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# Olomouc Pilot Action report & lesson learned

## City of Olomouc

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# A. Executive Summary

*Olomouc, like many European cities, is facing the need to make better decisions on mobility, parking and climate adaptation. Parking areas and busy traffic spaces can contribute to urban heat islands, while decisions on reducing, reorganising or redeveloping parking spaces often require clear evidence and transparent communication with citizens. Before the Pilot Action, the city lacked sufficiently detailed, integrated and accessible data to understand how urban heat islands, parking demand and local climate conditions interact in different parts of the urban area. Climate and mobility information were generally available only in isolation, making it difficult to assess the interrelations between these challenges and to support evidence-based planning decisions.*

*The Olomouc Pilot Action addressed this challenge by turning selected parts of the city into a practical testing ground for data-informed urban governance. The idea was simple: collect reliable information from real urban locations, make it openly available, and use it to support better planning, public discussion and innovation. During the Pilot Action, integrated data on climate (temperature) and parking conditions (occupancy and/or traffic) were collected in different urban environments, including one large shopping mall, two residential areas, four visitor parking areas and one urban park. In addition, night-time parking surveys and temperature measurements were carried out to extend the monitoring to additional locations and to validate the sensor-based observations. This holistic dataset, previously unavailable for the city, helped Olomouc better understand how parking areas are used, where heat accumulates, how these patterns change during the day, and how they are perceived by citizens.*

*The collected data were analysed by the project partners and shared with relevant stakeholders and the wider public. They were published as Open Data, allowing public authorities, universities, companies, students and other actors to reuse them for further analyses and to develop new digital solutions. A user-friendly dashboard was also developed to make the information easily accessible to non-technical users, increasing transparency and facilitating public communication on mobility and climate adaptation issues.*

*The Pilot Action demonstrated that the combined analysis of traffic, parking and climate data—supported by the micro-zoning approach adopted within the project—can provide practical evidence for better justified urban planning decisions. Data confirmed that parking areas are generally important urban heat island hotspots, while also showing that different locations require different policy responses depending on their actual use and local conditions. For example, the monitored shopping mall parking area, with approximately 1,000 parking spaces, was identified as a significant urban heat island, although its occupancy generally remained below 50% and never exceeded 80%. The analysis therefore indicated that around 150 parking spaces could potentially be converted into green infrastructure without negatively affecting parking availability, contributing to mitigating the local heat island effect.*

*Residential parking areas, on the other hand, were found to be almost fully occupied (up to 98-99% occupancy and never below 60%), while exhibiting comparatively favourable climate conditions. These findings provide additional evidence supporting the planned residential parking regulation and could help improve communication with citizens by demonstrating the actual demand for parking. Visitor parking areas presented different combinations of occupancy and heat accumulation, showing that detailed local data can support better-informed decisions on redevelopment priorities. In one case, a parking area close to the city centre was found to be only around half occupied, despite plans for an additional nearby parking facility, suggesting that the actual demand may not justify such investment. Data collected in the monitored urban park also highlighted that asphalt surfaces can reach potentially harmful temperatures for children and pets even within otherwise pleasant green environments, providing valuable information for awareness-raising and public discussions on climate adaptation.*

*In addition, the Pilot Action made it possible to test and better understand several key elements in the design of a sensor system, highlighting, for example, the importance of an appropriate definition of sub-urban areas (the "micro-zoning" process) to increase the relevance and usability of data, as well as the different levels of spatial coverage required for collecting climate data compared with the level of granularity needed for traffic and parking data. The pilot also confirmed that citizens often have an inaccurate perception of urban heat islands and their potential health impacts: the availability of measurements collected at different heights and in different urban contexts can improve the understanding of these phenomena and help explain the need for targeted interventions.*

*The pilot helped Olomouc move from isolated data collection towards a more integrated city-wide approach, with the City deciding to expand the monitoring network from the initial 10 pilot locations to around 40 monitored sites within the future digital twin. This expansion builds directly on the recommendations, methodology and lessons learned developed through the Pilot Action and demonstrates the confidence gained by the municipality in integrated environmental and mobility monitoring.*

*Overall, the Olomouc Pilot Action confirmed that Open Data and integrated environmental and mobility monitoring can make local decision-making more transparent, practical and future-oriented in the fields of climate adaptation and mobility management. While the actual impact on parking policies, mobility strategies and urban redevelopment will depend on local ownership, functions of individual parking areas and future planning processes, the Pilot successfully demonstrated that accurate, comparable and openly available data can substantially improve the evidence base for decision-making, facilitate communication with stakeholders and citizens, and provide operational recommendations and practical lessons for other cities, territories and operators wishing to establish integrated systems for collecting and analysing environmental and traffic data at urban and peri-urban level.*

# B. Introduction

The Olomouc Pilot Action has been developed as a frontrunner within the Project EnCLOD, serving as an advanced concept intended to inspire the other Pilot Actions. It benefits from close cooperation and effective knowledge sharing among the Czech project partners.

The concept is built on:

- **Providing a holistic city-wide design** of climate and traffic sensing and prove the feasibility by the pilot; delivering a concept of microzones, i.e. division of the city into zones to get a data reference model (applied then to other pilot areas)
- **Awareness raising and engagement** of potential stakeholders by various events, presenting the vision and the results to the wider audience, ranging from region and city governments and offices representants, academia and students, activists and local companies
- **Analysing and iterating on further data acquisition** (e.g. night parking and heat islands surveys) and supportive tools, providing a registry of existing and available open data – filling the pool of open data sets for microzones in one ArcGIS environment (applied then to other pilot areas)
- **Identifying practical use cases** (e.g. heat island and occupancy of a shopping mall parking, impact of Lidl outlet opening on traffic and occupancy…), defining the lessons learnt and system parameters into a technical standard to support potential public procurement,
- **Providing open data to third parties**, especially from dynamic sources, on national open data portal and to enhance design of digital tool(s) for heat island and test AI features on dynamic databases (the tasks for the hackathon)

So, the IoT infrastructure pilot consists of traffic and climate sensors piloting the collection of data on city districts (greenery and residential parking), parking areas (heating islands on visitor parking areas) and shopping mall area, measuring traffic load and parking occupancy, temperature in 5 different levels including -30 cm underground, complemented with surveys on night parking (capacity vs occupancy) and heat islands (heat accumulation to night air temperatures).

# C. Key info on the Pilot Action

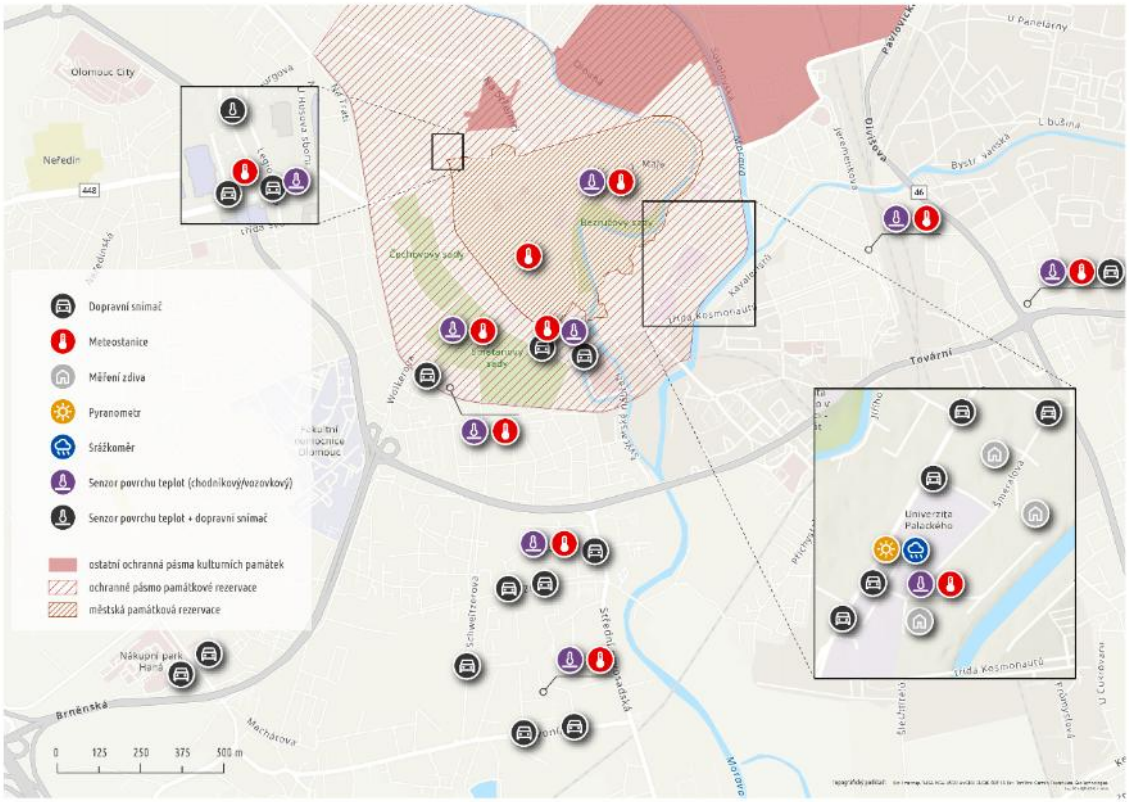
Inspired by the results of the Interreg SK_CZ project CleverNET project (urban lab in Žilina), the city of Olomouc's Pilot Action provides knowledge on the danger of heating islands for 10 places related to parking supported by data collected and visualised in graphs and maps. In addition, generated data is being made publicly available (Open Data principle), inviting the civil society and local tech ecosystem to further elaborate and re-use the data for contributing to local climate change adaptation and parking /mobility policies, and/or for developing new ideas, products or services for Olomouc territory.

The activity has been carried out by PP5 UPOL (Palacký University) and PP6 CityOne who co-designed the sensors deployment and communicated with the city to get necessary permissions, with direct involvement of PP4 CITIQ for sensor network deployment and data provision (Data as a service, DaaS).

The purpose of the pilot deployment of the sensor network is to investigate the occurrence of heat islands in connection with parking. The proposed network consists of the following types of sensors:

- Weather stations measuring air temperature at two heights (0.8 m and 2 m), air humidity and atmospheric pressure, as well as wind speed and direction
- Surface heating/freezing sensors measuring surface temperature, 6 cm and 30 cm below the surface
- Traffic sensors, primarily for investigating parking demand/space occupancy

All the sensors were installed on the city assets, the traffic sensors on 17. listopadu Street are administered by the Olomouc Region.



The traffic section was deployed at the end of August 2024, and the climate section in June 2025. Both networks intersect at several locations in Olomouc, some are purely climate-related, some purely traffic-related.

For clarity, we also provide the basic parameters of the sensors:

- **10 Weather stations** measure temperature, humidity, and atmospheric pressure at a standard height of 2 m, as well as temperature at 80 cm in certain locations, and wind direction and strength. The weather stations were deployed with a standard northward orientation.
- **10 sidewalk sensors (heat island sensors)** measure the surface temperature, 6 cm and 30 cm below the surface. At some locations, we measure the temperature at up to 5 height levels and compare the type of substrate, i.e., stone and concrete paving, with asphalt surfaces.
- **38 traffic sensors are magnetometers** that count traffic in one lane at a time, with the potential for three categories of length and speed depending on the specific location. Each profile (entrance and exit from the zone) is usually equipped with a pair of sensors, and each zone can have several profiles. The purpose is to obtain information not only about traffic intensity but also about the occupancy of a given zone. The same sensors have been deployed in Žilina and Debrecen pilot actions.

The pilot has been designed to showcase the potential of "IoT machines" collecting data in a wide area and their accuracy and reliability, but also to cover some of the identified use cases.

The main use cases, where EnCLOD open dynamic data is used, are related to:

- Heat island detection and comparison of 10 different locations (provided via a web tool),
- Impact of raining on car use among the residents in a city district,
- Impact of Lidl outlet opening of traffic and parking occupancy,
- Reduction potential of highly oversized parking capacities in favour of greenery at a shopping mall,
- Impact of a road closure due its reconstruction on traffic in adjacent streets and
- Tools design for road pavement maintenance (2 of the winners of the hackathon 2025).

# D. City Open Data strategy inputs - governance level

The Olomouc's Pilot Action has focused on the deployment of a sensor network aimed at collecting data to link the subject of city parking regulation with climate change impacts. In 2021, the city of Olomouc (EnCLOD Associated partner AO1) approved a 'Strategic Plan for a Smart Olomouc', which envisaged the transition of the city administration towards data-driven decision making for local policy-making. The city has been introducing a new parking regulation with the plan to extend it geographically zone by zone in time. As the traffic and parking infrastructures are the primal spaces for heating islands, the city is considering using potential information and data on climate change when communicating with citizens on parking places reduction. Green infrastructures are seen as very important in adaptation and mitigation strategies but there were no plan and/or specific steps on how to approach it in a data-driven way in connection with traffic and parking as there was no data available on the general indicators for these environmental aspects.

The sensor data is now published on the national open data portal and Olomouc region data portal since October 2025 and the city has become the second city in Czech Republic (after Prague) to provide such open data. This has been done with close cooperation among PP4 CITIQ and Olomouc region, for both a new learning opportunity that has succeeded, moderated by PP5 UPOL.

### 1.1.1. Open data agenda in the pilot area

The agenda of open data is well established at city as well as regional level; the city strategy for open data was developed by the university before the project EnCLOD and so the pilot could build on and improve the city strategy (especially by the knowledge of sensor data). The advanced level of open data work is seen in the local ecosystem as the city, together with the region and UPOL university organize regular (annual) hackathons. So, the third hackathon (held in November 2025) was assisted by all the EnCLOD Czech PPs who provided live data from sensor network, mentoring, data processing assistance etc., which was foreseen in the Pilot Action.

The project EnCLOD itself has been prepared in the sense that **Olomouc would be a frontrunner** for the other pilot actions and would attempt to manage advanced activities to enable sharing the knowledge with the others and to test the initial vision of the project. That is why the pilot design and its negotiation at the city, region and other stakeholders' level, together with local event organization were really fast and plentiful.

From the governance point of view the local ecosystem and common understanding were the crucial features to co-design a city-wide digital twin. There was already little experience with the sensors and their operation before the project started so the common understanding was easier to achieve. But there was no experience on how to make data from sensors open and this is seen as a valuable insight the Olomouc region and PP4 CITIQ have got.

So, the pilot itself was designed in such a way to demonstrate the future functionalities of wide area sensing. Thanks to the project EnCLOD activities (microzoning, holistic design of sensing, conversion of open data to the ArcGIS tool, presentation and discussion at the events and pilot open data use at the hackathon) the city accepted the holistic design and integrated it in the ITS (Intelligent transport system) strategy. This extra work in the project has led to the provision of a valuable input into the public tender (described in technical article, chapter D) as the city is to procure such a digital twin in 2026 (with potential deployment in 2027); the system is of a value of cca 570k Euro. The procurement is designed, based on the knowledge gained in the project EnCLOD, in such a way that the supplier is to deploy and operate the system for

5 years, including open data publishing and supporting actively future hackathons to maximize the enhancement of new digital tools development and prove that open data, backed with dynamic sensor data, can be a game changer in digital urban planning establishment. Thus, multilevel and multisector territorial governance can be enhanced, overpassing the barriers of various agendas and various levels of the governance at the city and/or regional level. The office of city architect has become the leader of the initiative, backed by both open data portals (city as well as region) so more city and region officers have been engaged.

The consensus has been found and the public procurement output, i.e. the digital twin, will also assure the sustainability of the EnCLOD pilot deployment as some of the locations match with procured microzoning coverage. There is a common understanding now that the use of open data by various tools and applications in the near future naturally enhances the sustainability of the sensor network which provides values and savings on such a scale that it becomes a mandatory item in the city budget. The city is aware now that dynamic open data can attract much more tool-and-app developers and increase the open data agenda potential. The open data on climate and traffic can back many city agendas and the cost of purchase and operation will be compensated by significant savings in time and money as well as provide new insights and increase digital literacy among the city officers. The sharing of such data with the region or other stakeholders can create an ecosystem of many open data investors sharing the data with the others and as such to decrease the cost of digitization for public budgets.

### 1.1.2. Future goals after the Pilot Action

Discussion with the city politicians and officers at various events and finally at the hackathon where the data from the pilot has been used publicly for the first time (its use was a compulsory condition for the hackathoners) have led to better understanding the benefits of the holistically designed digital twin. Also sharing a good practice from PP9 UNIZA on an existing mandatory agenda, the city traffic model, improved by using EnCLOD and other existing dynamic open data, while the understanding of the potential increased and the favour for running wide area sensing was gained. The valuable political and academia support has been gained as the vision of a digital twin and its benefits could be communicated via potential improvements and savings, as well as potential research, education and local digital economy support.

The holistic design approach has led to a closer cooperation with the city and the new design of an ITS has been inserted in the study made by a third party, focusing on ITS strategy. The study now serves as an input material for a public tender definition, partially focused on wide area sensing. Based on the public Design and Build tender the city is to purchase and operate a wide area sensor network, designed by EnCLOD PP5 UPOL and PP6 CityOne expertise, consisting of 226 traffic lanes/sensors and 66 different climate sensors, **creating a digital twin for urban planning and territorial governance.** All the data will be open and will boost the local innovative ecosystem. Olomouc thus can become a “sandbox” of territorial governance innovations, profiting from open dynamic data from sensors (a kind of near real time wide area sensing) and its combination with existing open data to deliver new range of digital tools, made by anyone interested, and supported by common regular annual region/city/university hackathon.

### 1.1.3. Key stakeholders

The pilot action of Olomouc has been devoted a lot of time and expertise as the Olomouc case has been seen as a frontrunner in the EnCLOD project because of a unique combination of knowledge, skills and already established cooperation. The partners PP6 CityOne and PP4 CITIQ cooperated in the design, deployment and operation of the sensor network for the urban lab in Žilina within Interreg SK_CZ project CleverNET so the first design of Olomouc pilot action has been made very quickly. The partner PP5 UPOL with the expertise in geoinformatics and open data supported the codesign with the knowledge of the local environment, with map graphics, and networking with local stakeholders.

There were two groups of stakeholders within the pilot action of Olomouc. The first group was involved due to the deployment of sensor networks, mainly asset managers (City of Olomouc is EnCLOD associated partner AO1), the second group was engaged within the local events.

Deployment of sensors stakeholders:

- Politician responsible for urban planning agenda
- city architect,
- department of mobility,
- department of urban planning,
- department of assets management,
- department of historical protection,
- city company for green space Flora Olomouc.

UPOL as a local partner has established a list of potential key stakeholders for open data agenda and local events and divided them into three groups:

- Public sector (32 persons identified)
- Companies and institutions (24 persons identified)
- City committees, i.e. for architecture, smart city and LA21, mobility (46 persons identified)

These stakeholders were invited to the local events.

To illustrate the variety of interested parties, the participants for the Olomouc June 2025 (hybrid) event were various stakeholders interested in the workshop ranging from politicians, city and region administration staff, university staff and students, research and innovations institutes, SW companies, a local hospital or a Slovak university.

Besides the city, the region and the university there were some other stakeholders who got involved formally or directly.

The city company Flora Olomouc has provided permission to deploy a meteo station and a heat island sensor on their premises (the city park) and expressed an interest in data. Finally, they have not engaged as their interest should be backed with a proper tool (the interpretation of data is much more important than the provision). Some IT companies like Tesco SW and IT traffic companies like Cross Zlín or VARS have engaged in an EnCLOD event, investigating the functionalities of new data sources and getting ready to profit from it (provision of a visualisation platform Invipo for Smart Olomouc to integrate the data, investigating data for road maintenance IT services).

There were other “external” stakeholders:

A national digital agency, DIA, has got involved in the hackathon, to learn more about this new potential of IT development and literacy enhancement by open sensor data.

Through promotion at national GIS conference the expert audience from the GIS sector has been addressed and Olomouc has become a place “where open data from sensors are tested” perceiving the potential that the city can become a sandbox for future GIS applications.

As PP6 CityOne is a national representative in CEN TC 278 and ISO TC 204 (urban ITS standardization) the vision has been presented in the Czech Standardization Office magazine (February 2025), followed by a presentation at an international event, CEN/ISO Prague meeting (September 2025), with the aim to work out a standard on climate and traffic sensing and the microzoning, which is now used for the public procurement and will be further on developed into a Czech technical standard. So, the national community

of ITS standards has been presented with the EnCLOD project and the Olomouc pilot action at December 2025 meeting to raise awareness and get support for the national standard.

The governance level for open data agenda is crucial as it may flourish only if a local ecosystem of cooperation is found. The City of Olomouc already has such an environment and so the project EnCLOD could work out fast, with a higher level of acceptance, backed with professional knowledge and skills of the partners. These partners have developed the most important output of the project – the logical framework for territorial governance to reference open data, the microzoning, enabling also to map existing open data sets as well as to compare various city areas among each other. The transfer of such a governance to other project pilot areas has enabled to compare the level of advancement among the cities in existing open data portfolio, a natural benchmarking, and also to compare various areas of various cities among each other, e.g. areas of Olomouc with areas of Žilina. This is of utmost importance as the following steps could be sharing digital tools among the cities and so to speed up the digitization of the territorial governance also by a readiness on the technical level. Students of UPOL university were also actively involved in working with the data within university courses, where the datasets from the pilot were used for practical exercises, as well as within bachelor's and master's theses focusing on data analysis and spatial evaluation. In addition, students further engaged through participation in the hackathon, where they worked with the sensor data and explored its potential for practical applications.

# E. City Open Data strategy inputs - technical level

In the Czech Republic a national service for LoRawan connectivity is provided which makes it significantly easier than to deploy own communication infrastructure (gateways). So, for the pilot action in Olomouc the national connectivity from České Radiokomunikace (ČRA) was used. As a common service the regular payments for devices operation is required so the volume (number of sensors) play a significant role. The Lorawan connectivity for the Olomouc pilot action can be seen as reliable, stable and without major problems. All the devices communicate steadily.

Such a wide area service is seen as a competitiveness advantage, saving much time which can be devoted to other technical issues. The project EnCLOD has investigated that such a service is not available in Slovakia or Hungary which is another burden any developer has to manage when deploying IoT sensors resulting in lower pace of advancement when deploying dynamic sensor data sources.

### 1.1.4. Sensor placement/deployment

The holistic approach, i.e. providing technical terms for IoT sensing to cover a whole city, has been evaluated as the most promising and we can recommend the procedure of not solving particular places but to design a whole city first (along with the microzoning) and then deploy a pilot. The pilot in Olomouc, resulting in the Design phase of the public procurement Design and Build, took into account the microzoning concept and the budget limit of the public procurement to select the most important places.

The importance of such an approach was twofold:

- considering which microzones are the most important and how they share traffic profiles (so adding 2 or 4 sensors enables to cover another microzone as it was partially covered by another zone sensing) and
- considering how they cope with an important use case (i.e. heat islands, city districts parking strategy, shopping malls traffic etc.).

PP5 UPOL and PP6 CityOne have spent a lot of time and discussions on the proper design as so they can share now their findings as follows:

**Holistic approach is a key** as it shows the relations among various places of sensing, it is an advanced approach to traffic monitoring. Without prior **microzoning** it can hardly be done. **The local knowledge** on what happens when (e.g. at sport events) also influences the detailed placement of the sensors. Also **sharing the design with the city** architect office and other fellows at the university enabled them to select key microzones that should be prioritized for the sensing equipment. It can be concluded that the more workforce and care is devoted to the design of microzoning, the more consensus and common understanding is gained and more suitable places for sensing are selected.

The public procurement is backed with **a single map** showing all the profiles mapped on the microzones so any supplier can dive deep into the expected scale of the supply.

The observation of which microzones are covered and **how many sensors are shared among the microzones** helps to select "the value for the money" for the actual public procurement, giving the insight into a possible extension in the future (see table 1). Each microzone is also described by **a list of traffic profiles** to see how many should be covered by the supplier (see extract from table 2). Some of the traffic profiles are not standard (a standard means 2 lane road) so the public procurement was provided with a special table showing all the **traffic profiles that are not standard** (table 3). Also, the mapping of **the infrastructure ownership** was required from the city so a table of traffic profiles with identification of the ownership has been created (extract table 4).

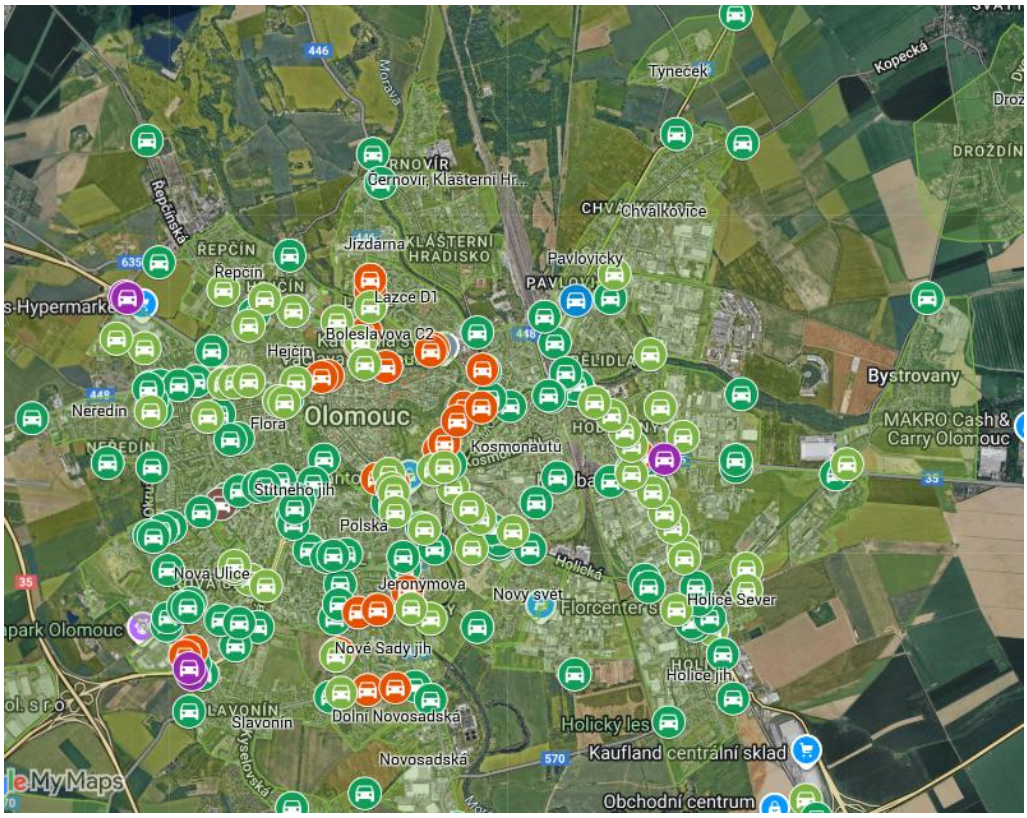



**Figure 1:** Overview of the whole city traffic sensing design

https://www.google.com/maps/d/u/0/edit?hl=cs&mid=1JPrvN64OmpMdvVS3p2PZdFcQQDzVrdg&ll=49.61902206435256%2C17.282917816165178&z=15

Note to the map figure: The green points represent the outcome, the whole city traffic sensing design; the light green points are new points that have been created due to some changes in the design, the dark green are the ones from the initial design, so it can be said that almost half of the initially designed sensing places have been reworked, the red points are existing sensing together with EnCLOD pilot action.

**Table 1:** The table with an overview of microzones with their number of traffic sensors, prepared for the public procurement to allocate the available budget for the highest value and preferences, *the blue microzones are the most crucial ones (selection based on the budget limits), the green can be added within a supplier offer to increase the chances to win the tender and white microzones are the least important (not covered by the public procurement)*

| Microzone name | No. of sensors in the zone (sum) | No. of new sensors (incremental) | No. of total sensors (cumulative) |
|---|---|---|---|
| Centrum | 28 | 28 | 28 |
| Vojenská nemocnice | 16 | 11 | 39 |
| UPOL | 4 | 4 | 43 |
| Kosmonautů | 20 | 17 | 60 |
| Morava | 17 | 8 | 68 |
| Polská | 21 | 20 | 88 |
| Flora | 28 | 20 | 108 |
| Hejčín | 30 | 16 | 124 |

| Microzone name | No. of sensors in the zone (sum) | No. of new sensors (incremental) | No. of total sensors (cumulative) |
|---|---|---|---|
| U Sportovní haly | 10 | 6 | 130 |
| Boleslavova C2 | 6 | 2 | 132 |
| Lazce D1 | 11 | 5 | 137 |
| Jízdárna | 11 | 4 | 141 |
| Černovír | 4 | 0 | 141 |
| Řepčín | 12 | 6 | 147 |
| Ovesniska | 8 | 2 | 149 |
| U Globusu | 10 | 10 | 159 |
| Malého Prince | 19 | 19 | 178 |
| Neředín | 7 | 7 | 185 |
| FNOL | 18 | 10 | 195 |
| Nová ulice | 15 | 9 | 204 |
| Vilapark, Balcárkova | 7 | 6 | 211 |
| Heyrovského | 12 | 12 | 223 |
| Slavonín | 10 | 8 | 231 |
| Nové Sady Sever | 7 | 7 | 238 |
| Nové Sady Jih | 24 | 16 | 254 |
| Dolní Novosadská | 12 | 4 | 258 |
| Nemilany | 6 | 2 | 260 |
| Novosadská | 6 | 4 | 264 |
| Jeronýmova | 13 | 6 | 270 |
| Za nádražím | 14 | 14 | 284 |
| Hodolanská | 11 | 3 | 287 |
| Hodolany, průmyslová zóna | 7 | 4 | 291 |
| Bělidla, Ondřejova | 11 | 11 | 302 |
| Chválkovice/Pavlovičky/Roháče z Dubé | 10 | 8 | 310 |
| U Panelárny | 11 | 0 | 310 |
| Týneček | 2 | 0 | 310 |
| Bystrovany | 4 | 4 | 314 |
| Nestlé | 2 | 0 | 314 |
| Baumax | 7 | 7 | 321 |
| Nový svět/Městský dvůr | 8 | 4 | 325 |
| Holice Jih | 11 | 9 | 334 |
| U Solných mlýnů | 13 | 8 | 342 |

| Microzone name | No. of sensors in the zone (sum) | No. of new sensors (incremental) | No. of total sensors (cumulative) |
|---|---|---|---|
| Holice Sever | 12 | 12 | 354 |
| Sladkovského | 12 | 10 | 364 |
| Olma | 13 | 11 | 375 |
| OC Haná | 10 | 10 | 385 |
| Olympia | 4 | 4 | 389 |
| Řepčín.Průmyslová zóna | 4 | 2 | 391 |
| Holická, U rybářských stavů | 6 | 4 | 395 |

**Table 2:** Extract from the table listing traffic profiles for each microzone

| Ranking | Microzone | List of traffic profiles |
|---|---|---|
| 1 | **Centrum** | 448.most u bristolu, na letné, dlouhá1, václava iii, na střelnici, masarykova třída2, 03551.17.listopadu1, třída svobody, vídeňská, havlíčkova, 448.palackého, Wellnerova, U Husova sboru, U Letadla, Billa |
| 2 | **Vojenská nemocnice** | 448.u podjezdu, 4464.sokolovská, 448.most u bristolu, masarykova třída2, masarykova třída, dr. m. horákové, jeremenkova2, na bystřičce |
| 3 | **UPOL** | šmeralova1, šmeralova, šmeralova3 |
| 4 | **Kosmonautů** | babíčkova.velkomoravská, morava1, morava2, 03551.wittgensteinova.šantovka2, tovární, jeremenkova.tovární, jeremenkova2, na bystřičce, tř. kosmonautů.envelopa, Holická3 |
| 5 | **Morava** | 03551.wittgensteinova.šantovka2, 03551.wittgensteinova.šantovka, domovina, domovina2, třída kosmonautů.envelopa2, babíčkova.velkomoravská, morava1, morava2 |
| 6 | **Polská** | polská, domovina2, švýcarské nábřeží.šantovka, v kotlině, švýcarské nábřeží2, rooseveltova, schweitzerova5, jihoslovanská, polská2, eduarda husserla, eduarda hamburgera, zamenhofova |
| 7 | **Flora** | havlíčkova, wolkerova, zamenhofova, eduarda hamburgera, eduarda husserla, štítného, na vozovce2, tř.svornosti2, za zlatou koulí, škrétova, dvořákova, polívkova, krapkova, krapkova2 |
| 8 | **Hejčín** | na šibeníku, tomkova, dolní hejčínská, u sportovní haly, Na Střelnici.2, 635.tomkova, na střelnici, boleslavova, bořivojova, wellnerova, 448.palackého, krapkova, polívkova, dvořákova, škrétova, 448.tř.míru |
| 9 | **U Sportovní haly** | u sportovní haly, 446.lazecká.2, na struze, Na Střelnici.2, 635sport |
| 10 | **Boleslavova C2** | na struze, boleslavova, bořivojova, boleslavova2 |
| … | | |

**Table 3:** Extract from the table showing non-standard terms

| Traffic profile name | Number of sensors/traffic lanes |
|---|---|
| Kšírova | 1 sensor |
| Rooseveltova2 | 2 sensors, without monitoring of the left turn lane |

| | |
|---|---|
| Rooseveltova1 | 4 sensors |
| Trnkova.Rooseveltova | 3 sensors |
| Pode Mlýnem | 1 sensor |
| 35.Baumax.Velkomoravská.OUT | 1 sensor |
| … | |

**Table 4:** Extract from the table on the asset ownership (SMOL is an abbreviation for the city of Olomouc, OK for the region of Olomouc)

| Name of a traffic profile | Cadastre no. | Plot no. | Owner_1 | Owner_2 | Owner_3 | No. of sensors |
|---|---|---|---|---|---|---|
| Vojanova | 710717 | 800/42 | | | SMOL | 2 sensors |
| Na Střelnici | 710504 | 79/44 | | | SMOL | 2 sensors |
| Schweitzerova2 | 710784 | 535/1 | | | SMOL | 2 sensors |
| Krapkova2 | 710504 | 135/1 | | | SMOL | 2 sensors |
| Slavonínská2 | 750387 | 1232/9 | | OK | | 2 sensors |
| 570.Keplerova | 641227 | 1920/1 | | OK | | 2 sensors |
| Sladkovského.HoliceJih | 641227 | 1922/5 | | OK | | 2 sensors |
| 4436Bystrovany | | | | OK | | 2 sensors |
| 4436.Hamerská2 | 641227 | 1918/1 | | OK | | 2 sensors |
| Hamerská3 | 641227 | 1918/1 | | OK | | 2 sensors |

Similar activities have been done for the climate part. The design was divided into:

- **the basic part (Z)** (weather station with wind measurement supplemented by surface and subsurface temperature measurement), representing the functional minimum of the digital twin being built
- **the reference part (K)** (background measurement), which must be built together with the basic part
- **the special part (S)** (rain measurement, solar radiation, etc.), which must also be installed together with the basic part.

To address potential wrong deployment of weather stations, based on the EnCLOD identification of bad practice, the design also selected a range of **public lighting poles that are suitable** for placement of a weather station reflecting to not to be influenced by barriers, walls, trees or other objects that would influence the output data and would make such a source as non-reliable. Also, the coverage of the city in all four parts (South-West, South-East, North-West and North-East) by rain metering and solar radiation have been designed on the **roofs of the schools**. The city then picked up the suitable ones and started a negotiation with the schools' managers.

The subject of the tender is the deployment of the basic, reference, and special parts of the climate network in a combined form. In total, these are the following types and numbers of devices (see Table 5):

- **Weather stations** located on selected poles owned by the city that meet the basic parameters for measuring microclimatic conditions; each microzone has a pole specified in Table 6 (with priority 1) that is preferred for installation. However, problems may arise during deployment (accessibility,

permits, etc.) that would prevent installation, so one or two alternative poles/locations are proposed. The total number of weather stations is 27, see the green thermometer icons on the map below.

- **Heat island sensor**, located near the weather station, allowing 5 different temperatures to be measured at each location, supplementing the weather station with surface temperature measurements, 6 and 30 cm below the surface, total number is 27, see green thermometer icons on the map below.
- **Weather stations with rain gauges and pyranometers**, located at two special locations, with a total of 2.
- **Rain gauges and pyranometers**, located together on the roofs of specific buildings, in a total of 4 locations (see alternatives with the roof icon on the map below)

All the required equipment has been placed at the map to enable the potential suppliers to browse and investigate more:
https://www.google.com/maps/d/u/0/edit?mid=1J1fApr9Y6gA4xVMAr5NCCE0vvkJKHQA&ll=49.592089275025344%2C17.262174180786293&z=14

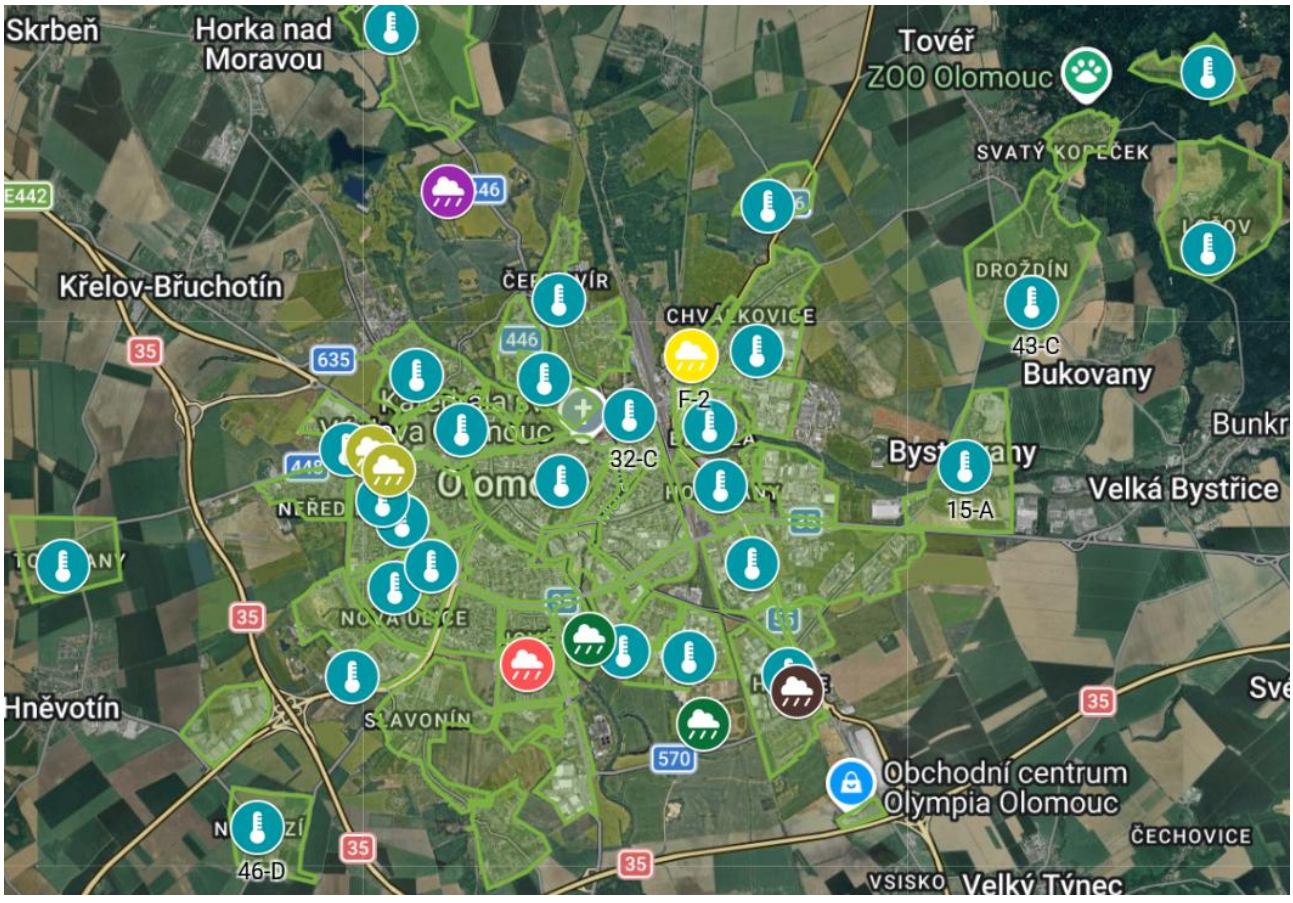



**Figure 2**: Overview of the whole city meteo sensing design

The climate sensing design is different from traffic sensing as the city itself can be covered by a limited set of sensing equipment and so the budget of the public procurement allowed for placing the equipment in the city territories which are out of the city itself (aka adjacent villages that are integral part of the city), see the map. This also enables to integrate more citizens claiming that the digitization is not just a city centre issue and it is supposed that these locations will have better climate change and heat island resilience that the areas in the city and so they can promote better living and attract new inhabitants.

**Table 5:** An overview of numbers of climate sensing equipment per a particular microzone

| The microzone name | No. of microzone | Coverage type | meteostation | Heat island sensor | pyranometer | Rain gauges |
|---|---|---|---|---|---|---|
| OC Haná | 7 | Z | 1 | 1 | - | - |
| Řepčín | 8 | Z | 1 | 1 | - | - |
| Hejčín | 9 | Z | 1 | 1 | - | - |
| Holice jih | 11 | Z | 1 | 1 | - | - |
| Nový svět | 12 | Z | 1 | 1 | - | - |
| Nová Ulice | 13 | Z | 1 | 1 | - | - |
| Bystrovany | 15 | Z | 1 | 1 | - | - |
| Hodolany | 18 | Z | 1 | 1 | - | - |
| Sladkovského | 20 | Z | 1 | 1 | - | - |
| Lazce D1 | 24 | Z | 1 | 1 | - | - |
| Černovír.Klášterní Hradisko | 26 | Z | 1 | 1 | - | - |
| Chválkovice | 27 | Z | 1 | 1 | - | - |
| Malého prince | 29 | Z | 1 | 1 | - | - |
| U Globusu | 30 | Z | 1 | 1 | - | - |
| Vojenská nemocnice | 32 | Z | 1 | 1 | - | - |
| Bělidla, Ondřejova | 35 | Z | 1 | 1 | - | - |
| Městský dvůr | 38 | Z | 1 | 1 | - | - |
| FNOL | 39 | Z | 1 | 1 | - | - |
| Radíkov | 42 | Z | 1 | 1 | - | - |
| Droždín | 43 | Z | 1 | 1 | - | - |
| Chomoutov | 44 | Z | 1 | 1 | - | - |
| Topolany | 45 | Z | 1 | 1 | - | - |
| Nedvězí | 46 | Z | 1 | 1 | - | - |
| Týneček | 60 | Z | 1 | 1 | - | - |
| Lošov | 61 | Z | 1 | 1 | - | - |
| Referenční stanice - Pevnost poznání | 22-REF | K | 1 | 1 | - | - |

| | | | | | | |
|---|---|---|---|---|---|---|
| Referenční stanice - Park Malého prince | 29-REF | K | 1 | 1 | - | - |
| Sever - Plané loučky | A | K | 1 | - | | |
| Jih - Holický les | D | S | 1 | - | 1 | 1 |
| Severozápad (NW) | E | S | - | - | 1 | 1 |
| Severovýchod (NE) | F | S | - | - | 1 | 1 |
| Jihozápad (SW) | G | S | - | - | 1 | 1 |
| Jihovýchod (SE) | H | S | - | - | 1 | 1 |
| **TOTAL** | | | **29** | **27** | **5** | **5** |

All the suitable poles have been selected and proposed in Table 6 which a print screen is provided below. Besides the priority for the deployment, it also provides the GPS coordinates, ID of the pole from the city asset management system, the number of the plot and cadastre area code, and finally the URL link to the google street view enabling suppliers to do the desk office preparation works.

**Table 6**: Suitable public lighting poles to deploy a meteostation

**Tabulka 6 – Seznam mikrozón a sloupů pro umístění meteostanic**

| Mikrozóna (ID) | Název | Priorita | Označení na mapě | Latitude (Y) | Longitude (X) | ID Sloupu | Pozemek | Kód katastrálního území | Odkaz |
|---|---|---|---|---|---|---|---|---|---|
| 7 | OC Haná | 1. | 7-A | 49,57356622110 | 17,22482239120 | 2917 | 1081/101 | 750387 | https://www.google.com/maps/@49.5735407,17.2247671,3a,75y,65.37h,70.87t/data=!3m7!1e1!3m5!1sgEg1U_TVCu1HUdIosJvgAA!2e0!6shttps:%2F%2Fstreetviewpixels-pa.googleapis.com%2Fv1%2Fthumbnail%3Fcb_client%3Dmaps_sv.tactile%26w%3D900%26h%3D600%26pitch%3D19.133511139560454%26panoid%3DgEg1U_TVCu1HUdIosJvgAA%26yaw%3D65.37084856936964!7i16384!8i8192?entry=ttu&g_ep=EgoyMDI1MDQwMi4xIKXMDSoJLDEwMjExNDUzSAFQAw%3D%3D |
| | | 2. | 7-B | 49.57404 38697059 | 17.22586 87047165 68 | - | 1081/5 | 750387 | https://www.google.com/maps/@49.5740629,17.2259074,3a,75y,229.02h,84.08t/data=!3m7!1e1!3m5!1sdoctnulAgTZ5mVSVKK2pzQ!2e0!6shttps:%2F%2Fstreetviewpixels-pa.googleapis.com%2Fv1%2Fthumbnail%3Fcb_client%3Dmaps_sv.tactile%26w%3D900%26h%3D600%26pitch%3D5.916460581608547%26panoid%3DdoctnulAgTZ5mVSVKK2pzQ%26yaw%3D229.02305033855691!7i16384!8i8192?entry=ttu&g_ep=EgoyMDI1MDQwMi4xIKXMDSoJLDEwMjExNDUzSAFQAw%3D%3D |
| | | 3. | | | | | | | |
| 8 | Řepčín | 1. | 8-E | 49,60525225030 | 17,23511470530 | 6874 | 341/24 | 710644 | https://www.google.com.au/maps/@49.6050599,17.2357181,3a,15y,301.35h,90.22t/data=!3m7!1e1!3m5!1sjcu77QQsKNsXCf8-UykZ6Q!2e0!6shttps:%2F%2Fstreetviewpixels-pa.googleapis.com%2Fv1%2Fthumbnail%3Fcb_client%3Dmaps_sv.tactile%26w%3D900%26h%3D600%26pitch%3D-0.22453140335116473%26panoid%3Djcu77QQsKNsXCf8-UykZ6Q%26yaw%3D301.3460050367951!7i13312!8i6656?entry=ttu&g_ep=EgoyMDI1MDMzMS4wIKXMDSoASAFQAw%3D%3D |
| | | 2. | 8-A | 49,60804577300 | 17,23413671670 | 6860 | 1029/22 | 710946 | https://www.google.com.au/maps/@49.6080673,17.2340262,3a,75y,74.61h,89.53t/data=!3m10!1e1!3m8!1s9wQLjo4G4AKg5W_4QEanIA!2e0!6shttps:%2F%2Fstreetviewpixels-pa.googleapis.com%2Fv1%2Fthumbnail%3Fcb_client%3Dmaps_sv.tactile%26w%3D900%26h%3D600%26pitch%3D0.4651852382688026%26panoid%3D9wQLjo4G4AKg5W_4QEanIA%26yaw%3D74.61128060945742!7i16384!8i8192!9m2!1b1!2i36?entry=ttu&g_ep=EgoyMDI1MDMzMS4wIKXMDSoASAFQAw%3D%3D |
| | | 3. | 8-C | 49,60561451180 | 17,23509095210 | 6869 | 341/3 | 710644 | https://www.google.com.au/maps/@49.6056545,17.2351049,3a,75y,164.21h,81.37t/data=!3m10!1e1!3m8!1sTj3MitzB2HPC8Wpcl_uyGg!2e0!6shttps:%2F%2Fstreetviewpixels-pa.googleapis.com%2Fv1%2Fthumbnail%3Fcb_client%3Dmaps_sv.tactile%26w%3D900%26h%3D600%26pitch%3 |

The background measurements are supported by special sensing, i.e. rain and solar radiation, covering the different parts of the city for which some suitable schools' roofs have been selected, see extract from table 7.

**Table 7:** Extract from the overview of the special sensors

**Tabulka 7 – Seznam lokalit pro nasazení pyranometrů a dešťoměrů na střechy škol, výběr jedné lokality pro zóny E, F, G a H**

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| E | 1. | Severozápad | Fakultní základní škola Olomouc, Tererovo nám. | Střecha | SMOL | 49.5950466 | 17.2306936 | 1027/0 | 710717 | Tererovo nám. 919/1, 77900 Olomouc Nová Ulice |
| | 2. | Severozápad | Mateřská škola Olomouc, Helsinská 11 | Střecha | SMOL | 49.5972001 | 17.2277946 | 278/0 | 710687 | Helsinská 256/11, 77900 Olomouc Neředín |
| F | 1. | Severovýchod | Základní škola a Mateřská škola Olomouc, Gorkého 39 | Střecha | SMOL | 49.607099 | 17.279500 | 116 | 710938 | Gorkého 96/39, 77900 Olomouc Pavlovičky |
| G | 1. | Jihozápad | škola dr. Milady Horákové a Mateřská škola Olomouc, Rožňavská 21 | Střecha | SMOL | 49.5748067 | 17.2966063 | 5/4 | 710814 | Rožňavská 728/21, 77900 Olomouc Nové Sady |
| H | 1. | Jihovýchod | Základní škola a Mateřská škola Olomouc – Holice, Náves Svobody 41 | Střecha | SMOL | 49.5719006 | 17.2966063 | 3/0 | 641227 | Náves Svobody 218/41, 77900 Olomouc Holice |

The table contains info on different coverage of the city ("zones" E, F, G, H representing geographical locations covering all the city, see the bottom of the table 5), the name of the school with the address, the GPS coordinates, the number of the plot and cadastre area code, and the address.

For each zone a set of suitable roofs and schools have been designed to provide alternatives for the deployment. Only zone E (North-East) has two suitable options after the city negotiations, the other options have been excluded by the city.

### 1.1.5. Sensor data

Based on the experience from the Olomouc pilot action the requirements for open data from sensor networks for the public procurement has been formulated. These requirements can be considered as a good practice for any public procurement on open data from sensor networks in any CE city. It requires a supplier not just to deploy and operate the sensor network but also to provide assistance to the use of open data by third parties or at the hackathons.

The terms are as follows *(the arguments in the two paragraphs below reflect the requirement of the funding scheme focusing on improved and smoother mobility by deploying intelligent transport systems)*:

Data from sensors is anonymized by default and will be made available for publication on the Olomouc Open Data Portal (opendata.olomouc.eu), where it will be accessible to the general public, developers, institutions and companies. If the supplier chooses other detection technologies in the field of transport, they shall document their technical parameters with regard to the GDPR and personal data protection, and provide any relevant permits.

The extension of this open data catalogue with new data sets will contribute to increased transparency and support the innovative use of transport information. The city will thus enable third parties, including technology companies, academics, and civic initiatives, to use this data to develop new applications, advanced analytical tools, and predictive models that can improve transportation, increase the efficiency of urban mobility, and contribute to more environmentally friendly and smoother traffic flow.

**List of features related to data processing:**

- **Unified data collection** (the supplier will operate databases with live data and resolve incidents related to connectivity or detection accuracy)
- **Data aggregation and transformation** (the supplier will operate a database with calculated short-term and long-term statistics in order to provide data analysis tools with good response times; this involves calculated data for individual traffic profiles, microzones, and climate points in 15-minute aggregation, i.e., "logical elements" will be created that combine several real elements—one traffic

profile consists of N detection sensors, one climate point consists of N detection sensors—this step contributes to the continuity of data series and thus addresses the need to replace malfunctioning sensors)

- **Online communication** (the supplier will operate a public website with city branding)
- **Integration API** (the supplier will operate a data registry with metadata descriptions and API documentation for the collection of published data; the API should comply with standard formats and specifications such as OpenAPI (https://www.openapis.org/))
- **Centralized device management** (the supplier will operate a register of sensing devices with the option to export a list of devices and their locations, which could be used by the administrator of the region's digital technical map; changes over time (i.e., replacements, repairs, preventive maintenance, etc.) must also be recorded)
- **Device status monitoring** (the supplier will operate a system monitoring the operational status of devices and, in the event of malfunctions, will inform data subscribers and the public)
- **Big data support and advanced configuration tools** (the supplier will operate a helpdesk as a service to potential customers, recording their requests and possible solutions to their needs, which may give rise to new dashboards or data sets; the supplier will keep a list of data customers, user roles, and permissions)
- **Open data** (the supplier, in cooperation with the city, will publish selected aggregated data on the city's open data portal and also publish it in the national catalogue)
- **Reports and statistics** (the supplier will operate a public dashboard with sample data and reports and will prepare a brief report for the city once a year containing quantitative and qualitative parameters of the system as feedback on the operation of the system)
- **City hackathon partnership** (the supplier will actively participate in the annual hackathon and will provide assistance for the use of sensor data by competitors)

In addition to the above-defined functionalities, sensor data is also visualised through operational dashboards implemented using the Grafana platform. These dashboards are used for monitoring and analysis of time-series data (traffic intensity and climate measurements) and enable near real-time inspection of sensor outputs.

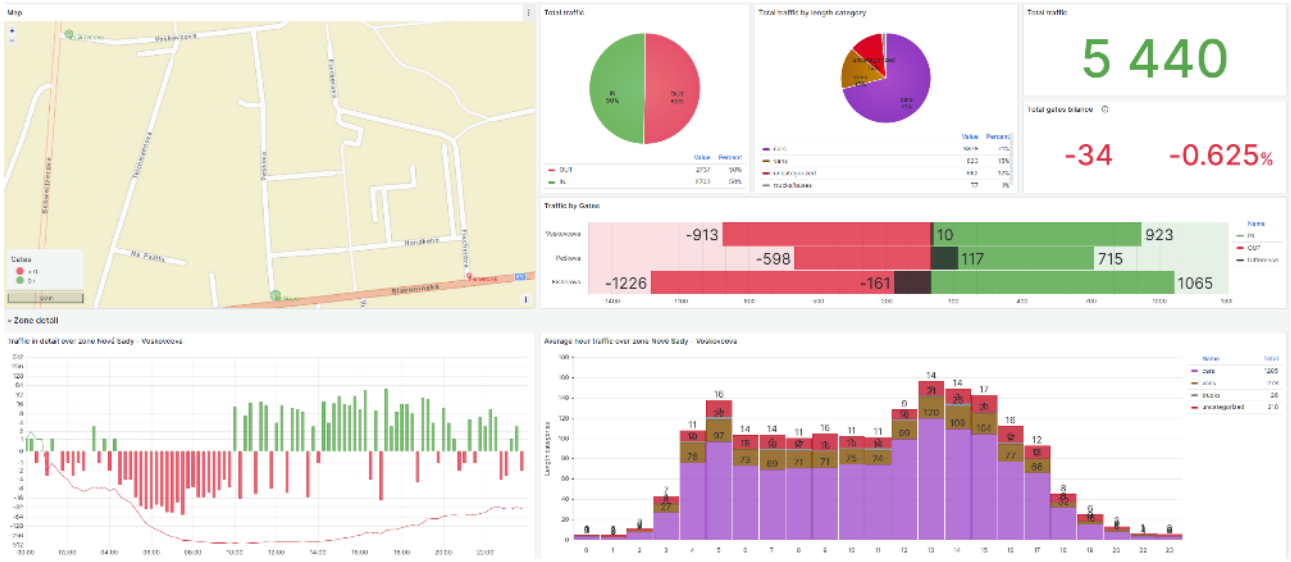



**Figure 3**: Grafana dashboard displaying traffic intensity data from the sensor network

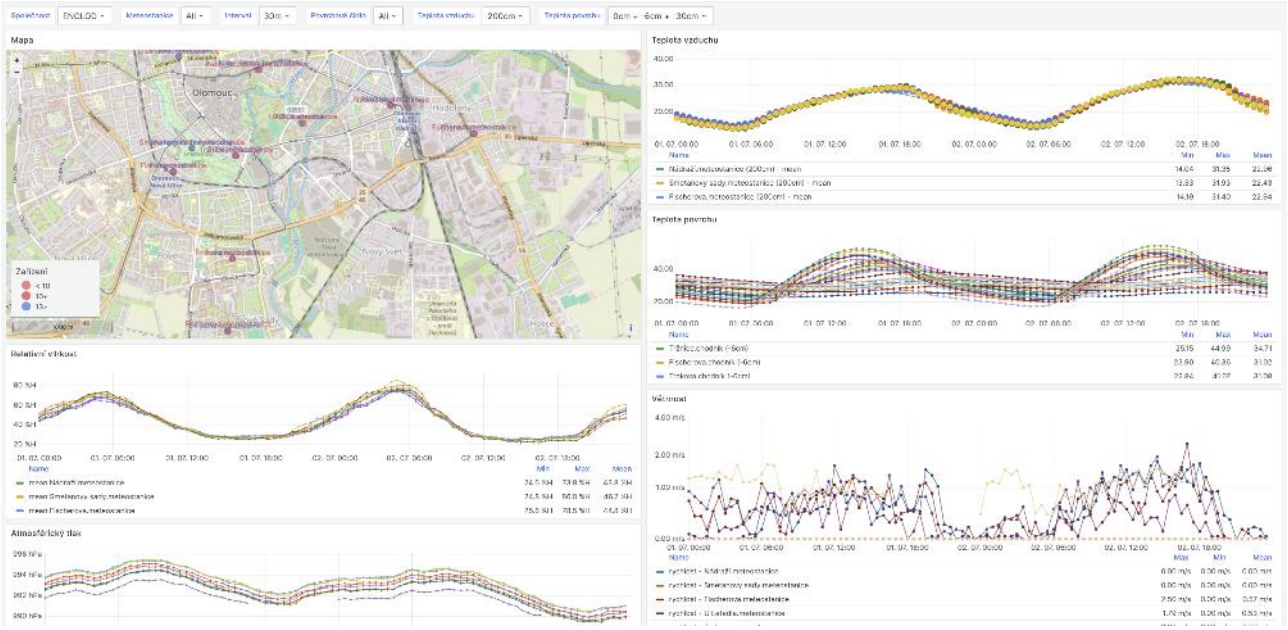



**Figure 4:** Grafana dashboard showing temperature measurements from urban climate sensors

### 1.1.6. Microzoning

For the purposes of open data application and transport geofencing design, it is necessary to divide the city into smaller territorial units (so-called microzones) with the potential for independent strategic planning using static and dynamic open data. The definition of these units is a key prerequisite for obtaining relevant and usable results by combining sensory, socioeconomic, demographic, and other indicators.

The basis for defining microzones is the use of the existing administrative division (in the case of the pilot city of Olomouc, these are basic settlement units (ZSJ)). A basic settlement unit is a unit representing parts of a municipality with unique territorial, technical, and urban conditions or catchment areas of groups of residential or recreational buildings.

Microzones are a concept that solves the problem of data collection for spatial planning in universal logic. It divides the municipality into zones, which allows all available data for individual zones to be used or recalculated directly to create a parametric comparison. The design of microzones is also a prerequisite for the design of IoT sensor placement for transport geofencing or the aggregation of more sensitive data, such as water or energy consumption.

The pilot action and the follow-up public procurement preparation have provided a unique opportunity to investigate the concept of microzoning design in a more detailed way with the following conclusions:

- **Zones can be of various sizes**, but census data units should be respected (each census unit should ideally belong to only one microzone).
- **Zones are designed according to transport logic**; i.e., there are natural boundaries such as rivers (bridges), other physical barriers such as railways or main roads in the city (collector roads), and neighbouring municipalities are individual zones.
- **IoT climate sensors are designed holistically**, so that one sensor can serve multiple zones (e.g., weather stations, rain gauges, solar radiation data, etc.).
- **Traffic detectors are located to cover the entrances and exits of the zone**, thus ensuring "traffic geofencing" of the zone. This can be done by physical placement at the entrances/exits to the zone or by calculation from the profiles of the main roads located at the zone boundary.

- **Microzones are also used for data aggregation**. This is particularly necessary for sensitive data such as water or energy consumption. Such data is a prerequisite for planning investments in green transition. Obtaining it can be challenging and may require changes to the microzone design.
- **The existing zoning concept** provided by the "National Statistics Office" **is very rigid** and does not reflect reality. Some of the field territories have become built areas and so the actual zoning, used for statistics, does not work anymore as they, for example, have become half the field half the built area. The microzoning concept overcomes these shortcomings and divides the city into functional parts that can be dynamically adjusted based on the real development of the city.
- **The traffic logic also helps to identify the existing zoning (for the statistics) that should be divided or merged**. The adjacent areas may be considered as one whole but they should be divided because they are accessible by different roads, see the example below for updating the microzones in Olomouc pilot action
- From the sensor deployment point of view, it is wise **to avoid small microzones** as these generate the unnecessary demand for more sensors which are not generally needed.




**Figure 5**: The former microzones design

Figure 5 represents the former design, used for the EnCLOD guidelines (i.e. design of microzoning for the Olomouc pilot action), showing an example of Commercial type of the zone (on the left Mikrozóna Baumax Holická) and Industry area (Mikrozóna Nestlé on the right) designed based on National Statistics zoning which has been investigated and evaluated as wrong.

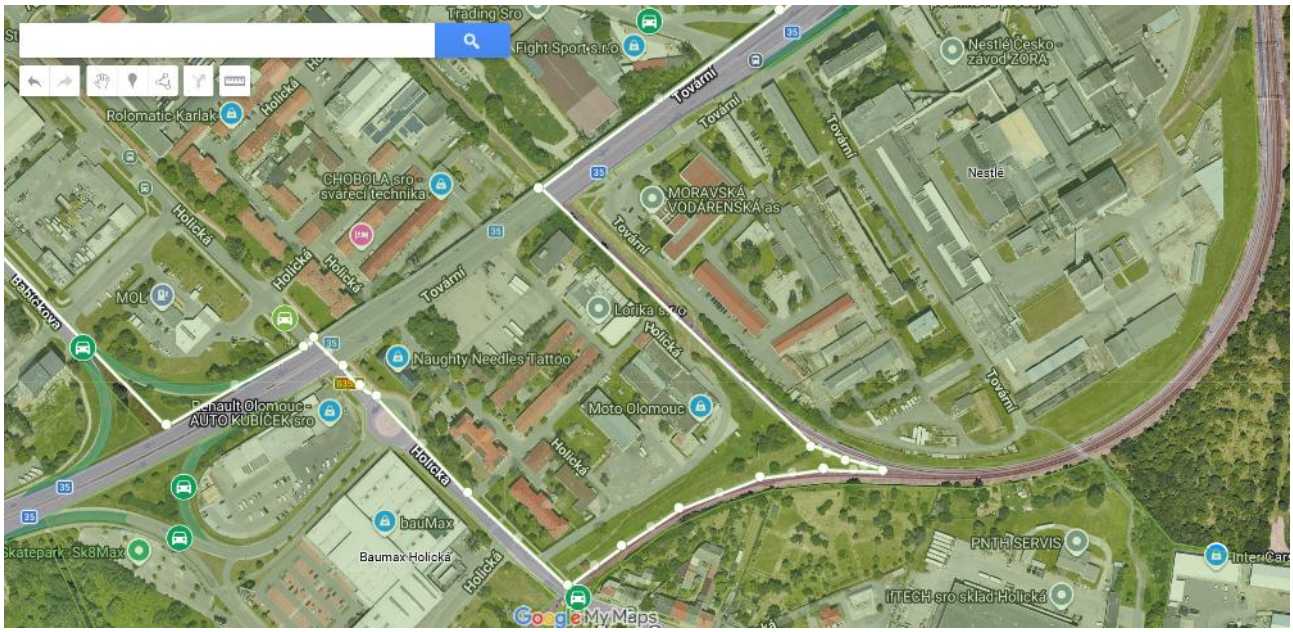



**Figure 6**: Updated microzones design

The natural (and new and right) division of the microzones is considered by:

- **traffic accessibility** (the ringroad Holická near Baumax is accessible by the road underneath the main road heading from the zone Kosmonautů which is at the North/on the other side of the main road). The microzone Nestlé is accessible from the North (another road than Holická) only and there is no direct traffic connection from Nestlé to Baumax zone as they are divided by the rail.
- **their function** (the main road just divided the former single built area as the nature of buildings corresponds to the North section, the microzone Kosmonautů), so the official zone Nestlé should be diminished, and this part of the territory should be merged with Kosmonautů microzone with the same function as there are connected under the bridge.

So, the result is that the area between Microzones Baumax and Nestlé has been divided from Nestlé and merged with Kosmonautů as they are accessible by the same road.




**Figure 7:** Microzone U Panelárny

Another example of the zones defined by National Statistics Office in 1970s on areas that have already been developed and so they should be adjusted; so, the green microzone U Panelárny which is an industry zone should cover also the area not covered by any zone (the industry area on the right) which still statistically belongs to another zone (fields). So, the microzone logically extended the zone with the rest of the industry area.

This detailed description of an advanced discussion on correct design of microzones illustrates the difficulty of the design. The team has tried to formulate the above principles of the design to enhance such works in other cities. With the vision of AI tools enhancement in territorial governance and also profiting from sharing developed tools and apps from other cities, the cities can be motivated to use the same logic as well as the same concept of IoT sensing deployment.

Such a vision enables to formulate the final recommendations for the potential followers and can provide cities with answers on how many sensors, which type and where to deploy as well as illustrate **the following benefits:**

**Open data registry based on microzoning as an ArcGIS environment**

The microzoning concept has been further operationalised in an ArcGIS-based dashboard environment, where individual microzones are enriched by a set of integrated indicators. These include demographic structure, transport infrastructure, technical networks, environmental characteristics, civic amenities, economic entities, housing stock and selected urban climate variables derived from sensor measurements. The dashboard enables comparison of individual microzones and supports spatial analysis combining static open datasets with dynamic sensor data.

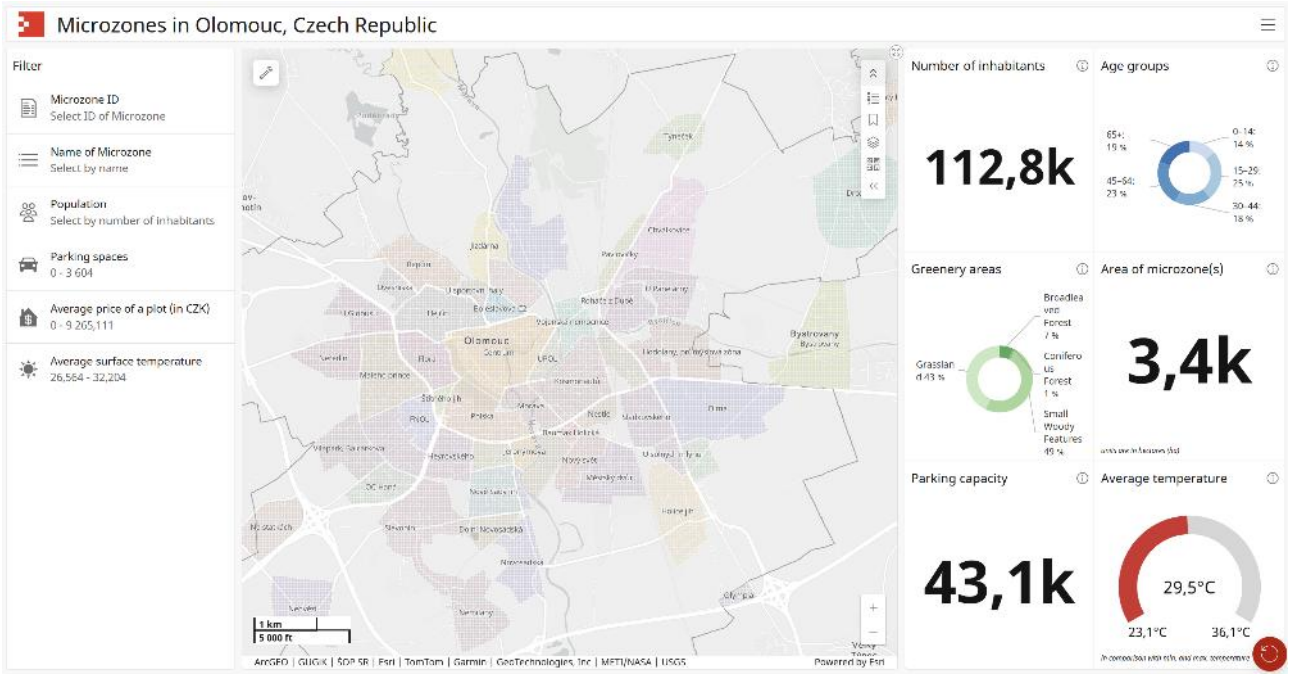



**Figure 8:** Overview of the ArcGIS dashboard environment

https://www.arcgis.com/apps/dashboards/71442d500c424230b0b917e8363a7d1d

# F. Data-driven governance: Pilot first findings

**Dedicated tools**

As a follow-up output of the pilot action, a dedicated digital tool was developed to analyse urban heat island effects based on sensor data. The tool enables comparison of selected locations and supports interpretation of temperature differences measured at different heights and surface types. It represents an application layer built on top of the collected and published open data. The tool is available at https://iot.citiq.cloud/dashboard/environmental/heat-islands.

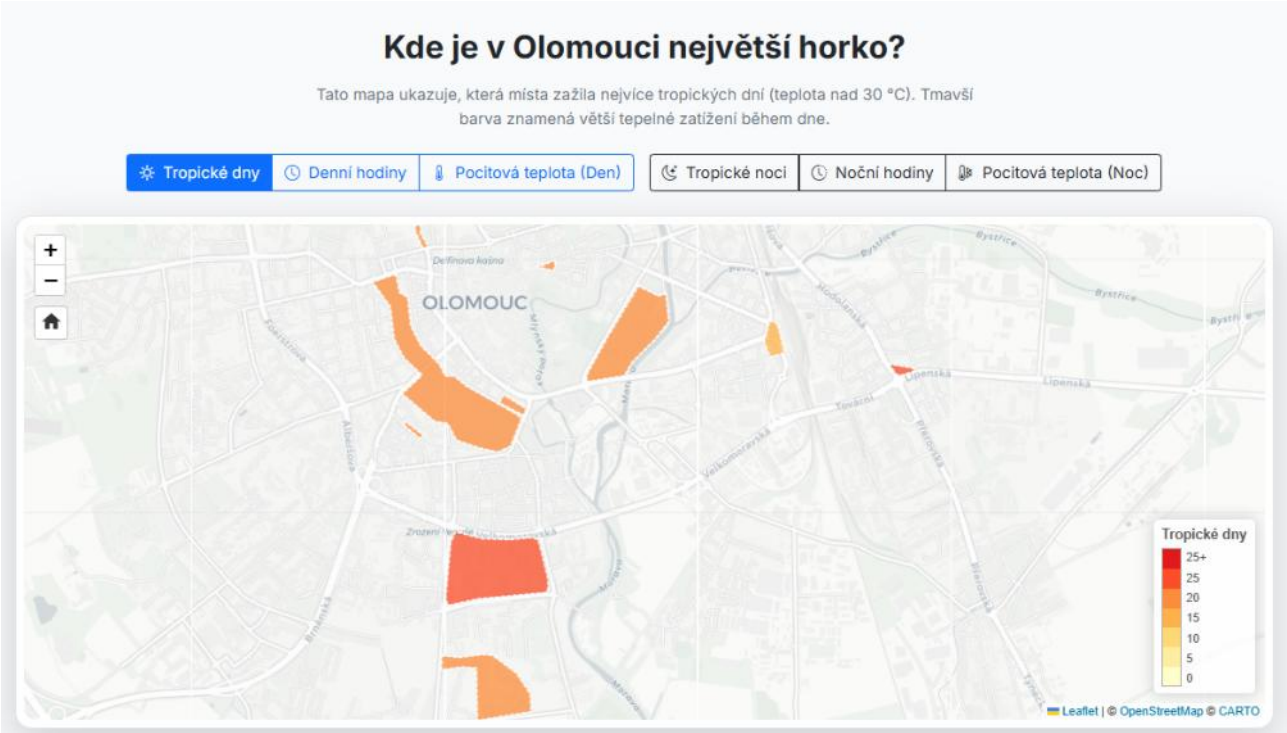



**Figure 9:** Digital tool for analysing urban heat island effects based on sensor data collected within the pilot action (the screen for Tropical days, where is the most heat in Olomouc?)

**An analysis by an AI interaction**

A 3-page analysis for a particular issue has been generated by an AI tool to illustrate the power of the digital twin. A user with access to static open data along with open data from sensor network can create an analysis by himself/herself or an expert within minutes/hours.

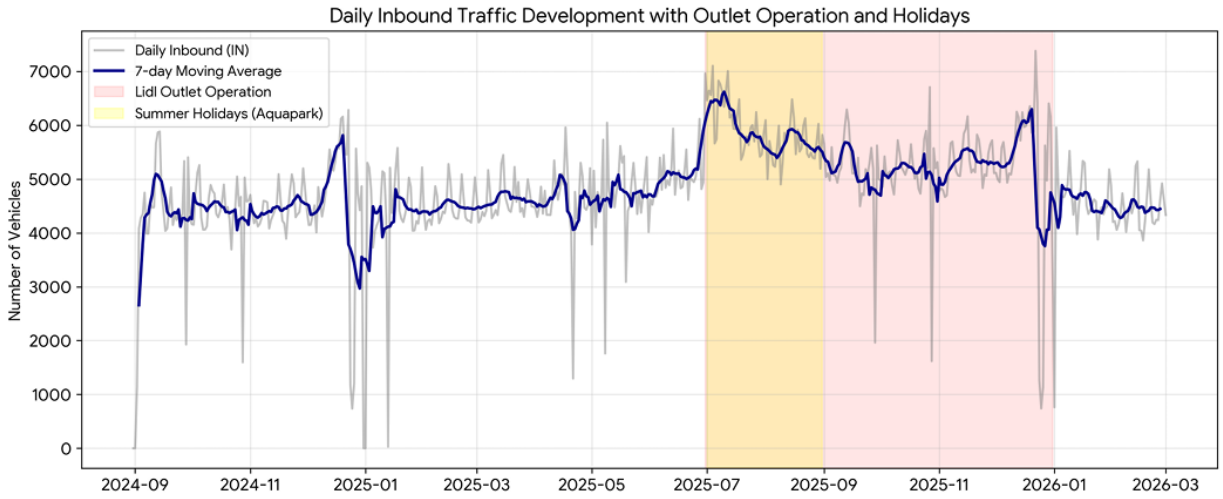



Figure 1: Time series of inbound vehicles with a 7-day moving average. The operating time of the Lidl Outlet (red) and the summer holiday period for the aquapark (yellow) are indicated.

The AI generated analysis, made by PP4 CITIQ and PP6 CityOne, and enclosed to the report as a single document, *"analyses daily traffic volumes at the Olomouc-Kafkova profile to quantify the impact of the temporary opening of a **Lidl Outlet store**, which operated from June 30, 2025, to December 31, 2025. Since the analysed profile is the only access road to the given zone without the possibility of transit traffic, the data reliably reflects the attractiveness of local destinations. In addition to the Lidl Outlet, an aquapark and other commercial entities are present in the zone, which was taken into account in the analysis. The results show that the opening of the Outlet significantly increased the traffic load in the area (on average by more than 18% compared to the autumn period without the Outlet). After its closure at the end of 2025, traffic volumes steadily returned to their previous normal levels."*

This benefit illustrates the very sense of the project EnCLOD – **to enhance territorial governance by digital tools using open data from sensor networks.**

**Relations between Parking Occupancy and Urban Heat Island Phenomena**

In general, the data collected through the Pilot Action confirmed the general assumption that large parking areas often represent urban heat island hotspots, while also demonstrating that each location requires a different planning approach depending on its actual use, ownership and redevelopment stage. For example:

- The monitored shopping mall parking area (approximately 1,000 parking spaces) was identified as a significant heat island, although its occupancy generally remained below 50% and never exceeded 80%. This indicates that around 150 parking spaces could potentially be converted into green infrastructure without negatively affecting parking availability, contributing to heat island mitigation.
- Residential parking areas showed a very different pattern. Parking occupancy reached up to 98–99% and never fell below 60%, confirming a consistently high demand for residential parking. At the same time, these areas exhibited relatively favourable climatic conditions compared with other monitored locations, providing additional evidence supporting the planned residential parking regulation and offering objective data that could strengthen communication with citizens.
- All monitored visitor parking areas were also identified as heat islands, but with substantially different occupancy rates and planning contexts. The collected data therefore support different policy options depending on local conditions. For example, one parking area close to the city centre

was found to be only around half occupied despite plans for constructing an additional parking structure nearby, suggesting that the actual demand may not justify the proposed investment. In other locations, the data can support the redesign or renovation of public spaces by identifying opportunities to introduce additional greenery while maintaining the required parking capacity.

- The monitored urban park demonstrated that even relatively small asphalt surfaces within otherwise pleasant green environments can accumulate temperatures that may expose children and pets to potentially harmful conditions. Making these measurements publicly available through the project's Open Data platform and dedicated dashboard contributes to raising awareness of urban heat island effects and encourages more informed public discussion on climate adaptation measures.

Overall, the Pilot Action demonstrated that integrated environmental and mobility data can significantly improve the evidence base for urban planning and governance.

While the practical implementation of parking policy or redevelopment measures depends on ownership, ongoing investment projects and political decisions, the Pilot successfully showed how objective, comparable and openly available data can support better-informed decisions, improve communication with stakeholders and citizens, and identify where climate adaptation measures can be implemented without compromising mobility needs. The practical value of this approach is already reflected in the City's decision to expand the monitoring network from the initial 10 pilot locations to approximately 40 sites as part of its future digital twin, building directly on the methodology and lessons learned developed through the EnCLOD Pilot Action.

# G. Summary of lessons learned and recommendations

**Legend:** ID: unique identification number, like Olomouc lesson learned 1, i.e. OL1;

- typology: G or T (Governance/Technical);
- brief description: a short text on the topic of the lesson learned (i.e. two sentences);
- final recommendation: 1 sentence;
- 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 |
|---|---|---|---|---|
| OL0 | G | Multilevel and multisector territorial governance can be enhanced 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 socioeconomic surveys | C, R |
| OL1 | G | For the purposes of open data application and transport geofencing design, it is necessary to divide the city into smaller territorial units (so-called microzones) with the potential for independent strategic planning using static and dynamic open data. Microzones are a concept that solves the problem of data collection for spatial planning in universal logic. It divides the municipality into zones, which allows all available data for individual zones to be used or recalculated directly to create a parametric comparison. The design of microzones is also a prerequisite for the design of IoT sensor placement for transport geofencing or the aggregation of more sensitive data, such as water or energy consumption. | Start city open data strategy with dividing the city into **microzones** and compute existing open data within an **ArcGIS tool** and add any local surveys and research data and collect them regularly**; Identify practical use cases** that should be the trigger points of the strategy (challenges the city is facing) | C, R |
| OL2 | G | The holistic approach, i.e. providing technical terms for IoT sensing to cover a whole city, has been evaluated as the most promising and we recommend the procedure of not solving particular places but to design a whole city first (along with the microzoning) and then deploy a pilot. | Follow with working out a strategy on city sensing as **a holistic city-wide design** of climate and traffic sensing and pick up a location for a pilot to get real data as well as real cost and as such possible inputs for the scale-up. Each microzone should be described by **a list of traffic profiles** to see how many should be covered by the supplier. | C, R |
| OL3 | G | The governance level for open data agenda is crucial as it may flourish only | Create and support **a local ecosystem of open data,** | C, R |

| ID | Typology | Brief description | Final recommendation | For whom |
|---|---|---|---|---|
| | | if a local ecosystem of cooperation is found. From the governance point of view the local ecosystem and common understanding are the crucial features to co-design a city-wide digital twin. | integrating the cooperation of the city, the region and the university with other potential stakeholders | |
| OL4 | T | The benefits of wide area sensing can be big, providing time and money savings, digital literacy, supporting local innovative ecosystems and profiting from evolving AI features. All this can serve for an improved, wiser and faster investment projects development with higher quality of public space. Open data can support such things but it should be reliable and trusted to motivate entities to develop the tools based on that. | **Prepare a public procurement** along with the available budget considering the scale of IoT sensing, the industrial quality of sensors (no hobby devices for hundreds of EUR) as well as the long-term provision of open data to make the data reliable and trusted as you want to enhance territorial governance and digitization, support the use of open data by a third party and within hackathons is an obligatory condition for the sensor network supplier | C, R |
| OL5 | T | Providing sensors and data is not enough, you should require the supplier to deliver long term open data services and support (even a help desk) | **Require a supplier to deliver these open data services:** Unified data collection in 15min granularity, Data aggregation and transformation, Online communication, Integration API, Centralized device management, Device status monitoring, big data support and advanced configuration tools, publishing open data on a data portal, Reports and statistics and City hackathon partnership | C, R |
| OL6 | T | Own connectivity may be an operation burden so if there are private services, use them as you make your project faster and you can focus on deploying the sensors right. In the Czech Republic a national service for LoRawan connectivity is provided which makes it significantly easier than to deploy own communication infrastructure (gateways). | **Use already existing connectivity coverage** if there is one and do not prescribe the connectivity types - let the suppliers pick the right one for their technical solutions. | C, R |
| OL7 | T | The climate sensing design is different to traffic sensing as the city itself can be covered by a limited set of sensing equipment so placing the equipment at the city territories which are out of the city itself (aka adjacent villages that are | **Prioritize to deploy the sensors on the city assets** to make the permission process faster and easier, **respect limits** of historical protection, **use schools´ roofs** (or other city assets) in prior as the | C |

| ID | Typology | Brief description | Final recommendation | For whom |
|---|---|---|---|---|
| | | integral part of the city), is preferable. This also enables to integrate more citizens claiming that the digitization is not just a city centre issue and it is supposed that these locations will have better climate change and heat island resilience that the areas in the city and so they can promote better living and attract new inhabitants. | main audience should be children and their parents and deploy sensing in adjacent villages to engage more citizens | |
| OL8 | T | The design of the climate part of sensor network is divided into: **the basic part** (weather station with wind measurement supplemented by surface and subsurface temperature measurement), representing the functional minimum of the digital twin being built, **the reference part** (background measurement), which must be built together with the basic part, **the special part** (rain measurement, solar radiation, etc.) and if possible an **extended part** focusing on special heat island places (industry zones, shopping malls etc.). | **Design climate part of the sensor network in four different parts/layers:** basic, reference, special and extended. Basic, reference and special layers are complementary and so procure them together. | C |
| OL9 | T | **Deploying meteostations** is not an easy task; provide a map of public lighting poles that are suitable for meteostation placement | **Provide a map of public lighting poles** that are suitable for meteostation placement, use GIS data layers to filter those poles that are not near walls or other barriers or areas where vehicle movement is limited (the wind should be as natural as possible) and **provide public procurement with the list of suitable poles**. | C |
| OL10 | T | Heat islands are not perceived as a health risk by residents. To enhance the communication, it is recommended to measure temperatures for adults (2m), kids (80-110cm), pets/ near surface temperature (0cm) and accumulated heat in two depths (-6 and -30cm) | **Climate sensing** requires to measure accumulated heat so deploy meteostations along with heat island sensors to **have 5 depths of temperature**, this should be a default set of climate sensing for the city. | C |
| OL11 | G | Without a local ecosystem the open data agenda will not thrive, and the benefits will be lower. Regular hackathon organization is one of the key agendas of the city digitization. | **Organize annual hackathons** with different topics promoting the use cases/challenges of the city, inviting key stakeholders including national digital agencies | R/C |

| ID | Typology | Brief description | Final recommendation | For whom |
|---|---|---|---|---|
| OL12 | G | Regular events and open data sets repositories are basics for long term, reliable and trusted open data, the prerequisites for development of advanced digital tools enhancing territorial governance. These activities require promotion at least on a national level. | **Publish the open data** on the city/region open data portal and also on national open data portal to promote their existence | N/R/C |
| OL13 | G | Sharing good practice can significantly increase the pace of digital transition, not just sharing tools but to share experience from their 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 your local ecosystem, you will help your innovative companies to thrive. | N/CE |
| OL14 | G | The valuable political and academia support has been gained as the vision of a digital twin and its benefits could be communicated via potential improvements and savings, as well as potential research, education and local digital economy support. | **Communicate the digital twin** and its benefits via potential improvements and savings, as well as potential research, education and local digital economy support. | N/CE |
| OL15 | G | The administration burden in investments is a major issue in EU competitiveness as well as Green Deal/green and digital transition projects, along with wiser project management (joint/collective investments) and consensus and public participation (NYMBY and other phenomena) | **Support open data and data from sensor network on national level by a distinguished funding scheme** to enhance digitization of cities, use of AI in urban planning as a supportive element of EU competitiveness and Green Deal agendas | N/EU |
| OL16 | 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 literacy, test data usability and support the local innovation ecosystem. | **Integrate open and sensor data into university education** and support student involvement through courses, theses and hackathons as a natural component of the open data ecosystem. | C/R |