



TENDENCIES IN THE AUTOMOTIVE INDUSTRY AND THE ROLE OF HUNGARY IN THIS NEW WORLD

BEST PRACTICE TRANSFER TO THE ELI SCIENCE PARK

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Content

What is the challenge?

(Road) mobility as social need

Opportunities and limitations of automatized vehicle driving

Why Hungary?

Previous activities in the field of electronic vehicle control

Status of academic and industrial research and development

Support of the community – decision on large scale testing infrastructure

What do we offer?

Unique vehicle testing facility for autonomous and electric vehicles

Extended Central-European testing zone



A hand in a white shirt and red tie points towards a futuristic interface. The interface features a central blue circle with a white car icon and four white wireless signal symbols (top, bottom, left, right). This central circle is surrounded by a dotted white border. To the left and right of the central circle are two green circles with white borders. The background is a blurred image of a person in a suit. The overall design is modern and technological.

What is the challenge?

Social, political processes – EU directions

- 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 logistics
 - Energy and environment
 - Safety and security
 - Competitiveness and affordability



What is the challenge?

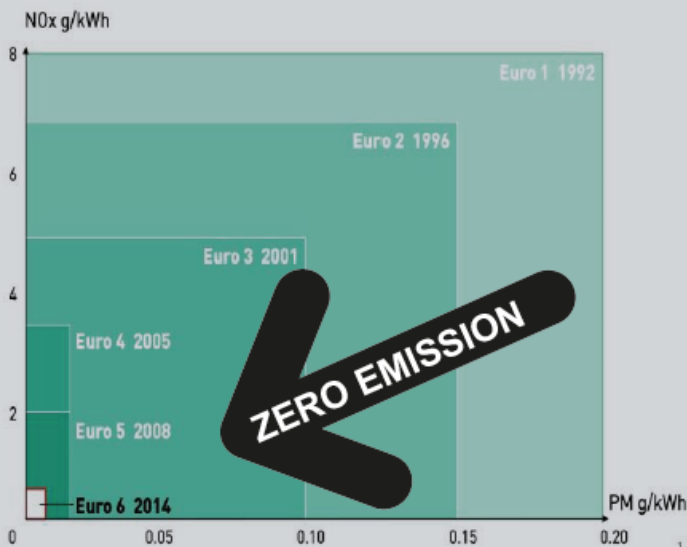


Technical background

Emission

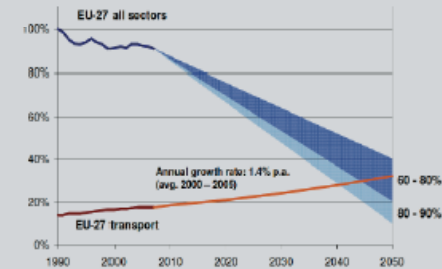


Implementation of EURO6 standard does not help further the increase of the motor efficiency

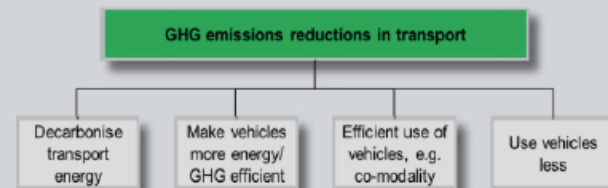


Next step CO2 reduction/reducing consumption

1. Problem



2. Solution



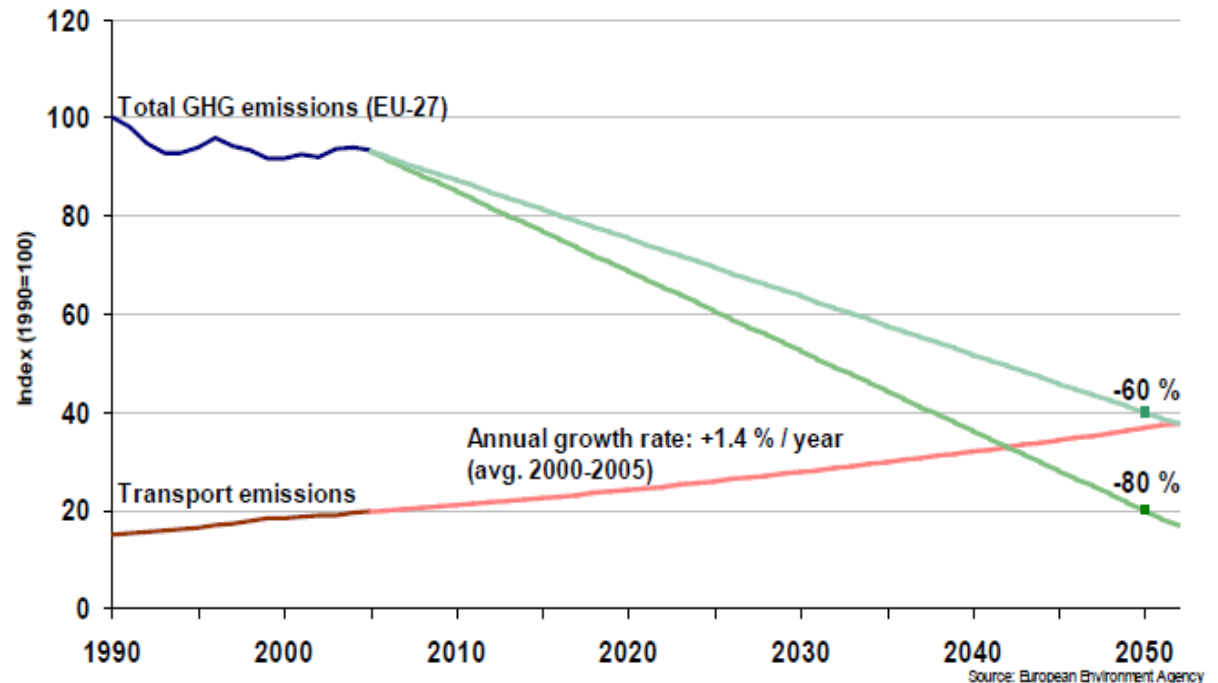
What is the challenge?

Can we do it?

It will be difficult – only transport will generate more!

- EU objective: reducing GHG emissions by between 80% and 95% by 2050.
- Reducing GHG emissions from transport is fundamental to meet these targets.
- This is likely to be challenging given that transport's GHG emissions have continued to increase.
- EU expects GHG growth > 160% by 2050 compared to 2010* for Commercial Vehicles

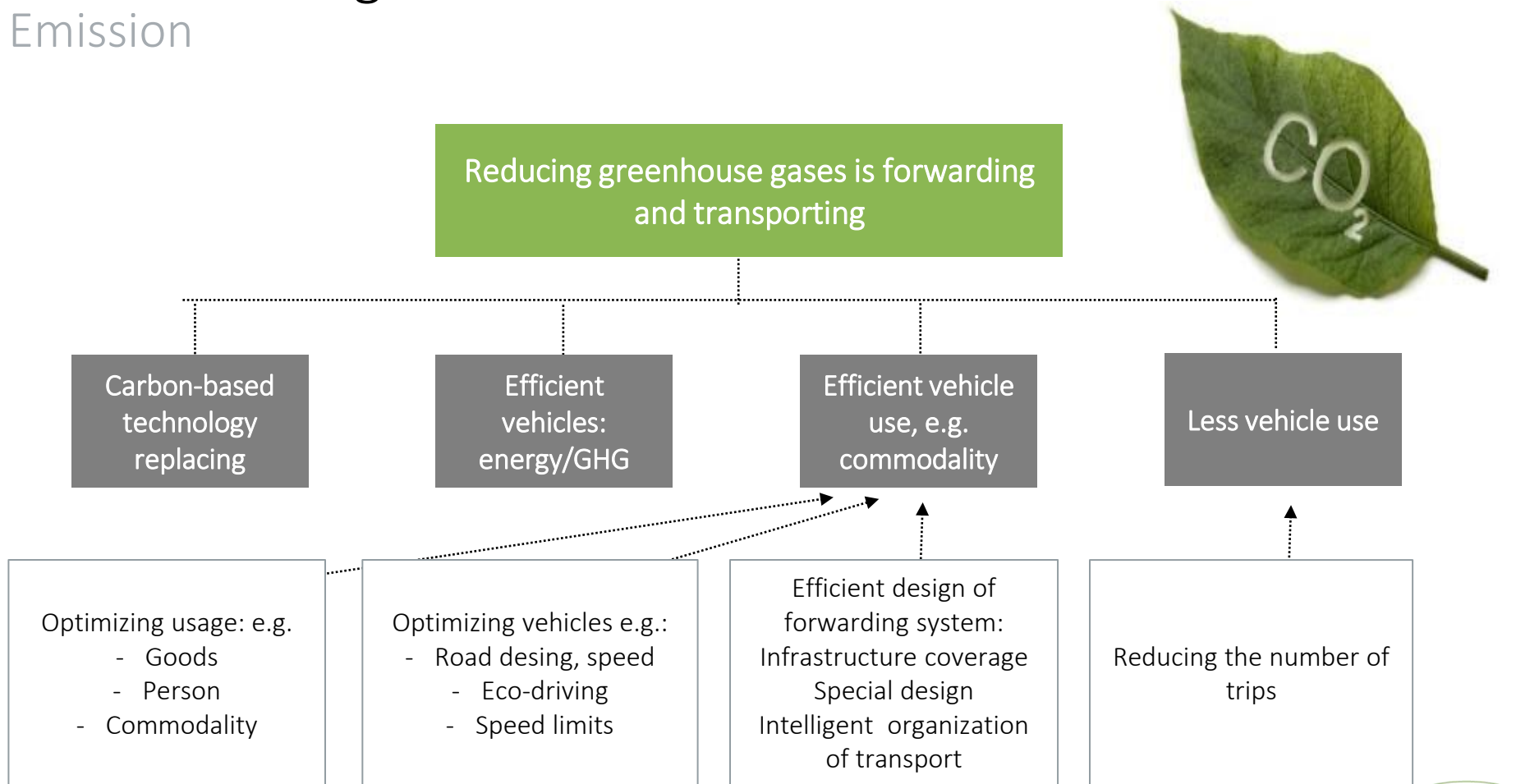
EU overall emissions trajectories against transport emissions (indexed)



What is the challenge?

Technical background

Emission



What is the challenge?

Mobility as social challenge

Inspiring factors for development

1 Zero Emission

- Fuel-consumption reduction
- Reducing emission



2 Demographic pressure

- Support of insecure leaders
- Increase the elderly mobility



3 Risk of accidents

- Avoidance of the accidents by 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, etc.)



Source: VDA



What is the challenge?

Mobility as social challenge

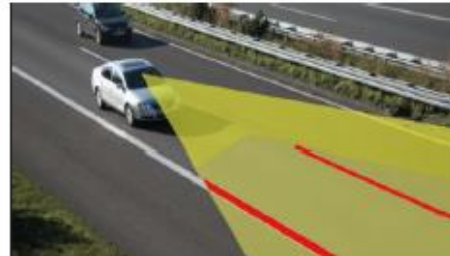
Technology is available

Longitudinal control



ACC traffic-jam assistant
emergency braking assistant

Transverse control



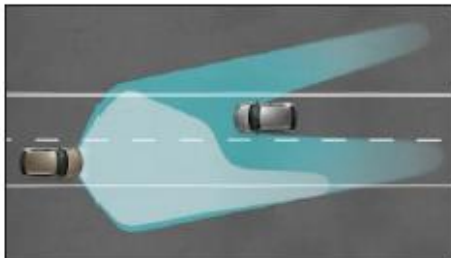
Lane-changing assistant, lane-keeping assistant

Parking, maneuvering



Automated parking assistant

Lighting



Adaptive long-distance lighting,
adaptive cornering lights

Drive supervision



Fatigue supervision

Environmental supervision



Traffic sign detection

Source: VDA



What is the challenge?

Technical background

Systems available nowadays

Traffic-jam pilot



2012
Volvo: Sartre (EU)

Highway pilot



2011
VW: HAVEit (EU)

Advanced Driving Assistance



2011-2015
VW: V-Charge (EU)

Google car



2014
AUDI

Pikes Peak



2015
Mercedes: FT2026

Emergency Brake Assistance



2016
Volvo: Drive Me

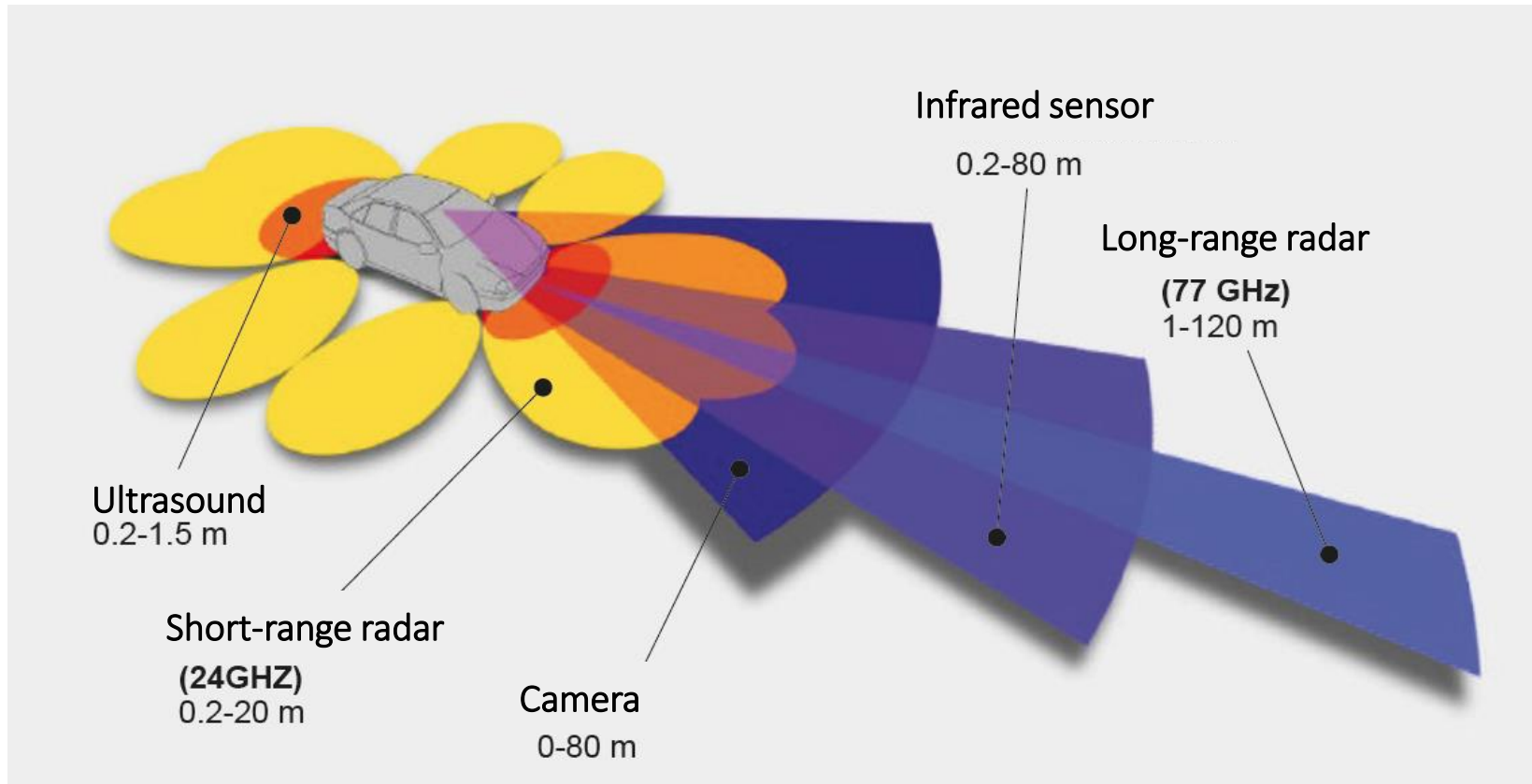
Source: VDA



Driverless vehicles

Technical background

Example - environment detection as a driver



What is the challenge?

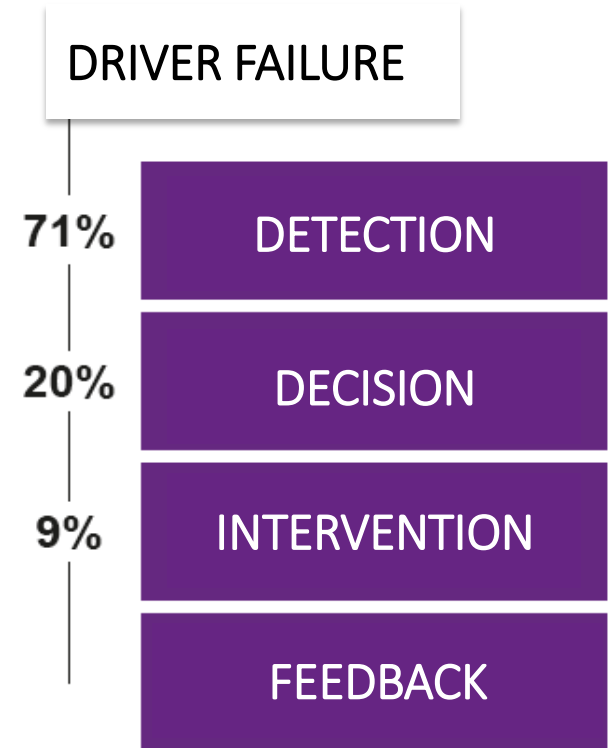
Human factor

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:

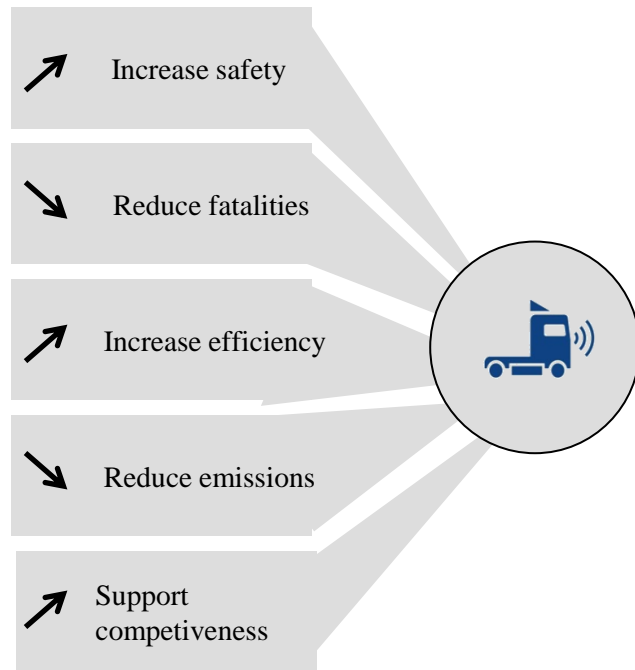
- If the driver intervenes into the intelligent system, the predictive elements of the system pass the control
- If the given situation cannot be avoided, the intelligent system can intervene



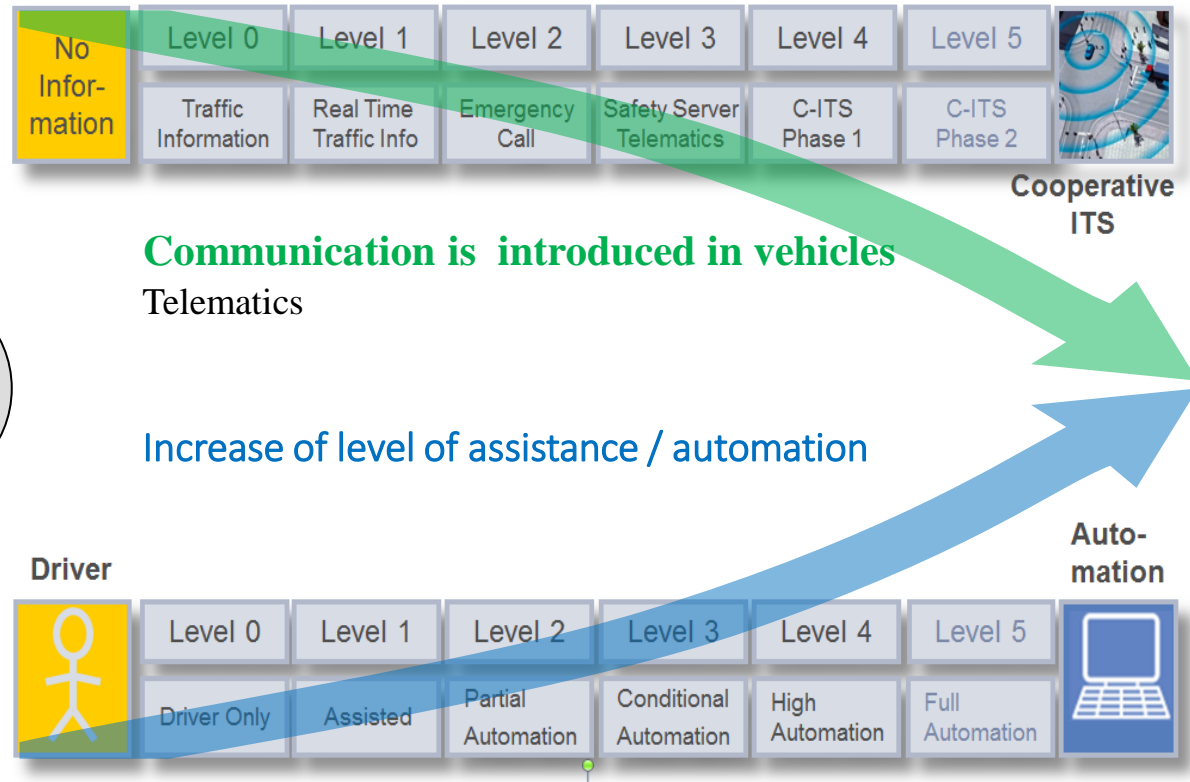
What is the challenge?



Increase level of automation and co-operative control



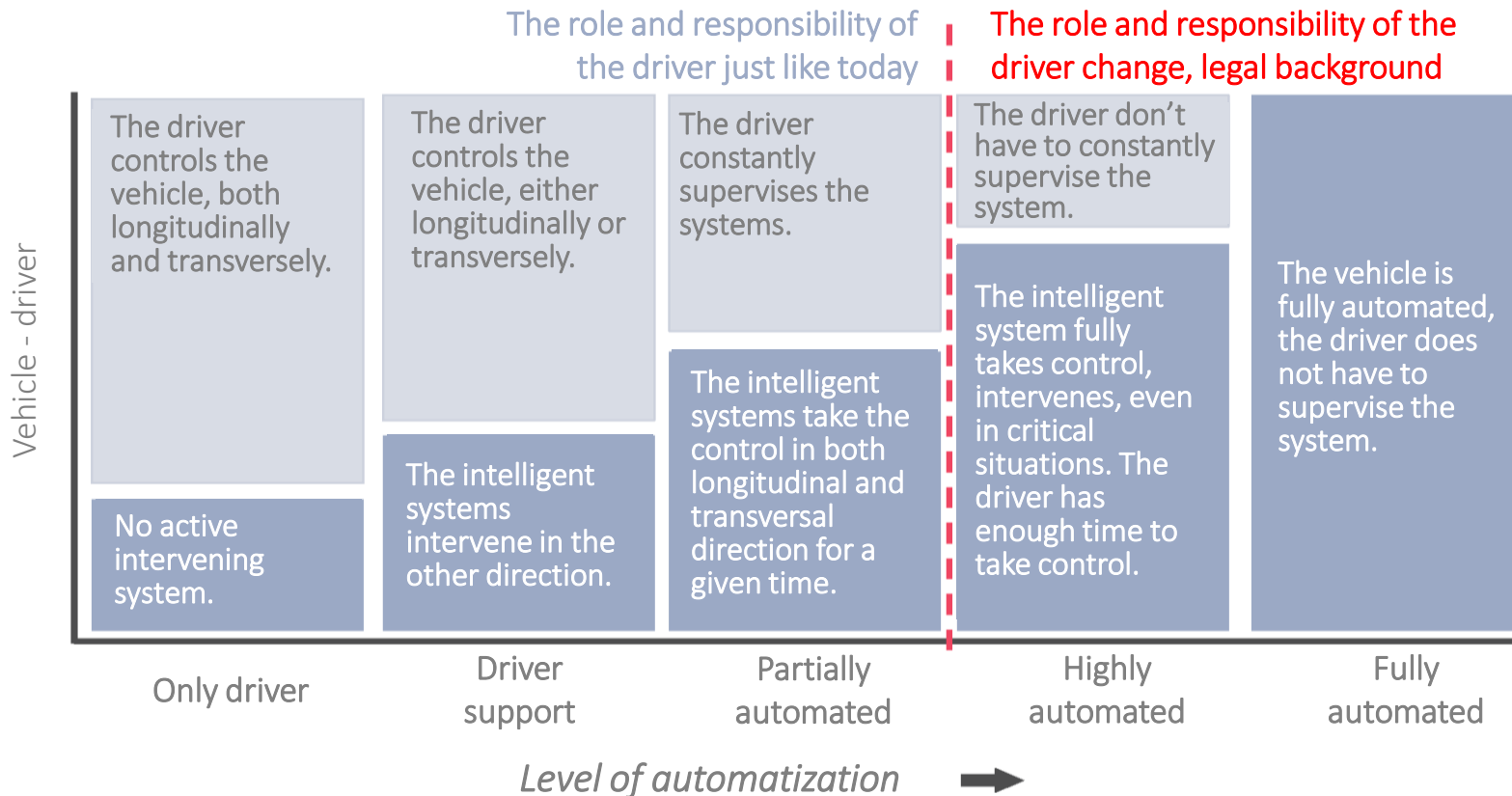
Governments are requested to provide a framework



What is the challenge?

Change in driver's responsibility

Levels of automatization



What is the challenge?

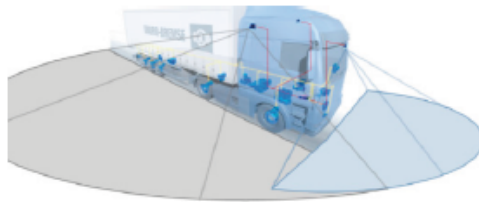
Mobility as social challenge

Change in driver's responsibility

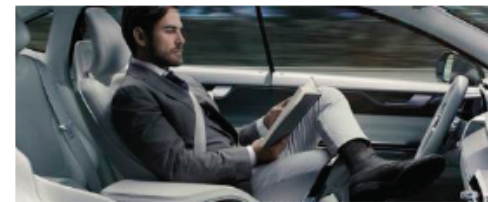
TODAY 2017



TOMORROW < 2020



FUTURE > 2020



Lane
departure
warning

Longitudinal
control

Emergency
brake
system

Active
steering

Object
detection in
dead spot

ACC
+ LKA

Automated
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

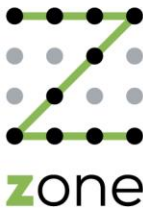
DRIVER IS INACTIVE „FAIL
TOLERANT” SYSTEM

Source: Volvo, Knorr-Bremse



What is the challenge?

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Technical background

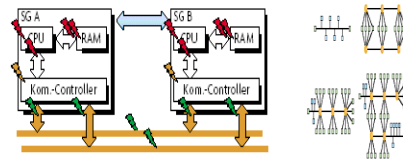
Technology is ready - is it enough?

Architecture



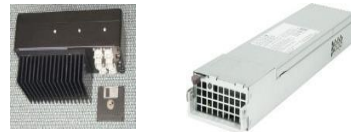
Redundant central control unit

Communication



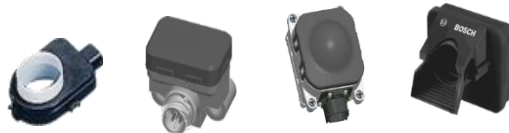
Redundant communication in the car and with the outside (V2V, V2I)

Power supply



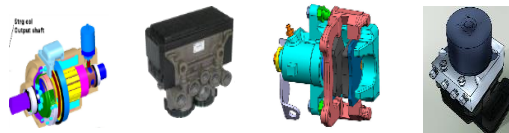
Redundant, galvanically separated energy storage and supervision system

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.)



What is the challenge?

Non-technical aspects

Vienna treaty (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

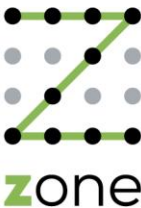
Drivers

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.



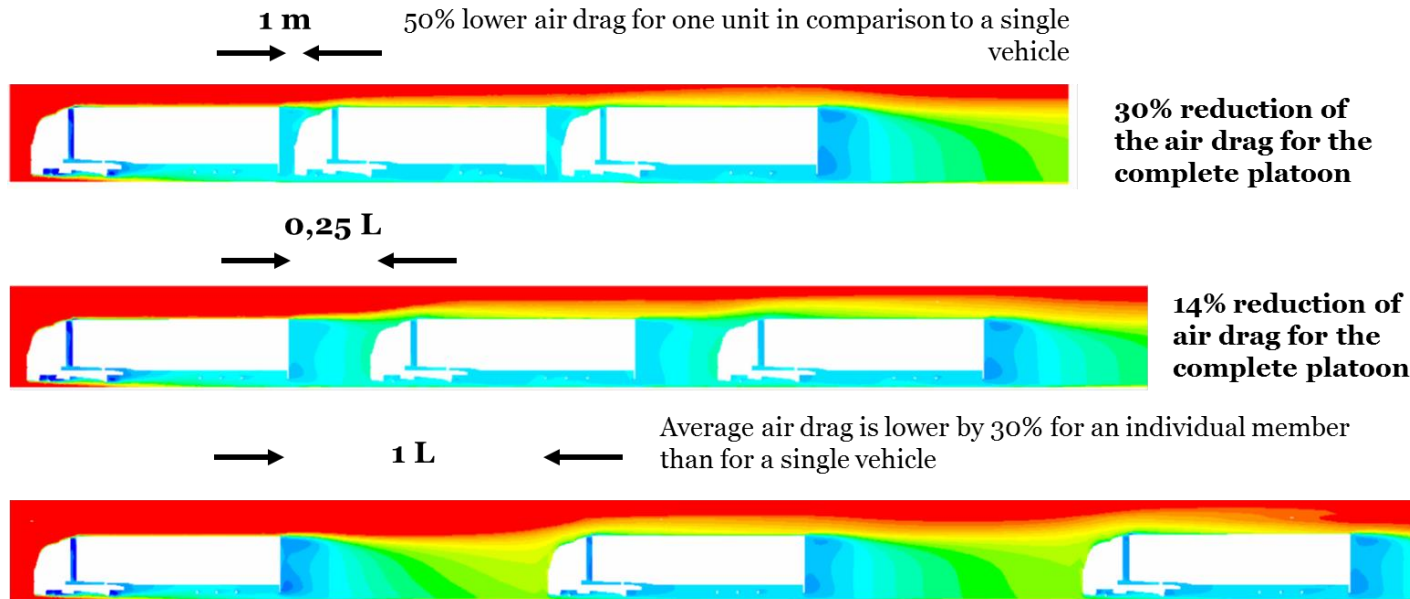
What is the challenge?

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How things will be combined?

Platooning is a good example!



Vehicles are travelling in a “platoon” are:

- Co-operatively controlled (communication among the members)
- Utilizing the road infrastructure in a more efficient way
- Reducing the fuel consumption and emission of the set of the vehicles
- Minimizing driver's fatigue and thus
- Probability of the accidents will be reduced



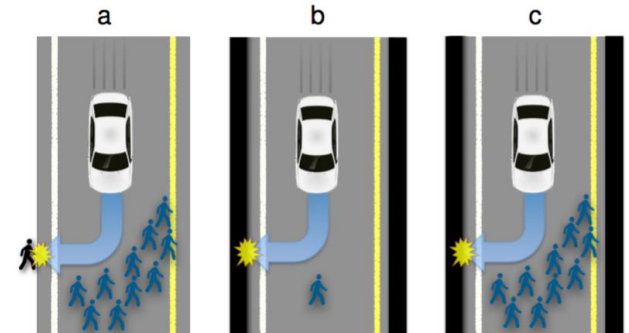
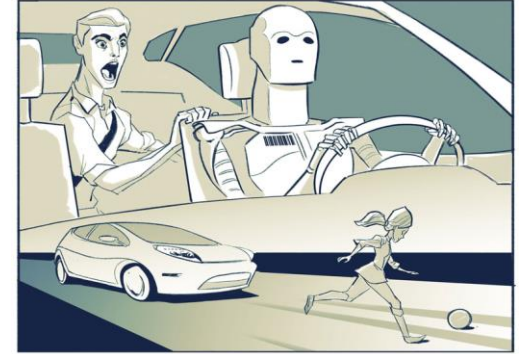
What is the challenge?

Mobility as social challenge

Non-technical questions

- Can we take away the enjoyment of driving from the driver?
- As different to the other co-operatively drivable vehicles (plane, boat, rail) we must be ready to manage the vehicles to handle the dangerous situations while having human participants with unperfect and very different abilities?
- What is the base of decision if we must choose from two bad options?
- Liability and legal concerns
- New business models will appear
- Can we guarantee, that autonomous vehicles will not be put in non-proper use?

Source: Technologiereview, VDA



Number of test/use cases is unknown



What is the challenge?

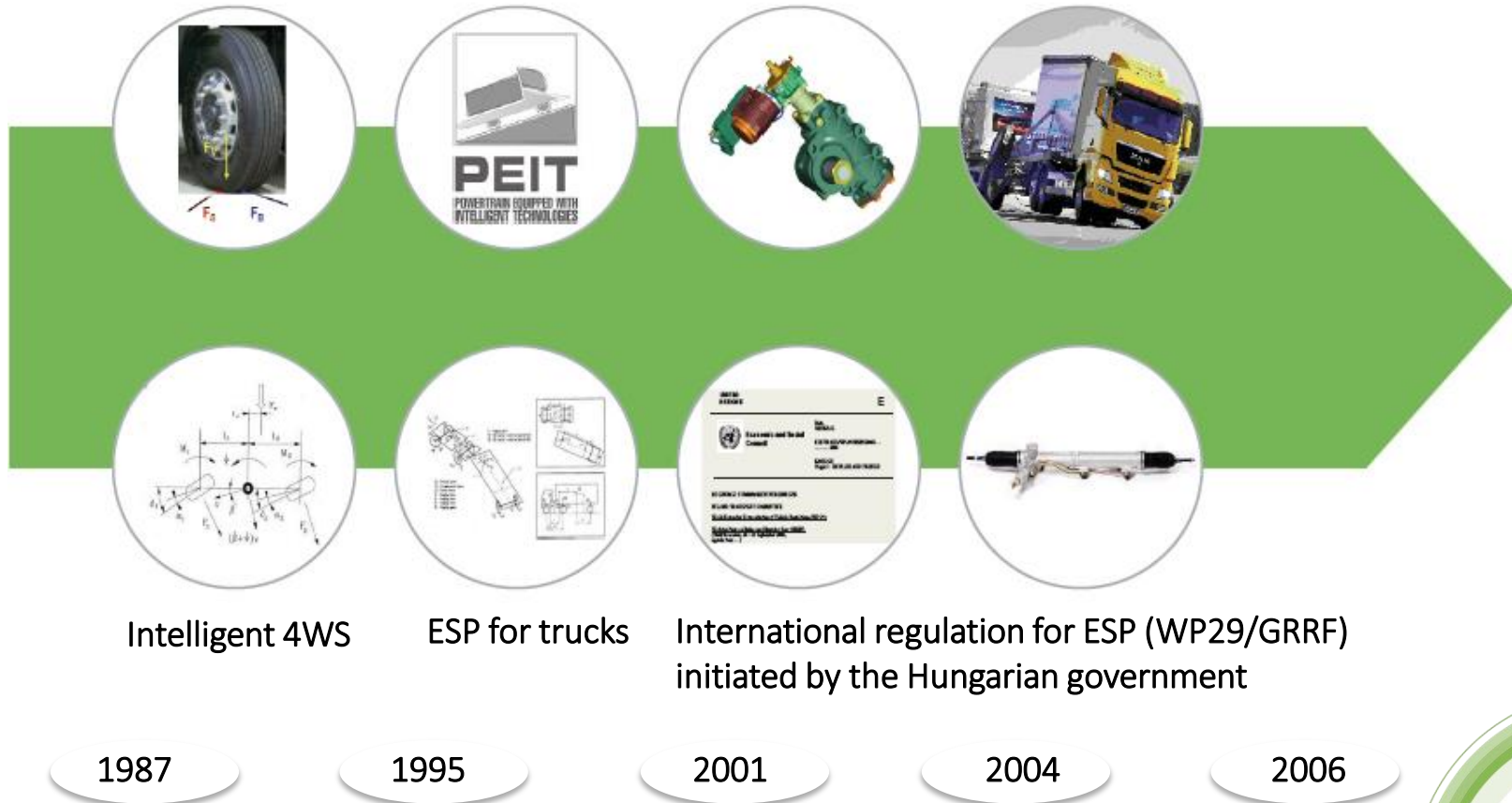


Why Hungary?

Long term competency in electronic vehicle control

High-level research already in the 80's

ESP with brake and steering intervention

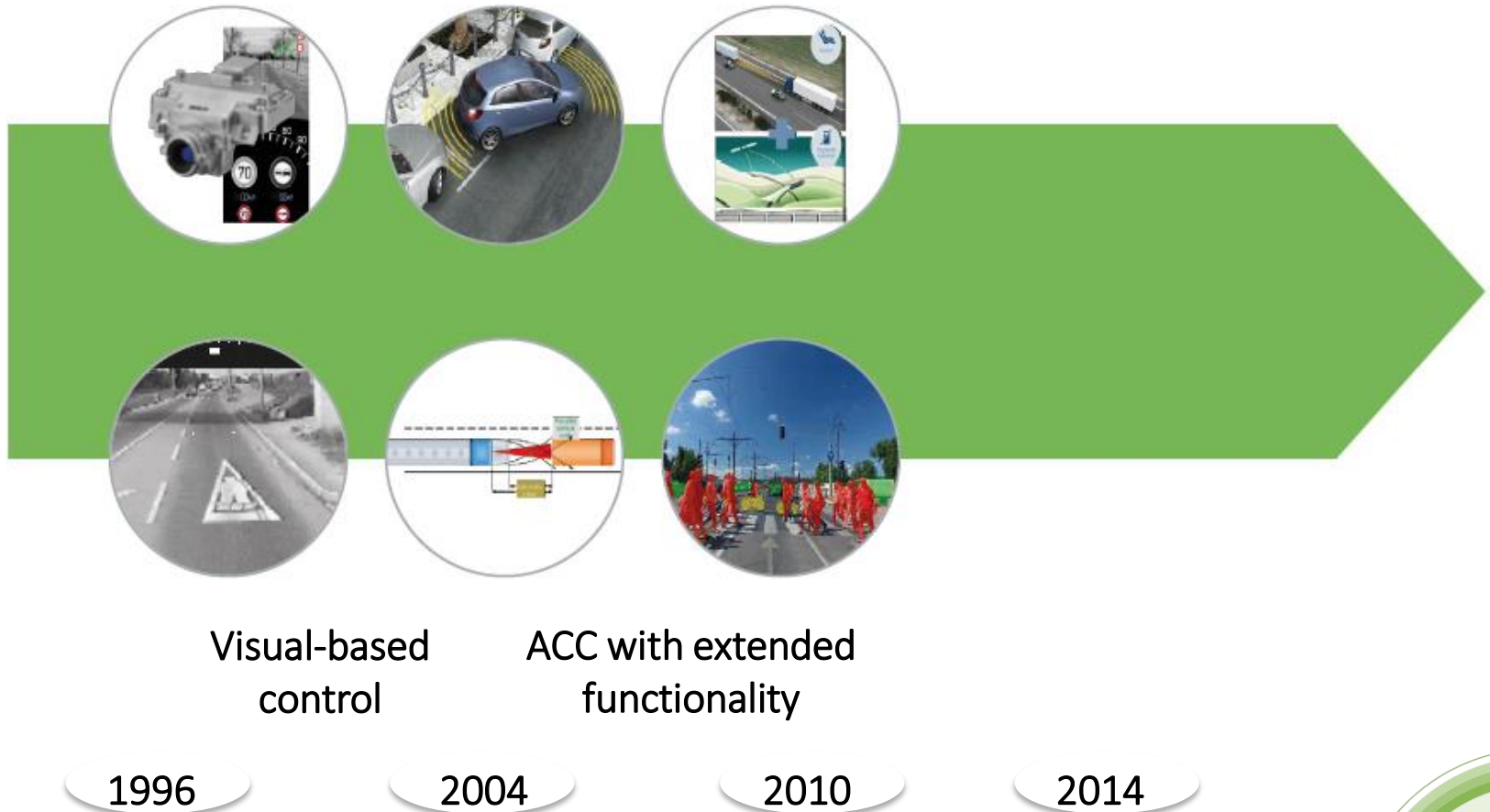


Why Hungary?

Research Projects in HUNGARY

ADAS Systems

Adaptive speed control



Why Hungary?

Research Projects in HUNGARY

Driverless Transportation

On-site driverless maneuvering



Platooning in 1999 and in 2012

1999

2002

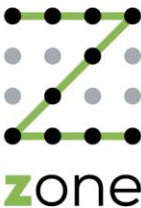
2012

2016



Why Hungary?

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Long term competency in electronic vehicle control

Participation in all relevant large scale EU FP projects



Cooperative
Vehicle
Infrastructure
Systems

PEIT



Powertrain
Equipped with
Intelligent
Technologies

SPARC

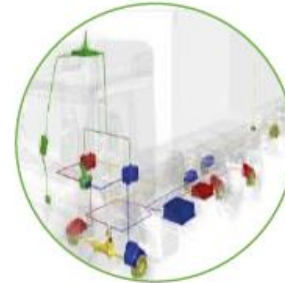


Secured
Propulsion Using
Advanced
Redundant Control



Highly Advanced
Vehicle and
Infrastructure

TRUCK-DAS



Truck Driver
Assisting
Systems



Budapest University
of Technology and
Economics



Hungarian
Academy of
Sciences



University
of Szeged



Széchenyi István
University



University
of Pannonia



Óbuda University



Why Hungary?

Long term competency in electronic vehicle control

Strong scientific community for autonomous vehicle technology research

Close cooperation

- Industrial partners (BOSCH and Knorr-Bremse)
- Academical background (BME, ELTE, MTA SZTAKI)



Market demand

- Global trends and actual developments in automotive
- 4 OEM's and 15 TIER1 companies from Hungary
- Constant need for qualified engineers



Strong government support

- Higher added value compared to manufacturing
- ROI calculation at national economy level
- Special research funding programs

Dedicated BSc/BEng and MSc courses

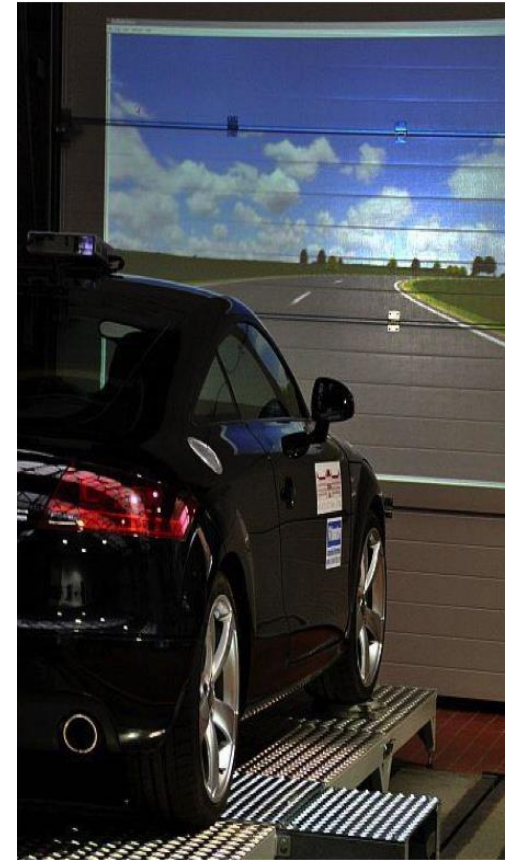
- Autonomous Vehicle Control Engineer MSc in English, 2018, Budapest, BME
- Computer Science for Autonomous Driving MSc in English 2018, Budapest, ELTE
- Vehicle Test Engineer Beng in Hungarian 2018, Zalaegerszeg



Why Hungary?

RECAR program – example research fields

- Basic and advanced research in **artificial intelligence**
- **Co-operative control** applications to vehicles
- **Redundant technologies** (sensors, actuators, energy and communication networks, software)
- **Insurance/reliability**: how can reliability be tested and improved?
- **Data acquisition/property rights**: how is it possible to make data access and management transparent? Personal data - how can the protection of personal data be guaranteed?
- **Cyber security**: how is it possible to avoid illegal use of intelligent functions?
- **Driverless technologies**: how can test and approval processes be improved to make autonomous vehicles safe and reliable?
- **Accident investigations** with involvement of automated vehicles



Why Hungary?

Industrial background

Close co-operation with the industry – specification of requirements

Automotive Working Group: Almotive, AVL, BME GJT, Bosch, Commsignia, Knorr-Bremse, Continental, EVOPRO, NKH, NI, SZTAKI, ThyssenKrupp Presta, TÜV Rheinland, ZF

- Detailed technical specification of the classic elements of vehicle dynamics and physical structure of the automated vehicle tests
- Draft specification of the autonomous environment and related communication infrastructure
- Technical proposal for autonomous vehicle public road testing

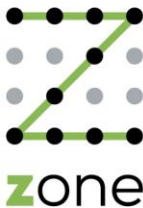
ICT Working Group: BME HIT, BME KJIT, BPC, Ericsson, HUAWEI, Kapsch, Magyar Közút, Magyar Telekom, NFM, NMHH, Nokia, Oracle, RWE, Siemens, SWARCO, T-Systems, Vodafone (compared to the new members of the automotive working group)

- Detailed specification of the autonomous vehicle environment and related communication infrastructure



Why Hungary?

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Commitment of the Hungarian Government

Investment into a European level RD infrastructure

- **Capacity constraints** in Europe in area of vehicle dynamic testing
- **Technology change** in vehicle industry – single vehicle vs. co-operative vehicle control: different development environment is required
- **Decision of Hungarian Government** in 2016

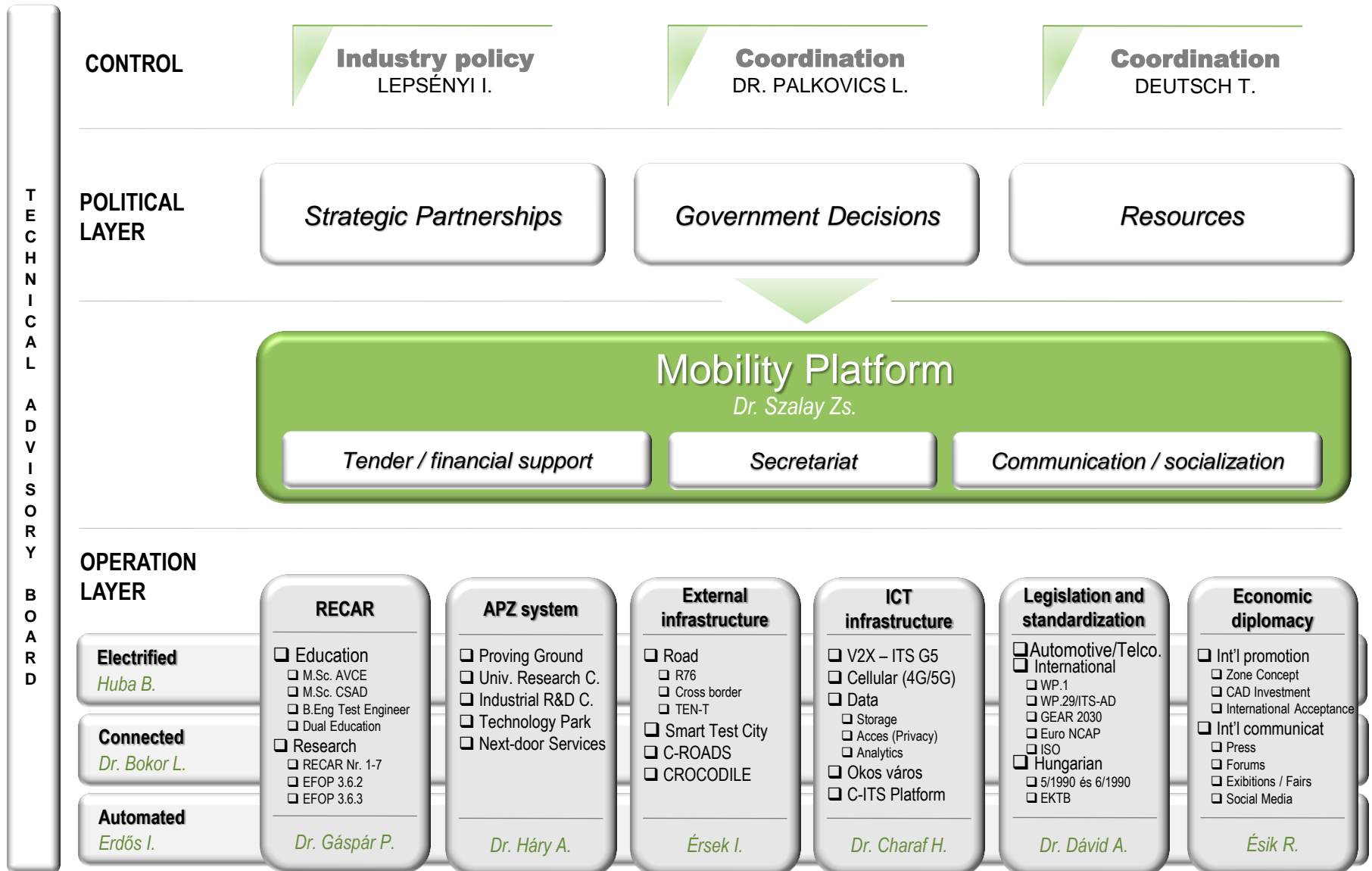
Test field for classic and automated and connected vehicles in Hungary



Why Hungary?

Commitment of the Hungarian Government

Investment into a European level RD infrastructure





What do we offer?

Multi-level testing environment

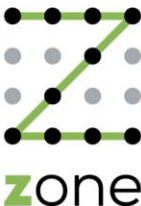
Designed on the demand of industrial companies

- Be able to **address all test levels of development process**, including the automated and connected vehicle tests, including passenger car, and commercial vehicles
- **Handling of prototype vehicles** must conform with internationally accepted standards and the customer needs
- **Full range service** for customers should be provided on-site (fueling, electric charger, meal, office, workshop etc.)
- **Flexible and connectable** track modules for special events and tests
- The test modules should be **visually separated**, the development and the public areas should be fully separated
- **Public road test** opportunity for autonomous vehicles
- Representative, **attractive environment** for presentations and conferences

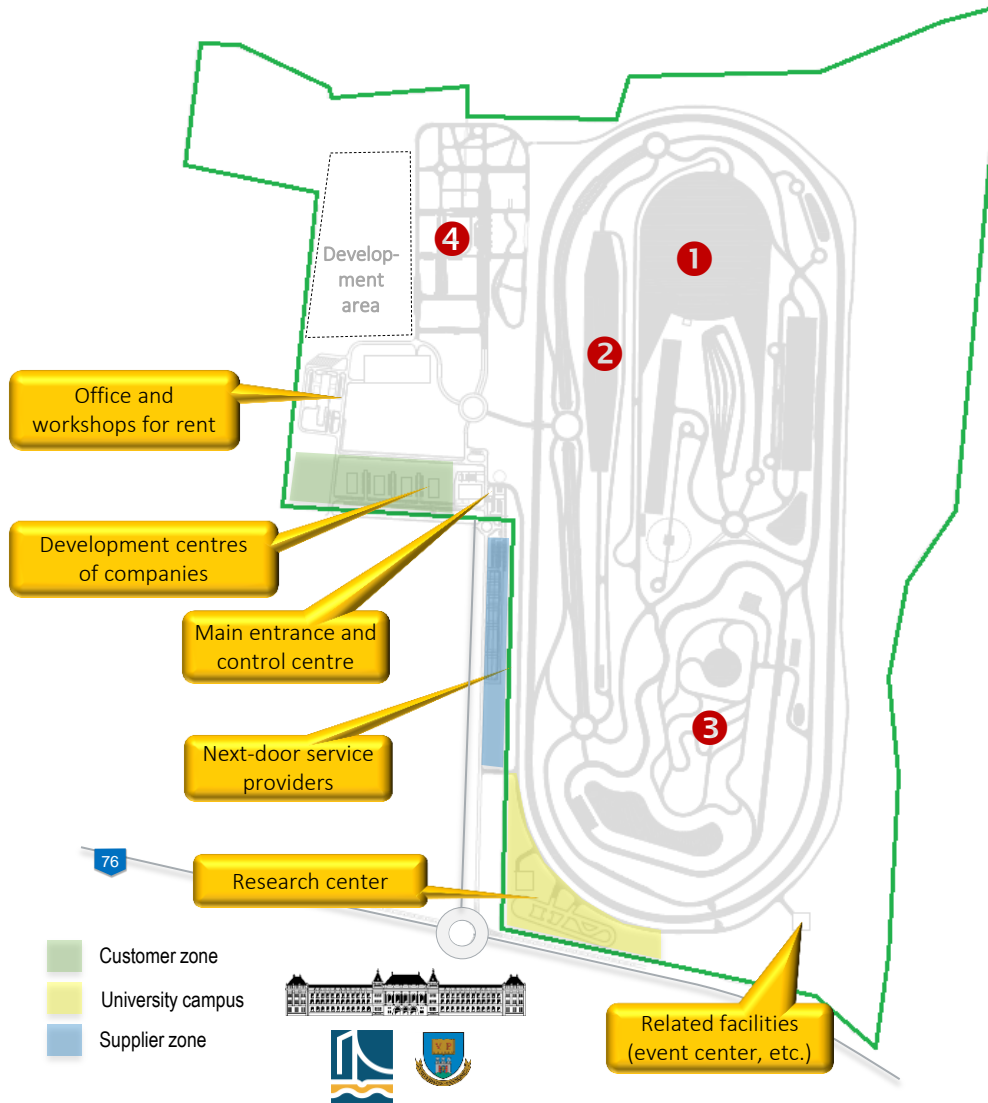


What do we offer?

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Proving Ground System – Overview



Project phase 1: 2017

Dynamic test elements I:

- ① • Dynamic platform
- ② • Braking surfaces
- ③ • Handling course
- ④ Smart City Zone I

Buildings I

Preparation of high-speed oval

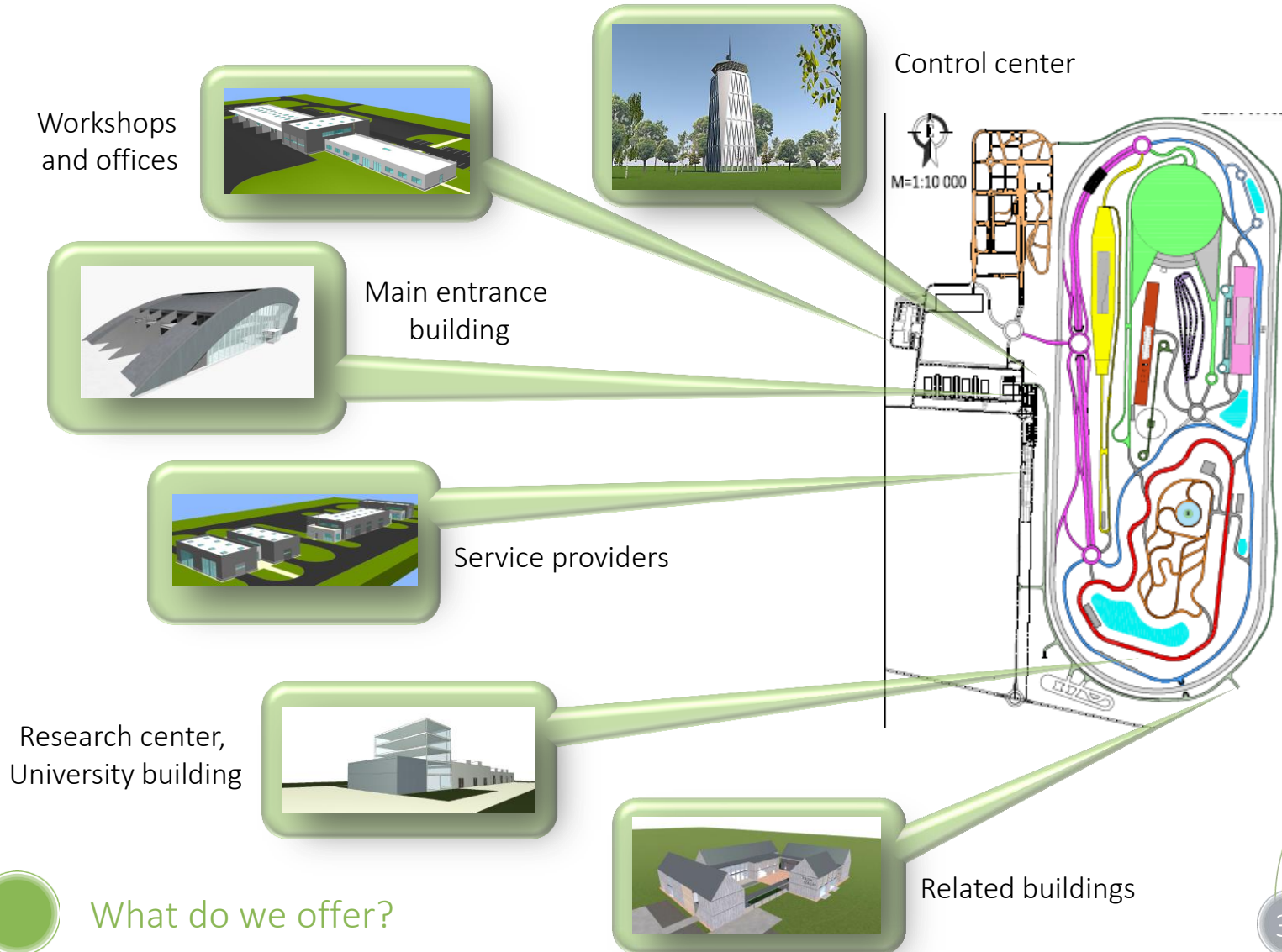
Project phase 2: 2018-2020

- Dynamic test elements II
- Smart City Zone II - III
- Buildings II
- High-speed oval

What do we offer?

Multi-level testing environment



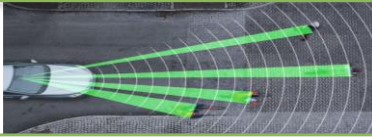

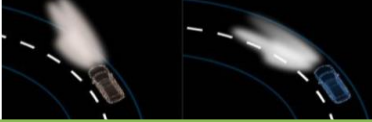
Buildings and functions



What do we offer?

Multi-level testing environment

From computer to real traffic – essential for automated driving



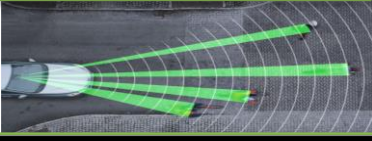
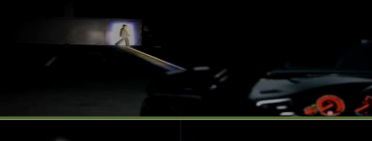
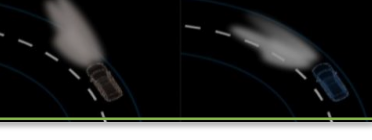
5	Intercity and motorway		Real public road environment
4	Real city environment		Controlled public road tests
3	Proving ground		Controlled system-test
2	Laboratory		Component test, integration test
1	Simulation		Conceptual and feasibility test



What do we offer?

Multi-level testing environment

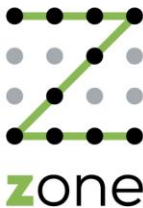
From computer to real traffic – essential for automated driving

5	Intercity and motorway		Real public road environment
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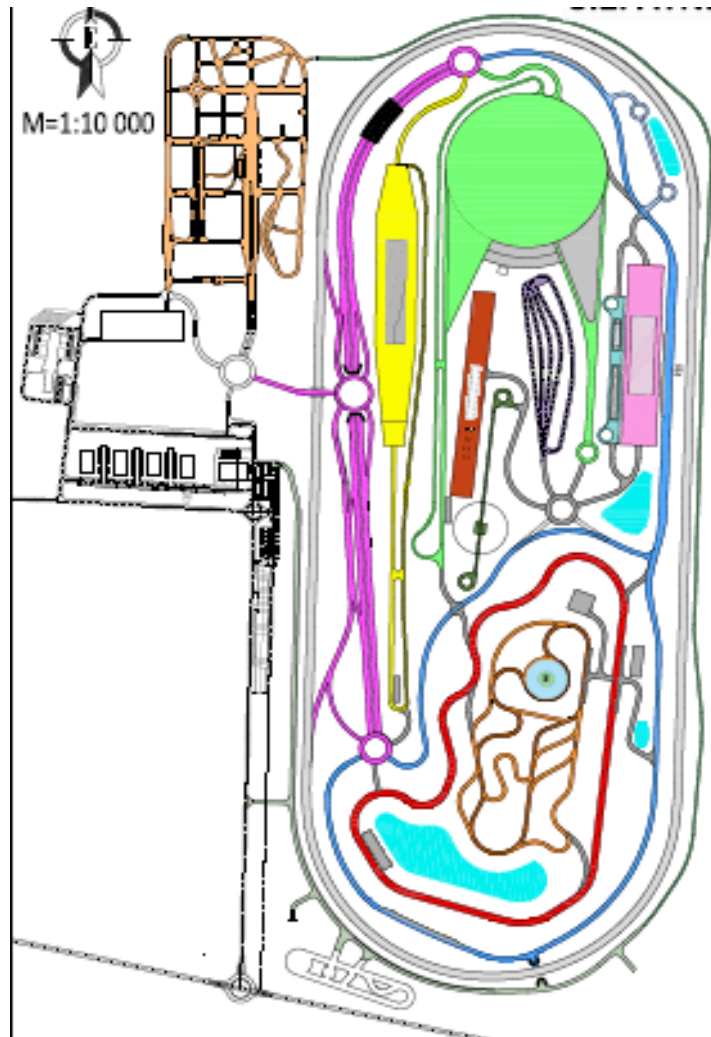
What do we offer?

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Multi-level testing environment

Combined traditional and autonomous testing modules



	HIGH SPEED OVAL
	DYNAMIC PLATFORM
	RAKING PLATFORM
	HIGH SPEED HANDLING
	LOW SPEED HANDLING
	AD
	MOTORWAY
	RURAL ROAD + ROADS
	HIGHWAY
	10% SUPERELEVATION
	SLOPES
	BAD ROADS
	KICK PLATE
	NOISE MEASUREMENT
	WATERBASIN
	SERVICE ROAD



What do we offer?

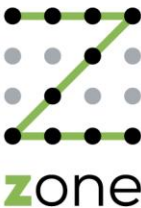
Multi-level testing environment

Combined traditional and autonomous testing modules

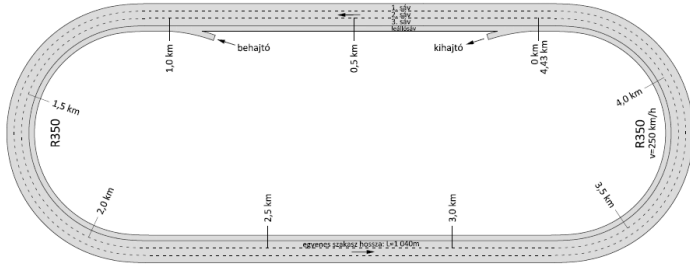


What do we offer?

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Example: High speed oval with automated drive functions*



Parameters:

- 4.400 m length
- 1.000 straight section
- Curve radius 350m
- max. 200km/h at curves
- max. 250km/h at straights
- 1% inclination to south
- 3+1 lanes
- V2X infrastructure for communication test at high speed



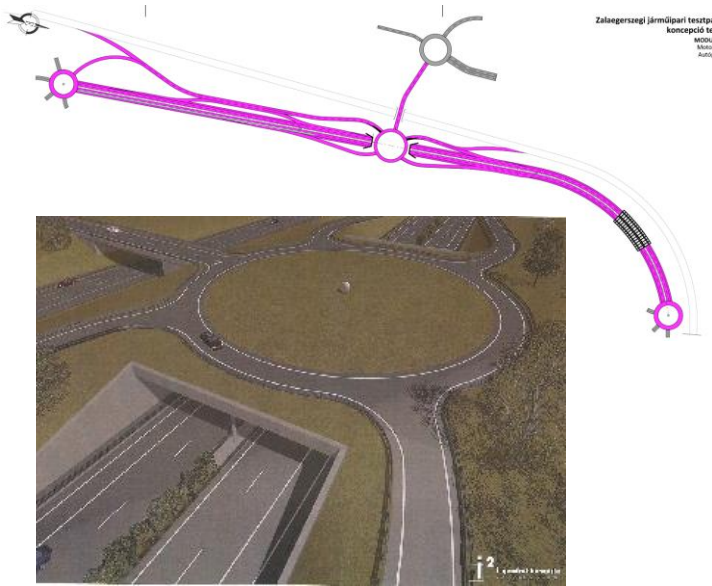
AD vehicle test services:

- **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

What do we offer?

Multi-level testing environment

Example: Motorway with special features*



Parameters:

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

AD vehicle test services:

- **Platooning** on motorway at realistic conditions, exits and entrances
- **Platooning** and cooperative control with limited communication (tunnel)
- Moving and static **obstacle**
- **Special situations:** road building situation
- Multi level **junction**



What do we offer?

* Other examples in the back-up



Multi-level testing environment

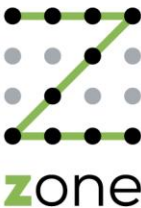
Automated and connected drive testing – special components

- Suitable for co-operative vehicle testing (e.g. platooning)
- Old cars for scenery, special cars
- Traffic gantry with variable message sign
- Railway crossing, construction zone, pedestrian crossings, trees, moveable road signs, tunnel, parking places, logistic yard, roadside objects, various street lights, SMART City features
- Highway road situations
- Rural road environment
- V2X communication system
- Environmental impact measurement opportunity (e.g. noise, EMC, rain, fog)
- Light measurement track
- High speed mobile network(LTE, 5G)
- Database about the environment
- External measurement infrastructure:



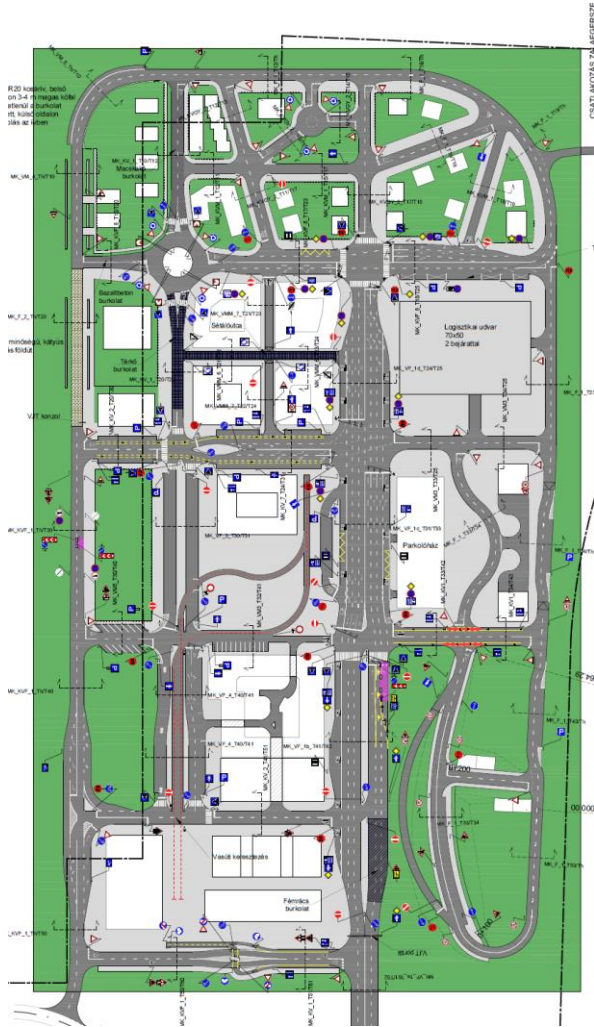
What do we offer?

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Multi-level testing environment



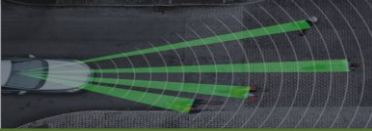

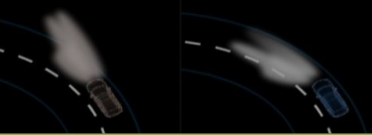
Smart city environment – part of the test track



What do we offer?

Multi-level testing environment

From computer to real traffic – essential for automated driving

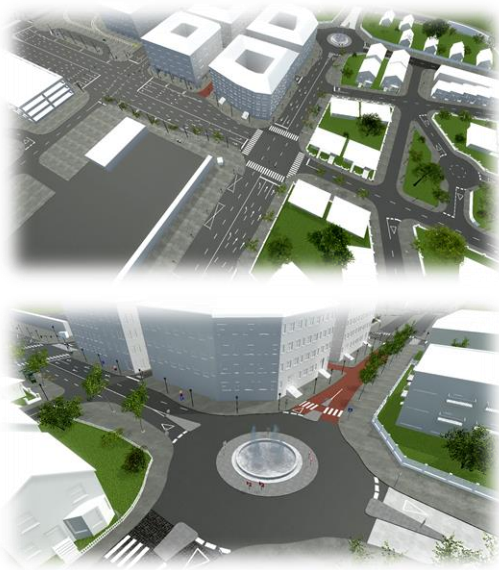
5	Intercity and motorway		Real public road environment
4	Real city environment		Controlled public road tests
3	Proving ground		Controlled system-test
2	Laboratory		Component test, integration test
1	Simulation		Conceptual and feasibility test



What do we offer?

Multi-level testing environment

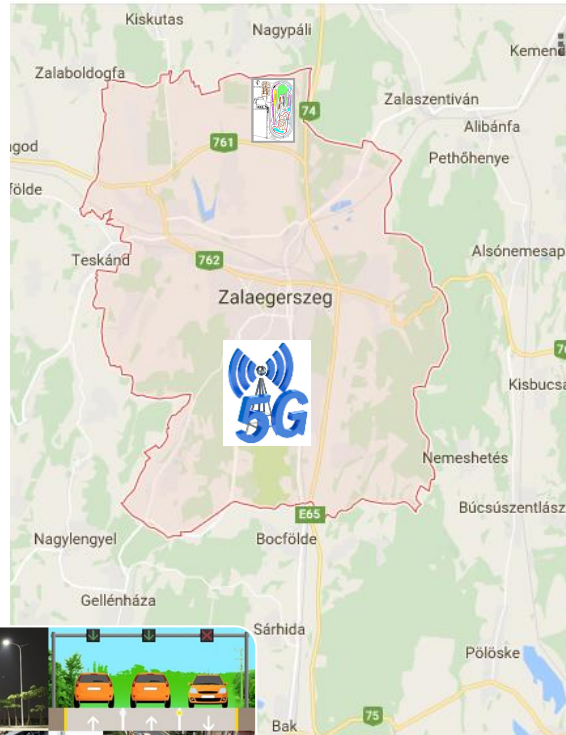
Zalaegerszeg will be turned into Smart/Digitalized City for testing



Out of the test track ...



... immediately to a real city environment

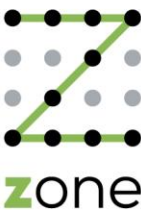


City environment for real-life testing





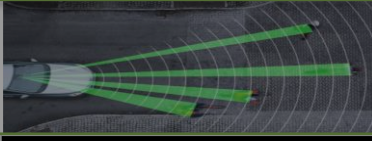
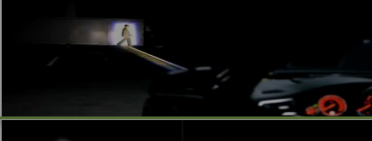
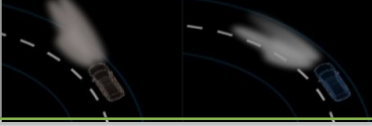
What do we offer?

43



Multi-level testing environment

From computer to real traffic – essential for automated driving

5	Intercity and motorway		Real public road environment
4	Real city environment		Controlled public road tests
3	Proving ground		Controlled system-test
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1	Simulation		Conceptual and feasibility test



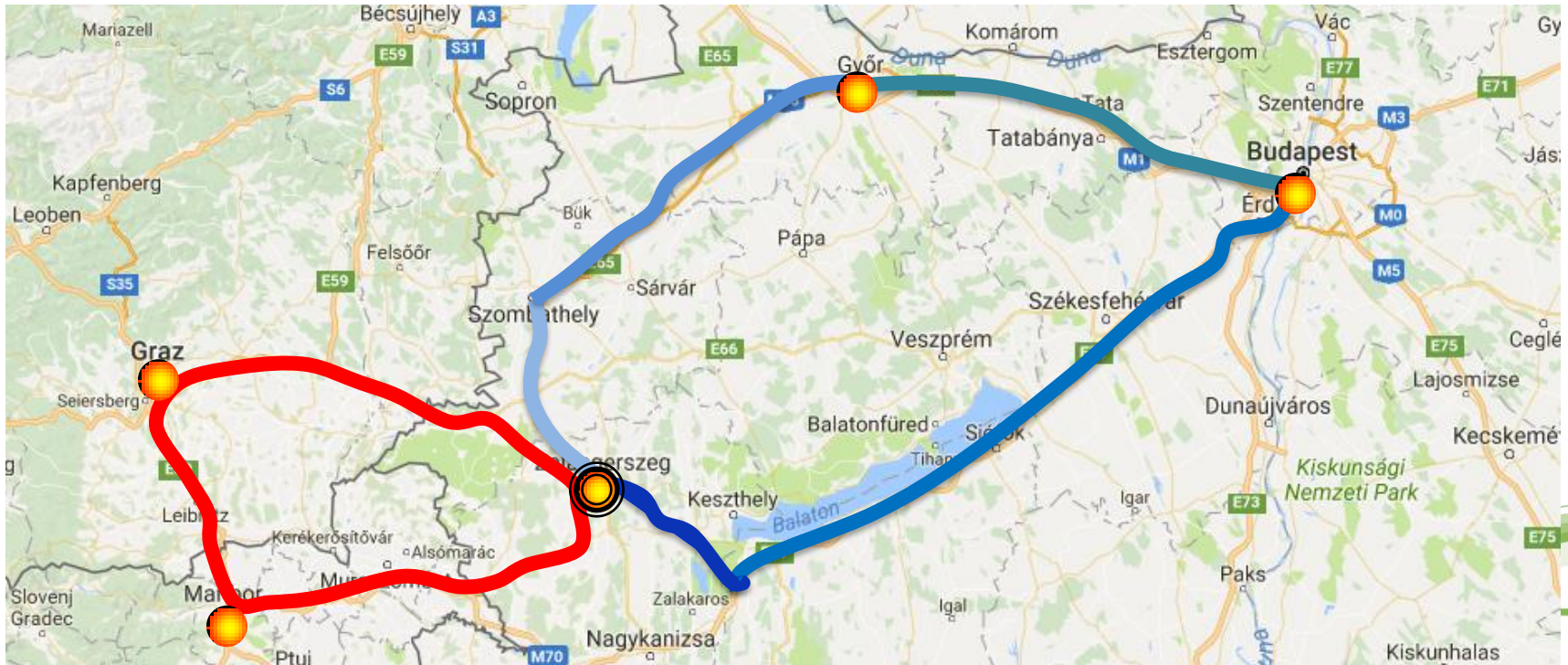
What do we offer?

Multi-level testing environment

Extended testing zone – test field *to city to public roads*

- Loop_1** Local roads (City Zalaegerszeg – being turned into “smart city”)
- Loop_2** Hungarian roads (Zalaegerszeg-Gyor-Budapest) – Actually designed R76 for automated driving, M7 with modified communication
- Loop_3** International roads (Graz-Zalaegerszeg-Maribor zone)

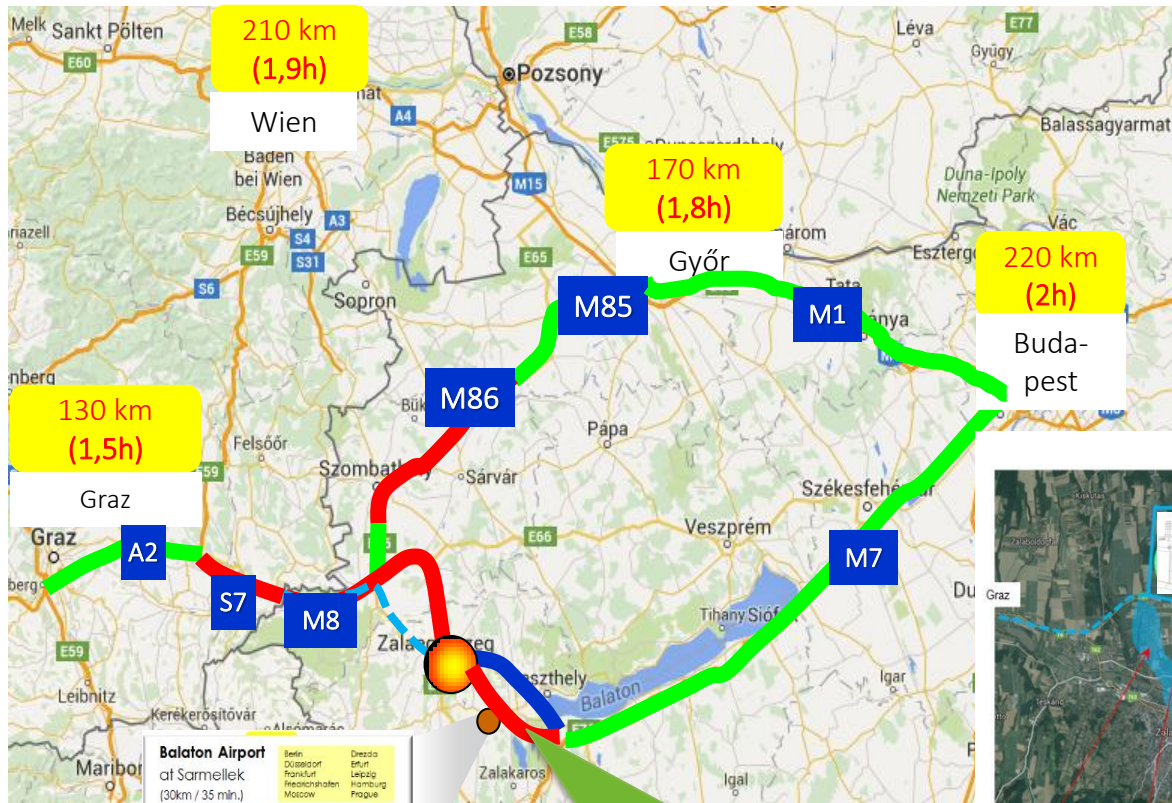
- Test road (R76) **plan**
- High level communication technologies for test (M7) **plan**
- Highway with RSUs (M1)
- Normal highway (M85-86)
- Normal road (86/76)



What do we offer?

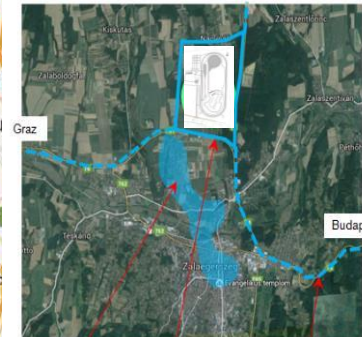
Public road test

Details



V2X infrastructure:

- 1x1/; 2x1; 2x2 lane —
- plan, 2x2 lane —
- available 2x2 —



R76 Zalaegerszeg-M7:
Special test road for AD
to be built 2018-2020

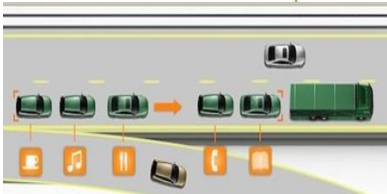


Proving Ground Program

Multi-level testing environment

Services

Platooning



Complete test programs



Tracks and modules

- Dynamical tests
- Automated vehicle use cases

Technical services

- Engineering and IT support services
- Electric charger and fuel station
- Vehicle repairing services
- Mechanical and electrical workshop
- Accredited vehicle inspection station

Other services

- Authority Office in place
- Logistic partner (shuttle bus and prototype carrying)
- Visitor and Event Center
- Hotel and accommodation opportunity inside the zone

Connected vehicle control



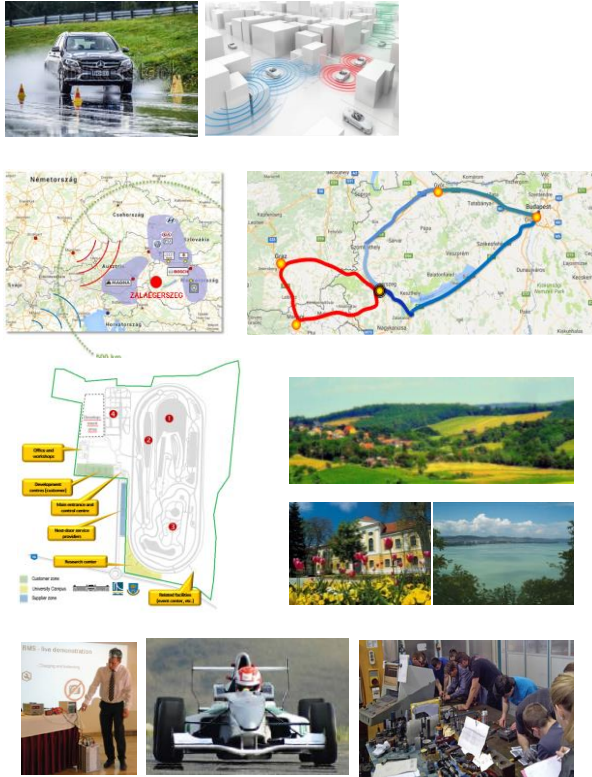
Special situations



What do we offer?

Multi-level testing environment - Summary

Unique selling propositions



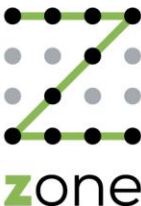
- **Autonomous & electric vehicle** test environment fusion with classic dynamic elements
- **Complete** validation services
- **Public road testing** possibility of autonomous vehicles
- **Attractive environment** of City of Zalaegerszeg
- **Complex services** at the proving ground area, trainings and accomodation opportunities
- **Education background** in City of Zalaegerszeg (test engineer, autonomous vehicle control engineer)
- **Opportunities for track development**, free development area

Several elements are available from 2018, complete finish in 2020.



What do we offer?

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ZALAZONE - Region Zala



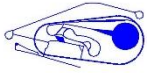


Back-up

Comparison of different test tracks world-wide - size



Mcity



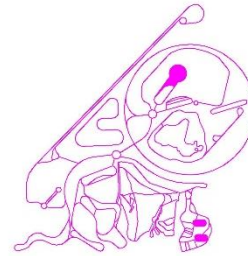
Aldenhoven



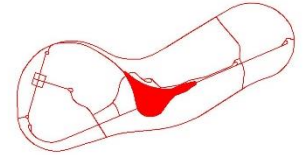
Boxberg



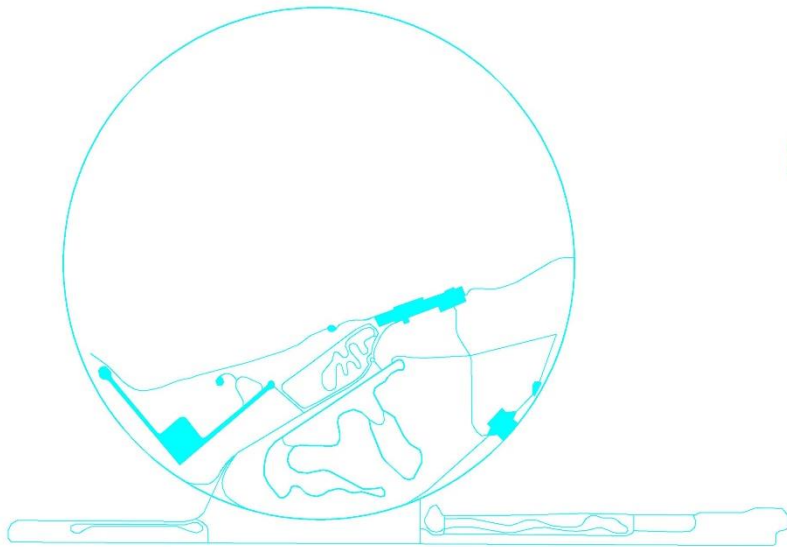
ZONE



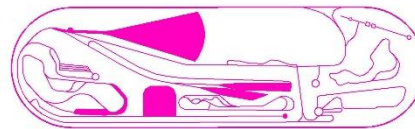
Millbrook



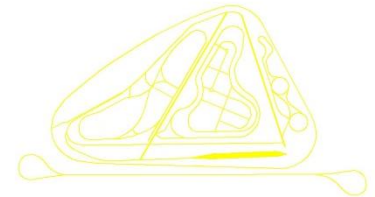
AstaZero



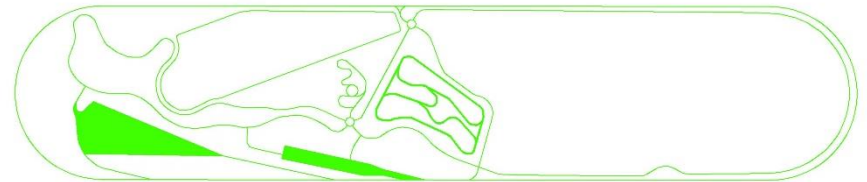
Nardo



Idiada



Horiba-Mira

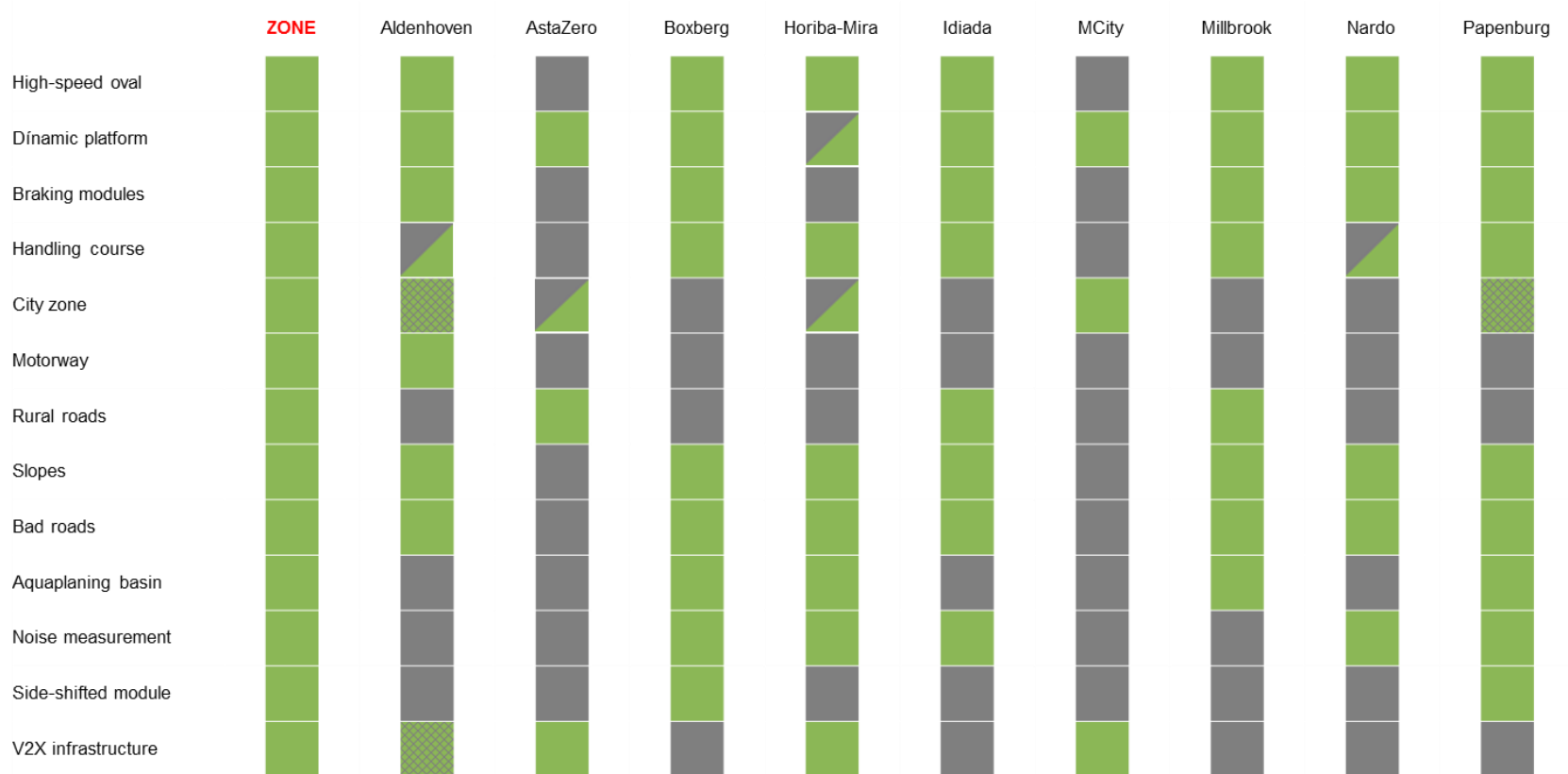


Papenburg

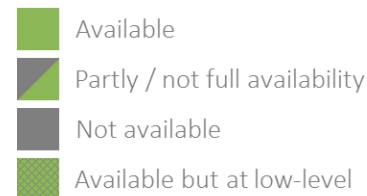


Proving Ground benchmarking

Comparison of different test tracks world-wide - modules



Proving Ground benchmarking



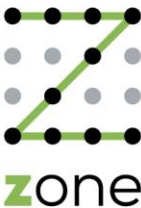
Comparison of different test tracks world-wide - services



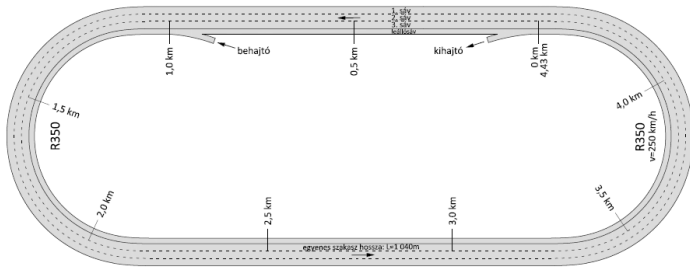
Proving Ground benchmarking

Available
Not available

53



High-speed oval



Parameters :

- 4.400 m length
- 1.000 straight section
- Curve radius 350m
- max. 200km/h at curves
- max. 250km/h at straights
- 1% inclination to south
- 3+1 lanes
- V2X infrastructure for communication test at high speed

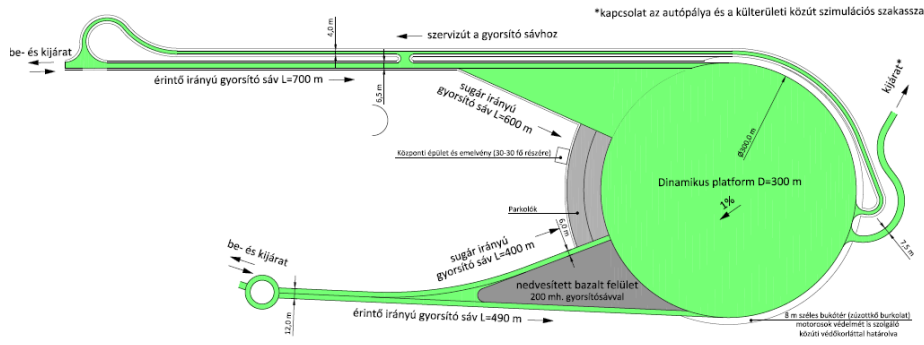
AD vehicle test services:

- **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



Track modules

Dynamic surface



Parameters:

- 300 m diameter
- Acceleration lane 700 m and 400m long
- FIA compatible emergency area (20m wide)
- Partly watered surface (optional)
- Watered basalt surface at Easter acceleration lane (phase 2.)
- 1% inclination to south
- Separated return way

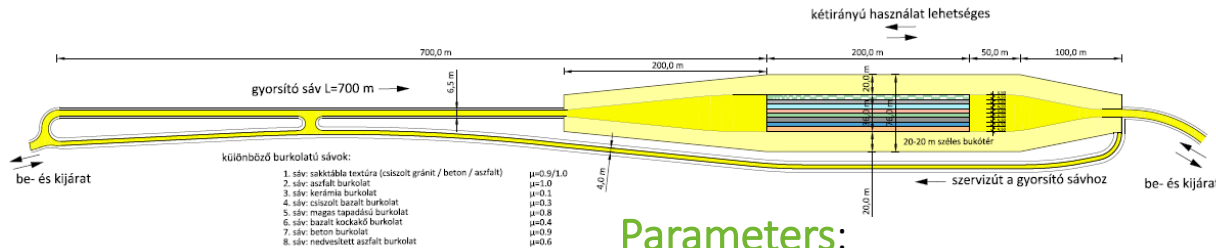
AD vehicle test services :

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



Track modules

Braking surfaces



Parameters:

- 6 different surfaces: *Chess surface - asphalt/tiles, asphalt $\mu=1$ (optional watering), tiles $\mu=0.1$ (wet), Blue basalt $\mu=0.3$ (wet), Treated concrete $\mu=0.6$ (wet), aquaplaning basin (max. 5cm wet depth)*
- 200 m length
- 700m acceleration lane
- 20m safety area at both side 150m at the end
- Separated return way



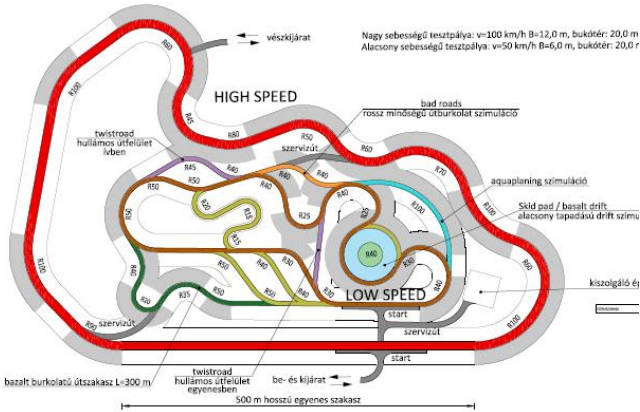
AD vehicle test services :

- **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



Track modules

Handling course



Parameters:

- Low and high speed section
- ~1.300m and ~2000m length
- width: 6 and 12 m
- Radius low speed section 15..50m
- Radius high speed section: 40..100m
- Asphalt covered safety zones
- Variable inclinations
- Watering system
- Different alternative surfaces

AD vehicle test services :

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



Track modules

Motorway



Parameters:

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

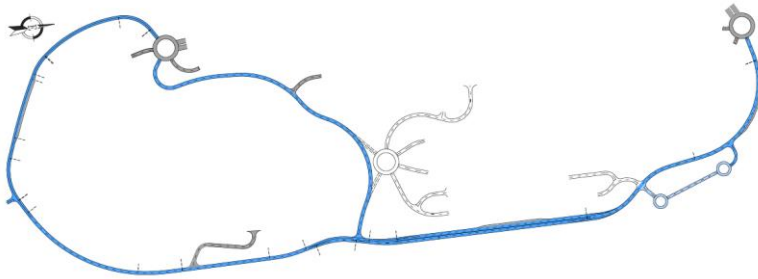
AD vehicle test services :

- **Platooning** on motorway at realistic conditions, exits and entrances
- **Platooning** and cooperative control with limited communication (tunnel)
- Moving and static **obstacle**
- **Special situations:** road building situation
- Multi level **junction**



Track modules

Rural road



Parameters:

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

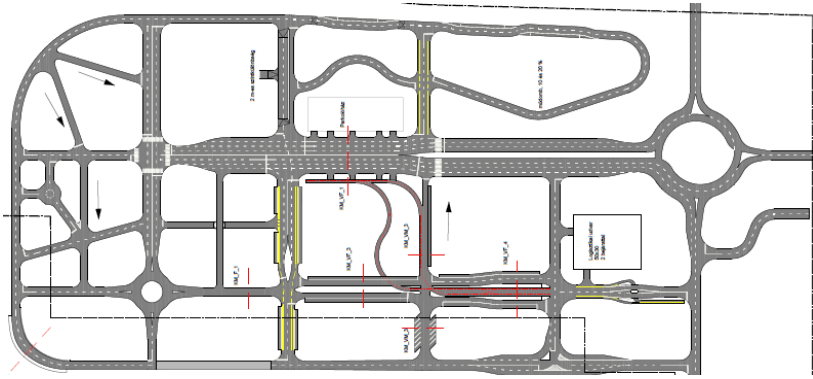
AD vehicle test services :

- **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**
- **Special situations:** road building situation
- **Various road** side elements: trees, fences, grass etc.



Track modules

Smart city zone

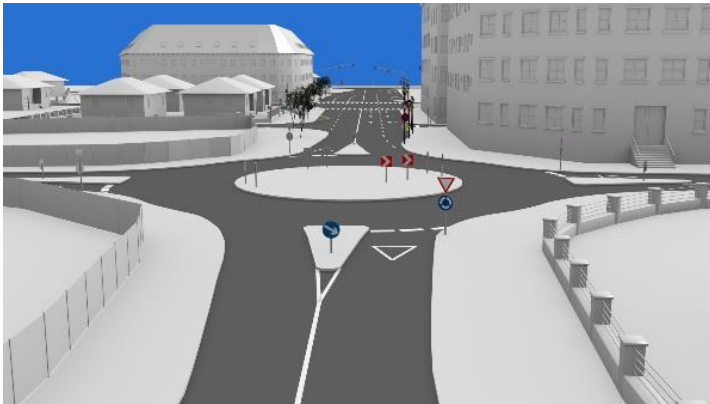
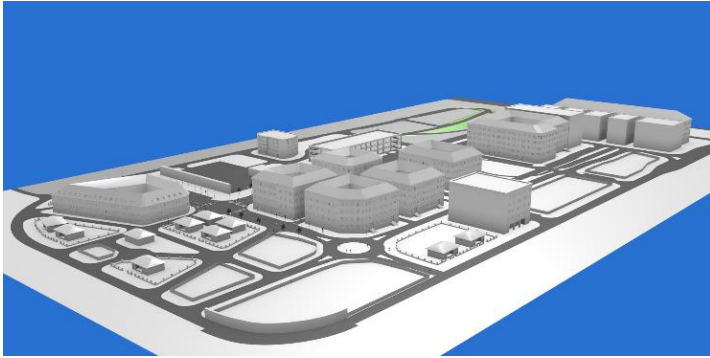


What do we offer?

Parameters:

- Various length 25..200 m
- Various lanes (1, 2x1, 2x2, 2x3, 2x4)
- Lanes width 2.75 .. 3.5 m
- Inclination 10%, 20%, 4 m slope height
- Various street material (asphalt, concrete, basalt, ceramit, gravel)
- Street orientation N-S & E-W
- Speed limit 50 .. 80 km/h
- Various junction types, roundabouts
- Low friction surfaces for AD interaction test at adherence limit
- min. 8 building blocks
- Varying size max. 25x60m
- min. 200m long streets
- Parking house
- Different fascades: brick, concrete, steel, wood, etc.

Smart city zone



Technical description:

- Sticky lane markings
- Adjustable curbs
- Real test vehicles
- Old cars for scenery, special cars
- Traffic gantry with variable message sign
- Railway crossing, construction zone, pedestrian crossings, trees, moveable road signs, tunnel, parking places, logistic yard, roadside objects, various street lights, SMART City features
- Highway road situations
- Rural road environment

Communication network:

- V2X communication system
- Environmental impact measurement opportunity (e.g. noise, EMC, rain, fog)
- Light measurement track
- High speed mobile network(LTE, 5G)
- Database about the environment
- External measurement infrastructure



What do we offer?

Smart city zone

AD vehicle test services :

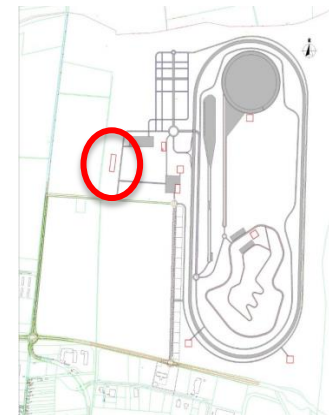
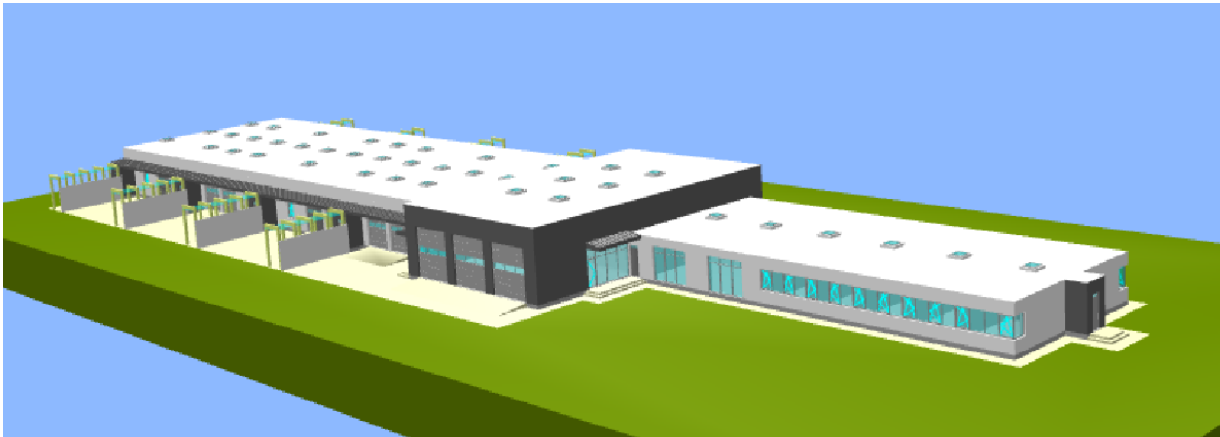
- Low-speed **platooning** at various junctions and lane layout
- **Emergency braking** in city environment with different barriers (static, moving) on high and low friction surface
- **Crossings** with low to medium friction surfaces for interactions with optional vehicle number with ABS, ATC, ESP activity
- **Cooperative tests** with vehicles, pedestrians, bikers etc.
- Different **parking situations**: parking house, valet parking, park assistant, different layouts, smart parking
- **Intelligent logistic yard**
- Different **road construction** zone scenarios in city environment
- Different road side **objects**: buildings, trees, parking cars, used road signs, fences, dust-bin etc.
- Changing **weather** conditions (rain, fog)



What do we offer?

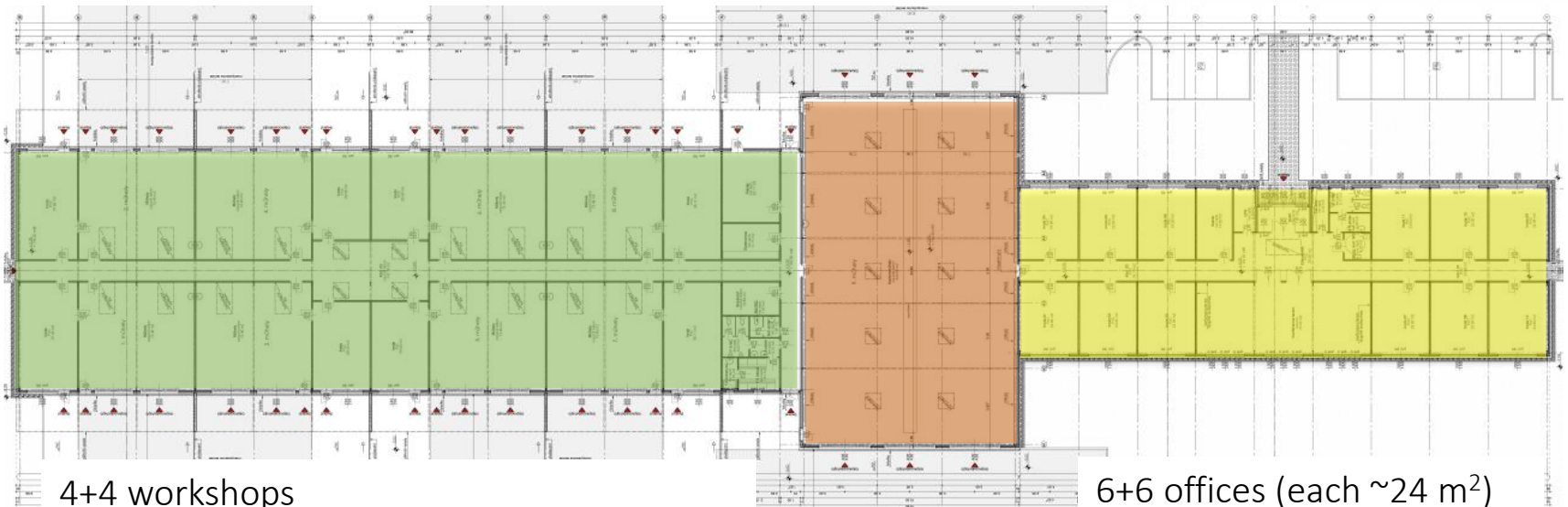
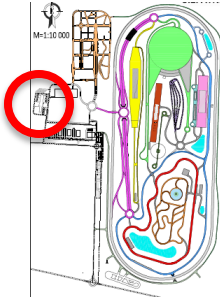
Central Building - Boxes and offices

- 8 **double workshops** (75 m² each) for passenger cars
- 3 **lane truck workshops** with 26 m length and service pit (410 m²)
- 20 **offices** (~25 m² each) with 6 people capacity each
- **Meeting room** with capacity for 30 people
- **Storage room**
- Complete **separation** from central building



Workshops and offices

At area with
special separation
(confidentiality!)



4+4 workshops
(each $\sim 100\text{m}^2$ – including office 36m^2)

Truck/Bus shop
($\sim 440\text{m}^2$)

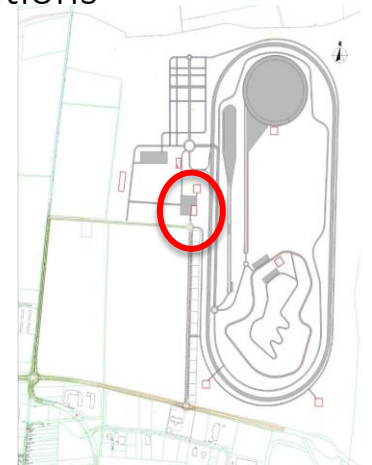
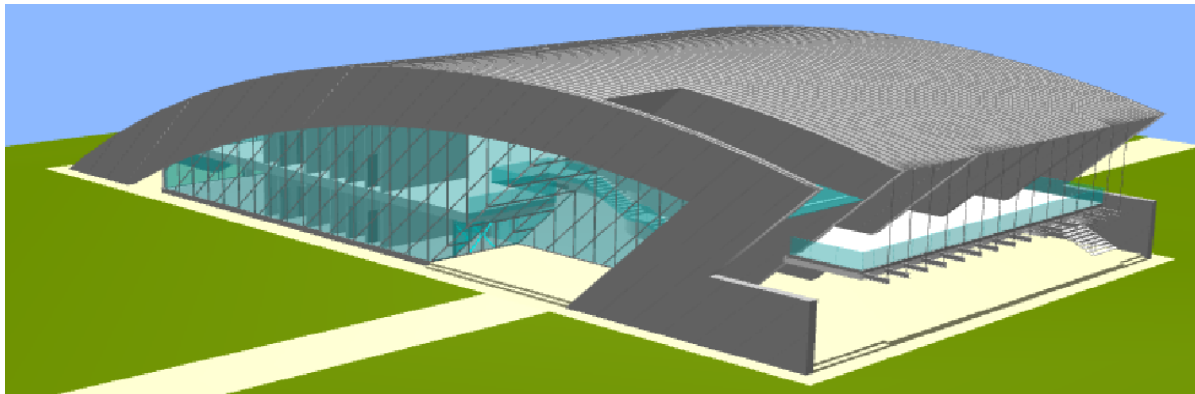
6+6 offices (each $\sim 24\text{m}^2$)
Meeting room



What do we offer?

Central Building - Reception

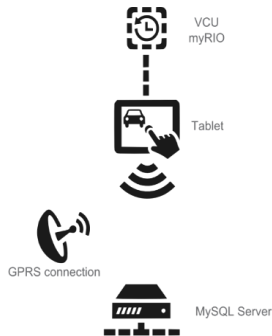
- 2 attractive **conference rooms** (max. 300 person)
- Unique, **high quality design** outside and inside for customer presentations
- **Flexible** room **structures**
- Complete separation from **development area**
- Cantine



Testing of electric vehicles

Special features:

- Charging systems
- Powertrain
- Vehicle control
- Telemetry and monitoring



Proving Ground Program