COURSE 3
INTELLIGENT TRANSPORTATION SYSTEMS

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- ITS for vehicles
- ITS for public transport
- ITS for the transport of goods
- ITS for infrastructure

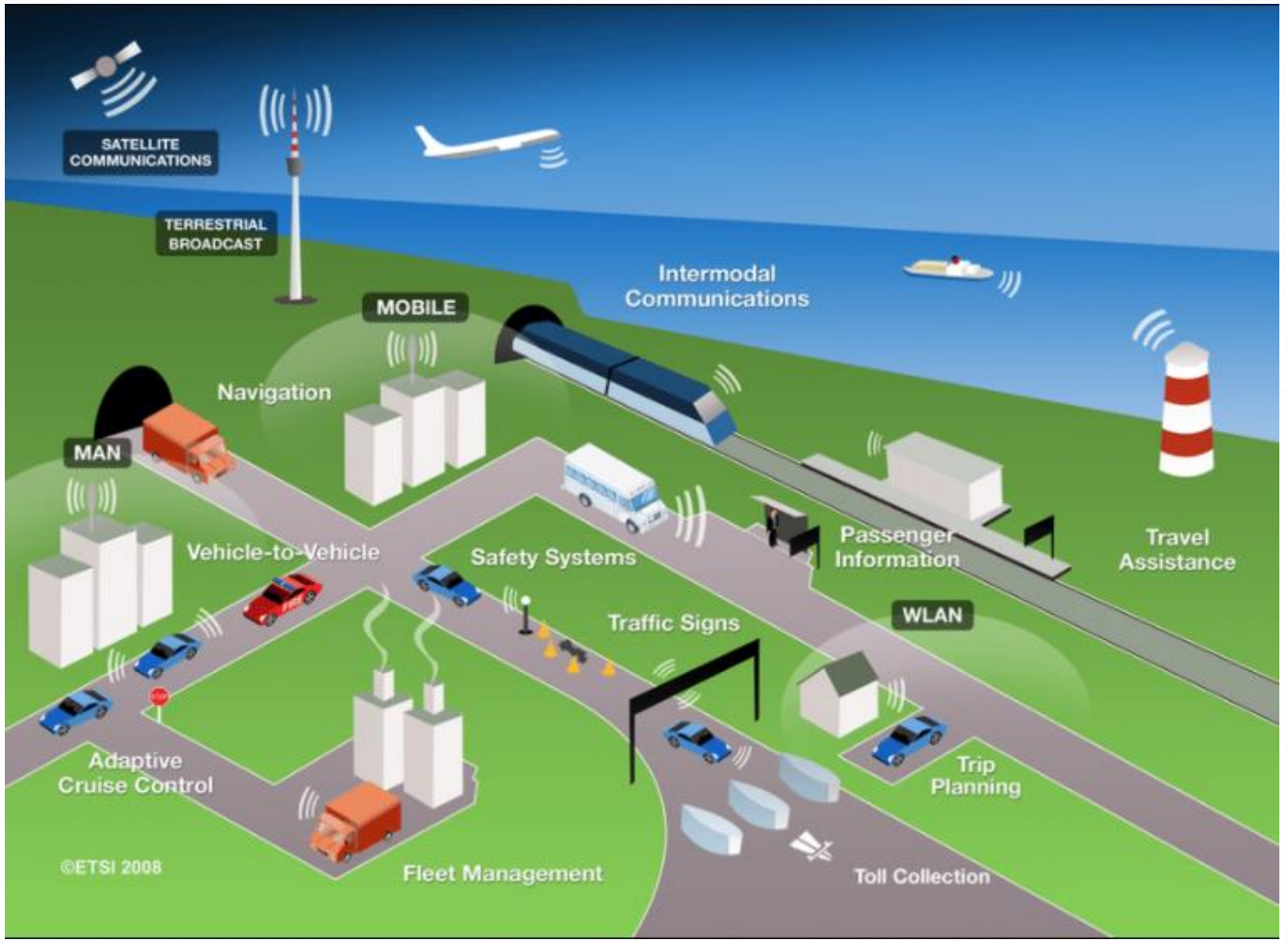
INTRODUCTION

- ITS definition: Directive 2010/40/EU of the European Parliament and of the Council:
  - “Intelligent Transport Systems (ITS) are advanced applications which without embodying intelligence as such aim to provide innovative services relating to different modes of transport and traffic management and enable various users to be better informed and make safer, more coordinated and ‘smarter’ use of transport networks.”
  - The directive only applies to road transport, but ITS can refer to all modes of transport
- The ITS combines telecommunications, electronics and information technology with transport engineering for the design, operation and management of transport systems

INTRODUCTION

- The application of information and communication technologies in the road transport sector and its interfaces with other modes of transport contributes to the improvement of:
  - Environmental performance
  - Efficiency, including energy efficiency
  - Road transport safety and security
  - Public security
  - Passenger and freight mobility
- Examples of services:
  - Emergency call in case of accidents
  - Using surveillance cameras to enforce traffic rules
  - Smart traffic lights, etc.

INTRODUCTION



- *ETSI

ITS CLASSIFICATION

- In case of road transport, ITS can be used for:
  - Vehicles (cars)
    - Traffic information systems
    - TMC channels (Traffic Message Channels)
    - Parking information
    - Navigation and location
    - eCall system
    - ADAS (Advanced Driver Assistance Systems)

ITS CLASSIFICATION

- Public transport
  - Data communications
  - Passenger information services
  - Automatic vehicle location
  - Prioritization of vehicle assignments
  - Electronic charging systems
- Transport of goods
  - Vehicle routing and monitoring
  - WIM (Weigh-in-Motion) systems – also used for railway and air transport
  - Intelligent accident localization
  - Digital tachographs

ITS CLASSIFICATION

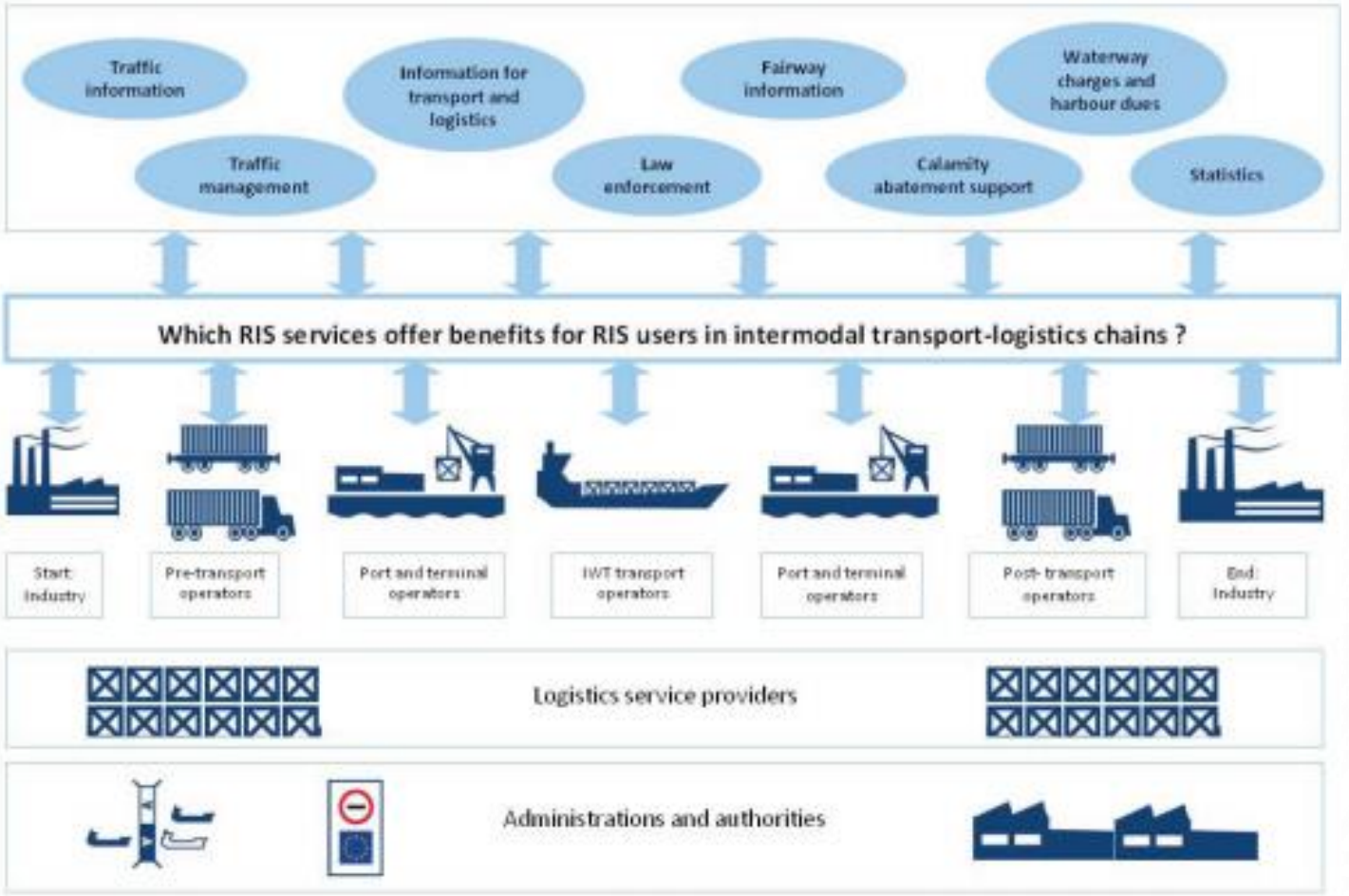
- Infrastructure
  - ETC (Electronic Toll Collection)
  - Variable message signs
  - Dynamic traffic light control
  - Automatic traffic control systems (e.g. EDS, Electronic Data System)
  - Automated highways for autonomous cars

- In the case of railway transport the main ITS components are (according to UNECE):
  - ETCS: European Train Control System
  - GSM-R: Global System for Mobile communication for Railways

- In the case of naval transport:
  - RIS (River Information Services)

ITS CLASSIFICATION

- RIS is designed to optimize traffic and river transport processes

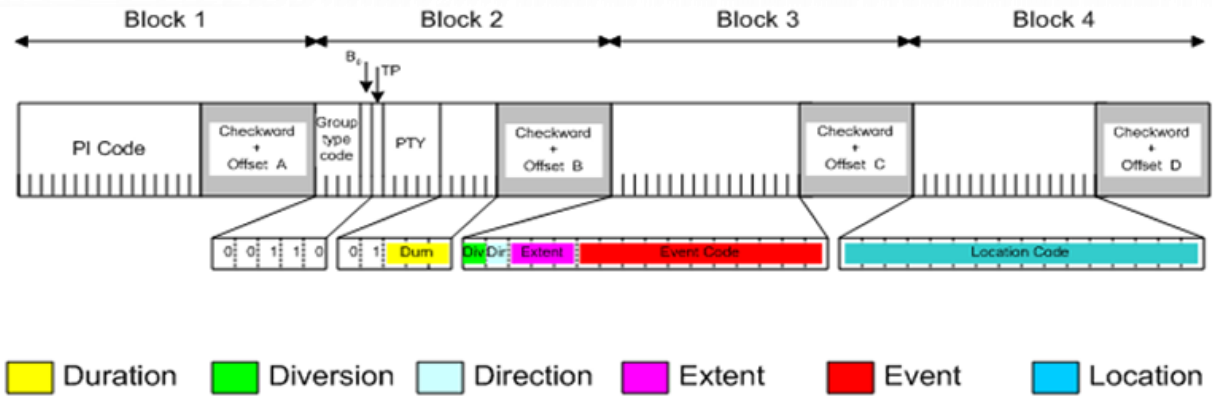


ITS FOR VEHICLES

- TMC – (Traffic Message Channel)
  - Information and traffic conditions are sent in the form of broadcast messages through a digital radio channel (RDS – Radio Data System)
    - RDS is used to provide information about radio stations such as PI - Programme Identification, PS - Programme Service, AF - Alternative Frequency list, PTY - Programme Type, RT - RadioText, TP - Traffic Programme flag, TA - Traffic Announcement flag, etc.
    - The information is transmitted in 104-bit RDS groups of which 64 bits of data
      - The data is divided into 4 16-bit blocks, of which the first 27 bits are fixed and appear in each RDS block, and the last 37 bits contain information specific to each block
    - TMC is the most widespread RDS service
      - The data is represented by a series of standardized codes

ITS FOR VEHICLES

- TMC announces an event in the form of:
  - Description, location, direction and other additional information such as duration, average speed, alternative routes, etc.



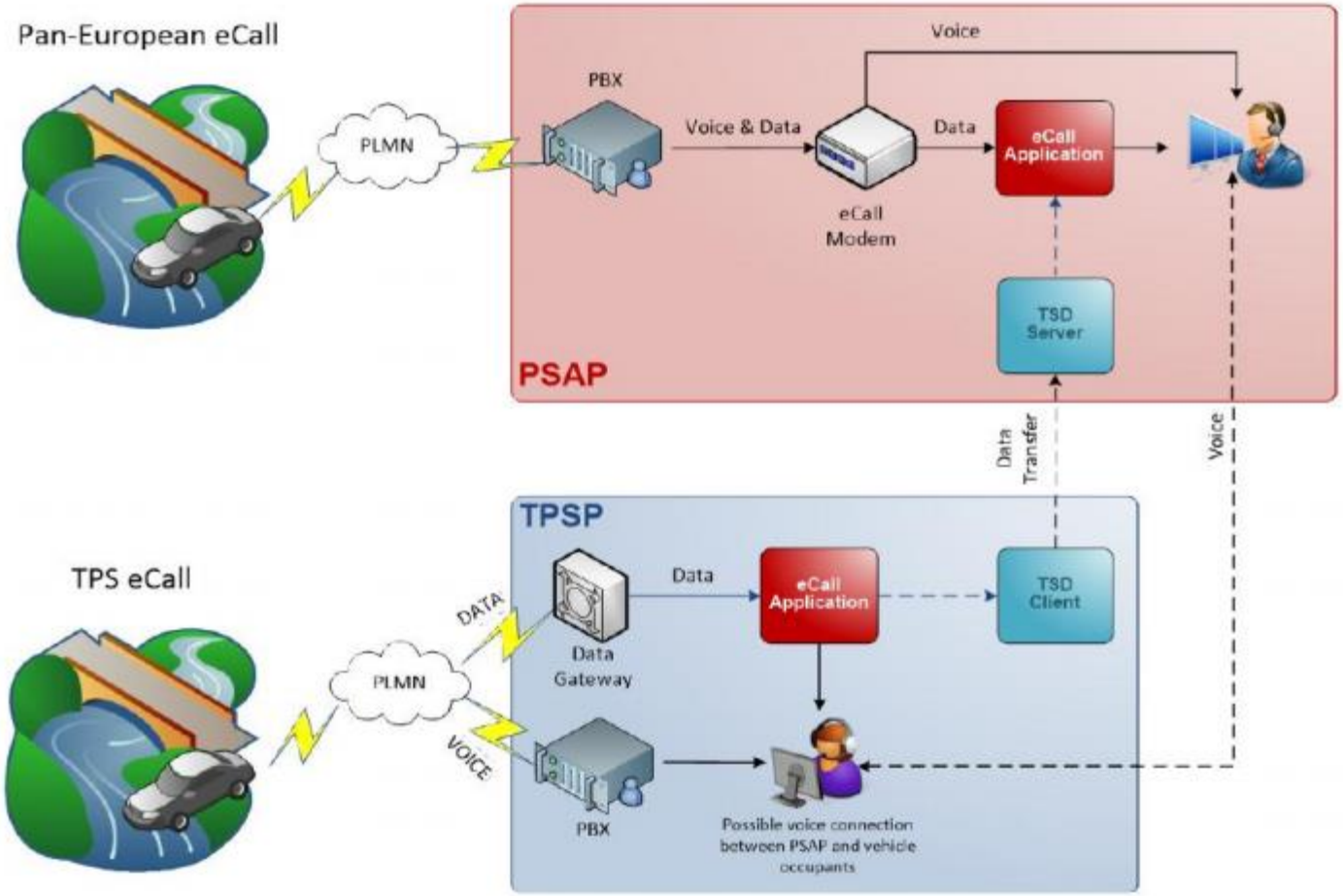
- Each TMC message is sent 3 times in a row
  - If two received messages are identical, it is considered a correctly received message
- TMC can be integrated with navigation systems
  - To enable traffic events to be displayed on the map, to each road segment is assigned a unique code in the world, TMC Location Code
  - In case of critical conditions, the navigation system may propose alternative routes

ITS FOR VEHICLES

- Cooperative technologies
  - Cooperation between infrastructure and vehicles
    - V2V (Vehicle to Vehicle) Communications
    - V2I (Vehicle to Infrastructure) Communications
- eCall System
  - Standardized in the EU, mandatory for every new car sold after 31.03.2018
  - Allows an on-board emergency call to 112
    - The call can be made automatically activated by sensors in the vehicle or manually
    - A Minimum Set of Data (MSD) is transmitted
      - Location of the vehicle, direction of travel, date and time, VIN (Vehicle Identification Number)
    - An audio channel is established between the occupants of the vehicle and the emergency response center

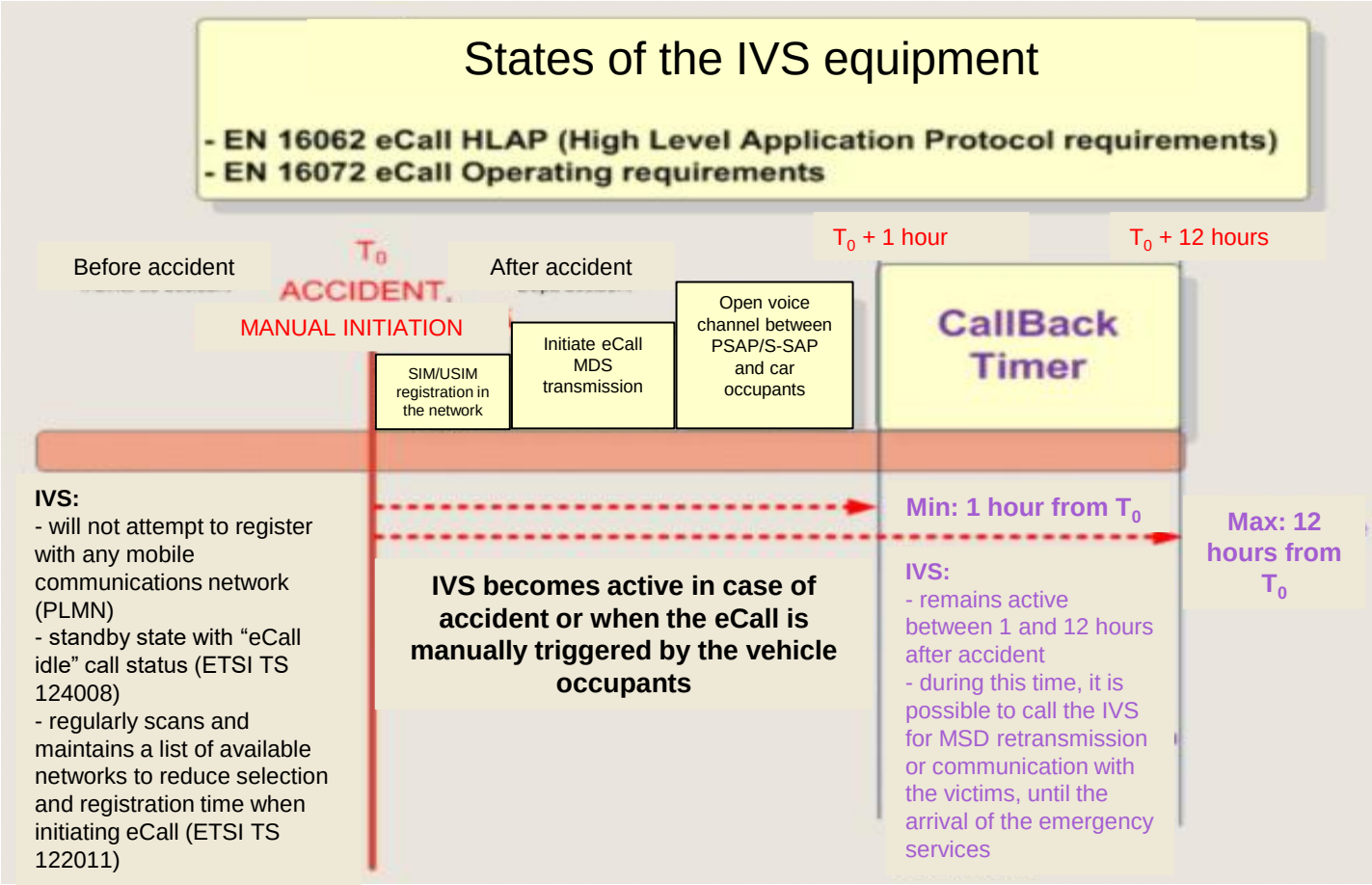
ITS FOR VEHICLES

- eCall architecture
  - IVS: In-Vehicle System, TPSP: Third-Party Service Provider, PSAP: Public Safety Answering Point, TSD: TPS eCall Set of Data



ITS FOR VEHICLES

- IVS states configured for eCall



ITS FOR VEHICLES

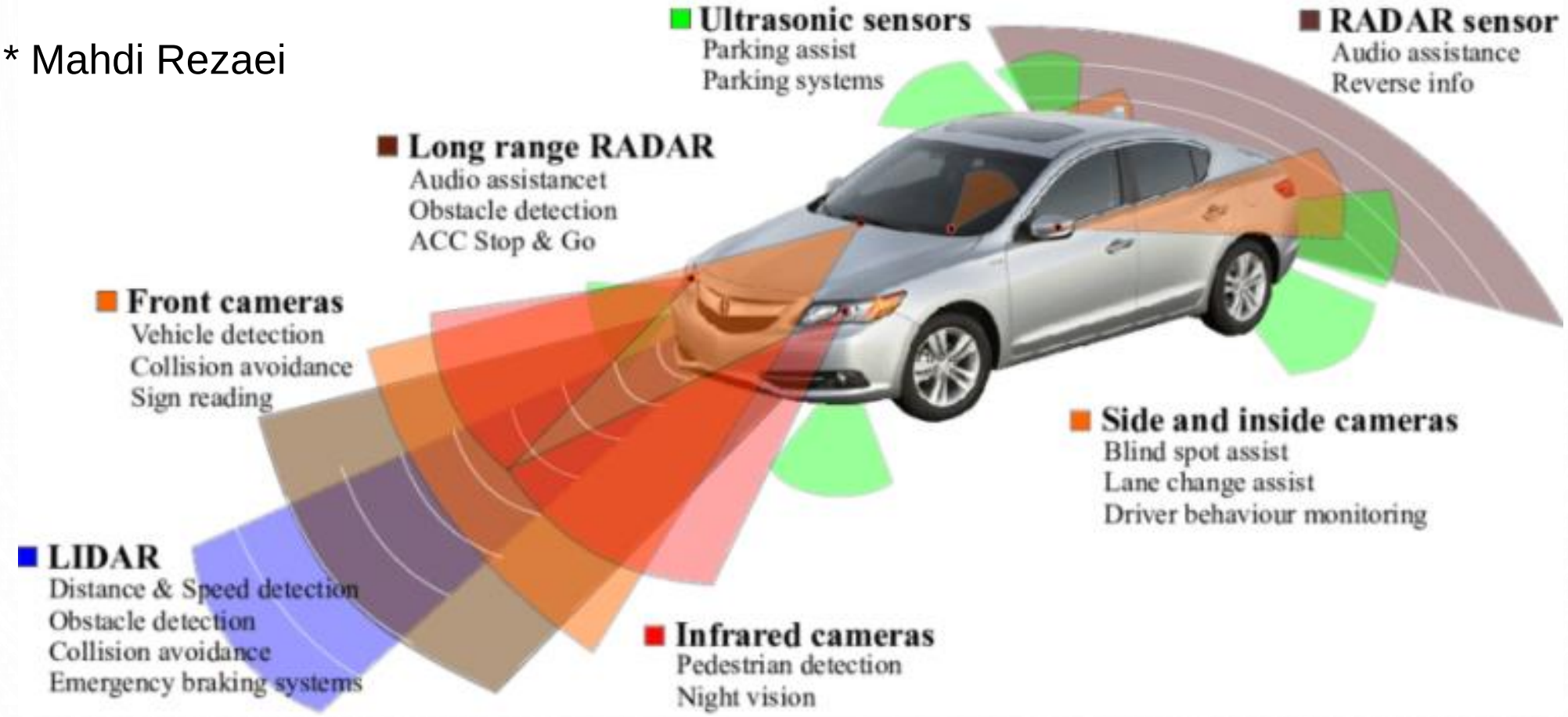
- Safety systems for vehicle
  - Active systems: offer advanced vehicle control reducing the probability of accidents
    - Widely used systems: ABS (Anti-lock Braking System), TCS (Traction Control System), AEBS (Automated Emergency Braking System), etc.
    - New systems: FCWS (Forward Collision Warning System), LDWS (Lane Departure Warning System), ISA (Intelligent Speed Assistant), DDR-AW (Driver DRowsiness and Attention Warning) etc.
  - Passive systems: prevent or reduce the severity of injuries in the event of an accident
    - Ex. seat belt, airbag, child seat
- Location-based services
  - They allow to find the closest POIs (Points of Interest), e.g. fuel pumps, charging stations, restaurants, hotels, etc.

ITS FOR VEHICLES

- ADAS (Advanced Driver Assistance Systems)
  - They are based on a series of sensors (ultrasonic, infrared, radar, LiDAR) and cameras
  - They represent several systems which can help the driver
    - ACC (Adaptive Cruise Control), LDW/LKS (Lane Departure Warning/Lane Keeping System)
    - Adaptive headlight control
    - Automatic parking, Navigation systems
    - Blind spot detection, collision avoidance systems
    - Driver drowsiness and attention warning
    - ISA (Intelligent Speed Adaptation), traffic sign recognition
    - Night vision, pedestrian protection systems
  - In Euro NCAP rating Safety Assist and Vulnerable Road User Protection systems each have 20% of final rating

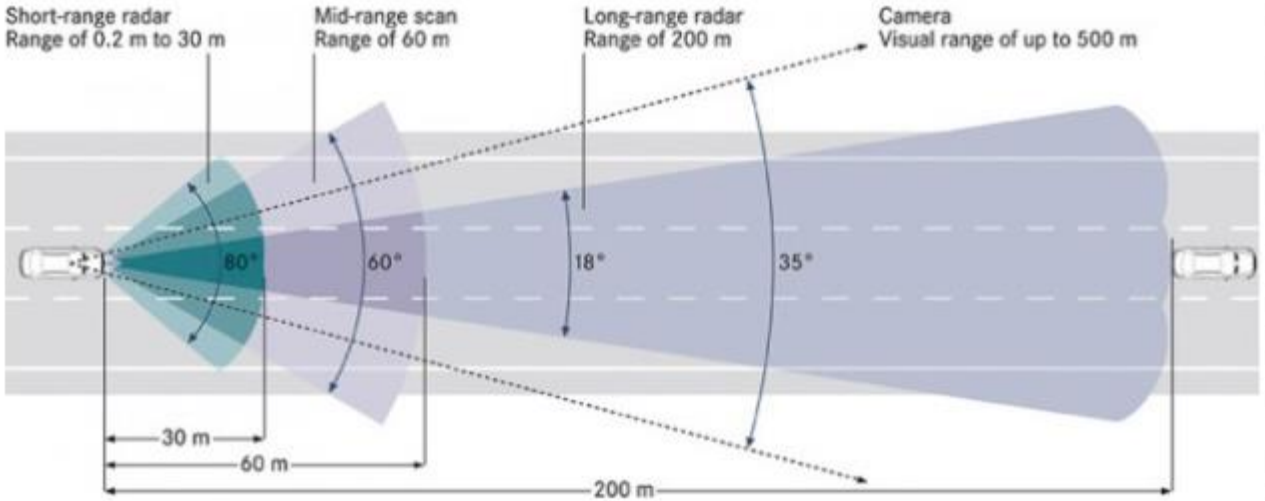
ITS FOR VEHICLES

- * Mahdi Rezaei



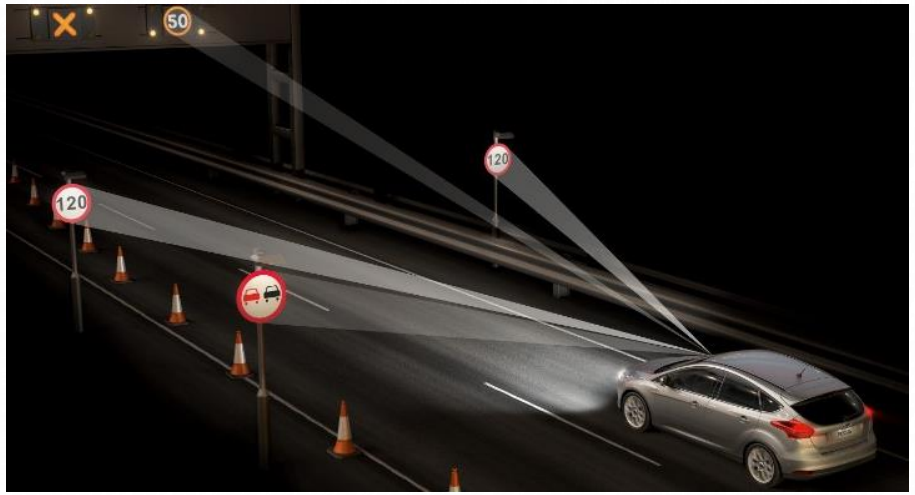
ITS FOR VEHICLES

- ACC (Adpative Cruise Control)
  - Uses Long Range Radar (LRR) that does not interfere with police radarsand does not trigger radar detectors – around 77GHz
  - The systems estimates the distance to the vehicle in front
  - Travel speed is adjusted according to the estimated distance
  - The efficiency of the system depends on the weather conditions
  - The first solutions were based on lasers



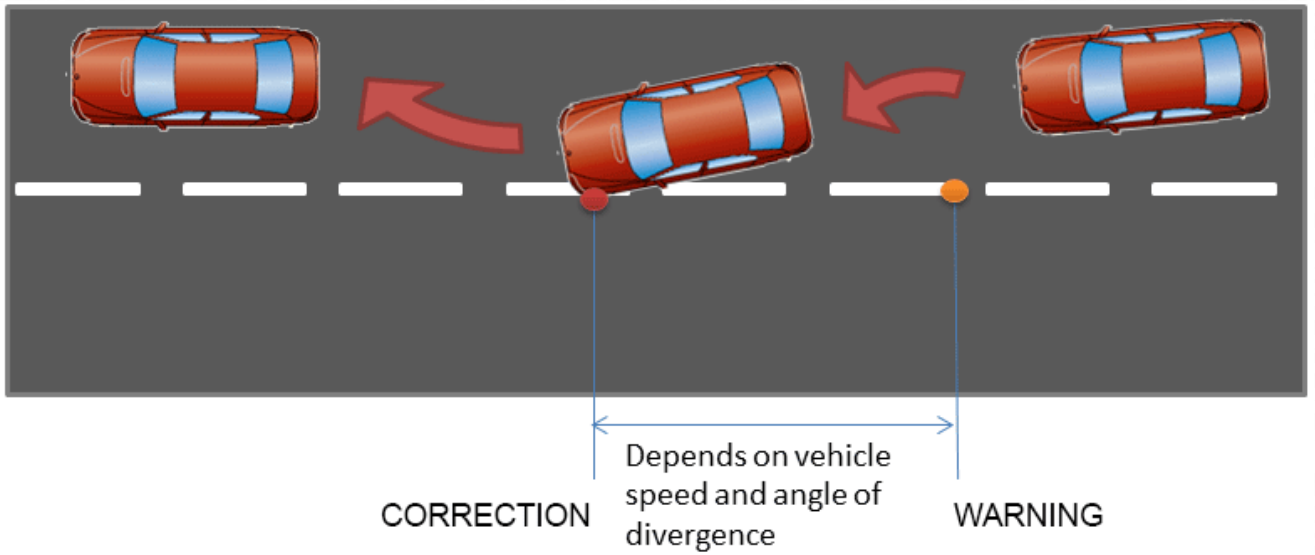
ITS FOR VEHICLES

- Traffic sign recognition
  - Uses a front camera positioned next to the rearview mirror
  - Consists of two stages:
    - Traffic sign detection using image recognition
    - Identification of detected traffic signs
      - Character recognition
      - Artificial neural networks can also be used
  - The traffic signs are displayed on different displays in the vehicle (dashboard, head-up display, infotainment)



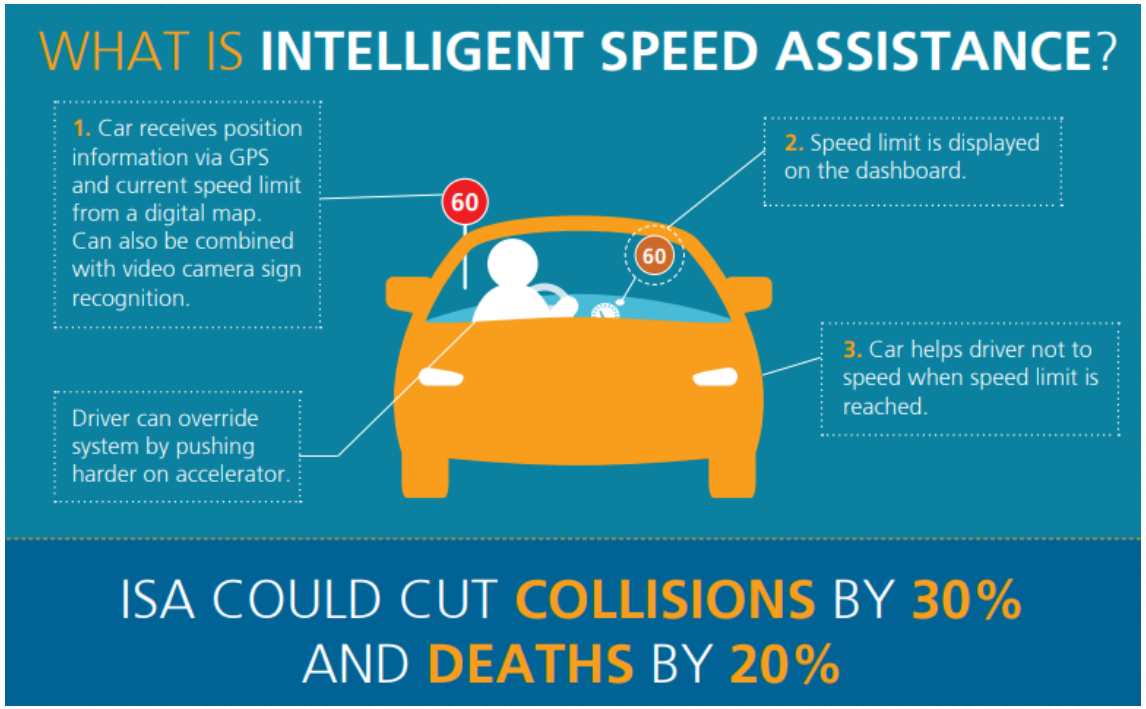
ITS FOR VEHICLES

- LKS (Lane Keeping System)
  - Uses the front camera to detect the boundary markings of the lanes
  - Checks if the driver is signaling
  - If the car inadvertently moves away from it's lane:
    - Warns the driver (LDW)
    - Performs the correction by operating the steering wheel (LKS)



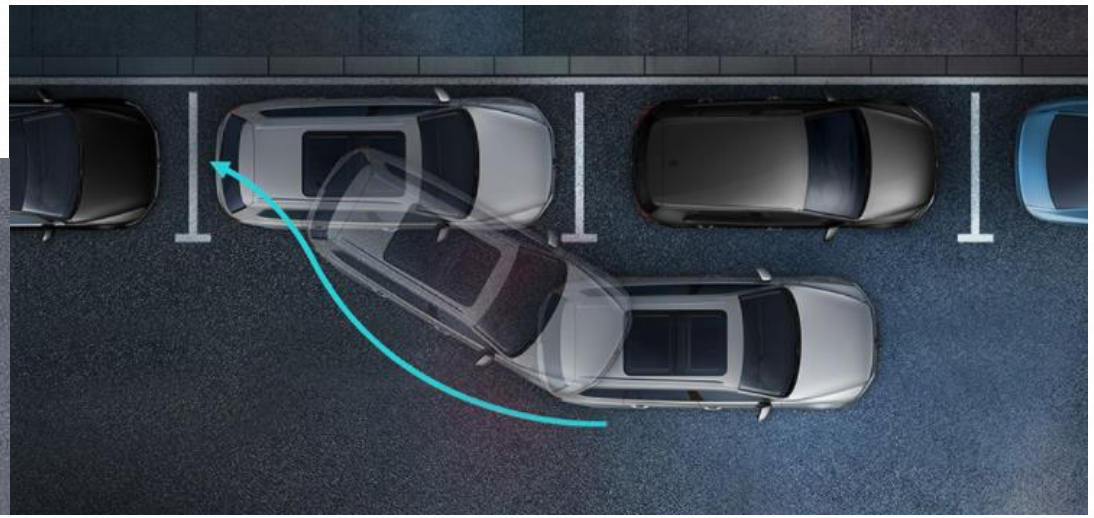
ITS FOR VEHICLES

- ISA (Intelligent Speed Assistance)
  - Uses traffic sign recognition system and/or GPS speed limit data
  - Warns the driver about the current speed limit
  - Automatically limits vehicle speed to the current limit
  - Mandatory in EU: for EU-type approval since 2022, for all new registrations from 2024
    - Together with Emergency Stop Signal (ESS), Alcohol Interlock Installation Facilitation (ALC), Driver Drowsiness and Attention Warning (DDR-AW), Tire Pressure Monitoring System (TPMS), Reversing Detection System (REV), Pedestrian and Cyclist Collision Warning (PCW), Blind Spot Information System (BLIS)



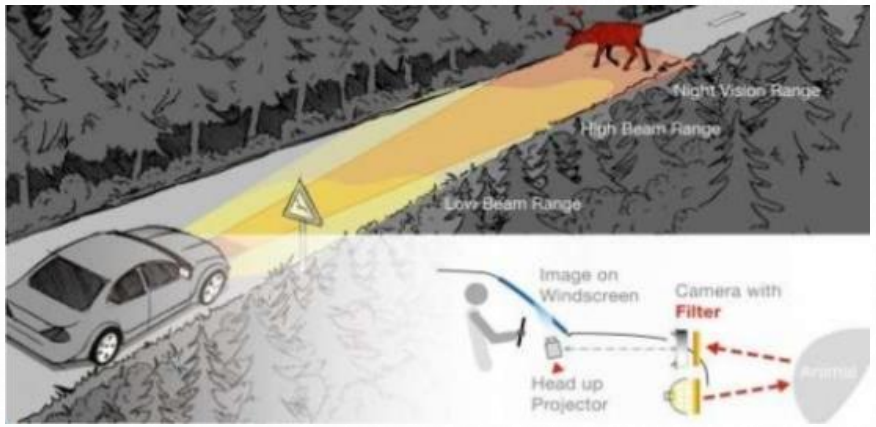
ITS FOR VEHICLES

- Park assist
  - Uses ultrasonic sensors to identify suitable parking spaces for the car
    - Can also use rear view camera to provide images of the surroundings and the direction of travel
  - Controls the steering wheel to perform the maneuver
  - The driver controls the acceleration, brakes and the gearbox



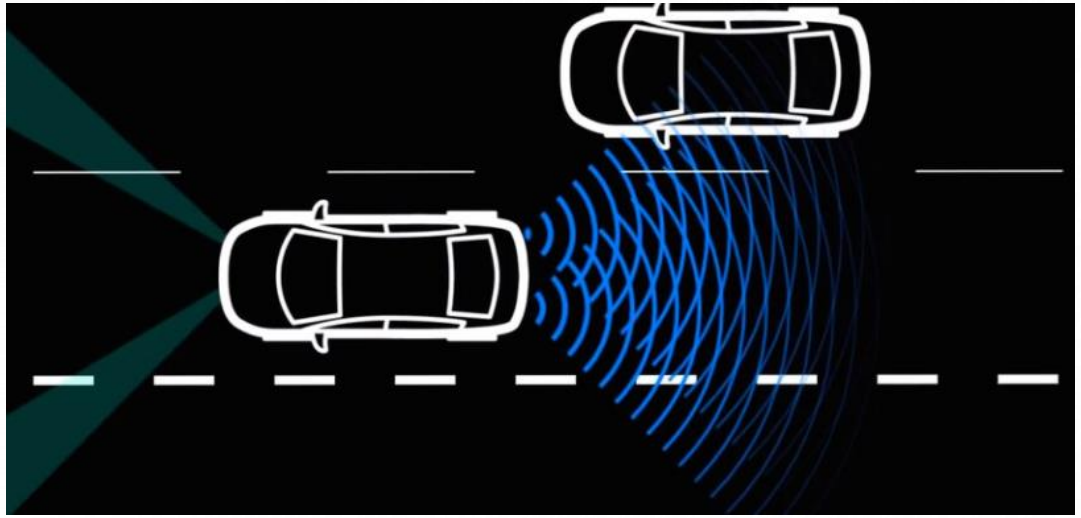
ITS FOR VEHICLES

- Night vision
  - Detects objects in the dark that are out of range of headlights
  - Passive systems
    - Use thermographic cameras to detect thermal radiation
    - High performance for animal/pedestrian detection
    - Cannot detect objects on the road
    - Less efficient in heat
  - Active systems
    - Light up the road using infrared light
    - Image quality is better compared to passive systems
    - It has a shorter range
    - It has low performance in adverse weather conditions



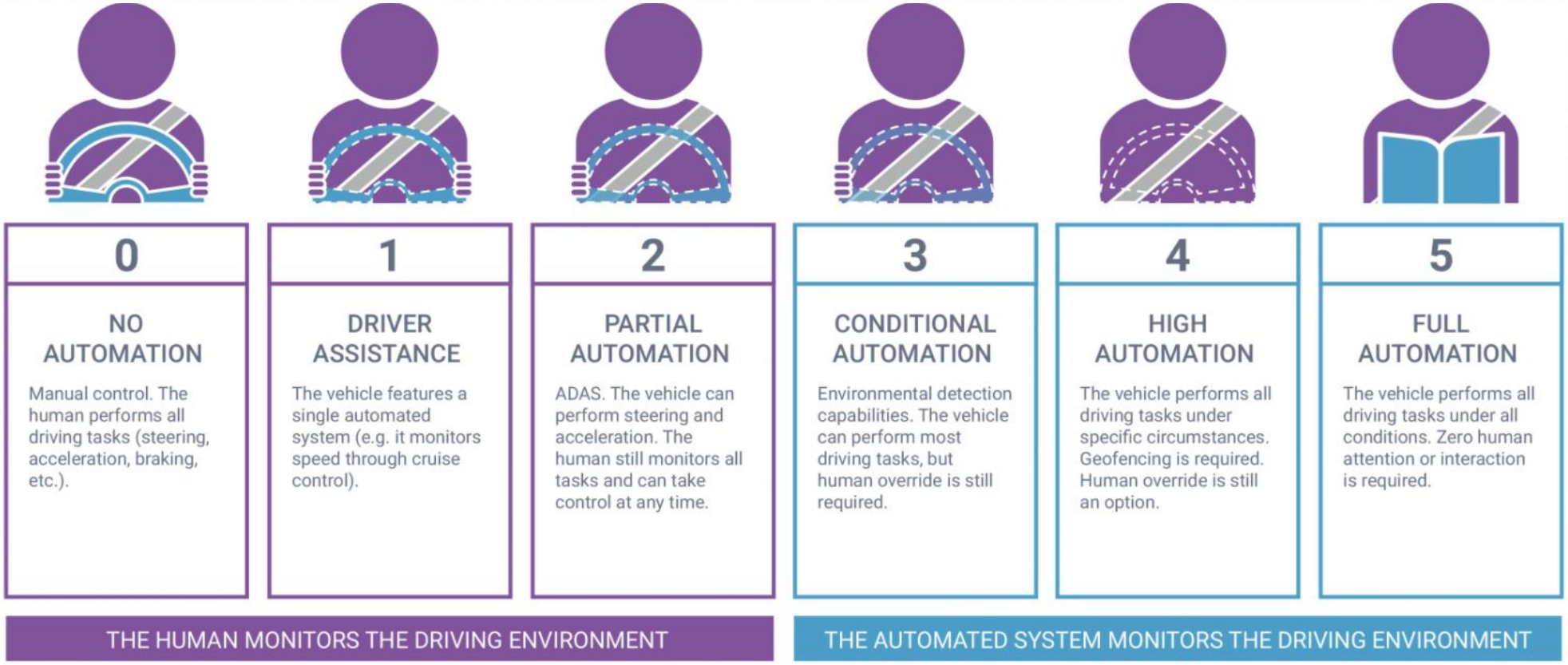
ITS FOR VEHICLES

- Blind spot monitor
  - It can use short-range radars or cameras to detect blind spot vehicles
  - Activates a warning in the form of an icon in the rearview mirror
  - If the driver is signaling and there is a vehicle in the adjacent lane, it may also sound an alarm



ITS FOR VEHICLES

- Levels of automation



ITS FOR PUBLIC TRANSPORT

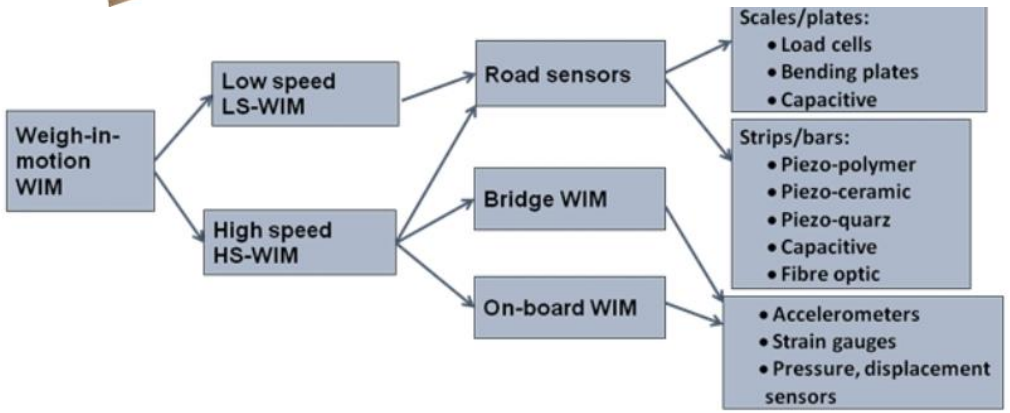
- Information before and during the trip
- Electronic displays for ETA (Estimated Time of Arrival) at stations and stops
- Electronic information devices: routes, costs, programs, etc.
- Displays in public transport, announcement of next station
- TVM (Ticket Vending Machines)
- Electronic tickets
- Security systems
- Other passenger information services

ITS FOR THE TRANSPORT OF GOODS

- Digital tachograph
  - EU directive EU 22/2006/EC requires the number of hours spent driving for the means of transport of persons and goods
  - Rest times are also required
    - These time periods can be verified by employers and authorities with the help of tachographs
  - The digital tachograph consists of:
    - Digital unit of the vehicle – ”vehicle memory”
    - Personal driver card – ”driver activity memory”

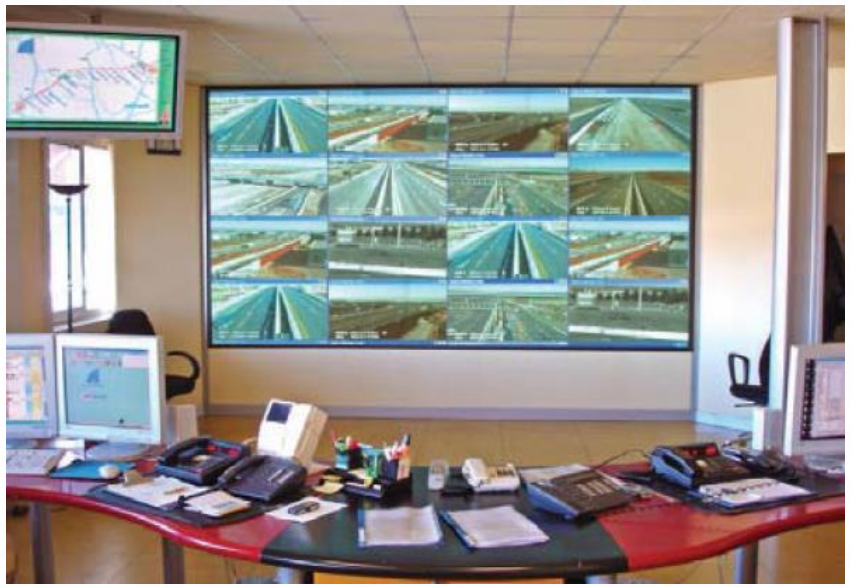
ITS FOR THE TRANSPORT OF GOODS

- WIM systems
  - Sensors installed on the road are used
  - Measure the weight of a moving vehicle
    - Identification data, date, location, vehicle type, speed, length, number of axles, weight, axle distribution, wheelbase
  - The data are used by the authorities, road administrators, bridge architects and various research institutions



ITS FOR INFRASTRUCTURE

- Traffic Control Center (TCC)
  - Receives and distributes multimedia information about road and traffic conditions
  - Collects data on environmental conditions (weather, tunnel pollution, etc.)
  - Activates contingency plans
  - Activates traffic management plans
  - Activates maintenance plans
  - It can intervene remotely by:
    - Activating smart variable road signs
    - Traffic light control
    - Changing ventilation in tunnels

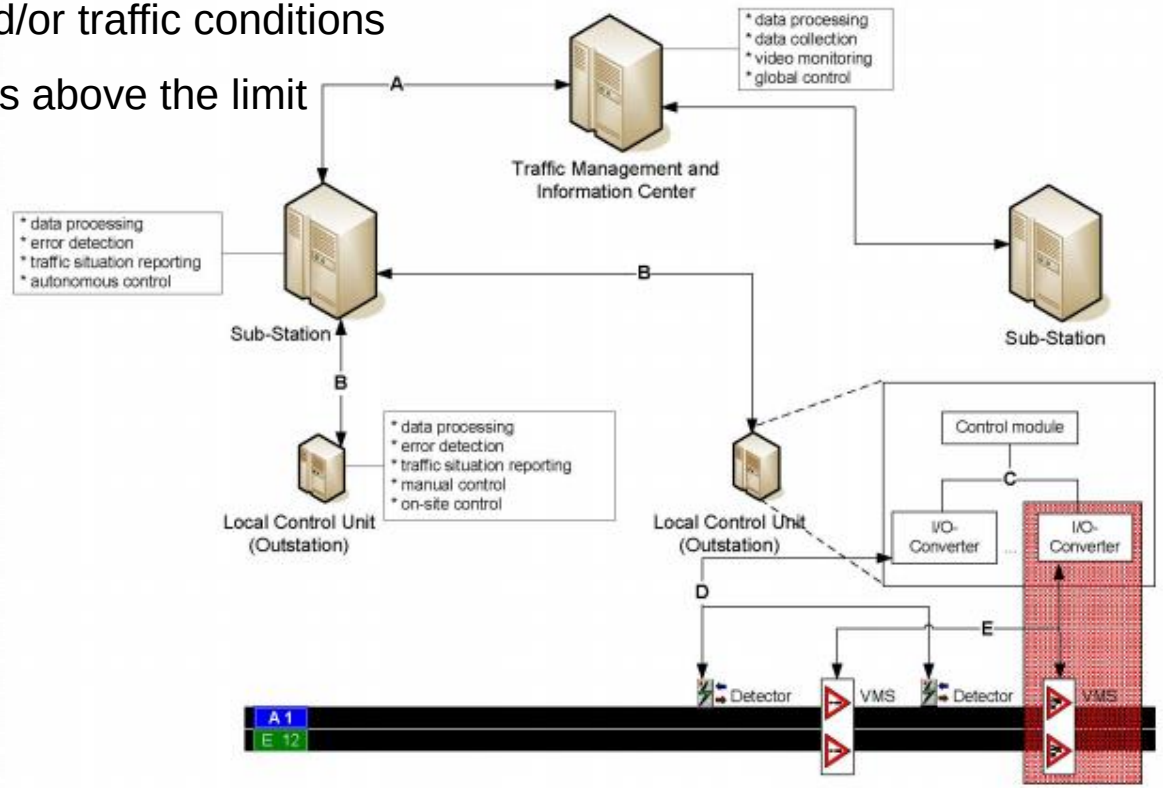


ITS FOR INFRASTRUCTURE

- Traffic Information Center (TIC)
  - Collects real-time information
  - Distributes information to traffic participants
- VMS (Variable Message Signs)
  - They are electronic traffic signs
    - They can inform about traffic congestions, accidents, road works, temporary
  - Significantly contribute to accident prevention

ITS FOR INFRASTRUCTURE

- Types of VMS:
  - Temporary speed limits due to weather and/or traffic conditions
  - Signs activated by drivers driving at speeds above the limit
  - Signs for parking places with free spaces
  - Tunnel management
- The basic structure of a VMS message:
  - Problem
  - Location
  - Recommended action



ITS FOR INFRASTRUCTURE

- Speed limit enforcement systems
  - Radars
  - Video cameras
  - Average speed measurement systems on motorways
    - It is done on distances between 10-25km
    - Two devices are used which record the registration number
    - The average speed is computed instantly
- ETC (Electronic Toll Collection)
  - Allows electronic payment of fees
  - It is among the first ITS services
  - It is based on the automatic recognition and classification of vehicles