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EnCLOD

D3.1.1
Common EnCLOD training/education materials on Open Data and IoT for territorial governance

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EnCLOD

TABLE OF CONTENTS

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A. Introduction

The training and education activities developed by Project EnCLOD aim at increasing the competences as well at raising awareness on the topics of Open Data and IoT among the public officers (city/region planner) and the decision makers of the five Pilot Areas: this Deliverable represent the first step in the implementation of this action of knowledge transfer.

Given its scope, the training and education of project EnCLOD adopt an informal and multi-faceted approach, in order to reach its destined audiences in different countries of the Central Europe area and to explicate the potential of Open Data for the improvement of territorial governance.

The Deliverable contains a set of guidelines and materials provided by P09 (University of Žilina) and recognized by the partnership as an example, a good practice and a starting point for the development of training activities in their Pilot Areas. The educational materials will be adopted by the Partners, adapting them to their specific technical and institutional context, as well as to the knowledge level of their audience.

These materials are based on real experiences by P09 from working with municipalities, are a combination of theoretical and practical information focusing on the most important aspects of open data and IoT, in the domestic and European context. The educational materials are the basis for the participants and lecturers of the planned trainings.

Educational materials are intended for municipal employees at various levels. It can be cities, municipalities or higher territorial units.

The target groups of education are:

- Officers
- Decision makers or Management employees
- Technicians or data-oriented officers

Some of the educational materials can also be used by other target groups - for example students and teachers of universities and colleges, employees of the state administration, etc.

No previous knowledge or skills are required to complete the training, only the basics of working with a PC (internet, e-mail) are required. Previous knowledge of working with data (e.g. Excel, Word, databases) or an overview of public administration is an advantage.

Training Guidelines and Approach in the EnCLOD Project

The EnCLOD training materials were developed to support local authorities across Central Europe by enhancing their awareness and skills in open data utilization and digital governance. This content is designed to empower municipal employees, technical staff, and decision-makers to incorporate data-driven insights into governance and planning, contributing to more effective and informed decision-making processes. Through a blend of practical examples and theoretical guidance, the materials draw on real experiences from EnCLOD's pilot areas, showcasing innovative approaches to open data and IoT applications in territorial governance. These materials provide essential knowledge on using data to address key challenges in mobility, environmental management, and climate adaptation, reflecting the goals of the EnCLOD project to enable data-driven solutions for sustainable local development.

As an international resource, these materials form a foundational version intended for further adaptation. Each participating pilot area will localize the content to ensure it aligns with regional needs, regulatory contexts, and specific territorial challenges. This localized approach ensures that the training is re levant and impactful for each unique area, supporting a comprehensive and collaborative improvement in digital governance across Central Europe.

Abbreviations

OD – Open Data

IoT – Internet of Things

API – Application Programming Interfaces

GIS - Geographic Information System

AI - Artificial Intelligence

HVD – High Value Datasets

GDPR - General Data Protection Regulation

UTF - Unicode Transformation Format

OECD - Organisation for Economic Co-operation and Development

IOV - Initiatives for Open Government

GDP - Gross Domestic Product

PM - The publication minimum

OGD - Open Government Data

B. Target groups

1. Officers

1.1. Description

- while fulfilling their professional agenda, they collect and process data and/or use information systems to process the agenda

1.2. Acquired knowledge after training programme

- they master the basic concepts in the field of open data and their benefits
- they have an overview of the relevant legislation, strategies, methodologies
- they know where to look for open data
- they understand the life cycle of open data and the basic rules of creating datasets
- they know how to work with open data at a basic level
- they know how to work with the community and involve it in the activities of the local government

2. Decision makers or Management employees

2.1. Description

- persons in management positions, members of the city council, heads of offices who participate and/or initiate strategic decisions in self-government and change processes
- coordinate/guide the activities of other departments and departments in accordance with strategic decisions

2.2. Acquired knowledge after the training programme

- they know the benefits of open data, they perceive the importance of data-based decision-making
- they know how to design a data policy in the office
- they know what technologies and managerial decisions are key to the functioning of open data

3. Technicians or data-oriented officers

3.1. Description

- employees of the IT department, computer scientists, data curator, GIS or data analysts

- provide technical support in the field of information technology management in self-government, process data, create data outputs and analytical data for decision-making (e.g. maps, analyses, ...)

3.2. Acquired knowledge after the training programme

- they master the basic concepts in the field of open data and their benefits
- they have an overview of the relevant legislation, strategies, methodologies
- they know where to look for open data
- they know how to work with data and information systems at an advanced level
- they coordinate and guide the management of open data
- they know how to work with the community and involve it in the events of self-government

4. Recommended procedure

Individual education modules are focused on target groups. Some modules are aimed at only one target group, others are aimed at several target groups (e.g. introductory module). We recommend that individual target groups progress in education according to the table below. We recommend proceeding chronologically, but it is not essential. The procedure can also be changed according to the user's preferences.

Tips for other modules for target groups other than those recommended: Especially officers who would like to work with data can also use module no. 6 (data visualization) or module no. 9 (GIS). In the event that they will also be involved in data management, module no. 4. Other modules may also be suitable for management employees, e.g. module no. 3, which deals with open data portals. We recommend the most modules for technicians or data-oriented officers. This group includes several specializations, e.g. data curator, analyst, GIS analyst, computer scientist, while not all specializations will use all modules equally. Therefore, we leave it up to the users to decide which modules they prefer.

5. Short description of the modules

Module no. 1

What is open data

It is dedicated to explaining basic terms in the field of open data, their benefits, quality of open data, metadata, formats, licenses. After completing the module, users will learn what attributes quality datasets have, what motivation leads municipalities to publish open data.

Module no. 2

How to publish open data in accordance with the legal framework, strategic and methodological documents

It deals with important laws, strategic and methodical documents in the National and European context. After completing the module, users will learn what obligations result from the relevant legislation for local governments, what the relevant strategic and methodological documents say.

Module no. 3

Where to publish and find assets

It deals with the concept of open data portal, European open data portal, central national portal and self-governing portals. After completing the module, users will learn information about open data portals - what functions they offer and what harvesting is.

Module no. 4

How to manage open data

It deals with activities that are important for the systematic grasp of open data (creating strategies, data audit, data cycle). After completing the module, users will learn what needs to be done in order for open data to be published systematically under the conditions of the self-governing office.

Module no. 5

Use cases

It deals with well-known cases of open data at the national and local level, including AI. After completing the module, users get inspiration from different cases (self-governing, non-profit, but successfully operating).

Module no. 6

Work with data and visualisation

It deals with the importance of visualization and working with data, includes a practical example. After completing the module, users will learn why it is necessary to work with data and how it can be easily and effectively visualized.

Module no. 7

How to build a community around open data

It deals with tools and ways to involve the community in using open data. After completing the module, users will learn how to involve other actors in self-government events with the help of open data.

Module no. 8

Introduction to IoT, Sensors, and Big data Analytics

It deals with the concept of the Internet of Things (IoT) and how it utilizes sensors to collect data for improving public services and urban management. After completing the module, users will learn what IoT is, the different types of sensors and communication protocols used, and the basics of big data analytics. They will also understand the importance of addressing security and privacy concerns in IoT projects and gain practical insights into implementing and scaling IoT solutions effectively in a municipal setting.

Module no. 9

How to use GIS for Effective decision-making

It deals with the practical application of Geographic Information Systems (GIS) in local governance, including data collection, spatial analysis, and visualization techniques. After completing the module, users will learn how to use GIS tools to analyze geographic data, create maps, and support planning and decision-making processes in various municipal activities.

Module no. 10

Key technologies and decisions for senior employees and decision makers

Summary of the entire course, important technologies and decisions for the target group of managers and decision makers. After completing the module, users will learn the basic knowledge needed to decide to start publishing open data and why it is relatively easy to implement.

	Recommended modules (1 to 10)									
Target group	1	2	3	4	5	6	7	8	9	10
1 Officers	■	■	■		■		■			
2 Decision makers or Management employees	■			■	■					■
3 Technicians or data-oriented officers	■	■	■	■	■	■	■	■	■	

Table 1: Recommended modules for target groups

6. Recommendations for training and workshops

- The content of the training is based on educational materials - The educational material is the basis for the content of the training. These will be enriched with other interactive blocks for the intensive involvement of participants, which are not yet defined in the educational material.
- Sending educational materials before the training - The educational material was created so that the participants of the training and workshops could familiarize themselves with the issue in advance, or they could return to it at any time.
- Reaching out to participants to find out their needs - Level of awareness and needs of participants may vary. For a more targeted delivery of trainings and workshops, it is therefore advisable to contact the participants in advance (e.g. via Google Forms).
- Combination of theoretical and interactive blocks - In order to grasp new knowledge as best as possible, it is advisable to combine theoretical blocks with interactive (practical ones), e.g. visualize datasets, display datasets in GIS.
- Inviting local experts and leaders from municipalities - Representatives of municipalities respond very well if an example of good practice is conveyed to them directly by a representative of another municipality that faces approximately the same challenges, resources and conditions. Changing their settings can also be supported by interactions with local experts - e.g. developers of open data applications.
- Personal contact - Training and workshops should be carried out face-to-face to promote cooperation between departments.
- Dedicate a block for decision makers - Due to their limited time, it is necessary to give them concentrated information in a very short time, which must be adapted to the workshop program.
- Certificates for Participants - participants could have benefit from the workshop participation. The idea of providing certificates raises practical questions on issue authority, examination, technical solution (when online) and the real impact of the certificate. This recommendation is for the consideration of every instructor who will lead the training programme.

- Data Tracking - implementation of the statistics tools (e.g. module completions and expressions of interest) can lead to better performance, visibility and targeting. This is relevant in the phase of publishing educational material online.
- Multimedia Asset Pack - creating a multimedia asset pack would enhance the implementation and teaching of the modules.

7. Repeat and practice

We recommend that users of educational materials, after studying the materials, practically start working with open data in their work or free time. There are many options - e.g. publication of data, use of data, participation in working groups, use of open data portals. During practical use, other questions and other possibilities for expanding your knowledge will certainly arise.

8. Resources and Supplementary Resources

At the end of the educational materials are listed the resources we used to create them. Additional resources are also listed, which are a recommended way to consolidate and expand the knowledge acquired through the study of educational materials.

C. Modules

1. What is open data

In fulfilling their duties, state and public administration organizations collect, process and publish a large amount of data in various areas, such as environment, finance, transport, social services, education or statistics. Data enable organizations to make qualified decisions (evidence based decision or data driven decision) and citizens to better understand what the decisions are based on.

If they are published in open data format, they enable their repeated use in the development of other commercial or non-commercial solutions - e.g. applications, web applications, analyses. This creates an added value over raw public data, which benefits the institutions themselves, but especially citizens as users of innovations.

The concept of open data (from the English open data) is based on the assumption that the data of a public sector organization should be (Open Knowledge Foundation):

- available to anyone - Everyone should be able to freely use, modify, combine and share data, for commercial and non-commercial purposes.
- unrestricted - Everyone must be able to use, reuse and share open data – there should be no discrimination against areas, persons or groups.

- without technical and licensing restrictions - Data are made available to everyone in a machine-processable format and under an open license.

„Technical and licensing openness“

Open data is defined by two basic attributes – technical and licensing openness:

Technical openness means that there are no technical barriers that would limit further data processing. The file is machine-readable, freely available, and in a format that does not require the use of a specific proprietary software tool. Open formats most often mean formats such as CSV, JSON or XML. As stated in the European Data Portal guide, in the case of geospatial data, the formats are GeoJSON, GML, KML, WKT, KMZ. (European Data Portal, p. 51)

License openness means that the data is published under an open license that allows its repeated use. They most often apply various types of Creative Commons licenses (CC0, CC BY, CC BY-SA, CC-BY-NC, CC-BY-NC-SA, etc.).

In the Slovak Republic, technical and licensing standards are defined in § 38-40 of the MIRRI Decree no. 78/2020 Coll. on standards for public administration information technologies.

1.1. Why publish open data

Public administration organizations are already required by many legal standards to publish data and information in various agendas, such as general binding regulations, etc. Part of this collection can be published in an open data format that is available to anyone, and in this way fulfill a legal obligation.

The published data can subsequently be used repeatedly for the development of other commercial or non-commercial innovations – e.g. applications, web applications, analyses. These innovations are mainly developed by technology companies, non-governmental organizations, or IT enthusiasts. These innovations have the potential to generate new business opportunities, value-added goods and services and create socio-economic values.

Publishing brings several benefits, both on the part of the institutions themselves and citizens (Alvaria) (European Data Portal, 2018):

- Cutting down bureaucracy
- Automation and digitization of processes
- Effectively managed organization based on data
- Support for innovation in the region and job opportunities, GDP growth
- Support for citizen participation
- Increasing the quality, efficiency and transparency of public services;
- Cost savings, as for example it is estimated that EU28+ governments could save €1.7 billion by 2020
- higher efficiency of processes and quality of public service provision (European Data Portal, 2020)

Figure 1: The figure summarizes the benefits of open data according to the European Data Portal. (source: European Data Portal, p. 17)

1.2. Quality of open data

Regarding the quality of open data, a 5-star open data model (scale) is used - the more stars, the better the dataset. In general, a dataset is considered open if it has at least 3 stars and is therefore published at least in .csv format.

*	Make your data available on the web (in any format) under an open license
**	Make data available as structured data (e.g. Excel instead of a scanned image of a table)
***	Use proprietary formats (e.g. CSV instead of Excel)
****	Use URIs to mark things so people can reference your data
*****	Link your data with other data to provide context

Table 2 : 5-star Open Data Model, translated into Slovak (source: European Data Portal, p. 50)

Data quality also includes other attributes such as metadata (data about data), quality of content, up-to-dateness, consistency (European Data Portal).

The overall quality of the data is influenced by the way in which the municipality approaches it during its life cycle. How it creates, updates, archives, links them. Standards for working with data in self-government help to create quality data (unified) for decision-making. In the future, this may reduce the additional costs of editing self-governing data so that they can be published in open data format at least in minimum quality.

The standards should fulfill the function of an internal directive and employees should be familiar with their content.

An example can also be the Standards for working with data from the workshop of the Banská Bystrica self-governing region, which define several basic rules (Banská Bystrica self-governing region):

- Create and save files in xlsx, csv, json, xml. Avoid .doc, PDF.
- Use prescribed data formats (e.g. date format, amounts and currencies)
- Use the UTF character set if possible
- Observe the correct structure of the table, such as: do not merge cells, do not keep totals/subtotals in the source table, 1 sheet = 1 table, etc.
- Keep the data current, "clean" and complete
- Use uniform nomenclature, even when naming files
- Use valid code books, registers and identifiers
- Lead metadata to files
- and others

Such rules can also simplify the work with data in the office.

2. How to publish open data in accordance with the legal framework, strategic and methodological documents

2.1. European legislation

2.1.1. Directive (EU) 2019/1024 on open data and the reuse of public sector information

The Explanatory Memorandum to the amended Reuse Directive states: *"Opening up access to public sector information so that it can be reused will have a positive impact on the transparency, efficiency and accountability of governments and will contribute to strengthening the role of the citizen."* The expected benefits are also included: *"Benefits resulting from improved access and facilitated reuse include: innovation in products based directly on public sector information and complementary products, reduced translation costs and increased efficiency in the public sector, and an increasing rate of combining various public and private information to produce new types of goods."*

The requirements of the directives on the repeated use of public sector information were transposed into the legal order of the Slovak Republic through two amendments to Act No. 211/2000 Coll. free access to kininformation of the provisions of later regulations. The European Commission prepared another amendment to the PSI Directive, which was published on April 25, 2018. Political agreement on the text of z22. January 2019 introduces new institutes, for example the so-called high value databases to be made available free of charge.

2.1.2. GDPR

GDPR (Regulation (EU) 2016/679 on the protection of natural persons in the processing of personal data and on the free movement of such data) did not bring an end to the processing of personal data, nor does it hinder the development of innovations. On the contrary, the Regulation supports the development of innovations by guaranteeing the boundaries and limits that must be maintained during this development - so that the rights of the affected persons to the protection of personal data are not affected.

Personal data as defined by the GDPR: "Personal data" is any information relating to an identified or identifiable natural person (hereinafter referred to as the "data subject"); an identifiable natural person is a person who can be identified directly or indirectly, in particular by reference to an identifier such as name, identification number, location data, online identifier, or by reference to one or more elements that are specific to physical, physiological, genetic, mental , economic, cultural or social identity of this natural person.

Further in the text, we explain some terms from the definition above.

Any information – means a broad understanding of processed data, e.g. information regarding persons objectively (health results) but also subjectively (Ján Novák is a good employee). In order to evaluate whether it is personal data, the veracity of the information is not essential. Likewise, the definition covers information related to personal or family life as well as information related to employment or business. And finally, personal data is not distinguished either by the format or the medium on which it is stored.

They relate to a natural person – means that personal data is information related to a natural person. In most cases, the fulfillment of this condition will be obvious, for example, the register of residents. Debatable are the cases where the processing is part of tracking another goal, for example the value of the property being sold or the dog tax. The decision then depends on the content, purpose or goal of data processing. There may be a situation where data will be considered personal data for one operator and not for another in terms of the purpose of processing.

Identified or identifiable natural person – a natural person must be determined or determinable based on one or more identifiers. Such identifiers are, for example, name, identification number, location data, online identifier, reference to one or more elements that are specific to the physical, physiological, genetic, mental, economic, cultural or social identity of this natural person. It should be remembered that all the information that is on the Internet is easy to find, if we can find this information and connect it, the person is identifiable. In order to determine whether the means are reasonably likely to be used to identify a natural person, all objective factors, such as the cost and time required for identification, taking into account the technology available at the time of processing, as well as technological developments, should be taken into account.

Open data often contain personal data of an identified or identifiable data subject. Municipalities are in the position of the information system operator and must ensure compliance with legal requirements in the field of personal data protection - with the GDPR legislation in the field of personal data.

The source of information is the e-learning of OZ Alvaria.

2.2. National legislation

The following part is suitable to be adapted by the Partners to their territory.

2.2.1. Constitution of the Slovak Republic

Article 26 of the Constitution of the Slovak Republic states: *"Public authorities have the obligation to provide information about their activities in the state language in an appropriate manner. The conditions and method of execution shall be established by law."* In modern times, a lot of information is processed on a computer in information systems, so it can be argued that the "reasonable method" mentioned in the Constitution means machine-processable open data.

2.2.2. Law on free access to information

The key legislative norm is the Act on Free Access to Information , which clearly defines mandatory published information, time limits, remedies, the range of obliged persons and the institute for making information available upon request.

Commands the so-called obliged persons (or certain categories of obliged persons) to publish information regarding their activities:

- basic information about the organization
- information on concluded contracts, orders and invoices
- public registers and records
- additional information at the sole discretion of the obligated person

Obliged persons are understood as:

- state authorities, municipalities, higher territorial entities
- legal entities and natural persons to whom the law entrusts the authority to decide on the rights and obligations of natural persons or legal entities in the field of public administration, and only to the extent of their decision-making activity
- legal entities established by law and budget/subsidy organizations established by a state authority, a higher territorial unit or a municipality
- legal entities founded by the persons mentioned in the previous points

Regarding the publication of datasets in the form of open data, the Information Act distinguishes between mandatory and non-mandatory datasets.

Special laws require public administration bodies to keep various records, while establishing their public status (e.g. business register, real estate cadastre, register of non-governmental organizations, etc.). In relation to the public nature of these registers, the Info Act obliges their operators to publish them on a freely accessible website (i.e. without any access restrictions) free of charge.

The law defines making information available for reuse (open data) upon request. The obliged person can publish information for the purpose of repeated use even without a request.

2.2.3. Decree on standards for information technology of public administration

Decree no. 78/2020 Coll. Office of the Deputy Prime Minister of the Slovak Republic for Investments and Informatization of March 16, 2020 on standards for information technology of public administration defines the standards of technical solutions in public administration information systems, it also applies to open data:

- the technical requirements for the publication of data datasets are processed in § 38 - § 40
- the decree precisely defines what an open data dataset is, sets the quality level of datasets (0-5), data marking standards, provision of metadata, or the type of licenses that can be used to settle the terms of use (especially Creative Commons)

2.3. HVD datasets

The European Union realizes that making data available to all member states in an open data format is important for multiplying their potential for European society and the economy, for example for research, informed decision-making and the creation of new products and services ([High value datasets, article on the data portal. europa.eu, 2020]).

In June 2020, Directive 2019/1024 of the European Parliament and the Council on open data and reuse of public sector information (Open Data Directive) was adopted. This Directive defines, inter alia, "high-value data sets" as documents whose repeated use is associated with significant benefits for society, the environment and the economy, in particular because they are suitable for the creation of value-added services, applications and new, high-quality and decent jobs, as well as the number of people who can benefit from these services and value-added applications based on these datasets. (Article 2, point 10 of the Directive)

These are mainly the 6 areas in which the datasets should be identified:

- observing the Earth and the environment, e.g. energy consumption and satellite images
- meteorology e.g. in situ data from weather instruments and forecasts
- statistics e.g. demographic and economic indicators
- companies and company ownership e.g. business registers and registration identifiers
- mobility e.g. traffic signs and inland waterways
- geospatial data, e.g. postcodes, national and local maps

In 2022, Commission Executive Order No. 2023/138 of 21 December 2022 establishing a list of specific high-value data sets and the conditions for their publication and reuse.

2.4. National concept of computerization of public administration

The national concept of informatization of public administration was created in 2015 and updated in 2021.

It includes the following activities:

- ensuring that the public administration publishes information by default in the form of open data, i.e. in an open machine-processable format cataloged in the National Open Data Catalog published on the Central Open Data Portal
- providing methodical, educational, educational, motivational and technical support for the entire public administration, including making available technical solutions that they can use for publishing data
- open data will be an active data set for the performance of public administration
- publishing high-value datasets for reuse for free and via API
- publishing requested priority datasets by the public and introducing monitoring of the level of use of open data

2.5. Action plans for open governance

- In the Initiative for Open Governance of Slovakia, Action plans come usually in 2 annual cycles, in the past AP Initiatives for Open Government (IOV) SR 2012-2013, AP IOV SR 2015, AP IOV SR 2017-2019, AP IOV SR 2020-2021, AP IOV 2022-2024, AP IOV 2024-2026.
- Thanks to the implementation of the action plans, the data.gov.sk portal was established, more than 2,000 datasets were published, technical standards for open data datasets were set, and the task of creating a publication minimum for individual state administration organizations was defined.

- The Data Act is created based on the task of the Action Plan of the Initiative for Open Government of the Slovak Republic.
- The Office of the Plenipotentiary of the Government of the Slovak Republic for the Development of Civil Society annually evaluates the state of data disclosure by individual ministries at data.slovensko.sk.
- The latest action plan for the years 2024-2026 includes the task of increasing the use, repeated use of open data of public administration and to draw up an annual report on the impact of open data in the Slovak Republic on selected areas in a participatory manner.

2.6. Methodology for assessing the impact of open data on selected areas of society

The methodology for evaluating the impact of open data on selected areas of society, developed by MIRRI in 2023, serves to evaluate the impact of open data on selected areas of society in Slovakia. The methodology is based on other comparable methodologies, on publications, analyzes and studies of the European Data Portal, Open Data Maturity rankings (European Commission) and OURdata (OECD) and knowledge of the current state of open data in Slovakia (2023) and the future desired state.

The methodology mainly focuses on monitoring indicators that indicate the positive social and economic benefits of open data and also on monitoring indicators that, according to the available literature, lead to the evaluation of open data.

The main sources of data for the methodology are the analysis of the central open data portal, information published on the open data methodological portal, surveys for open data users, data curators and for entities that create added value over open data, analytical studies of the impact of open data and a list of uses (use hours) of open data.

The methodology was used for the first time in 2024 when preparing the 1st report on the impact of open data on selected areas of society. The methodology is part of an effort to better understand the impact of open data, to create conditions for increasing their impact on the economy and the development of society. It also helps to improve the position of Slovakia in open data evaluation rankings.

2.7. Publication minimum of self-government

The publication minimum (PM) represents a list of datasets - data and documents in a structure, based on legal standards that already impose an obligation on cities to publish information. The publication minimum exists in the version for municipalities and for the state administration, while the PM of the municipality is recommended (it is not given as a legal obligation). The first wave of the publication minimum is currently in force, the second wave is being prepared, and consultations with the local government are currently underway.

Among the PM datasets of the municipality are e.g. Contact information, List of contracts, orders, invoices, list of subsidies, list of generally binding regulations, List of council meetings, list of commissions, list of deputies, etc. According to Erika Kusyová, an expert on self-government, the current situation at the local level in the field of publication is currently far from the declared goals of the state in this area. There are many obligations, but few municipalities publish everything that the law imposes on them and in the format in which the law requires it. On the other hand, the publication minimum can help municipalities in what data to publish machine-processable and under open licenses and in what structure, regardless of the supplier.

The PM contains a detailed description of the datasets and their recommended structures: source

3. Where to publish and search for datasets

3.1. Open data portals

They are specialized portals where you can find datasets and OpenAPI (open API) of open data. As a rule, each country has a central (national) open data portal that collects all datasets of organizations - data providers. These portals are then harvested by the central European portal data.europa.eu.

In addition to downloading and browsing data, portals often provide other functions - the possibility of registering applications, evaluating and commenting on datasets, monitoring the quality of datasets, educational materials, articles, blogs and news.

> **„Harvesting“**
>
> It is a method of obtaining metadata about datasets. Harvesting is used if we want to display the content of the portal (e.g. local) on the national portal as well. In practice, it happens periodically (eg every night) and only metadata information is transferred, not the files themselves.

The European Open Data Portal (data.europa.eu) offers datasets harvested from national open data portals of EU countries. There is also a lot of other interesting content such as education, publications and activities.

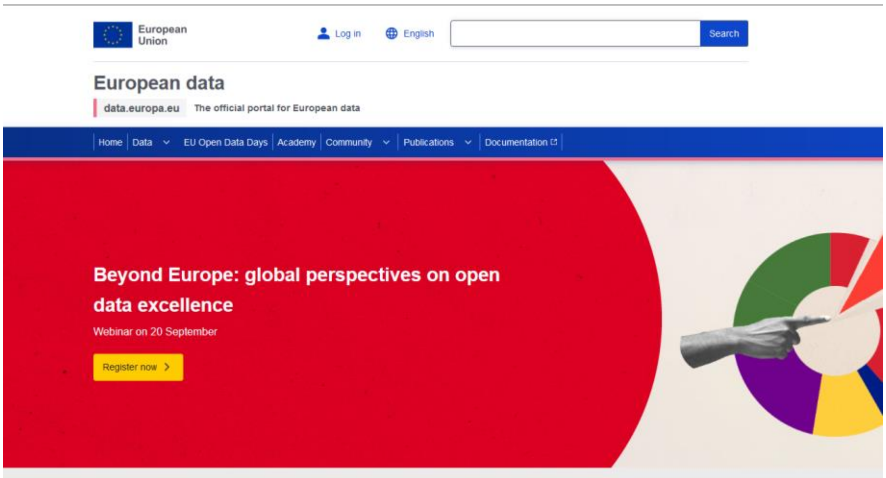


Figure 2: The data.europa.eu portal (source: data.europa.eu)

3.2. Other portals

In addition to regional, national, and European open data portals, there are other specialized portals that focus on topic-specific datasets. These portals provide valuable data resources tailored to various fields and are used to support diverse applications and sectors. For instance, portals dedicated to public transport, weather and climate, air quality, earth observation, mapping, and environmental sensor data offer datasets and APIs that cater to unique user needs. From developers and researchers to local planners and environmental analysts, these portals enhance access to high-quality, targeted data, contributing to data-driven insights across industries. The following table provides an overview of key topic-specific portals.

Category	Portal Description	Website

Public Transport	**Transit Land** - A community-edited data service aggregating transit networks across metropolitan and rural areas worldwide	Transit Land
	Open Mobility Data - A free service for power users of transit data, including app developers, web developers, and transit agencies	OpenMobilityData
Weather and Climate	**ECMWF** - The European Centre for Medium-Range Weather Forecasts	ECMWF
	ESA Climate Change Initiative - The European Space Agency's open data portal for climate change data	ESA Climate Change
Air Quality	**WHO Air Quality Database** - World Health Organization database on air quality (5th edition, released in April 2022)	WHO Air Quality
Earth Observation	**Copernicus Open Access Hub** - A portal for accessing data from the Copernicus program	Copernicus Hub
Maps	**OpenStreetMap** - Community-based free map data and portal	OpenStreetMap
Sensors	**Open Sensor Web** - A product by Pikobytes, an IT startup specializing in software and cloud services for integrating and analysing environmental data	OpenSensorWeb

Table 3 : Overview of key topic-specific portals

3.3. National open data portal

The portal is located at data.slovensko.sk and contains slightly more than 7900 datasets. In the past, this portal was located at data.gov.sk, in 2023 the new portal data.slovensko.sk was launched, as the old one no longer met the modern requirements for an open data portal. On this portal, it is possible to find mainly datasets of state administration - ministries, other central bodies of state administration, but also state enterprises. In addition, some municipalities also publish datasets here, for example the cities of Prešov, Trnava, Levoča and others. Among the functions, the portal offers users browsing of datasets, organizations, filtering by tag, format, license, search by any text. The portal also includes registration of applications (currently 10 are registered) and suggestions (for publishing the dataset, for the quality of the dataset, others).

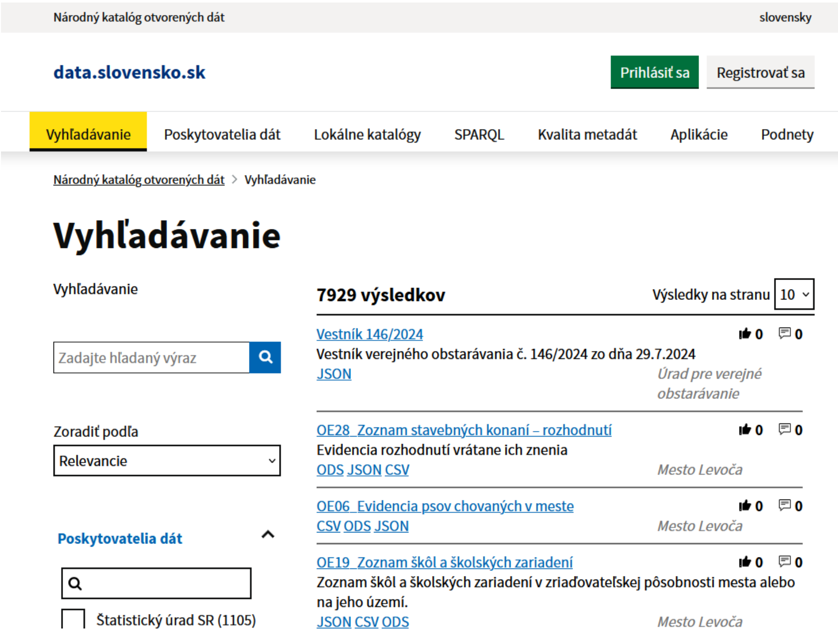


Figure 3: Portal data.slovensko.sk

It is possible to log in to the portal using an eID (slovensko.sk) - publishing or using any e-mail - community functions such as adding applications, suggestions, comments, likes.

The portal also supports local portal harvesting. Any public organization, municipality, company, non-profit organization can publish open data on the portal (it is important to have an ID number).

The most datasets on the portal are published by the Statistical Office of the Slovak Republic (1105), the Central Control and Testing Institute for Agriculture in Bratislava (828) and the Ministry of the Interior of the Slovak Republic (822).

štatistika	5,98%
register adries	4,53%
ulica	4,27%
voľby	2,98%
cesta	2,42%
cestný úsek	2,33%
geografická reprezentácia	2,33%
adresa	2,26%
Obec	2,03%
adresy	1,95%
byt	1,93%
časť obce	1,93%
kraj	1,93%
okres	1,93%
orientačné číslo	1,93%
súpisné číslo	1,93%
vchod	1,93%
budova	1,89%
ostatné	53,53%

Figure 4: The most used tags on the portal (source: Analysis of publication of ÚOŠS datasets for the year 2024)

For the MIRRI portal, several trainings have been published, which are available on the [methodological portal opendata.gov.sk](). Trainings are available on how to publish open data on the portal manually and automatically.

3.4. Self-governing portals

As of April 2022, Slovak municipalities published a total of more than 1,500 datasets. Currently, this number is several thousand. One of the largest providers of open data is the capital Bratislava, which publishes more than 250 datasets, the Prešov self-governing region publishes approximately 226 datasets, and the third Trnava self-governing region approximately 118. The municipalities also publish datasets containing georeferenced information and also make APIs (application programming interfaces) available.

Local governments are responsible for many topics that are important for the lives of citizens, e.g. environment, waste, transport, local communications. Datasets from all these areas can be published by municipalities.

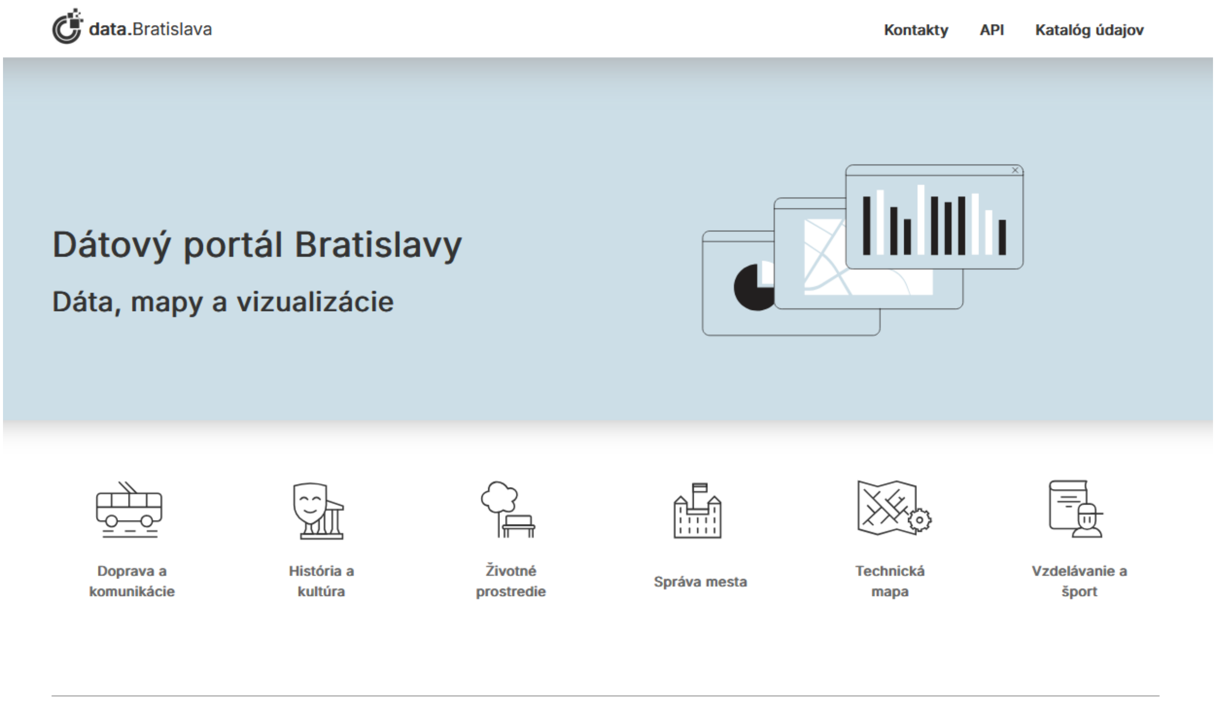


Figure 5: The data portal of Bratislava, in addition to datasets, also contains APIs, maps and visualizations (source: data.bratislava.sk)

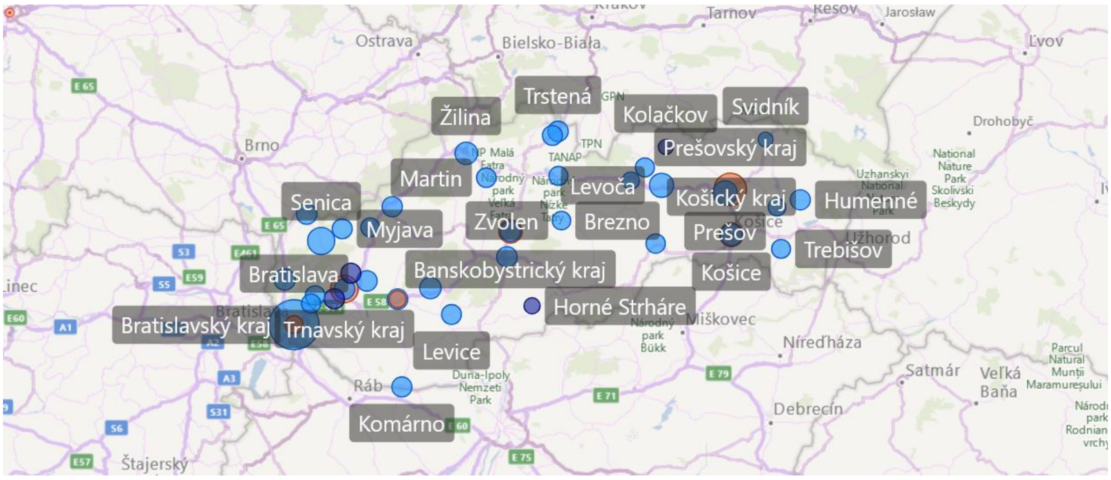


Figure 6: Open data is published by municipalities across Slovakia (source: alvaria.sk)

4. How to manage open data

Open data management is part of comprehensive data management in the organization. In order to be able to set up processes around the publication and use of open data, we need to know how data is created, organized, archived and maintained in organizations.

Open data management can be divided into two parts, namely the strategic (policy) and technical part (open data cycle).

4.1. Strategic component

Anchoring open data in local policies helps municipalities better implement open data and supports its sustainability. Before the actual publication of open data, it is necessary for the municipality to have a mapped starting state, a defined goal (measurable), the desired state and activities that will enable it to fulfill the goal.

Having an approved open data policy helps municipalities (Hupková, 2024):

- increase the legitimacy of projects and initiatives aimed at publishing open data
- to share a common vision within and outside the organization - to be in the same boat
- set short-term and long-term goals and define specific steps to reach them, including a timetable - grasp and solve the issue comprehensively
- allocate resources and determine responsible persons for individual tasks
- create a basic framework for measuring progress and success

In the Slovak Republic, it often happens that local governments start to publish open data "spontaneously", they are not part of wider strategic management, processes, and their success depends on enthusiastic individuals. Among dozens of municipalities that currently publish open data, only the municipality of Bratislava and Banská Bystrica self-governing region have approved data policy.

The EDP lists several topics that should be covered by an open data strategy (European Data Portal, 2018):

- a list of data (categories) within your organization
- evaluation of the status of data, current and those in the future
- compliance with legislative aspects
- necessary activities to achieve goals
- technical implications: implemented and planned decisions
- budget
- team or contact point including clear roles and responsibilities
- schedule
- indicators (KPI) for measuring progress in meeting goals

It is up to the municipality to decide whether to anchor the position of the so-called A data curator who oversees and coordinates the overall data management. Following the example from the private sector, where companies have filled the position of "Chief Data Officer", this position is also starting to be filled in public sector organizations.

A data curator is a person who should know exactly what data is collected, what information systems are used in it, what IT projects are planned and with what data outputs, who writes the data into the systems and in what quality they are collected (accuracy, timeliness, completeness, correctness) (Alvaria).

Open data strategy should be created transparently and participatively. It is crucial and necessary to involve people and organizations (e.g. working groups, workshops, etc.) that will participate in the publication and use of open data in the creation. Participatory creation enables municipalities to better understand the initial state, needs and interests of interested parties and validates and enriches the proposed solutions. At the same time, by inviting actors into the creation, joint ownership for commitments is built, which can lead to better implementation.

4.2. Technical component - open data cycle

The life cycle of open data is complex and involves several workers and entities within and outside the organization. It can be roughly divided into several phases that have their own specific aspects.

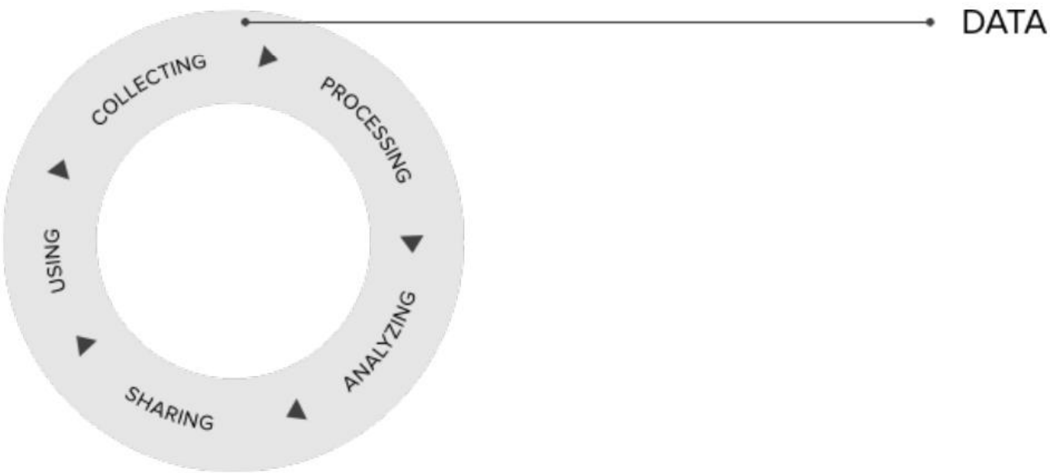


Figure 7: Life cycle of open data (source: Young et al., p. 6.)

4.2.1. Data collection

In this phase, data is created and collected. Ownership, authorship, source of data may differ, which also affects the possibilities of further making data available to the public. In practice, we encounter the following situations:

- The local government is the author and owner of unique data (authoritative source): Employees create data based on the implementation of the agenda, through the use of ICT. Data are created in agendas such as collection of taxes, purchase of goods and services, provision of subsidies, social services, waste management, etc. The data are unique, however, since they are created in proprietary IS, the possibilities of publishing the data also depend on the license conditions concluded between the municipality and the IS supplier.
- The local government publish the data and the source is a private supplier: The local government concludes contracts with private companies for the delivery of services, the output of which is data (e.g. cycle paths, green areas). Before the purchase, the local government defines the technical and licensing conditions so that it can also publish the data on the open data portal.
- The local government has access to data: For the purposes of implementing its agenda, the local government concludes agreements on the access or provision of data with organizations on the national or regional level. Despite the fact that these are data about its own territory, the licensing conditions are often very restrictive and the local government cannot disseminate the data.

4.2.2. Data audit

The data collection phase may also include a data audit. The audit can be carried out, for example, by means of a questionnaire for individual branches (e.g. Google or Microsoft Form). The audit should answer the following questions: (Alvaria):

- "What data does the municipality have at its disposal? What data is created directly in the municipality (and the municipality is therefore an authoritative source)? What information systems are used and what is in them? What data is collected from third parties and is the municipality only using it? (E.g. cadastral data.) What are the legal conditions for further use, remix (combination with own data) and publication for data that comes from third parties?"
- "Where is the data located? What databases, Excel tables, but also unstructured files (e.g. word documents) and non-digital information (paper notebooks, filing cabinets) store the data that the municipality works with? (It is important to have a good overview, also for data security, data backup and archiving.)"
- "What is the quality of the data? Who is responsible for their correctness and up-to-dateness? What information is missing?" (Alvaria)

As part of a data audit, information is typically collected such as:

- Dataset name
- Description of the dataset
- Dataset manager
- Author of dataset
- Date of issue

- Update frequency
- URI
- Technical description
- Publication (total, partial not possible)
- Publication date
- Contact

4.2.3. Data processing

This phase includes activities aimed at improving data quality - data is cleaned to make it usable, errors, irrelevant or inaccurate information are removed, data is verified, or modify them to be machine-processable (Young et al., 2021).

4.2.4. Data analysis

In this phase, it is possible to determine which datasets the municipality prioritizes for publication, given that the municipality has limited resources. Self-government when making decisions can be based on:

- User inquiry: The inquiry survey can be carried out via a web form (e.g. Google Forms)
- Frequently requested data: In accordance with the Act on Free Access to Information, self-government keeps records of requests for information disclosure. If some requests are repeated and the nature of the data allows it, the data can be made available to everyone in an open data format. By doing so, it is possible to break down bureaucracy.
- High-Value dataset concept: The European Commission has published a regulation that requires Member States to make high-value datasets available in open data format in the topics of Geospatial Data, Earth Observation and the Environment, Meteorology, Statistics, Companies and Company Ownership, and Mobility.
- “Low-hanging fruit”: Datasets that are of the desired quality and can be published immediately without additional costs.
- Mandatory published data: Many data must be published by local governments by law. If the nature of the data allows it, it is also possible to publish this data in an open data format (e.g. program budget, contracts, orders, invoices, etc.)
- Publication minimum for local governments: MIRRI defined a minimum list of open data datasets (1st wave) including attributes that should be made available by local governments as open data.

4.2.5. Sharing

In this phase, the municipalities make the datasets available to the public, while they can choose from several solutions (Alvaria):

- Create a catalog on the city's website - This is a simple solution in the form of a clear page, subpage, table, where datasets in various formats are available for download, including a detailed description of the data (metadata).

- Develop your own open data catalog: Within the internal capacities of the local government or contact the supplier of information systems. The ideal scenario is if open data is published from information systems in an automated manner.
- Data.slovensko.sk and its technical infrastructure – this infrastructure is provided free of charge, at the same time the municipality fulfills its task of publishing data on the data.slovensko.sk portal. Datasets can be published manually or automatically using a local catalog. It is not necessary to physically upload the data to the portal, it is sufficient to provide a link. Another advantage is that if the datasets are cataloged on data.slovensko.sk, they are also automatically downloaded to the European data portal, which makes the data more visible. In Slovakia, municipalities often use existing solutions from CoraGeo and ArcGIS suppliers.

4.2.6. Using

If the offer meets the demand, in this phase other commercial or non-commercial solutions are created over the data - web applications, mobile applications, analyses, interactive visualizations, or data integration into new or existing services. Stimulate development, or repeated use of data, the municipality can through work with the community (organizing hackathons, meet ups, etc.).

5. Use cases

The following part is suitable to be adapted by the Partners to their territory.

Examples of the use of open data are various applications of open data. They are created by the local government, the private, academic or non-profit sector. It is important to point out these examples and thus inspire various organizations or individuals to use open data. Many countries collect these examples on their central open data portals, as does the European Data Story Portal (data.europa.eu – data stories). Selected examples of use cases at local and international level are given in these materials and further examples can be found in deliverable 1.1.1 : “Report on Open Data & IoT Usage Good Practices for Territorial Governance at City-Region Level„.

5.1. Local Use Cases

5.1.1. Finstat

Finstat is a portal that contains clear information about companies and their turnover, profit, subject of business, debts and other information. Finstat exists thanks to the fact that the state publishes a lot of data from various registers – the Commercial Register, the Trade Register, the Register of Financial Statements and others. However, this data is difficult to connect, which is what Finstat does, which operates under the Freemium business model. Part of the information is provided free of charge and other data for more demanding users is charged. This is especially for companies or users who use the service often and need detailed information. The data can also be accessed automatically using an API.

Finstat is considered one of the most successful open data projects in Slovakia. The company employs more than 30 people, with revenues of 2.5 million euros in 2023.

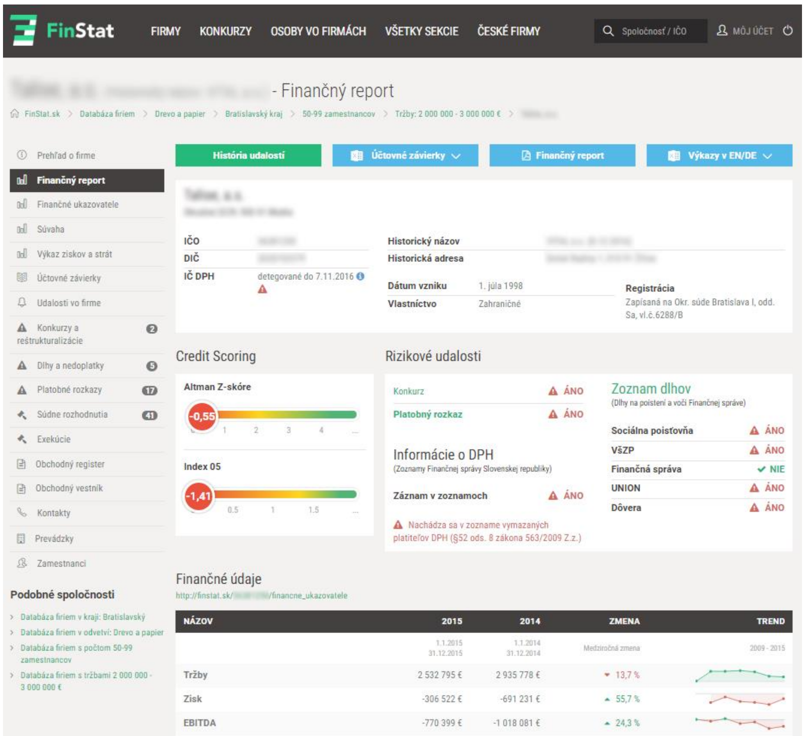


Figure 8: Information on the Finstat portal (source: finstat.sk)

5.1.2. Uvostat

Uvostat is a portal that analyses, provides and visualises data on public procurement in the Slovak Republic. The portal draws data from the open data of the Public Procurement Office in the Slovak Republic and combines them with other sources (Bulletin, Central Register of Contracts, Tenders, Register of Public Sector Partners, Register of Legal Entities, Register of Economic Entities, etc.) By connecting many sources, it saves users time and provides them with comprehensive information on where public resources go, to which companies, for what goods and services and in what volume. Uvostat has about 7,000 users per month. In 2018, the Uvostat portal won the ITAPA Award for the Best Digitalization Project of Society (3rd place).

At the beginning of November 2016, the first version of the portal was launched. After three years, a lot of data has been added to the portal, not only from public procurement, but also from other registers. The portal has started successful cooperation with watchdog organizations such as slovensko.digital, or the Stop Corruption Foundation, or the company Finstat and the Public Procurement Office.

The portal has participated in a number of projects in order to detect anomalies in public procurement. These included machine processing of verification documents at the initiative of Transparency International Slovakia, various analyses for the Stop Corruption Foundation, or various collaborations with other journalists. At the same time, Uvostat provided outputs directly to officers. It also cooperates with similar projects dedicated to open data, namely opendata.sk and verejne.digital.

The portal was founded as a hobby project. It is funded by the profits of other commercial projects, modest advertising, and Patreon. Contributions for a report or a customized service help the project to be able to cover at least its operation (server and domains).

The source of information is the blogs on the Uvostat: https://www.uvostat.sk/blog

5.1.3. Cycling portal of Trnava Self-Governing Region

The cycling portal is *"a central communication point for the office of Trnava Self-Governing Region with the public and the cycling community. It contains up-to-date data on infrastructure and events in the region. It provides space for volunteers to be engaged. It serves all fans of cycling with the aim of constantly improving the conditions for cycling"* (source: https://cyklo.trnava-vuc.sk/).

The bike portal contains several interesting datasets from bike counters, bike routes, Bike to work, bike stands, division of transport work (modal split). The data is visualised using maps and dashboards. The portal uses ArcGIS technology.

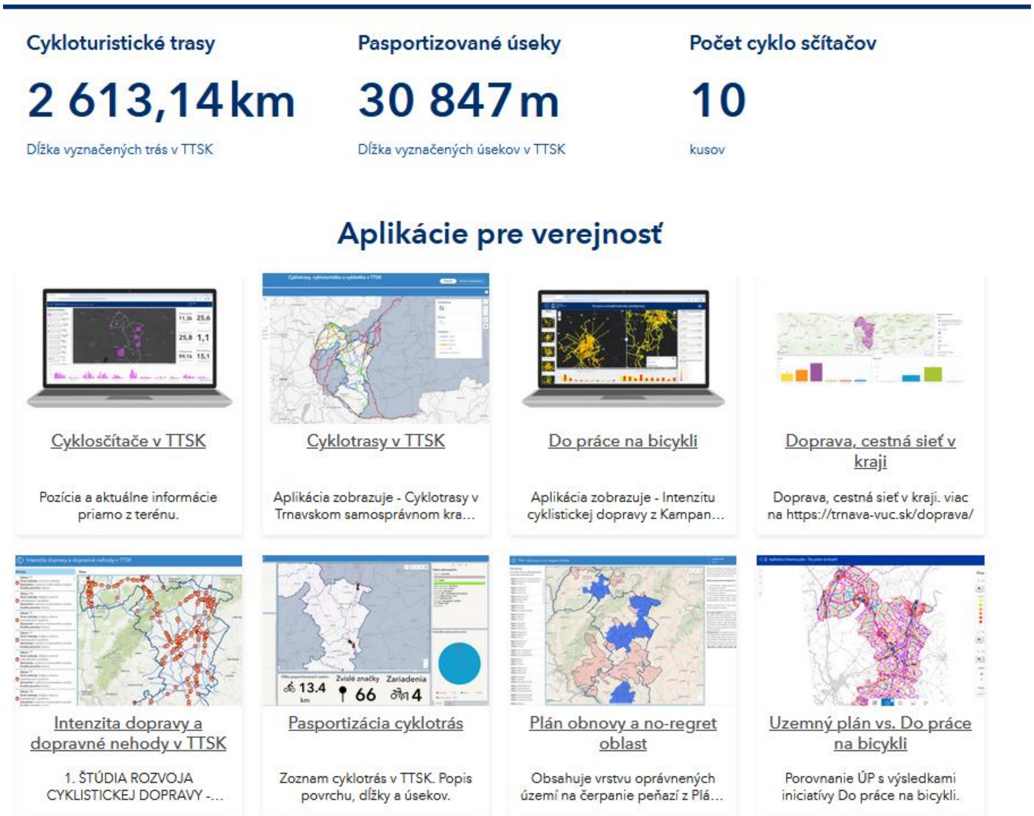


Figure 9: Applications on the cycling portal for the public (source: https://cyklo.trnava-vuc.sk/)

5.1.4. Visual smog

Visual smog is a type of smog that we understand as the saturation of public spaces with advertising. This topic is dealt with by several activists and non-governmental organizations, but recently by the municipalities themselves.

However, there is very little data on the subject. Bratislava was one of the first cities to try to bring data to the topic using a map and a blog.

However, in other Slovak municipalities, such work is still absent and it is mainly a leisure activity of individuals as a comprehensive collection of data on outdoor advertising. However, it could help if cities and municipalities would publish the data they have about advertising in public spaces.

So far, only two Slovak towns and villages have published open data about advertising in public spaces – **Žilina** and **Trnava**.

The basis for the visualization is data from Trnava, which contains data on the area of many advertising devices and is possible to create a visualization so that city residents and potential voters can better see where there is the most visual smog in the city, and to whom the advertising devices belong. This visualization should help the public to become more sensitive to this topic.

If municipalities want to strategically manage the city, it is necessary to collect and publish data, on the basis of which the public has a chance to help with data analysis, or to participate in the discussion on solving problems.

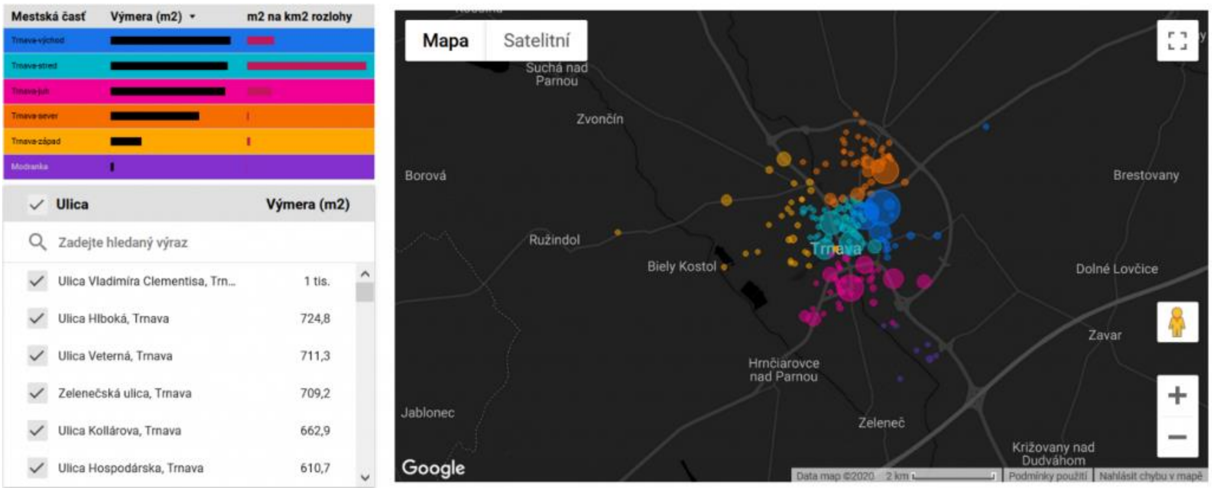


Figure 10: Visualization of open data on visual smog in Trnava (source: Alvaria.sk)

5.1.5. MHDPo

Dissatisfaction with the quality and form in which the Prešov Public Transport Company (DPMPO) publishes public transport timetables led Matej Lukáč, a UX expert, and his team to develop applications for Prešov public transport. The application is used to search for public transport connections, departure times and provides information about current delays of public transport vehicles. The company Nolimit Developers, which is behind the development, today provides an extended application for other cities - Košice, Žilina, Banská Bystrica and Martin. The functionality has been enriched with notifications, ticket sales, an interface for the inspector, and the printing of timetables. The applications are used by a total of 26,000 users per month.

From a UX point of view, using the application is very simple – minimizing texts, controlling via pictograms, counting down the minutes of the next departure of the connection. A bigger problem than designing a good UX solution was initially the unavailability of data on the current location of public transport vehicles in Prešov. A few years ago, this data was not available in open data format.

Based on the reverse engineering of the third-party application that had this data, the authors of the application identified the source where the data is located. Later, GPS data on the current location of vehicles was integrated into the application. Following these proceedings, DPMPO delivered a pre-suit notice to Lukáč, in which they described their activities as cybercrime, while also referring to the paragraph of the Criminal Code on manslaughter. The problem was that the municipality did not define when procuring the DPMPO that the data obtained on the GPS location of public transport vehicles should be made available in an open data format.

The authors of the application therefore call on other municipalities to make it clear that they want the data to be delivered in an open data format. *"This is my private information for local governments – let it be clear that you want the data to be open. . . . You are the contracting authorities, you will pay for* *it, make it a condition to have the data . . . Imagine a situation where you buy Microsoft Office, pay money for it, and now you can send the document you create only to a colleague, outside the office to no one. Who would buy it?", advises Matej Lukáč, from Nolimit Developers.*

Thanks to the personal contribution of the employees of the city of Prešov and the organization of the 1st Šariš Hackathon, it was possible to persuade DPMPO to make the data on the current location of public transport vehicles available as open data. Subsequently, Nolimit Developers managed to expand the functionality and launch the application in other cities in the Slovak Republic.

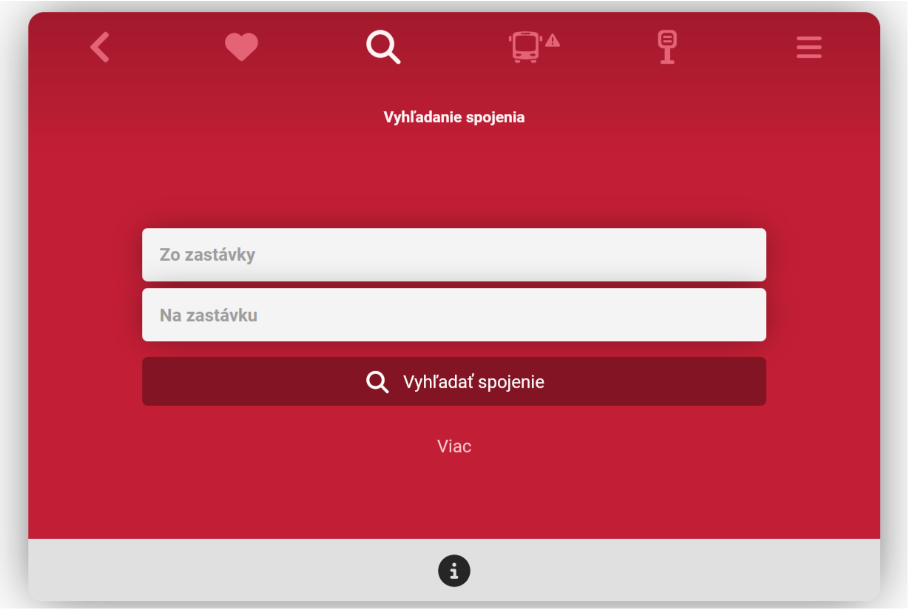


Figure 11: Example of the MHDPO web application (source: mhdpo.sk)

5.1.6. A series of hackathons in Prešov

Prešov is one of the first Slovak cities to start publishing open data. In addition to publishing [very interesting open data](), Prešov also organizes events, having organized 2 Šariš hackathons and 2 hackathons in cooperation with Ministry of investments, regional development and informatization of the Slovak Republic (MIRRI).

> **"Hackathon"**
>
> is an event in which programmers, or in cooperation with graphic designers and web designers, work intensively on a given software project. Its function can be purely educational, but in many cases the goal is to create a specific IT application. (source: wikipedia.cz). The hackathon often has a declared theme, or the goal of the hackathon and is usually limited in time (typically 1-2 days), participants work in teams and are physically present at the venue. The goal of the participants is to create the best possible idea at the given time and based on it the best possible product/prototype.

At the first two Šariš hackathons, very interesting applications were created, e.g. the Notifications Prešov portal (Oznamy Prešov), which allows users to selectively send selected information from the official board to e-mail.

In 2023 and 2024, Prešov organized 2 hackathons in cooperation with MIRRI:

- Hackathon Digital Twin of the City of Prešov
- Hackathon Digital Citizen of the City of Prešov

At both hackathons, very interesting prototypes of applications for the city were created – e.g. for measuring energy consumption, detecting water leaks, citizen participation, reporting suggestions to the city, voting on various topics. The best solutions from both hackathons will be implemented by the city, while funds are allocated for them in the city budget.

5.1.7. Data-based decision-making in PSK and KSK

Prešov Self-Governing Region (PSK)

PSK has built the Geoportal, which serves as a platform for the integration, storage and publication of spatial data. The PSK Geoportal combines a catalogue of open geospatial data, a map viewer, thematic maps and dashboards. PSK uses the Geoportal to set up various policies with the aim of developing the region. Data on the region is also used by municipalities in the region.

In an effort to best identify the problems and investment plans of individual parts of the region, the analysts prepared a thematic map that visualizes all the necessary information (results of questionnaire surveys, demographic and economic statistics, project plans,...) related to the preparation of the new programming period:

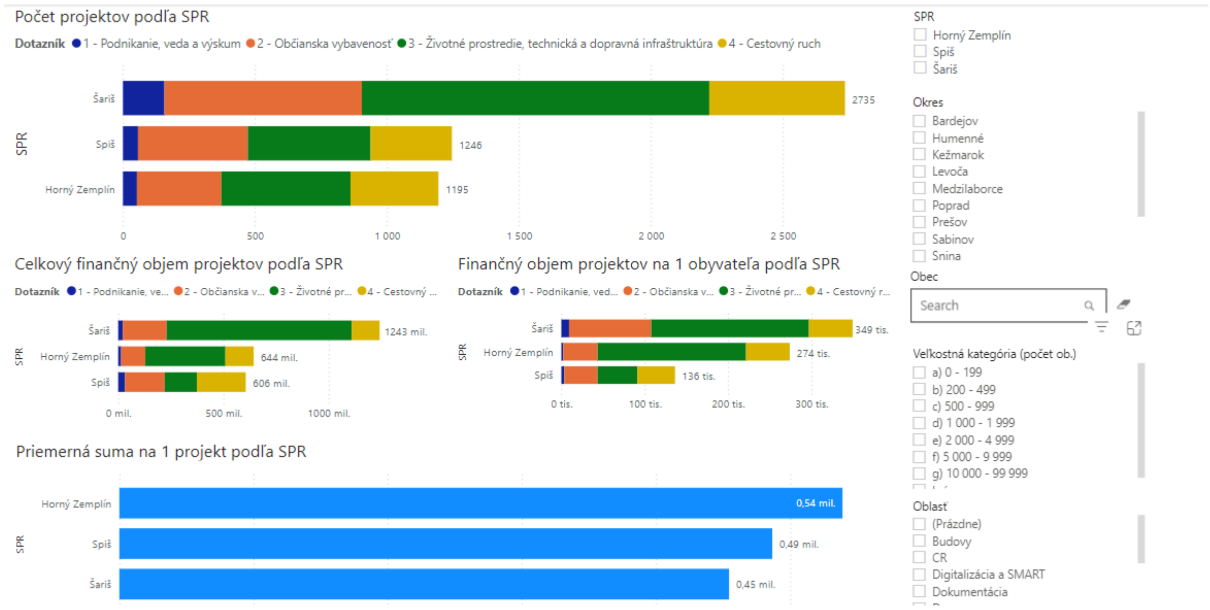


Figure 12: A preview from the PSK visualization, which analyses the investments of municipalities in the regions as part of the preparation of the programming period.

Košice Self-Governing Region (KSK)

Following the example of PSK, the Košice Self-Governing Region also built the Geoportal. The KSK geoportal offers similar functionalities and fulfills the role of a basic database for the region in decision-making.

KSK also used the portal to predict the consequences of climate change in the region:

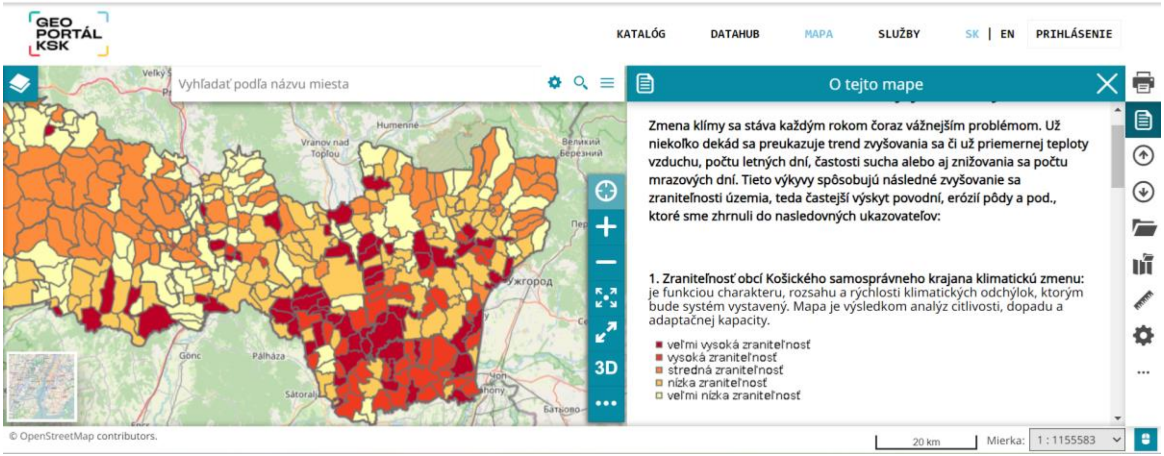


Figure 13: A preview from the KSK map application, which presents the impacts of climate change on the region (source: https://www.geoportalksk.sk/mapstore/#/viewer/3171)

5.2. International cases

5.2.1. Case study – Environment (Platform): IPR Praha

The Prague Institute of Planning and Development (IPR Prague) is Prague's main policy-making unit for architecture, planning, development, design, and administration.

The Prague Institute of Planning and Development develops and manages Prague's geographical data and performs spatial analyses of traffic accessibility, ownership relations within the city, and the structure of built-up areas, among others.

IPR Praha has a clear graphical identity, offers precise and publicly accessible information, and showcases various data in both 2D and 3D formats, making all content readable and easy to navigate.

It serves multiple functions all in one place:

1. Geoportal of Prague

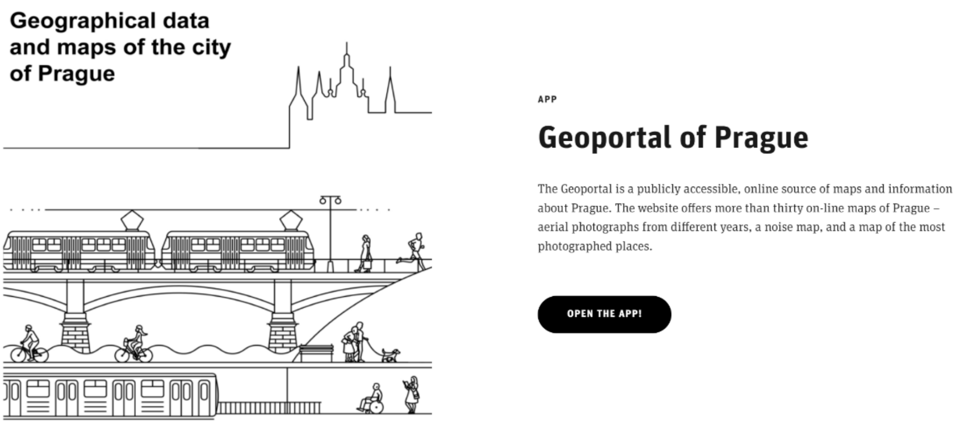


Figure 14: Geoportal of Prague (source: https://iprpraha.cz/en/)

2. Digital map

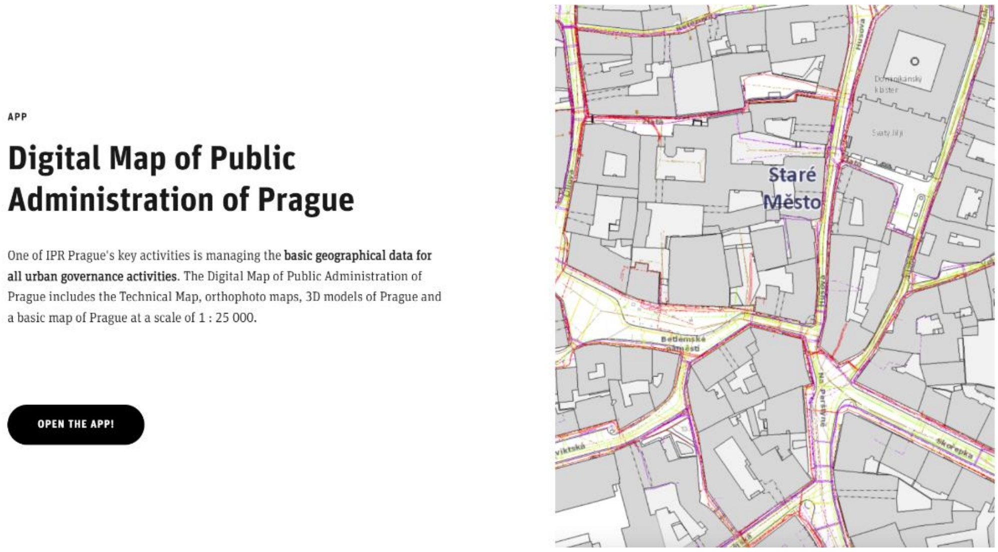


Figure 15: Digital Map of Public Administration of Prague

3. Open data

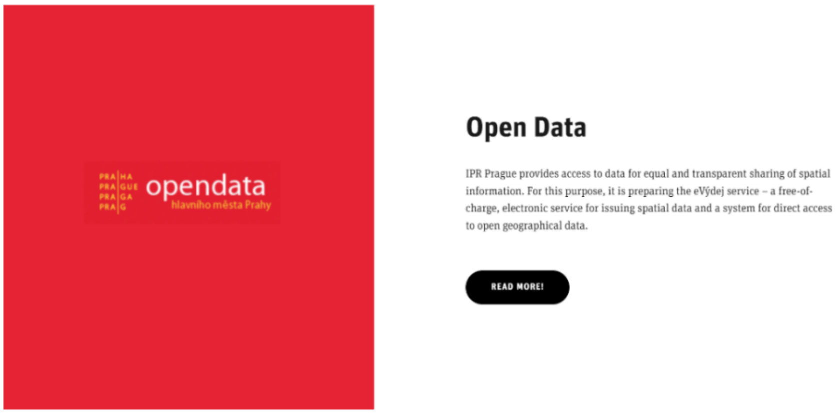


Figure 16: Open data of Capital City of Prague

4. Spatial analytical documentation

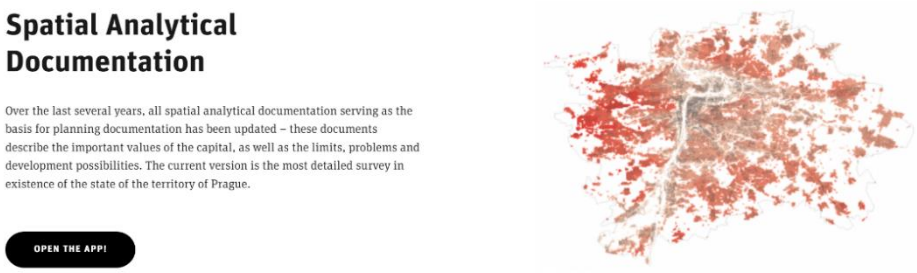


Figure 17: Spatial Analytical Documentation of the territory of Prague

5. 3D model application

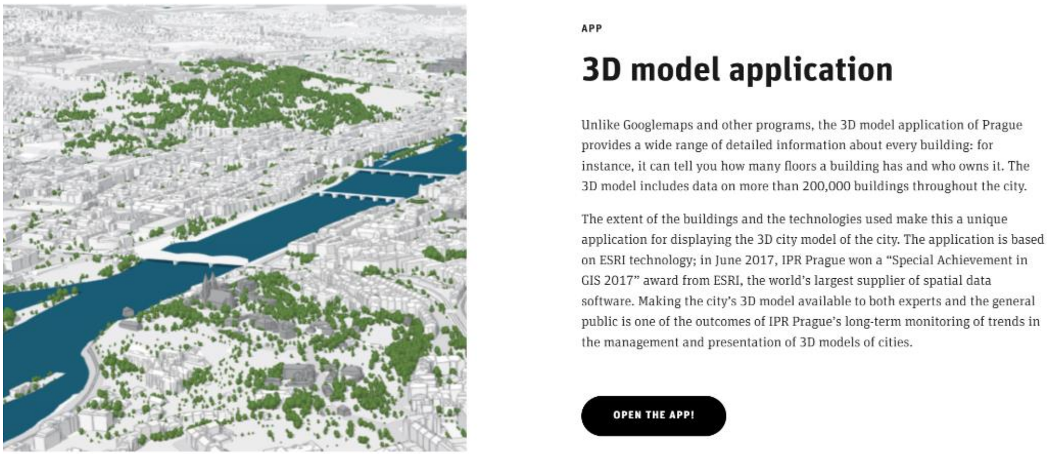


Figure 18: 3D model application of Prague

IPR Praha offers a comprehensive range of tools and information aimed at urban planning and development – more cities should take this as an example for an excellent approach.

5.2.2. Case study - Traffic: Traffic data analysis of the city of Zurich

The website from the City of Zurich's open government data (OGD) portal offers various applications that leverage IoT (Internet of Things) technologies for urban management, particularly in traffic monitoring (31).

Key Features

1.Focus on Vehicle Counting:

- Zurich has developed an IoT-based network that specializes in counting vehicles across various locations in the city. The data collection effort is aimed at gaining insights into traffic volumes and patterns.

2.Established in 2012:

- The vehicle counting system has been operational since 2012, giving it over a decade of data to draw from, which allows for comprehensive trend analysis and year-over-year comparisons.

3.Wide Coverage – 215 Counting Locations:

- The system is extensive, with 215 counting locations strategically placed throughout the city. This provides a thorough representation of traffic patterns in different parts of Zurich.

4.Trend and Comparative Analysis:

- The data collected is used to identify trends over time, enabling a comparative analysis of traffic patterns across different years. This provides valuable insights into the evolution of traffic volumes and the impact of policy or infrastructural changes on vehicle flow.

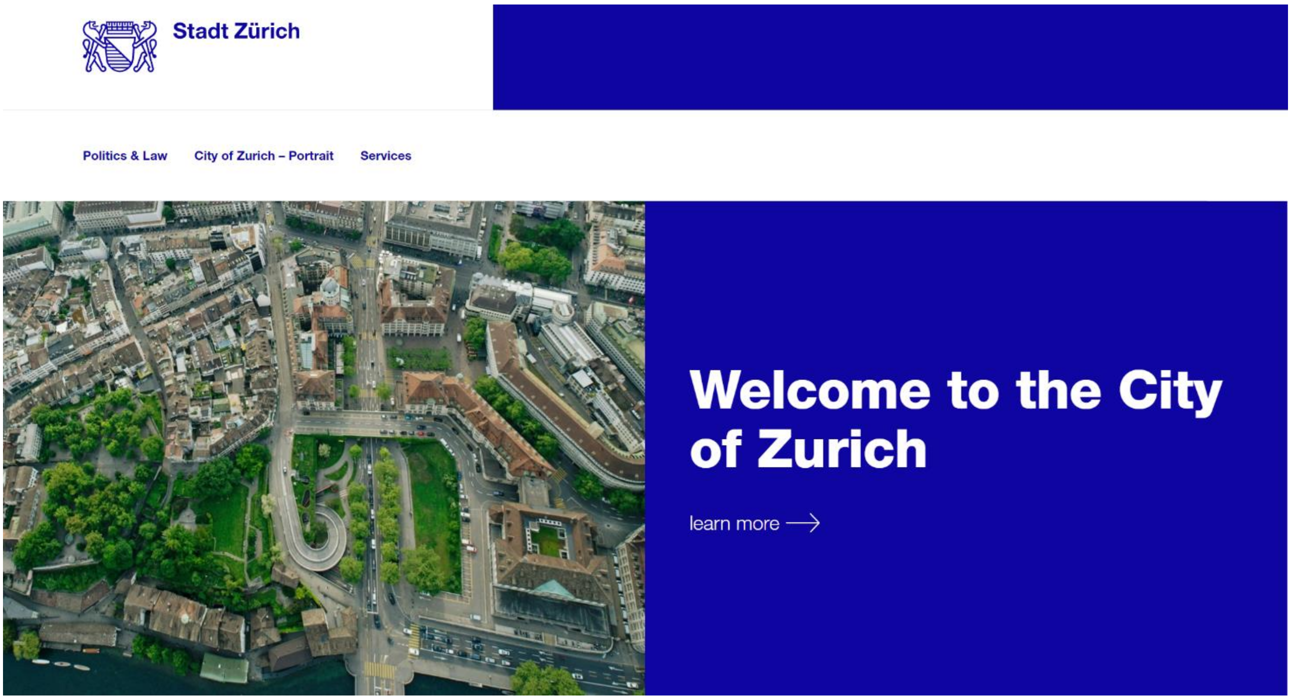


Figure 19: City of Zurich's open government data (OGD) portal (source: https://www.stadt-zuerich.ch/portal/en/index.html)

Use Cases and Impact:

- **Urban Planning:** This IoT-driven traffic monitoring system supports Zurich's urban planning and development initiatives by providing real-time data that can be used to optimize traffic flow, improve road safety, and manage congestion.
- **Sustainability Efforts:** By analysing vehicle volumes and traffic trends, the city can implement targeted measures to reduce carbon emissions and promote sustainable mobility solutions.
- **Decision Support:** The historical and real-time data serves as a valuable resource for decision-makers to assess the effectiveness of transportation policies and infrastructure projects.

Best Practices Observed:

- **Data Transparency and Accessibility:** this traffic data is openly available on its OGD portal
- **Scalability:** With 215 counting locations and frequent data collection, the system demonstrates scalability, showing how a comprehensive network can provide valuable insights.
- **Historical Comparison for Better Planning:** Using year-over-year traffic data comparisons helps inform long-term planning and strategic interventions in the city's transportation systems.

Possible Improvements or Future Expansion:

- **Integration with Other Data Sources:** Integrating the vehicle counting system with other IoT networks, such as public transport usage or air quality monitoring, could provide a more holistic view of urban mobility.
- **Real-time Public Dashboard:** Developing a real-time public dashboard showing live traffic data and trends could further improve citizen engagement and urban mobility.

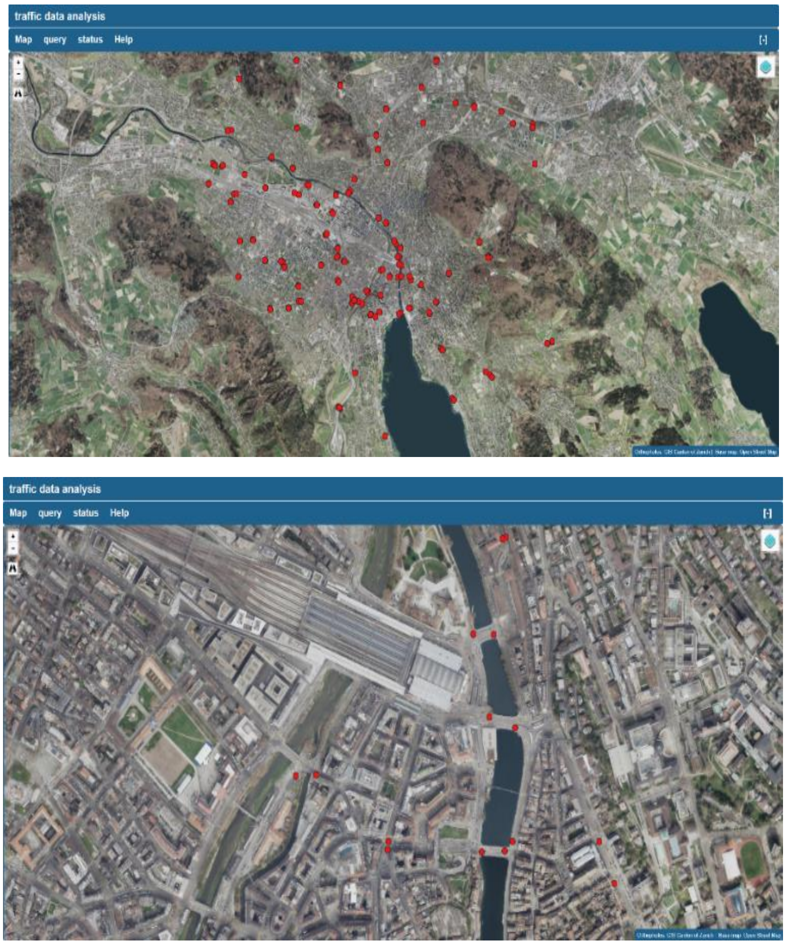


Figure 20: Traffic Data analysis in City of Zurich

Zurich's implementation of IoT for traffic management is a solid example of how smart city technology can be effectively utilized for urban planning, sustainability, and data-driven decision-making.

5.2.3. Case study – Platform: Sentilo

Sentilo is an open-source platform designed to connect sensors with applications, facilitating urban service management.

Sentilo (27) stands out as a powerful, flexible, and scalable platform for smart city management. Its open-source foundation and interoperability make it a compelling option for municipalities looking to improve urban services through IoT integration. By offering a full suite of services, from data processing to visualization, Sentilo presents a comprehensive solution for cities aiming to become smarter, more responsive, and more efficient.

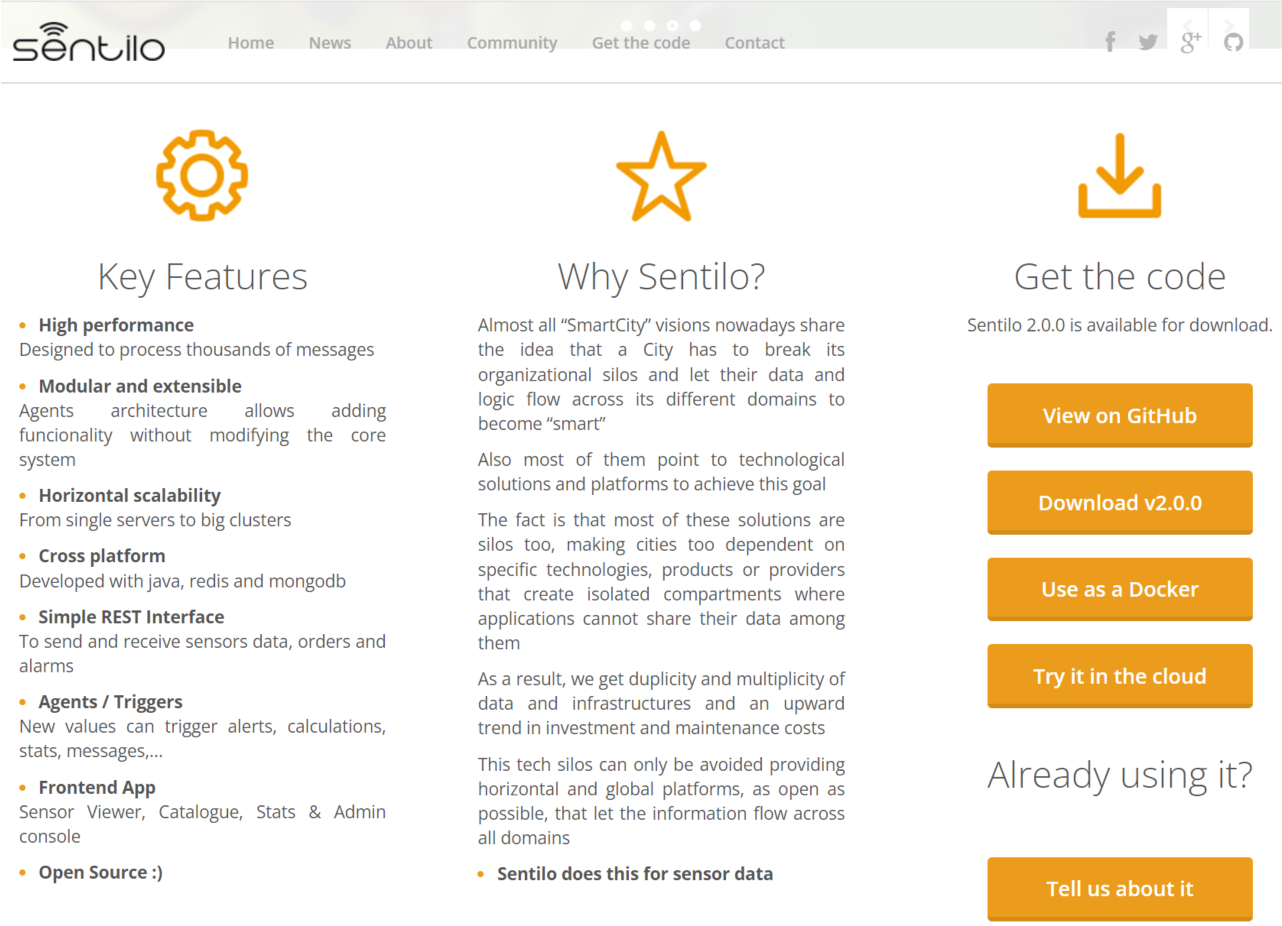


Figure 21: Open-source platform Sentilo (source: https://www.sentilo.io/)

Key points

1.**Open-Source & Collaborative**: Developed in 2012 by the Barcelona City Council and Municipal Institute of Informatics, aimed at easy accessibility for urban IoT systems.

2. Core Features:

- **Message Processing Front-End**: Manages data flow between sensors and applications.
- **REST API**: Simplifies integration with other systems.
- **Administration Console**: Allows system configuration and sensor management.
- **NoSQL Database**: Ensures flexibility, scalability, and high performance.
- **Universal Viewer**: Provides a demo for building custom visualizations.

3. Use Case: Ideal for smart city solutions, integrating real sensors to manage urban services like traffic, waste, and energy.

4. Best Practices:

- Open-source model promotes adaptability and innovation.
- Flexible and scalable, with performance-focused architecture.

5. Opportunities: Enhance user experience, security, and predictive analytics features.

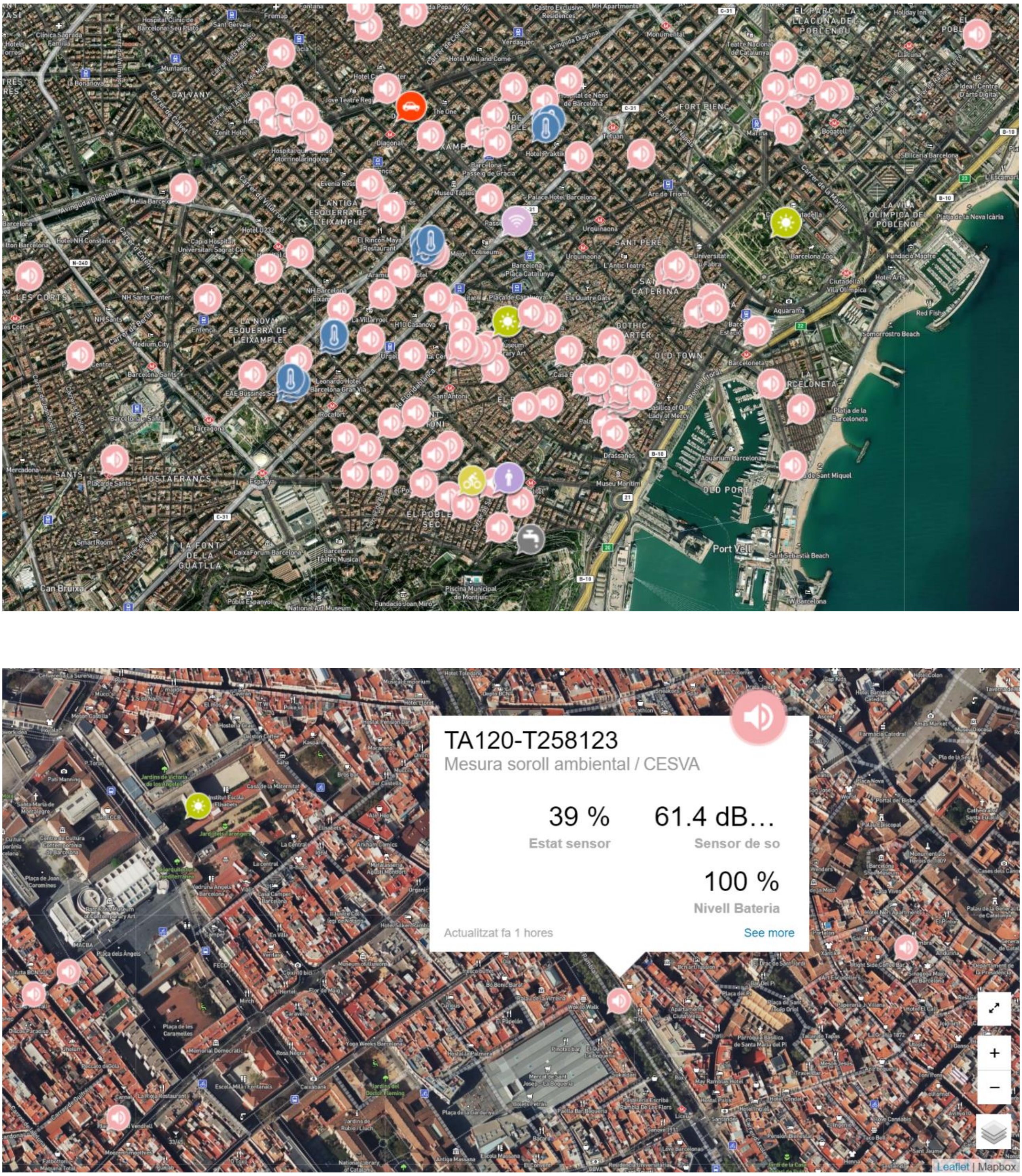


Figure 22: Integration of real sensors in Barcelona City

5.2.4. Case study - Water: NYC'S energy and water performance map

The NYC Energy & Water Performance Map provides an interactive data analysis platform covering 12 years of data on energy, water efficiency, and carbon emissions for nearly 30,000 of New York City's largest buildings

1.Benchmarking Ordinance - Local Law 84 (2009):

- **Local Law 84**, part of NYC's **Greener Greater Buildings Plan**, mandates annual reporting of energy and water consumption by:
    - Private buildings over **50,000 ft²** (reduced to **25,000 ft²** in 2017).
    - Public sector buildings over **10,000 ft²**.
- This law was one of the first of its kind in the U.S. and has served as a model for other cities aiming to reduce **greenhouse gas emissions** in buildings.

2. Data Coverage:

- The platform provides data on **energy and water consumption** and **greenhouse gas emissions** for all buildings covered by Local Law 84.

3. Purpose and Impact:

- The platform aims to help **property owners, tenants, and policymakers** make informed decisions by factoring in energy and water efficiency, as well as emissions.
- It supports **data-driven policy-making** to advance **climate action** and reduce emissions in the real estate sector.

4. Best Practices:

- **Transparency and Accountability**: Public disclosure of building performance data encourages improvements in energy efficiency.
- **Data-Driven Decision-Making**: The platform fosters informed real estate choices and supports the development of sustainability policies.

5. Opportunities:

- Expanding the platform's capabilities to provide predictive analytics and deeper insights could further enhance its utility for stakeholders focused on sustainability goals.

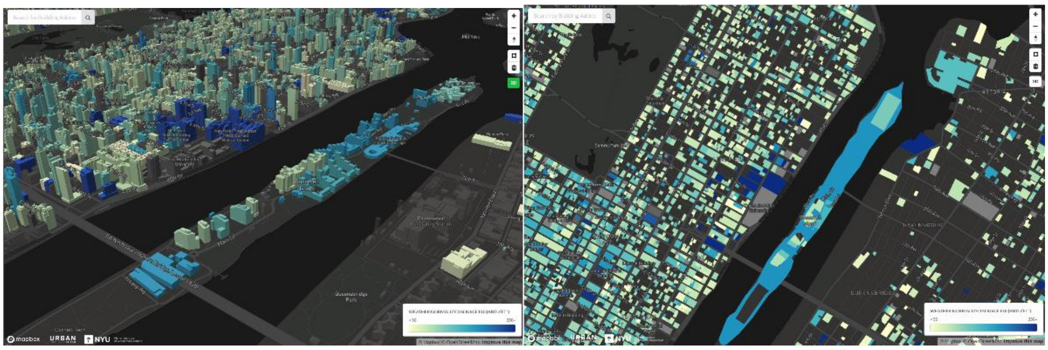


Figure 23: The NYC Energy & Water Performance Map

5.2.5. Case study – Waste: Moda Re- (Clothing Bank Collections)

Moda re- is Spain's largest clothing bank operator with +7,500 clothing banks and +125 stores. They use all funds raised from selling donated clothing to finance charitable projects that help vulnerable groups of people. Moda re- is a social project under the Caritas umbrella organization, which also includes A Todo Trapo and Koopera.

1. **Mentality**: Identify a problem

   Moda Re faced **inefficient collection routes** and **underutilized capacity** in recycling bins, resulting in unnecessary fuel consumption and higher CO2 emissions.

2. **Find a Solution**:
   - IoT sensors were installed in clothing collection bins to provide real-time data on bin fill levels.
   - The waste management system used this data to **optimize collection routes**, responding to actual need rather than relying on fixed schedules.

3. **Key Benefits**:
   - **Improved Efficiency**: Sensor-driven collection optimized routes, reducing unnecessary trips to half-empty bins.
   - **CO2 Emissions Reduction**: Optimized routing cut fuel usage, reducing **CO2 emissions by 35%**.
   - **Cost Savings**: Fewer trips resulted in reduced operational costs and resource consumption.

4. **Sustainability Impact**:

   By adopting this system, Moda Re improved operational efficiency while contributing to the **circular economy** and reducing their carbon footprint.

5. **Best Practices**:
   - **Data-Driven Operations**: IoT sensors enabled a shift from fixed to dynamic waste collection schedules.
   - **Sustainability Focus**: The case shows how integrating smart technologies can directly contribute to **environmental sustainability** while enhancing efficiency.

Figure 24: Materials collected in kg in selected months

5.3. Artificial Intelligence (AI)

"The AI boom or AI spring is an ongoing period of rapid advancement in artificial intelligence (AI) that began in late 2010" (Wikipedia). AI is expected to bring radical changes in the way of how people live, work and it contributes to solving of the global challenges facing the world - the consequences of climate change, regional disparities, or civilization diseases. According to Statista data, in 2023, up to 90 million Americans used AI-based products, which is about a third of the population. Statista further estimates that by 2030 it will be up to 241 million. (Statista)

AI is a complex mathematical model designed to process and analyze large amounts of data in order to identify patterns in data and then make predictions (European Data Portal, 2024). As stated in the UNESCO report, the greatest attention from the media and the public so far has been recorded by the so-called generative AI. By this term we know AI machine learning algorithms (and products), which generates artificial digital content such as text, images, audio and video, based on a large amount of training data. Thus, instead of processing existing data, generative AI generates new content (UNESCO, 2023).

AI-based products and services are also used by self-governments and are mainly focused on processing large amounts of data, e.g. generated through Smart Cities technologies. There are known examples of AI chatbots for communication with citizens, for optimizing transport based on data and subsequent predictions, or for simulating potential natural disasters (floods, fires, landslides, etc.).

Synergies between open data and AI

Open data and artificial intelligence are interconnected technologies. What are the synergies between these technologies? (European Data Portal, 2024) (UNESCO, 2023)

- **Better AI performance** - AI is trained by processing data. Higher availability of various data - also in open data format - helps to further development and more accurate AI results.

Interesting results came from a Spanish open data team that tested generative AI, i.e. ChatGPT. He was asked how many million inhabitants Spain had in the period 2015-2020. The question was asked several times with slight changes, but the answer was still slightly different (at a different time, in a different thread) and was not correct. ChatGPT did not use the available open data dataset of the Spanish Statistical Office, which led to inaccurate answers. Further testing showed that open data in ChatGPT *"still do not use as an authoritative source to answer factual questions, or at least that the model is not yet fully refined on the matter."* (Marín, 2023) Therefore, the use of open state data in AI technologies could lead to more accurate results.

Since (open) data on some phenomena - marginalized communities, the shadow economy, is still missing, are unreliable or inaccurate, AI models may not have knowledge about them, which reduces their performance (UNESCO, 2023).

- **New Identified Patterns and Predictions** – AI can efficiently analyze huge amounts of data. It can identify patterns and predictions that other data processing methods have not revealed. If an AI system is trained to predict forest fires, it can look for patterns across different data sources (weather data, satellite images, historical trends) that statistical comparison cannot determine.
- **New areas of application of AI** - Open data are published in many thematic categories, which allows the emergence of new use cases for AI in products and services, especially in combinations with other datasets. AI helps to bring the potential benefits of open data into common practice.

- **Quality open data = Quality AI products and services -** Research at the University of Potsdam has shown that qualitative data parameters such as completeness (no missing data), accuracy (no erroneous data) have a significant impact on the performance of the 3 tested algorithms. A small or moderate influence was noted for parameters such as consistency, uniqueness, and class group balance.
- **Open data releases can accelerate AI research in the state**
- **Using Open Data in AI Increases Transparency and Credibility -** Leveraging open data makes AI models more transparent because the data used to train AI is open to public scrutiny. This helps to ensure that AI systems are fair, transparent, and trustworthy.
- **AI improves the quality of open data -** AI can clean and validate open data by identifying discrepancies, missing values, or errors.

Among examples of the use of open data and AI include, the CROZ RenEUwable application, which integrates climate and energy data into an AI model that proposes personalized recommendations to citizens for more sustainable energy decisions.

Another example is the project for Catastral and Topographic Administration in Luxembourg, which uses AI to analyse aerial imagery stored in geographic databases to identify changes to buildings (newly constructed, demolished or modified buildings). Such manual control is difficult, so the government has supported the development of a tool to automatically identify these changes. In the future, they plan to include other objects, such as sidewalks. (European Data Portal, 2024)

6. Working with data and vizualization

6.1. The importance of working with data

Open data has benefits only if it is used. It is not enough to just publish the data (albeit in high quality, with a lot of metadata). It is important that the data is used either by the state administration itself and the self-government that creates it or by users in various spheres (non-public, academic, corporate, journalists, activists).

Education has important role, data literacy, but of course also support of the organization's management to make decisions based on data. Visualizing (open) data and working with it is no longer difficult or expensive and is not reserved for just a handful of very tech-savvy people.

6.2. Open Data Visualization

Data visualization helps:

- navigate your data faster
- draw conclusions faster;
- to see conclusions that were previously hidden,
- attract attention, popularize the topic,
- easier to remember,
- he basic information is understandable regardless of the language.

Interactive visualization differs from static visualization in that the user can set up a different view, e.g. filter data, choose a different type of chart, and so on. In the case of several linked charts and/or maps, we are already talking about an overview, in English a dashboard or an application. Interactive visualization is especially suitable for the web, it can be built into articles or blogs.

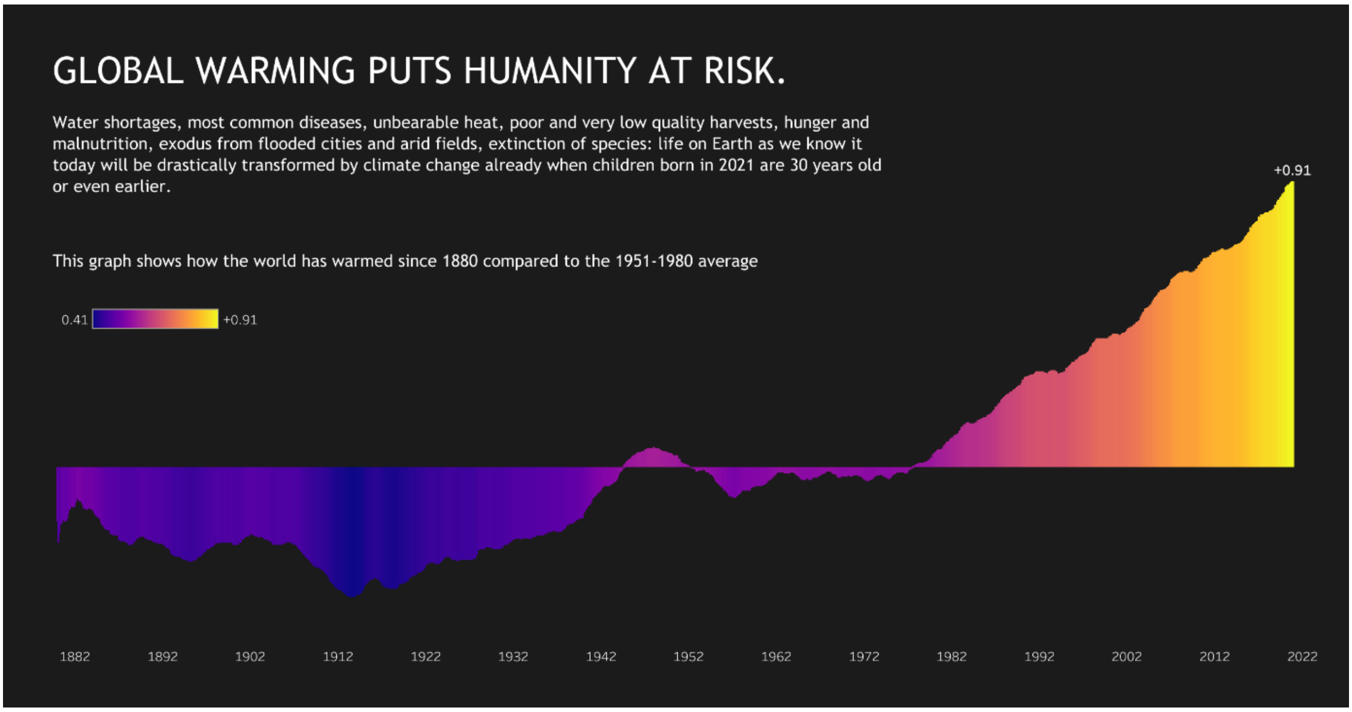


Figure 25: Data visualization can attract the attention of the audience (source: theclobalobservatory.org)

In the case of interactive visualization, the benefits are further multiplied by the fact that:

- we can get to exactly the data we need faster,
- we can adapt the visualization according to the audience,
- we can offer a larger amount of data in a smaller space,
- the ability to keep the data up to date,
- other options (e.g. the ability to download data, change the font size).

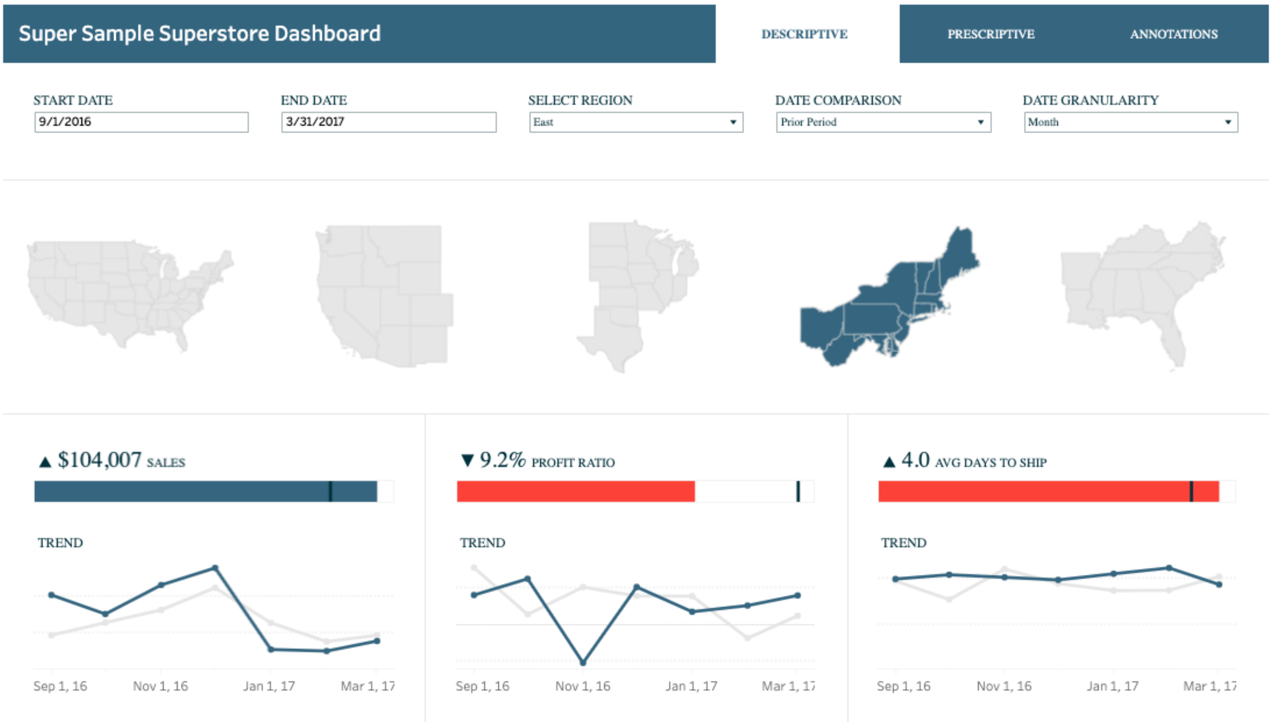


Figure 26: Interactive visualization created in Tableau Public (source: alvaria.sk)

6.3. Data Visualization Tools

Although visualizations can also be created in various programming languages using libraries and other tools, there are also tools for visualizing data without the need for programming.

These tools are especially suitable for beginners and less advanced users, who can present the data they work with in a visual form. One such tool is, for example, an office package with Excel (alternatively Calc), which allows you to filter data, create charts, maps, pivot tables, macros, etc.

However, Excel is more than 30 years behind in its way of working compared to the younger and more efficient tools that we summarize with the basic features in the table below.

There are more tools than the 3 we listed, important are especially tools designed specifically for working with map data (e.g. QGIS), but we focused on these specific ones mainly because of their ease of use, free availability and the offer of interesting options.

	Tableau Public	Looker Data Studio	Microsoft Power BI
Format support			
CSV	yes	yes (comma separated)	yes
Excel	yes	- (Google Spreadsheet)	yes
JSON	yes	payed plugin	yes
Data processing			
Data visualisation - charts	yes	yes	yes
Data visualisation - maps	yes	yes	yes
GPS coordinates	yes	yes	yes
Automatic data update	no	yes, from Google Spreadsheet	yes
Geocoding	no	yes	yes
Outputs			
Data sharing	Public	Public/Private	Public/Private
Embedding	yes	yes	yes
Embedding - maps	yes	no	yes
Plugins	no	yes	yes
General			
Operating system	Windows/Mac	All	Windows

Figure 27: Data visualization tools and their capabilities (source: alvaria.sk)

The tools can be downloaded for free from the following websites:

- Tableau Public
- Looker Data Studio
- Microsoft Power BI

6.4. Linking data

Data linking is essential for several reasons:

- we often need to visualize data from multiple datasets (e.g. data from multiple locations, unemployment data and its impact on other variables)
- we create added value over data (data comparison, normalization, increase of coverage)

- many use cases are based on data merging and consolidation (e.g. Finstat, Uvostat)

There are 2 basic ways of linking:

- **Merge -** we need to add columns (merge)
- **Connection -** we need to add lines (append)

These ways can be called differently in different software. We explain their principle in the figure below. When merging, we use a common column to add the corresponding rows from the 2nd dataset to the 1st dataset. A column that is unique is used as a common column, i.e. the values in the rows are not repeated (or repeated as few as possible). When connecting, we merge columns that contain the same data (usually it is required that the columns have the same name).

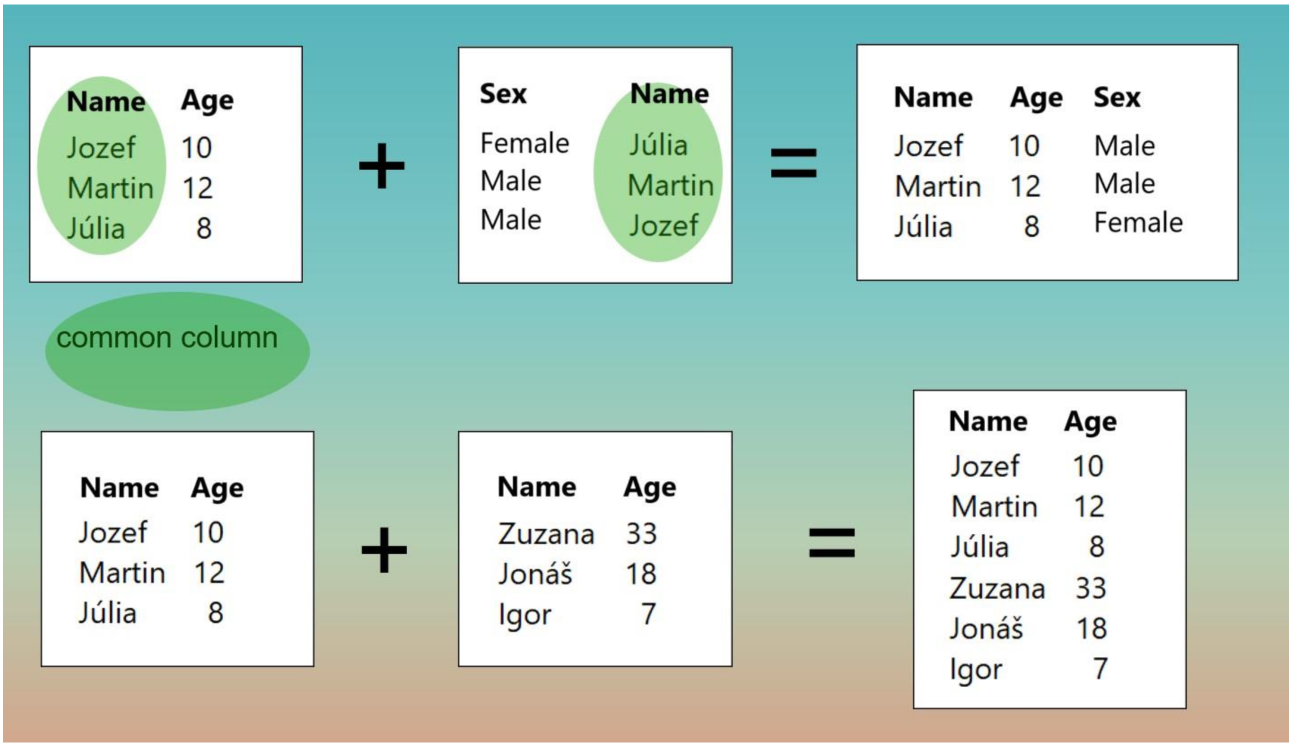


Figure 28: Merge and connect

6.5. Practical example

6.5.1. Visualization of the dataset of schools and school facilities

PowerBI allows you to visualize large number of formats e.g. csv, excel, json, xml and more. The program allows you to create calculations (calculated columns) on top of the data, summarize and filter and visualize the data using graphs and maps.

In this way, we can easily create a dashboard of schools and school facilities of the city from [Datasetu JSON](). We can connect the dashboard to the dataset so that it is regularly updated if there are changes in the list of schools. This doesn't require typing commands, it's just a configuration in the user interface similar to PowerPoint and Word.

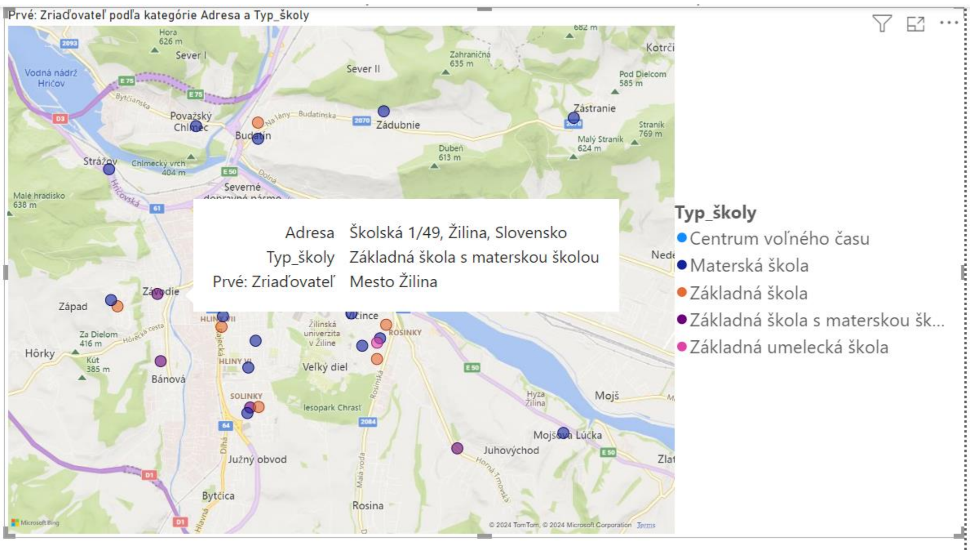


Figure 29: Schools on the map by type

6.5.2. Change the graph type

We can very easily create a different type of chart with identical data in 1 click, e.g. a bar chart. However, it would not be a problem to use another type of chart or table. Formatting (colours, font, size) can be changed as desired.

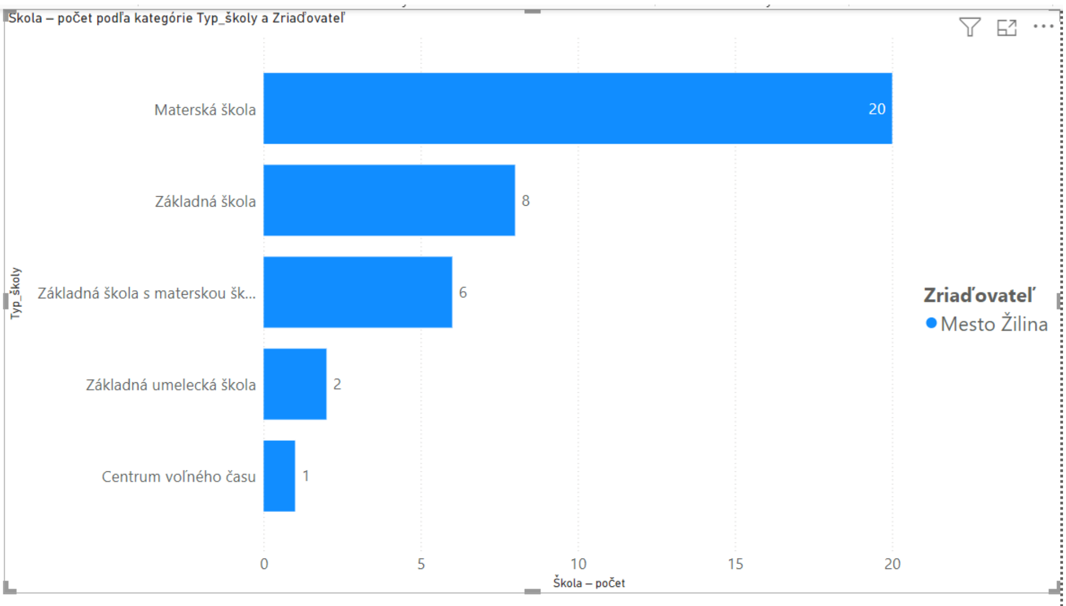
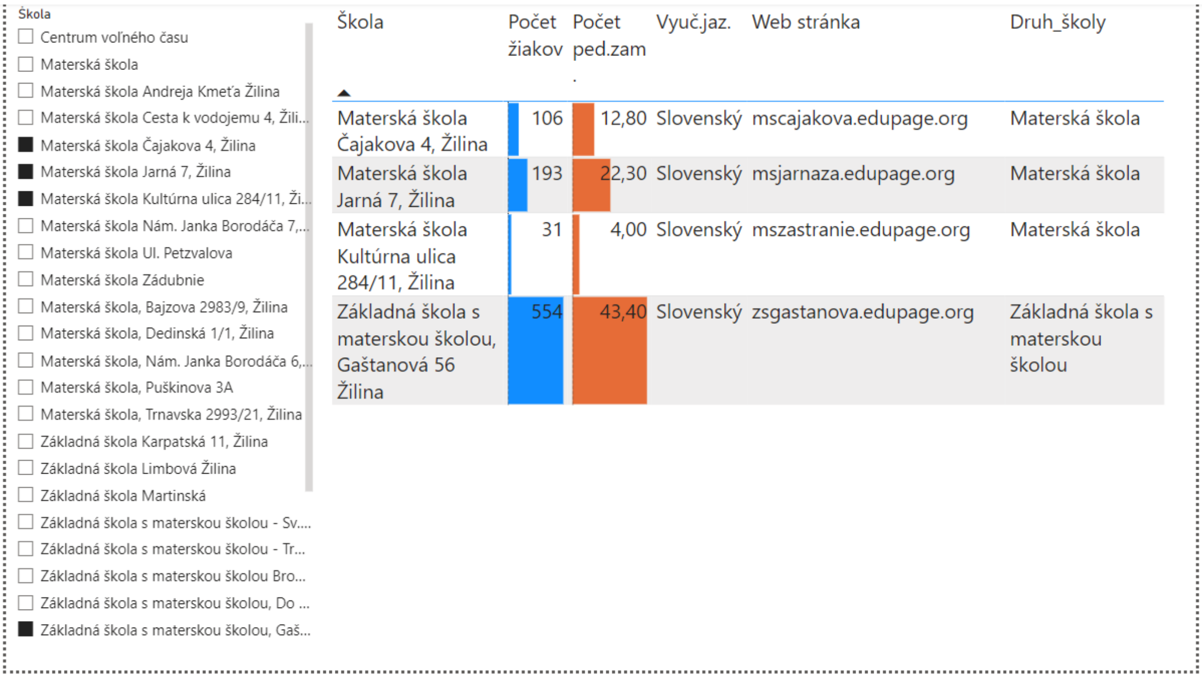


Figure 30: Number of schools and school facilities by type and founder

6.5.3. Link to other data

We will combine the data based on the ID number and EDUID with the digital map of schools dataset (published by the Ministry of Education, Research, Development and Youth of the Slovak Republic), which contains a lot of interesting information about schools such as the number of pupils, the number of teachers, the budget, contact, GPS coordinates and more. In order to be able to link data, we need to have the appropriate identifiers in the datasets, which increases their quality. Based on the combined datasets, we can create a dashboard as needed, such as the one below, which allows you to select a school/schools and display information about it in a table, including data bars. The possibilities of creating dashboards are very wide, it is possible to use maps, graphs, filters.



Škola	Počet žiakov	Počet ped.zam.	Vyuč.jaz.	Web stránka	Druh_školy
Materská škola Čajakova 4, Žilina	106	12,80	Slovenský	mscajakova.edupage.org	Materská škola
Materská škola Jarná 7, Žilina	193	22,30	Slovenský	msjarnaza.edupage.org	Materská škola
Materská škola Kultúrna ulica 284/11, Žilina	31	4,00	Slovenský	mszastranie.edupage.org	Materská škola
Základná škola s materskou školou, Gaštanová 56 Žilina	554	43,40	Slovenský	zsgastanova.edupage.org	Základná škola s materskou školou

Figure 31: Data-driven dashboard - preview

The dashboard can be shared with some colleagues or published on a website for the public.

7. How to build a community around open data

Open data is not just about neutral technology that breaks down barriers to data processing. An integral part is the community of data users. Community is needed to develop innovations based on public sector data. Therefore, the task of public administration employees is not only to make open data available, but also to proactively involve the community in its use. If community activities are not implemented, the data will probably lie unnoticed on the city's open data portals and the benefits will remain unused.

Figure 32:Build a community (source: Pexels by Fauxles)

Building and engaging a community needs a balanced mix of soft and hard skills in a responsible employee or team. Soft skills such as communication, organizing events, meetings, networking, forming partnerships are key to building long-term relationships with community members. Hard skills are equally important and help to make the presented needs and ideas of the community technically implemented (e.g. increase the quality of the provided datasets or documentation, make new datasets available, improve the user interface, etc.).

7.1. Who makes up the community

The open data community is broad. It is mostly made up of developers, technologists, data analysts, activists, non-profit organizations, universities, engaged citizens, companies, researchers, journalists, students and public sector employees. The needs of individual community members may vary slightly - from using your data for academic purposes (teaching staff, students), through integrating data into commercial software and applications (local or large companies) to finding anomalies or trends in data (journalists, researchers).

The basic prerequisite for building a community around your data is to know it well. Therefore, the first step is to do research in the region for which organizations, groups or individuals your data may be relevant.

7.2. Community enagagement tools

The intensity of community engagement can vary and change over time. The table below summarizes examples of tools that the city can use to engage the community:

Degree of involvement	Goal	Tools
Informing	Inform the general public that you are publishing open data, opportunities for engagement and other milestones	▪ Social networks ▪ City website ▪ Press releases ▪ Municipal or regional newspapers and television ▪ Mailing list or newsletter ▪ Data.slovensko.sk
Consultation and feedback	Consult for a better understanding of needs to improve data and processes	▪ Working groups ▪ Feedback form ▪ Survey of demand for the most requested datasets ▪ Online/ Physical Events ▪ Classic communication

Community involvement (in the creation of innovations)	Support the emergence of innovations built on top of your data	▪ Short-term: Hackathons, part-time jobs ▪ Long-term: Technology incubator, cooperation with universities - final theses, practical part of courses

Table 4: Examples of tools to engage the community *(source: author based on* Alvaria*)*

When working with data and developing an open data portal, the municipality can be inspired by another 5-star open data model. This model summarizes the principles that public administration employees should think about in order for the community to be involved and is authored by technologist Tim Davies (Davies, 2012):

*** Be demand-driven**

- Are your data decisions based on the needs of the community?
- Do you have a way to respond to open data demands?

**** Provide high-quality metadata and context**

- Do your catalogs contain clear metadata about updates, formats, and data quality?
- Do you share details about how the data was created and links to existing analytics or tools?

***** Encourage discussion**

- Can people comment on datasets and engage in structured discussion?
- Are there ways to contact the data owner in your organization?

****** Build skills and networks**

- Do you provide tools and tutorials for working with data?
- Do you organise skills building trainings?
- Do you focus on getting people to get skills for different types of datasets?

******* Collaborate on data**

- Do you have feedback mechanisms so that people can improve the datasets?
- Are you collaborating with the community to create new data and tools?

7.3. Community mapping

Community mapping has found many supporters in recent years. It allows the municipality to obtain new or update existing geospatial data on the territory and phenomena in it, through the involvement of volunteers in their collection.

Community mapping is an opportunity for the local government to create long-term and mutually beneficial partnerships with the professional but also lay community - universities, professional associations, which in this way participate in mapping, analysing and solving identified problems in the region.

Events that deal with mapping data in the field are called "mapathons" and last several hours. Participants need to be quickly "trained" what problem is being solved, how the mapping will take place and what technologies they will use. Mapathons take place either indoors, in a room with strong Wifi coverage with the help of satellite images, or in the field using mobile devices with location tracking (Wikipedia). Initiatives mostly use open source data collection technologies such as QFIELD, INPUT, and OpenStreetMap to create and host their data.

A good practice for community mapping is the activity carried out in 2020 by the Prešov Self-Governing Region (Slovakia) with the aim of improving the socio-economic situation of marginalized Roma communities. *"Over the course of three hours, the contributors added 1,156 buildings, 62 kilometres of new roads and modified 1,026 existing elements in Open Street Map, using publicly available high-resolution orthophoto images from the Cadastral Office of Slovak Republic."* (The World Bank, 2020)

Figure 33: Photo from community mapping in PSK (source: Miloslav Michalko in The World Bank)

Community mapping can be an alternative solution for municipalities to costly outsourcing of data collection, especially if it is a smaller area.

8. IoT and Sensors

8.1. Introduction to IoT, Sensors, and Big Data Analytics

8.1.1. What is the Internet of Things (IoT)?

The Internet of Things (IoT) refers to a network of physical devices embedded with sensors, software, and connectivity, enabling them to collect and exchange data autonomously. In the context of municipal governance, IoT offers transformative potential by providing real-time data that can enhance urban planning, resource management, and public safety. For example, sensors deployed in transportation or environmental monitoring systems enable municipalities to make data-driven decisions that improve efficiency, sustainability, and service delivery.

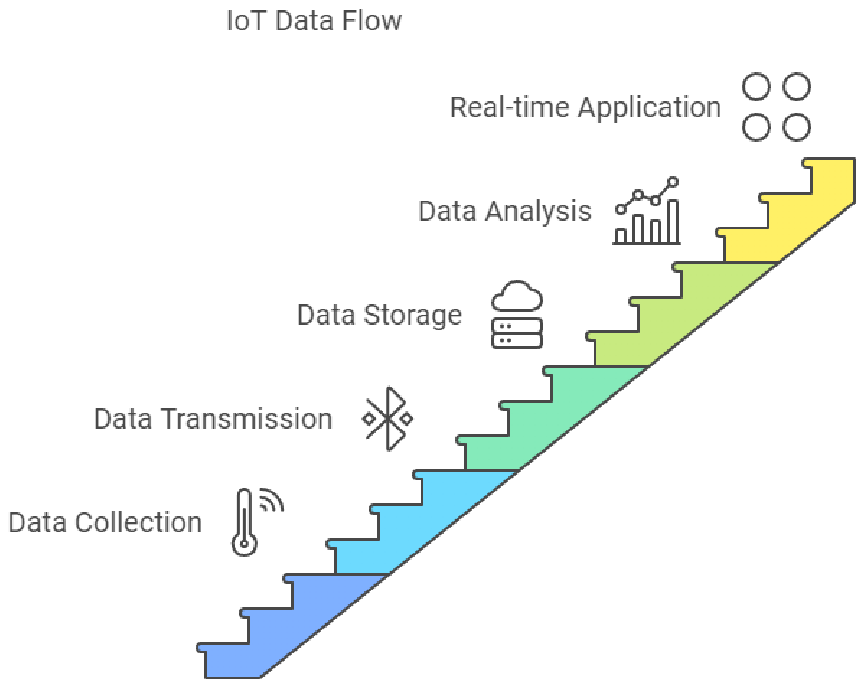


Figure 34: IoT Data Flow

How Does IoT Work?

At the core of IoT are three components: physical devices, connectivity, and data. Devices equipped with sensors gather information about their environment or operational state. This data is then transmitted over a network, using short-range communication protocols like Wi-Fi, Bluetooth, or Zigbee for localized data exchange, or long-range technologies such as 4G/LTE, LPWAN, or satellite communication for wider coverage. These communication protocols ensure seamless data exchange between devices, enabling real-time monitoring and decision-making across a variety of applications, from smart homes to urban infrastructure and large-scale environmental monitoring.

Short-range communication protocols like Wi-Fi, Bluetooth, and Zigbee are suitable for data transmission over short distances, such as within a building, home, or smaller urban area. These are typically used in scenarios where devices are located close to each other and the data volume is moderate.

For **long-range communication**, technologies such as 4G/LTE or satellite communication are needed. These are essential for applications that require data transmission over larger areas, such as city-wide systems or remote monitoring. LPWAN (Low Power Wide Area Network) technologies like LoRaWAN or Sigfox are particularly useful for transmitting small amounts of data over long distances with low power consumption, making them ideal for sensors spread across wide geographical areas or in locations without stable power supply.

This distinction between short- and long-range communication allows IoT systems to be effectively deployed in various environments, from densely populated urban centers to remote or rural areas, ensuring reliable and scalable connectivity.

8.1.2. Role of sensors in IoT

Sensors are essential components of IoT systems, providing the data needed to monitor and manage various aspects of urban life. A sensor converts a physical quantity, such as temperature, pressure, or motion, into an electrical signal, which is often already digitized for further processing. In municipalities, sensors are used to track environmental factors such as air quality, traffic flow, energy consumption, and public safety. These sensors collect real-time data, which can then be analyzed to optimize services, identify potential problems, and enable predictive maintenance. For example, air quality sensors can alert authorities to pollution spikes, allowing timely intervention to protect public health.

Different types of sensors are used in urban settings:

- **Environmental sensors**: Measure air quality, temperature, humidity, and other atmospheric conditions. These are often used to monitor pollution levels or detect extreme weather.
- **Motion and traffic sensors**: Track vehicle and pedestrian movements, providing insights for traffic optimization and public safety improvements.
- **Energy sensors**: Monitor electricity consumption in buildings and public infrastructure, helping optimize energy use and reduce costs.
- **Pressure and proximity sensors**: Used in smart water systems or to detect the presence of objects in specific areas, contributing to efficient management of resources like water and waste.

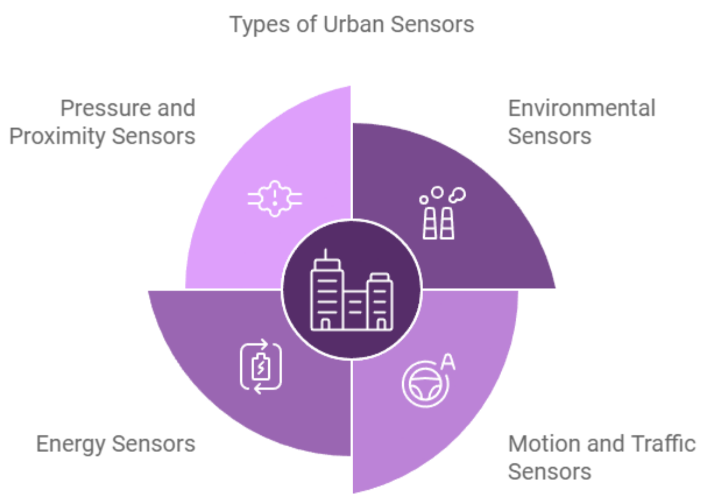


Figure 35: Types of Urban Sensors

By integrating these sensors into IoT systems, municipalities can significantly enhance the quality and efficiency of public services, from transportation to environmental monitoring.

8.1.3. IoT and Open Data

The integration of IoT and open data offers significant benefits for municipalities by enhancing transparency, citizen engagement, and innovation. IoT devices, such as sensors in traffic management systems, continuously collect large amounts of real-time data. By making this data available as open data, municipalities allow developers, businesses, and citizens to create solutions that improve urban life, from optimizing transportation systems to enhancing environmental monitoring. Open access to IoT data fosters collaboration and helps municipalities respond more effectively to local challenges.

The value of open data lies in its ability to be used by anyone to create new services, tools, or insights. For instance, traffic data from IoT sensors can be used by private companies to develop mobile applications that help citizens navigate congested areas, or by city planners to make informed decisions about future infrastructure development. Environmental data, such as air quality measurements, can be made available for public health applications, enabling communities to understand and respond to pollution levels in their areas. By leveraging IoT and open data, municipalities can enhance not only governance and decision-making but also public trust through transparency and citizen empowerment.

8.1.4. Benefits and Challenges of IoT in Public Infrastructure

Integrating IoT into public infrastructure offers numerous benefits for municipalities. Real-time data from IoT sensors can improve efficiency, optimize urban services, and enable predictive maintenance to prevent costly infrastructure breakdowns. Additionally, continuous monitoring through environmental sensors allows for better management of air and water quality, contributing to enhanced environmental protection. Open access to this data also increases citizen engagement, enabling residents to stay informed about local conditions such as traffic and pollution levels.

However, there are several challenges associated with IoT implementation. Data security and privacy are significant concerns, as IoT devices can be vulnerable to cyberattacks, and ensuring compliance with regulations like GDPR is critical. High costs related to the deployment and maintenance of IoT systems, along with the need for device interoperability, can also pose obstacles. Furthermore, the technical complexity of IoT systems requires specialized skills for installation, integration, and management, which might be a barrier for some municipalities. A detailed overview of the benefits and challenges of IoT in public infrastructure is provided in the table below:

Aspect	Description	Examples
Benefits	Real-time data improves efficiency and optimizes urban services	Smart traffic management, energy optimization
	Predictive maintenance prevents costly infrastructure breakdowns	Monitoring and maintenance of water systems, public transport
	Enhanced environmental management through continuous monitoring of air and water quality	Air quality sensors, water pollution monitoring
	Increased citizen engagement by providing open access to IoT data	Public dashboards displaying real-time data on traffic, pollution, and city services
Challenges	Data security and privacy concerns due to potential cyberattacks	Protecting sensitive information collected by IoT devices
	High costs of implementation and maintenance, and the need for device interoperability	Ensuring compatibility between diverse devices from different manufacturers
	Legislative and regulatory challenges related to data protection and sharing	Compliance with GDPR, local data regulations
	Technical complexity and the need for specialized skills for installation, integration, and management	Training for municipal staff, collaboration with technology providers

Table 5: Benefits and challenges of IoT in public infrastructure

8.2. Security and Privacy Concerns in IoT

The rapid adoption of IoT in public infrastructure brings not only significant benefits but also substantial security and privacy challenges. With billions of connected devices, the potential attack surface for malicious actors is greatly expanded. Unlike traditional IT systems, many IoT devices lack robust security features, making them more vulnerable to cyberattacks. This is especially critical in the context of municipalities, where compromised IoT systems could disrupt essential services and compromise sensitive data.

8.2.1. Security Risks in IoT

One of the primary security issues in IoT systems is the absence of strong authentication and encryption protocols. Many IoT devices still rely on default or weak passwords, which can be easily exploited by attackers. Furthermore, the data exchanged between devices and central systems is often transmitted without sufficient encryption, leaving it exposed to interception and unauthorized access.

For municipalities, the risks associated with such vulnerabilities can be significant. An attack on a smart traffic management system, for example, could lead to disruptions in city traffic, while unauthorized access to environmental sensors could result in the manipulation of data that informs public health decisions. To mitigate these risks, municipalities must implement robust security measures, such as two-factor authentication, secure communication protocols, and regular security audits.

8.2.2. Privacy Concerns in IoT

IoT can include sensitive information such as location, usage patterns, and even personal health data. In a municipal context, this data can be used to monitor citizen activities, raising significant privacy concerns. For example, smart streetlights equipped with cameras and motion sensors can provide valuable insights into public safety but can also be misused to track individuals' movements.

To address these privacy concerns, it is essential that municipalities implement clear data governance policies that dictate how data is collected, stored, and shared. Data should be anonymized whenever possible to protect individual privacy, and citizens should be informed about what data is being collected and for what purpose.

8.2.3. Best Practises for Enhancing IoT Security and Privacy

1. **Strong Authentication Mechanisms:** Implement multi-factor authentication for accessing IoT devices and systems. Avoid using default passwords and encourage the use of complex, unique passwords.

2. **Data Encryption:** Ensure that all data transmitted between devices and central systems is encrypted both in transit and at rest. Use secure communication protocols like HTTPS and MQTT over TLS.

3. **Regular Firmware Updates:** Keep IoT devices up to date with the latest firmware to patch vulnerabilities. Establish a process for monitoring and applying updates promptly.

4. **Anonymization and Minimization:** Limit the collection of personal data to what is strictly necessary and anonymize data wherever possible. This reduces the risk of privacy breaches if the data is compromised.

5. **Security Audits and Monitoring:** Regularly conduct security audits and monitor IoT networks for unusual activity. Early detection of potential threats can prevent larger security incidents.

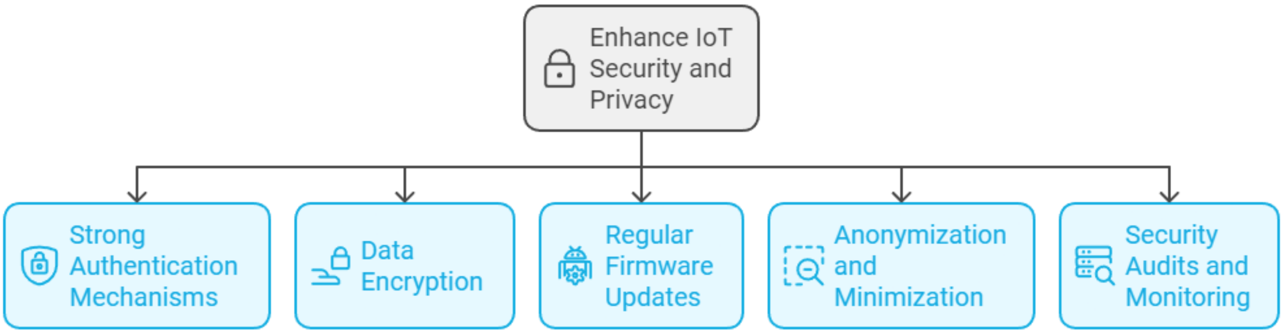


Figure 36: Enhance IoT Security and Privacy

8.2.4. Implementation in Municipalities

For municipalities looking to implement IoT securely, it is crucial to adopt a comprehensive approach to security and privacy that begins at the design phase and continues through implementation and operation. Security and privacy must be integral parts of the IoT system's architecture from the very beginning, addressing potential vulnerabilities before they can be exploited. This proactive approach, known as "security by design," ensures that all potential risks are considered during the planning stage.

During the implementation phase, municipalities should ensure that all devices and systems are configured with strong security measures, such as encrypted data transmission and robust authentication protocols. Ongoing monitoring and regular updates are essential to maintain system security as new threats emerge.

Finally, in the operational phase, regular security audits, staff training, and continuous monitoring of the IoT network are necessary to detect and respond to any potential issues. By incorporating security and privacy considerations throughout the entire lifecycle of IoT systems, municipalities can protect sensitive data, maintain public trust, and ensure the reliable functioning of their smart infrastructure.

8.3. Standards and Protocols in IoT

Standardization plays a vital role in the IoT ecosystem, ensuring that devices and systems from different manufacturers can communicate effectively and work together seamlessly. Without standardized protocols, the interoperability of devices would be limited, which could hinder the widespread adoption and potential of IoT solutions in municipalities. For local governments, using standardized IoT solutions is essential to avoid vendor lock-in, reduce costs, and ensure that their systems remain flexible and scalable for future needs.

Several organizations are actively developing and promoting IoT standards and protocols to address these challenges. The Internet Engineering Task Force (IETF) is one of the leading bodies, focusing on developing and promoting internet standards that support the interoperability of IoT devices. Other key organizations include the Institute of Electrical and Electronics Engineers (IEEE), which sets technical standards for wireless communication, the International Organization for Standardization (ISO), which provides global standards for information technology, and the International Electrotechnical Commission (IEC), which develops standards for electronic and electrical technologies.

8.3.1. Key IoT Standards and Protocols

Short-range Communication Protocols:

- **MQTT (Message Queuing Telemetry Transport)**: This is considered one of the most important IoT protocols due to its simplicity and efficiency in transmitting small data packets between devices and servers. It is widely used across various IoT applications, particularly in scenarios with limited bandwidth or constrained networks.
- **CoAP (Constrained Application Protocol)**: Also a key protocol, CoAP is designed for communication between constrained devices and is well-suited for low-power, low-bandwidth IoT applications. Its lightweight nature makes it ideal for environments where resource limitations are a concern.
- **Zigbee**: Primarily used in home automation, Zigbee is a low-power, wireless mesh protocol that connects devices within a limited range. While not universally critical for all IoT applications, it plays a significant role in specific use cases like smart home systems.
- **Z-Wave**: Similar to Zigbee, Z-Wave is used mainly in home automation, enabling devices such as lights, locks, and thermostats to communicate within short distances. It is more specialized and not as widely applicable as some other protocols.
- **Bluetooth Low Energy (BLE)**: BLE is widely used for short-range communication with low power consumption. It is particularly prevalent in personal devices such as wearables and health monitors, as well as in smart buildings. While important, its use is more niche compared to more general-purpose IoT protocols like MQTT.

Long-range Communication Protocols:

- **LoRaWAN (Long Range Wide Area Network)**: A critical protocol for wide-area networks, LoRaWAN is ideal for applications such as environmental monitoring and smart agriculture. It supports communication over long distances with minimal energy consumption, making it a key standard for IoT applications that require wide coverage and low power.
- **NB-IoT (Narrowband IoT)**: Standardized by 3GPP, NB-IoT is designed to provide connectivity for devices with low data rates over a long range. It is highly relevant for smart metering, smart parking, and remote monitoring, where secure and reliable communication over large areas is necessary.
- **Sigfox**: Known for its low energy consumption and long-range capabilities, Sigfox is suitable for applications that require minimal data transmission, such as asset tracking and environmental monitoring. It is a key player in cost-sensitive IoT deployments.
- **LTE-M (Long Term Evolution for Machines)**: LTE-M is designed specifically for IoT applications, offering better coverage, low power consumption, and support for mobility. It is suitable for a wide range of use cases, from smart cities to connected vehicles, and is part of the broader 4G/5G ecosystem.
- **5G**: As the next generation of mobile networks, 5G provides high-speed data transmission, low latency, and the capability to connect a vast number of devices simultaneously. It is expected to drive advanced IoT applications, such as autonomous vehicles, smart city infrastructure, and industrial automation.

8.3.2. Importance of Standards for Municipalities

For municipalities, adopting standardized IoT protocols and technologies is crucial for several reasons:

1. **Interoperability**: Standards ensure that devices from different manufacturers can work together seamlessly. This is essential when integrating various IoT solutions, such as smart lighting, traffic management, and environmental monitoring, into a single smart city platform.
2. **Scalability and Flexibility**: By adhering to standardized protocols, municipalities can expand their IoT infrastructure without being locked into proprietary solutions. This allows them to adopt new technologies and solutions as they become available.
3. **Security and Reliability**: Standards provide a framework for secure communication and data exchange, which is critical for protecting sensitive information and ensuring the reliable operation of municipal IoT systems.
4. **Cost Efficiency**: Using standardized devices and protocols can reduce costs by increasing competition among suppliers and reducing the need for custom integrations.

8.3.3. Implementation in Municipal Context

When implementing IoT solutions, municipalities should prioritize selecting devices and systems that adhere to widely recognized standards. This approach not only ensures compatibility and ease of integration but also facilitates future upgrades and expansions. Additionally, municipalities should stay informed about emerging standards and participate in relevant standardization bodies or initiatives to align their smart city strategies with global best practices.

By adopting and supporting standardized IoT protocols, municipalities can build robust, secure, and future-proof IoT infrastructures that enhance the quality of public services and improve the overall efficiency of city management.

8.3.4. Communication Protocols for IoT : Pros and Cons

Protocol	Advantages	Disadvantages
MQTT	Low power consumption, Low bandwidth usage, Lightweight and efficient	Limited interoperability, Inherent security constraints, Poor scalability for large networks
CoAP	Lightweight, Suitable for constrained devices, Low power usage	Limited data transfer rate, Not ideal for high-bandwidth applications, Relatively new and less adopted
Zigbee	Highly secure, Low power consumption, Mesh networking for long-range communication	Prone to interference from other 2.4 GHz devices, Limited to short-range communication, Higher cost of deployment
Z-Wave	Low latency, Low power consumption, Good coverage for short-range applications	Low data transfer rate, Higher cost compared to Zigbee, Limited device ecosystem
Bluetooth Low Energy (BLE)	Low power consumption, Wide adoption in personal devices, Easy integration	Short range, Limited scalability, Lower data rate compared to Wi-Fi
Wi-Fi	High data transfer rate, Widely available, Easy to install and use	High power consumption, Limited scalability for large IoT deployments, Not ideal for battery-operated devices

Table 6: Short-range Communication Protocols

Protocol	Advantages	Disadvantages
LoRaWAN	Scalability, Large area coverage, Low power consumption, Long battery life	Low data transfer rate, Requires custom LoRa gateway, Not suitable for real-time applications
NB-IoT	Deep indoor coverage, Low power consumption, Supports a large number of devices	Lower data rate, Limited by network operator's coverage, Higher latency compared to other LPWAN technologies
Sigfox	Ultra-low power consumption, Long range, Simple protocol with low operational costs	Very low data rate, Limited message frequency, Requires proprietary infrastructure
LTE-M (Long Term Evolution for Machines)	Better coverage than NB-IoT, Supports mobility, Low power consumption, Lower latency compared to other LPWAN technologies	Lower data rate compared to LTE, Limited by network operator's coverage, Higher costs than other LPWAN options
5G	High-speed data transmission, Low latency, High capacity and device density, Support for a wide range of use cases	High power consumption, Expensive infrastructure, Not yet widely deployed, Higher complexity

Table 7: Long-range Communication Protocols

8.4. IoT and Big Data Analytics

8.4.1. What are Big Data?

Big data refers to extremely large and complex datasets generated from diverse sources, such as sensors, social media, and transactional records. These datasets are characterized by their high volume, velocity, and variety. In the IoT context, big data is continuously collected from a network of interconnected devices, providing real-time information on various parameters, including environmental conditions, operational metrics, and user behaviors. The challenge lies in effectively storing, processing, and analyzing this data to extract valuable insights that can inform decision-making and drive innovation.

8.4.2. The Role of IoT in Generating Big Data

IoT devices, equipped with various sensors, generate massive amounts of data in real time. This data can range from temperature, humidity, and air quality measurements to traffic patterns and energy consumption. The data collected is often unstructured and varies in format, making it challenging to process using traditional methods. However, this data is crucial for developing smart city solutions, optimizing industrial processes, and enhancing customer experiences.

8.4.3. Big Data Analytics in IoT

Big data analytics involves using advanced techniques to process and analyze large datasets to uncover patterns and insights. In the context of IoT, it can be applied in the following ways:

1. **Predictive Maintenance**: Analyzing data from industrial IoT sensors to predict equipment failures and schedule maintenance, reducing downtime and costs.

2. **Energy Management**: Optimizing energy usage in smart buildings based on real-time data from sensors.
3. **Smart City Management**: Analyzing data from traffic and environmental sensors to improve urban planning and infrastructure management.
4. **Personalized Services**: Enhancing user experiences by analyzing behavior and usage patterns in smart homes and e-commerce.

8.4.4. Challenges in IoT and Big Data Analytics

- **Data Storage and Management**: Handling the large volume of IoT data requires scalable storage solutions.
- **Data Quality**: Ensuring accuracy and consistency across diverse data sources.
- **Real-time Processing**: Meeting the demand for real-time analytics in resource-intensive applications.
- **Security and Privacy**: Protecting sensitive data and maintaining user trust.

8.5. How to get started with IoT

Embarking on an IoT project can seem challenging due to the complexity and variety of technologies involved. However, with a structured approach, municipalities can successfully integrate IoT solutions into their infrastructure to improve public services and optimize resource management. Here are some practical steps to help get started:

1. Define Your Goals and Objectives

Before implementing any IoT solution, clearly define what you want to achieve. Identify the specific problems you aim to solve or the opportunities you wish to explore. For example, a city might want to reduce traffic congestion, improve energy efficiency in public buildings, or monitor air quality. Having a clear vision will help guide the selection of appropriate technologies and the overall project strategy.

2. Start with a Pilot Project

IoT projects can be complex, so it’s best to start small. Choose a manageable pilot project that addresses a specific issue, such as installing smart meters in a few buildings or deploying air quality sensors in a designated area. This allows you to test the technology, understand the challenges, and gain valuable experience without committing significant resources upfront. A successful pilot can then be scaled up to a broader deployment.

3. Select the Right IoT Platform and Devices

Choosing the right IoT platform is crucial for the success of your project. The platform should support the necessary devices and protocols, provide data analytics capabilities, and integrate with existing municipal systems. Consider platforms that offer scalability, security, and ease of use. Additionally, select devices and sensors that are compatible with your platform and meet your specific use case requirements, such as long battery life, appropriate range, and reliability.

4. Incorporate Security from the Start

Security is a critical consideration in any IoT project. From the initial design phase, incorporate security measures to protect devices and data. Implement strong authentication and encryption protocols, regularly update device firmware, and conduct security audits. Ensuring data privacy and protection from the beginning will help prevent security breaches and build trust with citizens.

5. Plan for Scalability and Integration

When designing your IoT solution, consider future scalability and integration. Choose technologies and platforms that can expand to accommodate additional devices, sensors, or even new use cases. Ensure that your IoT infrastructure can integrate with other city systems, such as data analytics platforms, geographic information systems (GIS), or public communication channels.

6. Engage Stakeholders and Build Partnerships

Successful IoT implementation requires collaboration across multiple stakeholders, including government departments, technology providers, and the community. Engage with relevant stakeholders early in the planning process to ensure alignment and support. Building partnerships with technology vendors and consulting experts can also provide valuable guidance and resources throughout the project.

7. Leverage Learning Resources and Best Practices

Take advantage of the wealth of resources available online to deepen your understanding of IoT. Join forums, participate in webinars, and read case studies from other cities or organizations that have successfully implemented IoT projects. Learning from others' experiences can help you avoid common pitfalls and adopt best practices that align with your goals.

8. Monitor, Evaluate, and Adapt

Once your IoT solution is deployed, continuously monitor its performance and impact. Collect data to evaluate whether the project is meeting its objectives and identify areas for improvement. Be prepared to adapt your approach based on feedback and changing needs. Regularly reviewing and refining your IoT strategy will ensure that it continues to deliver value over time.

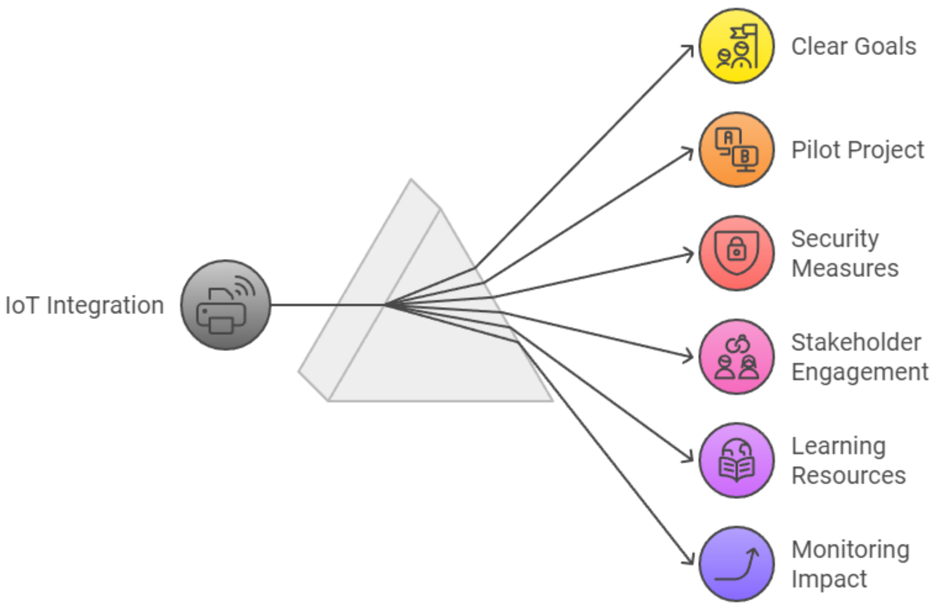


Figure 37: IoT Integration

9. Geographic Information Systems

9.1. Introduction to GIS: Defining the Tools and Principles

Information Systems (GIS) are powerful tools that manipulate spatial information, a crucial subset of information associated with objects in space. This spatial information, mainly geographic information related to a coordinate system, is the backbone of GIS. These systems deal with data defined on, below or above the earth's surface, making them invaluable for various scientific disciplines. GIS has many definitions influenced by these disciplines, but three stand out:

1. GIS is not just a tool but a comprehensive database system. Most of its data are spatially indexed, and it performs various operations to answer questions about the database's spatial objects,
2. GIS is a distinct information system where the database contains observations of spatial objects, activities, or events. GIS manipulates data through points, lines, and surfaces to enable ad hoc queries and analyses,
3. GIS is a powerful technical and software tool for collecting, storing, and deriving information about a country to facilitate management functions, research, and applications.

9.2. Components and Classification of Geographical Information and Data

Geographical information involves a geometric, topological and dynamic description of a real geographic object (geo-object), which is inseparable from the point of view of the required level of resolution. It defines a geographic object's position, shape and size in space directly or indirectly. Each geo-object must be identified by its spatial location, attributes and time, representing the period of existence of the given state of the object with the current geometry and attribute.

Spatial data is divided into reference data, core data and application-dependent data. Reference data provide a general spatial connection between applications and enable unambiguous information localisation. It links different data sources (administrative units, addresses, parcels, selected topographical objects, etc.) and affects their spatial resolution. Common base data should be usable by all users to ensure typical localisation. If information is defined in space, it has a direct or indirect spatial reference, and this link to a specific place in space is called georeference. Application-dependent data are necessarily usable in individual applications (socio-economic data, protected areas and trees, monuments, communication axes, etc.). According to other criteria, geographic data are divided according to the geometric dimension into two-, three-, or multi-dimensional, according to the representation into raster and vector, and according to the duration into temporal, which characterise their dynamic level.

The term metadata is used in connection with geographic data. Metadata is often referred to as data that describes other data. It is structured reference data that helps to sort, identify attributes and describe data properties. They act as a guide to using data because they tell the who, what, when, where, why, and how of the data. For example, the 01001 number format data does not provide additional information without further context. By adding metadata, the postal code of Žilina can be obtained from the number 01001. A markup language describes metadata, e.g. XML <zip>01001</zip>.

Data is a sequence of symbols based on syntactic rules that we can record and express specific facts about processes or elements of the real world. It can be letters, numbers, words, pictures, characters, sounds, etc. By assigning meaning to the data, the subject gains information.

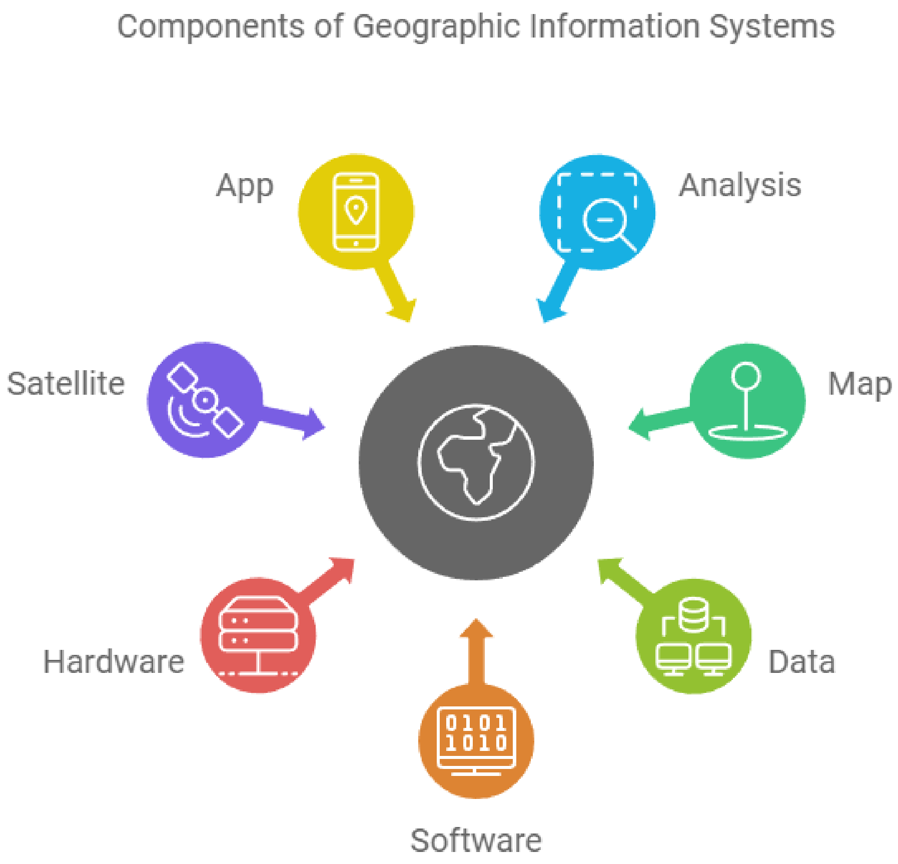


Figure 38: Components of Geographic Information Systems

9.3. Geography and Inforamtion Systems: Core Function and Operations

The term geographic is composed of the ancient Greek terms gé (earth) and graphein (to describe), which is related to the study and description of the planet, thus expressing the fact that all information with which GIS works has its spatial dimension, which is directly or indirectly related to the earth. Information systems (IS) are the purposeful organisation of relationships between people, data sources, procedures, and the technological means used. This arrangement represents the collection, transmission, preservation, transformation, updating and provision of data for their use. Computer-supported information systems also include available hardware and software equipment. The primary function of IS is usually realised by combining five operations:

1. Securing input information through data collection. Data can be obtained by the subject's physical presence or technical means.
2. Recording information on a suitable analogue or digital medium. Before storing the data, it is necessary to check the input information's quality, accuracy, completeness, scope, format, etc. Storage uses organised data structures, allowing quick selection based on specified requirements.
3. Transfer of data from the place of creation to the place of their processing and use, which takes place in the so-called communication process.
4. Data presentation in a suitable form, whether text, table, graphic, image, sound or a combination thereof.

5. Data processing is based on precisely defined and precisely expressed procedures, the algorithm of which is stored in various applications.

9.4. Core Components and Architecture of GIS

During data collection, it is necessary to correctly represent and process the objects in the database from the assumed point of view of use. In addition to the location, geometric and non-geometric properties, the temporal components of the object (origin, duration, validity, etc.) and its relations to surrounding objects should also be recorded. It is also necessary to specify the quality of the description and the description of the permitted operations that can be performed with the object (editing, deleting, displaying, etc.). To ensure essential functions, every functional GIS must contain five basic components:

1. **Hardware** that includes computers, input and output devices, and computer networks.
2. **Qualified personnel** that ensure the operation of technical and software equipment, including data preparation and processing.
3. **Software** includes an operating system, a database system, a data management and management system, editing program modules, and analytical and presentation modules designed to ensure input, processing, and visualisation.
4. **Data** that form the most critical component presents geographic data's positional and territorial validity with defined mutual spatial relationships and attributes that specify non-graphic properties, including printing.
5. **Methods** that involve analysis to derive new data.

Software, data, and methods make up the functional components of GIS. Technical and personnel equipment are created by the structural elements of GIS. The advantage of GIS is the separation of geographic data storage from their publication, with the possibility of applying various spatial analyses and simple updating.

9.5. Applications of GIS Across Various Domains

From the point of view of the use of GIS, three main perspectives prevail in practice:

- The **cartographic perspective** considers GIS as a means of processing and presenting digital maps.
- The **database perspective** emphasizes the correctness and functionality of the geographic database in the inventory, collection, sorting, and selection of data.
- The **analytical and modeling perspective** highlights the possibility of spatial analysis and modeling of objects.

Currently, GIS is used in various areas, such as:

- **Public administration**: for property registration and management, tax and fee management, transport infrastructure, spatial planning, elections, population census, traffic analysis, public urban transport, etc.
- **Environment**: for modeling natural processes such as erosion, pollution, floods, waste dumps, and inventory of natural resources.
- **Utility networks management**: for registration, management, and maintenance of utility networks (gas, electricity, communications, etc.), planning of transmission networks, modeling of responses to changes in requirements, modeling of faults, planning and construction of new

telecommunication networks and their equipment concerning the topographical situation (digital relief models).

- **Spatial planning**: for connecting with data from the fields of demography, industry, and real estate cadastre, where populated areas are divided into zones for creating spatial plans.
- **Transport**: for planning and maintenance of transport infrastructure, traffic optimization, navigation, etc.
- **Rescue services**: for helping with orientation, identification of events, approach to a traffic accident, location of vehicles in the field, guidance of rescue service vehicles, etc.
- **Police**: for defining trends and the development of crime and accidents depending on other events, the surroundings, or a specific phenomenon.
- **Retail industry**: for choosing the most suitable store locations, tracking the movement of goods, optimizing warehouse stocks, etc.
- **Finance**: for searching areas with increased insurance risk, such as flood areas, areas with a risk of landslides, with an increased accident rate, etc.
- **Natural resources**: for recording and analyzing natural resources using GIS tools.
- **Agriculture and forestry**: for planning land reclamation works, land use records, plant production management, etc.
- **Archaeology**: for documenting and searching archaeological sites using GIS tools.
- **Natural risks**: for predicting, analyzing, and modeling risks such as floods, fires, landslides, avalanches, etc., using GIS based on the integration of data from different areas and sources.
- **Geomarketing**: for determining the distribution of customers and people’s behavior in a particular area from various perspectives (economic, socio-demographic) based on geographic location. Its basic principle is the processing of digital maps.

9.6. Fundamental GIS Operations and Analyses

Among the primary and most frequently used operations when working with data in geographic information systems is to obtain answers to the questions: What is located? Where is it located? What is the number? What has changed? What is the cause? What will happen? Various manipulation and analysis functions and their mutual combinations are used to obtain answers to these questions. Some functions are performed only with geometric data, some with attribute data, and some with combined ones. Manipulation functions allow changing data structures from various sources to be advantageously used for multiple spatial analyses.

9.7. Advanced Spatial Analysis Techniques

Spatial analyses are a set of techniques created to obtain the required information depending on objects' spatial arrangement and properties. GIS analyses are divided into:

- **Map analysis**, based on analytical and visualisation operations on graphic objects based on their properties and location.
- **Mathematical modeling**, consisting of the creation of an abstract mathematical model used to describe and visualise the results of analyses of phenomena and processes in geographical space.
- **Statistical analyses**, which use statistical methods for the study of one- and multi-dimensional values on spatial objects and phenomena.

- **Interpolation methods**, based on calculations of unknown values occurring in intervals.
- **Localization analyses** focused on the influence of the location of objects and phenomena on the condition and behaviour of the surroundings.
- **Network analyses**, which form a separate part of graph theory, e.g., in technical and economic planning.

Spatial analyses use analytical functions that are classified according to the type of operation performed into the distance and area measurement functions, tools for searching attribute and spatial data, distance analyses used, e.g., in the optimization of the road network, network analysis of routing, adjacency or resources, layer overlap analysis, map algebra, used to process raster data using mathematical operations, analysis of relief models and other surfaces such as analyses of slopes, orientation, profiles, visibility, spread, etc., statistical analyses represented by graphs, maximum or minimum values, regression functions, etc., and image analysis often used in the processing of photogrammetric data and remote sensing images.

Some analyses are applied to vector data with discrete representation, some to raster data with continuous or continuous representation, and some can be used in both representations. Other functions of spatial analysis are based on the division; it can be a division by spatial operations, where we can recognize interpolations (value estimation), local operations (spatial filtering), surface derivatives (slope, exposure, gradient), visibility, radiation intensity, surface derivation, river derivation networks, and clustering.

9.8. The Strategic Importance of Geographic Information: Usability, Logistics, and Policy Frameworks

From the point of view of the usability of GIS, geographic information is essential in almost all human activities due to the influence of spatial situations on these activities. For reasons of high mobility, geographical information is most effectively utilized in the logistics of various operations. Logistics is constantly growing and is currently a crucial part of the economy. The need to enhance the efficiency and quality of decision-making processes in logistics through spatial information is undeniable. Consequently, the demand for spatial data across numerous human activities is steadily increasing.

Globalization has dispersed resources, storage, processing, and the use of information across different locations. The availability of geographic information is therefore critical for the economic development of any organization or region. To ensure the accessibility and usability of geographic data, the European Union introduced Directive 2007/2/EC, commonly known as INSPIRE (Infrastructure for Spatial Information in the European Community).

INSPIRE mandates that up-to-date spatial data be collected and maintained as efficiently as possible. It also emphasizes the necessity of integrating spatial data from various sources to ensure data compatibility and sharing among multiple users and applications. The directive's key objectives include:

- Collecting data at one level and ensuring it is usable at all levels.
- Enabling the combination of data from different sources and sharing it between various users and applications in real-time.
- Facilitating easy access to data, assessing its utility, and understanding the conditions for its use.

INSPIRE relies on reference data, which serves as a foundational layer for those who handle geographic information. This data acts as a common link between applications, forming a robust mechanism for sharing knowledge and information among different users and stakeholders.

10. Key technologies and Decisions for Executives and Decision Makers

10.1. Management summary

Quality data is a key and necessary resource for qualified self-government management, creation of targeted and sustainable public policies and services for citizens. Municipalities analyze, process and make available a huge amount of valuable data. They are producers and consumers of (open) data.

Data collected by self-government and not covered by specific legislation (personal data, confidential information, trade secrets) can be made publicly available as open data which can be used to stimulate:

- innovative growth at the regional and national level,
- business environment,
- GDP growth.

Open data helps municipalities:

- eliminate bureaucracy,
- automate and digitize processes,
- to provide better, more efficient and transparent services.

10.1.1. European legislation:

- Directive (EU) 2019/1024 of the European Parliament and of the Council of 20 June 2019 on open data and the reuse of public sector information. This directive was transposed into national legislation.
- Regulation (EU) 2016/679 on the protection of natural persons with regard to the processing of personal data and on the free movement of such data, and repealing Directive 95/46/EC (General Data Protection Regulation). Regulation supports the development of innovations by guaranteeing the boundaries and limits that must be maintained during this development - so that the rights of the affected persons to the protection of personal data are not affected.

10.1.2. National legislation:

The following part is suitable to be adapted by the Partners to their territory.

- **Act no. 211/2000 on free access to information**. The law defines mandatory published information, time limits, remedies, the range of obliged persons and the institute for making information available upon request. It defines making information available for reuse upon request and publishing information for the purpose of repeated use without request.
- **Decree no. 78/2020 Office of the Deputy Prime Minister of the Slovak Republic for Investments and Informatization of March 16, 2020 on standards for public administration information technology.** The decree defines the standards of technical solutions in public administration information systems, it also applies to open data - technical requirements for publishing datasets, quality levels, data marking standards, provision of metadata, type of licenses, etc.

- **National conception of informatization of public administration (updated in 2021).** It contains a description of the current state and several tasks, e.g. provision of methodical, educational, educational, motivational and technical support for the entire public administration, including making available technical solutions that they can for publishing data.
- **Action plans of the Initiative for open governance in Slovakia.** Published in biannual cycles, they contain tasks for ministries and central state administration bodies, recommendations for self-government.

Open data portals are specialized portals where datasets and open APIs of open data can be found. Each country has a typically central (national) open data portal that collects all datasets of organizations - data providers. The Slovak central portal has the address data.slovensko.sk, it contains more than 7,900 datasets from state and local government organizations.

In addition to downloading, browsing, searching and filtering data, portals often provide other functions – for example education, news, blogs, possibility of registering applications and requests.

Open data is defined by two basic attributes – technical and licensing openness. Technical openness means that the data and the file are machine-readable, freely available and in a format that does not require the use of a specific proprietary software tool (for example CSV, JSON or XML). License openness means that the data is published under an open license that allows its repeated use (for example CC0, CC BY, CC BY-SA, CC-BY-NC, CC-BY-NC-SA, etc.). They are mostly published in the online data catalogs of municipalities and are available to anyone, without restrictions, discrimination, without technical and licensing restrictions.

Open data can be used as an data source in the development of commercial or non-commercial products and services - applications, web applications, analyses. These innovations are mainly developed by technology companies, start-ups, non-governmental organizations, or IT enthusiasts. They mostly combine several data sources, and by connecting them, they create a complex service for the citizen with added value (see chapter G. Use cases).

Use cases in Slovakia include several applications (Finstat, Uvostat, MHDPo), portals (Cycling portal of Trnava self-governing region), visualizations (visual smog), hackathons (Prešov, Bratislava), use of data in decision-making (Prešovský and Košice self-governing regions).

Open data and artificial intelligence create mutual synergies, for example better AI performance, new identified patterns and predictions, increasing the quality of open data.

Open data management is part of comprehensive data management in the organization. In order to be able to set up processes around the publication and use of open data, we need to know how data is created, organized, archived and maintained in organizations.

From strategic point of view, anchoring open data in local policies is important for better implementation of commitments in the field of open data.

Open data has benefits only if it is used. It is not enough to just publish the data (albeit in high quality, with a lot of metadata). It is important that the data is used either by the state administration itself and the self-government that creates it or by users in various spheres (non-public, academic, corporate, journalists, activists).

Data visualization helps:

- navigate your data faster,
- draw conclusions faster,

- to see conclusions that were previously hidden,
- attract attention, popularize the topic.

Although visualizations can also be created in various programming languages using libraries and other tools, there are also tools for visualizing data without the need for programming. Many tools are available for free, and there are also many courses and tutorials. Nowadays, it is effective to create interactive visualizations and dashboards that are customizable, can be updated automatically, offer additional functions and can be shared, for example among colleagues, with the public.

Popular data visualization tools:

- Tableau Public
- Looker Data Studio
- Microsoft Power BI

Open data "doesn't work" without a community. The community - developers, data analysts, activists, non-profit organizations, universities, companies, researchers, journalists, etc. is necessary for the development of innovations. The key is not only to publish the data, but to involve the community in its use, through proactive communication (social networks, website, newsletter), consulting (working groups, surveys, events), or support for the creation of solutions that also benefit local governments (hackathons, voluntary work, technological incubators).

10.2. Key technologies

The key technologies required for the deployment of open data are:

- Digitization of information systems
- Data Portal
- Publish to the data.slovensko.sk portal

Digitization of information systems

It is best to have the information to be published stored in the information system. If the information is kept in a non-digital form or is not available, it must be digitized (e.g. passporting). If they are kept in files (e.g. excel), it is also possible to publish them, although this is less effective.

Data Portal

A data portal is a technology that is used to publish and view datasets and APIs. The data.slovensko.sk portal, a solution from a supplier or a custom solution can be used free of charge as a data portal.

Publish to the data.slovensko.sk portal

In accordance with the Information Act, open data should also be published on the central portal of data.slovensko.sk. You can publish manually or automatically by creating a local catalog. Datasets do not need to be physically stored on the portal, they can be linked to.

10.3. Key decisions

- Establish processes and accountability
- GDPR assessment

Establish processes and accountability

Although the publication of open data can also work to a large extent automatically, in practice it is always necessary to reserve human capacities to deal with the topic. We are talking about analysts, computer scientists and the position of a data curator who should coordinate the publication of open data. On the other hand, there are the managers of individual datasets who create and update them. It is also important to work on building community by organizing events, answering user questions and problems, or developing and publishing more and more data.

GDPR assessment

Each published dataset must be assessed in terms of GDPR and compliance with legislation. In most cases, datasets do not contain personal or sensitive data (e.g. street lists, schools), but in some cases it may be questionable whether the data can be published. In this case, it is advisable to contact a lawyer or publish an anonymized or pseudonymized dataset. Datasets from the publication minimum according to the recommended structures are suitable for publication in terms of GDPR and legislation.

D. Resource list

- General Data Protection Regulation (GDPR)
- Directive (EU) 2019/1024 of the European Parliament and of the Council of 20 June 2019 on open data and the re-use of public sector information
- Banská Bystrica Self-Governing Region. "Data Policy Concept: Standards for Dataset Creation and Data Work." November 2021, https://www.bbsk.sk/storage/app/media/strategicke-dokumenty/data/standardy_prace_s_datami_BBSK_1.1.pdf . Accessed 18 September 2024.
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E. Additional resources (Slovakia)

- OZ Alvaria: Open data in local government – e-learning (https://www.alvaria.sk/kurz/otvorene-data-v-samosprave/)
- data.slovensko.sk Portal
- Act No. 211/2000 Coll. on Free Access to Information
- Decree of the ÚPVII SR No. 78/2020 Coll. on Standards for Public Administration Information Technologies
- trainings carried out by the Ministry of Investments, Regional Development and Informatization of the Slovak Republic (MIRRI SR) - https://wiki.vicepremier.gov.sk/pages/viewpage.action?pageId=101822636
- recordings from working groups and workshops, published by MIRRI SR on Youtube - https://www.youtube.com/@datovakancelaria7258
- outputs of the OZ Alvaria Open Data Lab project (for universities) - https://www.alvaria.sk/otvorene-data-na-univerzitach-univerzity-chcu-pracovat-s-realnymi-datami-a-pripravovat-studentov-pre-prax/

- List of self-governing open data portals - https://www.alvaria.sk/kurz/otvorene-data-v-samosprave/lekcia/open-data-portaly-slovenskych-samosprav/
- Applications on top of open data on the data.slovensko.sk - https://data.slovensko.sk/aplikacia portal