

Achievements of the CROCODILE I-III projects in Hungary



Co-financed by the Connecting Europe
Facility of the European Union

SZÉCHENYI 

BACKGROUND OF THE CROCODILE PROJECT

The main goal of the CROCODILE project, co-funded by the European Union, is to implement new, seamless Intelligent Transport Systems (ITS) and services on the TEN-T network, the backbone of European transport, the modernization of which is essential for the competitiveness and economic development of the European Union. The coordination of the use of intelligent technologies is ensured by Directive 2010/40/EU of the European Parliament and of the Council, the so-called ITS Directive.

The implementation of Intelligent Transport Systems and the strengthening of cross-border traffic management activities have already been identified as priorities in the CONNECT (2004-2009) and EASYWAY (2007-2012) projects, that were predecessors to the project. Existing developments and established cooperations were continued starting back in 2013 within the framework of CROCODILE.

The European Commission announced an open call on 11 December 2013, which identified ITS systems and services as key areas of expertise. In response to this call, Member States of the former CONNECT region submitted a project proposal entitled ‘CROCODILE – Cooperation of Road Operators for COnsistent and Dynamic Information Levels’, which was supported by ‘Commission Decision C (2014) 8454 concerning the granting of Union financial aid for projects of common interest ‘CROCODILE’ – 2013-EU-50003-P – in the field of the trans-European transport network (TEN-T)’ published on 17 November 2014.

As a follow-up to previous ITS-related projects, co-operation has been established alongside cross-border transport corridors among ministries, road operators and system providers of traffic information services in Central and Eastern European countries participating in

the project. The CROCODILE project involved four core TEN-T corridors: Baltic-Adriatic, Rhine-Danube, Orient-East Med and Mediterranean.

The Hungarian beneficiary of the project was the legal predecessor of the Ministry of Construction and Transport, the Ministry of National Development, and its implementing bodies were Magyar Közút Nonprofit Zrt. and Budapest Közút Zrt. The estimated domestic budget for the first phase completed until 31 December 2015 was EUR 3,670,000, the actual project cost was a total of HUF 1,114,170,884, of which 20 percent was EU funding.

Following the first phase completed in 2015, the Hungarian Government decided in its Decree No. 1089/2016 (February 29) on road transport project proposals submitted for the 2015 call of the Connecting Europe Facility (CEF) funds. The Government specified a total net allocation for CROCODILE 2.0_HU for the implementation of the ITS projects of Magyar Közút Nonprofit Zrt. and Budapest Közút Zrt. as HUF 1,860,000,000, and also requested CEF funding of HUF 1,581,000,000.

The grant agreement for the third phase of CROCODILE was signed on April 30, 2019. The nominated beneficiary, the Ministry for Innovation and Technology and its legal successor, the Ministry for Technology and Industry, acted as granters during the third phase as well, while Magyar Közút and Budapest Közút acted as implementing bodies. According to the grant agreement signed at the start of the project, the third phase of CROCODILE was supposed to end on December 31, 2021. However, deadline has been extended to December 31, 2022, primarily due to the situation in connection with the COVID-19 virus which has developed during the program.

The submitted project package identified the development of on-site data collection and information infrastructure, the functional extension of the central systems supporting traffic management activities and the development of its automatic data exchange system as a priority task. In addition, a key element of the package was the design and implementation of the National Access Point (NAP) structure.

In the third phase, the implementation of the NAP has been completed by updating the existing DATEX node, introducing new formats, and developing multimodal information. In addition, the program focused on two additional areas, collecting information, and developing automatic data exchange, yet the project also aimed at strengthening real-time information. Additionally, further on-field data collection and traffic management devices (automated online sensors, C-ITS devices, traffic monitoring and automated incident detection cameras, web cameras) have been installed on the domestic sections of the TEN-T main network, as well as on the relevant network of Budapest directly or indirectly connected to it.



MAGYAR KÖZÚT			
	Full gross project amount	National budget	EU grant
CI	3,247,443.1 €	2,688,529.4 €	558,913.7 €
CII	4,851,234.8 €	2,347,103.3 €	2,504,131.5 €
CIII	1,227,865.1 €	386,139.8 €	841,725.3 €
BUDAPEST KÖZÚT			
	Full gross project amount	National budget	EU grant
CI	990,806.4 €	168,466.9 €	822,339.5 €
CII	3,636,801.6 €	1,141,890.9 €	2,494,910.7 €
CIII	1,090,265 €	163,539.7 €	926,725.2 €
HUNGARY			
	Full gross project amount	National budget	EU grant
CI	4,238,249.4 €	3,510,868.8 €	727,380.6 €
CII	8,488,036.3 €	3,488,994.2 €	4,999,042.1 €
CIII	2,318,130.1 €	549,679.5 €	1,768,450.6 €

The table shows the total project amount, containing the professional, project management and communication costs as well - the two latter are not presented in this document.

Throughout the presentation of the projects, the following legend has been used:

CI/CII/CIII: the phase of the CROCODILE project
2015/11: Closing date of the project

CI 2015/11

LIST OF ABBREVIATIONS

BI	Basic Interface
CAM	Cooperative Awareness Message
CEF	Connecting Europe Facility
C-ITS	Cooperative Intelligent Transport System
CROCODILE	Cooperation of Road Operators for Consistent and Dynamic Information Levels
FIR	Traffic Management Software of Magyar Közút
FMT	Traffic Management Plan
IKSZR	Integrated Traffic Organization and Regulation System
ITS	Intelligent Transport System
NAP	National Access Point
OBU	On-Board Unit
P+R	Park and Ride
RSU	Roadside Unit
TEN-T	Trans-European Transport Network
TN-ITS	Transport Network – Intelligent Transport Systems
VJT	Variable Message Sign

PROJECTS IMPLEMENTED BY MAGYAR KÖZÚT

FIELD OF DEVELOPMENT	PROJECT NAME	PROJECT PHASE	CLOSING DATE	PAGE	
Development and review of traffic management plans, international cooperation agreements	Review of current traffic management plans	CROCODILE I.	16.11.2015.	8	
	Implementation of international public road management agreements and review of traffic management plans	CROCODILE II.	13.11.2018.	8	
	Preparation of additional Traffic Management Plans and review of current plans	CROCODILE III.	31.12.2022.	8	
	Conclusion of cross-border cooperation agreements, participation in technical working group discussions	CROCODILE III.	31.12.2022.	8	
Development of data connection systems	Installation of fixed traffic monitoring equipment	Development of existing monitoring infrastructure	CROCODILE I.	15.12.2015.	9
		Installation of surveillance cameras on the TEN-T network	CROCODILE I.	15.12.2015.	9
		Installation of automated online sensors and surveillance cameras	CROCODILE II.	26.09.2019.	9
Traffic modelling	Development of a traffic control concept, preparation of technical specifications	CROCODILE III.	07.07.2021.	10	
	Acquisition of traffic simulation software	CROCODILE III.	31.12.2022.	10	
	Acquisition of traffic modelling software (LISA+)	CROCODILE III.	23.11.2018.	10	
Development of access to data	Development of DATEX-based information exchange platform	CROCODILE I.	16.11.2015.	11	
	Development of system interfaces	CROCODILE I.	21.12.2015.	11	
	Implementation of the National Access Point (NAP) – Phase one	CROCODILE II.	29.08.2018.	12	
	Implementation of DATEX II 3.0 and D2Light standards	CROCODILE III.	10.08.2022.	11	
C-ITS development	Implementation of the National Access Point (NAP) – Phase two	CROCODILE II.	10.01.2019.	12	
	Implementation of a cooperative pilot system on the motorway M1	CROCODILE I.	21.12.2015.	13	
	Implementation of a cooperative system on the M0 expressway	CROCODILE II.	28.05.2019.	13	
Improvements to end user services	Development of Traffic Management Software (FIR)	CROCODILE I.	21.12.2015.	14	
	Mobile application development	CROCODILE I.	21.12.2015.	14	
	Development of a DATEX based Travel Time Information Service	CROCODILE II.	14.05.2019.	14	
	Mobile application supporting individual travellers - "back-end development" and "front-end development"	CROCODILE III.	31.12.2022.	14	
Further development of the intelligent truck parking system	Development and extension of the intelligent truck parking system on the motorway M1	CROCODILE I.	30.12.2015.	15	
	Expansion of an intelligent truck parking system	CROCODILE II.	19.11.2019.	15	

PROJECTS IMPLEMENTED BY BUDAPEST KÖZÚT

FIELD OF DEVELOPMENT	PROJECT NAME	PROJECT PHASE	CLOSING DATE	PAGE	
Elaboration of harmonized national and Budapest traffic management plans	Development of traffic management plan with Magyar Közút	CROCODILE I.	20.12.2015.	16	
	Review and further development of the traffic management plan	CROCODILE II.	30.11.2018.	16	
	Review and supplement of action plans defined in the Traffic Management Plan	CROCODILE III.	30.11.2020.	17	
	Development of the dynamic services and databases of the capital traffic management center	CROCODILE III.	30.11.2021.	17	
Functional development of central systems	Supporting traffic information services through the development of source systems	Creating the client interface of the integrated data collection module, deepening the integration of existing systems	CROCODILE I.	15.11.2015.	18
		Expansion of the integrated camera center integration of cameras	CROCODILE I.	15.11.2015.	18
		Public parking management system pilot projects	CROCODILE I.	20.12.2015.	18
	Operational implementation of DATEX II electronic data exchange in cooperation with Magyar Közút	CROCODILE I.	20.12.2015.	18	
	Operational implementation of DATEX II electronic data exchange in cooperation with Magyar Közút	IT expert support provided for the development of central functions for traffic control and management	CROCODILE II.	28.02.2019.	18
		Development of Sittraffic Scala Traffic Control Center, Phase I	CROCODILE II.	31.12.2018.	18
		Development of call center display wall and related system components	CROCODILE II.	23.12.2019.	18
		Development of Sittraffic Scala Traffic Control Center, Phase II	CROCODILE II.	30.03.2020.	18
	Development of a dynamic parking management system - feasibility study	Development of Sittraffic Scala Traffic Control Center, Phase II	CROCODILE III.	30.11.2020.	19
			CROCODILE II.	31.12.2018.	18
Extension of on-site monitoring and information systems	Installation of traffic data collection and monitoring devices	CROCODILE I.	20.12.2015.	20	
	Extension of the communicational network of the traffic monitoring system	CROCODILE I.	20.12.2015.	20	
	Extension of the existing traffic management, traffic monitoring and public road information system in the capital	CROCODILE II.	31.12.2018.	20	
	Development of the communication network	Expansion of the communication network	CROCODILE II.	02.07.2018.	21
		Establishment of a geo-database for traffic control sub-structures in Budapest	CROCODILE II.	14.12.2018.	21

FIELD OF DEVELOPMENT	PROJECT NAME	PROJECT PHASE	CLOSING DATE	PAGE	
Realization of the Budapest road works database	Preparation of implementation of field data collection system	CROCODILE II.	31.03.2020.	21	
	Development of field data collection system	CROCODILE III.	15.12.2022	21	
	Development of field data collection system – acquisition of developer hardware	CROCODILE III.	12.09.2022.	21	
Improvements to traffic information services	Implementation of the Budapest traffic information mobile application, extension of the system functions	CROCODILE I.	20.12.2015.	22	
	Improvements to traffic information services	Preparation for the upgrade of end-user information platforms	CROCODILE II.	27.08.2019.	22
		Upgrades to end-user information platforms	CROCODILE II.	31.12.2019.	22
		Acquisition of hardware required for the operation of end-user information platforms	CROCODILE II.	28.10.2019.	22
	Acquisition of MacOS developer hardware package	CROCODILE III.	30.11.2020.	23	
	Development of "Közút Figyelő" mobile application and a web-based information interface	CROCODILE III.	16.12.2020.	23	
	Installation of optical cable network registration into the network registration software called NetStork	CROCODILE III.	30.09.2022.	23	
Development of a traffic database system	CROCODILE III.	15.10.2021.	23		
Implementation of connection to the National Access Points (NAP)	Storage capacity expansion of ACC center - hardware acquisition	CROCODILE III.	16.12.2020.	23	
	Development of central traffic control and traffic monitoring background systems	CROCODILE III.	17.12.2021.	23	
	Acquisition of hardware required for the connection	CROCODILE II.	31.12.2018.	24	
	Implementation of Phase I – data transmission to NAP	CROCODILE II.	06.09.2019.	24	
	Establishing an axis network system and expansion of data transmission to NAP	CROCODILE III.	23.11.2021.	24	
	Updating DATEX in traffic control center	CROCODILE III.	13.12.2022.	24	
	Updating DATEX in traffic control center – hardware acquisition	CROCODILE III.	07.11.2022.	24	
	Expansion of data transmission to NAP – development of TN-ITS converter software	CROCODILE III.	30.09.2021.	25	
	Expansion of TN-ITS service	CROCODILE III.	27.06.2022.	25	
	Supporting highly automated vehicles with map service	Preparation of the implementation of a high-resolution HD map	CROCODILE II.	20.12.2019.	26
Preparation of the implementation of a high-resolution HD map		CROCODILE III.	14.10.2022.	26	

PROJECTS IMPLEMENTED BY MAGYAR KÖZÚT

Preparation and review of traffic management agreements and implementation of international public road management agreements



Traffic Management Plans constitute the basis for traffic management. Regional, cross-regional and cross-border plans contain predefined measures to deal with certain traffic disruptions.

In the first phase of CROCODILE, the revision of previously prepared traffic management plans was completed. Under the project Magyar Közút prepared several detailed analyses and conducted a study of the traffic data for the last five years for the entire motorway network. In addition to the retrospective studies, traffic forecasts until 2020 were also compiled under the project. In parallel, a detailed evaluation of accidents occurred between 2010 and 2015, as well as an analysis of the causes and temporal characteristics of traffic congestions have been carried out. The review of the traffic management plans also included an overview of the available infrastructure. In addition, new TMPs have been developed for the entire Hungarian TEN-T core network, with particular emphasis on the motorway M1.

In the second phase of CROCODILE, Magyar Közút developed new traffic management plans and updated former ones again, as they can only be effectively implemented if they are constantly updated.

In addition to the revision of traffic management plans, along with other analyses, a traffic forecast until 2023 and a comprehensive analysis of accidents between 2013 and 2017 have been completed. The project was focusing on the Budapest region. As part of the project, scenarios

established for the M0 ring road have been merged by Magyar Közút and Budapest Közút with measures intended for major access roads to Budapest, developing coherent traffic management strategies.

In order to strengthen cross-border cooperation, one of the milestones of the CROCODILE project was the conclusion of international cooperation agreements supporting the exchange of information. Within the framework of the project, Magyar Közút Nonprofit Zrt. concluded a cooperation agreement with AKA Zrt, Asfinag Austria and DARS Slovenia for the automatic exchange of traffic information and sharing of webcam information.

In the third phase the Slovenian motorway company (DARS) carried out the development of joint traffic management plans with a unified approach, and the development of the application (TMP API) that can be used for communication between the parties. During the project, Magyar Közút developed the national integration of the API and the actions for each traffic management scenario. In addition, the TMP of M0 has been revised and updated.

Development of data collection systems

Installation of traffic counters and surveillance cameras



Efficient road operation and traffic management requires data collection and traffic control systems with adequate coverage. One of the cornerstones of the strategy developed by Magyar Közút is the continuous improvement of available monitoring infrastructure and traffic management devices, with particular emphasis on the operated TEN-T core network elements.

In the first phase of CROCODILE, under an investment project consisting of two parts it started to replace obsolete assets and raise monitoring coverage.

The first part involved the replacement of obsolete traffic counters at nine sites and the construction of six completely new measuring sites. As part of the development, traffic counting system on the motorway M1 has been almost completely renewed, with the vast majority of stations now operating online.

In the second subproject 22 new observation points have been set up with surveillance cameras, five locations were equipped with automatic incident detection (AID) cameras. These devices are capable of automatically evaluating the video stream and detecting incidents such as slowing down, stopping and reverse traffic. Eight of the 22 new devices have been added to the M0 ring road, while five new cameras monitor traffic on the motorway M1.

The use of advanced tools will shorten the time between the occurrence of accidents and their detection and reduce the length of traffic congestions and the number of possible secondary accidents.

Installation of automated online sensors and surveillance cameras



In line with its strategy, Magyar Közút continued the development and expansion of its monitoring and traffic control equipment during the second phase of CROCODILE.

The investment involved the replacement of obsolete traffic counter at one site and the replacement of the old CCTV camera in seven cases.

New devices were also installed during the project: 47 new observation points have been set up with surveillance cameras, new AID cameras were installed at five locations. Most of the devices were installed in the immediate vicinity of the M0 ring road, while others on the motorways M1, M3, M43, M7, M8 and expressway M85.

The automatic sensors and traffic monitoring cameras installed at 55 locations contribute to the identification of traffic incidents. The implementation of the project elements has improved the monitoring coverage of critical sections and sections with higher traffic volumes of the TEN-T network. As a result of the project the total number of measuring devices increased by 11.5%.



Traffic modelling

Development of a traffic control concept, preparation of technical specifications

CIII 2021/07

In order for road users to receive up-to-date information on the current state of traffic, as well as to effectively manage the ever-increasing motorization by the existing infrastructure, the current traffic management concept needs to be revised and updated.

In addition to the review of the current traffic control concept, the task aims at the long-term strategic goal of establishing a concept-level basis for the development of the Traffic Control Center, preparing a case study and a technical specification.

Acquisition of traffic simulation software

CIII 2022/12

Within the framework of the project, the development of a dynamic traffic simulation model has been launched. The network's terminating traffic matrix, the typical traffic volumes and the prepared macroscopic traffic model serve as input data. The model provides nearly real-time information on the current state of the traffic and its future development (predicting at least 30 minutes in advance), and it is able to effectively support the work of traffic management experts of Magyar Közút.

In addition to the visualisation of current traffic conditions, it enables the further processing and analysis of various traffic performances in order to provide the most accurate information for the traffic management experts. Due to the dynamic traffic simulation model, users can get real-time information on the changes of the road network.

In terms of territorial coverage, the macroscopic traffic model and the dynamic traffic simulation model involves the elements of the expressway network and the main road network. Furthermore, the elements of the TEN-T road network are prioritised. Because of modelling purposes some elements of the secondary network were also included in the traffic models.

Acquisition of traffic modelling software (LISA+)

CIII 2018/11

The application can be used to plan, model, evaluate and optimize various traffic light junctions and progressive signalling systems.

In controlled nodes, it is a constant task for the entire network level to review and adjust phase timetables to the changed traffic. The microscopic level traffic modelling and planning software has been acquired to implement a higher-quality operation of the traffic light junctions, by using own resources.

Development of access to data

Development of DATEX-based information exchange platform

CI 2015/12

DATEX II used by European public road authorities is a common data format and a data exchange standard which supports the exchange of traffic information. The primary task of the project was to establish automated national and international DATEX II data exchange connections.

The development of the of the existing Magyar Közút Data Portal included the upgrade of the system to the latest version of the standard, v2.3 and the implementation of the full code table. Location reference has been harmonized to support international data exchange, yet the system also supports the OpenLR standard as a new element. As a result, the development also opened up the possibility of interconnected cross-border automatic data exchange and international traffic management measures.

Development of system interfaces

CI 2015/12

In order to ensure that data collected and stored in the basic systems of Magyar Közút, and the information received from foreign partners is transmitted to all required destinations, it was essential to establish missing system connections.

The physical and logical communication interfaces developed under the project allowed the transmission of data collected by the Traffic Management System of Magyar Közút according to the DATEX II standard, and to receive data sent to the

Road Traffic Management System (e.g., information on accidents, congestion, traffic diversion).

In parallel, the central C-ITS-S module of the cooperative system has been implemented as part of the development, providing the monitoring of fixed and mobile roadside units. This system is responsible for information management: it transmits data from the traffic management system to roadside devices (R-ITS-S) and vehicles (V-ITS-S), and from the operating fleet to the headquarters.

Thanks to the development, the flow of information within the Magyar Közút systems and between the company and its external partners and end users has improved.

Implementation of DATEX II 3.0 and D2Light standards

CIII 2022/08

The development of an interface has been completed, which is capable of receiving and sending data packages to third parties, complying with the D2Light standard. This enabled the conversion of data in DATEX HUB into D2Light format, and its transmission to external parties.

The main function of the DATEX HUB is the collection of data on currently valid traffic events and measurements, and furthermore, making data immediately filterable by parameters and queryable for the connecting systems. Within the framework of the project, a conversion mechanism needs to be developed in the NAP to make DATEX data available for users in D2Light format, and to be capable of receiving messages in the same format.

Establishment of a National Access Point (NAP)

CII

2018/08

2019/01

Access to accurate and real time static road data as well as dynamic data and traffic characteristics for each road is essential for the provision of EU-wide real-time traffic information services. Therefore, public road management companies, public road authorities and real-time traffic information providers shall make data available to users through a National Access Point (NAP).

One of the flagship projects of the second phase of CROCODILE was the creation of Hungarian NAP, which was implemented by Magyar Közút in two stages.

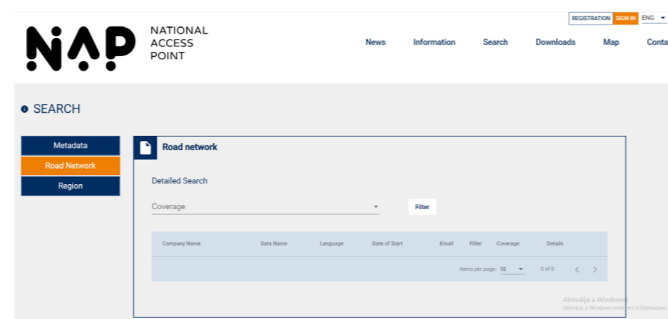
First, Magyar Közút explored the conditions for the implementation of NAP and developed possible technical design alternatives based on international examples. In the course of an international review, Magyar Közút explored three different solutions, the Dutch, Austrian and German systems in depth. In parallel, a feasibility study carried out a survey on which traffic systems can provide relevant data to NAP and which entities could be the primary target group.

Taking into account the legislative and system environment, based on international examples, the study suggested the introduction of a data market service structure similar to the German solution. The essence of the German model is that the service provider offers a neutral B2B platform but does not store historical data or perform logical data processing operations: it makes the uploaded data available to users without modification.

In the second phase of the development of NAP, a system following the data market model was developed based on the contents of the case study. A NAP HUB database responsible

for data distribution and an internet portal serving users (<https://napportal.kozut.hu>) have also been created.

The project also carried out a survey of the data and characteristics of safe and secure parking areas available within the five-kilometre radius of the Hungarian TEN-T core network. The survey identified 29 secure and protected parking places that can be used by trucks and commercial vehicles.



C-ITS development

Establishment of a cooperative pilot system on the motorway M1 and its expansion on the M0 expressway

CI

2015/12

CII

2018/05

The NAP provides background for the communication (between C-ITS system elements) of the cooperative vehicle center. In the first phase of CROCODILE a cooperative communication pilot system was implemented on the motorway M1 section between the M0 ring road and Hegyeshalom.

As part of the pilot project, elements of the Roadside ITS Station (R-ITS-S) have been installed to enhance the safety of road works. During the development, a fixed transceiver was installed at 27 locations (for variable message sign units, on emergency poles) and a total of 20 road maintenance vehicles and warning trailers were equipped with mobile transmitters. These roadside units communicate with vehicles passing by via short-range, standard ITS-G5 connection.

In the second phase, new roadside (R-ITS-S) units were installed at 13 locations along the M0 expressway. In designing the infrastructure, Magyar Közút took into account the recommendations of the C-Roads platform and the latest specifications of ECO-AT. In addition to new C-ITS stations, two new variable message signs were deployed on the M1 motorway.

As a result of the project, vehicle-to-vehicle and vehicle-to-infrastructure communication services have been tested in Hungary.



Improvements to end user services

Development of a Traffic Management Software (FIR)

CI 2015/12

As part of the project the traffic control system used by Magyar Közút was improved. The solution originally developed in 2009 displayed road sections managed by traffic control systems on its own map integrated into the application, which did not provide sufficient transparency.

The purpose of the development was to create a platform independent, browser-based interface that is suited to today's user trends, providing thematic display and management of all data managed by the system. Along with the system's interface, the background infrastructure has also been renewed. In addition, data received from external partners can also be displayed.

Improvement of an Estimated Journey Time display system

CII 2019/05

The purpose of the development of the second phase of CROCODILE is to extend the system to other sections of the M0 and M1 motorway. At the same time, the purpose of the project was to develop the possibility of cooperation with a similar system in the capital, which was followed by the related DATEX development.

Data acquisition is based on tracking Bluetooth devices in moving vehicles instead of the previous ANPR camera solution. A single scanner can capture data from multiple lanes in both directions, therefore it is more cost-effective, and the maintenance need of the device is also reduced. As part of the investment, Magyar Közút has installed such devices

at 22 locations on the M0 expressway and the M1 motorway between Budapest and Tata.

Mobile application supporting individual travellers - "back-end development" and "front-end development"

CIII 2022/12

The development intended to implement an easy-to-use and modern application that supports travellers in predicting dangerous situations.

The developed application is intended for travellers who plan to use or already use a function of their smartphone to support their travel. The application shall be available for free from online stores (Google Play Store, App Store etc.), which can be used without registration after installation, or some functions will only be available for registered users.

According to the concept, after launching the application, a selection of the most recently entered values will appear on the interface for parameter settings. The user can also easily start or change the previous settings. By the launch of the application, it goes into the background and follows the route of the traveller based on his location. The user, based on his route, receives alert during the travel about emergency events within close range. According to the plans, the following extraordinary events will appear by the launch: position of slow-moving or standing vehicles involved in winter road work on the national road network, vehicles with distinguishing sign (in the first stage, vehicles with distinguishing sign from the fleet of Magyar Közút, participating in accident prevention), as well as DATEX data of Útinform.

Further development of the intelligent truck parking system

Development and extension of the intelligent truck parking system on the motorway M1

CI 2015/12

One of the key objectives of the ITS Directive is to improve the provision of information on parking places for trucks and commercial vehicles.

In Hungary, a major part of the East-West transit traffic passes through the M1 motorway, and therefore it is a serious task to provide parking places for trucks to rest and to make optimal use of the available capacities.

Prior to the first phase of CROCODILE, there were only two locations on the M1 motorway (Arrabona and Moson rest stations) that were equipped with real-time rest area occupancy monitoring devices, and related data was displayed only on the way towards the border.

As part of the project, Magyar Közút extended the service to additional rest areas (Óbarok, Remeteség, Conco, both sides of the motorway) and traffic directions (Moson left side). The previous system covered 112 parking places, and the development included about 102 additional parking spaces.

Capacity data is displayed on new digital displays integrated into static signs, on existing variable traffic signs, and as a result of DATEX HUB development on web and mobile applications as well. As a result, truck drivers on the road towards Austria as well as coming from the west can plan ahead where to rest, thus avoiding the forced, possibly dangerous stops. Optimizing the use of rest areas' capacities may have contributed to the fact that the number of accidents with HGV involvement did not increase parallel to growing traffic volumes.

During the project, Magyar Közút also made it possible to display DATEX parking capacity data from the Austrian and Slovakian systems.

Expansion of an intelligent truck parking system

CII 2019/11

With the development of the first phase of CROCODILE, almost every rest area along the M1 motorway was covered with the intelligent truck parking information system developed in 2009. One of the key priorities of the second development phase was the extension of the existing system.

Magyar Közút intended to install a dynamic monitoring system at least at every 100 km on the Hungarian sections of the TEN-T core network.

As a result of the completed expansion, a real-time monitoring infrastructure based on an image processing system has been developed at eight locations and 14 parking spaces.

As a result of the development, by 2019 the number of parking places included in the system reached 531 nationwide, which is more than one third of the public truck parking places available along the TEN-T core network.



PROJECTS IMPLEMENTED BY BUDAPEST KÖZÚT

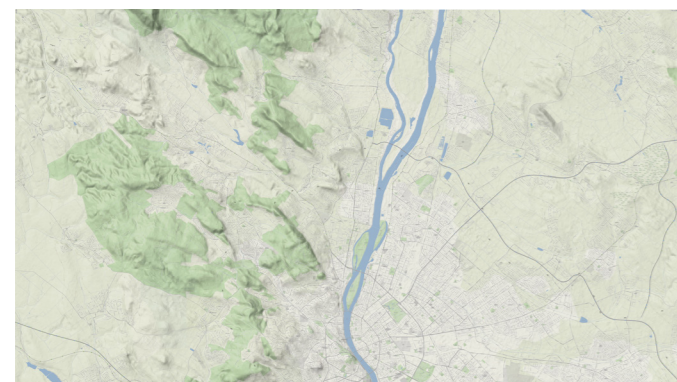
Elaboration of harmonized national and Budapest traffic management plans

CI 2015/12

The purpose of the project was to develop a joint traffic management plan for the road network of Budapest, the M0 ring road and the connecting expressway network components. The plan can make a significant contribution to improving the quality of jointly provided services.

The TMP developed within the framework of the project identified bottlenecks and focal points of the design area developed pursuant to an application guide called 'Traffic Management Plan Service for Corridors and Networks' (EW TMS-DG07). In parallel, an assessment of existing ITS infrastructure and development needs for further measures was completed.

The outstanding result of the FMT is that it harmonized the traffic management activities of Budapest Közút and Magyar Közút on common road sections and access roads. Specific strategies and concrete action plans can be integrated into the processes of the organizations concerned.



CII 2018/11

In the second phase of CROCODILE, the development of the management plan continued. As part of this, a review of the previously prepared FMT was carried out, and 15 action plans and scenarios for dealing with emergency events were developed.

The action plans are designed to mitigate traffic effects of capacity reductions attributed to unforeseen incidents. The revised FMT defined a single action plan, to-do list, information, and intervention thresholds for standardized scenarios. Action plans also identified the potential stakeholders and the data to be exchanged to effectively manage incidents. By implementing the prepared action plans, the traffic impact of an incident in the examined zones can be reduced.

The central algorithm of the EJT monitoring and information system currently used in Budapest was reviewed, which also provided an opportunity to explore development points inherent in the system. A proposal for the expansion and functional improvement of the system was prepared based on this study.

CIII 2020/11

In the third phase, implementable action plans have been developed in the selected area, South Buda.

The network's coverage with ITS elements, and its relative network sovereignty served as main aspects for the selection of the area, the two districts of South Buda. The project aims at developing and centrally programming action plans to be implemented, and possibly automated, based on which the impact of traffic disturbances can be reduced on the network with available spare capacities.

During the implementation, the following tasks have been performed:

- Developing action plans and elaborating the equipment expansion package required for the implementation (the installation of equipment is the part of another project) – automatic, central recognition and management of defined disaster events in 14 sections, in both directions;
- Automatically activated traffic light program packages for managing disaster events;
- Programming alerts required to recognize disaster events in the SITRAFFIC Scala traffic management system;
- "Action booklets" that support dispatchers in disaster management, which contain descriptions for the automation, signal images that can be used on VMS signs, switching instructions, and the picture of traffic monitoring cameras in the vicinity of alternative routes.

Related to the development, equipment has been acquired in the amount of 10 million HUF. The monitoring of 17 traffic lanes has been carried out at 9 locations by the acquisition and installation of 14 loop detectors, one radar- and one video detector.

Development of the dynamic services and databases of the capital traffic management center

CIII 2021/11

Operationally, the capital program aims at organising the international and domestic transit traffic affecting Budapest, the traffic in the agglomeration and within the capital more consistent, controlled, with less disturbance, thus safer and causing less environmental impact. The long-term, strategic goal is to encourage commuters to use more environmentally friendly modes of transport, by providing favourable conditions for changing means, and by raising the quality of service for each mode of transport.

Within the framework of the project, the installation of vehicle measurement sites, the realization of their continuous, operational data communication with the center, and their integration into the Siemens SITRAFFIC Scala traffic control center of Budapest Közút have all been implemented.

The on-site collection system of traffic management has been developed with the following elements:

- Vehicle traffic measurement sites: monitoring of a total of 121 traffic lanes has been implemented at 42 locations, using loop detectors in 104 lanes, video detectors in 14 lanes and radar detectors in 3 lanes;
- Building of bicycle traffic measurement sites and related information system: installation of bicycle vehicle counting at 12 locations (44 loop- and 1 video detector), and installation of information displays at 2 locations.

In total, during the project, loop detectors in 148 lanes, video detectors in 16 lanes and radar detectors in 3 lanes have been installed. In addition, 2 VMS displays have been installed and 8 traffic control devices have been replaced.

Functional development of central systems

Supporting traffic information services through the development of source systems

CI 2015/12

The main purpose of the multi-project development was to integrate the visual road traffic database into one system.

Within the framework of the project, the Integrated Traffic Management and Regulation System was created, which merges previously independent systems. The Integrated Traffic Management and Regulation System operates parallel with the Scala Traffic Control Center and offers extensive traffic analysis capabilities and the system's new real-time system monitoring module supports high-quality operational activities.

Operational implementation of DATEX II electronic data exchange in cooperation with Magyar Közút

CI 2015/12

An interface conforming to the DATEX II standard has been prepared, which enables data exchange with Magyar Közút. As a result of the development, the system is able to share real-time traffic counting data, accident, weather, congestion and parking information, as well as transit EJT data and variable message sign information between the parties.

Development of central functions for traffic control and management

CII 2020/03

The project includes several sub-projects supporting the implementation of intelligent transport solutions. The project involved upgrading and expanding the central system of Sittraffic Scala, which manages over 700 junctions equipped with traffic lights in the capital. Not only was the upgrade of the software aimed at improving IT and operational security, but it also contributed to the realization of cooperative vehicle communication (ITS-G5 DSRC). Dispatcher display infrastructure has also been upgraded to address functionality needs: the new low-cost LCD display interface and related system components meet professional expectations.

Development of a dynamic parking management system - feasibility study

CII 2018/12

Numerous studies have confirmed that nearly 30 percent of total city traffic is made up of vehicles seeking parking places. The development of parking management systems can improve the flow of traffic in populated areas, thus reducing congestion and the likelihood of accidents.

As a first step in the development of a dynamic parking management system, a comprehensive study has been prepared, and its methodology and proposals, depending on the available

resources, will contribute to the implementation of related developments in the future. The methodology presented in the study allows Budapest Közút to apply a uniform strategy when considering parking-related developments, primarily P+R, and, in the long term, to develop a dynamic parking management system in the capital.

Development of Sittraffic Scala Traffic Control Center, Phase II

CIII 2020/11

Due to cooperative vehicle communication, service providers with dynamic traffic information can make relevant information (real-time signal phasing information, congestion, accident information, etc.) directly available to vehicles, thus helping to reduce travel time and increasing safety. The system offers two-way communication, vehicles also provide data on the traffic situation of the passed road section. Due to this, not only drivers are provided with accurate information, yet central traffic management also receives more accurate information of the current traffic situation.

Within the framework of the project, Budapest Közút implemented the cooperative vehicle communication capability (C-ITS) of the central traffic control system and examined the operation of the system. During the development, a C-ITS location has been built on running track (M1-M7 entrance 7+590) and at a junction (Hungária krt. - Thököly út) with 1 RSU each. The deployed devices are being continuously tested by Budapest Közút with 2 on-board units acquired and installed as part of the project. The task also included the complete preparation of two nodes for installing C-ITS devices.



Extension of on-site monitoring and information systems

Installation of traffic data collection and monitoring devices, expansion of the system's communication network

CI 2015/12

In order for the centralized traffic systems to function effectively, it is essential that sufficient quality and quantity of traffic data is available related to the network concerned. As a result, activities aimed at developing device portfolios have become emphasized among CROCODILE-related investments. The projects implemented during the first phase of CROCODILE were aimed at improving the coverage of the traffic monitoring system.

As part of the investment to install devices, a total of 20 counting stations have been installed at ten locations along the M0 ring road, which transmit full cross-section traffic counting data to the headquarters via GPRS.

In addition, a total of 24 traffic surveillance cameras have been installed at 12 locations, providing real-time information to traffic management center dispatchers.

As a third pillar of the data collection system development, a total of 21 integrated measurement points have been installed at seven locations, providing real-time traffic data, overview camera images and camera streams suitable for extensive central analysis.

In order to ensure continuous data transmission, the communication network of the capital needs to be extended, which will take place under a dedicated project. Within the framework of the development the devices were connected to the optical network and the missing sections of the network were completed. A total of 8,840 meters of optical network was built under the project.

Installation of on-site traffic management, traffic monitoring and public road information devices

CII 2018/12

This project can be seen as a continuation of the data collection development investment started in the first phase of CROCODILE.

As part of the development, new measuring units were installed at strategically important cross-sections and road sections of the capital. Traffic measuring units have been established at nine locations monitoring 29 lanes in the vicinity of the M0 ring road.

Congestion detection and weather monitoring measurement units were installed at two locations including five lanes, and 78 new cameras were installed, 37 cameras were replaced and integrated, and 22 cameras at 56 locations were integrated into the central system.

In addition, the EJT monitoring and information system has been expanded: Budapest Közút monitors vehicles' unique identifiers in a total of 20 lanes at ten locations. Using the resulting EJT section data, it is possible, in cooperation with Magyar Közút, to provide Budapest EJT data on the M0 ring road and affected road networks operated by Magyar Közút.

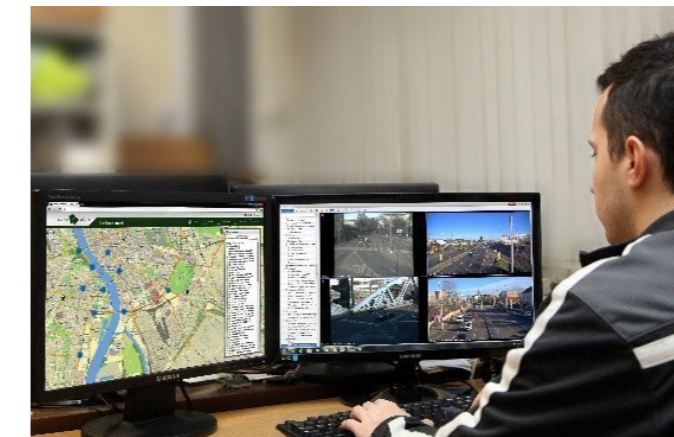
In addition to expanding the data collection network, the project also included improvements to inform road users. Three locations with variable traffic signs provide information to travellers about EJT and current traffic incidents.

Further development of the communicational network

CIII 2018/07 2018/12

Within the framework of the network development project, Budapest Közút has expanded the communication network of its on-site devices. Almost 37.5 km of fiber optic cable was installed into the existing traffic control substructure, and a new traffic control substructure was installed on a 2.5 km section.

At the same time, Budapest Közút has expanded and refined its geo-database covering 422 km, through its DWG based record of its traffic substructure and high-resolution orthophoto. The completed high-precision database can also be used in GIS systems, thus assisting in the preparation and implementation of maintenance, renovation and development work.



Realization of the Budapest road works database

Development of on-site monitoring and information systems, acquisition of developer hardware

CIII 2020/03 2022/09 2022/12

Real-time traffic control and the accurate, comprehensive information of travellers require the continuous development of data collection systems for traffic engineering operators. For this purpose, Budapest Közút implemented a widely applicable data collection and central data processing system (mobile and desktop application), which is planned to be introduced for its road inspection service. The new system ensures the complete digitization of the currently paper-based data collection. Due to its high degree of customization opportunities, in addition to road inspection processes, it supports the work of other areas of expertise (e.g., road and traffic engineering operation).

The data collection and processing are highly assisted by visual information, thus Budapest Közút purchased a pilot quantity (3 pieces each) of on-board cameras for its car and bicycle road inspectors, and furthermore prepared a platform suitable for storing recordings of daily patrolling. The recordings can be grouped and reviewed on the platform offering map integration, due to which the recordings can also be searched based on the name of the recorder, the date of the recording, and even its location.

Improvements to traffic information services

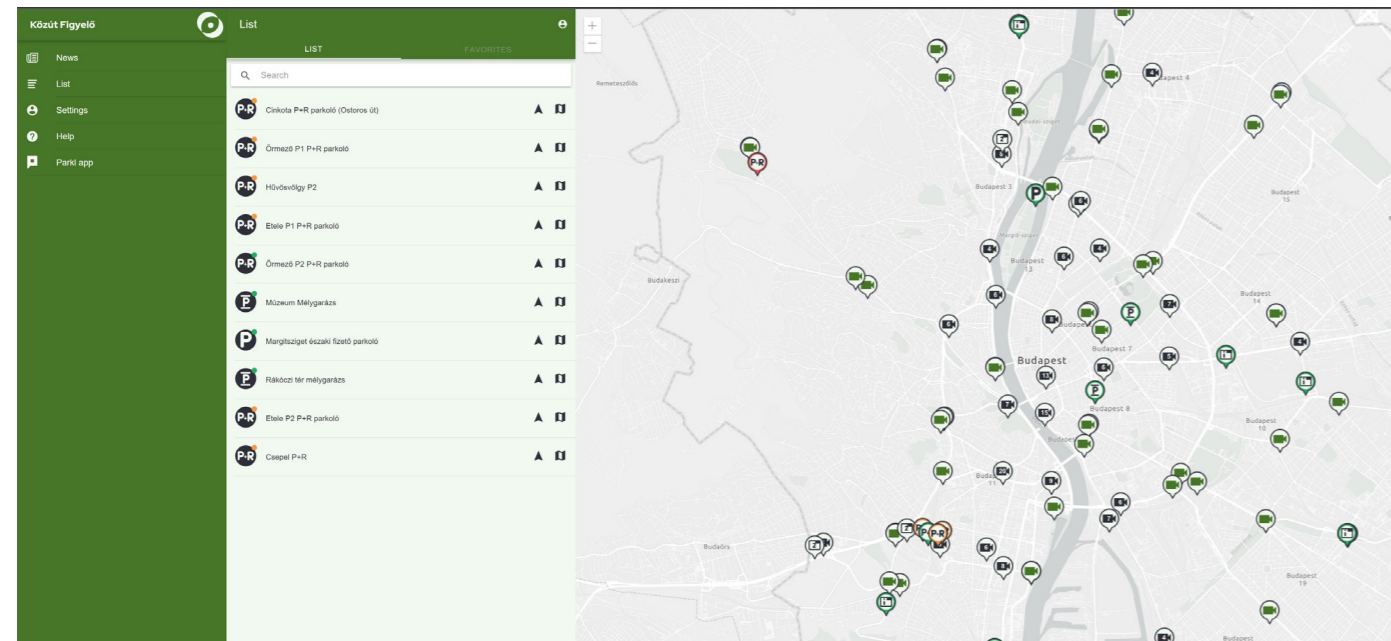
CI

2015/12

One of the cornerstones of the ITS Directive is that public road management companies shall provide public road transport information to end-users free of charge. To achieve this goal, Budapest Közút has implemented several projects within the framework of CROCODILE.

The purpose of the first phase of the information project is to develop a mobile application that provides users with real-time traffic information to help them make transport decisions.

Available on two of the most common mobile platforms, the 'Közút Figyelő' app displays real-time traffic camera images, dynamic board messages, and parking information based on a native map of the platforms.



CII

2019/12

In the second phase of CROCODILE, Budapest Közút continued to renew its information platforms, building on its ever-expanding database. The purpose of the investments was to develop a mobile application called Közút Figyelő (Public Road Monitor) and a web-based information system called Szakrendszerek (Professional Systems), in line with changing user needs and professional expectations.

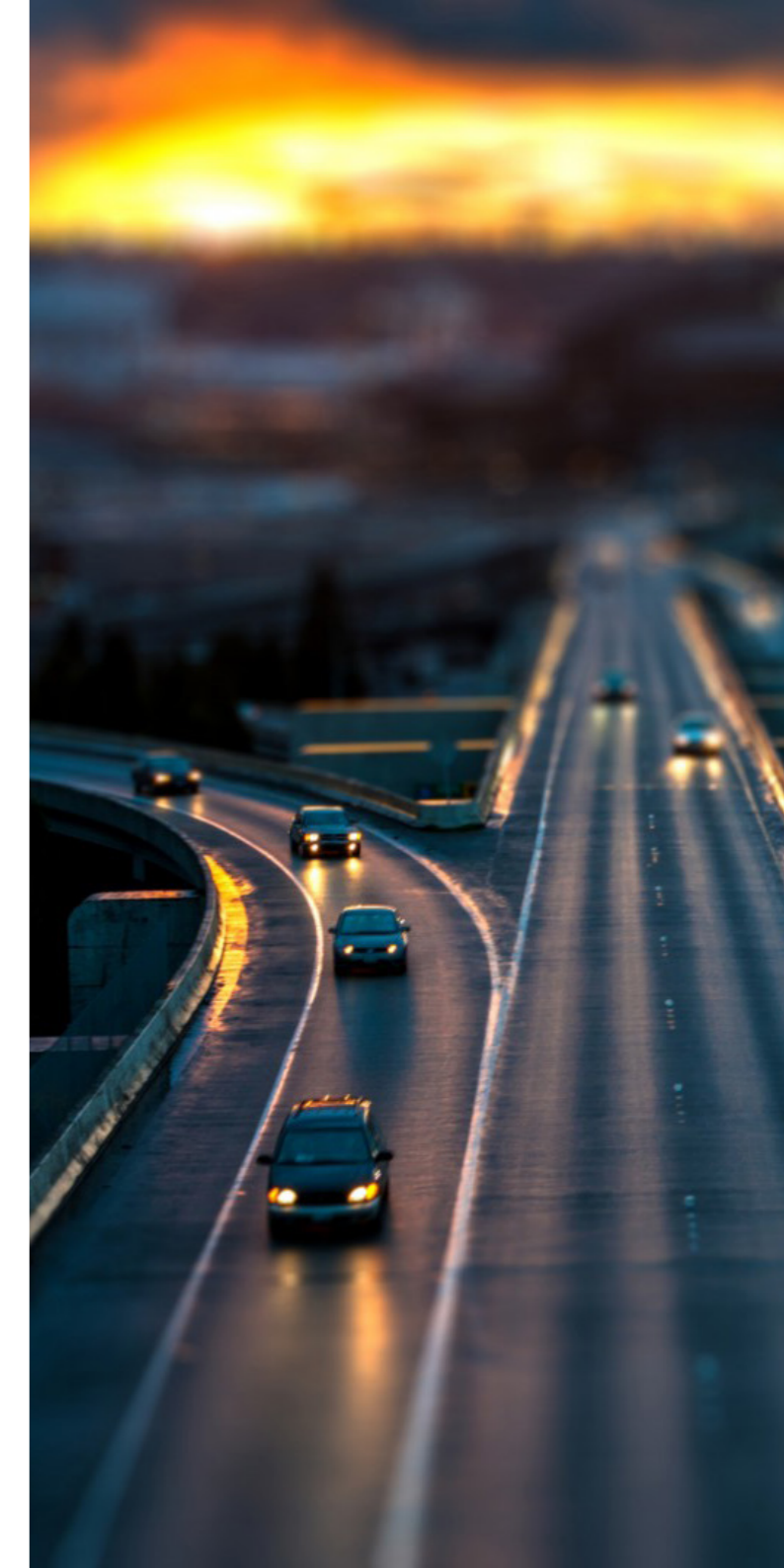
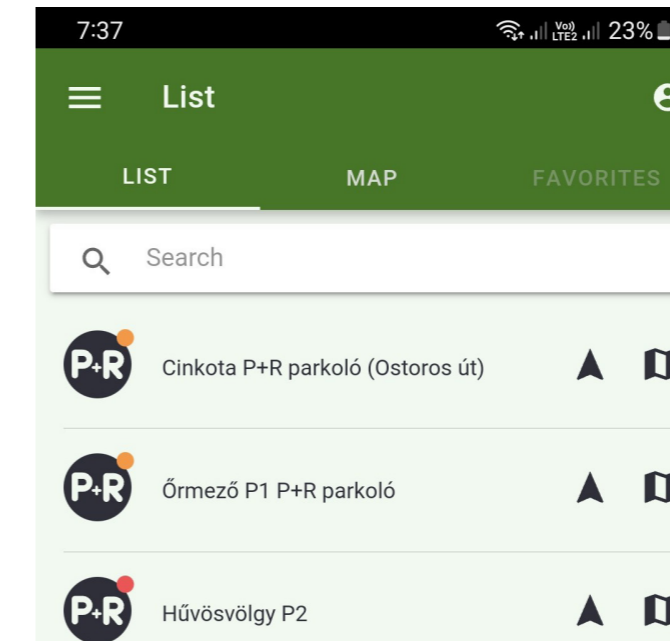
In addition to developing services, the project also resulted in the acquisition of background hardware (servers and equipment) required for its operation.

CIII

2020/12

During the third phase, the Közút Figyelő mobile application and web interface have been adjusted based on the feedbacks of operators. In addition to the several auxiliary functions supporting operation, functions supporting the company's managers and marketing specialists have also been integrated. Among the latter, a statistics module has been implemented, which supports the generation of detailed user statistics related to the use of the system.

In addition to the operation supporting functions, an automatic fault management service has also been carried out, which informs the operators about malfunctioning elements in case of errors which persists for at least 30 minutes, thus supporting faster troubleshooting.



Implementation of connection to the National Access Points

CII

2019/09

In line with the project objective, Budapest Közút, as one of the first data providers, has implemented standard data transmission to National Access Point (NAP). During the development of the data transmission system, Budapest Közút assessed the requirements of data provision, developed its concept, and defined the minimum specification of the hardware environment required for data transmission.

The system (implemented based on the case study) ensures the continuous, automated transmission of static map and dynamic parking data in a standard format. As part of the static map data transmission, the system, in addition to geometry, publishes data on road junctions, road classification, parking facilities and e-chargers, as well as terminating traffic restriction and freight traffic zone data in WFS format. Parking data published in the framework of the dynamic data transmission are sent in accordance with DATEX v2.3 standard. The project also included the acquisition of server computers required for the operation of the data transmitting system.

Establishing an axis network system and expanding data transmission to NAP

CIII

2021/11

During the third phase, the development of published datasets and data quality of the NAP data transmission have been emphasized. During this, Budapest Közút implemented data publication in TN-ITS format as a new service. The aim of TN-ITS is to provide spatial data and enable data exchange for road operators, data providers, map makers and other parties across Europe.

Within the framework of the project, the experts of Budapest Közút carried out tasks to specify and expand the axis network essential for the TN-ITS service, developed maintenance tools and data connections required for data transmission.

As a result of the development, the company's database produced the necessary data for the continuous and highly available publication of the following TN-ITS datasets: network geometry, road classification, freight traffic, terminating traffic, residential and recreational zone, speed, and height restriction datasets.

Expansion of data transmission to NAP – development of TN-ITS converter software

CIII

2021/09

During the project, a unique software development has been carried out. The software provides the standardized publication of the following datasets in TN-ITS format: geometry, road classification, zone data (freight traffic, terminating traffic, residential and recreational), restriction data (speed, height, width, length, weight, and axle load).

The major map and navigation providers (e.g., TomTom, Here Maps) integrate the TN-ITS data into their services. Therefore, the high-precision GIS database of Budapest Közút will directly help road users in their everyday life from the software activation at the end of 2021.

During the launch of the service, the functionality was not yet comprehensive. In the absence of source data, the service of Budapest Közút first included the publication of speed and height restrictions, zone restrictions (terminating traffic, residential and recreational), and the related geometry in TN-ITS format. The source data required for the publication of additional datasets supported by the converter software has been integrated into the service in 2022, as a result of the project called "Expansion of TN-ITS service".

In addition to the converter software, the project also included the development of individual ESRI ArcGIS system modules which are used for data maintenance and verification of the axis network.

Expansion of TN-ITS service

CIII

2022/06

Within the framework of the project, background databases have been uploaded of datasets, which are not included in the TN-ITS service of Budapest Közút yet can be provided by the converter software. Furthermore, the launch of the extended service, and the transmission development of speed data (implementation of a speed control service that can be specified in each direction) have been realized. Regarding the new datasets, the development of a consistency checking, and a maintenance tool has been carried out as well. As a result of the project, the service has been completed with data on width, length, weight, and other restriction data.

Updating DATEX in traffic control center



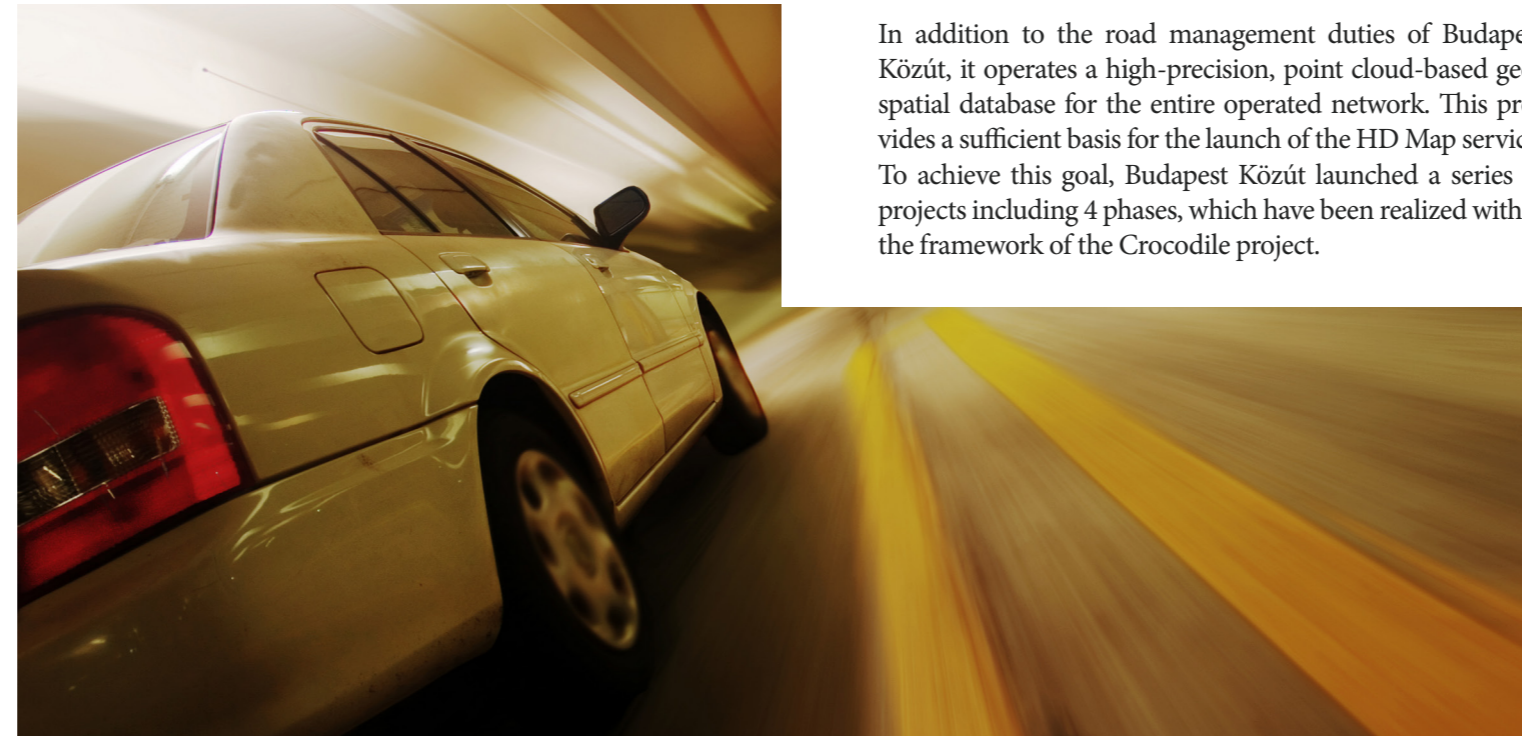
The development has expanded the standard dynamic data transmission of Budapest Közút in DATEX II format, as well as the datasets available to the traffic control center, by integrating the standard DATEX data packages of external partners.

The implementation of the task consisted of three assignments: internal (implemented with company resources), external (implemented by the developer of the traffic control center), and the acquisition of the required hardware for the operation of the extended service.

Within the framework of the external assignment DATEX II v3.2. version data transmission has been launched in addition to the existing DATEX II v2.3. service. This enabled the Siemens Scala traffic control center to be capable of receiving and displaying DATEX II v2.3. and v3.2 DATEX data. In addition, the range of publishable data has been expanded to include operational status data of devices controlling traffic lights.

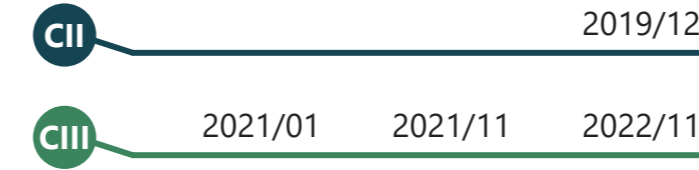
The internal assignment has completed and specified the service carried out during the external phase, as well as implemented physical data exchange with external partners. The data available in the static database of Budapest Közút (position, exact name, etc.) are added to the DATEX II v2.3 and 3.2 data packages by the unique software created during the internal assignment.

The related hardware acquisition included one server computer with high computing capacity required for the operation of the DATEX data transmitting and receiving system, the functionality of which has been updated and expanded within the framework of the external and internal assignments.



Supporting highly automated vehicles with map service

Preparation of the implementation of a high-resolution HD map



The availability of high accuracy, standardized maps (HD Map) is essential for the testing and subsequent transportation of vehicles with a high degree of automation (even fully self-driving). The most accurate data content for the preparation of the HD Map are available at the road and traffic engineering operators of each section.

In addition to the road management duties of Budapest Közút, it operates a high-precision, point cloud-based geospatial database for the entire operated network. This provides a sufficient basis for the launch of the HD Map service. To achieve this goal, Budapest Közút launched a series of projects including 4 phases, which have been realized within the framework of the Crocodile project.

In the first phase, a specification has been developed in cooperation with AI motive Kft., a leader in developing self-driving vehicles. Based on this specification, a pilot area has been assessed by using 3D point clouds, vector maps and panoramic images available at Budapest Közút as basic data.

In the second phase, further development of the realized end-products has been performed by using the HD Map OpenDRIVE specification in the context of defining an intermediate data format (.txt) and its structure. The database serving as a basis of the intermediate data format has been also uploaded with the reference line, lane polygon, and lane axis objects.

In the third phase, a high-capacity converter process has been developed, which produces HD Map data in standard OpenDRIVE format from the company's database for the following objects: reference line, lane axis, lane polygon.

Within the framework of the fourth phase, the objects of the converter software have been expanded with datasets of mandatory stopping places, pedestrian crossings, and speed limit signs. Furthermore, the curves forming the basis of the HD MAP have been generated, which have been assigned to the reference lines.

