HUNGARY AS ONE OF THE EUROPEAN HUBS FOR AUTOMATED AND CONNECTED DRIVING

Prof. Dr. Laszlo Palkovics
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
What is the challenge?
## Mobility as social challenge

### Inspirating factors for development

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| 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?
Change in driver’s responsibility

Levels of automatization

The role and responsibility of the driver just like today

- The driver controls the vehicle, both longitudinally and transversely.
- No active intervening system.

The role and responsibility of the driver change, legal background

- The driver don’t have to constantly supervise the system.
- The vehicle is fully automated, the driver does not have to supervise the system.

- The driver constantly supervises the systems.
- The intelligent systems take the control in both longitudinal and transversal direction for a given time.

- The driver controls the vehicle, either longitudinally or transversely.
- The intelligent systems intervene in the other direction.

- The driver support
- Partially automated
- Highly automated
- Fully automated

What is the challenge?
Mobility as social challenge
Change in driver’s responsibility

What is the challenge?

Source: Volvo, Knorr-Bremse
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?

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

1987
1995
2001
2004
2006

Why Hungary?

Intelligent 4WS
ESP for trucks
International regulation for ESP (WP29/GRRF) initiated by the Hungarian government
Long term competency in electronic vehicle control
Participation in all relevant large scale EU FP projects

Cooperative Vehicle Infrastructure Systems
Powertrain Equipped with Intelligent Technologies
Secured Propulsion Using Advanced Redundant Control
Highly Advanced Vehicle and Infrastructure
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

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?
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?
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:

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

Why Hungary?
Commitment of the Hungarian Government
Investment into a European level RD infrastructure

**CONTROL**
- **Industry policy**
  - LEPSÉNYI I.
- **Coordination**
  - DR. PALKOVICS L.
- **Coordination**
  - DEUTSCH T.

**POLITICAL LAYER**
- **Strategic Partnerships**
- **Government Decisions**
- **Resources**

**OPERATION LAYER**
- **Mobility Platform**
  - Dr. Szalay Zs.
  - Tender / financial support
  - Secretariat
  - Communication / socialization

**TECHNICAL ADVISORY BOARD**
- **Electrified**
  - Huba B.
  - Dr. Gáspár P.
- **Connected**
  - Dr. Bokor L.
  - Dr. Háry A.
- **Automated**
  - Erdős I.
  - Érsek I.
  - Dr. Charaf H.
  - Dr. Dávid A.
  - Ésik R.

**RECAR**
- Education
- M.Sc. AVCE
- M.Sc. CSAD
- B.Eng Test Engineer
- Dual Education
- Research
- RECAR Nr. 1-7
- EFOP 3.6.2
- EFOP 3.6.3

**APZ system**
- Proving Ground
- Univ. Research C.
- Industrial R&D C.
- Technology Park
- Next-door Services
- C-ROADS
- CROCODILE

**External infrastructure**
- Road
- R76
- Cross border
- TEN-T
- Smart Test City
- Okos város
- C-ITS Platform

**ICT infrastructure**
- V2X – ITS G5
- Cellular (4G/5G)
- Data
- Storage
- Acces (Privacy)
- Analytics
- Okos város
- C-ITS Platform

**Legislation and standardization**
- Automotive/Telco.
- International
- WP.1
- WP.29/ITS-AD
- GEAR 2030
- Euro NCAP
- ISO
- Hungarian
- EKTB

**Economic diplomacy**
- Int'l promotion
- Zone Concept
- CAD Investment
- International Acceptance
- Int'l communicat
- Press
- Forums
- Exhibitions / Fairs
- Social Media
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 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

What do we offer?

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
Multi-level testing environment
Buildings and functions

What do we offer?

- Workshops and offices
- Main entrance building
- Service providers
- Research center, University building
- Control center
- Related buildings
## Multi-level testing environment

From computer to real traffic – essential for automated driving

<table>
<thead>
<tr>
<th></th>
<th>Intercity and motorway</th>
<th>Real public road environment</th>
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<tbody>
<tr>
<td>5</td>
<td>Real city environment</td>
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<tr>
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<td>Proving ground</td>
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What do we offer?
## Multi-level testing environment

From computer to real traffic – essential for automated driving

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### What do we offer?
Multi-level testing environment
Combined traditional and autonomous testing modules

What do we offer?
Multi-level testing environment
Combined traditional and autonomous testing modules
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

* Other examples in the back-up
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**

* 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:
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*

### What do we offer?

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

Details

Wien
210 km (1,9h)

Győr
170 km (1,8h)

Graz
130 km (1,5h)

220 km (2h)

Budapest

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

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

Platooning
Complete test programs

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 accommodation 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?
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
Comparison of different test tracks world-wide - services

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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

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.
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

**What do we offer?**

**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
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 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 ~100m² – including office 36 m²)

Truck/Bus shop
(~440 m²)

6+6 offices (each ~24 m²)
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