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Debrecen Pilot Action report & lesson learned

City of Debrecen

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A. Executive Summary

Debrecen is one of the fastest growing cities in Hungary, with major industrial investments expected to bring new jobs, new residents and increasing mobility demand. While this growth represents an important opportunity for the city, it also places growing pressure on the transport system: without timely adjustments to public transport services, expanding commuting flows to and from industrial areas may increase congestion, private car use and environmental impacts. For DKV, the city's public transport operator, this creates a significant challenge in planning routes, schedules and services on the basis of reliable evidence on how traffic patterns are changing.

The Debrecen Pilot Action responded to this challenge by introducing new traffic data into public transport and city mobility planning, focusing on observing real traffic flows around 4 key industrial locations to support decisions on future services. In collaboration with public road and urban management authorities, the pilot installed 42 traffic sensors to collect information on vehicle volumes, direction, categories and speed, helping DKV and the city better understand traffic intensity in rapidly developing areas. Rather than treating this data as an isolated technical output, the pilot integrated it into a broader effort to build a more data-oriented city. The data collected from these sensors was combined with existing data on local environmental and meteorological conditions, as well as Waze data, enabling Debrecen to gain a more comprehensive understanding of how mobility, air quality and urban development interact. As data collection continues, this monitoring system will provide an increasingly valuable reference base for evaluating mobility trends in the areas affected by industrial growth, particularly around the BMW and CATL development areas.

The main results are both practical and institutional. On the practical side, the pilot created a new basis for analysing traffic conditions around industrial areas and for developing future traffic management and public transport planning tools. The availability of new traffic flow data allows DKV and the city to better assess how mobility patterns evolve over time, compare traffic intensity in different areas and evaluate possible adjustments to public transport services, such as the modification of selected routes or the strengthening of specific connections. In particular, the data generated by the pilot is providing useful evidence for understanding differences between industrial areas with different levels of public transport accessibility, supporting discussions on how to reduce dependence on private cars and better respond to future mobility needs. The pilot also contributed to reopening the political and planning debate on the possible development of a new West-East tram connection, which could improve accessibility to currently less-served industrial areas.

On the institutional side, the pilot strengthened cooperation between DKV, municipal departments, national road authorities, the city operator, the University of Debrecen and other local stakeholders. It also opened a stronger dialogue with the academic and innovation ecosystem through training activities and a local hackathon that engaged participants in developing traffic management and public transport solutions based on the sensor data and other pilot action results. The experience helped DKV strengthen its understanding of Open Data processes, identify new opportunities for data-driven service improvements and establish new cooperation models with the city and innovation actors.

The outcomes and lessons learned from Debrecen are applicable to many growing cities and can help define a useful pathway for analysing and scaling urban services, in particular public transport, in parallel with city growth. The pilot demonstrates the value of enabling public transport operators, rather than only municipalities or research institutions, to actively participate in Open Data ecosystems and use new sources of information to support future mobility decisions.

B. Introduction

There has been a high level of investments taking place in Debrecen with focus on industry and the city's population is expected to grow by approximately 20% with the new developments. The growing mobility needs can significantly influence city traffic. As an answer the city introduces new bus lines supported with MaaS (Mobility as a Service) features. Using mobility data from different sources already, DKV Zrt (PP3) will complement the decision making by data from traffic at specific sites to have the knowledge on traffic volume and the ability to compare it to the bus occupancy, to improve the service quality.

The Pilot Action successfully implemented a sensor network of 42 new EnCLOD traffic counter sensors. This sensor network generates near real-time data on vehicle counts, categories, and speeds, all of which are published through the project's analytical platform under an Open Data license. These datasets serve as a source for the development of the "Traffic management tool", intended to improve the service quality of DKV Zrt (PP3) and later could be connected to the City Traffic Operation Centre, an initiative of Debrecen city.

The pilot also involved substantial stakeholder engagement, including a mini conference on Open Data for city governance representatives, an Open Data training and technical workshop in 2025, and preparatory activities for the upcoming hackathon (20-21. May, 2026.)



Image 1 Meeting with representatives of Debrecen University

This report will provide insights both on governance and technical level, on how EnCLOD project initiatives will directly support DKV Zrt (PP3) to profit from data driven planning and management paving the path of sustainable and clean mobility. On the long run at city level creating a "Living lab" supported by OD sources in Debrecen, linking with other activities, such as raising awareness of IoT, Open Data, will result in a more efficient and transparent local government. Engaging civil society and the local technology ecosystem, as well as sharing and transferring knowledge and experience between them can enhance productivity and well-being.

C. Key info on the Pilot Action

DKV Zrt's direct aim is to collect traffic data to analyse volume and intensity of traffic around certain areas, focusing on rapidly developing industrial parks. From traffic data sets, we can create travel patterns, and with this knowledge new public transport routes, lines, schedules can be deployed in order, to decrease private car usage. Decreasing traffic congestion, increased traffic flow reduces air pollution in Debrecen and the surroundings. Comparing traffic data before and after public transport development, the effectiveness of our actions can be measured.

After successful negotiations with Hungarian Public Roads (Magyar Közút Zrt) and the Department of Urban Management, at the Mayor's Office of the City of Debrecen, our sensor network plan got approval. The design of the sensor network was created with the contribution of PP6 CityOne s.r.o.

The sensors were deployed at 4 main locations of the city, focusing on industrial sites with the supervision of a traffic engineering company ensuring the safe flow of road traffic. As road maintenance work is not allowed in Hungary under bad weather conditions and if temperature drops below 0 Celsius degrees, timing was crucial at the planning process. An important lesson had already been learned, that decision making at authorities is time consuming.

The traffic sensor deployed is an IoT magnetometer, a wireless, autonomous magnetic traffic flow detector, that counts traffic in one lane at a time, with the potential for three length categories, speed and direction.

In order, to provide stable data connectivity we contracted with DVÜ Ltd, (Debrecen's City Operator Company) who already operates a LoRaWAN gateway network on municipally owned properties. As the monitored territories are still under construction, we had to count with a certain level of data packet loss. As new buildings grow out from the ground the connection quality can decrease.



Image 2 IoT Magnetometer

The exact locations of the traffic counting sensors were placed onto a dedicated layer on the Google map, each location marked with different colour. The map also incorporates other available devices and counters in Debrecen, like: traffic counters, speed meters, bicycle counters, meteorological stations, air quality monitoring stations, LoRaWAN gateway network and the microzone layers of the city.

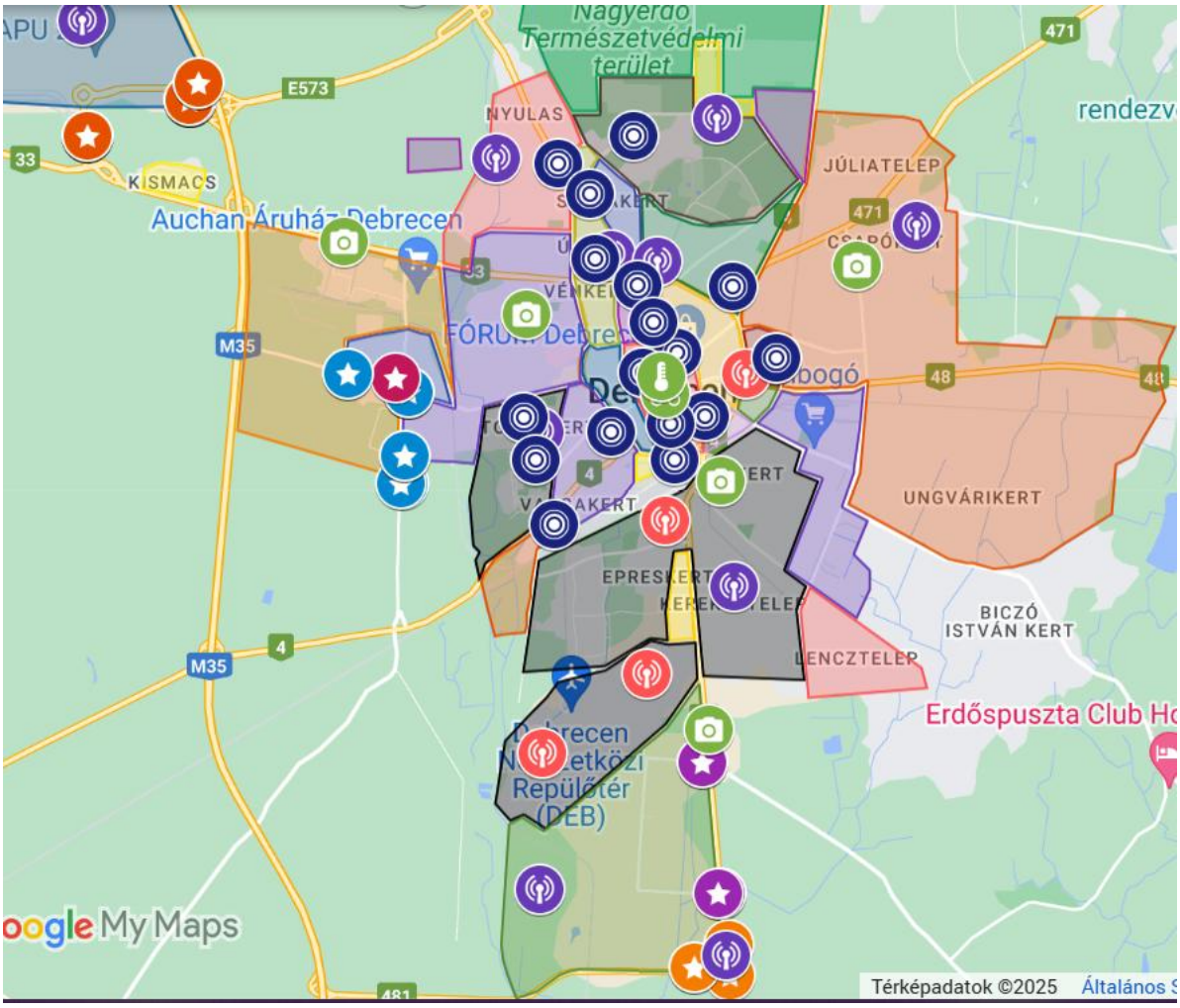


Image 3 EnCLOD traffic sensors and other data sources in Debrecen

The Debrecen pilot can contribute to the city's open data agenda and data based decision making initiatives as it involves relevant open data providers in the region that can support comprehensive city level decision-making.

On national level we cooperate with HungaroMet, the Hungarian Meteorological Service, and Hungarian Public Roads (Magyar Közút Zrt).

On local level, we involved the city's Environmental Monitoring System, an air pollution monitoring system that provides information for citizens about the status of their environment. Data from the monitoring system, along with available meteorological data provided by the Hungarian Meteorological Service can be integrated into the EnCLOD project strengthening the great use of open data. Cooperation with EDC, a city owned SME (Economic Development Center) provided us with unexplored city level data sources.

D. City Open Data strategy inputs - governance level

1.1.1. Open data agenda in the pilot area

Until 2016, Debrecen did not have a systematic approach to comprehensively address its data agenda, including open data. In 2016, Debrecen' SUMP has been introduced with dedicated section on "THE DEVELOPMENT OF SERVICES BASED ON OPEN DATA". This defines clear directives regarding data based governance. The city will establish a central data repository where data, which the city owns or has access to, would be systematically stored via defined interfaces. To achieve this, a detailed and comprehensive inventory of the city's data resources will need to be conducted. The city acknowledges the need to address this issue comprehensively and to systematically set up the necessary processes. It also recognizes the potential of systematic data collection, data opening, and their use for data-driven decision-making across a wide range of city agendas. However there has no dedicated municipal budget and staff been appointed to this domain.

Local use cases

The **Innovation Ecosystem Centre** and the **Faculty of Informatics at the University of Debrecen** shows evolving interest in knowledge transfer (hackathons) and the use of open data. (data asset management, national data assets, open data portal, sensitive data processing, cloud solutions etc)

Using **Waze data provided through Connected Cities Program,** in-house as a PTO, DKV Zrt can complement the decision making by data from traffic at specific sites to have the knowledge on traffic load and the ability to compare it to the bus occupancy to enable to improve the governance.

Parallel to the economic development of the city, the need for sustainable transport solutions and precise monitoring of environmental pollution grows. In order to have a clear view on the status of the city's environment, the **Environmental Monitoring System** has been deployed in 2025.

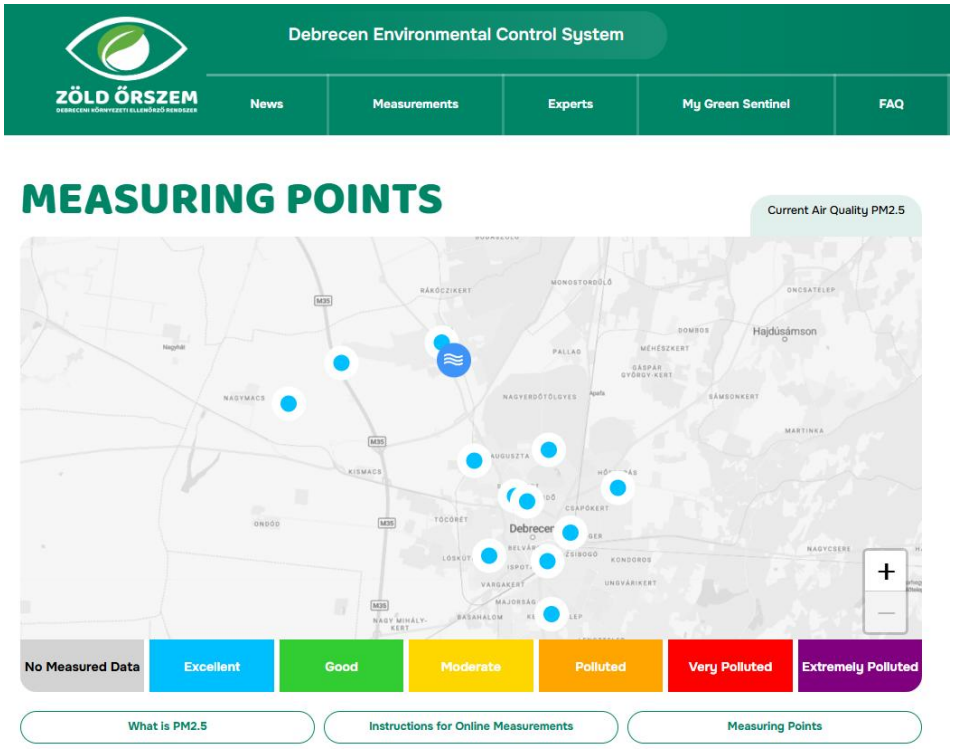


Image 4 Environmental Monitoring System dashboard

Besides air pollution level, other meteo data sets are collected. Altogether 18 monitoring stations were placed around the city, which provide data not only for the authority and the university (the owners of the system), but for the public as open data.

1.1.2. Future goals after the Pilot Action

The lessons learned from the EnCLOD pilot can support the Debrecen's transformation to a data governed city.

Future goals on city level:

- integrate the city's traffic, energy, meteo, and environmental datasets to support holistic urban planning and sustainability initiatives. Debrecen shall integrate new datasets on traffic to support comprehensive city transport planning with focus on new industrial areas of the city.
- Meteo, energy and environmental datasets will support sustainability initiatives (SUMP, Green Codex). The overall goal is to enhance mobility in the city while promoting sustainable urban development.
- citizen involvement should be enhanced by publishing validated datasets on public dashboards
- knowledge sharing, knowledge transfer can be fostered by the University of Debrecen. The signed MOU between DKV Zrt and the university paves the way for future public events organised in order to help citizens become more conscious users of data.

On company level:

- Public transport route planning optimization - the routes planned by passengers in DKV Zrt's mobile application, combined with our schedule and routes and with EnCLOD traffic datasets will provide a sustainable,dynamic flow of public transport operation.
- Future in-house trainings will be essential to help colleagues to adapt to new ways of service planning, based on structured open data sources.

1.1.3. Key stakeholders

The most involved partners in the project

Local stakeholders:

- EDC – Economic Development Center of Debrecen
- DVÜ - that is responsible for the operation and maintenance of the city
    - Traffic engineering
    - Energy services
    - Green area maintenance
    - Building maintenance
    - Operation and maintenance of building heating systems
- KER- that is responsible for operation of the Environmental Monitoring System
- Municipality's Urban Development Department
- University of Debrecen – Innovation and Ecosystem Center and the Faculty of Informatics

National stakeholders:

- HungaroMet - the National Meteorological Service
- National Roads

Missing stakeholders

In Debrecen, the municipality owned Debrecen Asset Management holding company oversees the operations of member companies that are responsible for tasks that support the public, including water and waste, that generate and store data. Opening and integrating these data sets, can complement city level open data platform initiatives.

- Water: Debreceni Vízmű Zrt.
- Energy: Debreceni Hőszolgáltató Zrt.
- Parking: DV Parking Kft.
- Waste: AKSD Kft.

E. City Open Data strategy inputs - technical level

1.1.4. Sensor placement/deployment

As main roads in Debrecen are shared -owned and maintained- between the municipality and the state, sensor network planning had to be well prepared and organized. Our project had to be approved by Hungarian Public Roads (Magyar Közút Zrt) and the Department of Urban Management, at the Mayor's Office of the City of Debrecen, that resulted a longer and more complicated procress. The take-away here was, that when planning such work, planners must take this into account.

The design of the sensor network was created with the contribution of PP6 CityOne s.r.o with regards to the conditions set by the above-mentioned authorities. As sensor deployment was supported by a traffic engineering company the roadworks could be completed safely, with a smooth flow of road traffic. As winter conditions were approaching we had a very short time slot for the installation work. Road maintenance work is not allowed in Hungary under bad weather conditions and if temperature drops below 0 Celsius degrees, but we were lucky with the weather and managed the deployment process in the planned timeframe. We recommend to schedule authorisation phase for the winter season, so roadworks can start at early spring.

The traffic sensor deployed is a magnetometer that counts traffic in one lane at a time, with the potential for three length categories and speed, depending on the specific location. Each road profile is equipped with a pair of sensors. Those with four-lanes, there were four sensors per profile deployed.

As the sensors run on batteries, with a lifespan of up to 3 years, there is no need for grid connection. In the other hand as a disadvantage the sensors must be replaced after 36-40 month, in order to keep data continuity. At sensor replacement, we advise the use of hand tools instead of power tools and work should be completed at daylight. When one of the sensors had to replaced at the BMW site, roadworks had to be carried out under night conditions, with power tools and during opening the asphalt layer, the sting of the drill, damaged the sensor, that got broken. Using hand tools would not have ended this way. It is also important to point out, that the approval for sensor replacement did not require time consuming, complicated application process.



Image 5 Damaged magnetometer

In order, to provide stable data connectivity we contracted with DVÜ Ltd, (Debrecen's City Operator Company) which already operates a LoRaWAN gateway network on municipally owned properties. Connectivity problems got solved by installation of new LoRa gateways running on solar panels. Changing position of the existing ones have greatly improved the reliability of the system. With some adjustments the rate of data packet loss lowered, and the detail of the data is now sufficient for analysis.

1.1.5. Sensor data

The specification of data set publications is a crucial activity of the EnCLOD project as it indicates the primary purposes and target groups of data users and serve for hackathoners as well as for open data portal publications.

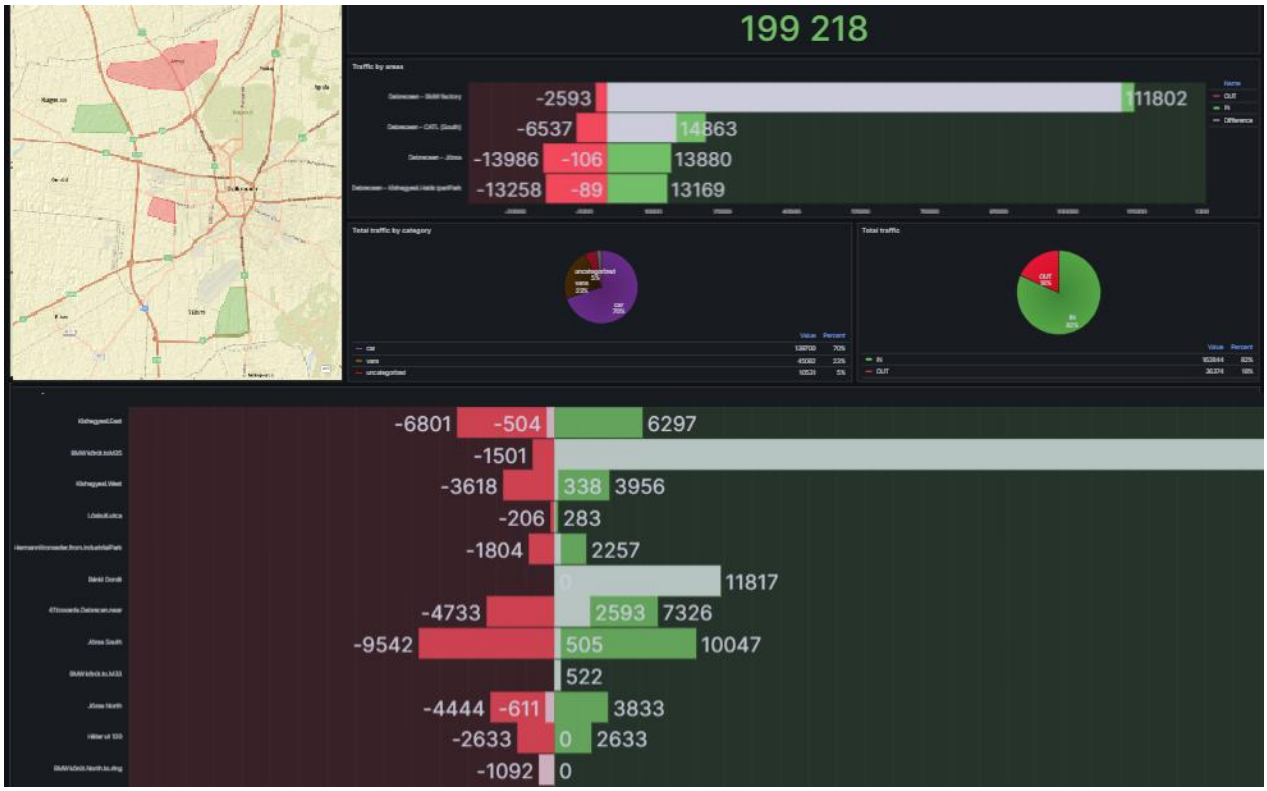


Image 6 Doprava digital - EnCLOD custom dashboard of Debrecen

The traffic sensors send data every 5 minutes which enables to publish data in 15 minutes granularity (which is a standard in traffic data) and overcome the packet loss events.

The data layer contains daily measurements of traffic intensity around Debrecen industrial zones. We measure total and hourly numbers of entries and exits, average daily numbers of vehicles by category (passenger cars, vans, trucks, uncategorized) and the average speed of vehicles and the proportion of vehicles exceeding the speed limit.

These datasets serve as a source for the development of the “Traffic management digital tool”, intended to improve the service quality of DKV Zrt and later could be connected to the City Traffic Operation Center.

The live EnCLOD datasets are designed to be the core resource for the upcoming hackathon in May, where participants will use these streams to build prototypes, MPVs and PoCs related to the challenges, all related to public transport and city traffic upgrade, towards a more convenient, more sustainable and accessible service.

1.1.6. Microzoning

There has been a detailed map of microzones created based on PP6 CityOne directives. The result is a holistic map of Debrecen (42 microzones) covering climate issues, where ideally each microzone is referenced to a particular meteo station. This enables us to see what is covered or will be covered by HungaroMet, and the Environmental Monitoring System and other projects and what is missing. Our finding is that there are zones in the city where the city needs to consider deployment of meteo sensors, in order to reach full coverage. Based on the microzones PP5 UPOL (Palacký University Olomouc) created a web application, providing the available data and the first "available open data mapping of Debrecen microzones" got ready. Adding the climate sensing references and traffic counting sensors/devices for the microzones and mapping the technology providers and their technologies a complete strategy of OD usage can be created. The city zoning provides a logical basis for the design of a citywide IoT network.

The microzoning design provides a directive on how to collect data, how to map open data availability for university students. It shows students where and what data is missing. There has been an intention shown by the university of Debrecen, to collaborate in upgrading the microzone web application with data sets from other segments.

Microzoning is a starting step for open data strategy for digital urban planning to enhance governance and to profit from potential AI tools.

F. Data-driven governance: Pilot first findings

The Debrecen Pilot Action represents an important first step towards a more data-driven approach to public transport planning and urban mobility governance. Before the Pilot, DKV had limited access to continuous and structured information on traffic conditions in the areas affected by the city's rapid industrial development. Through EnCLOD, a new network of 42 traffic sensors has been deployed around key industrial locations, generating Open Data on vehicle volumes, categories, directions and speeds. These datasets provide DKV and the City of Debrecen with a new evidence base to better understand how mobility patterns are evolving in areas where new industrial activities are generating increasing transport demand.

Although the full potential of the collected data will become clearer as the monitoring period continues and additional analyses are developed, the first results already demonstrate the value of integrating traffic information into public transport planning. The collected data allow the comparison of traffic intensity between different areas of the city and provide a reference framework for assessing future mobility needs, including the possible adaptation of public transport routes, schedules and services. In particular, the monitoring of the industrial areas served by different levels of public transport accessibility provides useful insights into how private car use and public transport availability are linked, supporting future evaluations of possible improvements to sustainable mobility connections.

An important outcome of the Pilot Action is also the strengthening of DKV's internal capacity to work with Open Data. As a public transport operator, DKV had limited previous experience with IoT-based traffic monitoring and data management. Through the Pilot, its staff gained practical experience in understanding traffic datasets, assessing their quality and exploring how new data sources can complement existing information, such as passenger demand and mobility data already used for service planning. This represents a significant step towards integrating data-driven approaches into future operational and strategic decisions.

Beyond the technical results, the Pilot Action contributed to the development of a broader Open Data ecosystem in Debrecen. The cooperation established between DKV, municipal departments, the city operator, the University of Debrecen and other stakeholders created the basis for future knowledge exchange, innovation activities and new data-driven services. The hackathon activities further supported this process by demonstrating how external innovators can use public datasets to develop ideas and prototypes for improving mobility services.

The experience of Debrecen highlights that the transition towards data-driven governance requires not only the availability of datasets, but also organisational learning, cooperation between different actors and the creation of long-term mechanisms for data reuse. The Pilot Action therefore provides a valuable example of how public transport operators can become active contributors to Open Data ecosystems and use new sources of information to support more informed and sustainable mobility decisions.

G. Summary of lessons learned and recommendations

Legend: ID: unique identification number, like DE1 = Debrecen lesson learned 1

- typology: G or T (Governance/Technical);
- for whom: level of territorial governance (National level, Regional lev., City lev., Other level) so N/R/C/O.

ID	Typology	Brief description	Final recommendation	For whom
DE1	G	Authorization processes are time consuming	Plan enough time for authorization processes, when creating a measurement plan. Road work related authorization processes should be submitted during winter time, so by the time approval received, fiel work can be started.	N/R/C
DE2	D + T	Authorities and city governance are aware the importance of data, data based decision making. However the use of it, has not been explored, not yet learned. This means, that trust has to be built first, then positive results will help adaptation.	Set up a department of data expert on city/municipality level, who can set up a trusted and usable data management environment.	R/C
DE3	G	Build up a complex ecosystem around data management.	Involve city owned/managed stakeholders, academia, and industry partners in order to cover all domains of data based governance. Involve citizens into processes fostering a more conscious citizenship and common understanding over time.	R/C
DE4	T	When planning a sensor network always need to consider city development plans well ahead.	High buildings, big structures may reduce sensor communication level and data transmission / coverage can be hindered.	N/R/C
DE5	G	Multilevel territorial governance can be supported by a digital twin, overpassing the barriers of various agendas and various levels of the governance at the city and/or regional level	Create a digital twin for urban planning and territorial governance by connecting open data from existing statistics, technologies and social and economic surveys	R / C
DE6	T	Deploying a complex sensor network that requires grid connection is a difficult task. Create or get a map of public lighting infrastructure (where	A map of public lighting poles that are suitable for sensor/device placement. In order to filter out barriers use GIS data layers and	R/C

		poles, connection boxes listed) that are suitable for sensor network placement.	provide public procurement with the list of suitable places.	
DE7	G	Engagement of university students in working with open and sensor data (within courses, theses and hackathons) proved to be an effective way to increase data inventory and literacy, test data usability and support the local innovation ecosystem.	Integrate open and sensor data into university education and support student involvement through courses and hackathons as a natural component of the open data ecosystem.	N/R/C
DE8	G	Sharing good practice can increase the speed of digital transition. Do share tools and experiences from data use and their transformative nature on territorial governance to gain the momentum of political support by promoting the good practice and its (even political) benefits.	Cooperate with other CE or national cities sharing the knowledge as well as the tools that were developed in a local ecosystem, will help innovative companies to thrive.	R/C
DE9	G	**Waze traffic data** usage at decision making to enable/improve governance.	**Use Waze data** to have knowledge on traffic load. It can be compared to the bus occupancy.	C