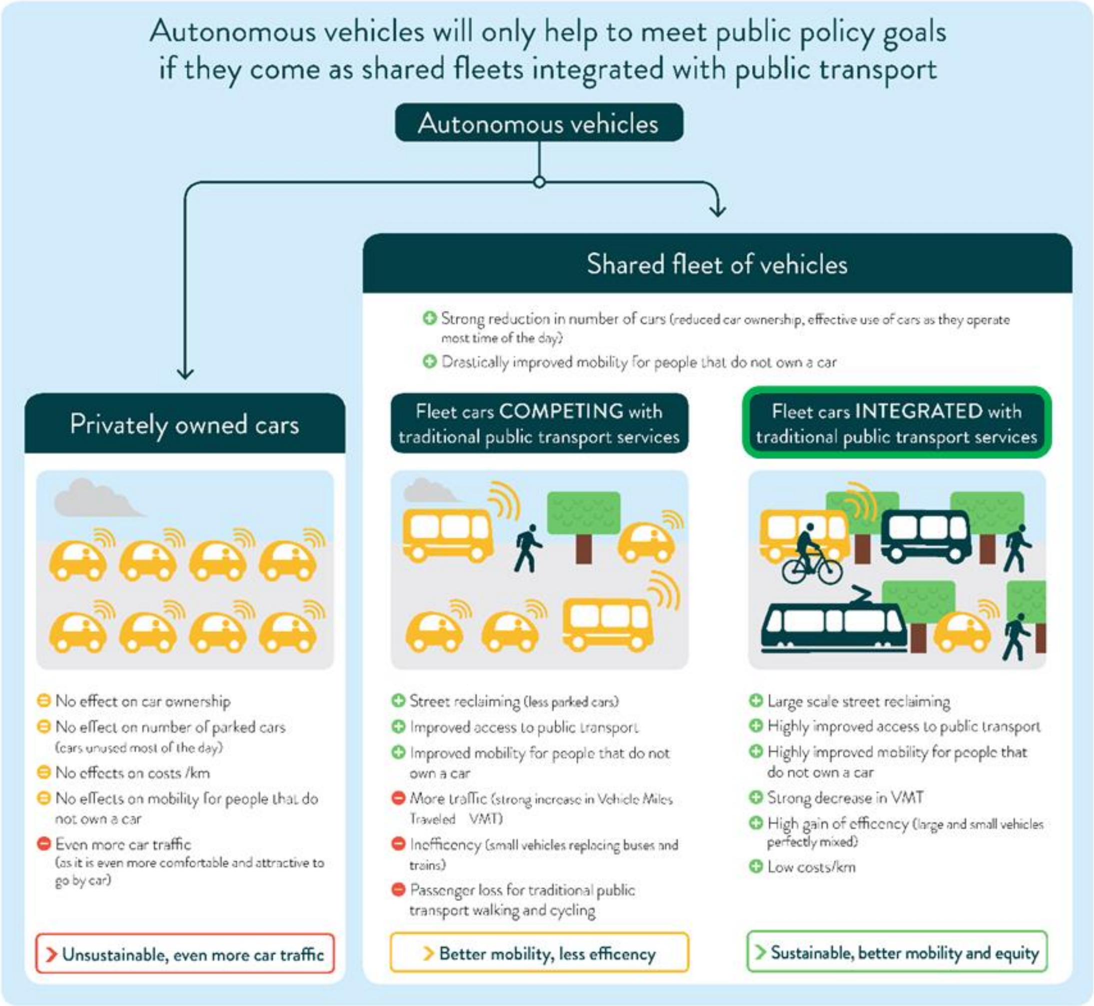
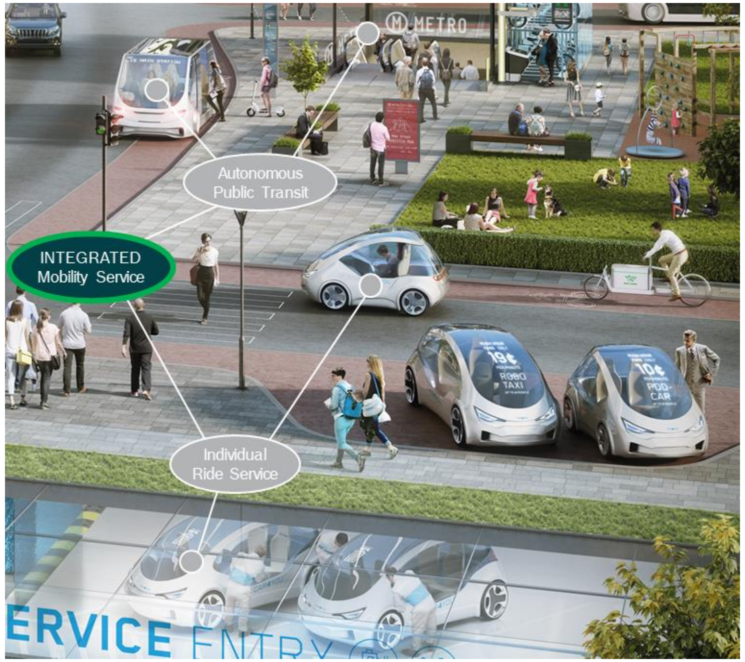
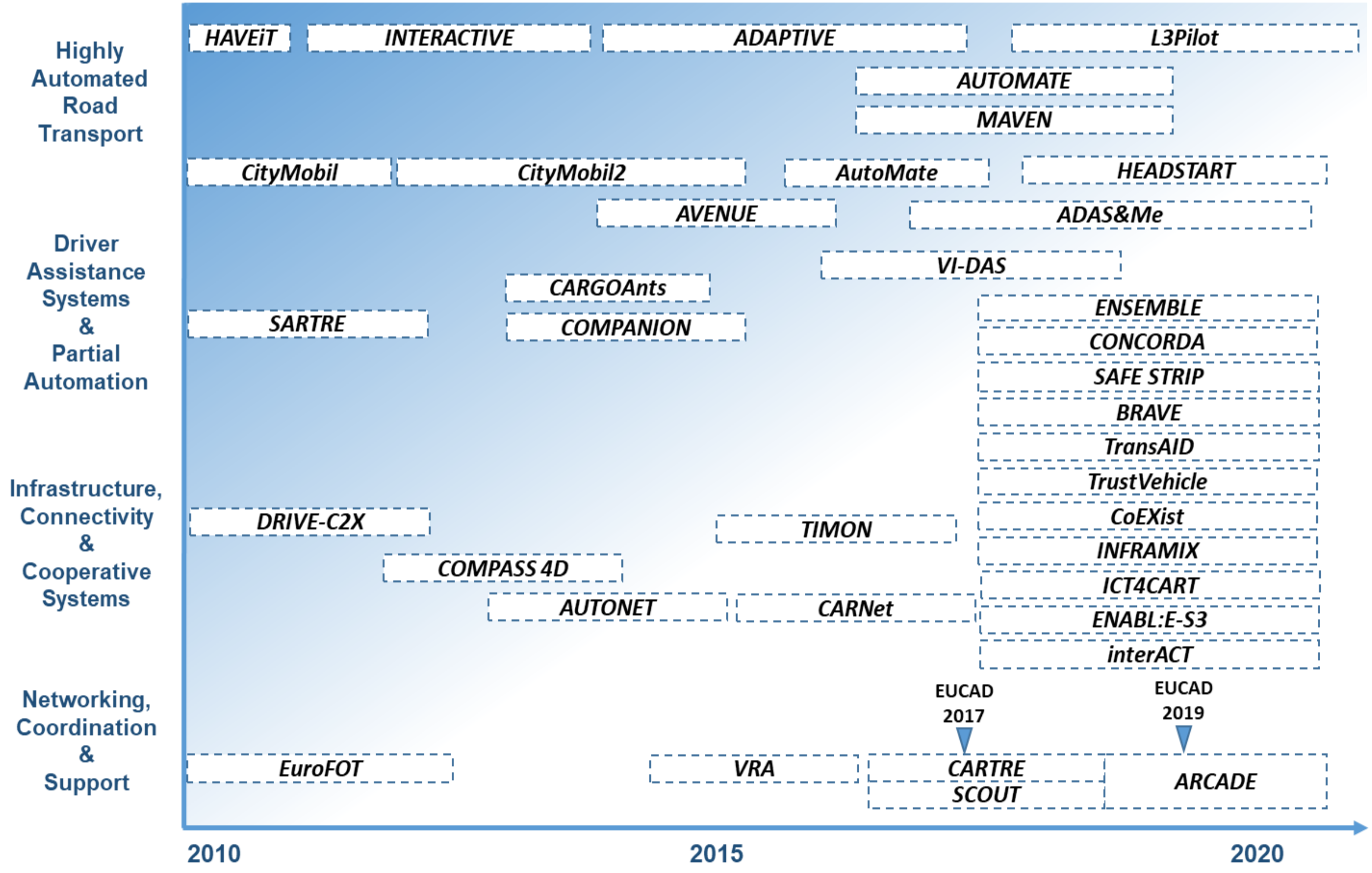


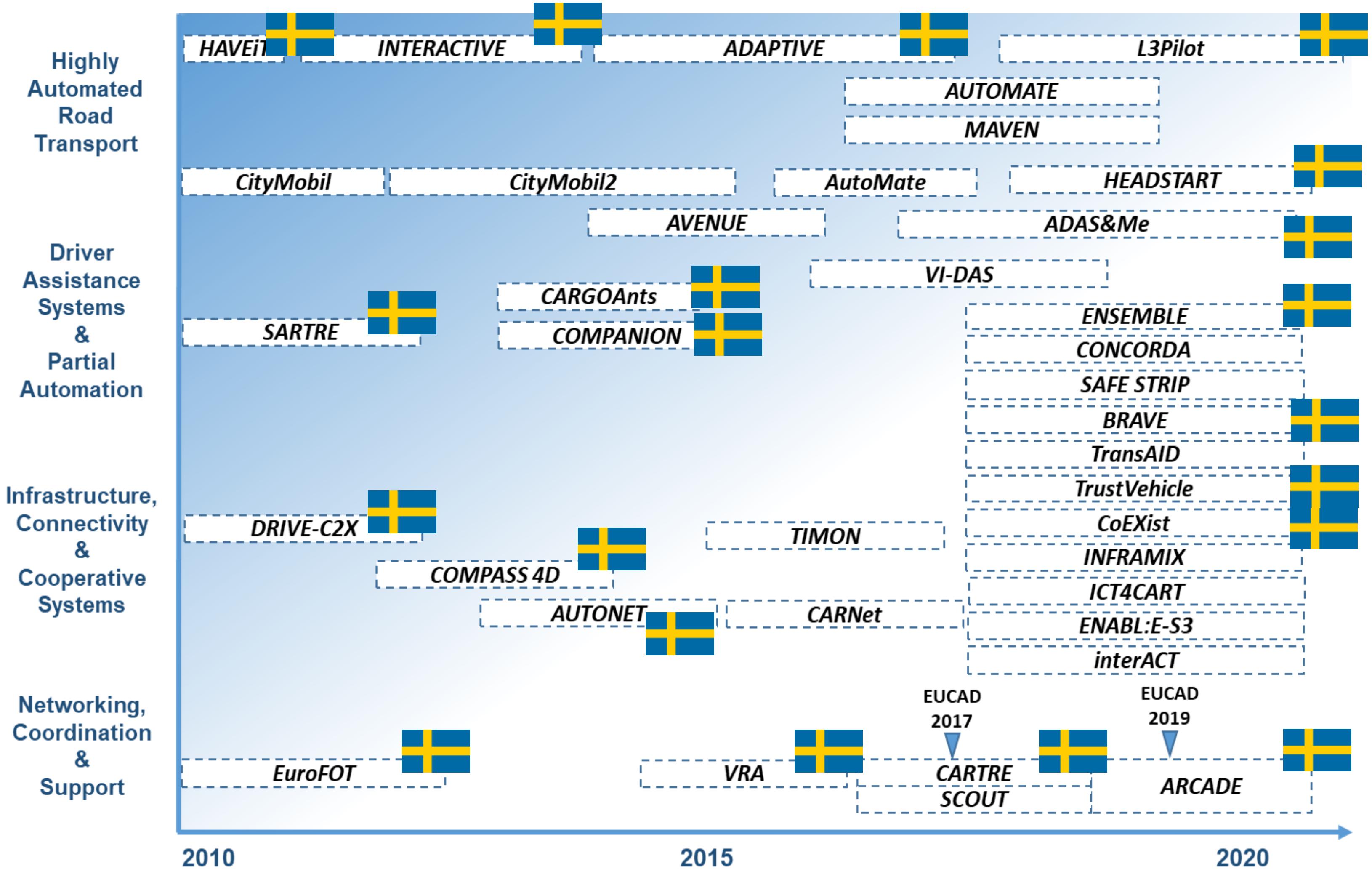
Image source: UITP, *Autonomous Vehicles: A potential game changer for urban mobility*. Brussels: International Association of Public Transport.



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



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



EU projekt med svensk medverkan;
https://connectedautomateddriving.eu/cad-knowledge-base/

Automated Road Transport Calls 2020

Grant **Efficient and safe connected and automated heavy-duty vehicles in real logistics operations** DT-ART-05-2020

Digitisation and transformation

Types of action: Innovation action | **Programme:** Horizon 2020

Forthcoming

Opening date: *03 December 2019*

Deadline model: *single-stage*
Deadline date: *21 April 2020 17:00:00 Brussels time*

Grant **Large-scale, cross-border demonstration of connected and highly automated driving functions for passenger cars** DT-ART-06-2020

Digitisation and transformation

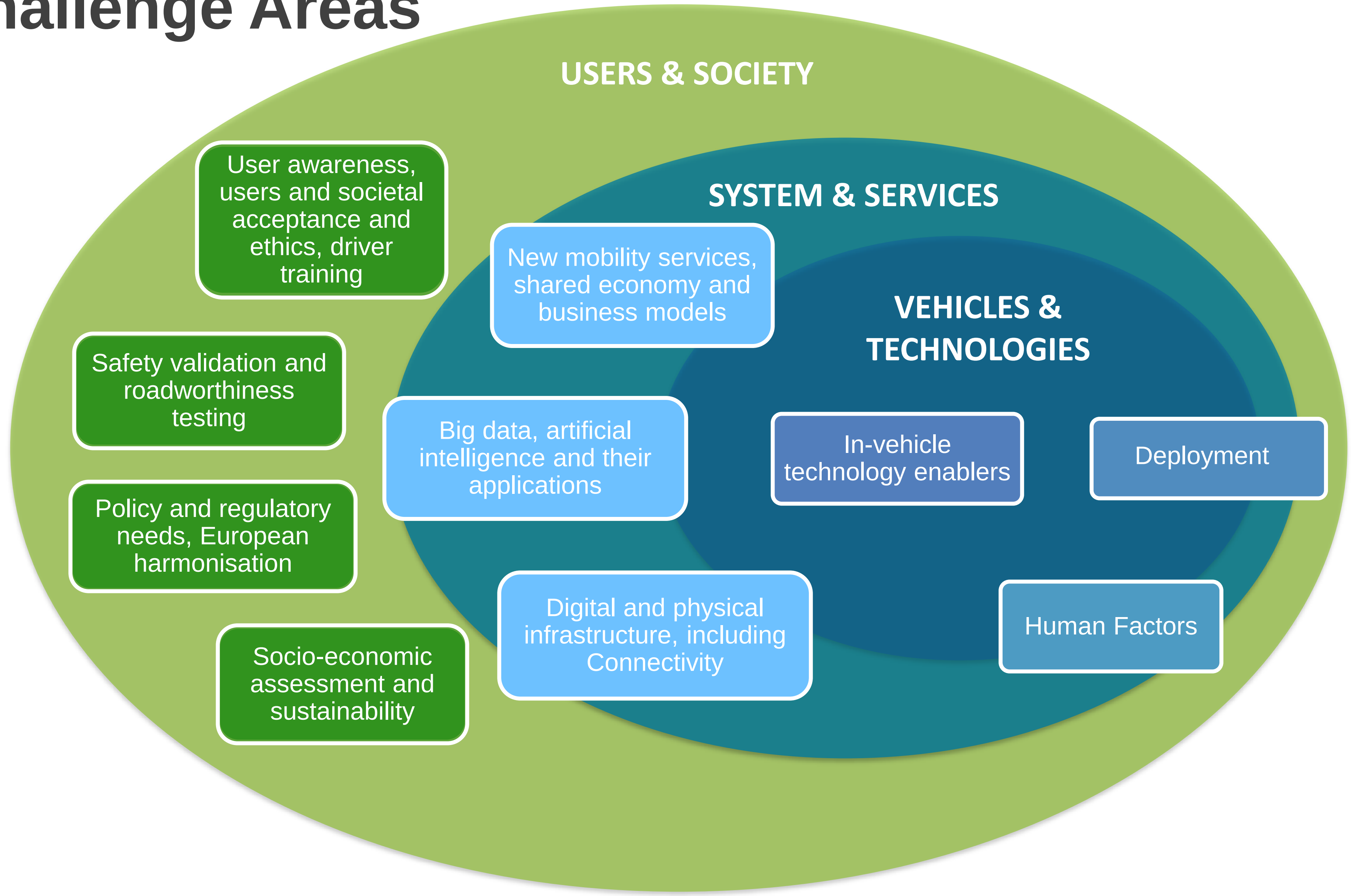
Types of action: Innovation action | **Programme:** Horizon 2020

Forthcoming

Opening date: *03 December 2019*

Deadline model: *single-stage*
Deadline date: *21 April 2020 17:00:00 Brussels time*

Key Challenge Areas



Collaboration and Exchange of Key Importance!

STRIA

R&I initiatives and Action Sheets:

- In-vehicle enabler
- Vehicle validation
- Large scale demonstration pilots to enable deployment
- Shared and automated mobility services
- Human factors
- Physical and digital infrastructure
- Big data, Artificial Intelligence and their applications

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ARCADE Project (CSA)

- **Joint-stakeholder Workshops**
- **Roadmap** Consolidation
- **EUCAD** Conferences and Seminar
- **Tri-lateral** (Japan, USA, EU) and beyond
- **Thematic Areas** Clusters;
  - Society & Users
  - Systems & Services
  - Vehicle & Technology

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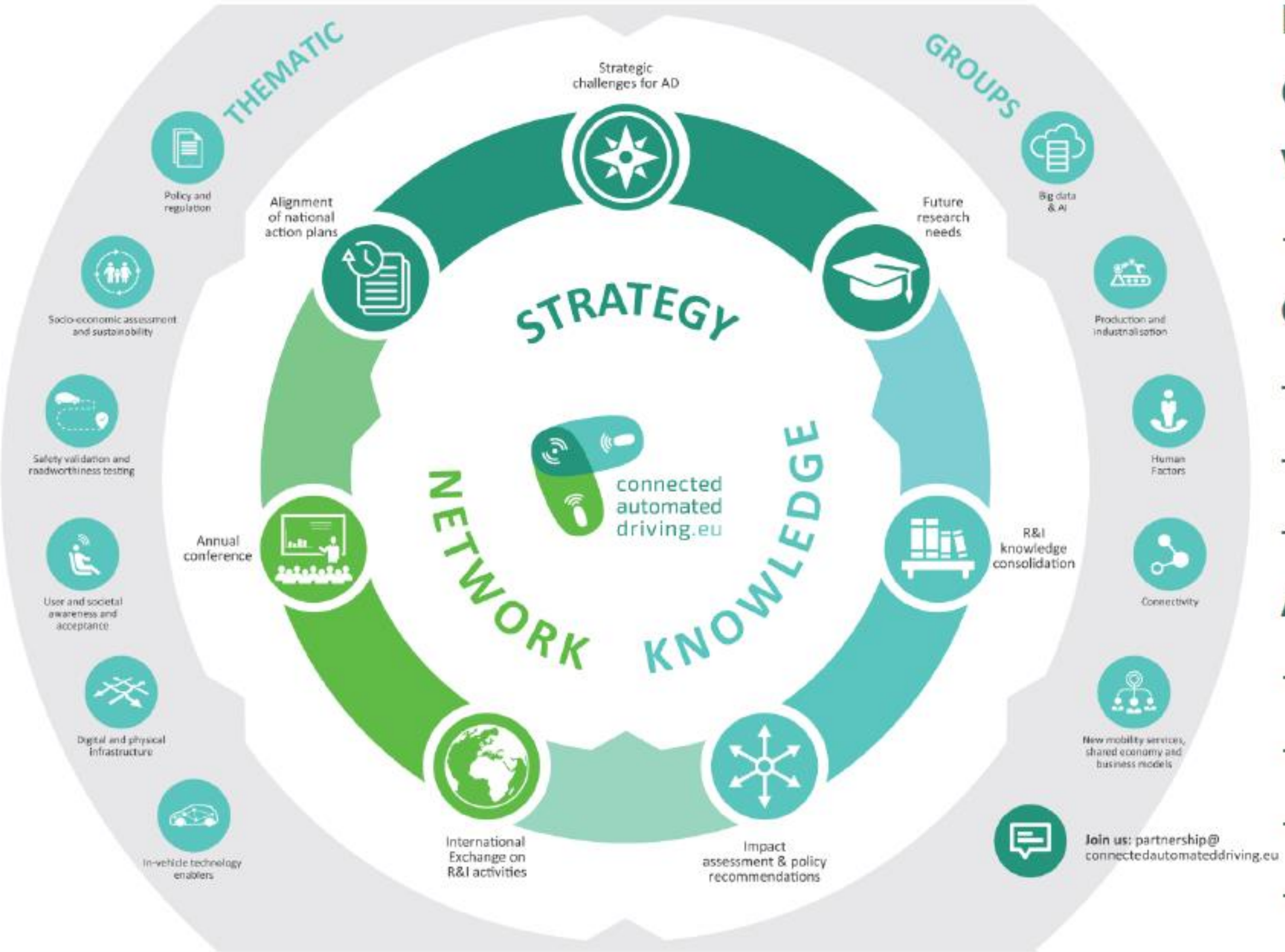
Coordination of Automated Road Transport For Europe

CARTRE
Coordination of Automated Road Transport Deployment for Europe

Objective: Support faster deployment of connected and automated driving across Europe



European Commission funded

Coordination & Support Actions

VRA

- July 2013 – Dec 2016

CARTRE

- Oct 2016 – Sep 2018
- 36 consortium partners
- 51 associated partners

ARCADE

- Oct 2018 – Sep 2021
- 23 partners from 11 States
- 30 associated partners
- 2000 subscribers

Thematic Areas

Technology
- In-Vehicle Enablers
- Connectivity
- Human Factors
- Deployment

System & Services
- Physical & Digital Infrastructure
- Big Data, AI and applications
- New Mobility Services, shared economy
- Freight & Logistics

Society & Users
- Safety Validation Roadworthiness testing
- Policy and regulatory needs
- User awareness, societal acceptance and ethics
- Socio-economic assessment

- Visions
- Challenge
- SoA
- Gaps
- Positions

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Consolidated Key Priorities per Use-Case vs Thematic area (ver.20190913)

Development Paths / Use Cases	D3.7 Society Challenges & Scenarios				D3.4 Systems and Services Challenges & Scenarios			D3.1 Technical Challenges & Scenarios			
	User awareness, users and societal acceptance and ethics, driver training	Safety validation and roadworthiness testing	Policy and regulatory needs, European harmonisation	Socio-economic assessment and sustainability	New mobility services, shared economy and business models	Big data, artificial intelligence and their applications	Digital and physical infrastructure	Human Factors	Connectivity	Deployment	In -vehicle technology enablers
Generic	Societal Needs Analysis from user and society perspectives	Alignment of vehicle regulation (and type approval) and corresponding assessment tools & procedures	Working for flexible AD regulation, enabling different solutions, within the boundaries of safety.	Impact assessment needs both pilots (low TRL) and FOTs (high TRL)	Proof of viability only possible when automated fleets is available	Consolidate data sharing framework (trust, privacy, liability, data protection, meta-data description, access, etc.) starting from success cases	Need for definitions, standardisation if the interaction of PDI and AVs (e.g. ISAD, ODD)	Integrated Safety (passive, active, seating positions, crash impact, etc)	Definition of connectivity requirements for AD functions (performance, QoS, resilience, etc.)	Tests and Demonstration e.g. Cross-border	Harmonize definition of ODDs and functionalities needed for given ODDs
	Positive Risk analysis	Determine proper combinations of virtual testing, closed test track and open road testing of AVs, connectivity and cyber-security	Learn from adaptation of regulation, work towards common approach	Development of EU-level databases to allow more reliable scaling up (data on accidents, mileage, etc. including ODD aspects, with sufficient details and granularity)	Pilots and FOTs are needed to validate business case, opetational models and specifications	Validation of AI is a bottleneck. Harmonisation, alignment needed for development and validation of AI functionalities for AV	Define Classifications of PDI	Interaction with external road users (mixed traffic)	Specification of Day 2 and Day 3 C-ITS services	L4 Pilots	Define, develop, and validate robust and scalable perception systems and sensor sets
	Ethics evaluation based on technology understanding	Share and harmonise driving/traffic scenarios and best practices, including cyber-security	Learn from adaptation of regulation. Build common framework.	Development of commonly available (validated) AV simulation and other evaluation tools	Raise authorites awareness of new role of services, system, integration and operation	Standards and solutions (HW/SW) for data management and data quality (e.g. L3Pilot)	AV-ready road planning and self-explaining roads. (e.g traffic signs and lane marking for Avs)	New role of remote operators (sustain attention, control evironments, etc)	Standardisation and further deployment of V2X technologies	L3 FOT (L4 FOT unclear when possible)	Develop technologies supporting vehicle's own understanding of ODDs and cooperation between AD vehicles. (incl. maps, localization,..)
	Impact on driver/users and operator training	Consensus building with respect to validation of methodologies, including Data-labeling standards	Make cross-border testing easy	Commitment to use common impact assessment methodologies (like FESTA, Trilateral framework)	Integration of new services with existing services (e.g. public transport) from start	New AI-concepts for cyber-physical road traffic systems	Promote the use of common definitions (e.g. ISAD). Create Living lab with PDI	Behavioral change. Social inclusion	(Cyber)secure and safe communications respecting privacy and various levels of trust	Promote deployment through simulations of scenarios, road transport & traffic management	Reach efficient integration of overall system in fail-operational architectures (costs, energy, redundancy)
	Secure privacy for mobility users	Developing procedures to manage validation of vehicle updates (eg., over the air software updates) monitoring during the whole lifecycle of the vehicle.	Harmonisation of the interpretation of traffic rules, digitalization of traffic sign information	Research on the long-term indirect impacts of automation, equity etc.	Further develop urban delivery AD solutions		Clarify the new roles and responsibilities of AD	Learning, education	Interoperability of communication technologies / Hybrid connectivity solutions		Maintain system integrity and well-functioning once in the field, monitor for updates
Passenger Cars		Homologation framework and simulations, self-certification		Impacts on safety and travel behaviour	Peer-to-peer sharing	New robust AI-passenger-car solutions				Customer pilots with non-homologated vehicles	
Freight Vehicles	New fleet operation sceems for AV	Homologation framework Hub-to-hub, semi-confined ODDs	Business case for platooning need to be clarified depending on regulation scenario	Impacts on transport network efficiency and environment	Logistics services Business need for AD (TCO)	New AI freight and logistics solutions	Hub-to-hub corridors Freight traffic management. Truck parking safe-zones for AD trucks	The role of professional truck drivers	Correctness and latency for multi-brand configuration	Commercial pilots	Superstructure, e.g. trailer)
Urban Mobility Vehicles	City authority perspectives	VRU scenarios for unmanned buses and shuttles	Support early introduction through exemptions	Impacts on transport mode choice and social inclusion	Further develop urban delivery AD solutions	New AI urban mobility solutions	Traffic management complementing public transport	The role of professional bus drivers	Specific requirements for remote operation "control-tower"	Identify needs.	Low-speed, low-tech AVs

Single platform for open road testing and pre-deployment of cooperative, connected, automated and autonomous mobility (CCAM)

- The EC has launched a “Single platform for open road testing and pre-deployment of cooperative, connected, automated and autonomous mobility (CCAM)”.
- For details see: https://ec.europa.eu/digital-single-market/en/news/call-applications-selection-members-single-platform-open-road-testing-and-pre-deployment

Working Groups established

WG1 Develop an EU agenda for testing

WG2 Coordination and Cooperation of R&I

WG3 Physical and Digital road infrastructure

WG4 Road Safety

WG5 Access to and exchange of data & Cybersecurity

WG6 Connectivity and digital infrastructure

Horizon Europe – Important to provide Swedish input

- **4.2 Cross-sectoral solutions for decarbonisation**
  - 4.2.1 Establish a competitive and sustainable European battery value chain
  - 4.2.2 Strengthen the European value chain for low-carbon hydrogen and fuel cells
  - 4.2.3 Develop sustainable infrastructure, services and systems for smart and sustainable communities and cities
- **4.5 Develop low-carbon and competitive transport solutions across all modes**
  - 4.5.1 Achieve zero-emission road transport
  - 4.5.4 Enable low-carbon, clean and competitive waterborne transport
- **4.6 Develop seamless, smart, safe and accessible mobility systems**
  - 4.6.1 Make automated and connected road transport safe and competitive
  - 4.6.2 Develop efficient and innovative transport infrastructure
  - 4.6.3 Develop the future transport network and integrated traffic management
  - 4.6.4 Enable multimodal freight logistics and passenger mobility services
  - 4.6.5 Increase transport safety across all modes

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Conclusions

- ERTRAC CAD Roadmap, an important common reference for European R&I and provides recommendations for the European Commission
- Two remaining calls related to Automated Road Transport 2020
- ARCADE CSA project maintains the Network, Knowlende Base, Thematic Areas towards further development of a Consolidated Roadmap
- CCAM Single Platform is important for common tests, R&I, Safety, data sharing, cyber-security, infrastructure etc.
- Co-Design for Horizon Europe is ongoing – Important to provide Swedish input and align with FFI strategies.
- **Use FFI projects to build Swedish capacity towards European exploitation of results!**