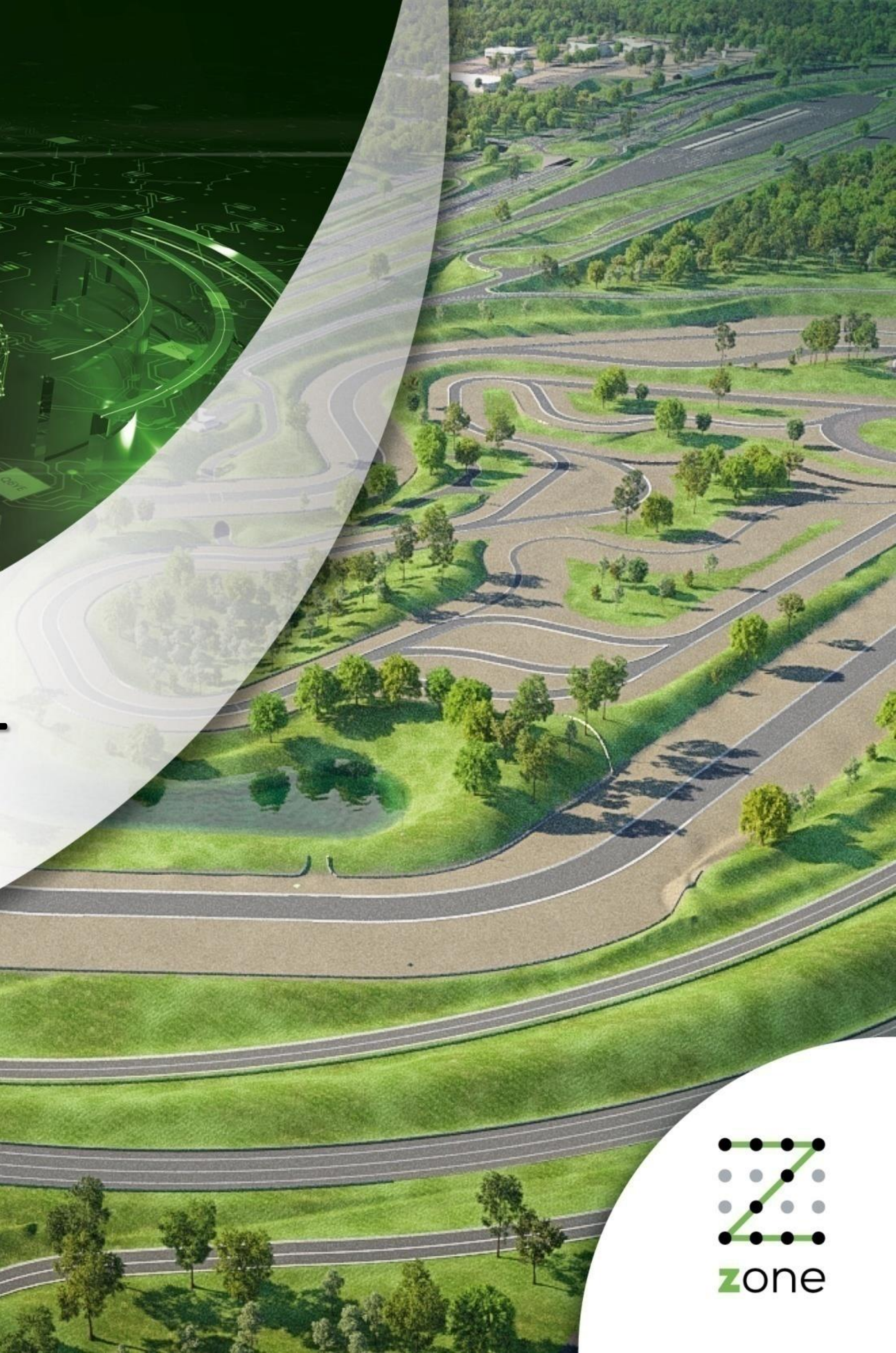


PROVING GROUND PROJECT HUNGARY

November/2018

zone

CONTENT

Driverless vehicles

Project concept

Proving Ground development

What can be tested

Driverless vehicles

zone

Social, political processes

- The transport and forwarding are one of the most important elements of the EU industrial and service sectors, and are important pillars of the economic and social processes.
- Without effective, ecological and safe transport systems, the population's and produced good's mobility, the economic growth cannot be guaranteed.
- The industry players have been identified those research and development areas, which strongly influence competitiveness of goods and services for long time:
  - Mobility and forwarding
  - Energy and environment
  - Safety and security
  - Competitiveness and affordability

Inspiration factors of developments

1	**Zero Emission**	• Fuel-consumption reduction • Reducing emissins
2	**Demographic pressure**	• Support of insecure leaders • Increase the elderly mobility
3	**Risk of accidents**	• Avoidence of the accidents with reducing the effect of human mistakes
4	**Increasing traffic density**	• Management of transport process • Comfortable, time-saving travel
5	**Assistance systems**	• Intelligent sensors for appropriate process • Intelligent actuators (steering, brakes, …)

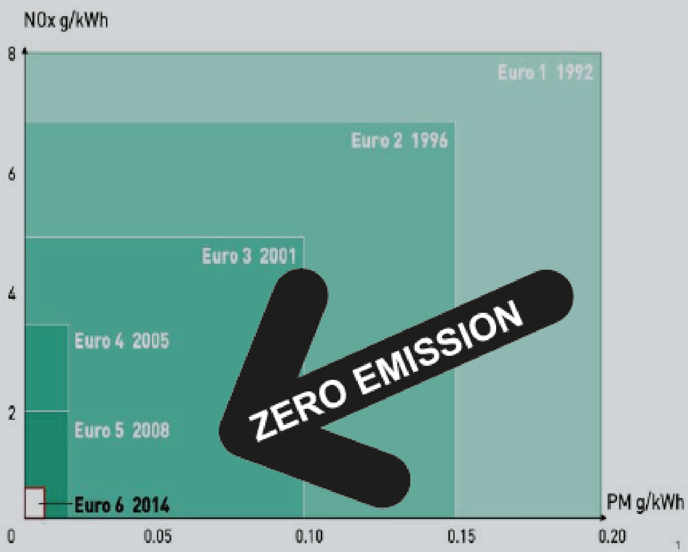
Source: VDA

Technical background

Emission

Emissions

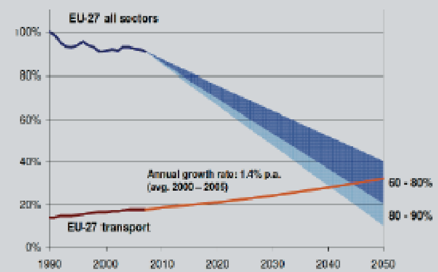
Implementation of EURO6 standard does not help further the increase of the motor efficiency



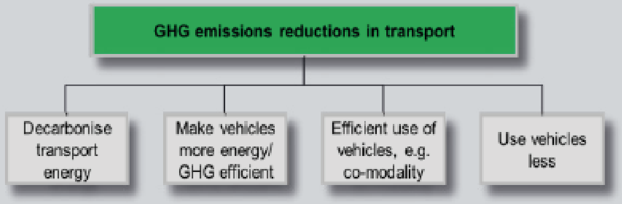
savingFuel

Next step CO2 reduction/reducing consumption

1. Problem



2. Solution



zone

Technical background

Emission

Reducing greenhouse gases is forwarding and transporting

- Carbon-based technology replacing
- Efficient vehicles: energy/GHG
- Efficient vehicle use, e.g. commodality
- Less vehicle use

Optimizing usage: e.g.
- Goods
- Person
- Commodality

Optimizing vehicles e.g.:
- Road desing, speed
- Eco-driving
- Speed limits

Efficient design of forwarding system:
Infrastructure coverage
Special design
Intelligent organization of transport

Reducing the number of trips

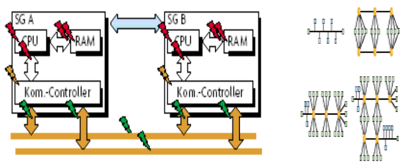
Technical background

Technology is ready - Is it enough?

Architecture

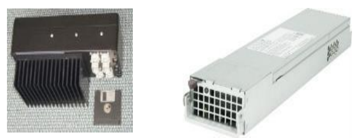
Rendundant central control unit

Communication



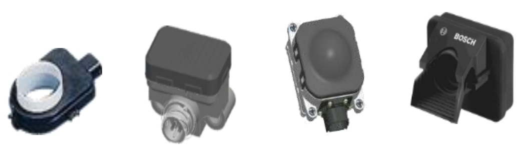
Redundant communication in the car and with the outside (V2V, V2I)

Power supply



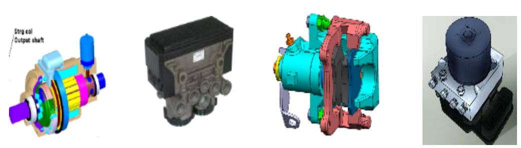
Redundant, galvanically separated energy storage and supervision system

Sensors



Redundant or error-tolerant sensors to supervise the condition of the vehicle

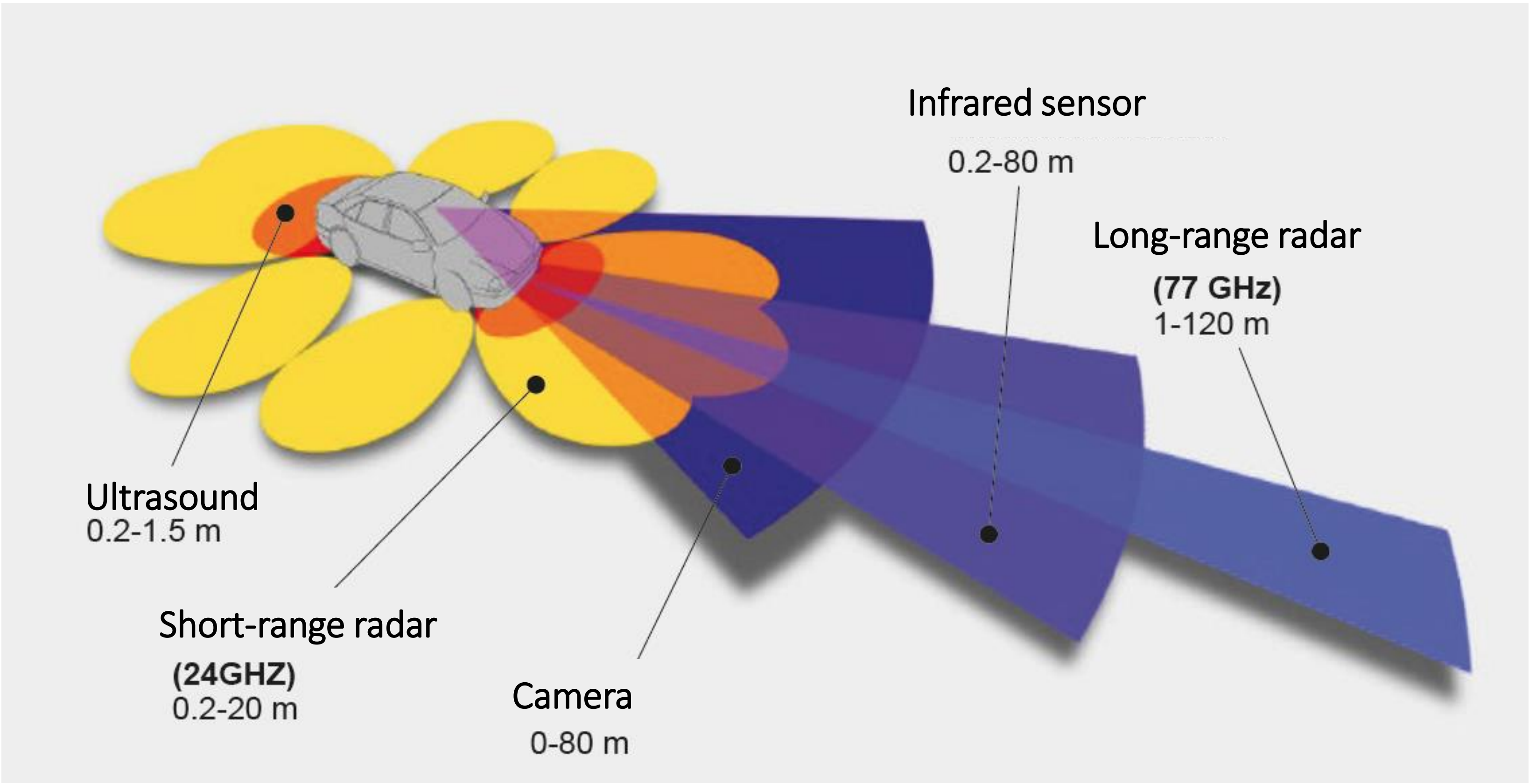
Actuators



Redundant or error-tolerant intervention elements in the vehicle (steering wheel, brake, etc.)

Technical background

Example - environment detection as a driver



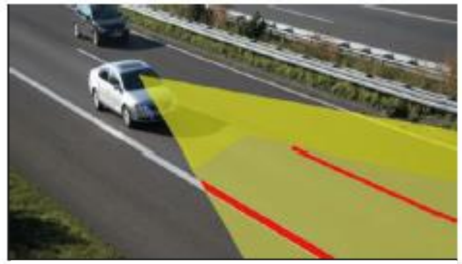
Technical background

Systems available nowadays

Longitudinal control

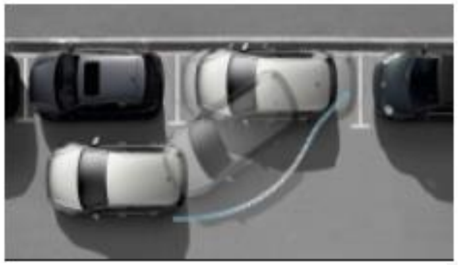
ACC traffic-jam assistant
emergency braking assistant

Transverse control



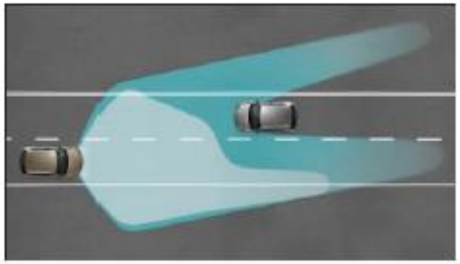
Lace-changing assistant, lane-keeping assitant

Parking, maneuvering



Automated parking assistant

Lighting



Adaptive ling-distance lighting, adaptive cornering ligths

Drive supervision

Fatigue supervision

Environmental supervision

Traffic sing detection

Source: VDA

Technical background

Systems available nowadays

Traffic-jam pilot

2012
Volvo: Sartre (EU)

Highway pilot

2011
VW: HAVEit (EU)

Advanced Driving Assisatance

2011-2015
VW: V-Charge (EU)

Google car

2014
AUDI

Pikes Peak

2015
Mercedes: FT2026

Emergency Brake Assistance

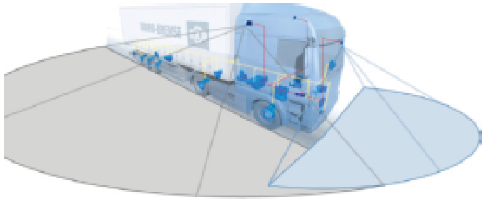
2016
Volvo: Drive Me

Source: VDA

Source: VDA

Technical background

Road to the autonomous vehicle

TODAY 2017	TOMORROW<2020	FUTURE>2020
		

- Lane leaving warning
- Longitudinal control
- Emergency brake system
- Active steering
- Object detection in dead spot
- ACC + LKA
- **Autonomous driving:** The driver can do other activities
- **Autonomous driving:** Low following distance, lower fuel consumption

DRIVER IS PART OF THE VEHICLE CONTROL „FAIL SAFE" SYSTEM

DRIVER IS INACTIVE „FAIL TOLERANT" SYSTEM

Source: Volvo, Knorr-Bremse

Human factors

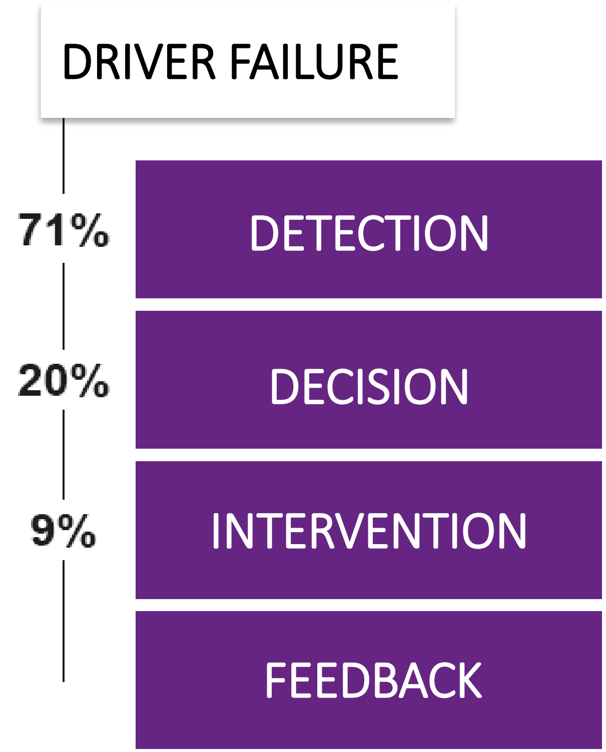
The responsibility of driver

As the responsibility of the driver, legally specified:

- The driver shall not totally relieved from the responsibility of the driving
- Since the skills of the driver are limited, the intervention can be performed - the priorities are the saving of human life and minimizing of the damage to property

The resolvers of the previous contradiction:

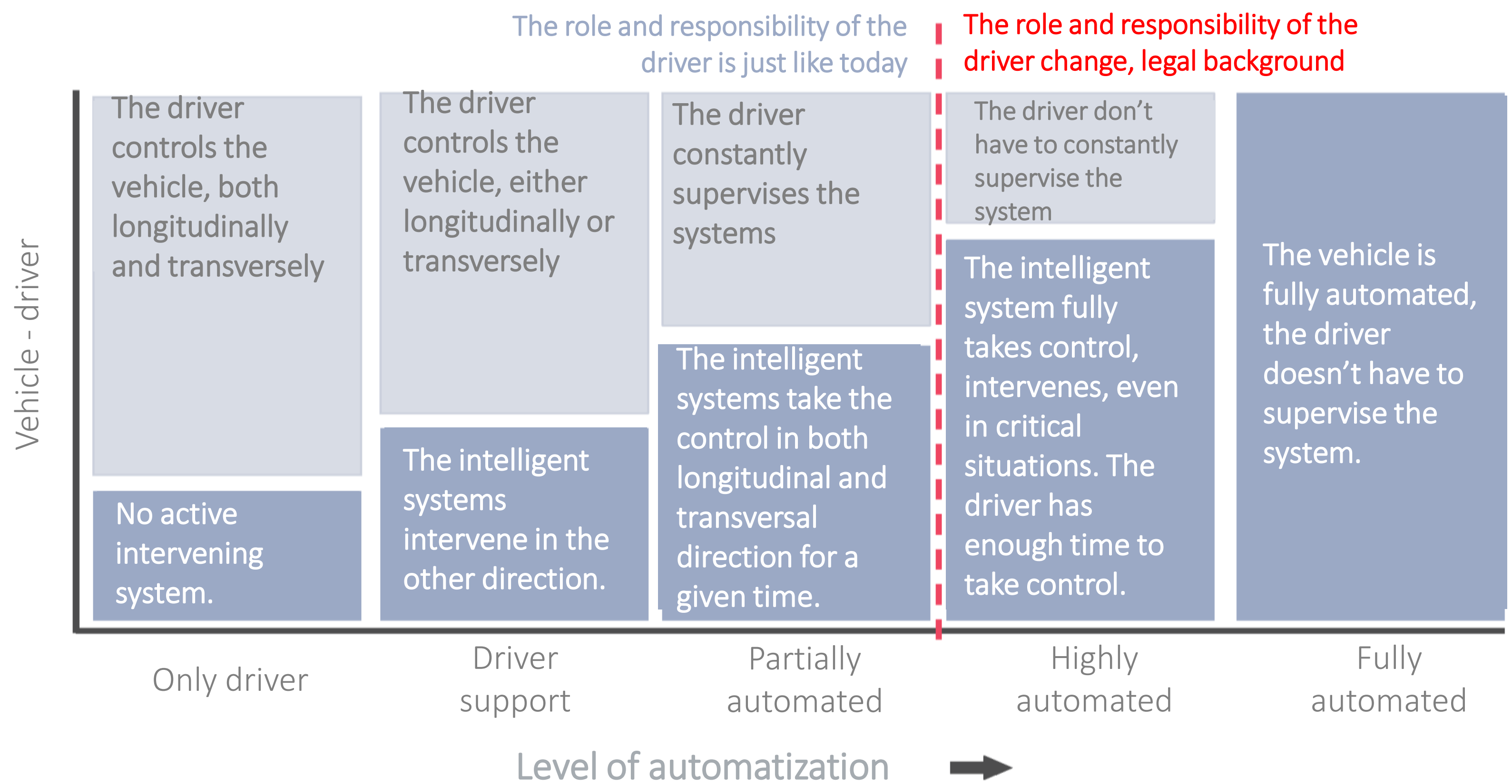
- If the driver intervenes into the intelligent system, the predictive elements of the system pass the control
- If the given situation cannot be avoided, the intelligent system can intervene



zone

Human factors

Automatization levels



Human factors
Acceptance

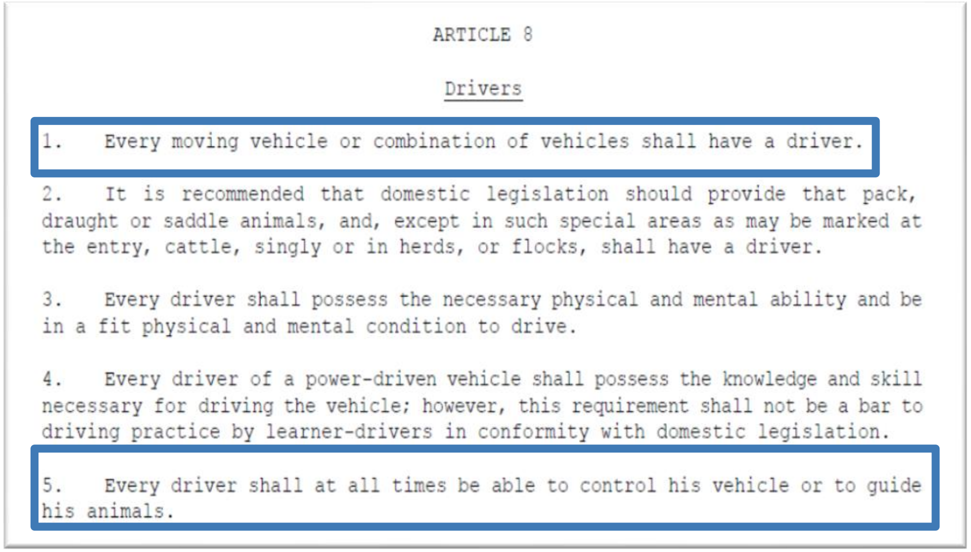
Example: Ford fieldtest with 33 participants, in urban environment, with level 2/3 ADAS systems

- The drivers have not evaluated the assistance systems as extra effort compared to driving without them
- The rating of the systems were positive in all cases, independently from the number of tests
- The systems were evaluated as easily useable, reliable and pleasant
- Nearly all participants want to use the assistance in their own car
- The older drivers evaluated the systems worse than the younger
- The participant with experience with ACC systems evaluated the systems better than the ones without it

Non-technical aspects

Agreement in Vienna (1968)

- Basic requirements from 1968:
  - All vehicles shall have a driver
  - The driver shall control the vehicle all the constantly
- 23rd of March, 2016:
  - A modification to the principles above, gives permission for automatization if the driver can overrule and turn it off



ARTICLE 8

Drivers

1. Every moving vehicle or combination of vehicles shall have a driver.

2. It is recommended that domestic legislation should provide that pack, draught or saddle animals, and, except in such special areas as may be marked at the entry, cattle, singly or in herds, or flocks, shall have a driver.

3. Every driver shall possess the necessary physical and mental ability and be in a fit physical and mental condition to drive.

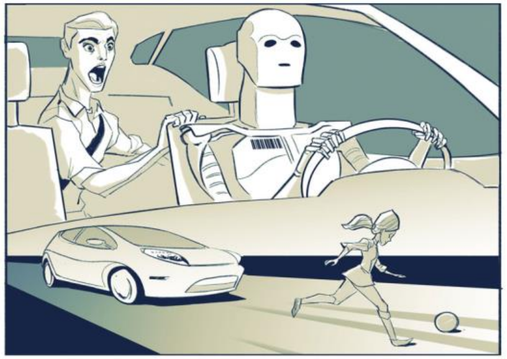
4. Every driver of a power-driven vehicle shall possess the knowledge and skill necessary for driving the vehicle; however, this requirement shall not be a bar to driving practice by learner-drivers in conformity with domestic legislation.

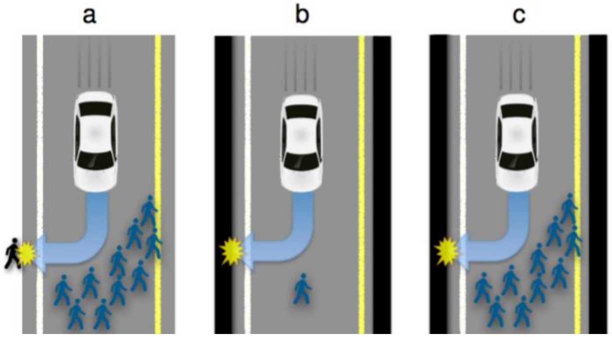
5. Every driver shall at all times be able to control his vehicle or to guide his animals.

Non-technical aspects

Moral, psychological and political questions

- Can we take the experience of driving?
- As different to the other co-operatively drivable vehicles (plane, boat, rail) we must be ready to manage the vehicles to handle the danger situations while having human participants with unperfect skills. But can we?
- What is the base of decision if we must choose of two bad options?
- Will the driver be mentally overloaded by the fact, that they do not drive the vehicle?
- Can we guarantee, that autonomous vehicles will not be put in non-proper use?



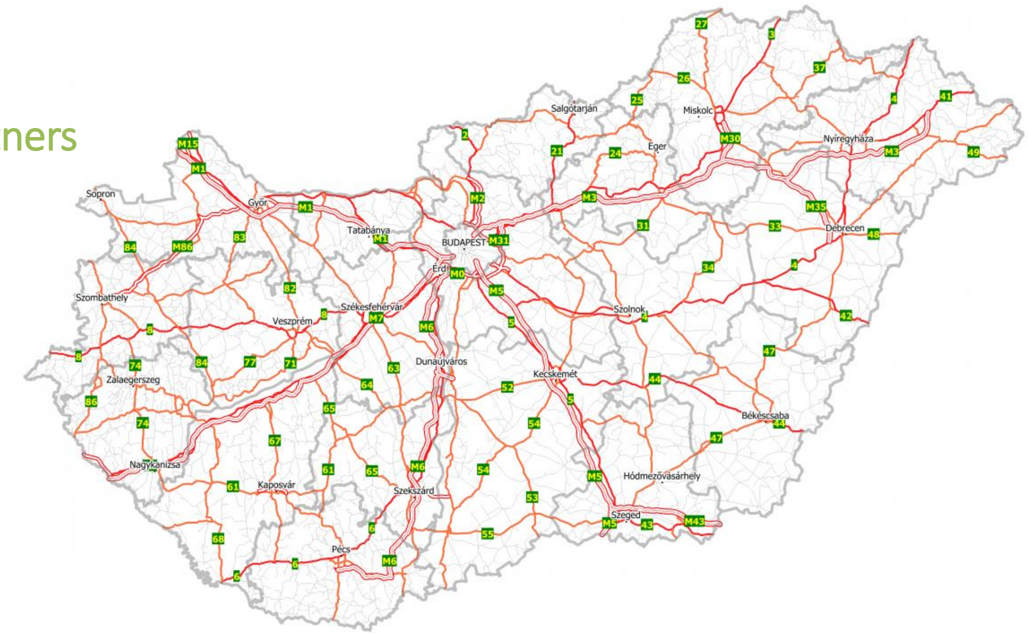


Source: Technologiereview, VDA

Public road tests in Hungary

Innovative regulation for test up to Level4

- Valid since: 12.04.2017
- Product responsibility type regulation
- Regulation defined with industrial partners
- Limitations:
  - NO territorial
  - NO time limitation
- Two stage approval process:
  - Company, organization approval
  - Test drive registration
- Requirements:
  - Skilled, experienced driver in the vehicle
  - Independent logging system in vehicle
  - Pre-testing in closed environment

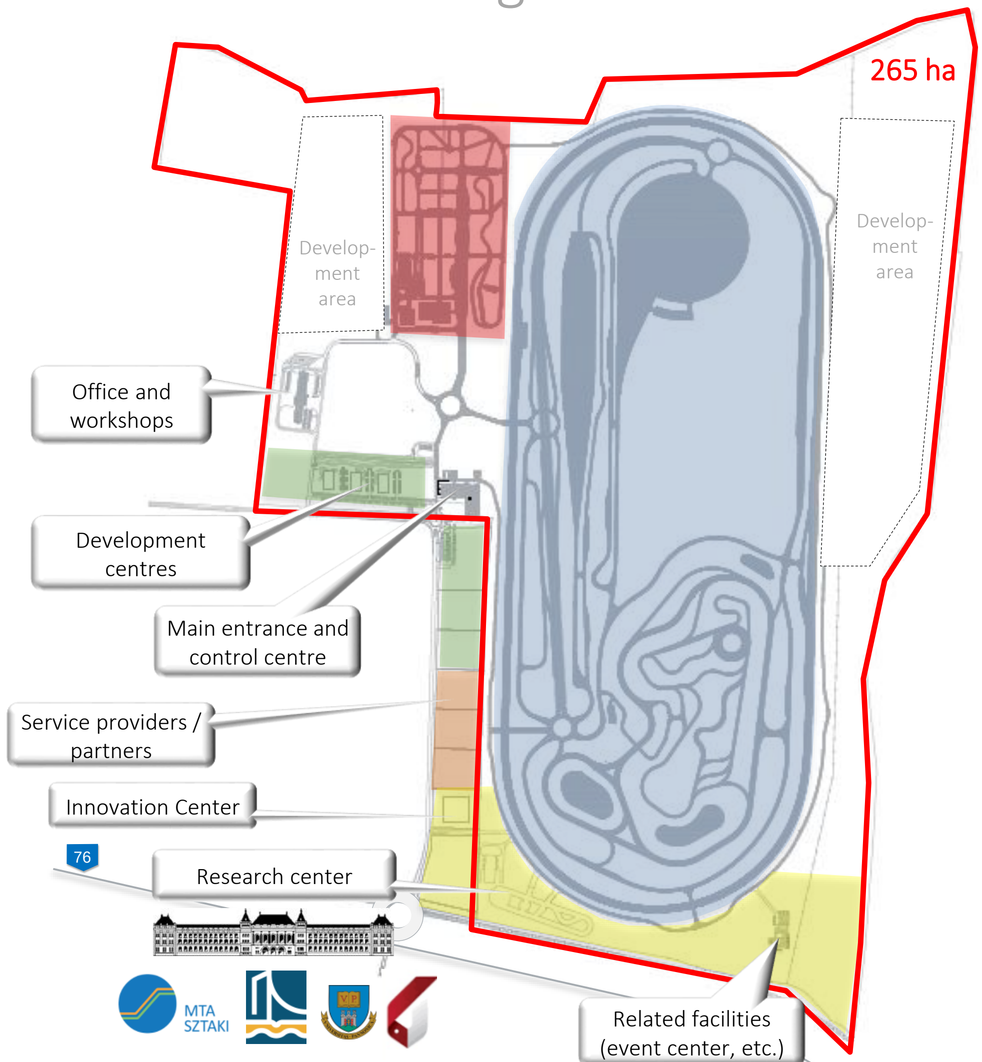


PROJECT CONCEPT

2014-2017
Industrial inputs
Iparági inputok

Layout of the Proving Ground

Traditional and autonomous testing modules

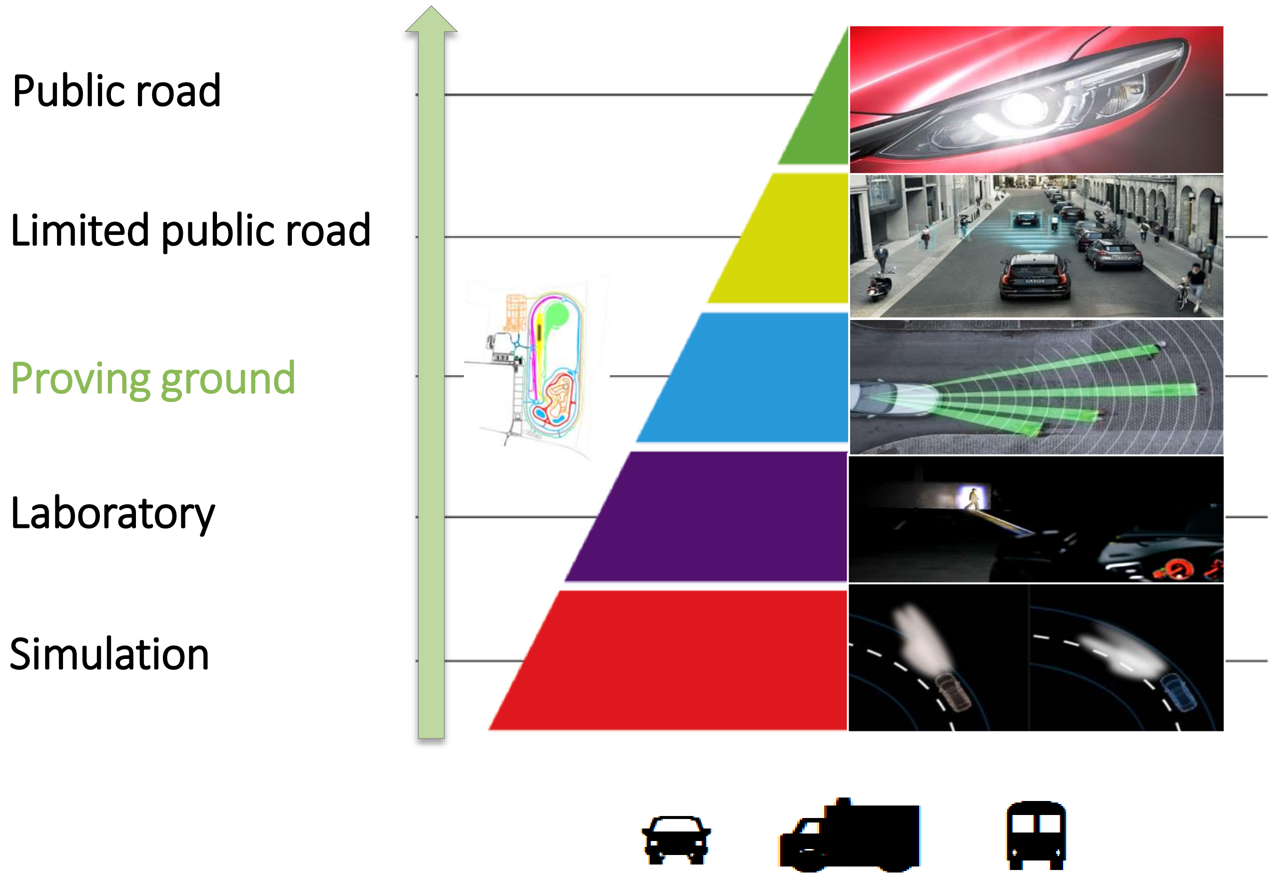


- Customer zone
- Service zone
- R&D&I campus
- High-speed CAV testing
- Low-speed CAV testing

Test track vision

Multi-level testing environment

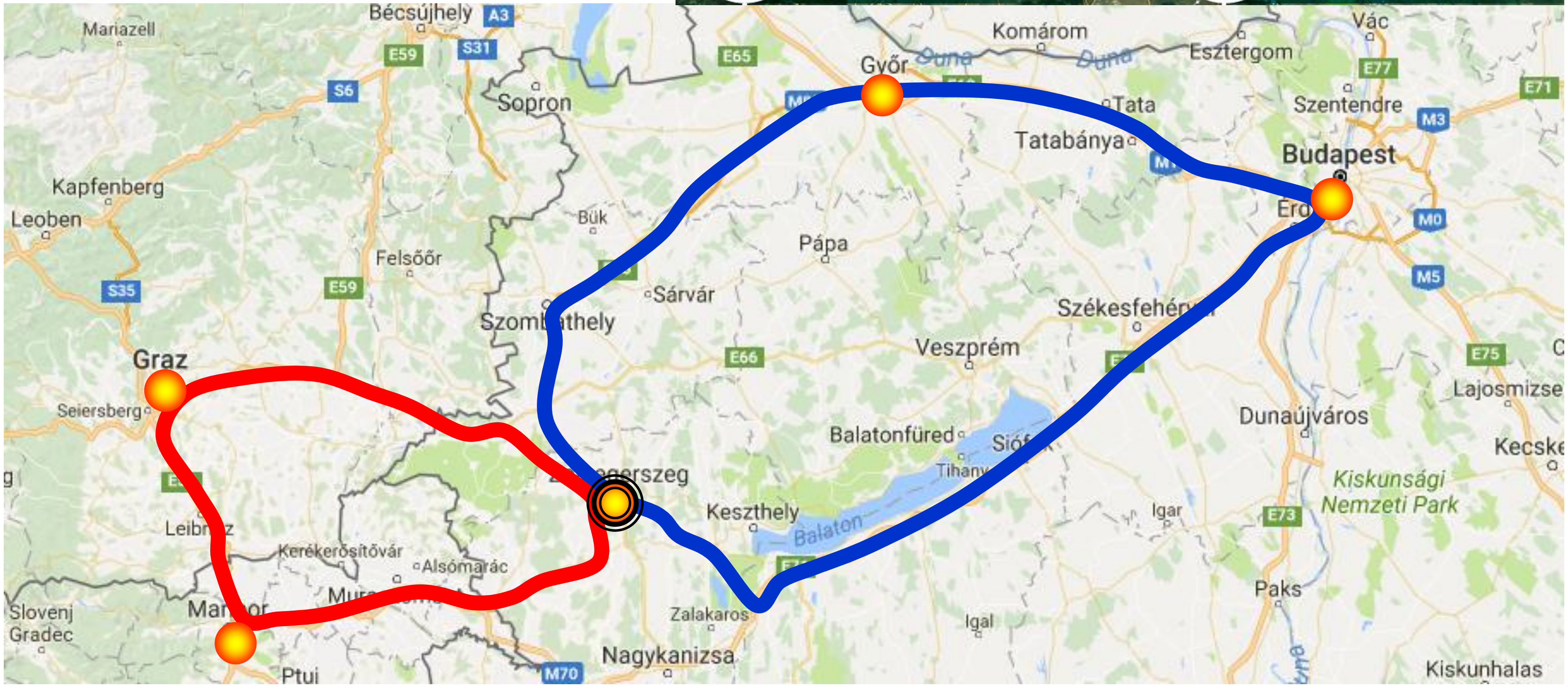
From computer to real traffic – essential for automated driving



Leaving the closed testing environment …

High speed testing in real environment – “Triple loop”

Loop_1: City local roads – smart infrastructure
Loop_2: Hungarian roads
Loop_3: International roads



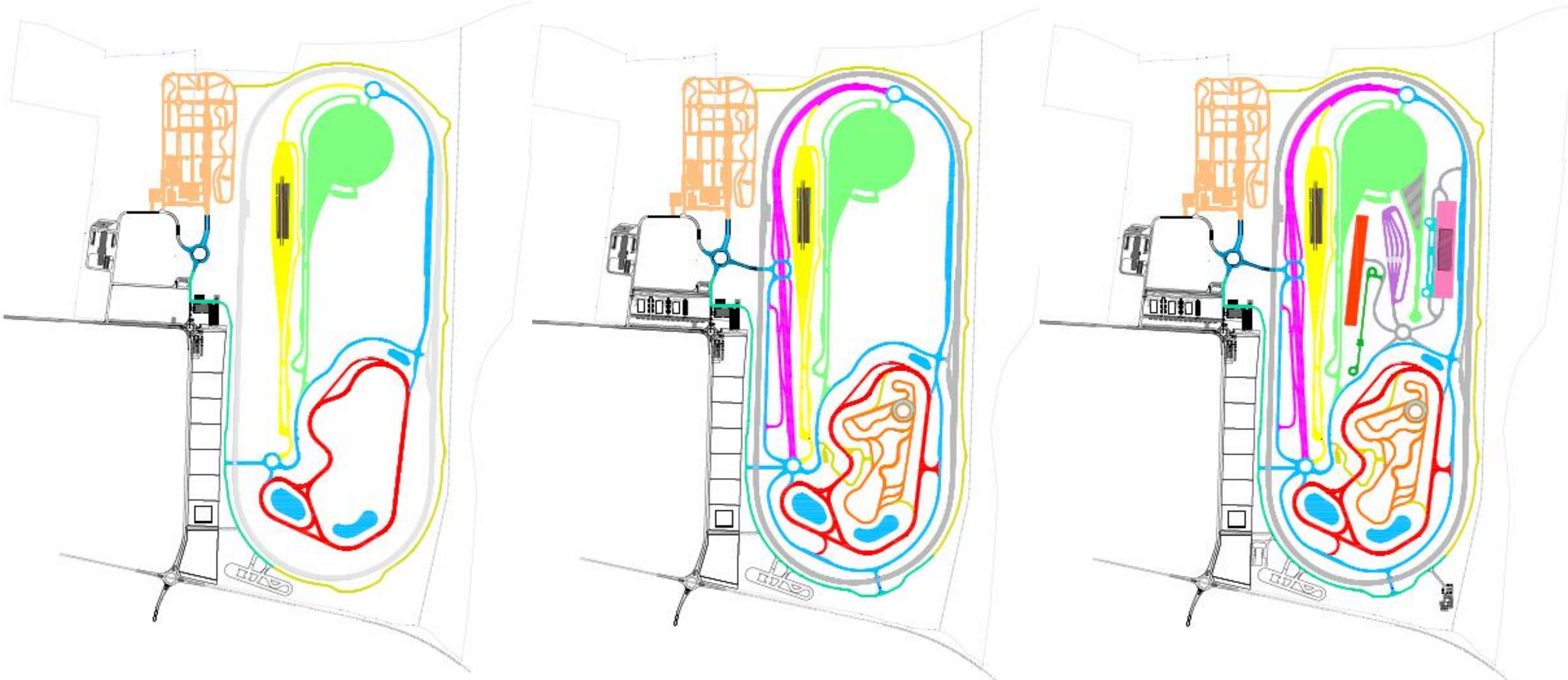
PROJECT DEVELOPMENT

Phases of the project

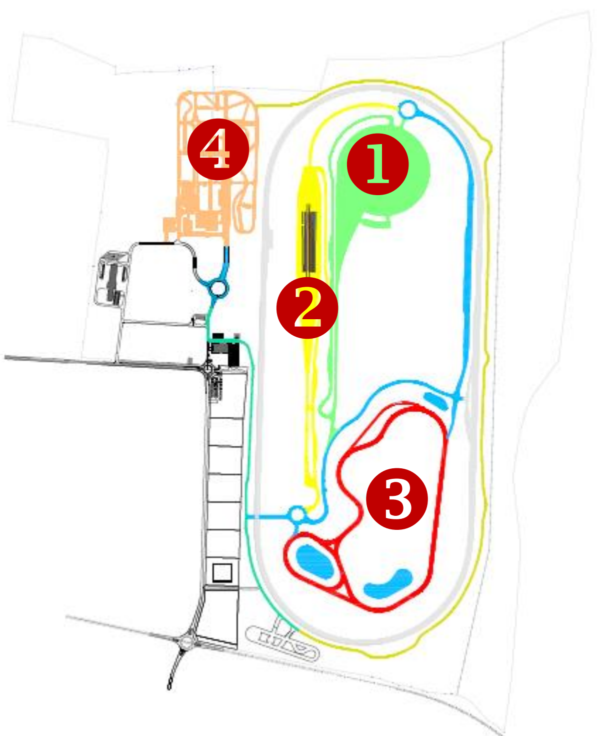
Phase 1: **2018 Q3-2019 Q1**

Phase 2.a: **2019 Q4**

Phase 2.b: **2020 Q2**



Status 2018 October

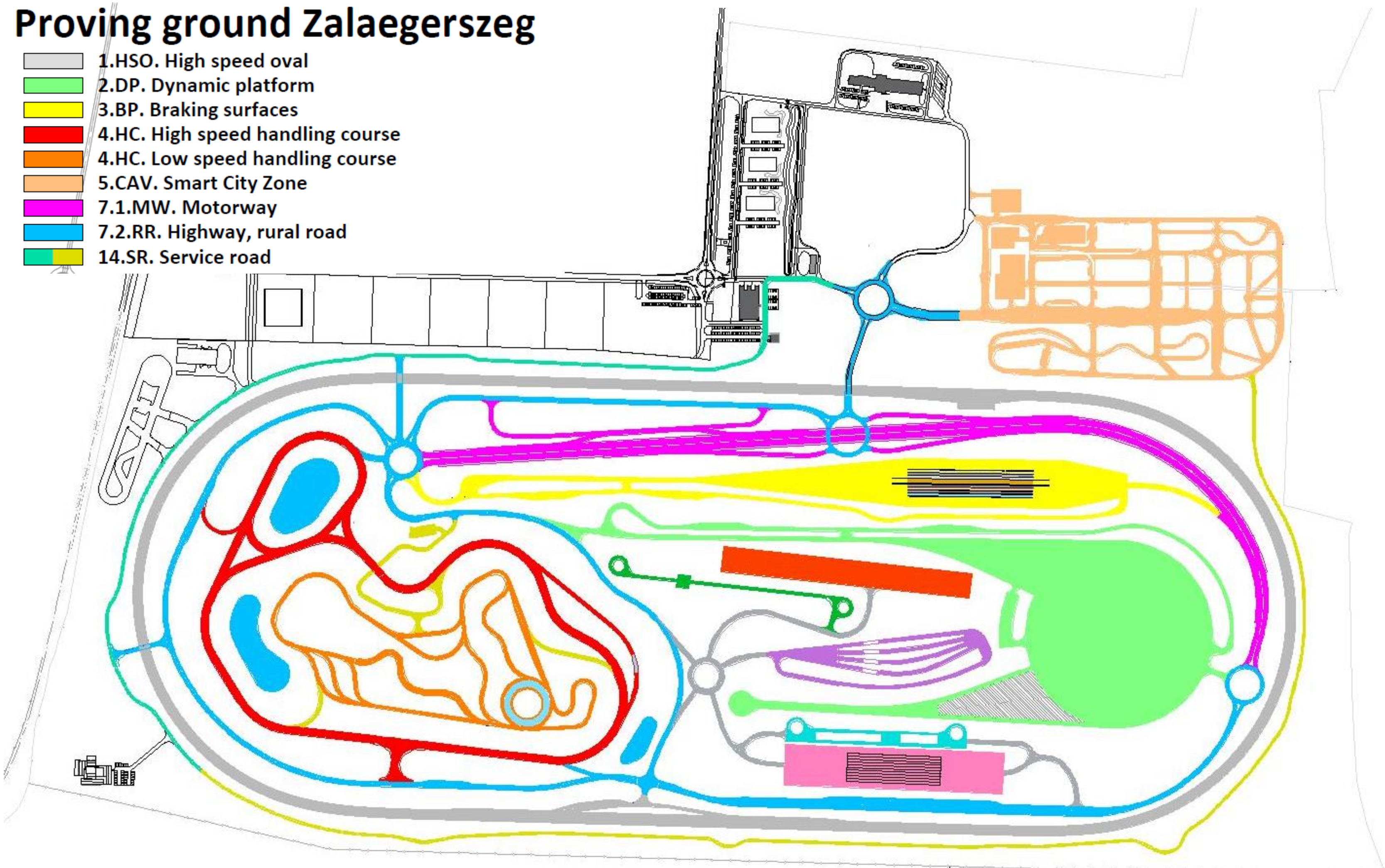


zone

WHAT CAN BE TESTED

Modules to be realized with Priority 1

Priority is defined with potential customers



DETAILS OF THE MODULES

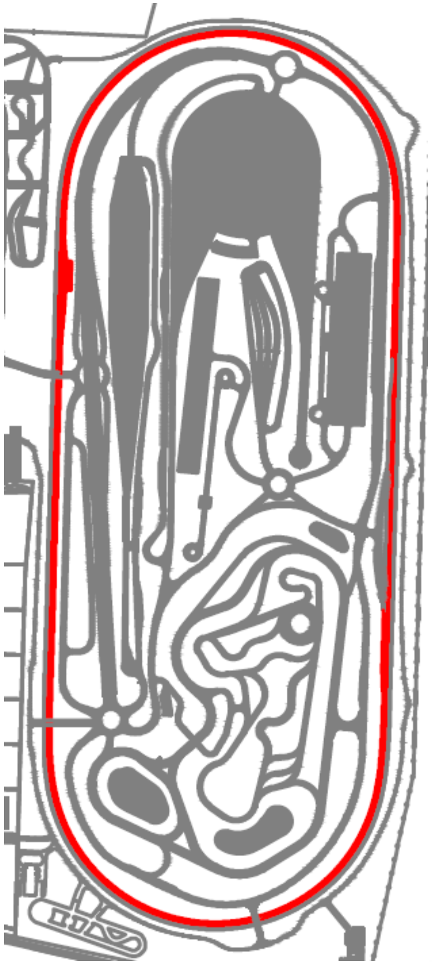
Proving Ground modules

High speed oval

Physical parameters:

- 4.400m length
- 920m straight section
- Curve radius 350m
- Neutral speed 200km/h at curves
- 1% inclination to south
- 3+1 lanes
- V2X infrastructure for communication test at high speed

Project Phase 2 2020



Autonomous vehicle test cases:

- Platooning at high speed motorway situations
- Cooperative vehicle control at high speed
- Fix position and moving obstacles (dummy car or pedestrian)
- V2I, V2V communication tests at high vehicle speed

zone

Proving Ground modules

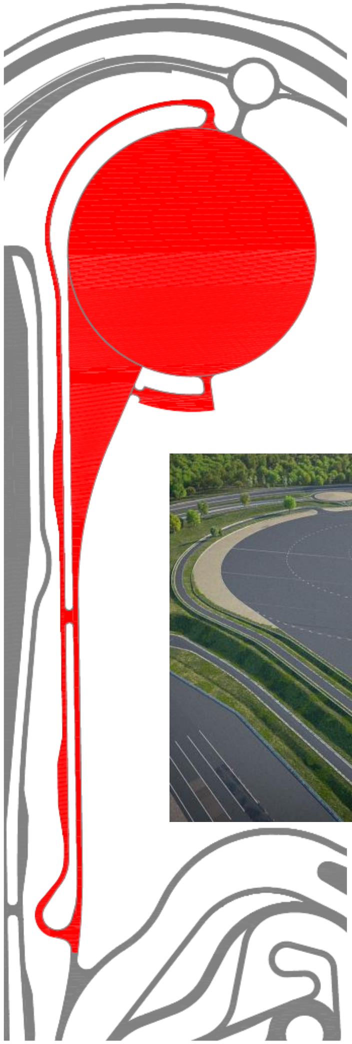
Dynamic platform

<u>Physical parameters:</u>

- 300m diameter asphalt surface
- Acceleration lane 760m and 400m long
- 20m wide FIA emergency area
- Watered surface (optional)
- Watered basalt surface at eas acceleration lane (phase 2.)
- 1% inclination to south
- Separated return way

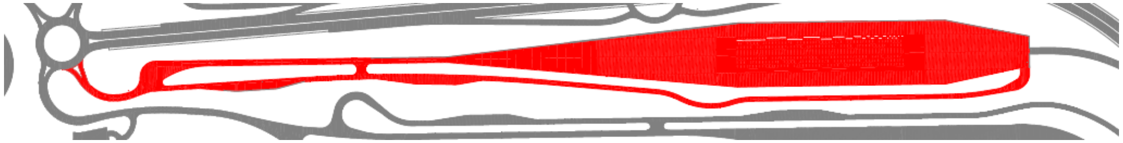
<u>Autonomous vehicle test cases:</u>

- Platooning at free trajectory
- Cooperative vehicle control at high and medium mue with different trajectories (double lane change, J-turn etc.) at stability limit (ABS, ESP activity)
- Fix position obstacle (dummy car or pedestrian)
- Euro NCAP scenarios



Proving Ground modules

Braking platform



Physical parameters:

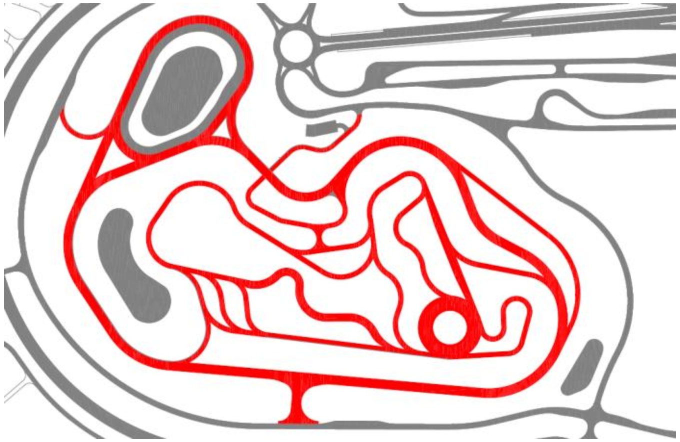
- 8 different surfaces:
  - *Chess surface: asphalt/tiles*
  - *Asphalt mue=~1 (optional watering)*
  - *Tiles mue=~0.1 (wet)*
  - *Blue basalt mue=~0.3 (wet)*
  - *Asphalt mue=~0.8 (optional watering)*
  - *Treated concrete mue=~0.6 (wet)*
  - *Asphalt mue=~0.8 (reserve surface)*
  - *Aquaplaning basin (max. 5cm wet depth)*
- 200m surface length
- 750m acceleration lane
- 20m safety area at both side, 150m at the end

Autonomous vehicle test cases:

- Platooning at physical limits; drive through or braking at various surfaces up to high speed
- Cooperative vehicle control at physical limit, moving or static obstacle, at various speeds during ABS, ATC, ESP activity

Proving Ground modules

Handling course



Physical parameters:

- Low (60km/h) and high speed (120km/h) section
- 1.300m and 2000m length
- width: 6 and 12m
- 20m wide gravel covered safety zones
- Various topography
- V2X coverage for communication tests at various terrain

Autonomous vehicle test cases:

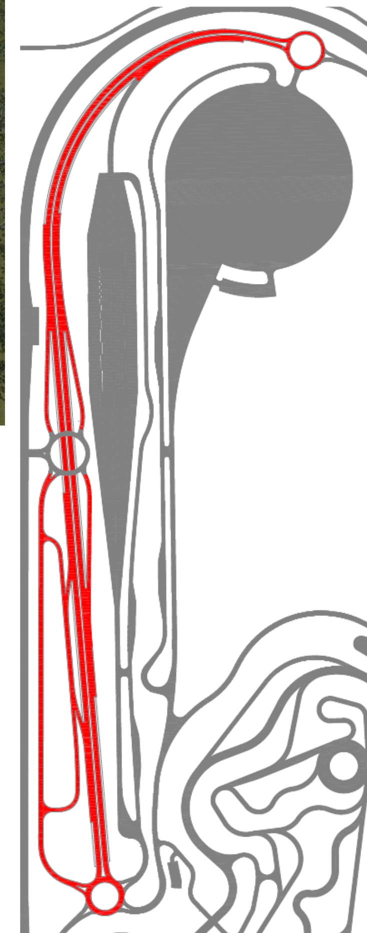
- Platooning at medium speeds at diverse topography
- Cooperative vehicle control at diverse topography and limited visibility

zone

Proving Ground modules

Motorway

Project Phase 2 2019



Physical parameters:

- 1500m 2 x 2+1 lane motorway
- 100m real tunnel
- Partly watered surface
- VMS, 5G test network
- V2X communication coverage
- GPS base station
- Public road like layout (junctions, road surface, geometry)

Autonomous vehicle test cases:

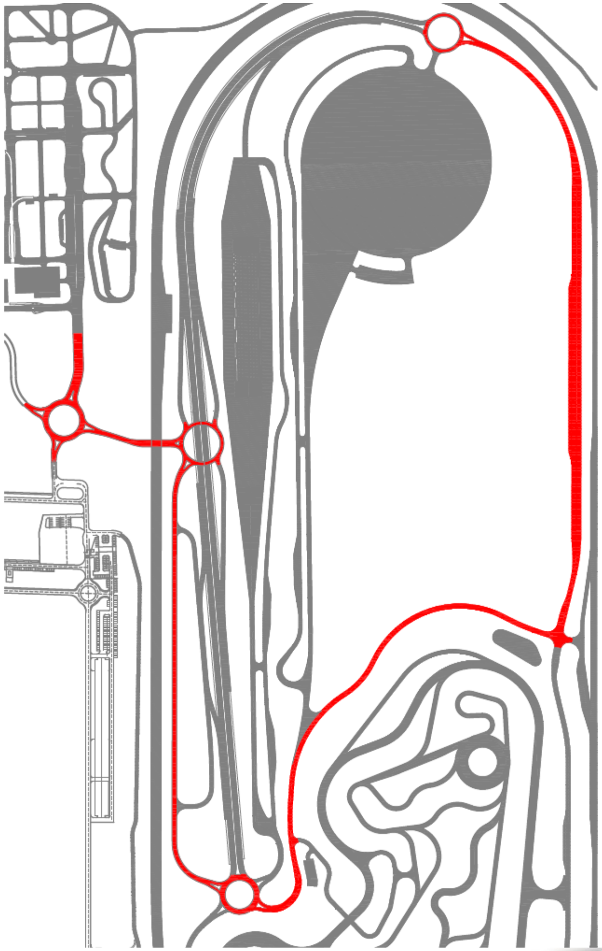
- Platooning on motorway at realistic conditions, exits and entrances
- Platooning and cooperative control with limited communication (tunnel)
- Moving and static obstacles
- Construction site situation
- Multi level junction

Proving Ground modules

Rural road

Physical parameters:

- 500m 2x2 lane motorway
- 2500m 2x1 lane rural road
- Partly watered surface
- 5G test network
- V2X communication coverage
- GPS base station
- Public road like layout (junctions, road surface, geometry)



Autonomous vehicle test cases:

- Platooning on rural road at realistic conditions, various type of junctions, roundabouts
- Diverse lane layout: 2x1, 2x2, 2+1,
- Diverse topography
- Moving and static obstacles
- Construction site situation
- Various road side elements: trees, fences, grass etc.

Proving Ground modules

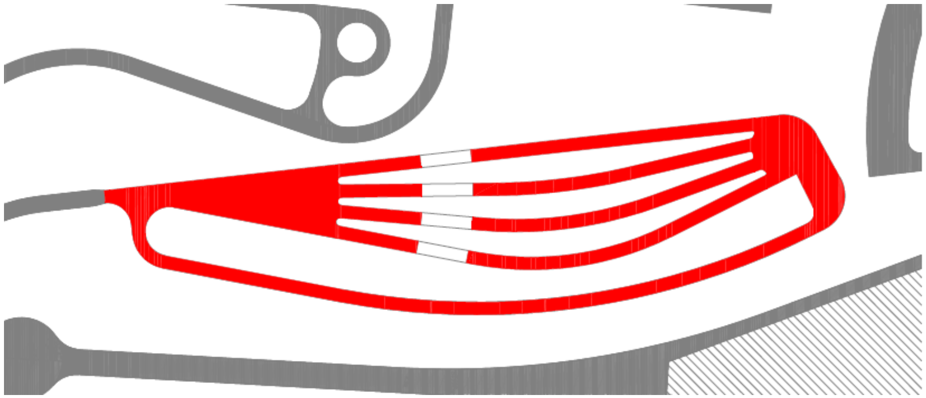
Slopes

Physical parameters:

- 100m length
- 20m height
- Low μ-split surface with a 25m length
- 5 different slopes: 5%, 12%, 18%, 25%
- Homogenous low friction surface, and diff. adherence test option on sides
- Integrated watering system
- Safety zone and reinforced guard rail

AD vehicle test cases:

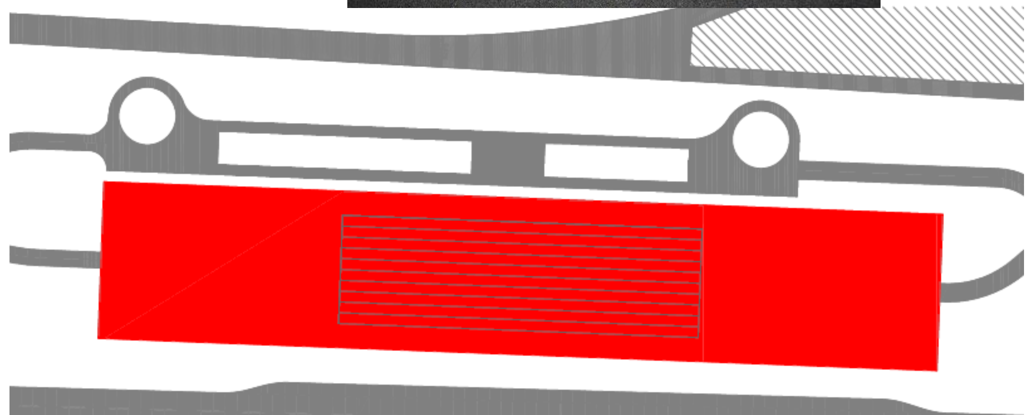
- Platooning at low speeds up and downhill and various friction conditions with limited visibility
- Cooperative vehicle control at low speed up and downhill and various friction conditions with limited visibility



Project Phase 2 2020

Proving Ground modules

Bad roades



Physical parameters:

- 8 different surfaces:Belgian pavement (2 diff. profile):
  - Spanish road
  - Washboard road
  - Road bumps, step-down
  - Block pave (3 kbz. profile)
- 150m length
- Acceleration lane 100m
- Safety zone 50m at the end
- 2 different water basin (max. 0.3 and max. 1m)

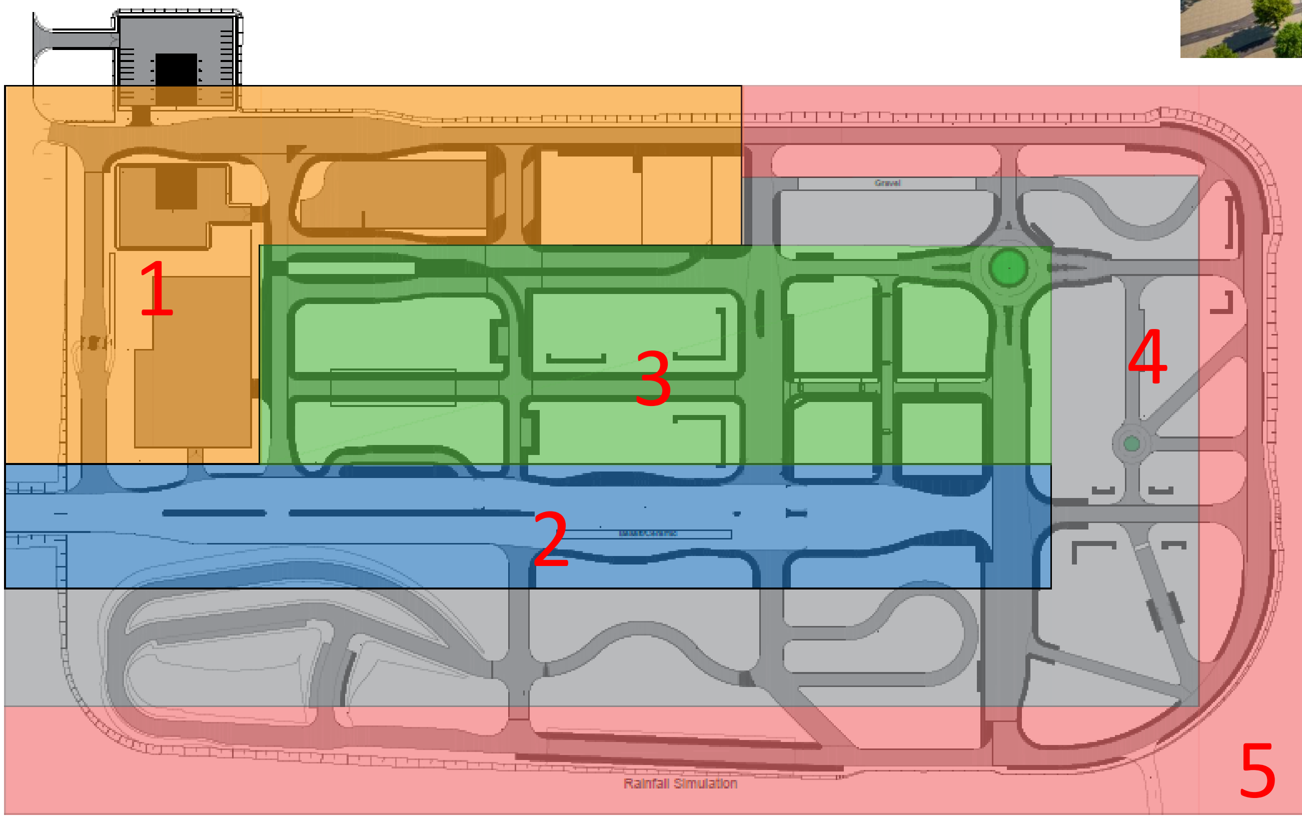
Project Phase 2 2020

AD vehicle test cases:

- Platooning at low speed on extremly bad road quality
- Cooperative control at low speed on extremly bad road quality
- Moving and static obstacles

Proving Ground modules

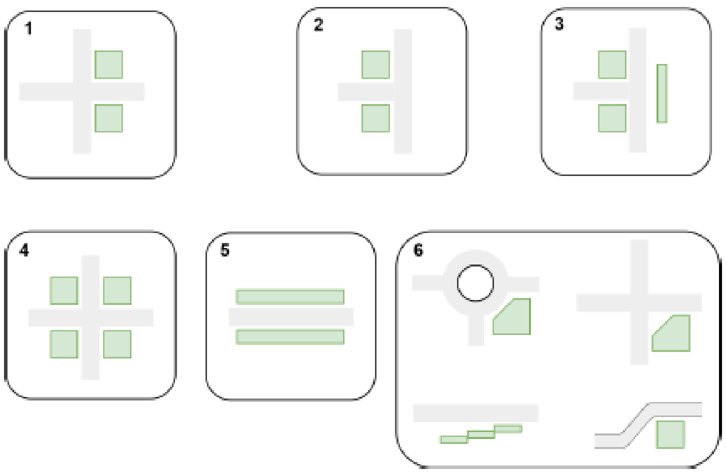
SMART City Zone – Separated Function Zones

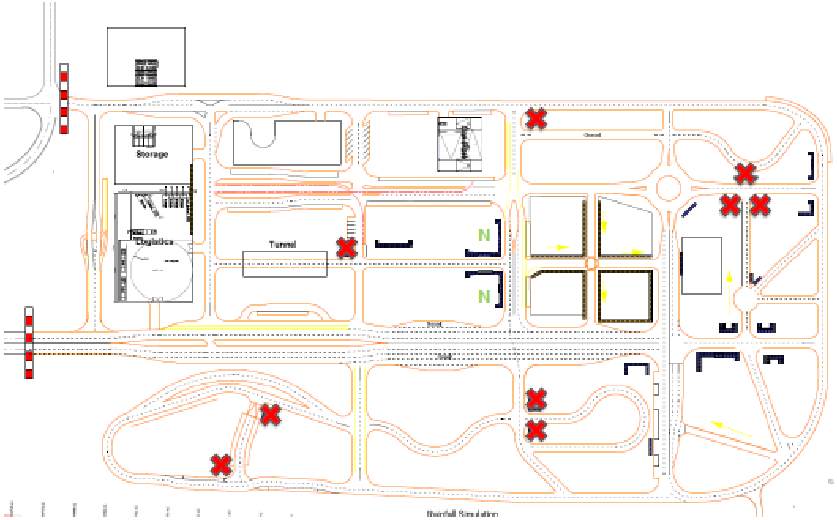


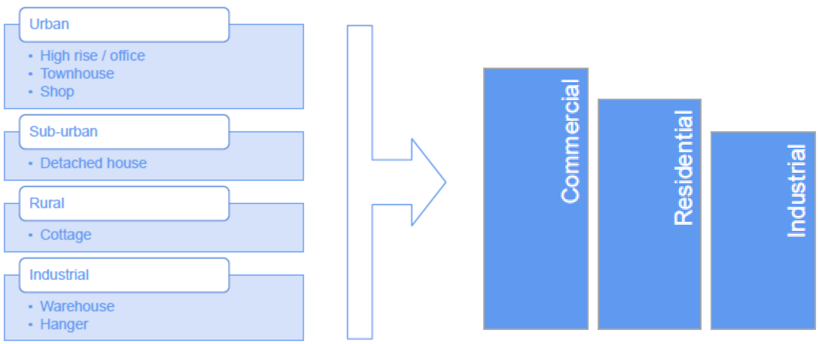
1. Low-speed, parking area
2. Multi-lane high speed area
3. Downtown area
4. Suburban area
5. T-junction area

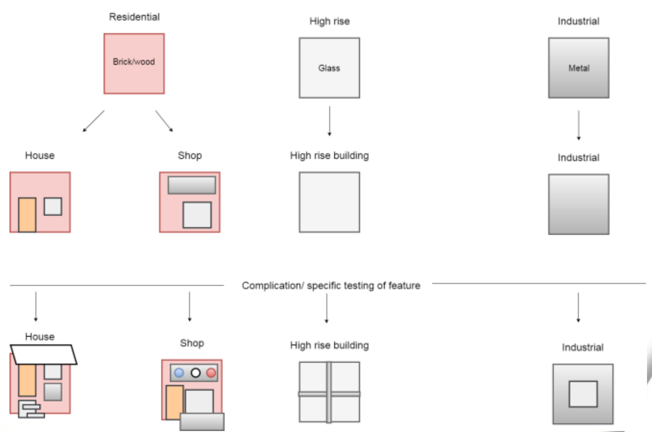
Construction of Complex Test Scenarios

SMART City Zone – Buildings





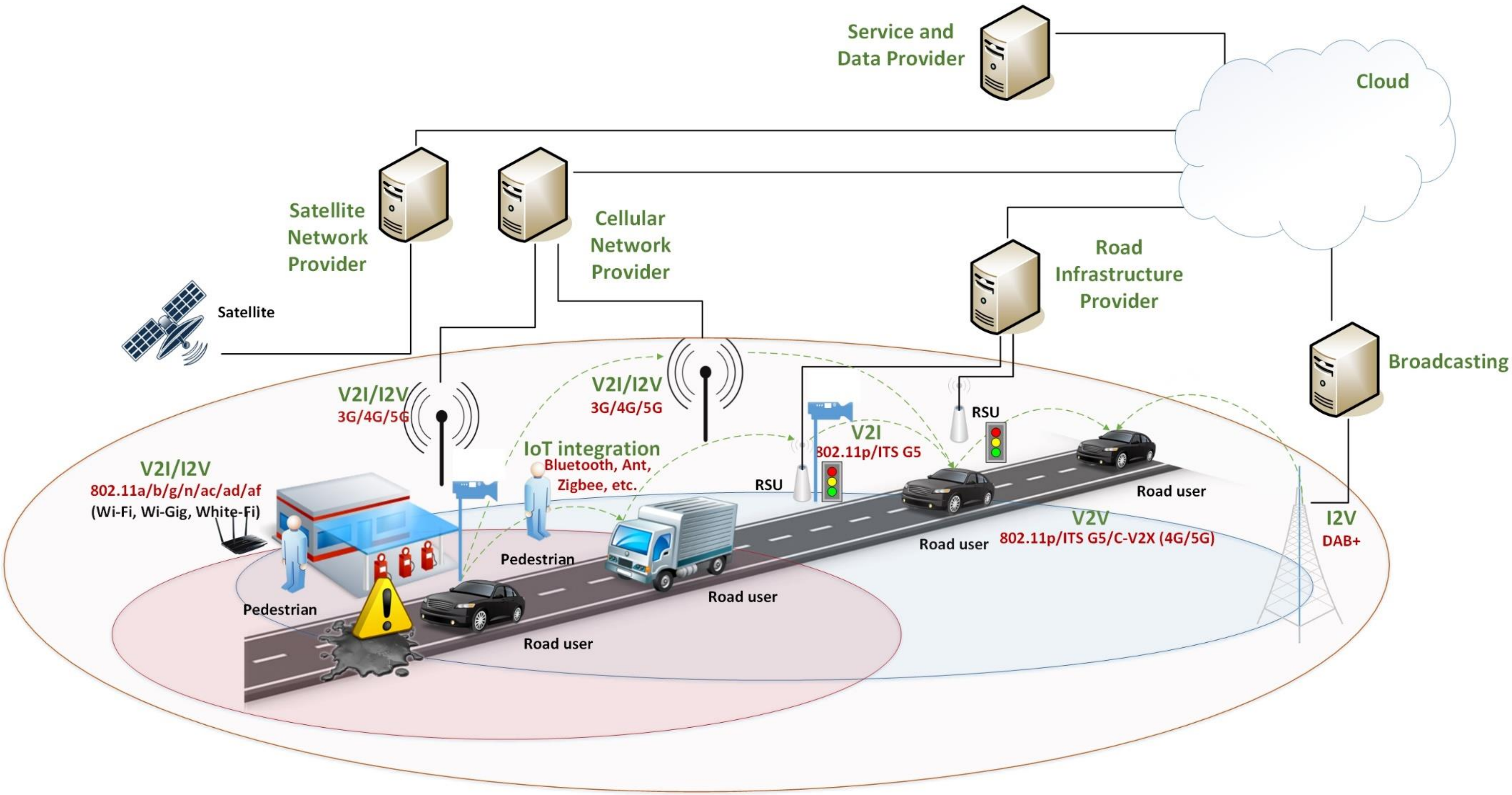




Details of the modules

Proving Ground modules

Communication network with WiFi and cellular technology



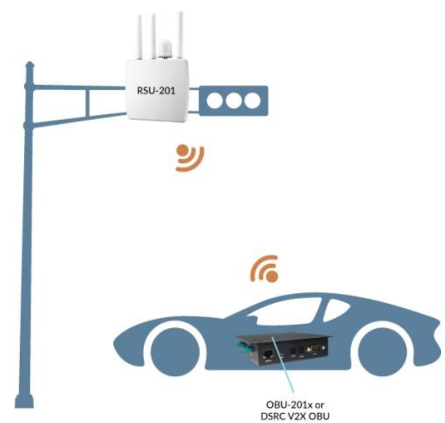
Proving Ground modules

Communication network

- **3 level** approach:
  - 1st level: ITS G5 basic V2X test environment
  - 2nd level: V2X developer environment: freely configurable, open interface for application developers, full data logging infrastructure
  - 3rd level: fully customer defined test environment

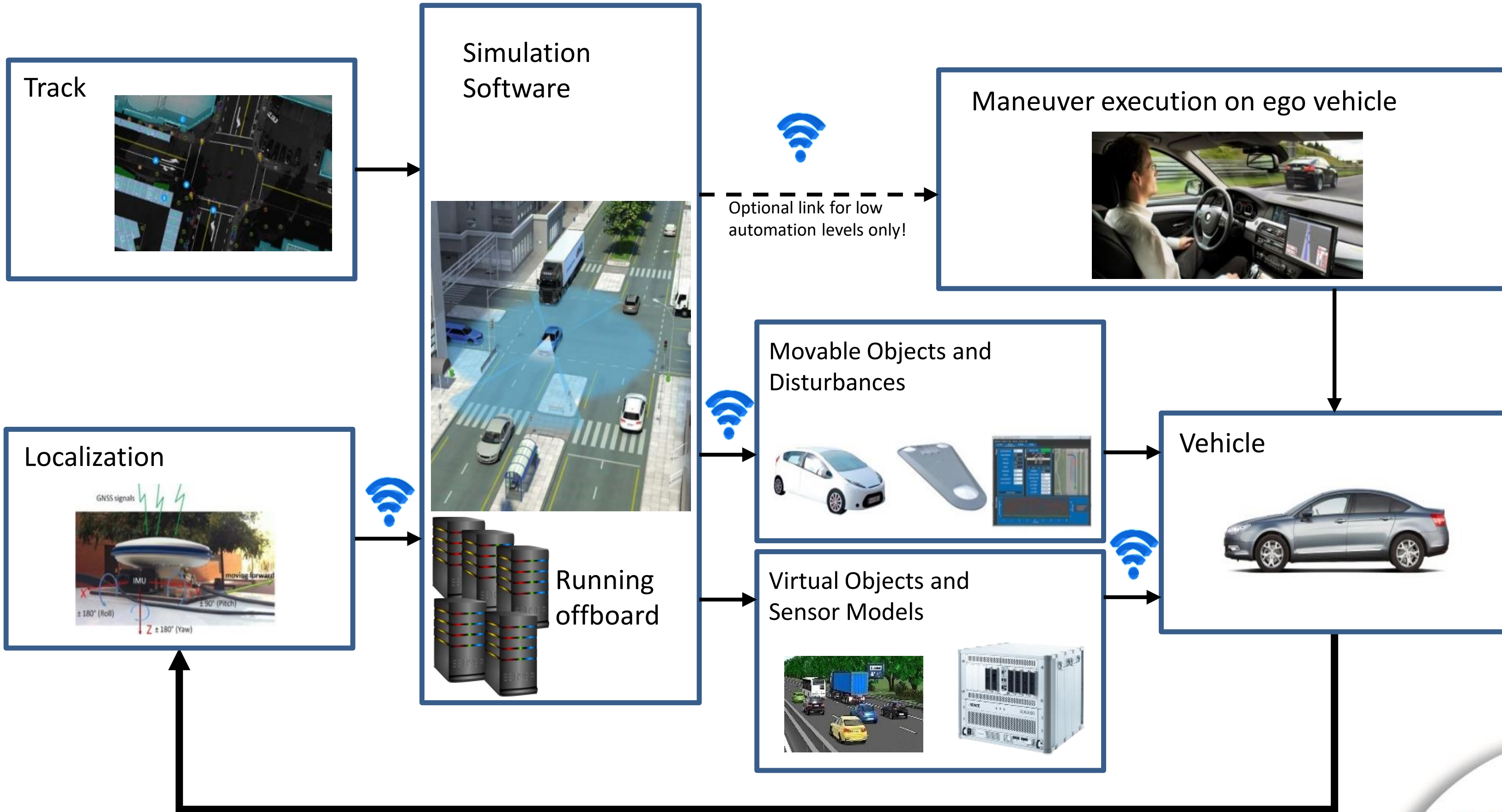
- **5G cellular** test network for future ITS applications

- **Redundant layout** for parallel customer networks



Construction of Complex Test Scenarios

Opportunities for the Scenario-in-the-Loop (SciL) Simulation



ZALAZONE - Region Zala