Interreg CENTRAL EUROPE

Co-funded by the European Union

EnCLOD

D2.4.2
Nova Gorica Pilot Action report & lesson learned

City of Nova Gorica

Version 2

08 2026



TABLE OF CONTENTS

0

A. Executive Summary 2

B. Introduction 4

C. Key info on the Pilot Action 5

D. City Open Data strategy inputs - governance level 8

1.1.1. Open data agenda in the pilot area 8

1.1.2. Future goals after the Pilot Action 8

1.1.3. Key stakeholders 9

E. City Open Data strategy inputs - technical level 10

1.1.4. Sensor placement/deployment 10

1.1.5. Sensor data 11

1.1.6. Microzoning 12

F. Data-driven governance: Pilot first findings 15

G. Summary of lessons learned and recommendations 17

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A. Executive Summary

Nova Gorica had to address a clear governance challenge within the EnCLOD project. Although the city had long been facing air quality problems, particularly high ozone levels during summer and episodes of particulate pollution in winter, the information available to understand these phenomena was limited. Before the project, only one official air quality station was in operation, and there was no continuous system to monitor traffic flows and their relationship with pollution. At the same time, the city was preparing to host the 2025 European Capital of Culture, an event expected to attract thousands of visitors and significantly increase mobility pressures. The 2025 title was a cross-border one, held jointly by Nova Gorica and Gorizia in Italy (GO! 2025), so the programme, the audiences and the additional traffic were spread across both cities. This is also the shape of the challenge itself: Nova Gorica is a city in its own right, but together with Gorizia and Šempeter-Vrtojba it forms a single functional urban area with one road network and one shared air basin, divided by a state border that neither traffic nor air pollution respects.

To better understand these challenges and support future decisions, the pilot action introduced a more structured system for collecting traffic and air quality data across the city. A network of budget-friendly sensors was gradually deployed to monitor both traffic and air quality, with particular attention to busy intersections, event venues, main traffic areas and other strategic locations. ***The resulting monitoring infrastructure combines 24*** *traffic sensors, 7 air-quality sensors and a reference meteorological station, providing continuous information on traffic flows, vehicle categories, particulate matter and local weather conditions. Traffic sensors were deliberately placed at the former border crossings as well (Erjavčeva-Via S. Gabriele, Rožna Dolina-Casa Rossa, Solkan-Via del Monte Santo), which today are freely passable, so the network measures the flows between the two halves of the cross-border urban area and not only traffic internal to Nova Gorica. All devices were installed on the Slovenian side, because the network is owned by the Municipality of Nova Gorica; the cross-border dimension comes from where the measurement points are placed, from the air basin the two cities share and from open publication of the data, and not from hardware on the Italian side. The data collected was made openly available, allowing public authorities, researchers, students, companies and citizens to access and reuse it, while creating the basis for more evidence-based policymaking on mobility and air quality issues.*

The experience demonstrated that reliable information can be generated without relying exclusively on expensive monitoring infrastructure*. The combination of different technologies and the use of existing communication networks made it possible to achieve broad territorial coverage and continuous data collection. The pilot also showed the usefulness of adopting a holistic approach, bringing together traffic and environmental information instead of treating them separately, which made it easier to identify local pollution patterns and understand when and where interventions may be needed.*

One of the most interesting findings concerned the patterns of air pollution. Measurements revealed that pollution episodes are often short and highly localised, with significant peaks concentrated at specific places and times, while overall air quality remains relatively good during most of the day. These observations suggest that targeted and place-specific measures may be more effective than broad interventions. Because air masses move continuously across the conurbation, an episode recorded in Nova Gorica also describes conditions in Gorizia, and the other way round, whatever the location of the source. This is one of the reasons why all measurements are published as Open Data: both municipalities, civil society organisations and citizens on either side can consult and compare the same data, which makes it easier to trace the origin of pollution and to respond to it in a coordinated way, without a bilateral agreement having to be concluded first. The integrated analysis of traffic, environmental and meteorological data is also providing the first evidence base for the preparation of Nova Gorica's Air Quality

Plan, allowing the municipality to identify local pollution hotspots, establish a reference baseline and design future mobility and environmental measures on a more objective basis.

Several lessons emerging from the pilot may be valuable for other cities and territories. The project highlighted the importance of strategic sensor placement, stakeholder cooperation and flexibility during implementation, as some planned locations had to be adapted to practical constraints. It also confirmed that low-cost technologies, if properly calibrated and combined with Open Data principles, can provide valuable evidence for urban policies. In this pilot, the micro-zoning approach adopted by all project pilot territories was applied in a cross-border context, taking into account the shared urban system and mobility flows of a city divided between Nova Gorica (Slovenia) and Gorizia (Italy). Cross-border cooperation in the pilot took place mainly through joint events and direct working contacts: the public event on air quality in the Goriška/Gorizia area and the open data hackathon brought together participants from both sides of the border, a meeting with a representative of the Municipality of Gorizia and with the Italian environmental organisation Legambiente was held in in the premises of the Gorizia municipality, and the representative of EGTC GO was kept informed of the activities and attended EnCLOD public events and workshops. The clearest lesson is that joint events are the fastest route to cross-border data exchange.

Overall, the pilot provides a replicable example for cities seeking practical ways to connect mobility management, air quality monitoring and Open Data in support of healthier and more sustainable urban development.

B. Introduction

The Nova Gorica Pilot Action within the EnCLOD project focuses on strengthening data-driven territorial governance through the deployment of an urban sensor network measuring traffic and air quality followed by the publication of the open data related to it. The initiative responds to the city's need for improved monitoring of mobility patterns and environmental conditions, particularly in the context of increased activity associated with the European Capital of Culture 2025. Prior to the project, the city had only a single official air-quality monitoring station and no continuous local traffic counting system, limiting the ability to understand the relationship between mobility patterns and environmental impacts.

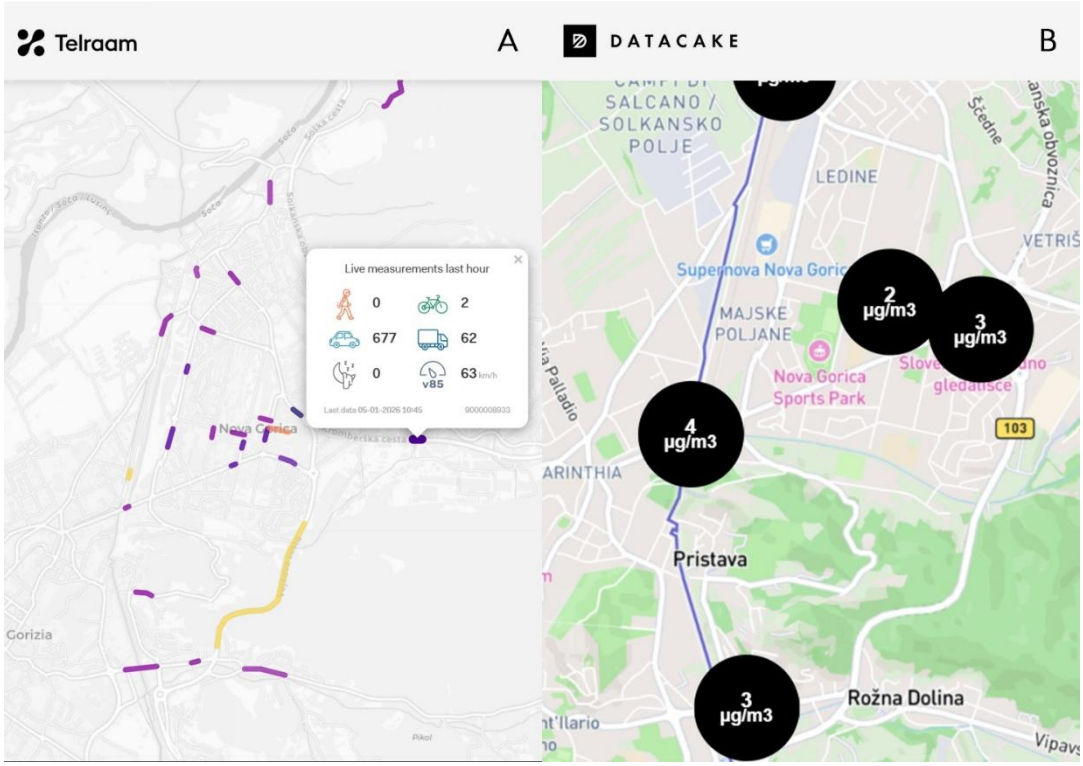
To address these gaps, the pilot implemented a network of Internet of Things sensors across the city, including 24 traffic monitoring devices, 7 air-quality sensors, and an additional reference meteorological monitoring station. The sensors collect multimodal traffic counts and environmental parameters such as particulate matter (PM1, PM2.5, PM10), temperature, humidity, and pressure. The collected data is transmitted through a hybrid connectivity infrastructure using cellular IoT and LoRaWAN networks and is made publicly accessible through open data platforms and APIs. Alongside the technical deployment, the pilot also included stakeholder engagement activities such as workshops and hackathon aimed at encouraging the reuse of open data and promoting data literacy among local stakeholders.

This report summarises the key results of the Pilot Action and reflects on the lessons learned from both governance and technical perspectives. It discusses how the pilot contributed to the development of Nova Gorica's open data agenda, identifies key stakeholders involved in the process, and highlights insights gained from the deployment and management of the sensor network. The document also outlines recommendations for future development of open data infrastructures, sensor deployments, and data-driven urban governance in Nova Gorica and other cities.

C. Key info on the Pilot Action

The Nova Gorica Pilot Action was developed within the EnCLOD project to explore how open data and Internet of Things (IoT) technologies can support evidence-based urban governance, particularly in the domains of mobility and environmental monitoring. The primary objective of the pilot was to establish a local sensor network capable of generating reliable and openly accessible data on traffic flows and air quality conditions. This information enables the municipality to better understand urban dynamics, support informed decision-making, and encourage external stakeholders to develop new services or analytical tools based on publicly available datasets.

The pilot specifically investigated the relationship between traffic patterns and environmental conditions in the city. Prior to the project, Nova Gorica had only one official air-quality monitoring station and lacked a continuous local traffic monitoring system. The pilot therefore aimed to create the city's first integrated monitoring infrastructure capable of collecting real-time data on both traffic flows and environmental parameters. The initiative was also closely connected to the preparation for the European Capital of Culture 2025 programme, which was expected to increase visitor numbers and mobility flows across the city. By deploying sensors during this period, the city established a baseline for monitoring traffic and air quality conditions and evaluating potential policy responses.



Picture 1. A. Traffic sensors map. B. Air quality sensors map

The deployed infrastructure consists of a distributed network of traffic and environmental sensors across Nova Gorica. In total, the pilot includes **24 traffic monitoring sensors, 7 air-quality sensors, and one additional reference meteorological monitoring station**. Traffic monitoring is performed using Telraam S2 sensors, which are AI-powered devices capable of detecting and classifying multiple road users including cars, trucks, bicycles, pedestrians, and other vehicle types. These sensors process video data locally using edge computing and transmit only anonymised aggregated counts, ensuring privacy-by-design operation.

Environmental monitoring is carried out using LoRaWAN-based air-quality sensors capable of measuring particulate matter concentrations (PM1, PM2.5, PM10), as well as meteorological parameters such as temperature, humidity, and atmospheric pressure.

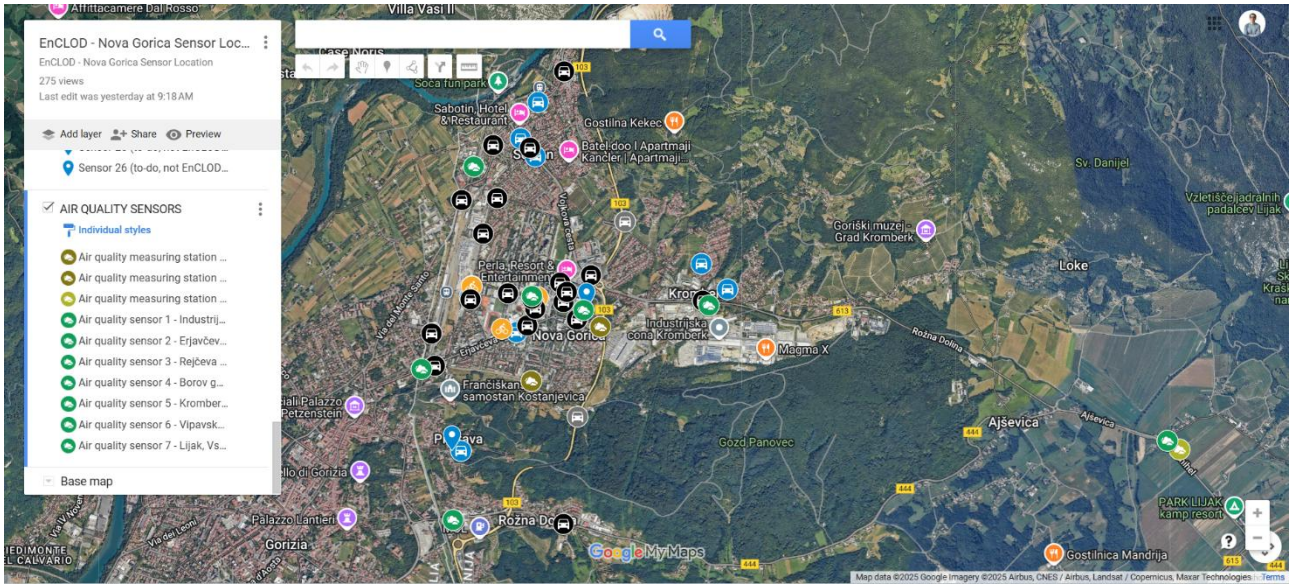
All traffic data is publicly available at https://telraam.net/#14/45.9555/13.6450

Air quality map available at https://app.datacake.de/dashboard/d/4b3a11c2-15f1-4cb7-8f13-2fca037e5ad3

A city map was used to visualize these positions and ensure coverage; the network provides a broad city-wide picture despite the modest number of sensors, thanks to careful strategic placement.

Following this strategic placement, we created a holistic map of the entire sensor network (existing and new), ensuring comprehensive coverage of the city's key areas.

This map is publicly available on Google Maps at https://www.google.com/maps/d/u/0/edit?mid=1IqNYqYBL6n5MIMgVC2aO5DhCN86LlqQ&ll=45.95848893461216%2C13.649211470269863&z=14, offering a transparent and accessible resource for the community. The deployment strategy was further refined to leverage this comprehensive spatial data, allowing for the real-time identification of emerging traffic and pollution anomalies and enabling data-driven interventions.



Picture 2. Map of sensor network

Guide:

- TRAFFIC SENSOR (ENCLOD)
- TRAFFIC SENSOR (EXISTING)
- TRAFFIC SENSOR (ENCLOD, OUTDOOR)
- BIKE COUNTER (EXISTING)
- AIR QUALITY SENSOR (ENCLOD)
- AIR QUALITY STATION (ENCLOD)
- AIR QUALITY STATION (EXISTING)

The sensors are strategically distributed across the city in order to capture conditions in areas with different mobility characteristics, including major traffic corridors, residential areas, and locations close to important urban destinations. Indoor traffic sensors were typically installed on public or residential buildings with a clear view of the road, usually between the first and fourth floor, while a small number of outdoor units were mounted on poles or other structures. Environmental sensors were deployed in locations selected to represent both background conditions and areas potentially affected by traffic emissions or other local pollution sources. The complete sensor network has been documented through a publicly accessible map showing the approximate locations of all deployed devices.

The pilot relies on a hybrid connectivity architecture combining **cellular IoT communication and LoRaWAN networks**. Traffic sensors transmit data directly through integrated cellular modules to the Telraam cloud platform, while environmental sensors send data through LoRaWAN gateways connected to the local network infrastructure. This approach minimises deployment complexity and allows the system to scale easily by adding additional devices in the future.

A key feature of the pilot is the commitment to open data publication. Traffic data generated by the Telraam sensors is publicly accessible through the Telraam platform and its open API, allowing users to retrieve datasets in standard formats such as JSON or CSV. Air-quality data is also made available through an open dashboard that allows users to explore measurements and export datasets. By ensuring open access to the collected data, the pilot encourages researchers, developers, planners, and citizens to analyse urban conditions and develop new applications based on the available information.

In addition to the data generated by the deployed sensor network, the pilot action is complemented by several external open datasets that support broader analysis of mobility and environmental conditions. These include national environmental monitoring data published by the Slovenian Environment Agency (ARSO), which provide reference air-quality measurements, as well as meteorological datasets that help interpret pollution patterns and atmospheric conditions. Spatial datasets such as road networks, land-use maps, and urban infrastructure layers available through national spatial data portals or OpenStreetMap can further support spatial analysis of traffic flows and environmental exposure. Combining the locally generated sensor data with these external open datasets increases the analytical value of the pilot and enables more comprehensive understanding of urban dynamics in Nova Gorica.

Overall, the Nova Gorica Pilot Action demonstrates how relatively affordable sensor technologies and open data practices can be combined to create a practical foundation for data-driven urban governance. The deployed network provides continuous monitoring of traffic flows and air-quality conditions while simultaneously supporting transparency, public engagement, and innovation through open data access.

D. City Open Data strategy inputs - governance level

1.1.1. Open data agenda in the pilot area

Prior to the EnCLOD Pilot Action, Nova Gorica represented a promising landscape for open data development, with growing opportunities for deeper integration and coordination. While certain datasets were available through national platforms and institutional websites, the city did not operate a dedicated municipal open data portal nor a structured system for continuous publication of machine-readable datasets. Data relevant for urban governance, such as environmental monitoring results or mobility-related information, were mostly provided through national institutions or isolated systems rather than through an integrated local open data infrastructure.

Key examples include PISO - https://www.geoprostor.net/piso/ewmap.asp?obcina=nova_gorica

In the field of environmental monitoring, Nova Gorica relied primarily on a single reference air-quality monitoring station operated at the national level. This station provided important environmental data but did not allow the city to analyse local spatial variations in air pollution or to directly link environmental conditions with traffic patterns across different parts of the city. Similarly, systematic local traffic monitoring infrastructure was largely absent, limiting the city's ability to produce consistent datasets related to mobility and urban dynamics. The main source of information was official state DRSI sensors https://www.promet.si/sl/stevci-prometa

Institutionally, the management of data related to urban governance was distributed across different departments of the municipality and external partners. Although the municipality recognised the importance of data-driven decision-making and transparency, the organisational structures, technical infrastructure, and resources required for systematic open data management were and are still developing. In particular, there is no dedicated staff unit focused specifically on open data governance or the coordination of data publication across departments.

The EnCLOD project therefore provided an opportunity to initiate a more structured approach to open data at the city level. Through the deployment of the traffic and air-quality sensor network, the pilot introduced a new source of locally generated datasets that are designed to be openly accessible. The project also encouraged the municipality to consider how these datasets can be integrated into broader smart city initiatives and open governance strategies. By establishing the first city-wide infrastructure for generating and sharing real-time traffic and environmental data, the pilot action represents an important step toward a more systematic open data agenda in Nova Gorica.

1.1.2. Future goals after the Pilot Action

The experience gained during the EnCLOD Pilot Action provides a foundation for further development of Nova Gorica's open data strategy. One of the key lessons learned is the importance of establishing a clear governance framework for the management, publication, and long-term maintenance of urban data. In the future, the city aims to strengthen its institutional capacity for open data by defining clearer responsibilities for data governance and by integrating open data principles into municipal decision-making processes.

A central future goal is the development of a more comprehensive urban data ecosystem that combines sensor-generated data with other relevant datasets related to mobility, environment, spatial planning, and urban services. The pilot has demonstrated that relatively affordable sensor technologies can generate valuable insights into urban dynamics, and similar approaches could be extended to other domains such as noise monitoring, microclimate measurement, or energy consumption.

Another strategic objective is the integration of sensor-generated data into digital platforms that support planning and policy-making. This may include the development of a municipal geoportal or other digital tools where traffic, environmental, and spatial datasets can be visualised together and used to support evidence-based decision-making. By linking open data to digital planning tools, the city can improve its ability to analyse urban conditions and evaluate the impacts of specific policy measures.

The city also intends to continue promoting open data reuse through collaborative activities such as hackathons, workshops, and educational initiatives. These activities can encourage local stakeholders, researchers, and developers to explore new applications based on the available datasets and to contribute ideas for improving urban governance. In the long term, the knowledge generated through these initiatives may lead to new services or decision-support tools that benefit both citizens and municipal authorities.

Overall, the pilot action demonstrates that open data can play an important role in strengthening transparency, improving policy design, and fostering innovation in urban governance. Building on the results of the EnCLOD project, Nova Gorica aims to gradually expand its open data infrastructure and embed data-driven approaches more firmly within its governance framework.

1.1.3. Key stakeholders

The implementation of the EnCLOD Pilot Action involved a diverse group of stakeholders from the public sector, academia, technology providers, and the wider community. At the local level, the Municipality of Nova Gorica played a central role by providing institutional leadership, coordinating the pilot activities, and supporting the deployment of the sensor network. The University of Ljubljana contributed technical expertise and methodological support, particularly in relation to data analysis, open data frameworks, and the broader research context of the project.

Private-sector partners also played an important role in the deployment and operation of the technical infrastructure. Technology providers were responsible for supplying and configuring the sensors, connectivity infrastructure, and supporting platforms used to collect and publish the data. In addition, several private building owners and organisations hosted indoor traffic sensors, allowing the network to achieve broader spatial coverage across the city.

Local stakeholders, including municipal staff, students, and members of the public, were engaged through educational workshops and outreach activities designed to introduce the concepts of IoT technologies and open data. These activities aimed to increase awareness of the potential benefits of open data and to encourage stakeholders to explore possible applications of the newly available datasets.

Future stakeholder engagement could further expand to include additional groups such as local businesses, mobility service providers, environmental organisations, and technology start-ups interested in developing services based on open data. At the national level, cooperation with institutions responsible for environmental monitoring, meteorological services, and spatial data infrastructures could also strengthen the integration of local datasets into broader national data ecosystems.

By fostering collaboration between public institutions, researchers, technology providers, and citizens, the pilot demonstrates how open data initiatives can create new opportunities for innovation, transparency, and participatory governance at the city level.

E. City Open Data strategy inputs - technical level

1.1.4. Sensor placement/deployment

The deployment of the sensor network in Nova Gorica provided several important technical lessons related to the practical implementation of IoT infrastructure in an urban environment. The pilot included 24 traffic monitoring sensors and 7 air-quality sensors distributed across the city in locations selected to represent different urban conditions, including major traffic corridors, residential areas, and zones expected to experience higher visitor activity during the European Capital of Culture events.

The design of Nova Gorica's sensor network was guided by an **initial analysis of pollution sources, traffic patterns, and strategic locations in the city.** The network had to capture conditions at critical hotspots (e.g. busy intersections, event venues, main traffic arteries) as well as background locations for reference. It also needed to combine **traffic sensors** and **environmental sensors** in a complementary way. This section describes the chosen sensor locations, the types of sensors (technologies) deployed, and the technical solutions adopted.

To keep costs low while maximizing spatial coverage, we used **low-cost sensors** that trade laboratory-grade precision for dense, distributed measurements, simple power/communications, and calibration/validation in software. We selected **Telraam S2** for multimodal traffic counts and set them up on suitable windows and outdoor mounts; each unit was registered to the project dashboard and activated with its built-in cellular IoT connection, while companion air-quality nodes were joined to our LoRaWAN gateways.

For the indoor traffic sensors, we primarily chose public buildings with an accessible window between the 1st and 4th floor with a view of the road, without obstructions such as greenery and street lighting.

The sensors were deployed from May to September 2025. A part of the traffic sensors was deliberately located at the former border crossings between Nova Gorica and Gorizia (Erjavčeva-Via S. Gabriele, Rožna Dolina-Casa Rossa, Solkan-Via del Monte Santo), which today are freely passable, so that the network also captures the flows between the two halves of the functional urban area and not only traffic internal to Nova Gorica. All devices were installed on the Slovenian side, as the network is owned by the Municipality of Nova Gorica and municipally owned equipment could not be installed on the territory of another state.



Diagram 1. Principles of good sensor placement

One of the key lessons from the deployment process concerns the selection of suitable locations for the sensors. Traffic monitoring devices required a clear line of sight towards the road, stable mounting positions, and access to a reliable power source. Indoor installations proved to be the most practical solution in most cases. Sensors were typically installed on windows of buildings overlooking the street, usually between the first and fourth floor. This approach allowed the devices to be protected from weather conditions while still maintaining a clear view of the traffic flow. However, identifying suitable buildings and securing permission

from property owners required coordination with local stakeholders and occasionally led to adjustments of the originally planned sensor locations. At two indoor locations - in the northern part of Solkan and at the border crossing in Rožna Dolina - the sensors had to be installed lower than the recommended first floor level and very close to the roadway due to the lack of more suitable mounting positions. This resulted in noticeable deviations in vehicle classification accuracy, where some larger passenger cars were occasionally recorded as light commercial vehicles or even minibuses. For this reason, it is recommended to follow the manufacturer's installation guidelines regarding sensor height and distance from the road as closely as possible.

Outdoor installations presented additional technical and regulatory challenges. A small number of traffic sensors were planned for mounting on street infrastructure such as lighting poles. Initially, solar panels were considered as a power solution due to the low energy consumption of the sensors. However, the national infrastructure authority did not approve the installation of solar panels on public lighting poles because of structural safety requirements. As a result, alternative solutions had to be implemented, including the use of battery systems and connection to public lighting circuits that provide electricity only during nighttime hours. This experience highlighted the importance of early consultation with infrastructure authorities and the need for flexible technical solutions.

Connectivity choices became a key technical lesson. The hybrid model proved efficient and scalable: cellular modules removed the need to negotiate Wi-Fi credentials at every host site for traffic sensors, while LoRaWAN provided the long-range, low-power link suitable for distributed environmental sensors. The main lesson is that connectivity decisions should be locked early in the deployment plan, since they propagate downstream to power requirements, host-site negotiations, and the cost of adding sensors later.

Air quality monitoring also revealed important methodological considerations. The data are collected using sensor-based measuring devices, where the concentration of particulate matter is determined through optical particle counting under the current ambient humidity conditions. A comparison between the collected data and the reference measurements from the ARSO monitoring station at Grčna in Nova Gorica showed significant deviations in the recorded concentrations of PM10 and PM2.5 during periods of high relative humidity (above 90%). In some cases, the values measured by the low-cost sensors were up to ten times higher than those recorded by the reference station. The EnCLOD sensor used for this comparison is installed at Grčna in Nova Gorica in immediate proximity to the ARSO reference monitoring station. These results highlight the trade-off between deploying a larger network of low-cost sensors that provide broader spatial coverage and relying on fewer but highly accurate laboratory-grade monitoring stations.

Overall, the deployment experience demonstrated that low-cost IoT technologies can be effectively implemented in small and medium-sized cities, but careful planning is required regarding sensor placement, power supply, and regulatory permissions. Future deployments could benefit from standardised procedures for obtaining installation permissions and from early mapping of potential host locations that satisfy both technical and regulatory requirements.

1.1.5. Sensor data

The pilot generated two main categories of datasets: traffic monitoring data and environmental monitoring data. These datasets are produced continuously by the sensor network and made available through open data platforms, supporting transparency and enabling further analysis by researchers, planners, and developers.

Traffic data is recorded by the Telraam S2 sensors in short time intervals and aggregated into hourly datasets available through the Telraam platform and its open API. The use of an established platform substantially simplified data management for the municipality, as automatic data storage, visualisation tools, and exports in standard formats such as JSON or CSV are handled by the platform provider rather than by the city.

Environmental monitoring data is generated by air-quality sensors measuring particulate matter concentrations (PM1, PM2.5, PM10), along with meteorological parameters such as temperature, humidity, and pressure. These sensors transmit their measurements through the LoRaWAN network to a central server where the data is processed and made available through an open dashboard. The combination of traffic and environmental datasets enables the city to explore correlations between mobility patterns and air-quality conditions across different locations.

Several lessons were learned regarding data management and publication. First, the use of established platforms and standardised APIs significantly reduces the technical burden on municipal administrations, as many data management functions are handled automatically by the platform provider. Second, the use of open formats and publicly accessible APIs ensures that the datasets can easily be reused by external stakeholders.

Another important aspect of the pilot was the use of the datasets during collaborative activities such as workshops and hackathons. These events demonstrated how open data can be transformed into practical applications, including visual dashboards, environmental alert systems, and decision-support tools. Such initiatives help to bridge the gap between data generation and real-world applications, encouraging the development of new services based on open datasets.

From a technical perspective, future developments could focus on integrating these datasets into a unified municipal data platform or geoportal where different types of urban data can be visualised together. Such integration would further strengthen the role of open data in supporting digital urban planning and evidence-based policy making.

1.1.6. Microzoning

Microzoning was explored in the EnCLOD project as a method for structuring and analysing urban data at a finer spatial scale. The technique divides a city into smaller analytical units (**microzones**) within which data from different sources can be aggregated and compared on consistent spatial boundaries. Once microzones are defined, every observation - a sensor reading, a traffic count, a land-use attribute - can be tied back to a zone, making it straightforward to compare neighbourhoods, detect outliers, and target interventions. For Nova Gorica, microzoning is not a peripheral analytical exercise but the spatial backbone that links the sensor network to the city's open data agenda.

During the Nova Gorica pilot, the sensor network itself already provided a form of spatially distributed monitoring that reflects different parts of the urban environment. Sensors were intentionally placed in locations representing diverse mobility conditions, including central areas, residential neighbourhoods, and major traffic corridors. This distributed monitoring approach aligns conceptually with the principles of microzoning, as it enables analysis of urban conditions at a more granular spatial level.

A central lesson from Nova Gorica is that small and medium-sized cities are, in fact, an ideal scale for microzoning rather than a difficult one. In a compact urban area, a single team can cover the entire city with a manageable number of zones, walk or drive every boundary, and consult directly with the people who live and work in each one. This produces zones that match how residents actually perceive their neighbourhoods, rather than the abstract statistical units used in larger cities. The signal-to-noise ratio is also higher: a handful of sensors can characterise a meaningful share of the urban fabric, and any change - a new event venue, a closed bridge, a school reopening - is visible at the zone level almost immediately. Microzoning therefore turns the limited size of small cities from a perceived weakness into a methodological strength, giving local administrations a fast, low-cost lens for evidence-based decision-making that larger cities struggle to replicate.

The main practical consideration when integrating different datasets within a microzoning framework is that traffic counts, environmental measurements, and other urban indicators rarely share the same spatial

resolution or update frequency. The pragmatic response is not to wait for perfectly aligned data but to standardise where it matters most: a shared geometry of zones, consistent metadata, and a clear convention for how each indicator is aggregated to the zone (sum, mean, density, or maximum, depending on what the indicator describes). Once those conventions are written down, additional datasets can be plugged in over time without redesigning the framework.

Several iterations of the microzoning framework were required during the project in order to refine the spatial boundaries and arrive at a final structure that accurately reflects the city's urban dynamics and available data.

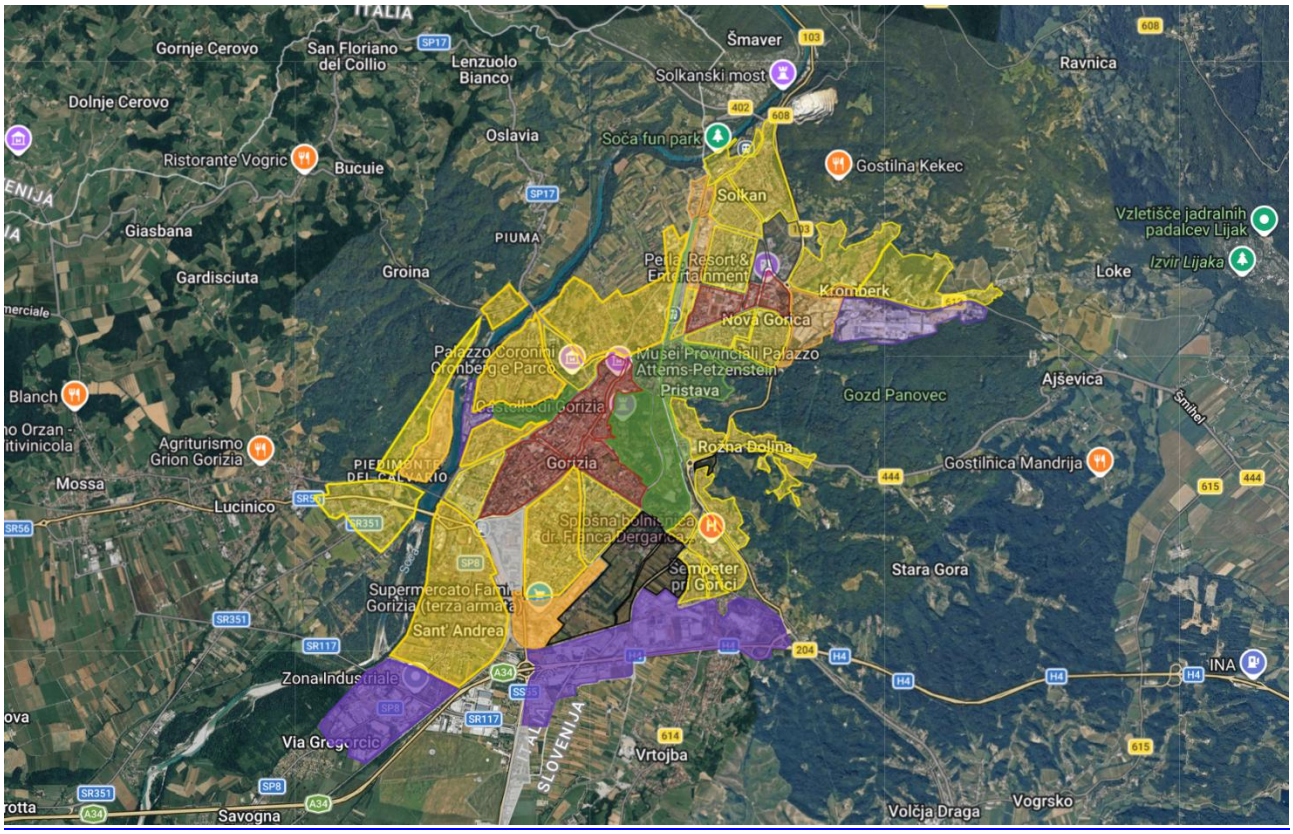
The cross-border dimension was the most distinctive aspect of the Nova Gorica microzoning exercise and arguably its most transferable contribution to other European border cities. Nova Gorica and Gorizia function as a single urban system - residents, workers, students, and visitors cross the former state border dozens of times a day - yet the two halves are governed by different national administrations, different planning frameworks, and different open data ecosystems. A microzoning geometry that stops at the national border would systematically miss the daily reality of the city. The pilot therefore extended the microzones across the border, treating Nova Gorica and Gorizia as one continuous analytical fabric and paying particular attention to the points where flows of people and vehicles enter and leave each zone, especially at the historical border crossings (Erjavceva-Casa Rossa, Rozna Dolina-San Andrea, Solkan-Salcano). Refining the geometry to reflect both cities, and analysing the entrances and exits of every zone, proved essential for a microzone structure that mirrors how the cross-border city actually works on the ground - and that can serve as a methodological reference for other twin and border cities across Europe.

How to apply the methodology - practical workflow. The Nova Gorica experience suggests a five-step workflow that other small and cross-border cities can replicate without specialised in-house GIS staff. **(1) Assemble a base of spatial reference data:** official cadastral and land-use boundaries, the road network, points of interest, and any existing administrative subdivisions used by the municipality. **(2) Draft an initial set of zones from this base** - typically 15 to 40 zones for a city the size of Nova Gorica - by combining areas with homogeneous land-use, traffic regime, and morphological characteristics. **(3) Iterate with stakeholders:** each draft zone should be discussed with municipal staff, urban planners, and where possible local residents, with explicit attention to the entry and exit points (the streets, intersections, and bridges through which traffic actually moves between zones).

(4) Validate against real measurements: once sensor data starts arriving, zones that group very different conditions should be split, and zones that consistently behave alike can be merged. Three to five rounds of iteration were needed in Nova Gorica before the geometry stabilised. **(5) Publish and version:** the final microzone geometry should be released as an open dataset (GeoJSON or shapefile) with metadata describing how each zone was defined and which indicators are aggregated to it. This last step is what turns microzoning from an internal analytical tool into a reusable spatial framework that researchers, NGOs, and developers can build on. Cities considering this approach should plan from the outset for the geometry to evolve: microzones are best treated as a living dataset, versioned and documented, rather than a one-off output.

The pilot demonstrated that microzoning is a useful concept for organising urban data and supporting future digital planning tools. As additional sensors and datasets are added in the coming years, the microzone framework will become an increasingly powerful analytical layer for the municipality, enabling more precise identification of local environmental issues, traffic patterns, and urban development needs.

Future work may therefore focus on refining the spatial structure of microzones and integrating them into municipal digital tools such as geoportals or urban dashboards. This would allow the city to visualise and analyse data at a neighbourhood level and support more targeted policy interventions.



Picture 3. Microzones in Nova Gorica and Gorizia

F. Data-driven governance: Pilot first findings

The Nova Gorica Pilot Action has created the conditions for a more evidence-based approach to environmental governance. By combining continuous traffic monitoring with distributed air-quality measurements, the municipality now has a substantially richer and more representative knowledge base than was previously available. This information provides the technical foundation for the preparation of Nova Gorica's Air Quality Plan, currently under development and expected to be formally adopted by the end of 2026. Unlike previous planning exercises, the new Plan will rely not only on general environmental assumptions and national datasets, but also on objective and locally generated evidence describing the relationship between traffic, air quality and meteorological conditions across different parts of the city.

Although the Air Quality Plan is still under preparation, the Pilot Action has already produced several concrete outputs that remain available to the municipality, researchers, citizens and other stakeholders. The Open Data generated through the sensor network can be freely consulted through the online traffic and air-quality dashboards, making it possible to explore both current and historical conditions across Nova Gorica and, where relevant, the wider cross-border urban area including Gorizia. The first analyses have already shown that pollution episodes tend to be highly localised in space and time, confirming the value of continuous monitoring and of combining traffic, environmental and meteorological information to better understand urban dynamics. Beyond supporting municipal planning, these datasets provide a shared evidence base that can be reused for research, educational activities and the development of additional digital services.

The Pilot Action also generated practical governance lessons regarding the adoption of Open Data within local administrations. Experience from Nova Gorica suggests that municipalities do not need to wait for large investments before starting to build a useful urban data ecosystem. Networks of affordable sensors, if properly calibrated and supported by adequate metadata, can already provide valuable information for planning and decision-making. Equally important is the organisational dimension: assigning clear responsibility for data management within the municipality, publishing data openly from the outset, engaging citizens and external stakeholders through workshops or similar initiatives, and considering cross-border cooperation where appropriate all contribute to creating a more sustainable and effective Open Data ecosystem. These are lessons that Nova Gorica itself intends to build upon as it further develops its data governance framework and integrates Open Data more systematically into future environmental and mobility policies.

Cross-border and functional urban area dimension. The challenge addressed by the pilot is a shared one. Nova Gorica, Gorizia and Šempeter-Vrtojba form one functional urban area with a single road network and a single air basin, and the 2025 European Capital of Culture was itself cross-border, held jointly by Nova Gorica and Gorizia. The pilot therefore built one common evidence base instead of two national ones: microzones drawn across the border, traffic counting at the former border crossings, air quality measured in the air basin the two cities share, and every dataset published openly so that it can be used on either side without a prior agreement. The baseline was recorded during the GO! 2025 year, which gives both cities a common reference point for assessing future measures. Cooperation was practical rather than formal: joint public events and the hackathon with participants from both sides, a working contact with the Municipality of Gorizia and with Legambiente, which during the project period began preparing a joint environmental report covering Gorizia and Nova Gorica, and regular information of EGTC GO, which brings together Nova Gorica, Gorizia and Šempeter-Vrtojba. Measures remain the responsibility of each municipality and the Air Quality Plan under preparation is an instrument of Nova Gorica, but because the monitoring, the data and the microzones cover the whole urban system, both administrations can read the same picture of pollution patterns and act on it in a coordinated way.

Practical recommendations

Practical recommendations are formulated in plain language and grouped by audience: city decision-makers (mayors, councillors, urban planners) and citizens or everyday users of city data.

For policy makers and city decision-makers.

- Start small but start now: a network of low-cost sensors costs a small fraction of a single laboratory-grade station and produces immediate, locally relevant insights.
- Assign a clearly named owner inside the municipality for open data, even if it is a single half-time position; without that owner, datasets fragment and lose continuity over time.
- Treat open data not as an extra task but as infrastructure - it pays back through better planning decisions, faster grant applications, and external services that the city does not have to build itself.
- Plan for the cross-border or inter-municipal dimension from day one if your city has one, since retrofitting cooperation is consistently harder than building it in from the start. Pair every sensor deployment with at least one engagement event (workshop, hackathon, school visit), because data without an audience does not change decisions.
- Finally, do not wait for perfect data before publishing: imperfect data accompanied by clear metadata is far more useful to citizens, researchers, and other municipalities than perfect data kept in a drawer.

For citizens and everyday users of city data.

- The traffic and air-quality data produced by the pilot are publicly available and free to consult: anyone can check current and historical conditions on their street through the Telraam map and the air-quality dashboard linked earlier in this report.
- Low-cost sensor data should be read with realistic expectations - it is excellent for spotting patterns and trends over hours, days, and weeks, but less reliable as a single instantaneous reading, particularly for fine particulate matter during very humid weather.
- If your neighbourhood is missing from the network, you can ask the municipality to add a sensor: hosting a Telraam unit on a building with a clear view of the road takes very little space and no maintenance, and adding one more sensor is one of the easiest ways for residents to contribute to the city's understanding of itself.
- The data is most useful when layers are combined - looking at traffic counts and air-quality on the same map often reveals more than either layer alone. And because Nova Gorica and Gorizia share the same air and the same traffic flows, citizens on both sides of the former border benefit from looking at the cross-border picture rather than only their own half of the city.

G. Summary of lessons learned and recommendations

ID	Typology	Brief description	Final recommendation	For whom
NG1	G	The pilot showed that open data initiatives require clear institutional ownership and coordination within the municipality. Without defined responsibilities, the management, publication, and long-term maintenance of datasets can become fragmented.	Cities should establish clear governance structures and assign responsibility for open data management within the municipal administration.	C
NG2	G	Stakeholder engagement through workshops and hackathon proved valuable for increasing awareness and encouraging the reuse of open datasets. These activities helped translate raw data into practical applications and new ideas for urban services.	Cities should complement technical deployments with regular stakeholder engagement activities to stimulate the use and value of open data.	C
NG3	T	The deployment of the sensor network highlighted the importance of flexible installation strategies, as regulatory restrictions, power supply limitations, and unsuitable viewing angles required adjustments to the planned locations.	Future sensor deployments should include early consultation with infrastructure authorities and allow flexibility in site selection and power solutions.	C
NG4	T	The pilot demonstrated that using established platforms and open APIs simplifies data collection, storage, and publication while ensuring interoperability and easier reuse of datasets by external users	Municipalities should prioritise solutions that provide open data access through standardised APIs and interoperable data formats.	C
NG5	T	Several iterations of the microzoning framework were required to refine the spatial boundaries and align them with real urban dynamics across Nova Gorica and Gorizia. Considering zone entrances and exits proved essential for defining meaningful analytical units.	Cities implementing microzoning approaches should allocate sufficient time for iterative spatial refinement and cross-city coordination when defining zones.	C
NG6	T	The deployment of low-cost sensors revealed measurement deviations under certain conditions. This was observed both in air quality sensors measuring particulate matter (especially during periods of high humidity) and in traffic counters during rain, poor visibility, or	Adequate time and technical expertise should be allocated for data validation to ensure reliable interpretation of sensor measurements. If significant deviations are detected, careful consideration should be given to whether the data should be	C

		when sensors were not optimally positioned.	published as open data, and in all cases clear metadata and explanations should accompany the datasets to avoid misleading interpretations.	
NG7	G	Nova Gorica and Gorizia form one functional urban area with a single road network and a single air basin, but they belong to two national data and policy systems. In the pilot, cross-border cooperation worked where it was built on joint events and openly published data, and it advanced slowest where a formal institutional partner on the other side of the border was missing.	In cross-border and polycentric urban areas the monitoring area should follow the functional area and not the administrative one, all data should be published openly so that no bilateral agreement is needed for their reuse, and technical work should be paired with joint events. An institutional partner from the other side of the border should be secured before the technical design is locked.	C