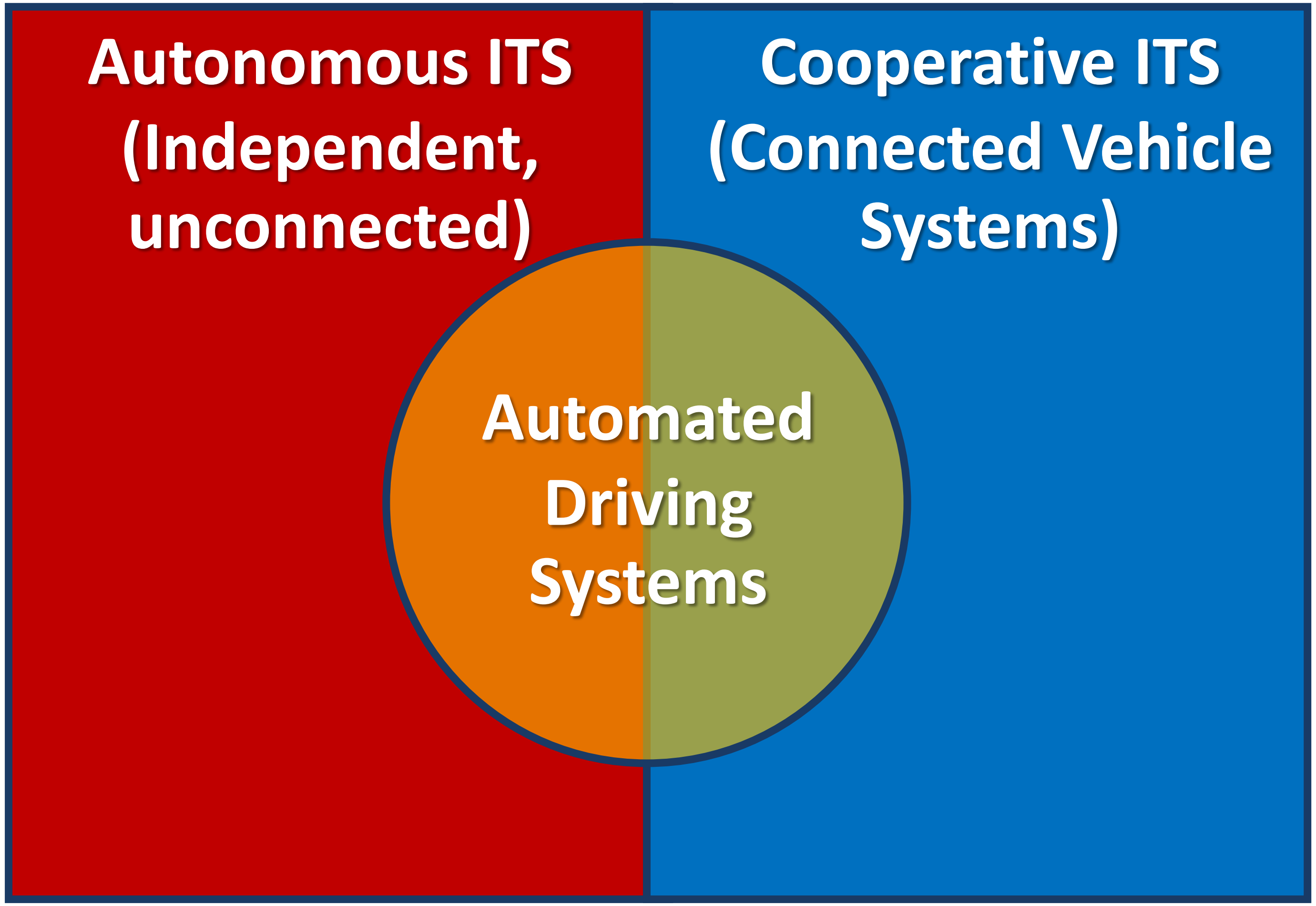
Connected and Automated Vehicles "CAV"

BUREAU OF ROAD RESEARCH AND DEVELOPMENT
DEPARTMENT OF HIGHWAYS

Ponlathep Lertworawanich
Director of Road Research and Development Bureau,
Department of Highways, Thailand

Classification of CAVs



Schematic depiction of distinctions among autonomous, cooperative, and automated systems

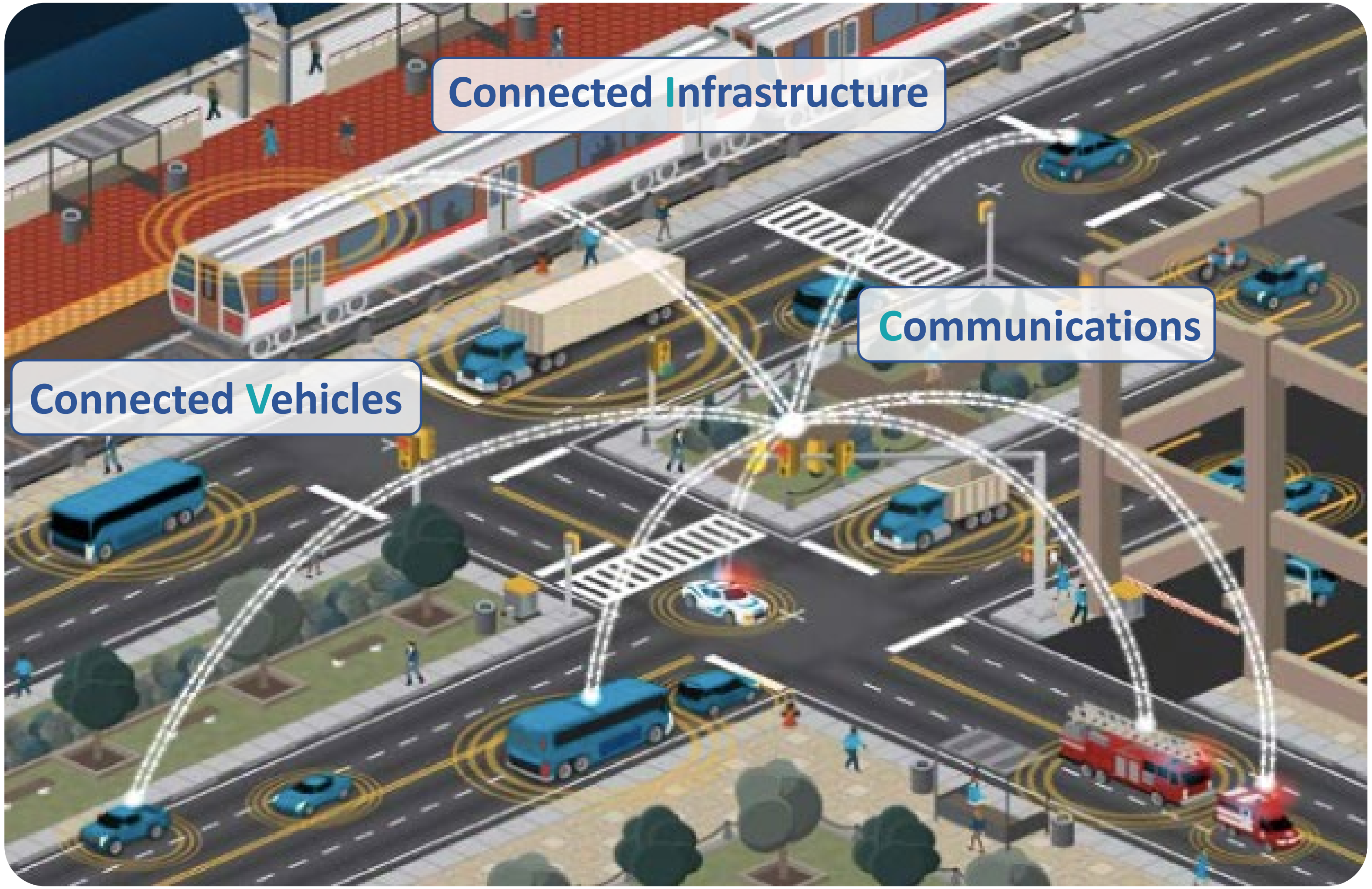
Ecosystem of Connected Vehicles

The Connected Ecosystem enables **improvements in**

- Safety,
- Mobility,
- Operations,
- and Environmental impacts

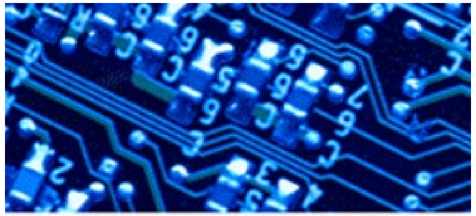
by **sharing situational** awareness data and alerts among

- Vehicles,
- Infrastructure,
- Pedestrians,
- and other travelers.



Connected Vehicles

What is inside the connected vehicle?

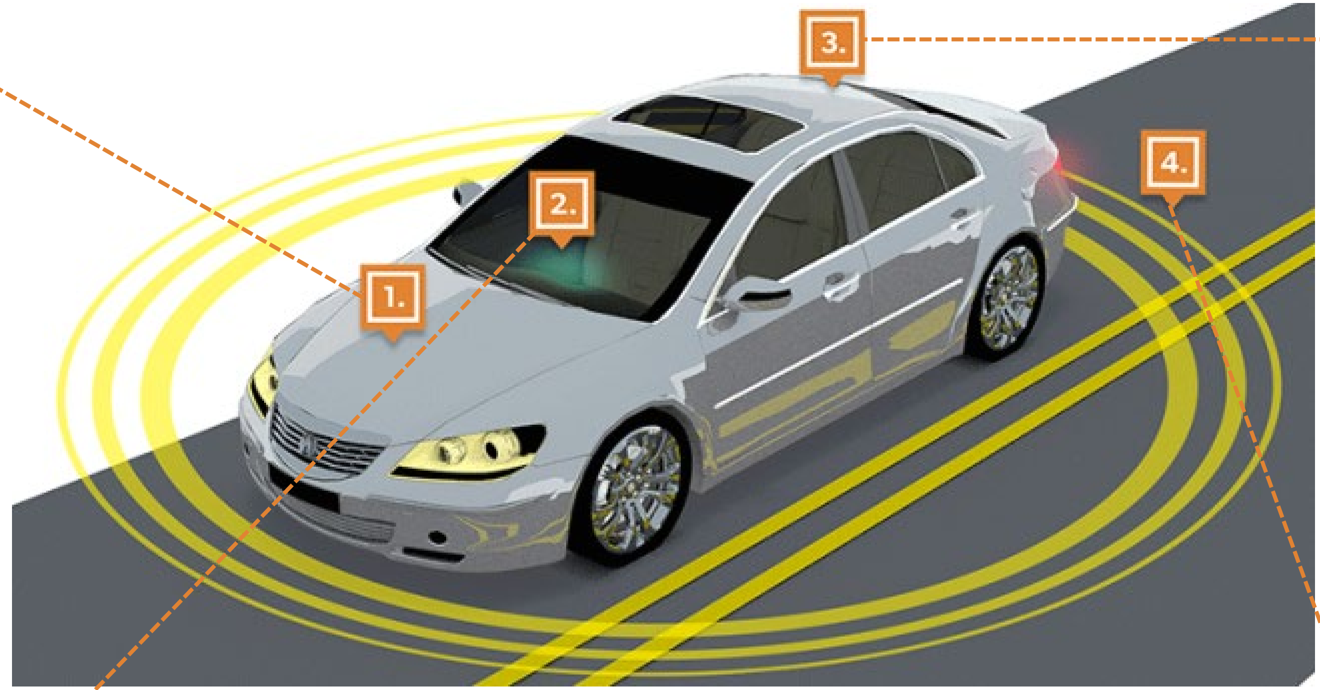


1. Processors

An under-the-hood box (a processor with memory) collects and transmits data between the vehicle's onboard equipment (OBE) and between OBE on near-by connected vehicles and safety devices along the roadside.

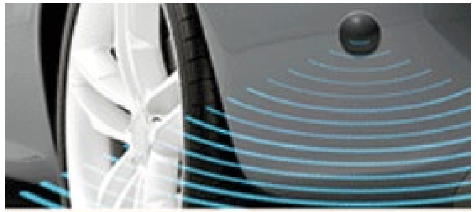
2. Display panel

A display panel, sitting in the vehicle's center console opposite the driver's dashboard, displays audio or visual safety warnings to the driver.



3. Radio communication (DSRC and C-V2X)

A radio and antenna, using dedicated short-range communications (DSRC) and a GPS receiver, receive and transmit data about the vehicle's position to other vehicles and to safety devices along the roadway.



4. Sensors

Sensors collect additional information that improves the accuracy of the data being collected and transmitted by the vehicle.

Smart highways is a functional Class

- Propose smart highways as a new functional class for highways

Conventional Classification

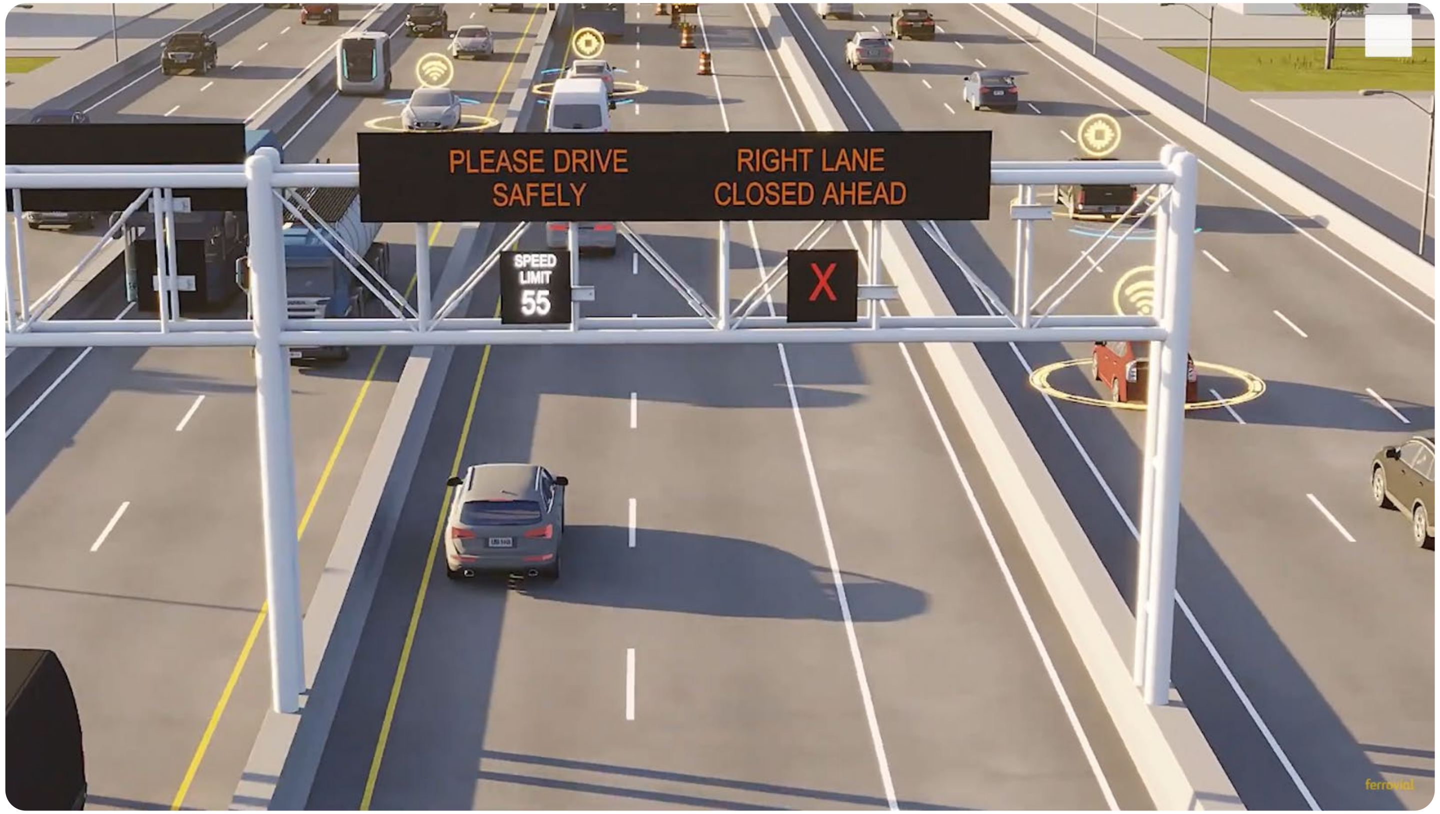
Freeways

Arterials

Collectors

Local

Smart highways (New Class)



Smart highways is a functional Class

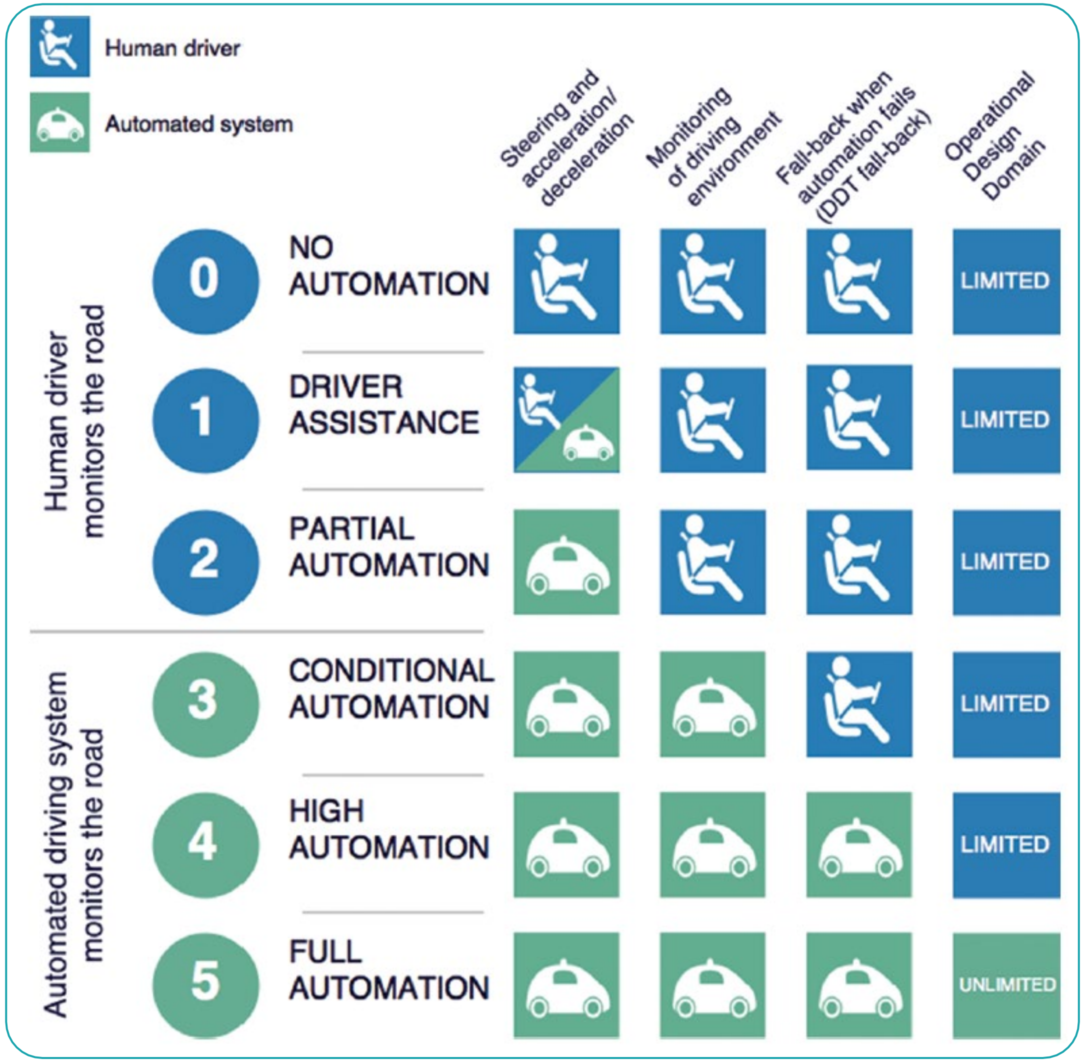
How to classify smart highways

It will depend on how smart highways are

- Smart Road Classification (SRC) application (Yes/No)
- SAE Level operate on those highways
- Digital Infrastructure Availability (Yes/No)
- Data about Disengagement and Operational Design Domain

  The availability on where or specific locations of highways that the CAV(s) will disengage from the smart highway (infrastructure)

SAE J3016 levels of driving automation.



Smart highways is a functional Class

Considering the previous scenarios, a five-level SRC is suggested:

- **Humanway (HU) road segments.** These road segments do not support automation.
- **Assistedway (AS) road segments.** These road segments present partial support for automation, with remarkably less disengagements than on HU road segments.
- **Automatedway (AT) road segments.** These road segments present similar physical characteristics than AS road segments, but also present connectivity capabilities that could help connected vehicles prevent and avoid disengagements.
- **Full Automatedway (FA) road segments.** These road segments present full support for SAE level 4 vehicles, and good connectivity capabilities.
- **Autonomousway (AU) road segments.** These road segments present full support for SAE level 4 vehicles and exceptional connectivity capabilities. They can only be used by SAE level 4 and 5 vehicles.

Digital Transport infrastructure

- **During the automate part of their journey, the CAV rely on on-board systems (Camera, Sensors) and digital feeds from the road infrastructure.**
  - **Maintenance of physical road infrastructure** (Marking, Signs and signals) to ensure a high level of readability by the vehicles on-board system.
  - **Provision of Digital Information:** Infrastructure to Vehicle services (I2V) to support recognition of physical as well as legal elements of roadways. Automated vehicle functions are supported by providing information on active regulations, max speed limit or access restrictions.
- **Physical and Digital elements**, a harmonization of the supporting elements is needed by Road Authorities to ensure good inter-operability.

Digital Transport infrastructure

- **The Digital Road Infrastructure is defined as the digital representation of road environments required by Automated Driving System**
  - **Static**

    - Basic Map Database *(e.g. Digital cartographic data, Topological data, Road Facilities)*
  - **Semi-Static**

    - Planned activities and forecast *(e.g. traffic regulations, road works, weather forecast)*
  - **Semi-Dynamic**

    - Traffic Information *(e.g. accidents, congestion), local weather current conditions - Smart Traffic Management Center requests, variable speed limit;*
  - **Dynamic**

    - Information through Vehicle to X communication *(e.g. surrounding vehicles, vulnerable road users, traffic signals, traffic management);*
  - **Dynamic driving recommendations** *(e.g. lane change, distance gap, speed).*

Digital Transport infrastructure

- **Digital Transport Infrastructure can be classified into different levels as shown in the figure below.**

Source: Routes/Roads 2021 - N° 391 - www.piarc.org

TABLE 1 - LEVELS OF THE INFRASTRUCTURE SUPPORT FOR AUTOMATED DRIVING[3]

	Level	Name	Description	Digital information provided to AVs: Digital map with static road signs	Digital information provided to AVs: VMS, warnings, incidents, weather	Digital information provided to AVs: Microscopic traffic situation	Digital information provided to AVs: 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.				
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 (landmark 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 from and can be provided to AVs	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	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 Transport Infrastructure

is

the Digital TWIN

of

Automated Vehicles