
# HUNGARY AS ONE OF THE EUROPEAN HUBS FOR AUTOMATED AND CONNCECTED DRIVING

Prof. Dr. Laszlo Palkovics

# 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



zone

# What is the challenge?

# Mobility as social challenge

## Inspirating factors for development

| | | |
|---|---|---|
| 1 | Zero Emission | • Fuel-consumption reduction<br>• Reducing emission |
| 2 | Demographic pressure | • Support of insecure leaders<br>• 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<br>• Comfortable, time-saving travel |
| 5 | Assistance systems | • Intelligent sensors for appropriate process<br>• Intelligent actuators (steering, brakes, etc.) |

Source: VDA

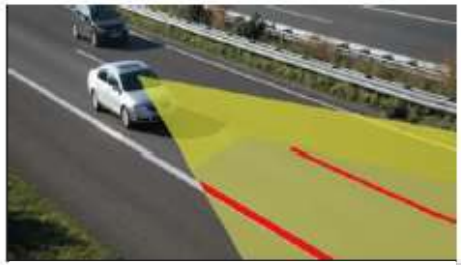
# Mobility as social challenge

## Technology is available

### Longitudinal control

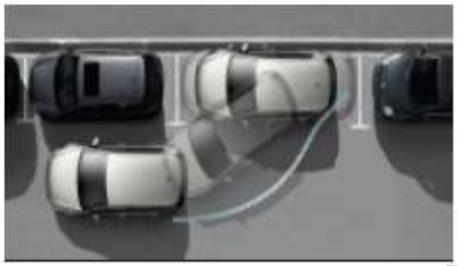
ACC traffic-jam assistant
emergency braking assistant

### Transverse control



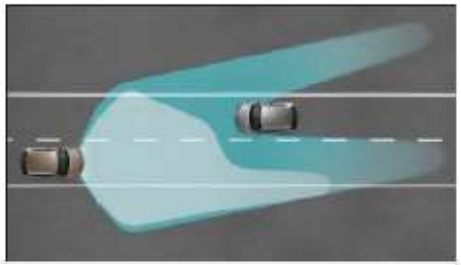
Lane-changing assistant, lane-keeping assitant

### Parking, maneuvering



Automated parking assistant

### Lighting



Adaptive long-distance lighting, adaptive cornering ligths

### Drive supervision


Fatigue supervision

### Environmental supervision


Traffic sign detection

Source: VDA

What is the challenge?



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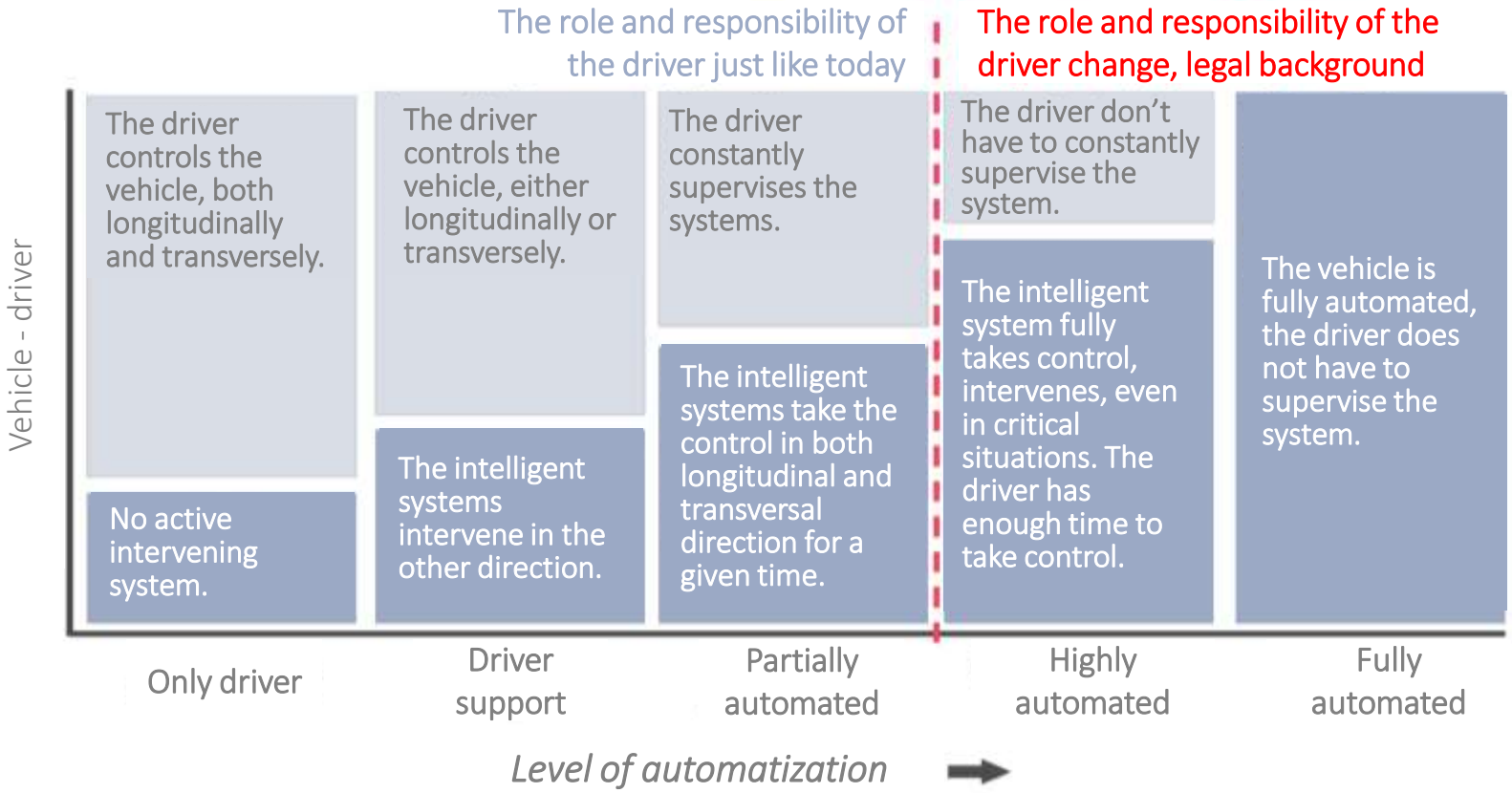
# Change in driver's responsibility

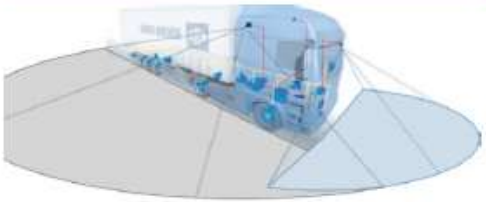
## Levels of automatization




What is the challenge?

# Mobility as social challenge

## Change in driver's responsibility

| TODAY 2017 | TOMORROW < 2020 | FUTURE > 2020 |
|---|---|---|
|   |  |  |
| Lane departure warning<br>Longitudinal control<br>Emergency brake system | Active steering<br>Object detection in dead spot<br>ACC + LKA | Automated driving: The driver can do other activities<br>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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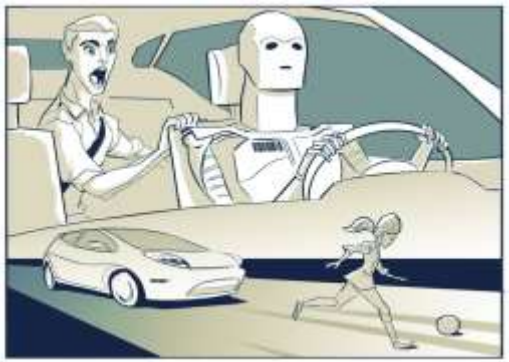
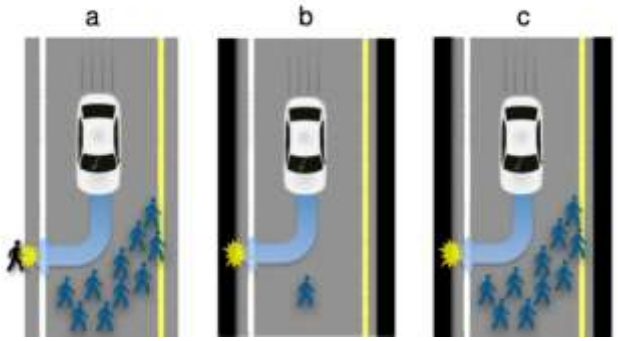
# Mobility as social challenge

## 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
- Will the drivers be mentally overloaded by the fact, that they do not control the vehicle?
- 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?



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# Why Hungary?

# Long term competency in electronic vehicle control

## High-level research already in the 80's

ESP with brake and steering intervention


Intelligent 4WS

ESP for trucks

International regulation for ESP (WP29/GRRF) initiated by the Hungarian government

1987 1995 2001 2004 2006

Why Hungary?



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# Long term competency in electronic vehicle control

## Participation in all relevant large scale EU FP projects

CVIS

Cooperative Vehicle Infrastructure Systems

PEIT


Powertrain Equipped with Intelligent Technologies

SPARC


Secured Propulsion Using Advanced Redundant Control

HAVEit

Highly Adcanced 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?



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# 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

# Industrial background

## Close co-operation with the industry – specification of requirements

**Automotive Working Group:** AImotive, 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

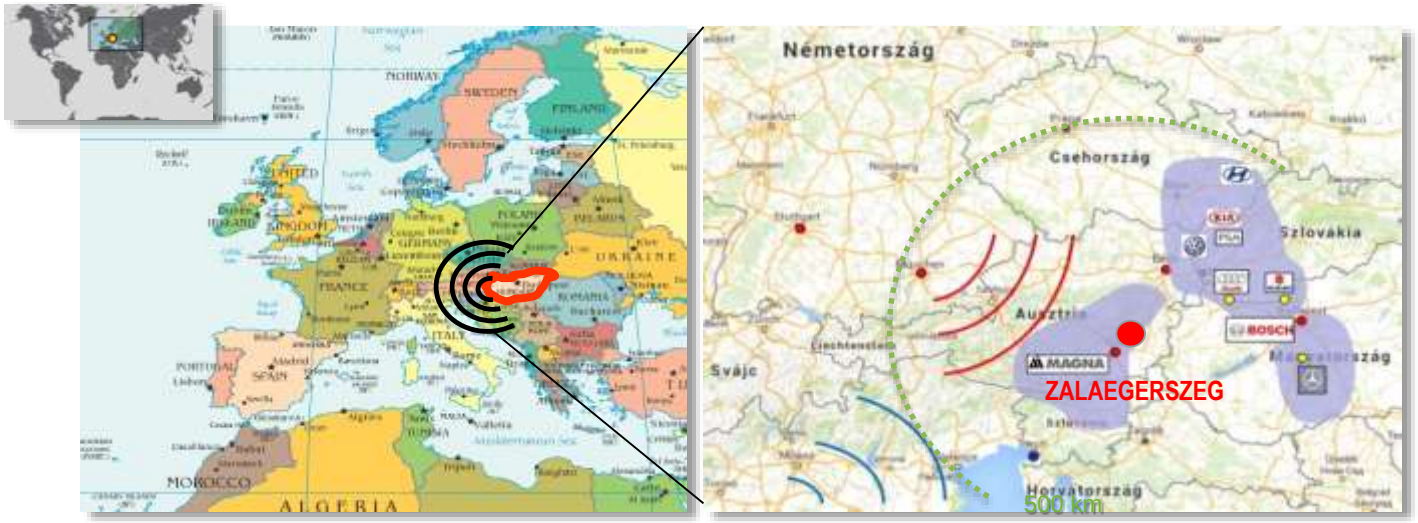
Why Hungary?

# Committment of the Hungarian Government

## Investment into a European level RD infrastructure

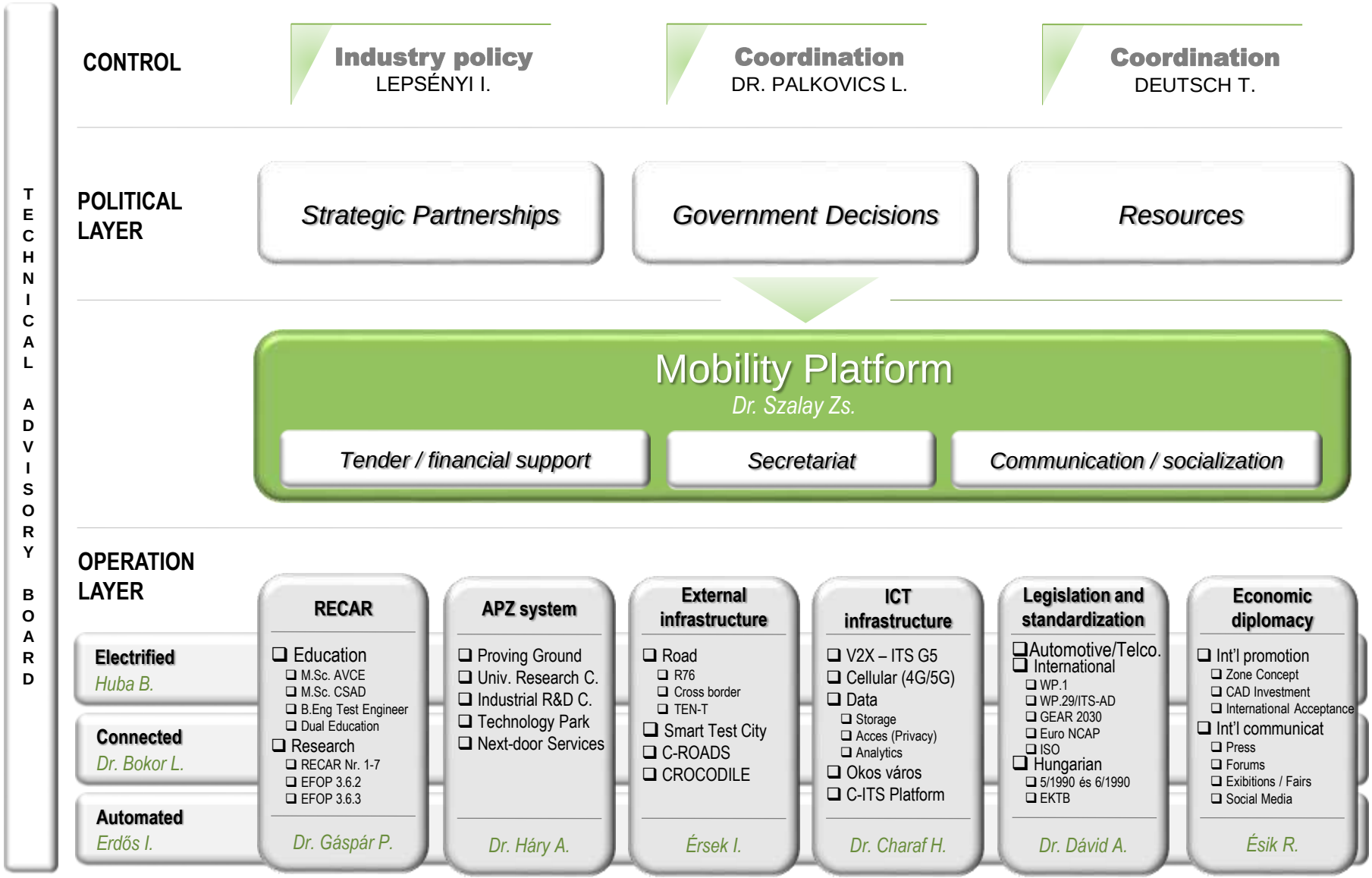
- Capacity constraints in Europe in area of vehicle dynamic testing
- Technology change in vehicle industry – single vehicle vs. co-operative vehicle control: different development environment is required
- Decision of Hungarian Government in 2016:

**Vehicle Proving Ground** as **research infratructure** to be created **at Zalaegerszeg**.



# Committment of the Hungarian Government

## Investment into a European level RD infrastructure



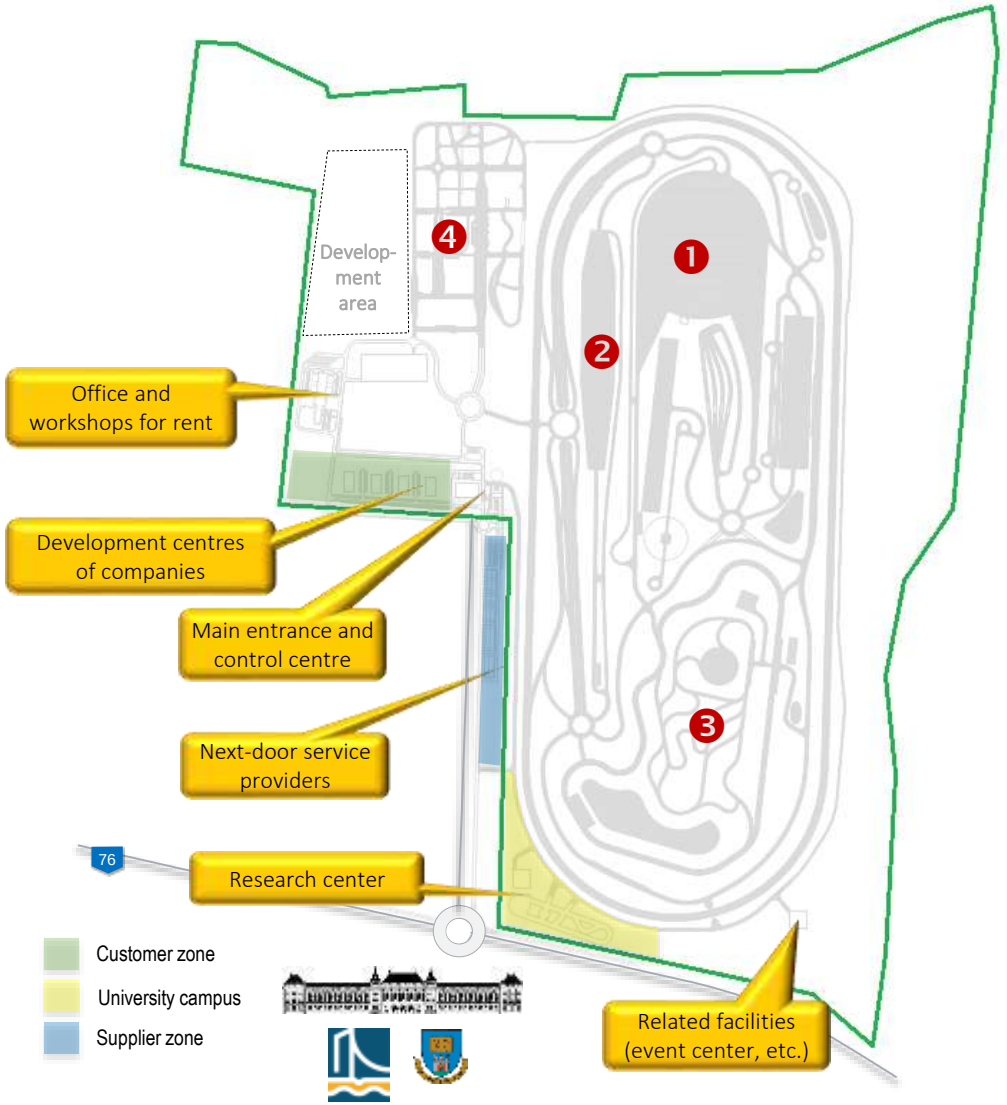
# What do we offer?

# Multi-level testing environment

## Designed on the demand of industrial companies

- Be able to address all test levels of develpment process, including the autmated and connected vehicle tests, including pass car, and commercial vehicles
- Handling of prototype vehicles must be 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

# 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?



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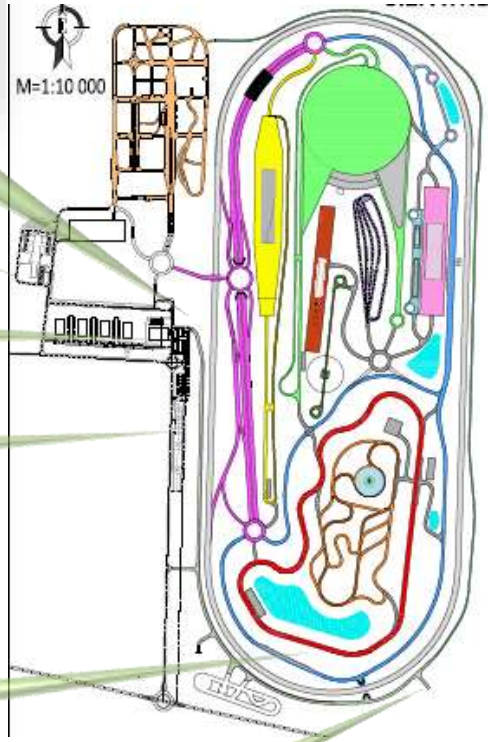
# Multi-level testing environment

## Buildings and functions

Workshops and offices

Control center




Main entrance building

Service providers

Research center, University building

Related buildings

What do we offer?



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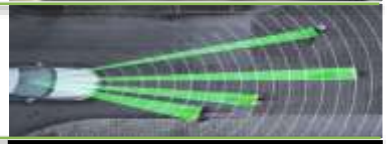
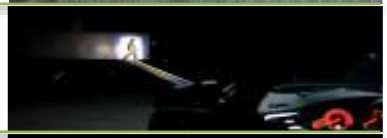
# Multi-level testing environment

## 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 feasability test |

What do we offer?



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# Multi-level testing environment

From computer to real traffic – essential for automated driving `

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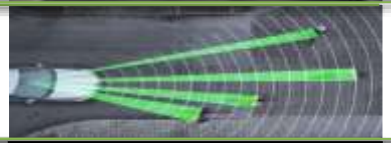
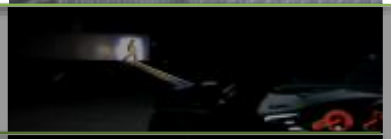
| 3 | Proving ground |  | Controlled system-test |
| 2 | Laboratory |  | Component test, integration test |
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What do we offer?



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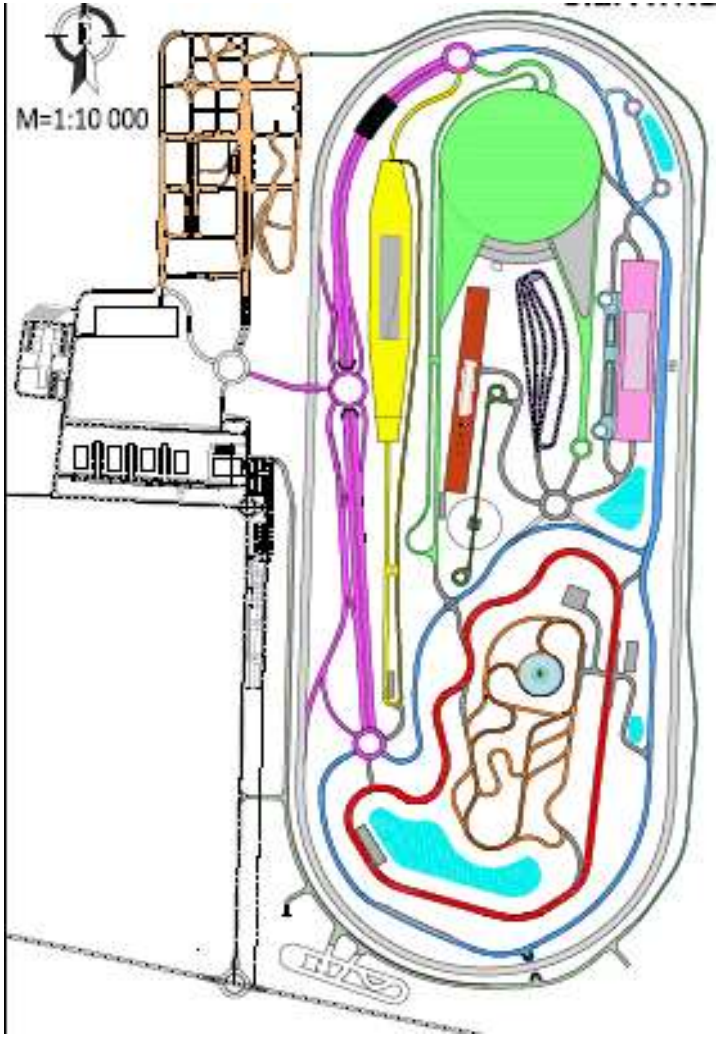
# Multi-level testing environment

## 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?



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# Multi-level testing environment

## Combined traditional and autonomous testing modules

What do we offer?



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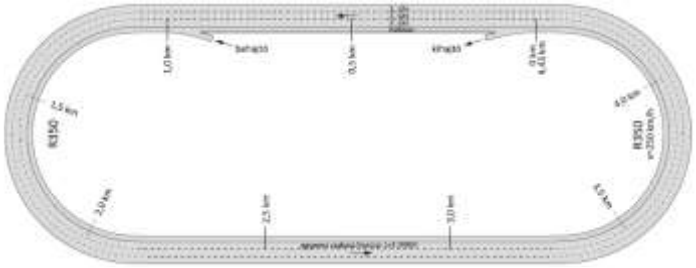
# Multi-level testing environment

## 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?

* Other examples in the back-up



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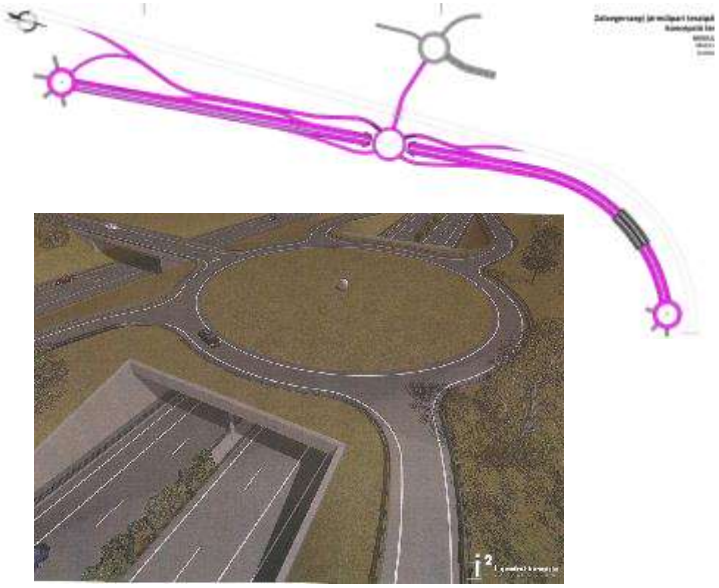
# Multi-level testing environment

## 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



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# 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?



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# Multi-level testing environment

From computer to real traffic – essential for automated driving `

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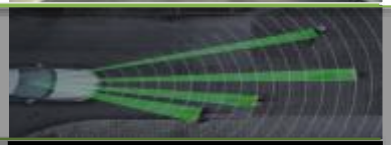
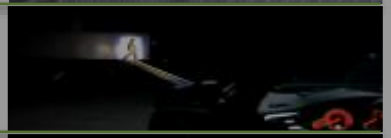
| 3 | Proving ground |  | Controlled system-test |
| 2 | Laboratory |  | Component test, integration test |
| 1 | Simulation |  | Conceptual and feasability test |

What do we offer?



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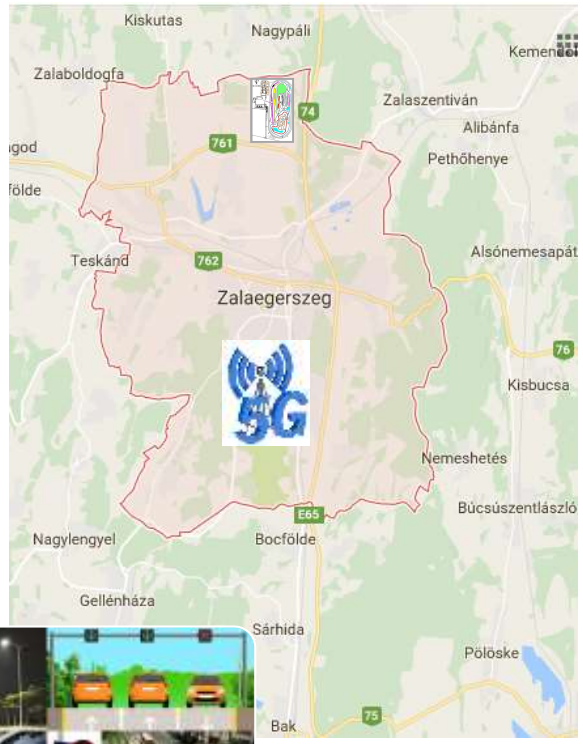
# Multi-level testing environment

## 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?

# Multi-level testing environment

From computer to real traffic – essential for automated driving `

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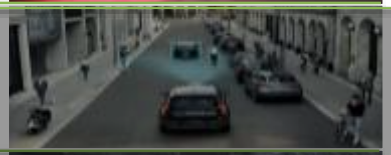
| 4 | Real city environment |  | Controlled public road tests |
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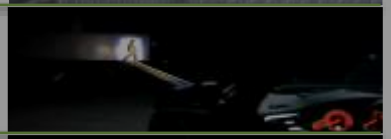
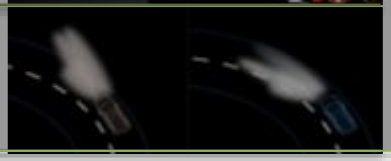
| 2 | Laboratory |  | Component test, integration test |
| 1 | Simulation |  | Conceptual and feasability test |

What do we offer?



zone

# Multi-level testing environment

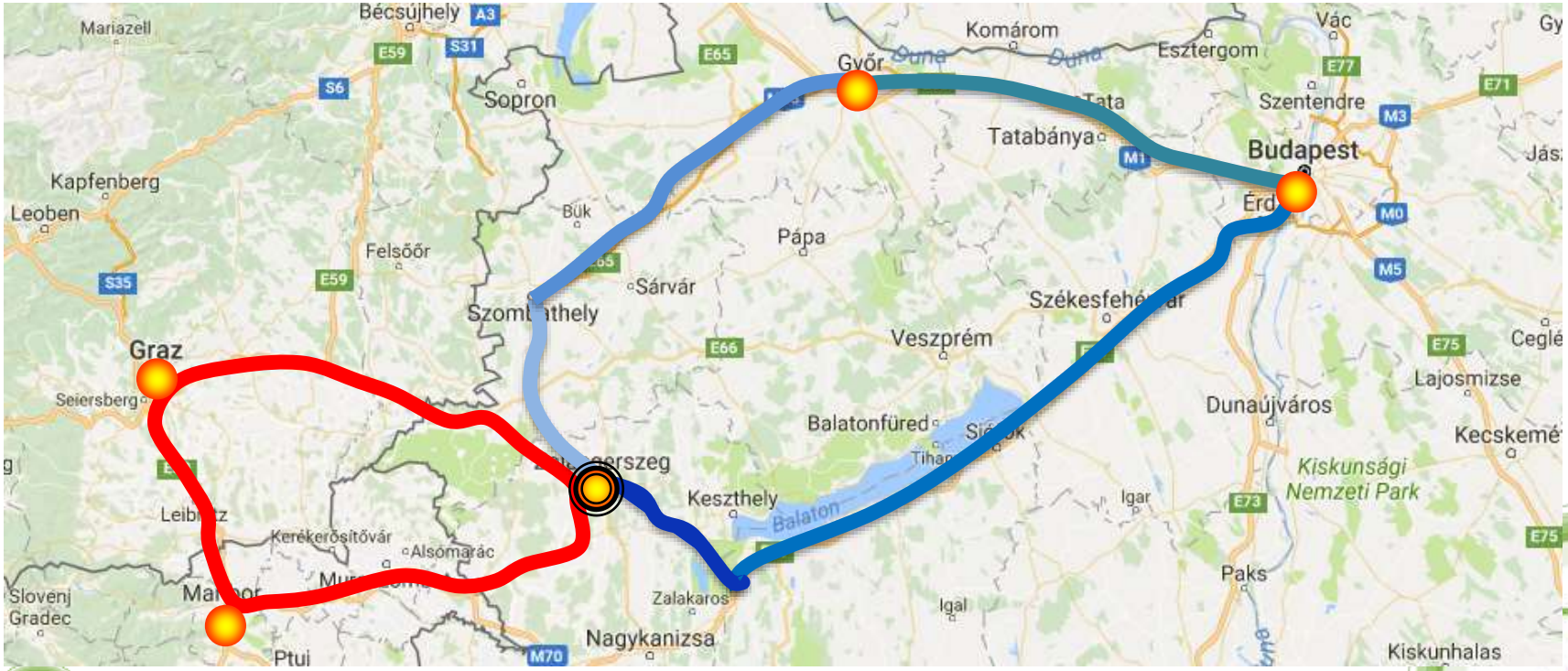
## Extended testing zone – test field *to* city *to* public roads

**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

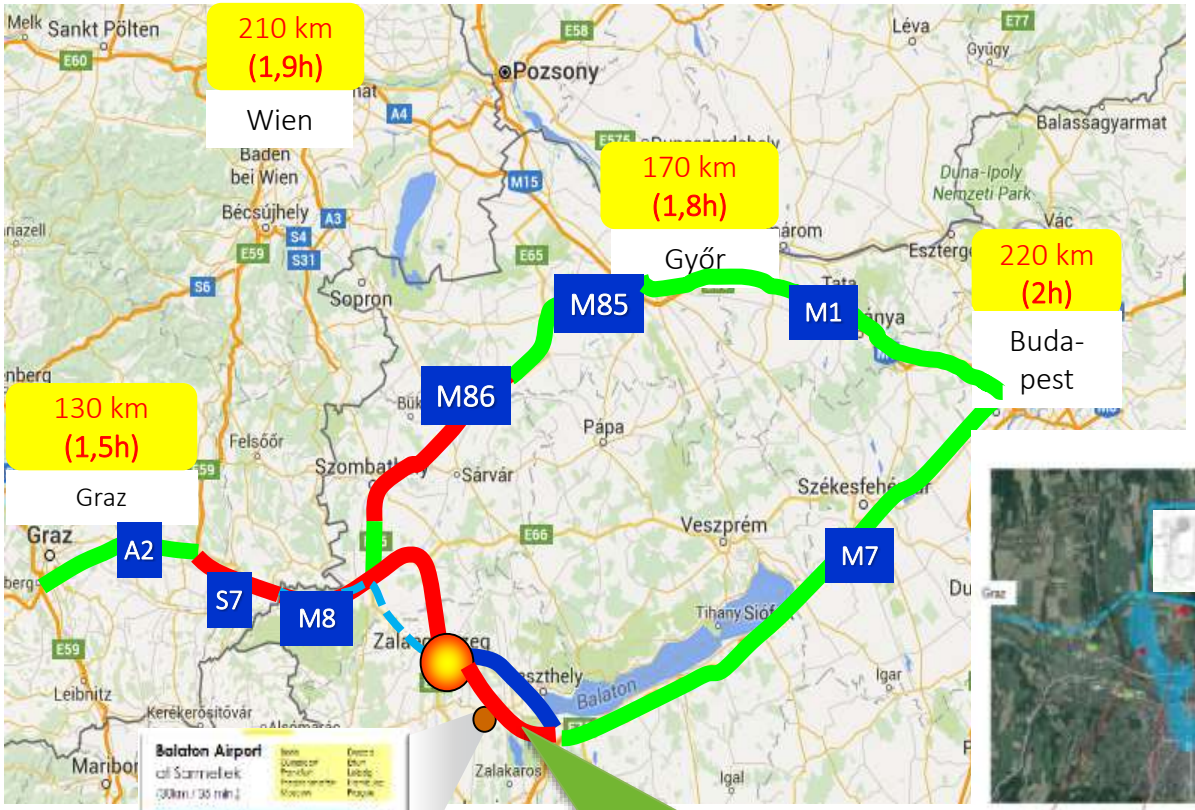
**Loop_3** International roads (Graz-Zalaegerszeg-Maribor zone)

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



# 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

# Multi-level testing environment

## Services

### Tracks and modules

- Dynamical tests
- Automated vehicle use cases

Platooning

Connected vehicle control

### Technical services

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

Complete test programs


Special situations

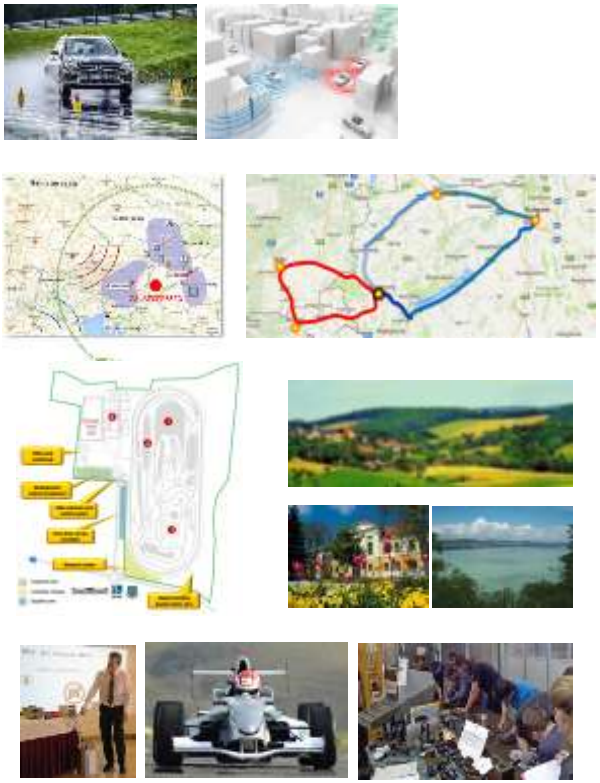
### Other services

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

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

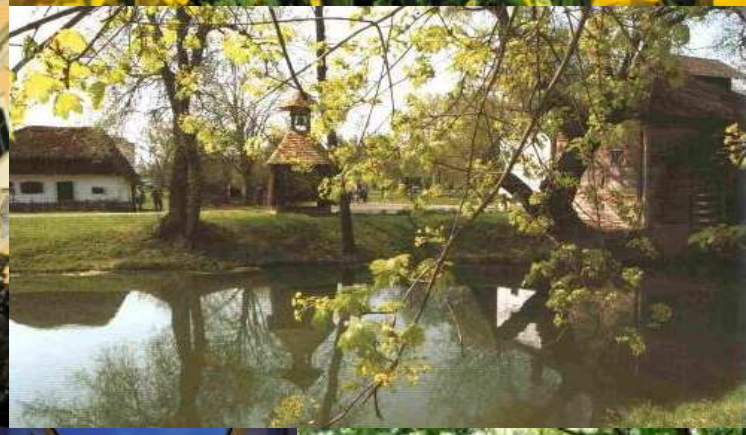
Several elements are available from 2018, complete finish in 2020.

What do we offer?

# ZALAZONE - Region Zala







# Back-up

# Comparison of different test tracks world-wide - size

Mcity

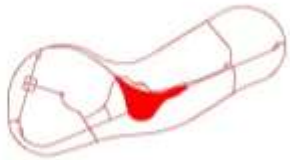
Aldenhoven



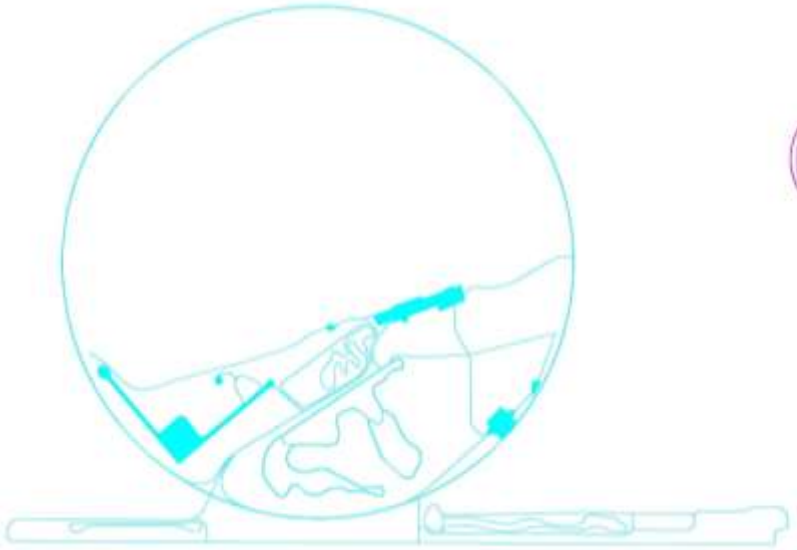
Boxberg

ZONE

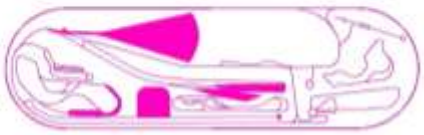
Millbrook



AstaZero



Nardo



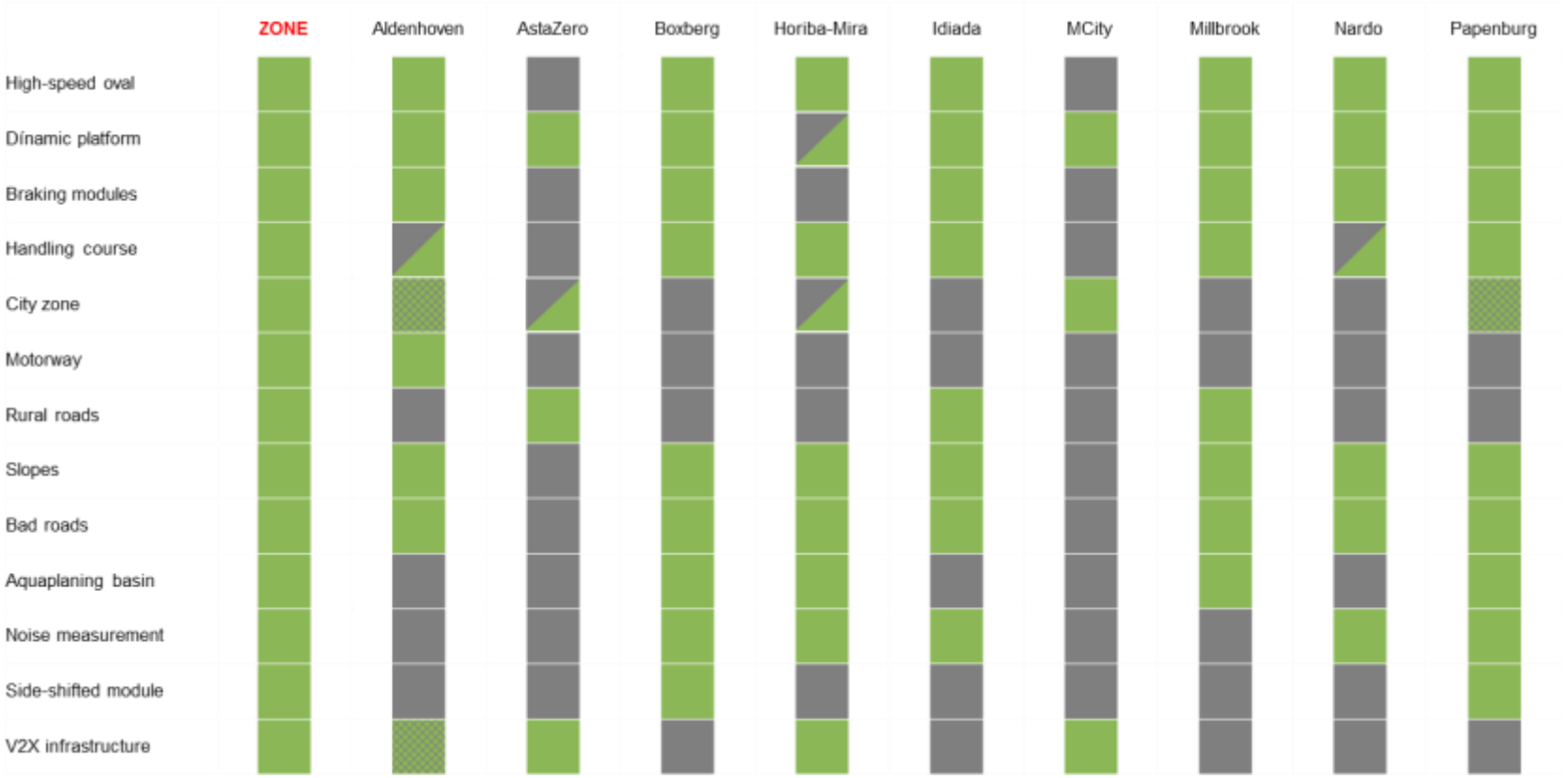
Idiada



Horiba-Mira

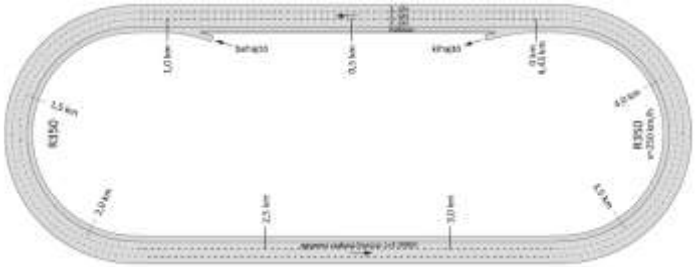
Papenburg

# Comparison of different test tracks world-wide - modules



# Comparison of different test tracks world-wide - services

# High-speed oval



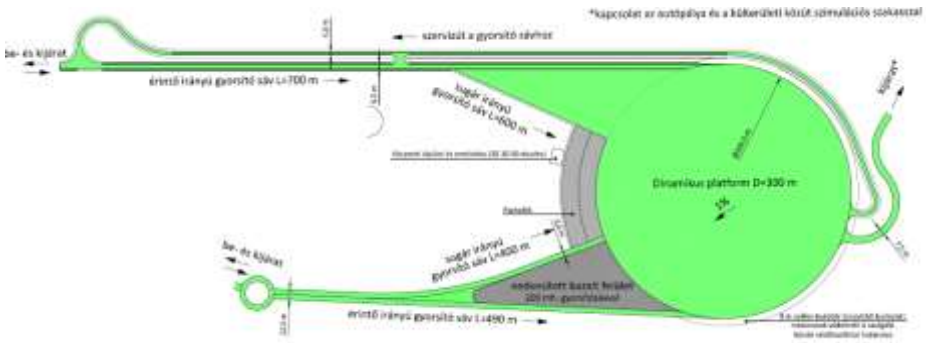
## Parameters :

- 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

# 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 mue 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 mue=~1 (optional watering), tiles mue=~0.1 (wet), Blue basalt mue=~0.3 (wet), Treated concrete mue=~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

# Handling course

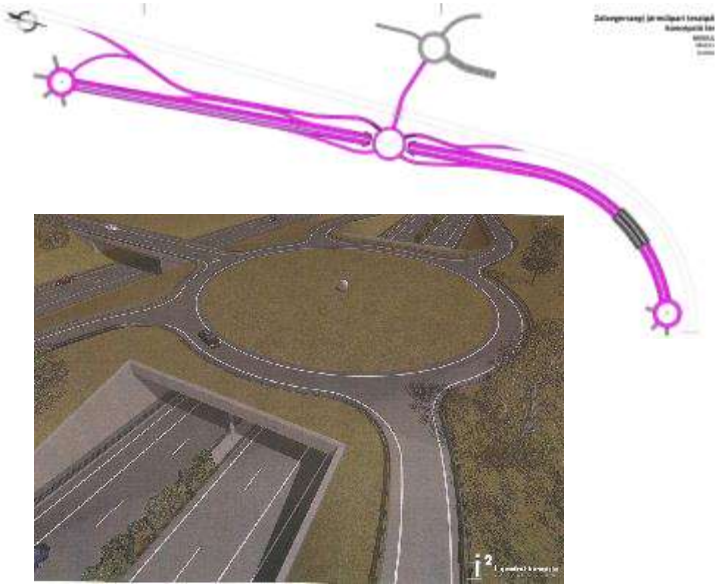

## Parameters:

- 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

# Motorway



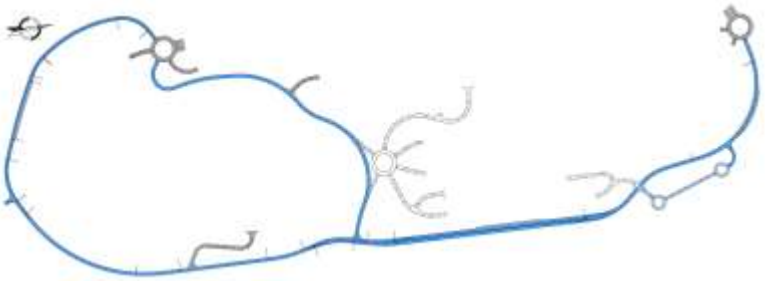
## Parameters:

- 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**

# Rural road



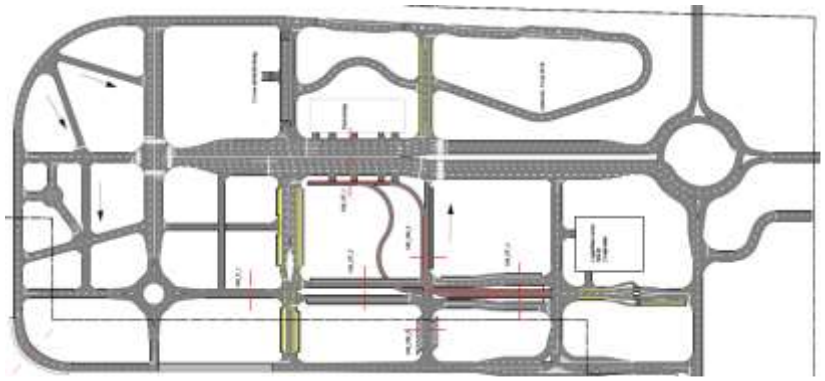
## Parameters:

- 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.

# Smart city zone

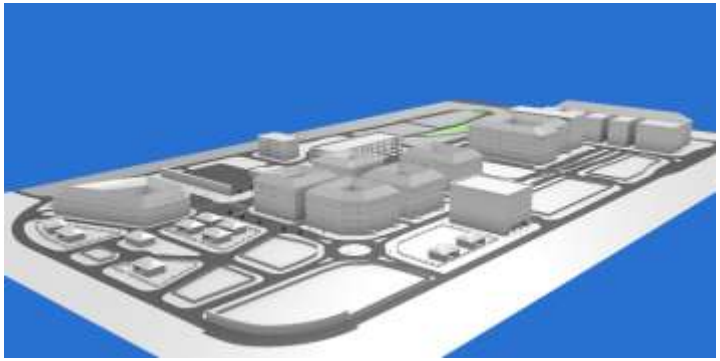


## Parameters:

- 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.

What do we offer?

# 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?

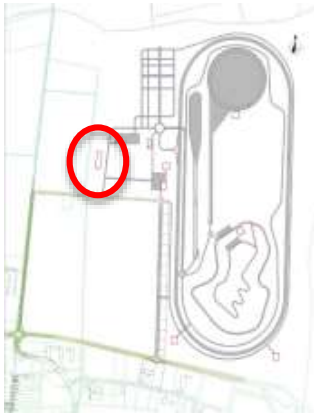
# Smart city zone

## 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)

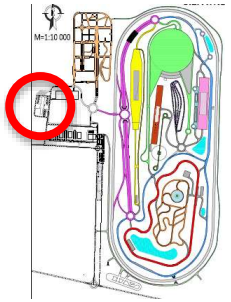
# Central Building - Boxes and offices

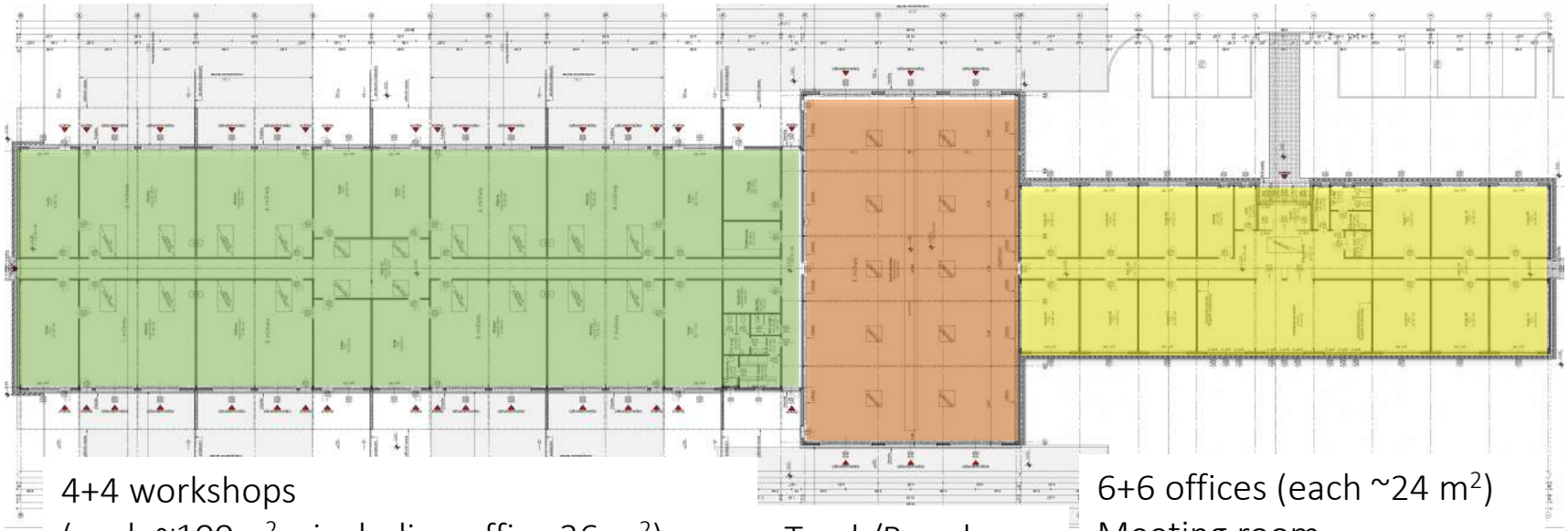
- 8 double workshops (75 $m^2$ each) for passanger cars
- 3 lane truck workshops with 26 m length and service pit (410 $m^2$)
- 20 offices (~25 $m^2$ each) with 6 people capacity each
- Meeting room with capacity for 30 people
- Storage room
- Complete separation from central building



# Workshops and offices

At area with special separation (confidentiality!)





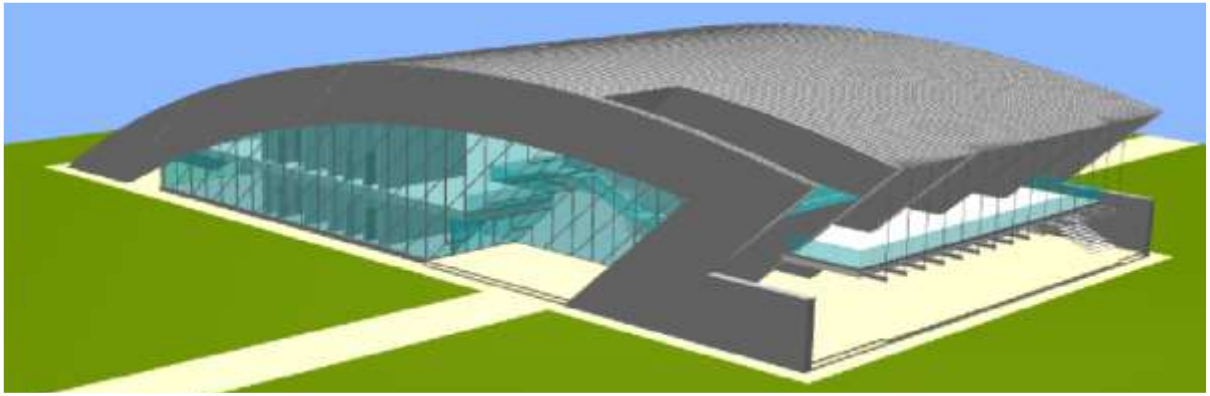
4+4 workshops
(each ~100m$^2$ – including office 36 m$^2$)

Truck/Bus shop
(~440 m$^2$)

6+6 offices (each ~24 m$^2$)
Meeting room

# 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