Interreg
EUROPEAN UNION
Danube Transnational Programme
RADAR

Project co-funded by European Union funds (ERDF, IPA, ENI)

O3.3c STUDY VISITS

THEMATIC AREA 3: SPEED MANAGEMENT AND ITS

RADAR – Risk Assessment on Danube Area Roads

https://www.interreg-danube.eu/radar

Output Number	3.3c	Output Title	Study Visits TA3
Work Package Number	WP3	Work Package Title	Road Safety Training
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Status (F: final, D: draft, RD: revised draft):	F		
Version Number	4		
File Name	RADAR_project_Study_Visits_Smart_Speed_Management_Infrastructure		
Issue Date	22/06/2020		

Abbreviation list

AADT	Annual Average Daily Traffic
ABS	Anti-lock Brake System
ATC	Automatic Traction Control
C-ITS	Cooperative Intelligent Transport Systems
CCAD	Cooperative Computer-Aided Design
DHE	Dunakeszi Highway Engineering
DTP	Danube Transnational Programme
ESP	Electronic Stability Control
EuroRAP	European Road Assessment Programme
HGV	Heavy Goods Vehicle
IoT	Internet of Things
iRAP	International Road Assessment Programme
ITP	Intelligent Truck Parking
ITS	Intelligent Transport Systems
KTI	KTI Institute for Transport Sciences Nonprofit Ltd.
MK	Magyar Közút (Hungarian Public Road Nonprofit PLC)
NAP	National Access Point
OBU	On-Board Unit
PP	Project Partner
RADAR	Risk Assessment on Danube Area Roads (DTP project)
RWW	Road Works Warning
SciL	Scenario-in-the-Loop
TCC	Traffic Control Centre
TIC	Traffic Information Centre
TRA	Transport Research Arena
V2I	Vehicle-to-Infrastructure communication
V2V	Vehicle-to-Vehicle communication
V2X	Vehicto-to-Everything communication
VMS	Variable Message Signs
VUT	Vehicle Under Test
VRUs	Vulnerable Road Users

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Executive Summary

RADAR PP3, KTI Institute for Transport Sciences Nonprofit Ltd. (Budapest) from Hungary organised 3rd project´s Study visit dedicated to Thematic area 3 – Speed management and ITS.

The event organized on November 19-20, 2019 in Budapest offered an opportunity to RADAR team of project partners, associated strategic partners (ASPs) and other road safety experts invited to the subsequent meeting of project´s Road Safety Expert Group to visit several interesting sites in Hungary, which are primarily focused on traffic speed management on highways with the utilization of Intelligent Transport Systems (ITS), as well as facilities for testing autonomous vehicles.

Besides the visit and exchange of knowledge with professionals of Hungarian Public Roads on ITS traffic management on highways, including practical tour to several real installations, participants had a unique opportunity to visit the testing area of ZalaZone near Zalaegerszeg, which has been constructed to take care of all kinds of car tests, but specifically to those dedicated to testing of autonomous cars´ performance under all potential traffic situations – slow/high speed, manoeuvres in varying weather conditions, drive on various road types and surfaces, parking and many more.

1. Study visit itinerary

Hungarian Study visit organized by KTI was a 2-day event focused primarily on the use of modern ITS solutions to increase road safety through advanced speed management and increasing safety. The event consisted of two thematic parts, enabling the participants to visit road schemes ITS implementation, traffic calming, as well as the site of ZalaZone test track for autonomous vehicles. Below are the itineraries of both days.

Tuesday 19 November 2019	
8:00 – 12:00	Transfer from Budapest to Zalaegerszeg
12:00 – 13:00	Zalaegerszeg Traffic Calming solutions
13:15 – 13:45	Transfer to the ZalaZone test track
13:45 – 14:15	Introduction of ZalaZone test track (presented by Kálmán Gangel, chief engineer)
14:15 – 14:45	Presentation of VRU situation/scenarios (functional safety) by Márton Pataki, project support engineer
14:45 – 15:15	Presentation of Scenario-in-the-loop (SciL) – (Functional safety) by Bálinth Tóth, project support engineer
15:15 -16:15	Guided tour on the track by bus
16:15 – 20:00	Transfer to Budapest

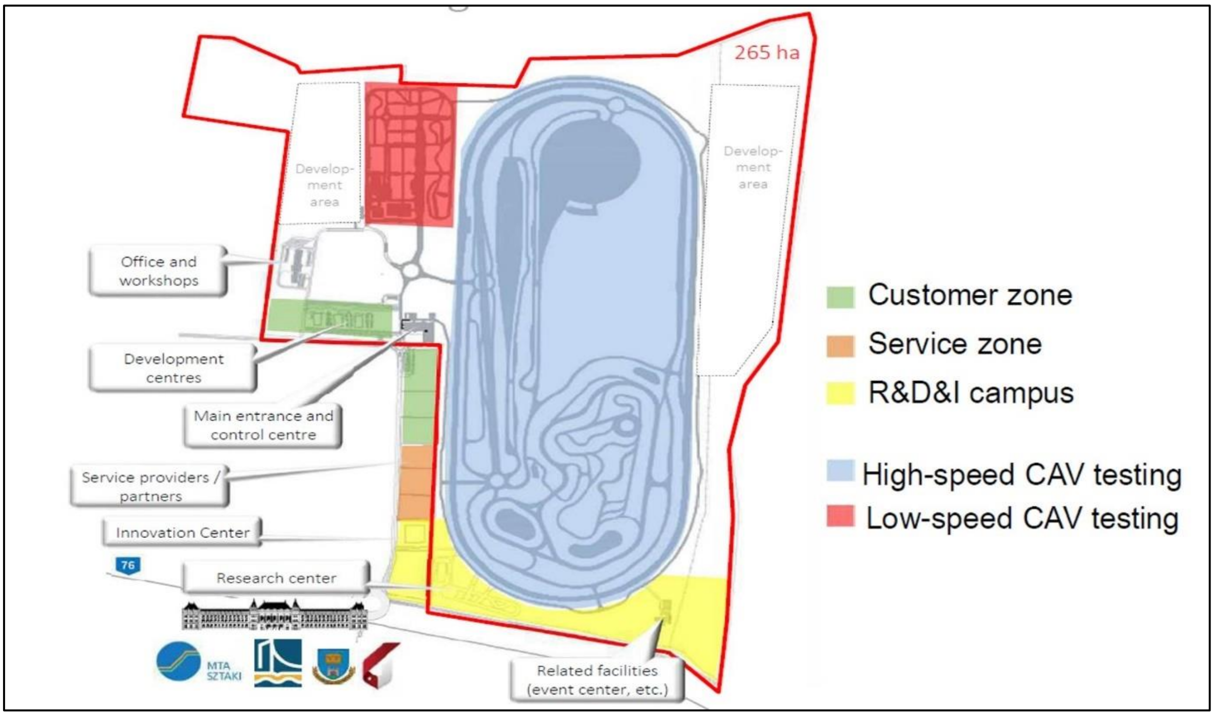
Wednesday 20 November 2019	
9:00 – 10:00	Transfer by bus to the dispatcher centre of Dunakeszi Highway Engineering
10:00 – 12:00	Presentations of experts from road authority (Hungarian Public Road Nonprofit Plc.) • Introduction of ITS activities of road authority in Hungary • Introduction of speed-management activities of road authority in Hungary • Introduction of work in the dispatcher centre of Dunakeszi Highway Engineering
12:00 – 13:00	Lunch break
13:00 – 16:00	Site visits around the M0 motorway by bus, guided by experts from road authority: • Introduction of Bluetooth scanner-based travel time display system • Introduction of cooperative ITS system on M0 motorway • Speed-management activity at places with traffic diversion • Introduction of monitoring system of truck parking lot at Alacska Pinenőhely near Vecsés
16:00 – 17:00	Transfer back to Budapest

2. ZalaZone test track

2.1 Overview of testing facilities

First day of the study visit brought participants to Zalaegerszeg, where KTI team, together with representatives of the ZalaZone, presented an ambitious project of "proving ground" (test track). Project concept was prepared between 2014 – 2017 based on business analysis, good practices from other similar facilities abroad and environmental studies.

In the beginning, representatives of KTI together with ZalaZone managing director, Mr. Kálmán Gangel welcomed the RADAR team at the test track. Mr. Gangel then took the floor to introduce the track in detail. ZalaZone is located on 265 ha of land and consists of customer zone, service zone, research and development campus, high speed testing and low speed testing areas. The ground is focused on public road tests, autonomous testing services and classic services, while fitting into the concept of multi-level testing (from computer simulations, through laboratory tests and proving ground towards limited public road testing and final public utilization), which is essential for automated driving tests.



While ZalaZone itself serves as the closed testing environment, the nearby Zalaegerszeg serves as the smart digitalized city environment for testing. Public road tests are allowed on Hungarian roads according to innovative regulation of April 2017 for testing (semi-)autonomous vehicles up to level 4 (please, refer to Appendix to understand different levels of automation).

These tests in real environment make use of three testing loops:

- Loop 1 – City local roads – smart infrastructures;
- Loop 2 – Hungarian roads;
- Loop 3 – International roads.

Important parts already finished or under construction

- Dynamic platform;
- Braking surfaces;
- Handling course;
- Smart City (basic road grid);
- Rural road;
- Main entrance building with conference centre;
- Technical building;
- Innovation centre by Industrial park.

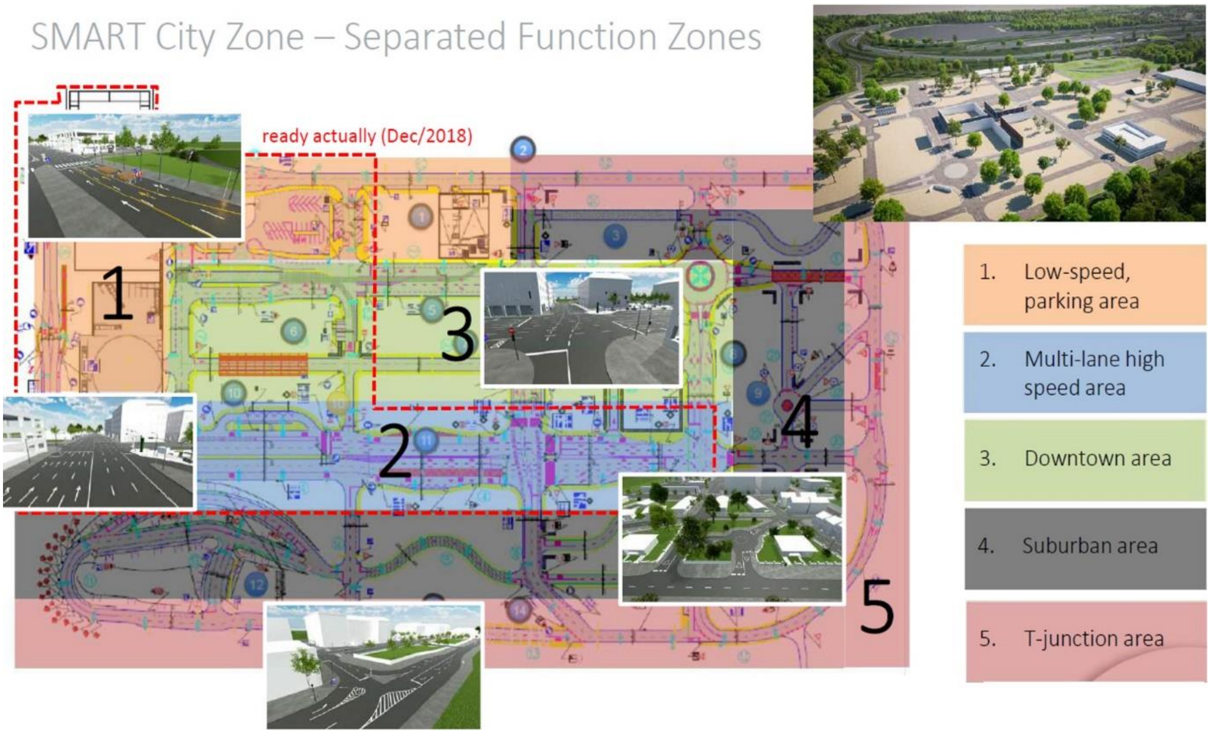
Individual modules of ZalaZone were introduced in detail, explaining their parameters and also the test types carried out on them. The presentation was very detailed, providing participants with all necessary details into the schemes and procedures of individual tests. The slides are available for RADAR partners to use.

Summarized autonomous vehicle test types performed at ZalaZone:

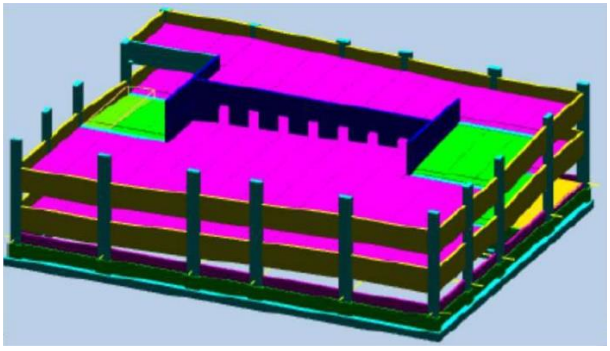
- Cooperative vehicle control
    - at high/medium speeds; different trajectories (double lane change, J-turn etc.) at stability limit (ABS, ESP activity);
    - at physical limit, moving or static obstacle, at various speeds during ABS, ATC, ESP activity;
    - at diverse topography and limited visibility;
    - at low speed up- and downhill and various friction conditions with limited visibility;
    - at low speed on extremely bad road quality;

- Platooning:
  - at free trajectory;
  - at high speed motorway situations;
  - at physical limits, drive through or braking at various surfaces up to high speed;
  - at medium speeds at diverse topography;
  - on motorway at realistic conditions, exits and entrances;
  - with cooperative control with limited communication (tunnel);
  - on rural road at realistic conditions, various types of junctions, roundabouts;
  - at low speed on roads extremely bad quality;
  - at low speed up- and downhill and various friction conditions with limited visibility;
- Euro NCAP scenarios;
- Fix position and moving obstacles (dummy car or pedestrian);
- Fix position obstacle (dummy car or pedestrian);
- V2I, V2V communication tests at high vehicle speed;
- Environment with dynamic and static obstacles;
- Construction site situation;
- Diverse lane layouts: 2x1, 2x2, 2+1;
- Diverse topography;
- Various traffic junction scenarios;
- Various roads side elements: trees, fences, grass etc.;

SMART City Zone:



Smart City zone consists of various installations and elements to simulate urban environment with advanced technological features. Parking house of 60 cars in 3 levels with configurable parking place layouts is also Part of the Smart City zone, as so are typological buildings and other urban elements.



Special features and technical parameters for testing include:

- Sticky lane markings;
- Real test vehicles;
- Old cars for scenery, special cars;
- Traffic gantry with variable message sign;
- Railway crossing, construction zone, pedestrian crossing, trees, moveable road signs, tunnel, roadside objects, various street lights, SMART City features;

Thanks to such facilities and equipment, it is truly possible to create a vast scope of testing scenarios. Presently the following cases can be identified:

- Low-speed platooning at various junctions and lane layouts;
- Emergency braking in city environment with different barriers (static, moving) on high and low friction surface;
- 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 roadside objects: buildings, trees, parking cars, used road signs, fences, dust-bins etc.;
- Changing weather conditions (only rain).

2.2. Communication network

It is obvious that the project of such a scale and nature as ZalaZone would not be possible and functional without a robust and advanced communication networks. This had been a vital pre-condition from the initial planning phase. Since the subject itself is not particularly of RADAR´s primary interest area, only a basic description and scheme are included in this report.

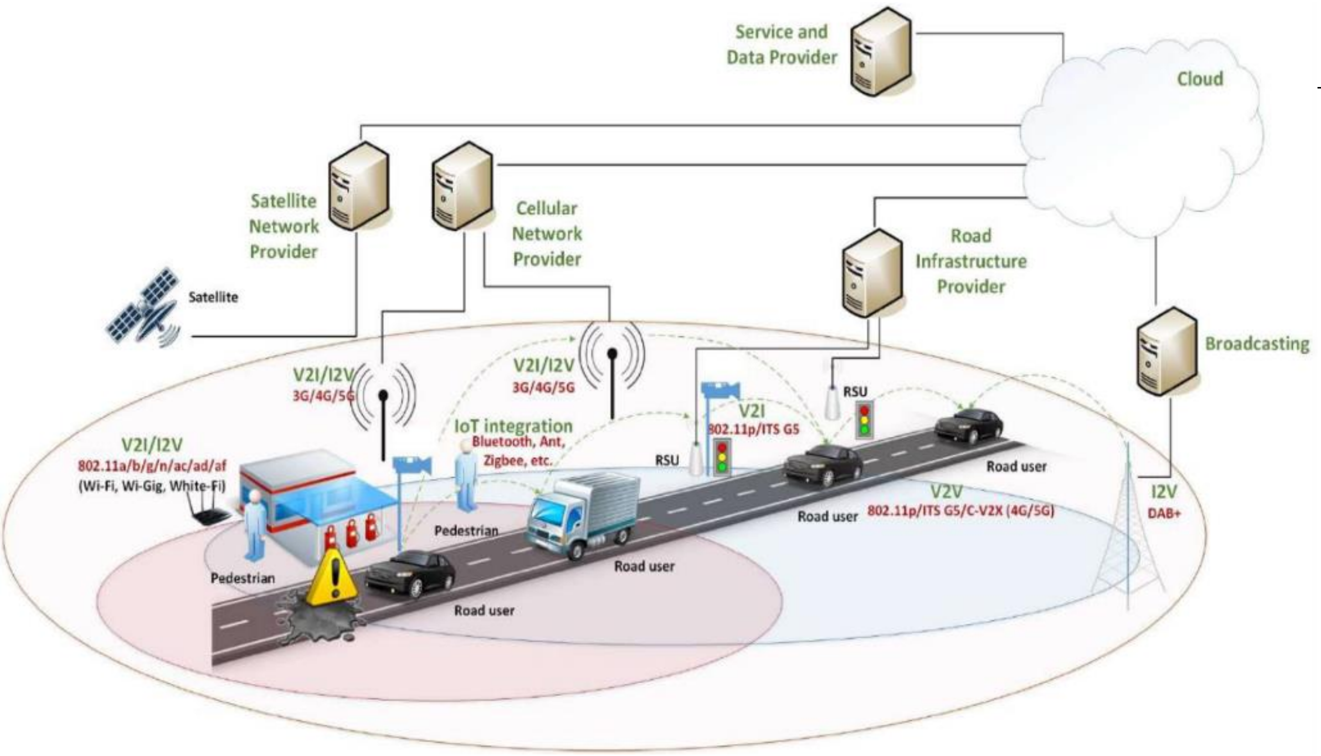
The core of the communication system is a **3-level structure**:

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

Beside the core architecture, the system offers a variety of additional systems, which are ready to accommodate future needs of testing, incl. third-party solutions:

- **5G** cellular test network for future ITS applications;
- **Redundant layout** for parallel customer networks;

Communication network scheme



Overview of modules available in individual systems

DSRC/ITS G5 network features:

- EU/US standards conformance;
- Support for hybrid radio;
- Message, event and activity logging;
- Time stamping, time synchronization capabilities;
- Multi-vendor interoperability;
- Authentication, Authority Center;
- Traffic Management Center integration;

5G cellular network features:

- Coverage of the Test Proving Ground and the designated Smart City Area;
- Handover capability;
- Network slicing capability (e.g. part for C-ITS, another for Mobile Broadband);
- Feature set evolution towards 5G (invoking frequent network upgrade);
- Flexible architecture (virtualized network functions);
- Local computing capability (a.k.a. edge computing);
- Security including system access, usage logging, communication encryption;
- Massive IoT support (primarily for the Smart City Area);
- Message, event and activity logging;
- Time stamping, time synchronization capabilities;
- Multi-vendor interoperability.

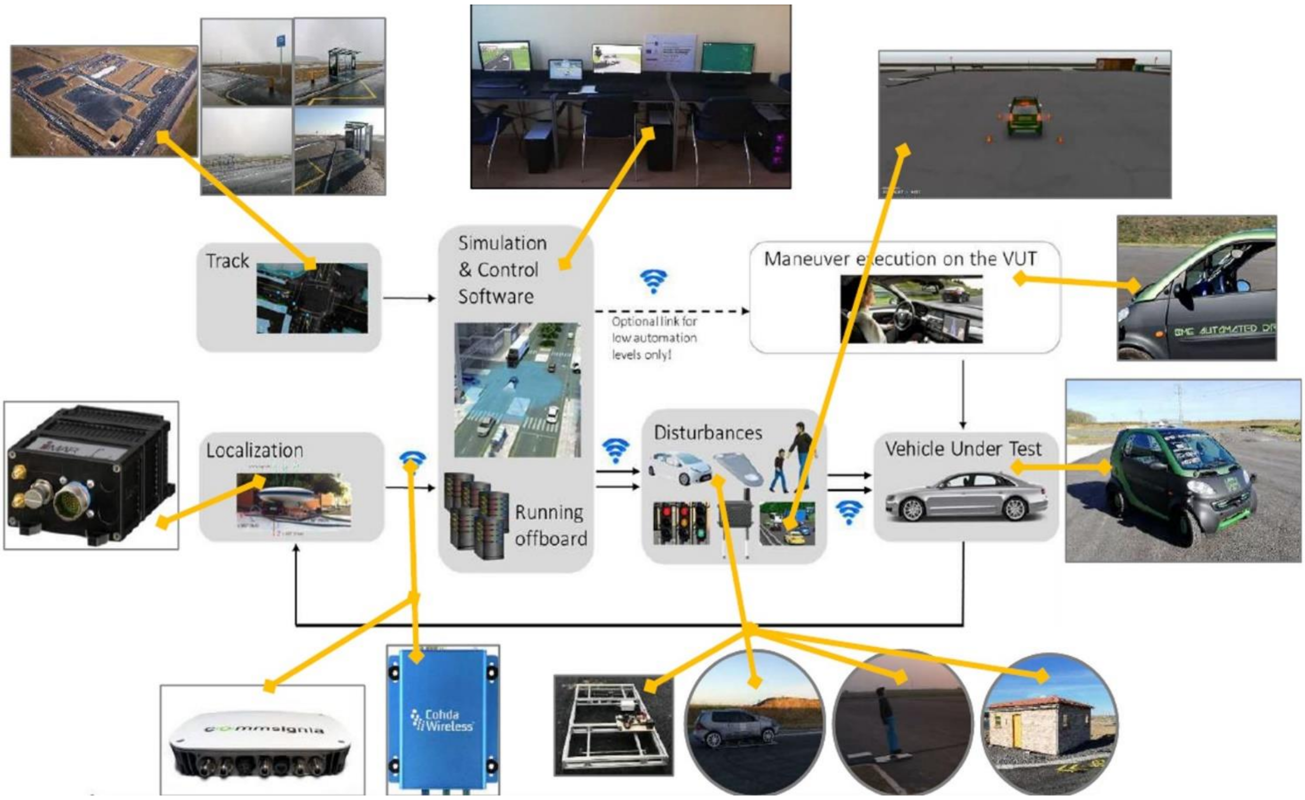
2.3. Scenario-in-the-Loop (SciL) simulations

Besides the communication infrastructure there is another key element enabling ZalaZone to perform such a high level of testing opportunities – a simulation software, which enables generally unlimited opportunities in terms of defining and setting-up specific environments to complement the hard infrastructure of the proving ground.

The simulation software, which runs separately from the vehicle (off board in the control tower), controls the entire testing process. During the test the software can recalculate the scenario in real-time which enhances the reproducibility.

The software has two main inputs, the precise description of the real test track in a 3D software environment, and the localization data from the VUT (Vehicle Under Test). The software can calculate the trajectory and timing of the disturbance targets, controls the environmental elements and sends information about non-real participants of the scenario. There are presently assessments being performed on different software, in order to decide on the most effective and user-friendly solution for the future.

Simulation tests scheme



Examples of performed tasks and outputs

SciL technologies enable a large variety of testing exercises and bring opportunity for advanced assessments of interaction among vehicles, users and infrastructures. From the RADAR project perspective, this is particularly valuable as it comes to evaluating the risks and benefits of different infrastructure and enforcement measures planned to increase safety – particularly as it comes to vulnerable road users and their interaction with (autonomous) vehicles in traffic.

The software can calculate the trajectory and timing of the disturbance targets, control the environmental elements and sending information about non-real participant of the scenario.

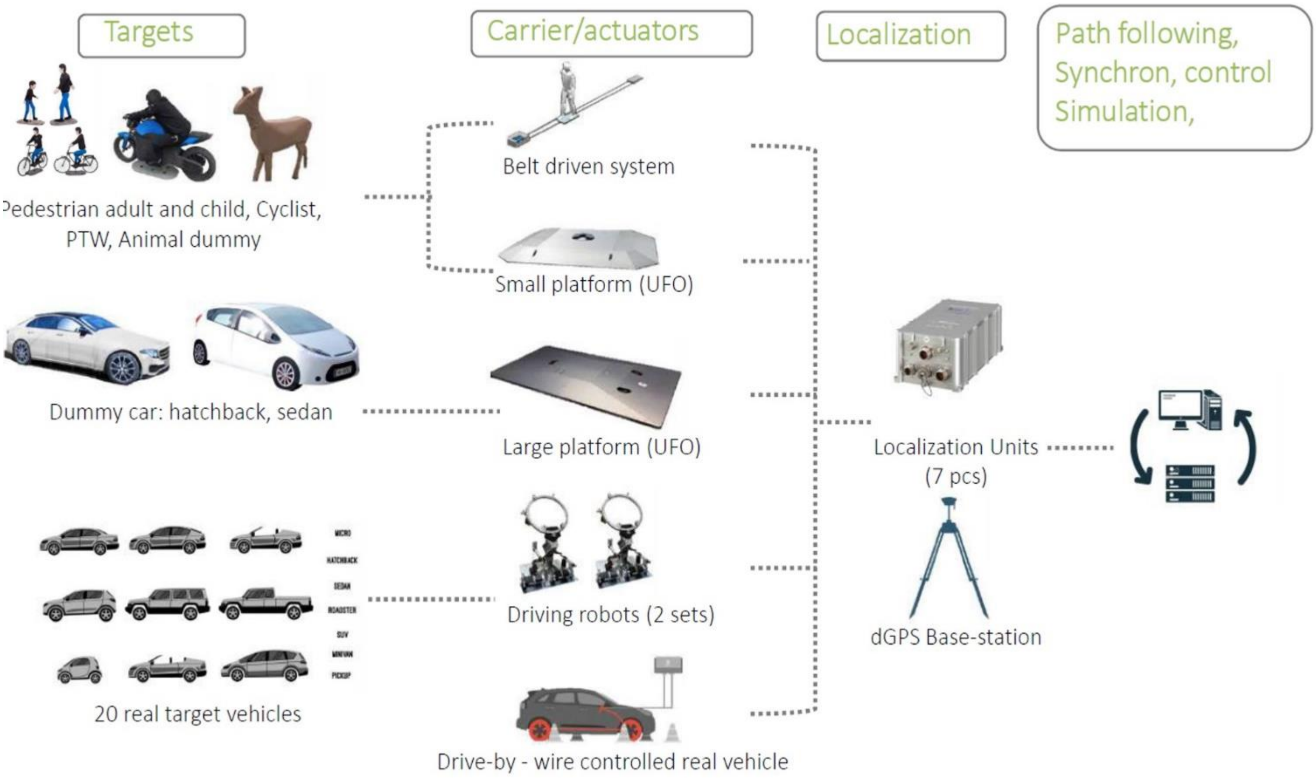
Movable objects and disturbances:

- VRU dummies (adults/children, pedestrians/cyclists);
- soft vehicle targets like Global Vehicle Targets (GVT) with GPS guided platforms;
- environmental elements (traffic signs, rain machine, mirroring surfaces, street lights);

Virtual objects and sensor models:

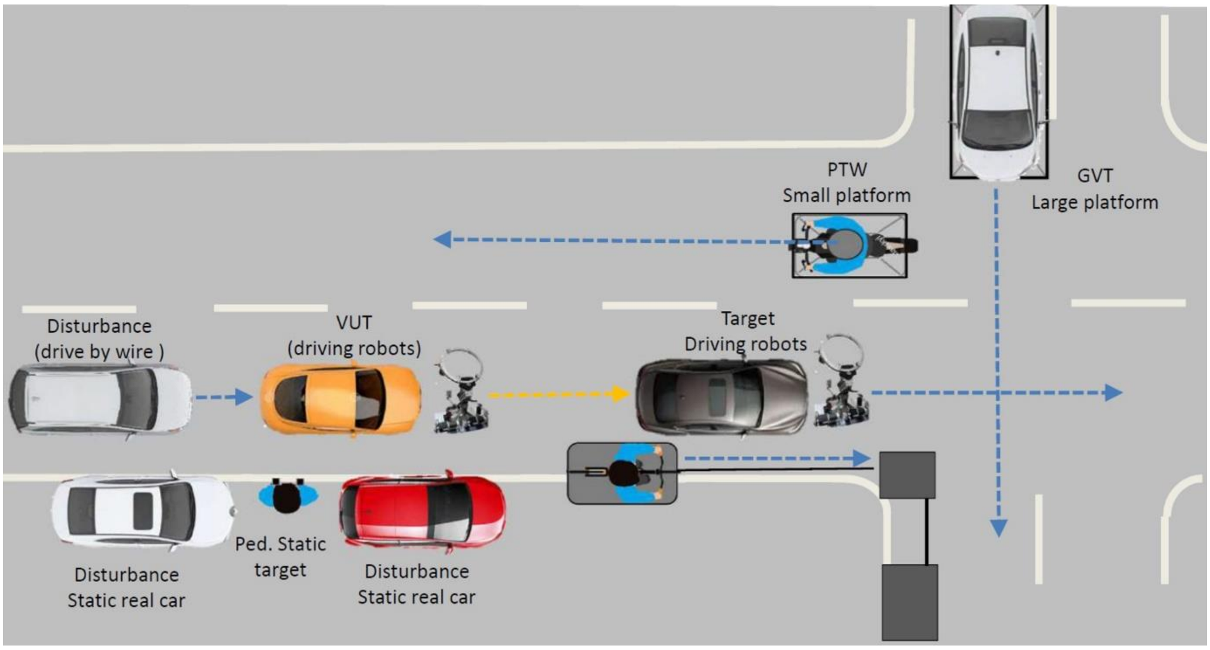
- V2X messages about other road users, road and weather conditions;
- virtual presence of additional participants.

All the equipment used for active safety testing with SciL technology are conform with EuroNCAP specifications for targets and tools.



Further testing tools and accessories:

Practical simulation cases were shown to RADAR participants in order to demonstrate the SciL development process, including the cases concerning VRU safety assessments, as illustrated below.



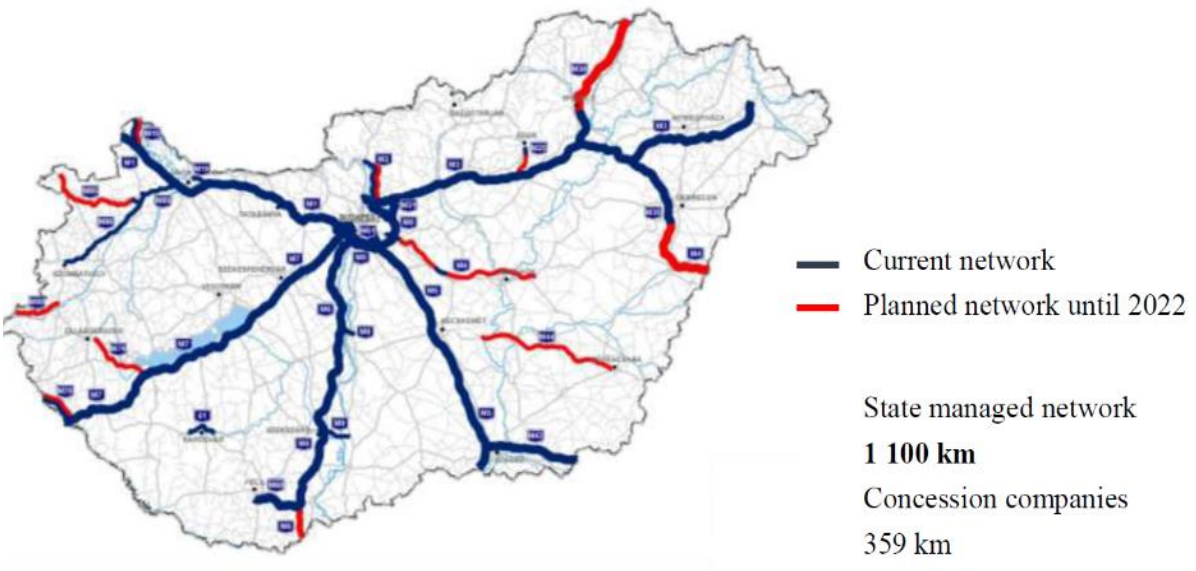
3. Traffic management on Hungarian motorways

The second day of Study visits was dedicated to the theme of ITS implementation and management. An interesting programme was prepared by KTI in cooperation with Hungarian Public Road Authority (MK). At first, participants were dropped in the traffic control centre of Dunakeszi Highway Engineering (DHE) in order to visit the operations and listen to introductory presentations.

After that RADAR group enjoyed a bus tour around numerous ITS installations for traffic management on motorways and parking facilities.

3.1. Hungarian Public Road Authority introduction

In the beginning of MK´s presentation at the traffic control centre (TCC), its representatives gave a brief introduction on MK´s structure and activities. The authority is responsible for managing the motorway and expressway network as can be seen in the picture below, however, not the whole network is managed by MK, certain part belongs to the responsibility of various concession companies.



MK´s structure consists of:

- 19 county directorates;
- 94 maintenance centres (16 for motorways);
- 5 574 own employees;
- 1590 employees through the public works programme.

Activities of MK

Scope of actions carried out by the public road authority includes:

Operation:

- Operation of roads and bridges;
- Winter maintenance;
- Operation of roadside electronic devices;
- General operation;
- Management tasks;

Maintenance:

- Pavement maintenance;
- Maintenance of ditches, earthworks, and road surroundings;
- Maintenance of road equipment;
- Maintenance of bridges and structures;
- Other environment protection related activities;

Road related technical and financial activities:

- Road network protection;
- Quality inspection;
- Operation of the road database;
- Operation of the sensor network;
- Education.

3.2. *Traffic management centre*

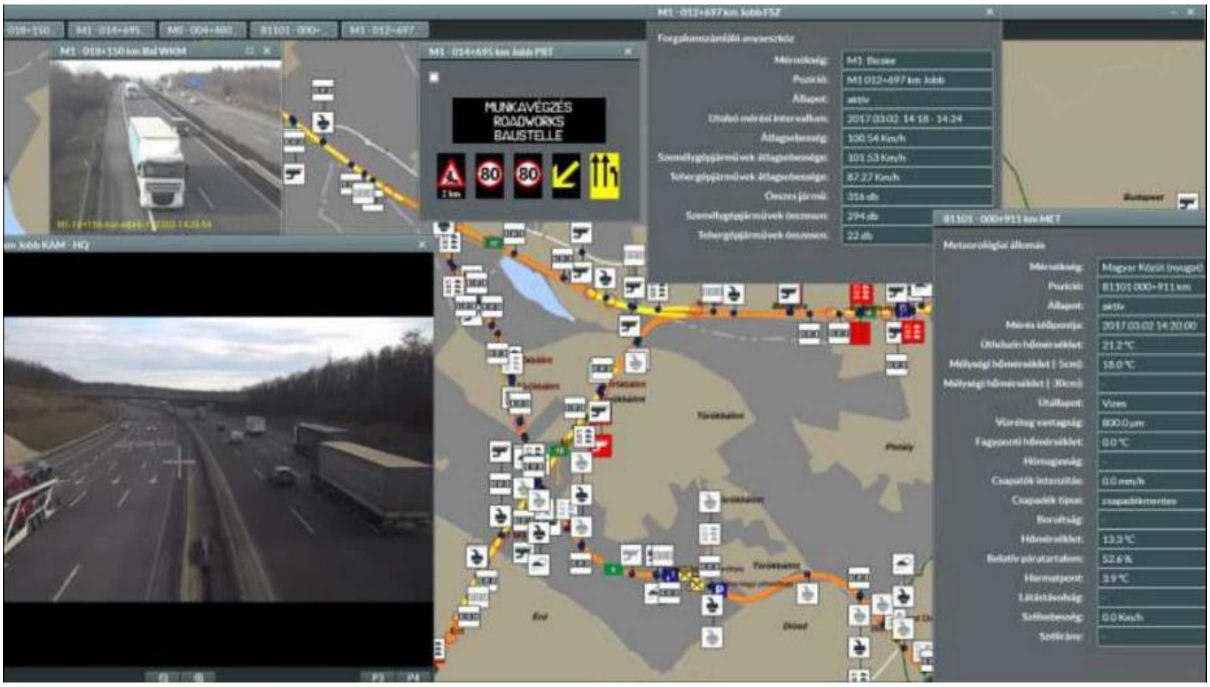
After the introduction MK´s representatives switched to describe the services and operations of TCC in more details, focusing primarily on motorway traffic management through ITS installations (incl. speed enforcement, intelligent parking and safety in work zones), as well as traffic information services.

TCC of MK collects information on circumstances, events and incidents affecting traffic flows and safety on the national public road network. Based on the collected information, road users are promptly informed through various communication channels – typical messages consist information on traffic accidents, road closures, weather-related obstacles.

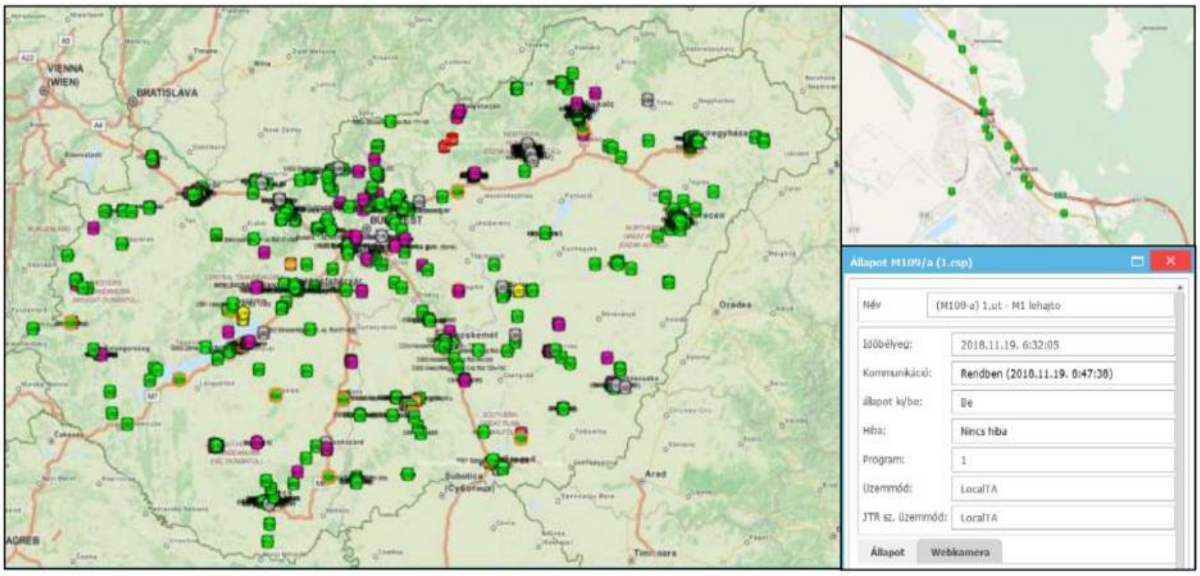
Basic specification of TCC systems and services:

- Traffic Mangement System (FIR 2.0);
- Traffic Light Management System (JTR);
- National Road Database (OKA);
- DATEX HUB;
- Data-portal;
- National Access Point (NAP HUB).

Traffic management system (FIR)



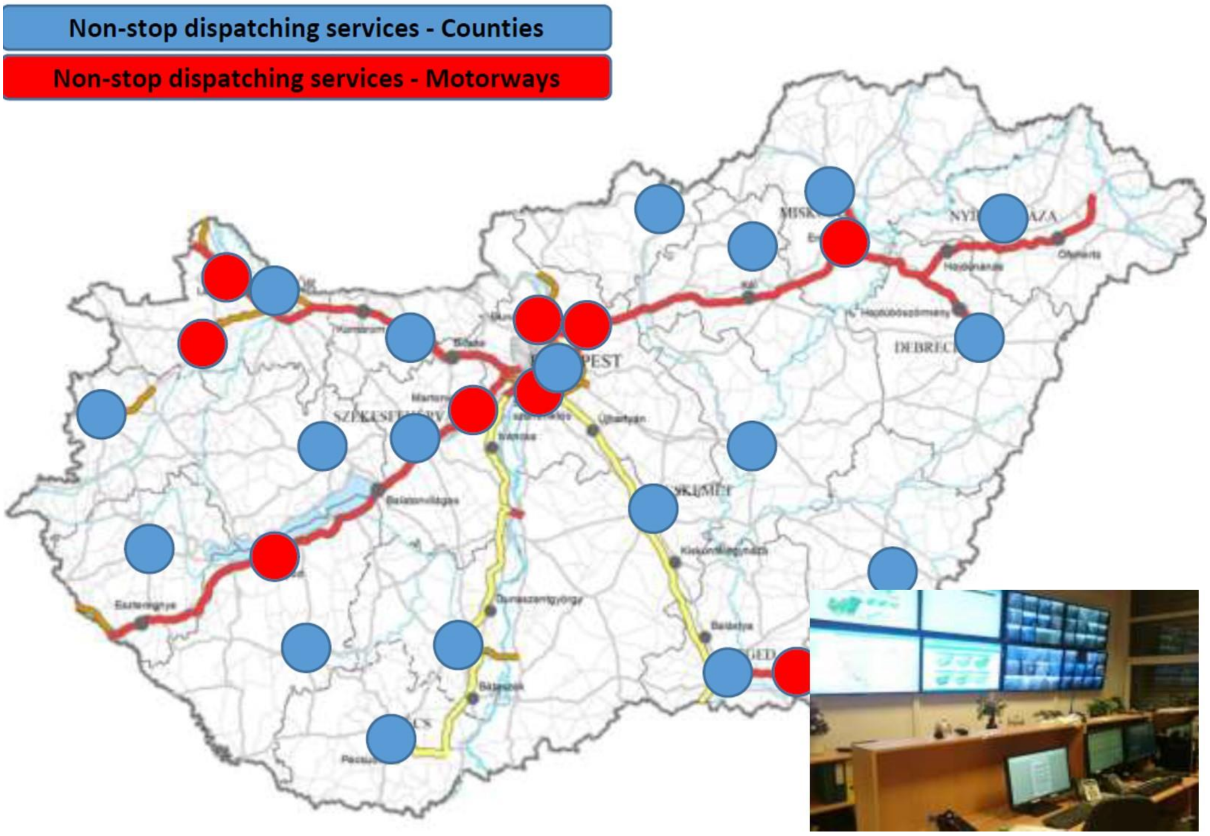
Traffic lights management system (JTR)



Structure of Traffic information centres

- responsible for collecting information from the whole interurban road network
- coordination and distribution of traffic information

Territorial coverage of traffic information centres in Hungary:



3.3. Participation in ITS projects

After the session on traffic management and information services, space was given to the overview of various ITS international cooperation projects, which have been implemented in Hungary, and which provided opportunity to develop, test and even pilot some of very important and useful systems.

The list of key projects includes the following initiatives and some of their major achievements are mentioned in the following part:

- C-Roads;
- TN-ITS GO (Map Data Exchange);
- Crocodile;
- Connect;
- Easyway
- Frame Next;
- HiDalgo;
- Közop.

The Hungarian roads network is equipped with several cameras, sensors and signalling devices, facilitating the work carried out by public road operators and providing valuable information to travellers. These systems have undergone many changes in line with the dynamic development trends of the telecommunications and IT industry, giving rise to new openings for both travellers and road operators.

The number of meteorological stations on the expressway network has now reached 160, the number of traffic counting stations today is 164, the traffic camera network already includes 400 cameras and the number of Variable Message Signs has grown to 291.

Crocodile Project

Crocodile is one of the largest EU ITS projects implemented in many of the Member States in several phases. Some of its key objectives include:

Overall goals:

- establishing connections/co-operations with neighbouring countries/road operators;
- upgrading quality and availability of traffic data, including automatic data exchange (DATEX II. node);
- implementation of the National Access Point;
- improving road safety, especially work zone safety (C-ITS pilot);
- upgrading/extending services for road users:
  - traffic information;
  - intelligent truck parking.

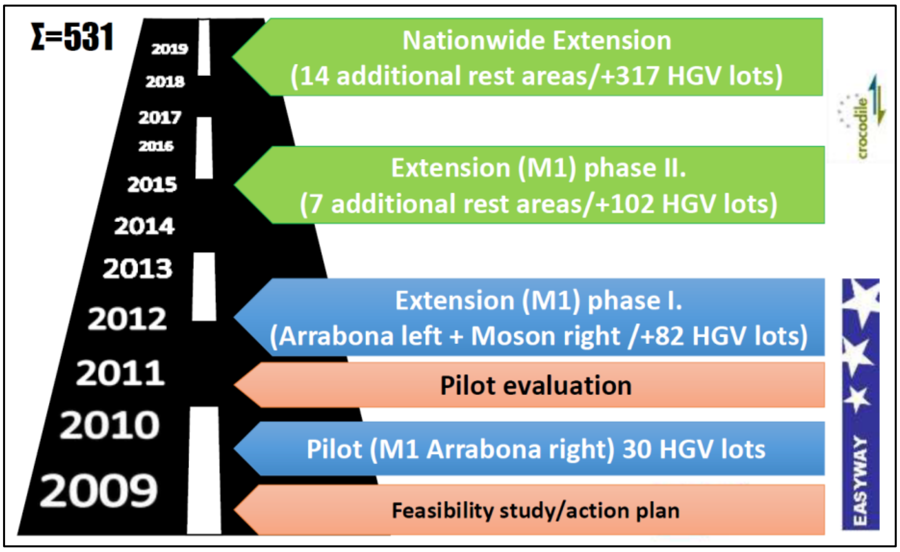
3.3.1. Intelligent Truck Parking (ITP)

The parking management system for cargo vehicles was set up on M1 motorway. The system uses an image recognition camera for monitoring the parking area. When the camera detects a change in parking spaces´ occupancy (arriving/departing heavy vehicles), the number of available parking spaces indicated on variable parking information signs is adjusted. Besides optimization of truck parking capacities at rest areas across the network, the system also contributes to higher road safety by providing early and precise information for truck drivers to make early decisions.

Presentation of data collected through ITP camera system – traffic signs and TCC record:

Motorway	TEN-T corridor	Parking places in total	Observed parking places	Coverage
M0	Mediterranean	101	49	48.5 %
M1	Orient East-Med	316	224	70.9 %
M15	Orient East-Med	0	0	-
M3	Mediterranean	489	60	12.3 %
M43	Orient East-Med	94	60	63.8 %
M5	Orient East-Med	135	45	33.3 %
M7	Mediterranean	335	93	27.8 %
M70	Mediterranean	10	0	0.0 %
Total		1,480	531	35.9 %

The development of ITP facilities under the EU projects Easyway, followed by Crocodile, is illustrated in the following figure – indicating the total of 531 available ITP spaces across Hungarian motorway network by 2019.



3.3.2. Work-zone safety

Another important theme with direct effect on road network safety performance is safety in work-zones – quite frequently mentioned road safety aspect, which tends to be slightly overlooked by experts but intensively and repeatedly raised by road infrastructure operators, as it very much affects and endanger their human and technical resources for road network maintenance.

Crocodile project also enables to test technological solutions of sending advanced warning messages of ongoing road works ahead to approaching vehicles based on WLAN communication.

As far as work-zone safety is concerned, there are additional pilots and tests being implemented in the field of Road works warning (RWW) information generation and distribution. A set of warning message signs are not only shown on VMS facilities but also transmitted into a vehicle´s OBU.

Name	Picto	ID	String ID
No warning		0	noWarning
Accident		1	accident
Traffic jam		2	trafficJam
Other Danger		3	otherDanger
Road closed, reroute to right (1)		4	roadClosedRight1
Road closed, reroute to right (2)		5	roadClosedRight2
Road closed, reroute to left (1)		6	roadClosedLeft1
Road closed, reroute to left (2)		7	roadClosedLeft2

Crocodile 3 (2018 – 2020)

A third phase of Crocodile project is presently being implemented in several Member States (A, CY, CZ, H, HR, I, SLO), including Hungary. While the beneficiary of the project is the Ministry of Innovation and Technology, Hungarian Public Roads together with Budapest Public Roads are the implementing bodies.

The scope of activities contains the following with the action in bold being supervised and implemented by the National Traffic Management Centre.

- Project management/communication;
- Cross-border cooperation, implementation and upgrade of traffic management plans (TMP);
- **Implementing the ITS Directive – National Access Point/National Body;**
- **Data access, implementation of DATEX nodes;**
- Service delivery to the end-user.

3.3.3. National Access Point

Another important ITS activity realized in Hungary is the development of a National Access Point (NAP) for collection, processing and storage of traffic data – a central element integrating all data providers, users and relevant public bodies into one single forum and data platform. Under Crocodile 3 the following actions are planned:

Improvement of existing Datex nodes

- basis (main feed) of the future NAP – 'Datex HUB';
- traffic data related to priority action „b" „c" and „e";
- DATEX II (version 2.3.);
- Push&pull also available.

Setting up the NAP&NB is planned

- **1st step: feasibility study**
  technical specifications, legal framework and procedures – the German model Data Marketplace is followed, with some additional functionalities;
- **2nd step: implementation**
  portal operational since 01/2019 in internal beta test, public beta test on 01 July 2019.

3.3.4. Travel Time Information System

RADAR participants to the Study visit also learned about an interesting project, which shall have secondary positive impacts to road safety, too – newly developed Travel Time Information System, which shall provide real-time and quality data on traffic flows across the network based on Bluetooth technology (BT scanners) and display calculated travel times onto the information portals.

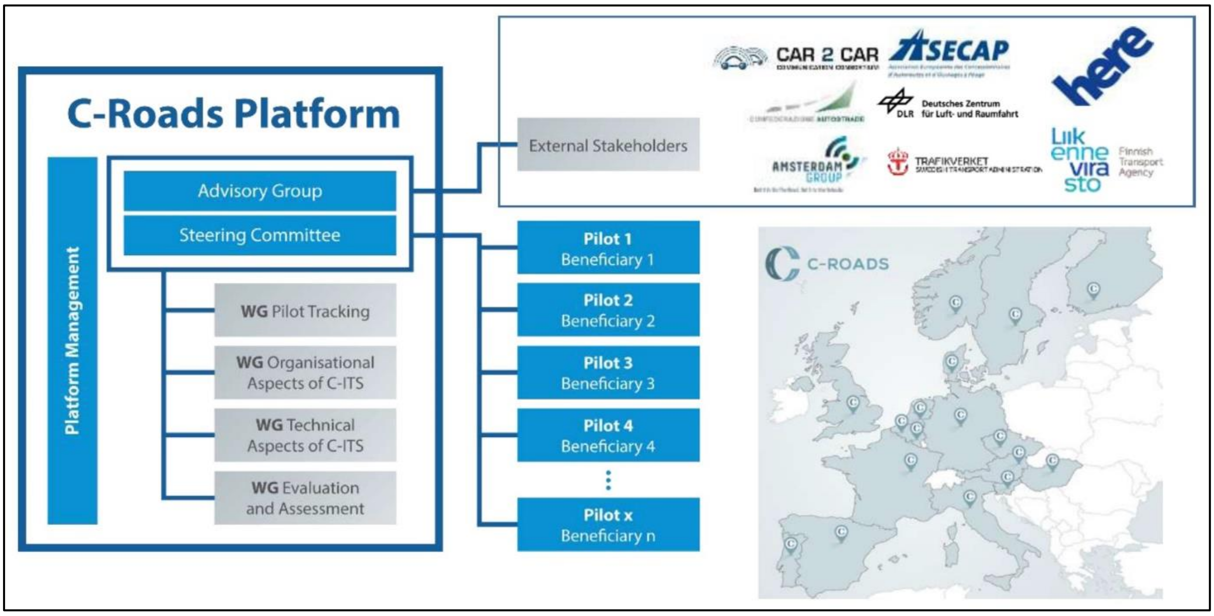
Basic information on the project

- Location: M0 (Budapest Ring-road), M1, M3
- Devices: 22 BDS (Blue Data System) Bluetooth scanners
- Partner: Budapest Road Company
- In accordance with: Traffic Management Plans

Once implemented, the system will step-by-step substitute the present system based on video camera surveillance and portal display.

PROJECT C-ROADS

Although left to the very end of the report, C-Roads presently constitutes one of the largest European ITS initiatives, including 18 members from EU Member States, further 6 associated partner countries and 43 European cities. Together with external stakeholders and private players, who are invited to project´s Advisory Group, C-Roads provides the largest platform to coordinate and deploy C-ITS services development across Europe.



From RADAR perspective, this is an important initiative, since it focuses on the development of communication between vehicles and infrastructure – a phenomenon with quite significant future impact on road safety performance on national primary networks, and which has been tackled **iRAP**, too – in its report **"Roads that cars can read"**. Third edition of this paper was published in January 2020 and gives more focus to increasingly autonomous vehicles.

4. Lessons learned

The study visit on Thematic area 3 – Speed management and ITS provided RADAR participants with quite extensive overview of ITS activities that are being carried out in Hungary, mostly implemented by Hungarian Public Roads in cooperation with many public and private stakeholders, as well as international partners.

It is clear, that among RADAR project countries, Hungary shall be considered as one of the leading countries in ITS deployment, together with Austria and the Czech Republic. Participants had an opportunity to learn more about technical background of various projects. Later they visited by bus many interesting installations, such as Intelligent truck parking facility, travel time information system based on Bluetooth technology, speed enforcement and variable message signing.

In addition, RADAR team had a unique opportunity to visit ZalaZone test track – the advanced and ambitious project of a test track for autonomous vehicles. It provides extensive scope of infrastructure and SW/HW facilities for testing autonomous vehicles and their performance and "behaviour" in real-life situations, many of which are directly related to road safety. And it is not just vehicle´s safety as such – ZalaZone facilities and equipment bring a large scope of opportunities for testing various schemes and solutions for vulnerable road users´ safety. Particular focus is given to interaction between autonomous vehicles and VRUs but similar environment and equipment would definitely be very useful even for testing the measure on existing infrastructure and with traditional vehicles.

4.1. General key success factors

The Study visit on ITS deployment in Hungary was focused on very innovative and technology-oriented expert fields. Even though different ITS solutions have already started to be implemented in Hungary, as well as other European countries (mainly under several large-scale international initiatives such Crocodile, Easyway, C-Roads), the conceptual development of this technological segment will not be an easy and fast one, for several reasons.

When it comes to autonomous mobility, the situation is even more blurred and uncertain – especially as it comes to legislation and policy framing the level 5 automation. But the hardest battles in this field will not take place on the side of technology. Therefore, it is very promising to see such huge investments into testing facilities for autonomous vehicles.

Except for level 5 automation concerns, both topics explored do not suffer from any controversial tendencies and professional opinions. Generally speaking, technology is (and will be) here to help and serve to road traffic safety and efficiency. It is rather a question of available resources that countries can allocate to ITS deployment. To succeed, the following is vital:

- **Financial resources**

  Road infrastructure development is always about money, and it is even twice as relevant for ITS implementation, as ITS technologies are often considered as "bijouterie" of road networks – they are not necessary or compulsory and as such, they are often considered as the first-to-go, in case budgets are being cut. ITS solutions are often very costly and large-scale implementations lastsdecades. Therefore, it is very important and recommended to ensure that estimated financial resources are allocated to all priority areas/measures/projects defined in the ITS strategy. Although majority of funding must be provided from public sector, ITS field can potentially constitute a suitable sector for any innovative PPP funding schemes.

- **Strategic framework for ITS implementation**

  ITS strategy is an absolutely crucial pre-condition for achieving expected benefits in future. It starts with a long-term vision and goes down through mid-term strategic priority areas with defined measures, and it ends with short-term, annually updated action plans, where exact financial resources are earmarked to concrete actions and outputs.

  ITS strategies are vital for one more reason – there are tens or hundreds of private providers of different technologies nowadays and each and every one of them is trying to develop service and estimate future demand. Without formulating precisely, what a country wants in terms of future ITS, it can easily happen that the market becomes full of individual partial solutions without any possibility to consolidate the sector and implement a network-wide unified, or at least coordinated concept. It typically happens in the field of traffic information services and traffic data collection, but cases might differ from country to country.

4.2. *Critical issues*

As per above, budgets and strategies are considered as the most important assets, when looking at future development of ITS services. And for sure, absence of any of those two represents a critical issue. But compared to autonomous mobility, ITS implementation does not suffer so much from a divided professional community.

The automotive industry is leading the path towards more and more automated vehicles and it is inevitable that drivers, as well as car passengers will experience many breaking innovations in coming years. And even though a vast majority of assistance systems being introduced to vehicles are safety-oriented and shall contribute to a safer system, it will become more and more complicated as the industry gets closer and closer towards the final automation level 5.

Given the Hungarian example, national legislation so far accepts testing vehicles up to automation level 4. The full automation level 5 needs important legal changes related to the responsibility of car manufacturer or other body in case of accident and in the Highway Code as well. Moreover, there is even not a common agreement among experts on whether level 5 automation shall be the final stage and if yes, in which transport segments and modes.

Last but not least, many ethical questions need to be answered before the whole system could be built. A well-advised person, who is not controlling a car at all (Level 5) would be understandably reluctant to accept liability for something out of his/her control. But the question of liability and responsibility is perhaps even more complicated for levels 3 and particularly 4, where vehicles might try to pass control back to driver when detecting an incident, but in such a late stage that driver would not have any chance left to avoid the situation. Question is whether a driver would accept such a liability scheme.

4.3. Potential for transfer across DTP countries

The study visit on ITS facilities for traffic management and speed enforcement was very valuable and inspirational in several aspects.

Firstly, it was clear from the information received, how intensively and widely relevant Hungarian authorities (e.g. ministries, MK) are involved in various international cooperation projects, mostly co-funded by EU financial instruments. This is something to “take home” and to encourage relevant national ITS authorities and stakeholders to follow the approach.

Even though the topics discussed during Study visit TA3 might seem a bit too advanced and “far from now” for many RADAR partner countries, it is necessary to point out that it might represent an advantage, too. Referring to the success factor of “strategic framework”, some less-advanced countries can easily start to develop their national visions and strategies step by step “from scratch”, without necessarily dealing with many negative consequences of already penetrated and partialized markets. In these terms, the sooner they start implementing best practice schemes from abroad, the better.

At last, it was also very inspirational to see another “testing site” – while the first one visited under RADAR Study visits was the Vransko training centre in Slovenia (focused on rather traditional, driver-oriented educational techniques), ZalaZone Proving Ground is a project to admire, illustrating and proving the already mentioned dedication of Hungarian road authorities towards future development and innovations. Such an approach and strategic vision is also something that might be transferable, should political will exist at right levels and places.

5. Appendix

5.1. Definition of automation levels in vehicles:

- **Level 0 – No Automation**
  This describes your everyday car. The driver performs all operating tasks like steering, braking, accelerating or slowing down, and so forth.

- **Level 1 – Driver Assistance**
  Here we can find our adaptive cruise control and lane keep assist to help with driving fatigue. At this level, the vehicle can assist with some functions, but the driver still handles all accelerating, braking and monitoring of the surrounding environment. Think of a car that brakes a little extra for you when you get too close to another car on the highway.

- **Level 2 – Partial Assistance**
  Most automakers are currently developing vehicles at this level, where the vehicle can assist with steering or acceleration functions and allow the driver to disengage from some of their tasks. The driver must always be ready to take control of the vehicle and is still responsible for most safety-critical functions and all monitoring of the environment.

- **Level 3 – Conditional Assistance**
  The biggest leap from level 2 to level 3 and above is that starting at level 3, the vehicle itself controls all monitoring of the environment (using sensors like LiDAR). The driver´s attention is still critical at this level but can disengage from "safety-critical" functions like braking and leave it to the technology when conditions are safe. Many current Level 3 vehicles require no human attention to the road at speeds under 37 miles per hour.

- **Level 4 – High Automation**
  At levels 4 and 5, the vehicle is capable of steering, braking, accelerating, monitoring the vehicle and roadway as well as responding to events, determining when to change lanes, turn and use signals. At level 4, the autonomous driving system would first notify the driver when conditions are safe, and only then does driver switch the vehicle into this mode. It cannot determine between more dynamic driving situations like traffic jams or a merge onto the highway.

- **Level 5 – Full Automation**
  Last and least (in terms of human involvement) is level 5 autonomy. This level of autonomous driving requires absolutely no human attention. There is no need for pedals, brakes or a steering wheel, as the autonomous vehicle system controls all critical tasks, like monitoring of the environment and identification of unique driving conditions like traffic jams. Drivers simply feed into their destination and leave the rest up to the vehicle itself.

5.2. Team photos

ZalaZone presentations

Presentations at Traffic Control Centre of Dunakeszi Highway Engineering

Visit to the Traffic Control Centre

Visit to the Traffic Control Centre

Tour around various ITS installations