
JRC TECHNICAL REPORT

# Sharing and using geospatial data across borders

*Spatial Data Infrastructures*

*for the Digital Economy*

Ytrehus, L.

O'Neill, G.

Hernández Quirós, L.

Vrečar, S.

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**Contact information**
Name: Lorena Hernández Quirós
Address: Via E. Fermi 2749, TP263, I-21027 Ispra (VA), Italy
Email: lorena.hernandez@ec.europa.eu
Tel.: +39 003278 6653

Name: Francesco Pignatelli
Address: Via E. Fermi 2749, TP263, I-21027 Ispra (VA), Italy
Email: francesco.pignatelli@ec.europa.eu
Tel.: +39 0332 786319

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### *Authors*

— Lea YTREHUS (Deloitte)

— George O'NEILL (Deloitte)

— Lorena HERNÁNDEZ QUIRÓS (European Commission, Joint Research Centre)

— Simon VREČAR (European Commission, Joint Research Centre - Consultant)

### *Reviewers*

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## Abstract

Spatial Data Infrastructures (SDIs) are key for effective cross-border data-sharing. A Spatial Data Infrastructure is "*a framework of policies, institutional arrangements, technologies, data, and people that enable the sharing and effective usage of geographic*." As such, they can play a pivotal role in digital government transformation.

The present study demonstrates how geospatial data from multiple countries can be used to develop location powered insights. In addition, it provides information on the types of enabling environments that can foster data-driven innovation.

The overarching question that the study seeks to respond to is: "*What is the current state of play on sharing and using geospatial data across European borders? What can we learn from these practices to support the evolution of Spatial Data Infrastructures*?"

The study builds on the analysis of data collected through desk research, eight case studies and a dedicated workshop. The case studies, through customised interviews, provide first-hand knowledge and experiences on the exchange of geospatial data across borders in the European context of public, private and non-profit organisations.

Insights include benefits such as improved collaboration, economic gains, improved access to information, and new and improved services. Among the challenges that emerged are worth mentioning the lack of technical and organisational interoperability to establish a sustainable ecosystem with a culture of sharing data, including problems with licensing, data portability and privacy issues.

This study forms part of the ***E**uropean **L**ocation **I**nteroperability **S**olutions for **e**-Government* (ELISE) action of the European Interoperability solutions for public administrations, businesses and citizens Programme, better known by its acronym ISA$^2$. ELISE aims to facilitate the cross-border use of location data and support the digital transformation of public services.



### *Keywords*

Cross-border, SDI, Spatial Data Infrastructure, data exchange, geospatial, interoperability, location interoperability, European digital services, paneuropean dataset, Digital Single Market, European Data Strategy.

## Executive summary

In an increasingly interconnected world, the need for seamless data sharing across borders is more relevant than ever before. This is especially true in the European context, where the free movement of goods, services, capital and labour is at the cornerstone of our shared values, and where the promotion of a harmonious economic, social and territorial development of the Union as a whole is key.

While the availability and volumes of datasets are unprecedented, there is insufficient knowledge about the extent to which organisations are using cross-border geospatial data, the barriers they experience and the extent to which existing Spatial Data Infrastructures (SDI) address their needs.

As there is limited information on this topic, this study provides a qualitative assessment of the perspectives of a group of selected stakeholders. It addresses the following research questions:

> *What is the current state of play on sharing and using geospatial data across European borders?*

> *What can we learn from these practices to support the evolution of Spatial Data Infrastructures?*

This study forms part of the ***E**uropean **L**ocation **I**nteroperability **S**olutions for **e**-Government* (ELISE) action of the European Interoperability solutions for public administrations, businesses and citizens Programme, better known by its acronym **ISA²**. ELISE aims to facilitate the cross-border use of location data and support the digital transformation of public services. The present study demonstrates how geospatial data from multiple countries can be used to develop location powered insights. In addition, it provides information on the types of enabling environments that can foster data-driven innovation.

### *Why now? The relevance of cross-border location data in the digital decade*

The European Commission has placed digital transformation at the centre of its policy agenda with its Communication on Europe's Digital Compass [1]. Given digital technologies' crucial role in accessing a wide range of services, the Commission is increasingly emphasising digital sovereignty. Europe must develop its digital capacities and infrastructures rather than depend on others. This entails developing secure and sustainable digital infrastructures, the further digitalisation of public services, as well as ensuring that these solutions support the continuous free flow of goods, services, capital and people across borders.

Reform to data policy provides an integral part of driving a European digital transformation. Efforts to create a single market for data have been reinforced through the European Union's strategy for data [2]. Under this strategy, new legislative measures on access and data reuse are proposed, making high-value datasets [3] such as geospatial data available and free for reuse. The data strategy also entails financing a High Impact Project on European Data spaces to develop infrastructures and data sharing tools and support the rollout of common European data spaces in key sectors.

These and other European Union (EU) policies and initiatives aim to create a sustainable space for data-sharing, enabling data-driven innovation in trusted environments and improving the quality of public services in the EU. The position of the geospatial domain should not be neglected in this, as geospatial data is the second most reused type of data [4]. The evolution of Spatial Data Infrastructures (SDI), allowing for improved geospatial data access and sharing across European borders, is essential to realise these broad EU ambitions.

> According to Bernard et al., 2005, a Spatial Data Infrastructure is "*a framework of policies, institutional arrangements, technologies, data, and people that enable the sharing and effective usage of geographic information*".

Spatial Data Infrastructures are essential tools to ensure that geospatial data is easily discoverable and accessible to users. They facilitate the development of new services and applications, and they support the upgrade of existing ones.

> *"Like a road infrastructure makes it possible to connect different sites, a spatial data infrastructure makes it possible to combine data located at various sources."* [5]

### *The study approach: drawing on desk research, case studies and an expert workshop*

This study analyses data collected through desk research, eight case studies and a workshop on cross-border sharing and use of geospatial data. The case studies are a mix of public, private and non-profit cases, with diverse geographical coverage and size. They provide insights into the actual practice of sharing geospatial data across borders within Europe and their benefits and challenges. Based on these findings, the study team has developed lessons on the evolution of Spatial Data Infrastructures.

### *The study findings: benefits and challenges of cross-border data sharing*

The case studies reveal numerous successful initiatives that rely in whole or in part upon cross-border sharing of location data. The benefits of these initiatives include improved collaboration, economic gains, improved access to information, and new and improved services. To achieve these benefits, stakeholders highlight the importance of positive feedback loops that incentivise public-private partnerships, for example, in the case of private sector companies who process and interpret public sector data and re-share the results of this work.[1]

However, certain challenges and obstacles currently impact such cross-border activities and limit their potential to scale up. Such challenges include the lack of sustainable funding, the cost of obtaining and accessing data, lack of interoperability in terms of harmonisation and licensing, and organisational challenges related to establishing a sustainable ecosystem with a culture of sharing data. An additional challenge mentioned during the interviews is that cross-border data sharing is rarely considered a political priority. Therefore it is necessary to convince decision-makers to prioritise it. A solid and transparent ecosystem of partners is needed to achieve this. Finally, although geospatial data has become more accessible and affordable, there is still a lack of ready-to-use applications utilising and analysing this data.

The further development of projects relying on cross-border data sharing is particularly hindered by a lack of interoperability between organisations, whether along technical, organisational or legal and political dimensions. These barriers result in high costs for the organisations involved, which must dedicate time and resources to overcome them. For example, the study found that:

- Different data formats and standards are applied across countries and regions. Cross-border projects currently have to devote significant time and resources to clean and harmonise data;
- Regarding the organisational and legal aspects, disparities in licensing models, data sharing culture and language/terminology can pose challenges to establishing a sustainable ecosystem to share data across borders;

In general, it was found that obstacles to data sharing should be understood as policy issues rather than technological ones since they are associated with how entities collaborate[2].

Innovative approaches are often developed to overcome the technical hurdles to sharing and using data across borders. These solutions include the use of linked data for interoperable systems, creating new standards, and exploiting non-traditional data sources. Stakeholders who took part in the study workshop highlighted that use-cases and stakeholder needs would continue to drive technological trends related to data sharing.

[1] Finding from the validation workshop for this study.
[2] Finding from the validation workshop for this study

### *Lessons for the development and evolution of Spatial Data Infrastructures*

The evolution of Spatial Data Infrastructures can help expand the benefits mentioned above and address the challenges related to the cross-border exchange of geospatial data. In the future, promoting public-private collaboration in using and re-using geospatial data through positive feedback loops can be a key element of this, for example, by ensuring that companies using public sector data share the processing of their resulting data.

As voiced in the study workshop, the evolution of SDIs may even entail a shift from the concept of "*spatial data infrastructures*" to that of "*data infrastructures*". The latter reflects that location data is no longer analysed in isolation but should be treated as an integral part of all emerging data spaces.

Based on the key findings from the case studies, the study proposes four lessons for the further development and evolution of SDIs:

**Lesson 1:** *SDIs should have a holistic focus to support access to location data across borders*

SDIs should address not only technical challenges but also legal, organisational and institutional challenges to sharing geospatial data at local, regional, national and EU levels. In addition, efforts should be made to integrate geospatial data with other forms of data. The development of future European data spaces could be used as a central focus for this effort.

**Lesson 2:** Technology and innovation supports a Europe fit for the Digital Age

Approaches making use of new technology (e.g. artificial intelligence, machine learning and blockchain), data sources (e.g. citizen science, citizen-generated data) and innovative techniques i.e. linked data, the proliferation of Service Level Agreements (SLA), Application Programming Interfaces (APIs) are being employed. They will have an increasing impact on the facilitation of sharing and using cross-border data. The uptake of such technologies and innovative approaches can support SDIs in automating and facilitating the collection, enrichment, validation, and integration of new data sources.

**Lesson 3:** Access to data can be improved through harmonised and interoperable solutions

Access to geospatial data remains the key driver of cross-border project and initiatives. However, challenges remain, especially from the user perspective. There is a need to raise further awareness on the *FAIR principles* (*Findable, Accessible, Interoperable and Reusable* data) as well as providing practical guidance and tools that can support the re-use of the data.

**Lesson 4:** People are at the centre of the digital transformation – long-term benefits come from cross-border partnerships and ecosystems thinking

Building sustainable partnerships, broader ecosystems and adopting collaborative approaches are essential to SDIs. From the case studies, it is evident that while there may be barriers to enlarging a data ecosystem and building new partnerships, the benefits experienced far outweigh the initial costs. By adopting ecosystem approaches, stakeholders can obtain higher volumes and more diverse data sources while establishing long-term partnerships and innovative approaches.

# 1

# Introduction

Image by PIRO4D from Pixabay

This document presents the objective, scope, methodology, findings and overall conclusions for the "Study on Spatial Data Infrastructures for the Digital Economy: Sharing and using geospatial data across borders".

The study has been coordinated by the Joint Research Centre (JRC) and developed together with Deloitte Belgium through the ***E****uropean* ***L****ocation* ***I****nteroperability* ***S****olutions for* ***e****-Government* (**ELISE**) action of the European Interoperability solutions for public administrations, businesses and citizens Programme (**ISA$^2$** ) in the frame of the project "*ELISE Knowledge Transfer: Digital Transformation and the Future of Spatial Data Infrastructure*".

The document is structured in the following way:

1. **Introduction** Describes the objectives and scope of the study, its methodology, and the context concerning data policy and geospatial data in which it has been developed;
2. **Key characteristics of cross-border data sharing and use**: Explores the key characteristics of data sharing/data use across borders in Europe: presents the main features of the case studies developed on the cross-border sharing of location data;
3. **Current challenges of cross-borders data-sharing and data use in Europe**: presents the main challenges to cross-border data sharing as experienced in the analysed initiatives;
4. **Benefits and lessons learned from sharing data across borders**: expands on the main types of benefits observed in the case studies and develops four key lessons that can be drawn for the future of spatial data infrastructures;
5. **Conclusion**: summarises the study's main results.
6. **Annexes**
    - **Annex 1**. Overall methodology
    - **Annex 2**. Selection matrix
    - **Annex 3**. Summary of workshop findings
    - **Annex 4**. Mapping of relevant case studies
7. **References**

## 1.1 Objectives and scope

### 1.1.1 Objectives and scope of this study

This study aims to develop lessons for Spatial Data Infrastructures (SDIs) on how they can foster the cross-border sharing of geospatial data. It aims to provide evidence on the state of play of geospatial data sharing across European borders, including the key characteristics, challenges, and benefits of sharing this data. The study supports the ELISE action's wider efforts to improve European digital public services by using location data. It will provide concrete examples of leveraging geospatial data from multiple regions to develop location-powered insights and provide data-driven innovation.

These findings will aim to answer the following questions:

> *What is the current state of play on sharing and using geospatial data across European borders?*

> *What can we learn from these practices to support the evolution of Spatial Data Infrastructures?*

The study and its findings are scoped according to:

- **Desk research** – to explore the current state of play on sharing and using geospatial data across European borders and the perceived key enablers and barriers;
- **Eight interviews** – with the owners of the eight shortlisted case studies, to obtain first-hand insights and experiences on sharing geospatial data across borders in the European context;
- **A workshop** - to obtain wider stakeholder feedback and discussion of the preliminary findings of the case studies.

The study develops lessons on the evolution of Spatial Data Infrastructures in Europe based on these sources by emphasising the experiences of the case study owners **Table 1** the eight case studies analysed. They are a mix of public, private and non-profit cases, with diverse geographical coverage and size.

**Table 1** - Summary of case studies

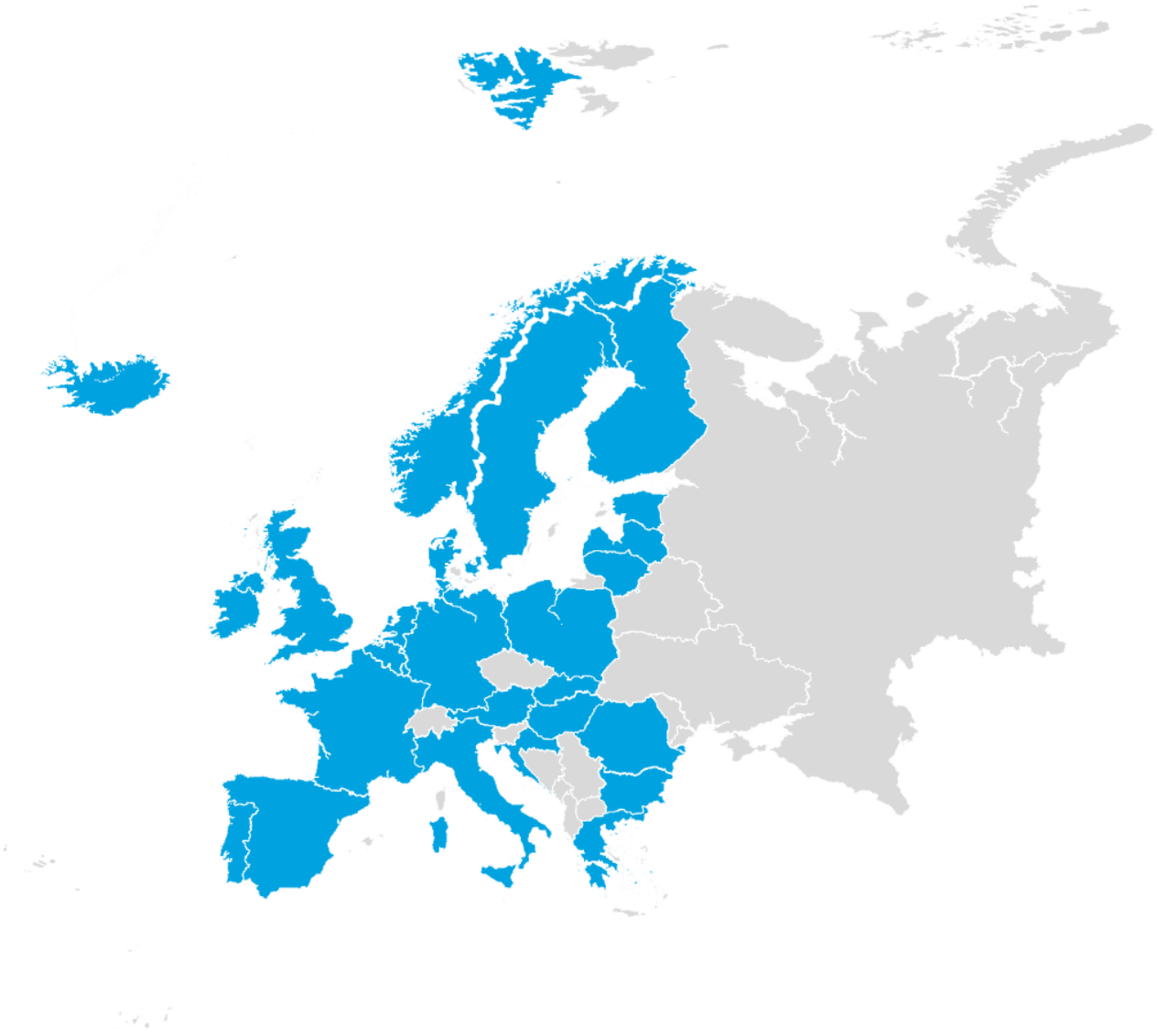
| Case | Private/public sector | Business Model[3] | Geographical scope/coverage | Product /offering |
|---|---|---|---|---|
| the Locator | Public/Private | G2B | Euregio Meuse-Rhine (Maastricht, Aachen and Liège) | Open-source database |
| Grande Region (SIG-GR) | Public | G2x | Luxembourg, Rhénanie-Palatinat, Sarre, Grand Est, Wallonie | Web service providing thematic maps |
| FAIRway Danube | Public | G2x | Austria, Slovakia, Hungary, Croatia, Bulgaria and Romania | Platform |
| NordicSmartGovernment | Public | G2B | Norway, Sweden, Denmark, Finland | API |

[3] See Glossary section for definitions.

| Case | Private/public sector | Business Model[3] | Geographical scope/coverage | Product /offering |
|---|---|---|---|---|
| Esri | Private | B2x | Global | Data, analytics, solutions (APIs) |
| Seapilot | Private | B2C | Europe, US, Canada and Australia | App |
| European Rail Agency | Public | G2x | Europe | Platform |
| Eurobird | Non-profit | NP2x | Europe | Knowledge graph, platform |

The geographical scope of this study is the EU27 and the UK. Two out of eight case studies cover the entire EU. One case study has a global scope. The remaining five covered multiple or neighbouring EU countries (see **Figure 1**).

**Figure 1** - Geographical scope



### 1.1.2 What is out of the scope of this study

This study does not attempt to:

- Measure cross-border data flows across European borders. In other words, the study will not measure the volume of data being exchanged and/or stored across European borders.
- Provide macroeconomic assessments of economic benefits or burdens at the European level.

Instead, this study will try to describe the overall state of play based on stakeholder perceptions through eight case studies and a dedicated workshop. Additional case studies would have allowed a more complete view on the subject of research, including the use of particular spatial data typologies such as imagery/orthophotos or Digital Elevation models, for example, the Common Agricultural Policy.

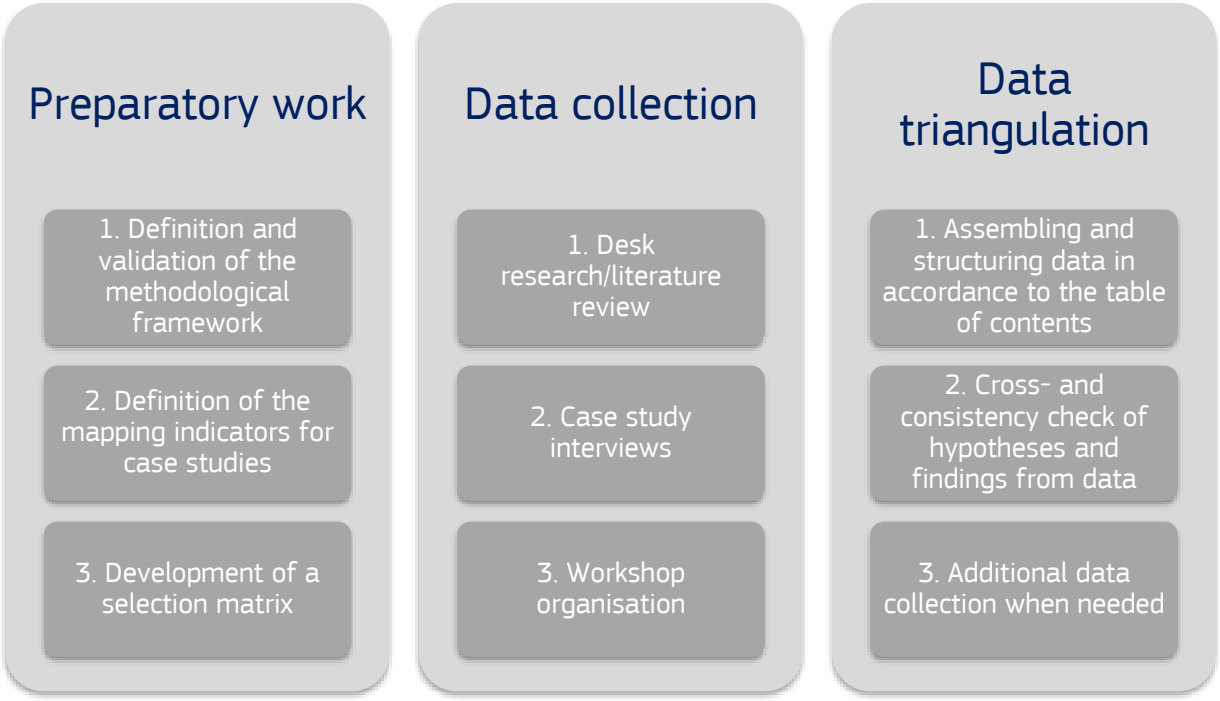
The case studies analysed present diverse perspectives; however, they cannot be assumed to be representative of all organisations, companies, projects and initiatives that use and exchange geospatial data across borders. As such, they also cannot serve as the basis for economic analysis.

## 1.2 Methodology

### 1.2.1 Introduction to the methodology

The figure below presents the overall methodological approach for this study. Refer to the annexes in section 6 for a more detailed account of the methodology.

**Figure 2** - Overall study methodology




The study approach is based on a methodological framework designed in the **preparatory work phase**. This framework sets out research questions, sub-questions, indicators and data sources. In this way, it enables a structured analysis. The mapping indicators[4] developed provided a list of basic criteria against which each case study could be compared. The study team built a long list of potential case studies and scored them against

[4] Indicators were developed to ensure diversity in the selection of case studies, especially emphasising domain, ownership and geographical scope. See Annex 1 for more information.

these indicators. Finally, the study team developed a selection matrix (see Annex 2) to compare the initiatives identified against all indicators and ensure a diverse final selection of case studies.

The **data collection** phase involved three steps. Firstly, the desk research/literature review activity aimed to obtain an overview of the current state of cross-border data-sharing and use in the European Union. While there is limited literature available on organisations' experiences with the cross-border sharing of geospatial data, the exercise provided useful contextual information. Secondly, the study team commenced drafting interview guidelines (see Interview Guidelines under Annex 1) and prepared case study briefing documents. The interviews were semi-structured. Lastly, the study team conducted a validation workshop on "*Cross-border sharing of geospatial data*" with a broader range of stakeholders. The workshop brought together representatives from academia, small and medium-sized companies, international organisations, large companies, data providers and project coordinators. During the workshop, the study team collected stakeholder opinions validated the preliminary findings from the case studies. A summary of the workshop can be found in Annex 2.

For the **data triangulation phase**, the study team developed a table of contents and conducted a data analysis exercise. The results gathered from each data collection technique were compared and enriched. When necessary, the study team approached the various information sources to obtain additional data to analyse and explain possible contradictions and/or differences in the findings.

### 1.2.2 Challenges encountered

The methodological challenges encountered in carrying out this study are listed in **Table 2**, together with the mitigation actions taken to address them:

**Table 2** - Challenges encountered

| Challenge | Mitigation action |
|---|---|
| **Identifying relevant case studies**<br>*The identification of relevant case studies was challenging as the cross-border use and exchange of data is often implicit rather than explicit.* | The study team conducted additional desk research activities. It widened the scope to find the most relevant case studies. By maintaining a mapping file as a living document throughout the study, 42 case studies were identified. |
| **Covering information needs with a limited set of case studies**<br>*The study team experienced difficulty covering some sub-questions set out in the methodological framework, as stakeholders had limited input to provide on these points.* | The study team ensured diverse case studies using a selection matrix that set out the most key criteria. A flexible approach was adopted for the data triangulation exercise as stakeholder opinions were limited regarding certain sub-questions set out in the methodological framework. |
| **Obtaining comparable information across case studies**<br>*Through a diverse selection of case studies and semi-structured interviews, the variety in experiences and perceptions also meant that information was not always comparable.* | The study team conducted a validation workshop to fill data gaps and obtain collective feedback on key findings. The workshop allowed the study team to develop conclusions even where there was limited input from the case studies. |
| **Collecting data during COVID-19 transition to virtual ways of working**<br>*The study was launched in the first quarter of 2020 when organisations had to adapt to new ways of working. This crisis may have impacted the response rate from stakeholders and their willingness to engage in voluntary work.* | The study team ensured the virtual facilitation of meetings and workshops to minimise the burden on stakeholders. Besides, when response rates were low, the study team followed up actively with reminders via e-mail. |

## 1.3 Context and definitions

### 1.3.1 Policy Context

The creation and support of cross-border digital public services is a key policy goal for the EU [6]. In its Communication on the *2030 Digital Compass: the European way for the Digital Decade*, the European Commission has restated the importance of digital technologies to the European economy and society and declared its intention to act to counter Europe's current vulnerabilities in this space [1]. Success in this will require the further development of digital skills among the population, the provision of high performing digital infrastructures, the digital transformation of businesses, and the digitisation of public services. In support of these objectives, the European Commission has initiated a series of actions, described below.

The European Union's strategy for data [2] aims to create a Single Market for data, achieve data sovereignty and ensure global competitiveness. Among other things, the strategy intends to realise this goal by adopting legislative measures on access and reuse of data, making high-value datasets [3] available and free for reuse, financing a European high impact project that will develop infrastructures and data sharing tools, and fostering the rollout of common European data spaces in several key sectors. The public sector can play a crucial role through regulatory and policy measures and by improving its use of data to support decision-making and public services.

Organisations' ability to share and store data across the EU's internal borders is a core element of a true Single Market for data storage and processing services. To this end, the Regulation (EU) 2018/1807 on a framework for the free flow of non-personal data in the European Union enshrined a ban on data localisation requirements [7]. Two more recent legislative initiatives, the Digital Services Act and the Digital Markets Act, have been proposed to ensure a safe digital space and level playing field in the European Single Market and beyond [8]. They ensure that consistent rules are provided for cross-border digital services across Europe.

The Open Data Directive, on its side, provides a common framework to increase transparency and fair competition regarding public sector data. As part of the 2019 amendment of the Open Data Directive, some datasets were labelled as bringing powerful benefits to society and the economy (High-Value Datasets). The first of these six *High-Value Datasets* is geospatial data. The Commission considers these datasets vital to enrich research, develop new products and services, and inform decision-making in the EU. As a result, the strategic importance of public access to geospatial data has been further solidified. In this context, data protection and General Data Protection Regulation (GDPR) through Regulation (EU) 2016/679 GDPR [9] remains a cornerstone of building a Europe fit for the digital age. European data protection aims to ensure individuals' fundamental rights and create a fair and competitive business environment. Data protection is essential regarding the sharing of geospatial data across borders, as location data can disclose an individual's location and interests and preferences. While location data privacy has many aspects in common with general data protection principles, particular location characteristics need to be considered, and actions can be taken to mitigate the potential risks associated with using (personal) location data [10].

To foster further availability of geospatial data, it is necessary to have the appropriate infrastructures to find, access and reuse such datasets. In this regard, the INSPIRE Directive represents one of the most significant harmonisation efforts at the EU level. It has been a milestone in moving towards a common European Spatial Data Infrastructure (SDI) that facilitates public access to data and information and assists policy-makers across domains, sectors and borders in the environment and beyond [11].

Article 3 of the Directive defines the European infrastructures for spatial information as composed of "*metadata, spatial datasets and spatial data services; network services and technologies; agreements on sharing, access and use; and coordination and monitoring mechanisms, processes and procedures, established, operated or made available in accordance with this Directive*". [12]

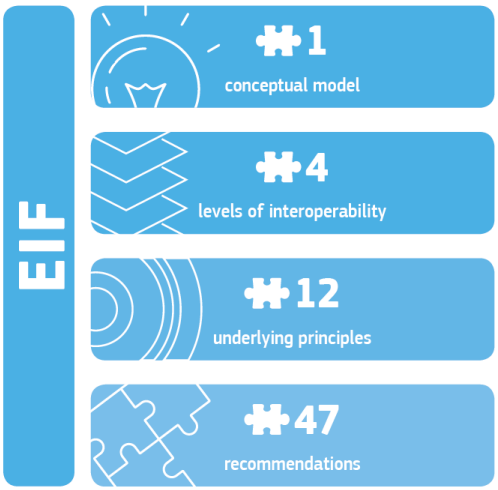
Although the INSPIRE Directive focuses on the environmental domain, it serves as a basis and inspiration for enabling access and reuse of geospatial data and information across all levels of government and borders. Integrating environmental concerns into all EU policy areas is also key to reach the EU's climate and energy targets. To achieve a Common European Green Deal Space, the Commission explicitly points in its European strategy for data [2] towards evaluating and possibly reviewing the INSPIRE as an essential component. In a

cross-border context, one can draw lessons from the many Environmental Impact Assessments (EIA) carried out across borders in Europe. The latter highlights the importance of the availability of comparable geospatial data.

Another focus area the European Union invest greatly is on regional and cohesion policy. The European Territorial Co-operation (Interreg) Programme [13] provides a framework for implementing joint actions and policy exchanges between national, regional and local actors from different Member States to promote a harmonious economic, social and territorial development of the Union as a whole. The use and exchange of geospatial data across borders are necessary for cohesion to happen. It must not be surprising that several of the case studies analysed started as Interreg projects.

In light of exponential developments in the overall availability of data and advancements of technologies that use, reuse, exchange, and generate data, the EU is leveraging these advancements to improve its public services. In doing so, the ability of systems to exchange and make use of information in conjunction with one another presents a key challenge for data sharing. To address this, the European Interoperability Framework (EIF) [14] under ISA$^2$ provides public administrations with concrete recommendations to improve interoperability and sets out the four layers of interoperability (legal, organisational, semantical and technical)[5]. The ultimate goal is to improve the quality of European public services and create an enabling environment for public administrations to collaborate digitally [15].

**Figure 3** - European Interoperability Framework




**Source:** European Commission

In sum, EU policies and initiatives aim to create a sustainable space for data-sharing to enable data-driven innovation in trusted environments to improve the quality of public services. The evolution of Spatial Data Infrastructures, allowing for improved data access and sharing across European borders, is essential to realising this ambition.

### 1.3.2 Definitions for sharing and using geospatial data across borders

The definition of geospatial data – used as synonyms of location data, spatial data or geodata - is central to the study. We draw upon the definition used in the ELISE Glossary [16] as follows:

> *"Data with a direct or indirect reference to a specific location or geographical area" (cf. The legal definition in the inspire Directive, Directive 2007/2/EC).*

[5] Ibid.

Other work by the Joint Research Centre draws on a similar definition. For example: "Geospatial or Location data covers any data with an implicit or explicit geographic or geospatial reference, ranging from address data to radio signal-based triangulation or IP address location" [10].

For this study, the concept of cross-border data sharing refers to cross-border exchange and usage of geospatial data. Hence, the term *across borders* can mean data sharing, use and reuse of geospatial data:

- in two or more bordering countries (e.g. in a cross-border region); but also
- in multiple countries, either in cross-border regions or different cities across large geographies.

The term *cross-border data flow* is also used in reference to legal restrictions to cross-border data transfers, i.e. in the mention of the term in the *Free flow of non-personal data Regulation* [7]. However, this study does not focus on such restrictions.

The concept of *Spatial Data Infrastructures* is also central to the study. We make use of the definition provided by Bernard et al., 2005, collected in the ELISE Glossary as follows:

> *A* Spatial Data Infrastructure is "*a framework of policies, institutional arrangements, technologies, data, and people that enable the sharing and effective usage of geographic information*".

SDIs can be important tools to successfully share geospatial data across borders, as they ensure that data is easily discoverable and accessible to users. Moreover, SDIs can facilitate the development of new services and applications and can improve existing ones. The JRC says of SDIs that "*like a road infrastructure makes it possible to connect different sites, a spatial data infrastructure makes it possible to combine data located at various sources*" [5].

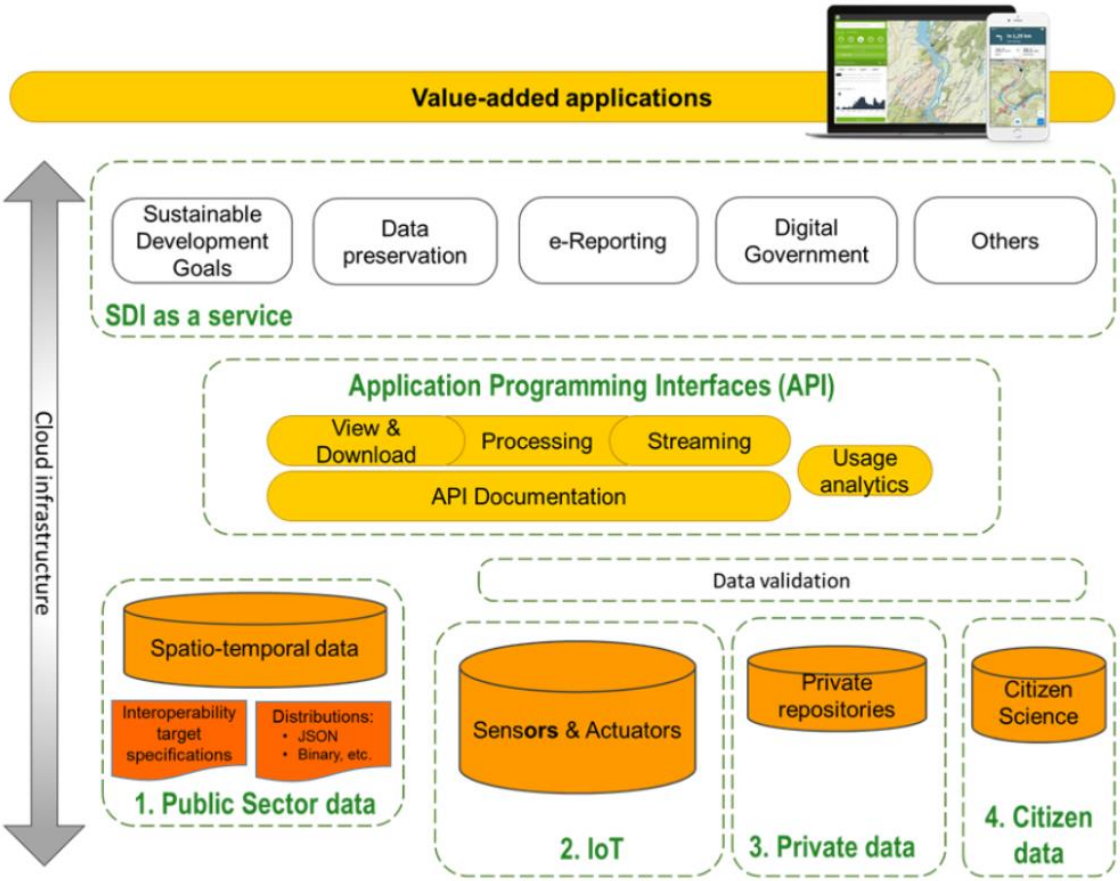
As shown in Figure 4, modern SDIs combine different geospatial data sources and access them via Application Programming Interfaces –APIs-. In turn, this allows for the development and provision of a range of different services and value-added applications. For this study, the framework of policies, institutional arrangements, technologies, data and people surrounding SDIs are of principal interest.

**Location interoperability** is another key term in this study available in the ELISE action glossary.

> *Location interoperability is "the ability of organisations, systems and devices to exchange and make use of location data with a coherent and consistent approach."*

The concept is integral to this study because the deployment of SDIs will impact the ability of any organisation to share and use geospatial data across borders successfully. The Location Interoperability Framework Observatory's 2019 State of Play report [17] provides an overview of the implementation of the EULF Blueprint recommendations. Looking at the overall findings, an overall balanced approach to geospatial interoperability can be observed in Europe. Particular focus is given to policy, strategy alignment and return on investment, but also to digital government integration and standardisation and reuse. The picture is more mixed regarding aspects of organisational interoperability and capabilities (e.g. investment in skills).

**Figure 4** – Architecture of a Spatial Data Infrastructure




**Source:** MDPI, **2021**

Other relevant definitions for this study are location intelligence and **data ecosystems**.

> *"A Data Ecosystem (or 'data-driven digital ecosystem') is where several actors interact with each other and their environment for a specific purpose, generating value from the network by producing, exchanging and consuming data in a collectively governed and operated way". [18]*

Throughout the study, this concept will be mentioned concerning cross-border collaboration between actors. Ecosystems thinking can be instrumental in deriving new and deeper geospatial insight. That is where the concept of **location intelligence** comes in, which refers according to definition in the ELISE action glossary to:

> *"The process of deriving meaningful insight from geospatial data relationships — people, places or things — to solve particular challenges such as demographic or environmental analysis, asset tracking, and traffic planning."*

## 1.4 Drivers of sharing and using cross-border geospatial information by governments and the private sector

The use of cross-border geospatial information by the public and private sectors can be motivated by many reasons. The public sector can use geospatial data to derive new insights that improve service quality and effectiveness, increase efficiency and deliver cost savings. The cross-border sharing and use of geospatial data can also enable collaborations with other organisations and engage the public [19].

Regarding the cross-border aspect, our research shows that stakeholders perceive the sharing of geospatial data across borders as crucial due to challenges that transcend national boundaries, such as environmental issues and disease outbreaks[6]. Such challenges call for data sharing across borders to support efficient and effective policy design and disaster response supported by interconnected systems. Location interoperability is crucial to help organisations, systems, and devices exchange and use location data coherently and consistently.

As 20% of EU citizens reside within 50 km of a State border, the need for cooperation between neighbouring countries is essential. This goal remains fundamental for continuing building the European project.

The private sector may also reap significant benefits from sharing location data across borders. The use of geospatial data across borders presents opportunities for private companies to deliver new and innovative products, services, and business models and build cross-border ecosystems. However, their ability to do this depends upon improved and harmonised access to data across the Member States.

Regarding the importance of cross-border data sharing, stakeholders' perceptions are that increased use of (geospatial) data leads to a higher return to investment from the business point of view.[7] This argument is based on the idea that one may derive new and deeper insights to inform decision-making or improve products and/or services by integrating location data. Second, and relatedly, data is critical for companies to generate new business applications and provide value to customers and society. Access to geospatial data is therefore essential for the private sector to develop innovative and data-driven solutions. With this context in mind, the following chapters of this study dive deeply into the findings from our research on cross-border sharing and the use of geospatial data.

## 1.5 Literature review

As part of this study, a literature review was conducted. This exercise aimed to collect information on the state of play of sharing, using, and reusing geospatial data in Europe. To achieve this, ongoing projects, literature and reports were consulted.

A substantial proportion of public sector information has a geospatial component, whether this is a street address, place name, administrative unit, geographic or map coordinates or others. This component makes it possible to combine and integrate information from multiple sources, which allows the creation and delivery of new products and services. That, in turn, opens up new ways of policy development and implementation.

Geospatial data is currently the second most reused data type with reported reuse by 25.8% of stakeholders [4]. The OpenDataImpactMap also states that the sectors of IT and Geospatial make the most use of Open Data. IT and geospatial organisations use open data for various purposes, ranging from the development of products and services, organisational optimisation or research. As a result of the unprecedented level of data availability, technological advancement, and European integration, the sharing and (re)use of data across borders is as relevant as ever in the European context.

### 1.5.1 Pan-European datasets

The relevance of cross-border geospatial data is demonstrated by the increasing attention and awareness-raising around the need for pan-European (and global) datasets. Pan-European datasets are crucial for the

[6] Findings from the ELISE action Workshop on Cross-border sharing and use of Location Data, 2020.

[7] Findings from the ELISE action Workshop on Cross-border sharing and use of Location Data, 2020.Opinion expressed by a representative from the private sector.

private and public sectors alike in obtaining comparable data from multiple geographies. In cross-border regions, it is essential to enable collaboration in key policy areas. These areas include spatial planning, environmental monitoring and measures, and emergency and disaster response. The latter is particularly relevant in light of the current Coronavirus pandemic.

Pan-European (or global) datasets can also be a powerful tool to achieve the Sustainable Development Goals without collating datasets from different countries [20]. A survey carried out as part of the JRC study on SDIs supporting access to environmental data (2021) showed that a significant number of users (20/129) rely on transboundary data and refer to various policy domains and application fields, such as education, transport, hazard mapping, forest management and others [21].

There are many examples of actions and initiatives at the European level to develop and maintain pan-European datasets. For instance, Eurostat's *Geographic Information System of the Commission* (GISCO) whose database contains core geographical data covering the whole of Europe, such as administrative boundaries, and thematic geospatial information, such as population grid data. Another example is the GO-PEG Action, funded by the EU Innovation and Networks Executive Agency (INEA), which aims to provide access to harmonised thematic open datasets (including metadata) in areas such as the environment and emergency and disaster management by making the results available through the European Data Portal and in harvested catalogues. The Open Cadastral Index Map provides cadastral parcels with addresses, administrative units and buildings in seven European countries. Users can find unique cadastral parcel references using the service. Multiple EuroGeographics members provide the underlying data. However, it is all provided through a single access point under an open data license.

Another example is the EuroGlobalMap, which has pan-European small scale topographic data for five themes; water networks, transport networks, settlements, named locations and administrative boundaries (including their administrative hierarchy). EuroGlobalMap covers 55 countries and territories. The map uses topographic features (e.g. rivers, transport network, settlements on a small scale) as background for applications such as planning, monitoring, network analysis and presenting environmental policies.

### 1.5.2 New technologies and sources of data

The role of new sources of data and technologies is providing new opportunities to share data across borders. We are currently witnessing the increased use and availability of non-authoritative third party data and volunteered or citizen-generated data. As a result, new business models and initiatives capitalise on the increased availability and diversity of data sources.

For example, new data sources can be exploited and integrated into broader ecosystems via the emergence of geodata marketplaces. Geodata marketplaces allow providers and users to meet in the same virtual space and obtain and exchange personalised, domain-specific information. Such marketplaces can operate independently of borders. Examples of such marketplaces include SMEs such as Geodatahub and global geospatial players such as Esri and Carto as shown by an ELISE webinar on Geodata Marketplaces supporting Location Intelligence [22].

This evolution is supported by the rapidly changing technological landscape, which leads to increased data availability and provides new and more efficient ways of collecting, processing, using, and reusing data [23]. Examples of such technologies are artificial intelligence, machine learning and data from sensors and satellites. Concerning geospatial data, new technologies impact how they enable the realisation of new initiatives such as Smart Cities [24], Digital Twins [25] and more.

Conversely, the continued development of new technologies also depends on the open cross-border exchange of data. Although the volume and storage of data that travels across borders are outside this study's scope, it is an enabler of sharing and using geospatial data in cross-border contexts. The ELISE action has produced studies related to GeoAI [26] and blockchain technologies [27] and their potential for increasing location intelligence. However, such technologies rely on the access to high-quality data from multiple geographies to be applied and scaled up. In crises, such as the Coronavirus pandemic, the data economy has proved its importance in sustaining economic growth in Europe and beyond [28].

Harmonisation of gazetteer data can also lead to significant benefits when sharing geospatial data across borders at the European level. A "*Gazetteer*" is a directory of instances of a class or classes of features containing some position information. The JRC Feasibility study for an EU Gazetteer common service (2017) [29] and later on the follow-up EU gazetteer evaluation study (2020) [30] results clearly showed that there is demand for an EU gazetteer to support multi-national applications or complement existing national gazetteers, for purposes such as emergency response, searching for datasets, news items, or tourism / cultural heritage sites, validating foreign addresses, etc..

In 2019, EuroGeographics published the first version of the Open Regional Gazetteer Service, a pan-European service for georeferencing. This service provides authoritative multilingual geographical names as a web feature service to be used by any application requiring name services.

### 1.5.3 Challenges to sharing geospatial data

Finally, the challenges related to sharing and using geospatial data across borders vary. One critical challenge for the public sector in sharing geospatial data across borders is disparities in legal landscapes and frameworks [31]. Collecting data in a harmonised way is also challenging in cross-border contexts as differences in availability and capacity persist between countries [20]. Moreover, issues in cross-border regions include the lack of coordination between public authorities, obtaining long term and sustainable funding, differences in fiscal standards, legal frameworks, language and timescales [31].

There is an increasing appetite amongst small and medium enterprises (SMEs) and businesses in reusing geospatial data across borders in the private sector. Still, several challenges persist for this sector too [32]. In 2018, Eurogeographics and Deloitte found that companies, especially SMEs, think twice before expanding their services to other countries. This is because the process of collecting public geospatial data across borders is labour intensive. In the same study, a company explained that they spend approximately 90% of their time and resources merely to collect public data (from OpenStreetMap, open data from public authorities, energy data etc.), representing a significant burden.

### 1.5.4 Organisations and projects sharing cross-border geospatial data

As part of the selection process for the eight case studies of this study, 41 different private (16), public (23) and non-profit (2) initiatives using geospatial data across borders in Europe were explored (see Annex 3). These initiatives all use or exchange geospatial data across borders to develop and support their projects. The most common type of initiative (10/41) was government-to-all (i.e. government providing services to citizens, businesses and other government institutions). The second most common was business to all (10/41). There were equally as many government-to-government initiatives as business-to-business initiatives (9/41 for each). The remaining three initiatives were non-profits (2) and government-to-business (1).

The organisations running the initiatives ranged from large global companies to SMEs and non-profit organisations. Some were also EU-funded projects and environmental impact assessments case studies. While a handful of the initiatives had an international scope, the vast majority focused on cross-border data sharing activities within Europe. Although the exchange of geospatial data across borders is not always explicitly stated or evident in the description of these cross-border initiatives, it was found that location data usage or exchange was an integral part of the functioning of the consulted projects.

In sum, many pan-European projects, initiatives, datasets, and services are already operating or in development. These initiatives will continue to share and use geospatial data cross-border or support this behaviour. The current context provides unprecedented availability of (diverse) data and technologically advanced means to process, share and derive new and deeper insights. However, challenges and obstacles remain, such as legal/administrative, economic, technical and organisational burdens. In the context of these trends and realities, this study examines eight selected case studies to examine their characteristics and the stakeholders' perception of the challenges and benefits of sharing geospatial data across borders.

# 2

# Key characteristics of cross-border data sharing and use

Photo by Joshua Sortino on Unsplash

This chapter examines in detail the features of a set of shortlisted initiatives sharing geospatial data across borders. Although the public and private sectors use and share geospatial data across borders for different ends, their reasons are often related. While the public sector typically looks to obtain and share geospatial information to improve decision-making and the provision of public services, the private sector seeks the same kind of information for business purposes. Both the public and private sectors rely on finding and accessing geospatial data to improve their services and products.

An overview of the eight case studies analysed in this study is provided in the table below. The relevant objectives, data collection processes, and stakeholders are highlighted to describe how these actors work with geospatial data. The second part of this chapter provides information on the key aspects of data sharing across borders for the private and not-for-profit sectors. The key characteristics of data sharing are explored by looking at their specific business models, data collection processes and product offerings.[8]

[8] For a more detailed overview please consult Annex 2.

**Table 3** - Overview of case studies

| Case | Description | Private / public sector | Business Model | Geographical scope / coverage | EU funded? | Data type | Data Source | Product/offering |
|---|---|---|---|---|---|---|---|---|
| **the Locator**   | The Locator is a public initiative undertaken by the Euregio Meuse-Rhine (Maastricht, Aachen and Liège) and funded under the Interreg A programme, aiming to provide a solution for companies to easily identify settlement opportunities and available industrial sites. The project uses addresses and location data concerning industrial sites, real estate and other economic data from public administrations to provide an open database for businesses. | Public / Private | G2B | Euregio Meuse-Rhine (Maastricht, Aachen and Liège) | Yes (2010-2014) | Addresses<br><br>Location data concerning industrial sites, real estate<br><br>Other economic data | Public administrations - each city has its own system/method, self-generated data (contacting businesses who fill-in form)<br><br>Commercial third-party providers | Web service providing maps |
| **Grande Region (SIG-GR)**   | SIG-GR is a public partnership between Luxembourg, Rhénanie-Palatinat, Sarre, Grand Est, Wallonie funded under Interreg A, intending to create a geographic information system for the Great Region (SIG-GR), within the context of the work carried out by the summit of the Great region in the domain of planning and territorial development.<br>The project uses geospatial base data and thematic data collected from a wide variety of partners. The project has established web services providing thematic maps. | Public | G2G (but the user group is also private companies, researchers etc.) | Luxembourg, Rhénanie-Palatinat, Sarre, Grand Est, Wallonie | Yes (2010-2013) | Geospatial base data<br><br>Thematic data | Regional offices, institutes<br><br>EU sources (thematic data)<br><br>Geographic institutes (geospatial base data)<br><br>Other stakeholders/partners | Web service providing thematic maps |

| Case | Description | Private / public sector | Business Model | Geographical scope / coverage | EU funded? | Data type | Data Source | Product/offering |
|---|---|---|---|---|---|---|---|---|
| **FAIRway Danube** | FAIRway Danube is a public EU-funded project between authorities in the Danube region (Austria, Slovakia, Hungary, Croatia, Bulgaria and Romania) to ensure safety routing on the inland waterway for vessels. It also aims to increase knowledge on shallow sections of the Danube to optimise routing and draft rehabilitation measures.<br>The project has set up an online platform using self-generated and authoritative data to measure rainfall levels, the status of infrastructure, depth of river (river bed) in conjunction with other reference data | Public | G2X (industry and authorities) | Austria, Slovakia, Hungary, Croatia, Bulgaria and Romania | Yes | Rainfall levels<br>The status of infrastructure<br>Depth of river (river bed)<br>(in conjunction with other reference data) | National authorities<br>Self-generated data | Online Platform (members only) |
| **NordicSmartGovernment** | NSG is an initiative set up by government authorities in Norway, Sweden, Denmark and Finland. The realisation of NSG will happen through an interoperable ecosystem of digital solutions. It will provide real-time business data for business-to-business and business-to-government.<br>The project will set up a range of solutions to automate the collection and reporting of bookkeeping data across borders. | Public | G2B | Norway, Sweden, Denmark, Finland | No | Bookkeeping data (revenue and other financial reporting) | National tax authorities | API |
| **Esri** | Esri is a global company and front-runner of location data products. Esri offers ArcGIS software and apps, which combine mapping and data analytics to deliver location intelligence and meet digital transformation needs for organisations of all sizes. | Private | B2x | Global | No | Geospatial data<br>Other thematic and georeferenced data | Private companies<br>Public authorities<br>Citizens | Data, analytics, solutions (APIs) |

| Case | Description | Private / public sector | Business Model | Geographical scope / coverage | EU funded? | Data type | Data Source | Product/offering |
|---|---|---|---|---|---|---|---|---|
| | They collect data from various sources (private companies, public authorities and citizens) to create state-of-the-art data and analytics solutions. | | | | | | | |
| **Seapilot** | Seapilot is an SME with global reach and ambition. The company has set up a sea navigation app for hobby boaters in Europe, the US, Canada and Australia. The app offers professional navigation technologies, automatic identification system (AIS) boat tracking and up-to-date nautical charts of 20 European countries.<br>Seapilot collects hydrographic data and weather information from national hydrographic offices and third parties. | Private | B2C | Europe, US, Canada and Australia | No | Hydrographic data (nautical maps)<br>Weather information | National hydrographic offices<br>Commercial third-party sources | App |
| **European Rail Agency** | The European Rail Agency has launched a linked data pilot, which will set up an EU-wide platform for rail operators, producers and wagon keepers. The project integrates the railway databases of different member States through Linked data technology. Some of the data models specifications used are INSPIRE related.<br>The project uses all data related to rail operations (technical specifications, timing and routes). | Public | G2x | Europe | Yes | Data related to rail technical specifications timing and routes | Rail operators<br>Producers<br>Wagon keepers | Platform |
| **Eurobird** | Eurobird is a platform set up by a foundation (EBCC) composed of non-profit bird-watching organisations and authorities in Europe. The purpose of EBP is to establish a European data repository based on aggregated data from online bird recording portals from across Europe<br>By collecting bird data (observation and non-observation) from volunteers, the platform is the first of its kind to cover migratory bird patterns in the entire EU. | Non-profit | NP2x | Europe | No | Observed birds and non-observed birds (both in the form of casual records or structured data collection) | NGOs<br>Volunteers<br>Public authorities | Knowledge graph, platform |

## 2.1 Public sector: objectives, structure, data and stakeholders involved

For the five public sector case studies, projects and initiatives from different geographies and fields were selected. The data collected covers the Danube region to the East, the Nordics, the Benelux region, and one EU-wide project. The information obtained covers aspects and challenges in cross-border activities across multiple sectors, covering transport, navigation, business and spatial planning.

### 2.1.1 Objectives/rationale

**Table 4** - Key objectives

| Key objective | FAIRway | SIG-GR | the Locator | NSG | ERA |
|---|---|---|---|---|---|
| **Fostering collaboration** | ✓ | ✓ | ✓ | ✓ | |
| **Sharing information** | ✓ | ✓ | ✓ | | ✓ |
| **Informing decision making** | ✓ | ✓ | | | ✓ |
| **Innovate** | ✓ | | | ✓ | ✓ |

The objectives of public sector actors to share and use geospatial data across borders are diverse and multifaceted. In most cases, there was a need to innovate, obtain or share information to achieve a certain policy objective. For example, the Locator case set up a platform in response to the need to provide companies with the information to easily identify potential areas for settlement in the cross-border region. The overall goal was to increase collaboration between the relevant regions and share information to attract economic activity.

Some cases had the goal of obtaining additional information via the cross-border sharing of data which is often linked to improving future decision-making. *FAIRway Danube*, a project that developed a water management system in the Danube region, provides an example of this. Its objective was to provide a shared system with the necessary information to secure routing on inland waterways. Besides, the system intended to increase the participating actors' shared knowledge on shallow sections, helping them optimise routing and draft rehabilitation measures. Similarly, the SIG-GR project aims to create a geographic information system for the *Greater Region*[9] to inform planning and territorial development.

Several of the public sector case studies had the objective to innovate in one way or another. For example, the *European Railway Agency* (ERA) launched its linked data project to provide a system where datasets can be uploaded. Semantic ontologies are applied to link them automatically. The linked data approach will significantly reduce the burdens of using standards once the project is deployed. *NordicSmartGovernment* provides another example of public sector innovation. This initiative sets up an interoperable digital solution ecosystem to bring real-time business data for business-to-business and business-to-government purposes. Such solutions depend on the smooth access and findability of data across borders and geographies.

### 2.1.2 Structure and stakeholders involved

The public sector case studies provided evidence that cross-border data sharing has evolved into a new stage where *Data as a Platform* (DaaS) is a predominant mode of thinking. In these case studies, data sharing is no longer characterised by unidirectional transactions but instead traded, exchanged and reused via platforms. Platforms are core technologies enabling data exchange as the key commodity instead of another service or application. [10]

[9] Luxembourg, Rhénanie-Palatinat, Sarre, Grand Est, Wallonia

[10] In this context, platform refers to a place for exchanges of information, goods, or services to occur between producers and consumers as well as the community that interacts with said platform (Source: https://www.bmc.com/blogs/digital-platforms/)

In terms of infrastructure, four out of the five public sector case studies provided their data for users via web services, while the fifth was a mix of digital solutions. In all cases but one, the partnership for the solution or service consisted of public actors only.

**Table 5 -** Project partners (public sector)

| Project | FAIRway | SIG-GR | the Locator | NSG | ERA |
|---|---|---|---|---|---|
| **Active partners** | Authorities from Austria, Slovakia, Hungary, Croatia, Bulgaria and Romania. | Regions of Luxembourg, Grand Est, Rhenanie-Palatinat, Sarre and Wallonia. | Cities Maastricht, Aachen and Liège. | Nordic tax authorities, statistical agencies and registration offices. | ERA-led. |

Despite the partnerships behind these case studies primarily involving public sector actors, the end-users and broader pool of related stakeholders were generally more diverse. For example, the users of the platform developed by FAIRway Danube are public authorities and any other stakeholder requiring the infrastructure for navigation purposes. Similarly, the SIG-GR platform is also used by researchers and academia. Meanwhile, the Locator platform provides private companies with up-to-date location and economic data. A broad group of stakeholders, therefore, benefits from these cross-border initiatives.

### 2.1.3 Data sources and data collection

The selected case studies relied upon different data sources and methods of data collection. The specificities for each case are presented below, including how they overcame the hurdle of collecting data across borders.

FAIRway Danube uses datasets on rainfall levels, infrastructure status, and the depth of river beds in conjunction with other reference data. This data is collected to be published on their platform. The published data provides information on waterway axis with kilometre indication, restrictions for vessels or convoys in terms of length, width, draught and air draught, operation times of restricting structures, in particular locks and bridges, location of ports and transhipment sites, and reference data for water level gauges relevant to navigation. It is sourced from national authorities and otherwise self-gathered through the platform.

**Table 6** - Data sources (public sector)

| Data sources | FAIRway | SIG-GR | the Locator | NSG | ERA |
|---|---|---|---|---|---|
| **User-generated**[11] | | | | ✓ | ✓ |
| **Public authorities** | ✓ | ✓ | ✓ | ✓ | ✓ |
| **Third-party commercial sources** | | | ✓ | | ✓ |
| **Self-generated**[12] | ✓ | ✓ | | | |

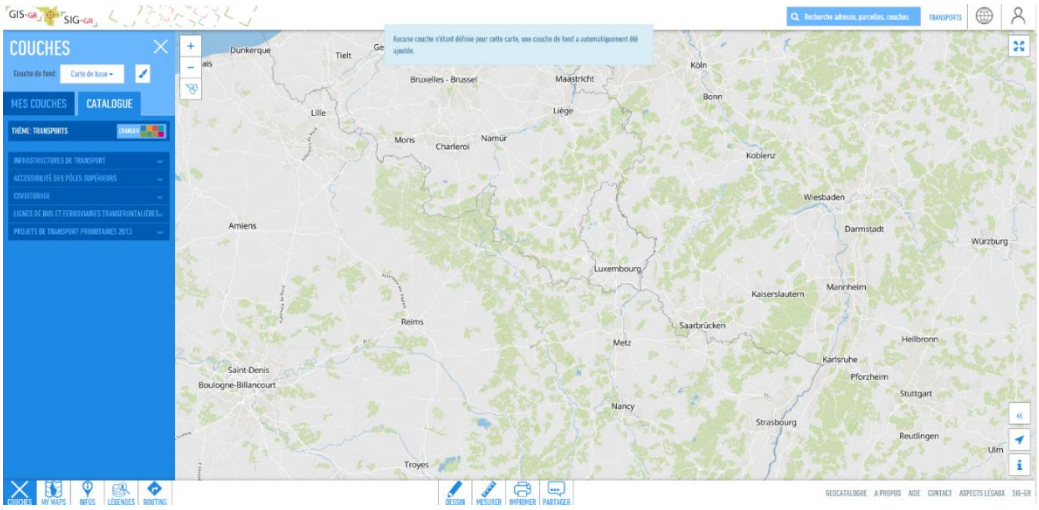
For FAIRway Danube to collect the necessary data, they first decide on the granularity level of the data and what will be collected internationally. The frequency of updates and the baseline information to be provided depending on the availability of resources. The resources of data collectors in partner countries remain limited. Concerning data harmonisation beyond standards set out in the INSPIRE [12] and River Information System Directives [33], the reference data management system is harmonised when gathered. In certain instances, it is necessary to harmonise certain datasets further. Therefore, the FAIRway project supports waterway administrations in providing standardised datasets for reuse by collecting them in a harmonised way. The

[11] Refers to data generated by the direct users of the product.
[12] Refers to data generated by the owners of the product.

project is based on a contract with a specific lifetime. Ensuring data collection activities and maintenance sustainability will be critical for the future.

SIG-GR uses geospatial base data and thematic data obtained through a broader range of sources, including regional offices, institutes, and EU sources for thematic data and geographic institutes for geospatial base data. For SIG-GR, an enabling aspect is their extensive network of stakeholders and partners who share data. To facilitate this project's data collection, project partners have signed an agreement. This agreement stipulates the conditions for access to the datasets. A clear formal agreement from the beginning of the project is highlighted as especially effective in enabling cross-border data sharing. The project works to harmonise the data as much as possible. Some of the data offered on their platform are restricted to specific audiences due to the licensing agreement for the source data.

**Figure 5**: SIG-GR Map




**Source:** SIG-GR

For the Locator case, the relevant datasets are addresses and location data concerning industrial sites, real estate, and other economic data sourced from public administrations. Each partnering city has its own system and method for this project, including self-generated data, where businesses are contacted directly to fill in a form. If not, the data may come from a third-party provider (paid). In Belgium, real estate property is identified and entered into public registries manually. For instance, the source of information for the official source of addresses is the Walloon address dataset. Municipalities are then asked to correct and update the data. Each partner to this project has its way to update the data. In some cases (Germany and Dutch Limburg), direct interfaces are connected to the Locator, while the data is entered manually in Belgium. Therefore, some of the Locator's added value is its harmonisation of data and the platform's unique presentation.

*NordicSmartGovernment* aims to use business data from sales and purchase processes that contain information on business transactions. This data is planned to be obtained from existing enterprise resource planning systems. The initiative will ensure that existing systems apply standardised interfaces such as APIs to achieve this. This way, data can be shared from business to business and from business to government automatically in the future for the entire Nordic region.

Lastly, the European Railway Agency (ERA) uses various data sources, including national rail operators, technical specifications from rail producers, and linked data obtained from wagon keepers. Linked data is a set of design principles that enables the sharing of machine-readable data [34]. For the linked data pilot project of ERA, data is collected to their platform and knowledge graph. The system automatically links data of the same category by applying semantic ontologies. The former allows mitigating non-harmonised data and disparities in standards and significantly simplifying the data collection process.

In sum, these case studies provide evidence of the role of the public sector in collecting and sharing cross-border information and delivering new and innovative services.

## 2.2 Private sector and not-for-profit: the role and value of geospatial data in business models, data sources and service/product offering building on cross-border data

For the private and non-profit case studies, the study team selected:

- one global company specialised in geospatial data (Esri),
- one SME working in the field of navigation (Seapilot); and
- one non-profit project in the field of natural preservation (Eurobird).

### 2.2.1 Objectives/rationale

For all three case studies, geospatial data is essential to the functioning of the business or the initiative.

Esri is a global company working in what they call "*the science of where*". Their business model is centred on developing the powerful mapping and geospatial analytics software ArcGIS. Geospatial data is, therefore, at the core of their business model.

Seapilot is a Swedish SME providing a sea navigation app based on digital nautical charts. The application is already present in more than 20 countries. Obtaining geospatial data in territorial waters is essential for expanding their application. The development of such digital maps relies heavily on cross-border access to data.

Lastly, Eurobird is a project initiated by the European Bird Census Council to update traditional data collection approaches at the national level regarding birds to describe their spatial distribution more comprehensively.

### 2.2.2 Data sources and data collection

**Table 7 -** data sources (private/non-profit)

| Data sources | Eurobird | Esri | Seapilot |
|---|---|---|---|
| **User-generated** | ✓ | ✓ | |
| **Public authorities** | ✓ | ✓ | ✓ |
| **Third-party sources** | | ✓ | ✓ |
| **Self-gathered** | ✓ | ✓ | |

The private sector case studies demonstrate innovative approaches to data collection. For example, Eurobird collects three types of data. First, it collects casual records containing simple information on when and where a bird is observed. A casual record refers to data collected in a non-structured way, based on the casual observation of a volunteer bird-watcher. Second, a complete list includes simple details on when and where a bird is observed and the species observed and not observed. Third, in some instances, data is collected from ornithological institutions. The so-called "complete lists" go a step beyond traditional bird observation, allowing data collection not just on what has been observed in a specific geographic area but also on what has not been observed. The latter provides entirely new data describing the spatiotemporal migration of birds on the European continent. The project relies heavily on local, regional and national NGOs in birdwatching to receive data, with a large number of volunteers conducting data collection activities.

> As stated in the Eurobird website regarding the accuracy and interpretation of third-party sources data:
>
> *Each on-line bird recording scheme submitting data to the project has its own data validation protocols to deal with potentially erroneous observations. Moreover, additional data quality checks are conducted at the – Eurobird portal- level. However, overall, the EBP demo viewer synthesises more than 320 million bird records in about 55,000 weekly maps. […] The possible existence of some erroneous records or counts, however, shouldn't distort the overall large-scale patterns of bird distribution shown in the viewer, which is the ultimate interest of the EBP*

Eurobird established its own data specification capturing the vast majority of the information collected by its partner organisations to address the issue of harmonisation and standards. It is a simple specification based on three tables: records on birds, information on the effort needed to record this data and a protocols table. This specification sets the ground to establish protocols to improve future capacity to handle harmonised data. Eurobird does not have to invest in data cleaning or integration. They provide a simple solution for national partners to conduct this work on their end.

Esri works based on constantly collecting, merging and generating data products. Some of their datasets are obtained from authorities or businesses, while others are based on citizen-generated data. Esri sustains a living ecosystem where it, its customers and others may share and exchange data. Under this model, data is no longer treated as a unidirectional business transaction but instead becomes a commodity that can be produced, exchanged and reused among a wide array of stakeholders.

Seapilot, on the other hand, depends on traditional authoritative data sources to provide their digital nautical charts. To obtain their data, they must identify the access point of each national hydrographic office and come to a licensing agreement to acquire the data needed. The interviewee explained that hydrographic offices in Europe operate with different pricing models, meaning that the steps for obtaining data differed depending on which European country they entered.

### 2.2.3 Offering (products/services)

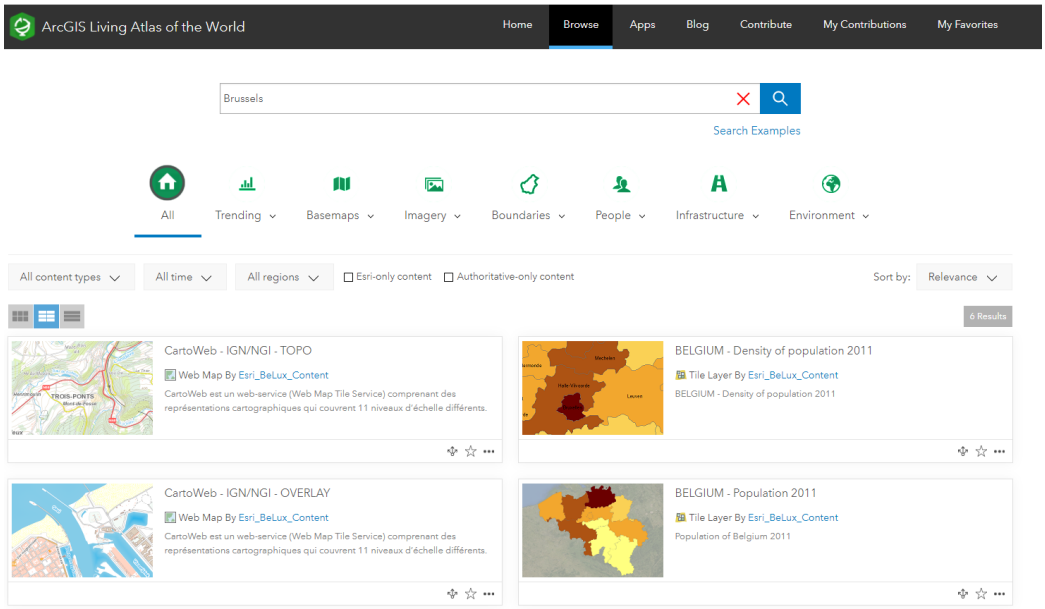
**Table 8** -Offering and users (private/non-profit)

| Project | Offering | Users |
|---|---|---|
| **Eurobird** | Web platform with near real-time data on bird migratory patterns in Europe. | Bird watchers (citizens), NGOs, public authorities, EU institutions |
| **Esri** | Data products and ArcGIS solutions. | Businesses, public authorities, citizens |
| **Seapilot** | Smartphone application with up-to-date digital nautical charts, weather forecast and social networking features. | Hobby boaters (citizens) |

Access to geospatial data across borders has been instrumental in these case studies' offerings, products, and services. By applying ecosystem thinking to some of the industry's most state-of-the-art solutions, Esri obtains and generates data across multiple geographies. According to the authors, this is an essential value of their business model and allows Esri to provide innovative data products covering a large spatio-temporal scope. For example, the Living Atlas, where customers and other third parties can share data and maps.

Seapilot uses nautical data to produce an application that facilitates hobby boating. The result of data collection from authorities across Europe is up-to-date digital maps with real-time forecasts for smartphones, allowing social boaters to navigate and connect at sea.

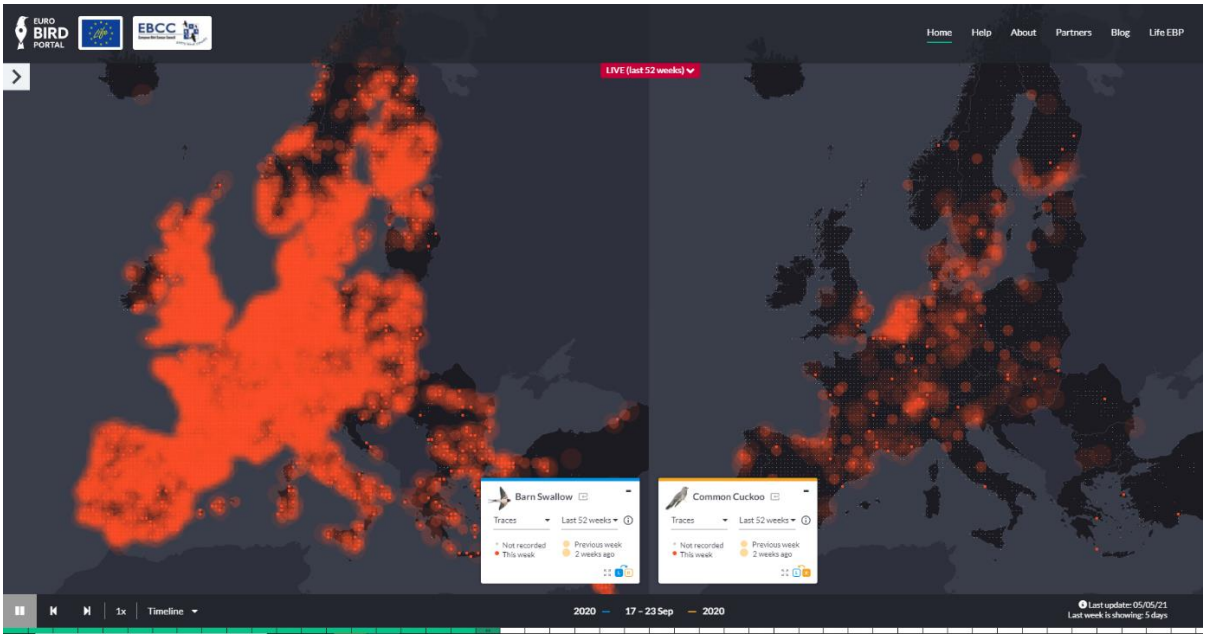
**Figure 6**: ArcGIS Living Atlas




**Source:** Esri

Lastly, Eurobird provides essential data for the overall natural preservation of birds in Europe. By collecting and delivering data in the Eurobird platform, their output is a dataset that offers new and powerful insights. These insights do not just inform bird watchers but are also vital for natural preservation and can feed into decision-making in the future.

**Figure 7**: Eurobird portal




**Source:** Eurobirdportal

In sum, the private sector's role in using and sharing geospatial data across borders is exploring new possibilities, finding innovative ways of collecting information, whether through volunteered information, creating own specifications, public-private partnerships, or establishing new ecosystems. The next chapter will focus on the challenges faced by both private sector and public sector actors.

# 3

# Current challenges of cross-borders data-sharing and data use in Europe


Photo by Edgar MORAN on Unsplash

The analytical framework of this study tackles five types of challenges: technical, economic, organisational, legal and other challenges. Each of these challenges to cross-border data-sharing between organisations can be understood as barriers to interoperability.

The ELISE glossary uses the revised version of the European Interoperability Framework (EIF) to define "**interoperability**":

> *Interoperability allows entities to exchange meaningful information electronically in ways that all parties understand. It addresses all layers that impact digital public services delivery in the EU and beyond, including legal, organisational, semantic, and technical aspects.*

Obstacles to the seamless exchange of information that all parties commonly understand across borders hinder interoperability. Consulted stakeholders mentioned that while INSPIRE data models and formats are helpful, and there has been immense progress in achieving increased interoperability over the past years, its implementation still lacks some interoperability aspects. For example, to further improve the usability and sustainability of SDIs, data attributes must be harmonised across borders. Moreover, for the future, overcoming challenges such as lack of funding, visibility, and findability is essential to ensure cross-border initiatives' sustainability.

**Table 9** - Key challenges[13]

| Case study | Economic challenges | Technical challenges | Organisational challenges[14] | Legal and political challenges |
|---|---|---|---|---|
| the Locator | Providing solutions to attract business to the cross-border region. | The difficulty in mapping, data access, maintaining updates and non-harmonisation of data remains a key cost of non-interoperability in the region and updates of datasets. | Linguistic differences amongst project partners is an obstacle to harmonisation. Such differences impact both organisational and technical aspects. | |
| Grande Region (SIG-GR) | Securing sufficient funding and sustainability. | Issue of non-harmonised data requiring time-consuming formatting. | Overcoming cultural challenges in data sharing. | Political efforts needed in putting cross-border data sharing on the agenda for reuse and to enable sustainability |

[13] These challenges are based on the authors' analysis and interpretation of the interviews, and should not be interpreted as the interviewees' direct opinion.

[14] including cultural and linguistic challenges

| Case study | Economic challenges | Technical challenges | Organisational challenges[14] | Legal and political challenges |
|---|---|---|---|---|
| FAIRway Danube | Challenge of ensuring continued and sustainable funding. | Lack of standards and harmonised open data sharing traditions across countries. Need for interoperability of system to support the logistics sector in the cross-border region. | Lack of shared open data traditions across countries. | Liability aspects of data sharing moving forward. |
| NordicSmartGovernment | [No data] | Setting up a system for data portability and facilitating data storage abroad. | Changing behaviours of private companies. | Legal barriers and legal interoperability are key challenges for public authorities to cooperate and share this kind of data across borders. |
| Esri | [No data] | [No data] | [No data] | [No data] |
| Seapilot | Disparity in public data pricing models. | Key challenge is data access, i.e. finding the right access points and obtaining data. | [No data] | Disparities in licensing models. |
| European Rail Agency (ERA) | [No data] | Obtaining data access from intermediaries. | Awareness-raising amongst the non-technical audience on the importance of creating an interoperable system. | [No data] |
| Eurobird | Economic sustainability in terms of long term funding. | [No data] | Challenges related to local capacity building. | [No data] |

*[No data]= nothing relevant mentioned by interviewee(s).[15]

The below sections provide examples of these challenges from the case studies.

[15] All interviewees were asked to describe challenges. As part of the data triangulation exercise, the mentioned challenges were grouped into categories. Blank cells mean that nothing was mentioned within this category, but does not necessarily mean challenges do not exist within the given category.

## 3.1 Technical and economic challenges related to collection, harmonisation, availability and sustainability of cross-border datasets

Three major trends stood out on an aggregate level regarding technical and economic challenges. First, among public and non-profit case studies, obtaining long-term and sustainable funding is crucial for cross-border (geospatial) data-sharing projects. Secondly, it was observed that obtaining data is a common challenge that is often related to data findability and/or availability. Lastly, a key technical challenge for all case studies is the non-harmonised formats of datasets obtained across borders.

### 3.1.1 Economic challenges

Economic challenges to the sharing and using of geospatial data across borders are observed in the non-profit, private and public sectors alike. They can be divided into two high-level themes – limited funding and high costs. On the one hand, a lack of sustainable funding can endanger the long-term viability of projects. On the other hand, high costs related to data and infrastructure can prevent both the initial development and scaling up of data-sharing endeavours. For the public and non-profit sector case studies, sustainable funding is the most prominent concern. In some cases, the financing of such projects strongly relies on their visibility and political and strategic importance. For example, in the case of Eurobird, the interviewee claimed that future funding for their platform would depend on its ability to provide value for policymakers at a European level.

Sharing and using cross-border geospatial data frequently has technical challenges (see 3.1.2) with economic implications. For instance, in the Locator case, the integration of different regional sources requires considerable effort. In some cases, regions are hesitant to invest due to these high initial costs. Even if the benefits eventually outweigh the costs[16], this may require a long-term horizon that not all investors are willing to take.

A related economic challenge is the cost of obtaining data. Pricing conditions may differ from country to country. They may cause a challenge for those who wish to enter new countries/regions. That is particularly challenging when, for example, information on access points, legal specifications and/or pricing is available only in the destination country's language. It may also be the case when a lack of knowledge of the local context and governance becomes restricting. The labour cost and the actual cost of obtaining data across borders may deter businesses and public sector actors from entering new geographies. In the case of Seapilot, negotiations regarding pricing and pricing models were experienced as highly fragmented and even unfair in certain instances. The interviewee urged hydrographic offices to provide fixed costs to contribute to more harmonised pricing models that could improve access to data for SMEs.

**Box 1-** Sustainable funding and the case of Eurobird

The development of the Eurobird platform was made possible through funding from the Commission and was crucial to setting up their automated collection tool.

The interviewees claimed that available grants, especially for conservation, are based on local application or action regarding challenges. Pan-European initiatives may not easily satisfy these criteria, and this issue can be exacerbated if they need funding every year. Therefore, a key challenge is finding the right funding and long-term support to ensure long term sustainability.

Moreover, at the local level (where data is collected), interviewees felt that it is often easier to receive funding for a new project than sustain an existing initiative. New tools get financing more easily. This is a problem for projects that require to be sustained for further innovation. Ensuring the integration of local data to their harmonised model largely depends on the local partners' capabilities. However, they see the critical need for the data they collect and provide and hope that this need will eventually result in long-term funding.

[16] As was the opinion of the interviewee for this case study.

Some data providers may rely on the data for their revenue. Changing the status quo for disparities in data pricing may be difficult in such cases. In the case of Eurobird, this challenge was solved by establishing partner agreements.

### 3.1.2 Technical challenges

Technical challenges to the cross-border sharing and use of geospatial data primarily relate to findability, accessibility, harmonisation, standards and interoperability. The **FAIR guiding principles** for data management describe the need to improve technical infrastructures, such as SDIs, to enable data sharing [35]. FAIR stands for *Findable, Accessible, Interoperable and Reusable*; four pre-requisites for data management. The technical challenges found in this study reflect the need to achieve these principles.

First, in four out of eight case studies, findability and accessibility were a central challenge, and stakeholders describe fragmented data provision as an obstacle to cross-border geospatial data sharing and use.[17] To identify data sources, an actor had to map all regions/countries involved to understand which information is available at which level and the relevant and competent authority. In several instances, public authorities' ability to provide accessible and functional data was lacking. For example, while expanding into new geographies, Seapilot experienced that data access points were different from country to country. In the workshop conducted in the framework of this study, the participants agreed that funding, visibility and findability of (geospatial) data portals are essential to ensure the sustainability of cross-border initiatives and address accessibility challenges.

It should be noted that there are diverging opinions on the findability and accessibility of data from public authorities. Some stakeholders (end-users and those from the private sector) argue that data is hard to find and that the Member States do not publish data to a satisfactory extent. However, Member State representatives do not necessarily share this opinion. The argument made by certain national data providers is that while national geoportals are up-to-date, the transnational infrastructures are "too complex", making it challenging for data providers to integrate their data. As a result, it deters data providers from making their data more readily available in a cross-border context[18].

> **Box 2-** Findability and accessibility: SME Seapilot's experience in expanding into new Member
>
> Seapilot found it challenging to grow its coverage beyond Sweden, Finland, Denmark and Norway, as they perceived the conditions beyond the Nordic countries to be difficult in terms of data access.
>
> When problems occurred, SOLVIT (an EU service that "*reminds the authorities in question what your EU rights are and works with them to solve your problem*") helped Seapilot communicate to national authorities that they had to share data. In some instances, assistance was also requested from the Commission.
>
> Such assistance provided good leverage for future endeavours into the new Member States, as it supported their discussions with national hydrographic offices.
>
> The process of obtaining licences is described as having been time-consuming and lengthy. Seapilot entered into new countries one by one and set priorities concerning the market situation (i.e. the number of pleasure crafts per country).
>
> The process to access and/ or purchasing data is described as very different for each country. Moreover, legal agreement types are very varied, so the data access been granted ranging from web portals to Compact Discs.

Second, the lack of harmonisation and interoperability concerning widely recognised and applied standards constitute a challenge to sharing geospatial data across borders. In SIG-GR, FAIRway Danube and the Locator, the non-harmonisation of datasets across regions meant that they had to invest significantly in harmonisation and data cleaning. This also posed a challenge with maintaining the data and providing updates

[17] Opinion reflected in workshop discussions and interviews.
[18] Opinions reflected in workshop discussions.

in terms of achieving location interoperability, establishing a consistent and coherent technical approach between cooperating organisations is key to using the collected data.

Third, new and innovative methods have been explored in instances where there is a lack of supporting technical infrastructure to collect and share data. For example, the European Railway Agency's linked data pilot aims to counter the challenges of non-harmonised data, lack of standards and the cost of non-interoperability. This is done by "linking data", applying the Linked Data design principles for sharing machine-readable data on the Web for its use by public administrations, businesses and citizens. In the case of Eurobird, the initiative created its own specification accepted and applied by all stakeholders and volunteers, enabling the project to invest minimally in data cleaning.

Stakeholders participating in the study workshop also described edge matching procedures as necessary to incorporate into cross-border data production. As the need for consistent and coherent location data for cross-border use increases, resolving issues of formats and standards is essential. Edge-matching can help matching correspondent features from multiple sources and countries and establish links. Edge-matching can therefore be an impactful tool to resolve cross-border technical challenges.

## 3.2 Organisational, legal and political challenges related to collection, harmonisation, collaboration and sustainability of projects

Organisational and legal challenges can occur when managing a network of stakeholders across geographies (areas they operate) and jurisdictions. From an organisational perspective, managing partnerships composed of organisations from different countries can be challenging. In addition, legal obstacles include those related to licensing and legal interoperability between countries. The below section explores the main organisational and legal challenges raised by stakeholders.

### 3.2.1 Organisational challenges

Organisational challenges can arise, for example, when sharing and using data from multiple sources and geographies. When sharing data and achieving location interoperability, some key challenges relate to managing diverse ecosystems/partnerships. Specifically, this may be challenging when ecosystems and partnerships consist of participants who apply different standards, formats, languages, or other factors.

First, when managing a large network of partners and stakeholders across borders, raising awareness and building capacity can be challenging. For example, the Eurobird platform depends on an extensive network of volunteers in all Member States, comprising NGOs and private citizens across Europe. Reaching local volunteers can be challenging in cross-border projects. These volunteers operate through their local NGOs and may be hard to reach directly. All process steps from data collection, harmonisation, and integration must be streamlined and communicated to the local NGOs to provide a continuously updated platform in near real-time. The unique asset of the Eurobird platform is its volunteer-driven approach. Therefore, building capacity, motivating and raising awareness amongst local volunteers is essential.

A similar challenge is observed for the ERA pilot project. Raising awareness of the importance of linked data in transport to stakeholders with a non-technical background has been a significant challenge. It is essential to find ways to communicate its importance, value, and function to all stakeholders to optimise solutions that support interoperability.

Lastly and relatedly, differences in the culture of sharing data may occur when working in a cross-border context. Changing behaviours is an important organisational challenge in moving towards an open data culture and freely sharing data across borders. In the *NordicSmartGovernment* case, overcoming traditional sharing business data is a prerequisite to implementing a package of interoperable digital solutions. To achieve this, *NordicSmartGovernment* foresees the need to dedicate efforts towards incentivising business owners. In this case, the business owners are the data providers who will need to transition from the current systems, standards and data formats to provide their data in new formats and standards. This change of habits and processes may pose a challenge in the implementation phase.

**Box 3 -** Organisational necessities and the case of SIG-GR

For SIG-GR, the first step of a cross-border project is to ensure the necessary financing is secured at the national level, including for the period after the initial EU funded project ends.

The key element needed to achieve this is the appropriate partners on board to ensure continuity, demonstrate added value and share advancements and application areas.

SIG-GR is active in two large networks where many cross-border observatories participate in supporting its ecosystem of partners. These are important structures to communicate the need for comparable data towards higher decision making.

The case study emphasised the key importance of reuse, mainly when users are increasingly accustomed to quick access to data. It is key to have a network of partners with a similar knowledge basis and administrative procedures. It was stated that politically speaking, the "cross-border" aspect is never truly a priority. For this reason, it is even more important to involve decision-makers to the greatest extent possible. A solid and transparent ecosystem of partners is necessary to achieve this. The interviewee further explained that a lack of transparency should be avoided, especially when partners are not fully informed. He advised projects not to try to work too narrowly in one area but rather perform work linked to multiple issues and ensure that overlaps are exploited. The more one understands interdependencies, the more value the project can bring.

### 3.2.2 Legal and political challenges

When analysing legal challenges, two topics were particularly prominent: licensing/rights to use and data portability, including privacy issues. Facilitating cross-border sharing and use of geospatial data requires an enabling legal environment combined with recognising strategic importance and the political will to attain it.

First, licensing was mentioned by stakeholders as a significant legal challenge.[19] Certain stakeholders consider obtaining licensing costly, time-consuming, and cumbersome, discouraging them from pursuing cross-border projects and initiatives. Disparities in licensing models between countries and data providers are mainly causing this issue. Stakeholders highlighted that it might be beneficial to harmonise such schemes and provide accessible information on the pricing models linked to such licences. Appropriate licensing is vital to allow for reuse understanding clearly the rights to use the data resources. The Open Data Directive [36] sets out certain obligations such as making information reusable, charging no more than marginal cost, and publishing licences in digital formats. However, the actual licensing model applied varies according to data providers, data type and the organisational culture of data sharing [37]. Licensing requirements can also limit the distribution of outputs of cross-border projects to the public. For example, in the SIG-GR project, some datasets were restricted to the public due to third party licensing agreement requirements. Second, data portability is a legal challenge that may increase in importance as volumes of personal data increase, including cross-border contexts.

> Data portability is described in Art 20 of GDPR [9]: *"The data subject shall have the right to receive the personal data concerning him or her, which he or she has provided to a controller, in a structured, commonly used and machine-readable format and have the right to transmit those data to another controller without hindrance from the controller to which the personal data have been provided (..)"*

[19] Opinion reflected in workshop discussions and interviews.

Data portability will become increasingly important as digital solutions modernise and emphasis is placed on ensuring the interoperability of systems across borders. Currently, the development of codes of conduct on data portability between IT environments is encouraged by Regulation (EU) 2018/1807 [7]. *NordicSmartGovernment* emphasised the need to find solutions to strengthen legal requirements related to data portability to improve the cross-border exchange of business data in the Nordic countries. Moreover, *NordicSmartGovernment* emphasised that legal interoperability will be of significant importance in the future as cross-border data sharing and use are fostering innovative approaches in cross-border areas. Ensuring a legal landscape that encourages and enables new cross-border digital solutions in the Nordic countries will be essential for the success of *NordicSmartGovernment* and other similar initiatives.

# 4

# Benefits and lessons learned from sharing data across borders

Photo by Anna Go on Unsplash

## 4.1 Key benefits

The key benefits found in the case studies were new services, improved services, improved access to information, economic benefits and improved cross-border collaboration. Please consult the table below to overview the key benefits identified in the case studies.

**Table 10** - Key benefits

| Key benefits[20] | FAIRway | SIG-GR | Locator | NSG | ERA | Eurobird | Seapilot | Esri |
|---|---|---|---|---|---|---|---|---|
| **New services** | | | | | | ✓ | ✓ | ✓ |
| **Improved services** | ✓ | ✓ | | ✓ | ✓ | | | ✓ |
| **Improved access to information** | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| **Improved cross-border collaboration** | ✓ | ✓ | ✓ | ✓ | | ✓ | | |
| **Economic benefits** | ✓ | ✓ | ✓ | ✓ | | | ✓ | ✓ |

The following elements were highlighted when consulting the stakeholders working in a cross-border context:

- New and improved services are made possible by accessing and using data from across borders. All stakeholders consulted reported new and/or improved services being created as part of their cross-border activity. In cross-border regions, the collection and integration of cross-border data resulted in improved river navigation services (FAIRway) and spatial planning (SIG-GR). New applications (Seapilot), platforms (Eurobird) and data products (Esri) were developed based on the cross-border data.
- Improved access to information has been a key motivator and benefit resulting from cross-border data sharing initiatives. This access can be particularly beneficial in cross-border regions where information sharing may be essential for planning, navigation or attracting business. Improved access to information is also necessary for creating value for customers in the private sector case studies. For example, Esri has built a successful international business by providing access to local, regional, and global data across borders.
- In the European context, cross-border projects and initiatives improve collaboration between partners and stakeholders. For the public sector, improved collaboration and an enlarged data sharing ecosystem enable better access to information.
- Better access to data improves decision-making and the ability to innovate. The latter is also true for the private sector, where access to data is increasingly important to enter new markets. Importantly, cross-border collaboration may result in lasting partnerships and continued data collection and production across borders, paving the way for future innovation in products and services.
- There are significant economic benefits to sharing and using geospatial data across borders. Some stakeholders pointed to their improved ability to innovate and bring new products and services to the public; others pointed towards the increased return to investment when geospatial data is exploited.

[20] Kindly note that this list and categorisation is non-exhaustive, and only reflects the authors' analysis of key findings from the case studies.

— It should be emphasised that the cross-border use and sharing of data are essential for the existence of the case studies examined. For this reason and to materialise the benefits mentioned above, creating an enabling environment and infrastructures in Europe for cross-border sharing of data is of great importance.

## 4.2 Lessons learned for Spatial Data Infrastructures

The case studies developed have revealed that numerous successful projects rely in whole or partly upon cross-border sharing of location data.

This study has explored the current state of play of sharing geospatial data across borders in eight case studies. These case studies have shown some substantial benefits of cross-border data sharing activities. Such benefits include improved collaboration, economic gains, improved access to information, new and improved services. However, as explored in this study, particular challenges and obstacles currently impact such cross-border activities. Especially prominent is the need to ensure sustainable funding, the cost of obtaining and accessing data, interoperability, harmonisation and licensing, and address organisational challenges related to establishing a sustainable ecosystem with a culture of sharing data.

In particular, the development of projects relying on cross-border sharing and use of data is hindered due to the constraints imposed by a lack of interoperability between organisations and projects situated across national borders. These interoperability challenges can be broken down into legal, organisational, semantic, and technical aspects.

As can be extracted from the challenges section above, some of the most persistent and wide-ranging challenges relate to the technical and semantical challenges. For example, cross-border projects currently have to invest heavily in time and resources to harmonise and clean data. Different data formats and standards applied across countries and geographies create obstacles to engage in cross-border data sharing. Regarding the organisational and legal aspects, disparities in licensing models, data sharing culture and languages can challenge establishing a sustainable ecosystem to share data across borders.

By understanding the current state of play, lessons learned to support the evolution of SDIs can be drawn. As already mentioned, SDIs are "*a framework of policies, institutional arrangements, technologies, data, and people that enable the effective sharing and use of geographic information*" [Bernard et al, 2005]. The below section shows some lessons learned to improve such framework policies, institutional arrangements, technologies, data, and people to support SDIs for data sharing across borders. The case study analysis reported above has implications for each of these aspects.

### 4.2.1 Policy and institutional arrangements

Regarding policies and institutional arrangements, it was found that EU policy can be an enabler specifically by providing clear use cases, funding opportunities, visibility to local and national initiatives and ensuring smooth data sharing (via, i.e. EU Data spaces).[21] More specifically, the following elements were mentioned by stakeholders to moving forward:

— Ensure policy and strategic direction to tackle cross-border issues and challenges. The INSPIRE Directive already provides a solid basis, but more can be done to lay down sound building blocks for open and harmonised data sharing;

— Ensure coherence of policy initiatives around data sharing, supporting the once-only principle and aligning instruments at a European level. In the field of transport, data sharing is legislated through many instruments (most notably the Open Data Directive, the Intelligent Transport Systems Directive and the INSPIRE Directive), leading to potential different interpretations and applications in practice. This may complicate efforts to achieve improved interoperability.

— Complement national policy goals. Notably by supporting the implementation of INSPIRE at the national level through funding and support of longer-term cross-border data exchange initiatives, but also by

[21] Opinion expressed by stakeholders during the validation workshop.

encouraging the sharing data between actors at the regional and local level where resources and use cases for data sharing may be limited;

— Facilitate and enable organisations to collect and share data across Europe. This can be done by harmonising aspects related to data licensing, which are significantly heterogeneous across the Member States. Moreover, harmonising semantic issues and focusing on data usability can help provide a clear governance structure for data sharing.

— Prepare the move from "Spatial Data Infrastructures" to "Data Infrastructures". Increasingly, location data is not analysed in isolation, and its value is in its combination with other forms of data. In this regard, one of UN-GGIM: Europe goals is to help to integrate geospatial data with others based on user needs and requirements [38].

> ***Lesson 1:*** *SDIs should have a holistic focus to support access to location data across borders*
>
> SDIs should address not only technical challenges but also legal, organisational and institutional challenges to sharing geospatial data at local, regional, national and EU levels. In addition, efforts should be made to integrate geospatial data with other forms of data. The development of future European data spaces could be used as a central focus for this effort.

### 4.2.2 Technology and innovation

Technology and innovation are essential in supporting the effective usage of geospatial data across borders. SDIs include providing infrastructure to support data sharing and reuse data from new and diverse data sources. Progress in the field can be supported by the latest trends and technologies such as AI, citizen science and more. Also connecting SDIs with other core registers and interoperable frameworks and merging them in open data catalogues and INSPIRE. In addition, stakeholders point to the unprecedented scaling of applications during the COVID-19 crisis and its quick delivery to the market. The latter proves the potential and necessity for infrastructures supporting cross-border sharing of geospatial data.

More specifically, the following elements were mentioned by stakeholders as being of importance in moving forward:

— Technology can impact the harmonisation of semantic aspects to ensure compatibility in different countries. According to stakeholders, the most impactful technological trends in cross-border data sharing are artificial intelligence and citizen science[22]. Technological developments in AI coupled with increased reliance on crowdsourced data opens new business opportunities. In this context, stakeholders consulted in the framework of this study said that even though spatial data is increasingly available and affordable (due in large part to cloud and webGIS), applications for even more specific needs and domains would be useful.

— Citizen science is a trend that brings about new opportunities to collect data, derive new insights and enlarge data ecosystems. Stakeholders claim that citizen science should be incorporated to a larger extent into overall data collection exercises. It could fill gaps in data and further facilitate data availability.[23] However, citizen science projects can come with their own sets of challenges, such as data validation. As explored in the case of Eurobird, an extensive network of volunteers across the Member States requires close coordination. Supporting policies are seen as instrumental in enhancing this development.

— Artificial intelligence and, more specifically, machine learning and deep learning are foreseen to significantly improve both cross-border data collection and quality in the future. Two of the case studies,

[22] Opinion drawn from the validation workshop of this study. Interactive polling was performed in order to determine which technological trends are perceived as most impactful in their context: Artificial intelligence (+ML, DL) (9/14); Citizen Science (9/14).

[23] Opinion drawn from the validation workshop of this study.

Esri and Seapilot, pointed towards AI as creating new and powerful new solutions for business opportunities in location intelligence.

— The technical hurdles to sharing and using data across borders result in technological innovation to overcome them. Participants in cross-border projects explore new and innovative solutions, such as linked data for interoperable systems, new standards, and the use of non-traditional data sources.

> **Lesson 2:** Technology and innovation supports a Europe fit for the Digital Age
>
> Approaches making use of new technology (e.g. artificial intelligence, machine learning and blockchain), data sources (e.g. citizen science, citizen-generated data) and innovative techniques i.e. linked data, the proliferation of Service Level Agreements (SLA), Application Programming Interfaces (APIs) are being employed. They will have an increasing impact on the facilitation of sharing and using cross-border data. The uptake of such technologies and innovative approaches can support SDIs in automating and facilitating the collection, enrichment, validation, and integration of new data sources.

This study has found that additional attention should be focused on implementing the FAIR principles [35] [24] to support access to geospatial data. Meanwhile, difficulties in obtaining data and differences in language and terminologies were pointed out as issues hindering the cross-border use of data.

Stakeholders mentioned that while INSPIRE formats are useful and there has been immense progress in the past years, in many cases, data models and guidance are still lacking, which are necessary to ensure interoperability.

Moreover, it was observed that stakeholders generally did not speak of interoperability in the broader sense of the word, i.e. covering legal, organisational, semantic and technical aspects. They instead tended to focus on semantic and technical issues. While this may, in part, reflect the ongoing challenges in these areas, it could in part indicate the need for an increased focus on both legal and organisational interoperability. This should particularly be considered in the light of stakeholder complaints regarding the over-complexity of current SDIs. As one stakeholder pointed out, there is a need to ensure "interoperability by design."

> **Lesson 3:** Access to data can be improved through harmonised and interoperable solutions
>
> Access to geospatial data remains the key driver of cross-border project and initiatives. However, challenges remain, especially from the user perspective. There is a need to raise further awareness on the *FAIR principles* (*Findable, Accessible, Interoperable and Reusable* data) as well as providing practical guidance and tools that can support the re-use of the data.

[24] Opinion expressed by stakeholders during the validation workshop for this study.

### 4.2.3 People

It is essential to consider the approach to facilitate data-sharing amongst different organisations and/or institutions in a cross-border context. Ecosystems thinking, referring to a tool to help ecosystems of actors continue to evolve, is crucial to ensure that a given data ecosystem remains self-sustainable in the long term [39].

Those with experience working in cross-border contexts report that despite specific barriers in the initial phases, such collaborations can be highly fruitful in technical, organisational and economic terms. New innovative approaches are co-designed. It sets the foundation for future collaboration, can help inform cross-border policy and support business models. Moreover, stakeholders reported the importance of feedback loops to incentivise public-private partnerships, e.g., private sector companies who use public sector data to re-share the result of their processing/interpretation of the original data.

Another key outcome is capacity building and fostering data sharing and collection skills. Increased knowledge of why and how data can be used, shared, and reused in an interoperable way supports the future for SDIs. For example, in the case of Eurobird, local volunteers across Europe provide harmonised data that feeds into the platform.

> **Lesson 4:** People are at the centre of the digital transformation – long-term benefits come from cross-border partnerships and ecosystems thinking
>
> Building sustainable partnerships, broader ecosystems and adopting collaborative approaches are essential to SDIs. From the case studies, it is evident that while there may be barriers to enlarging a data ecosystem and building new partnerships, the benefits experienced far outweigh the initial costs. By adopting ecosystem approaches, stakeholders can obtain higher volumes and more diverse data sources while establishing long-term partnerships and innovative approaches.

Above mentioned four lessons and the supporting evidence from the case studies are summarised in **Table 11**.

**Table 11** - key lessons learned from case studies

| | |
|---|---|
| **Lesson 1:** SDIs should have a holistic focus to support access to location data across borders<br><br>SDIs should address not only technical challenges but also legal, organisational and institutional challenges to sharing geospatial data at local, regional, national and EU levels. In addition, efforts should be made to integrate geospatial data with other forms of data. The development of future European data spaces could be used as a central focus for this effort. | |
| Grande-Region (SIG-GR) | The first step is to ensure one has the necessary financing at the national level and not forget about the time after the initial EU funded project ends. It was said that politically speaking, cross-border has never been so far a priority. This is why it is even more important to involve decision-makers to the greatest extent possible. |
| NordicSmartGovernment | There is a need for strategic importance and a dedicated interest to collaborate across countries. It has to be beneficial, and not simply marginal, because then authorities and private industry alike will invest neither time nor interest. |
| Seapilot | The legal aspects require that you are pragmatic. The conditions should be the same for all businesses (mostly the case in European countries). Understanding conditions for pricing is the most important. |

| | |
|---|---|
| European Railway Agency | It was emphasised that cross-border data sharing is indeed increasing. To play fair and give opportunities to all actors, there is a need for institutions to adopt a strategic direction and raise awareness and facilitate information exchange. |

**Lesson 2:** Technology and innovation supports a Europe fit for the Digital Age

Approaches making use of new technology (e.g. artificial intelligence, machine learning and blockchain), data sources (e.g. citizen science, citizen-generated data) and innovative techniques i.e. linked data, the proliferation of Service Level Agreements (SLA), Application Programming Interfaces (APIs) are being employed. They will have an increasing impact on the facilitation of sharing and using cross-border data. The uptake of such technologies and innovative approaches can support SDIs in automating and facilitating the collection, enrichment, validation, and integration of new data sources.

| | |
|---|---|
| Esri | The interviewees (representing a global company) did not reduce the message to any key learnings. However, the importance of exploiting new and innovative technologies, data sources and ecosystems was highlighted as key aspects for success. |

**Lesson 3:** Access to data can be improved through harmonised and interoperable solutions

Access to geospatial data remains the key driver of cross-border project and initiatives. However, challenges remain, especially from the user perspective. There is a need to raise further awareness on the *FAIR principles* (*Findable, Accessible, Interoperable and Reusable* data) as well as providing practical guidance and tools that can support the re-use of the data.

| | |
|---|---|
| the Locator | It takes time to build common solutions, but this really makes sense as it adds value to all partners. Integrating different regional sources needs efforts. In some cases, authorities may hesitate to invest due to these high initial costs. However, in the end, the benefits compensate the costs. |
| Grande Region (SIG-GR) | You need the appropriate partners on board to ensure continuity, demonstrate added value, and share advancements and application areas. It is crucial to think about reuse, especially when people are used to easy and fast access to data. |
| Seapilot | A lesson learned is to be patient and stubborn and not to take "no" for a "no". According to the interviewee, hydrographic offices are traditional, and some belong to the national navies, which generally makes accessing data more administratively burdensome. |
| Eurobird | The partners have clear autonomous responsibility and direction to work in the same direction. Eurobird is set up to give them the responsibility to choose which data is relevant to share in their national/regional/local context. The success formula, in their opinion, is the decentralised approach to collecting data. |

**Lesson 4:** People are at the centre of the digital transformation – long-term benefits come from cross-border partnerships and ecosystems thinking

Building sustainable partnerships, broader ecosystems and adopting collaborative approaches are essential to SDIs. From the case studies, it is evident that while there may be barriers to enlarging a data ecosystem and building new partnerships, the benefits experienced far outweigh the initial costs. By adopting ecosystem approaches, stakeholders can obtain higher volumes and more diverse data sources while establishing long-term partnerships and innovative approaches.

| | |
|---|---|
| the Locator | Despite certain barriers to working together, especially language barriers, working together and getting to know each other in cross-border regions is beneficial. There is much more to learn than anything else. |
| Grande Region (SIG-GR) | It is mentioned as key to the success of a cross-border project to have a network of partners with a similar knowledge basis, also concerning administrative procedures. |

| | |
|---|---|
| FAIRway Danube | One of the most important outcomes achieved by the project is the high level of inter-cooperation between the Danube countries. All have different sets of strengths and weaknesses. The project is serving as a learning opportunity and creating a positive spirit that is moving things forward. |
| Eurobird | A best practice highlighted by the interviewees is that they set the rules of collaboration from the beginning. They have agreements with all partners of the European Bird Census Council. Partners have specific agreements for the Eurobird platform so that they know how to collaborate. |
| Esri | Esri's living atlas consists of a comprehensive ecosystem of data users and providers exchanging data. New ways of interactively sharing and enriching data provide added value to their business model. |

# 5

# Conclusions


Photo by Eric Weber on Unsplash

This study has provided evidence regarding the current state of play in sharing and re-using geospatial data by examining literature, eight case studies from the private, public and non-profit sectors and a dedicated workshop. Across all public, private and non-profit case studies, the analysed projects improved access to location information. The majority (6/8) reported on either direct or indirect economic benefits. For the public sector and non-profit case studies, improved cross-border collaboration was the main benefit. For the private sector case studies, the provision of new services based on cross-border geospatial data was considered a key outcome. In other words, cross-border sharing of geospatial data generates gains and benefits. However, it was found that despite these benefits, the sharing and use of cross-border data still involve significant challenges which hamper the stakeholders' efforts to scale up their projects. Some of these challenges are the need to ensure sustainable funding, the cost of obtaining and accessing data, barriers to interoperability, lack of harmonisation of licensing and other practices, and organisational challenges related to establishing sustainable ecosystems with a culture of sharing data. Some challenges on data portability and data privacy emerged in some case studies; these should be further investigated in upcoming studies. An additional challenge is that cross-border data sharing is rarely considered a political priority. Therefore, it is necessary to convince decision-makers to prioritise it, alongside the capacity-building to enable this. A solid and transparent ecosystem of partners is needed to achieve this. All of these challenges to cross-border data sharing constitute costs of non-interoperability. However, progress has been made. The case studies show how cross-border projects improve technical conditions in cross-border regions by exploring new and innovative solutions. Such solutions include, for example, the use of linked data for interoperable systems, the creation of new specifications, and the exploitation of new and less traditional data sources. Moreover, the COVID pandemic has shown how cross-border geospatial data sharing solutions can be scaled and deployed quickly when the demand is imminent.[25]As explored in this study, the current cost of non-interoperability is a significant burden on stakeholders. For example, cross-border stakeholders currently invest heavily in data harmonisation and even building infrastructures and specifications from scratch. SDIs provide the infrastructure enabling cross-border geospatial data sharing. Therefore, efforts to develop more effective SDIs can reduce these investment costs and challenges for stakeholders.

Regarding the future evolution of SDIs, some stakeholders expressed the view that it may be time to move from Spatial Data Infrastructures to simply “Data Infrastructures”. Geospatial data is no longer necessarily analysed in isolation, so infrastructures should support location and other data. This further underpins the need for cross-border and multi-stakeholder ecosystems and data spaces to fuel the evolution of data infrastructures. With this in mind, four key lessons have been drawn to support SDIs in the future.

- First, there is a need to support a holistic approach to supporting access to cross-border geospatial data. Not only technical challenges but also legal, organisational and institutional challenges must be addressed.
- Second, new technologies and techniques are being employed to facilitate the sharing and use of cross-border data. The uptake of technologies such as Artificial intelligence can support the SDIs in automating and easing collection, sharing, using and reusing data, and integrating new data sources as citizen-generated data, now and in the future.
- Third, additional work is needed to provide access to geospatial data that meets the FAIR principles, including the provision of practical guidance and tools to support the re-use of data.
- Last, building sustainable ecosystems and adopting collaborative approaches is essential to SDIs. From the case studies, it was evident that despite barriers to enlarging data ecosystems and building new partnerships, the benefits experienced far outweigh the initial costs.

Europe faces a variety of challenges that are cross-border in nature, including most notably a range of environmental issues. Cross-border data covering the entirety of the EU are a central part of an effective response to these challenges. In the geospatial domain, this, in turn, requires the modernisation of SDIs. This study has suggested several ways in which such modernisation can be pursued. Future research should focus on how SDIs should fit into and ensure interoperability with European Data Spaces focused on different domains in light of current European priorities.

[25] See for example the John Hopkins’ COVID 19 dashboard, at: https://coronavirus.jhu.edu/map.html

# 6

# Annexes

Photo by Mariah HewinAes on Unsplash

# Annex 1. Overall methodology

### *Framework*

The study approach is based on a methodological framework that provides the foundation for the work and enables a structured analysis.

Establishing a detailed methodological framework is beneficial to set out the key questions to be answered, the information needed and how to obtain it. The starting point building upon the main research question and establishing second-level and third-level sub-questions as stated below.

**Research question:**

What is the current state of play on sharing and using (geospatial) data across European borders and what can we learn from these practices to support the evolution of Spatial Data Infrastructures (SDIs)?

**Second level research questions**:

Q.1: What are the key enablers for sharing geospatial data across borders?

Q.2: What are the key obstacles for sharing geospatial data across borders?

Q3: What is the role of public and private sector for sharing geospatial data across borders?

The framework serves as an overview of data needs for the data collection phase, whereby gaps can quickly be identified. The drawback of establishing a detailed methodological framework in advance is that it may limit flexibility to investigate new angles or issues as they emerge during the research. As one obtains more information, the understanding of the key issues at stake and information needs may change. A flexible approach should be adopted in these instances, where information can be added and sub-questions and indicators adapted.

**Table 12** - Methodological framework

| Second level research Question | Third level research question | Indicators | Sources of information |
|---|---|---|---|
| **Q.1: What are the key enablers for sharing geospatial data across borders?** | SQ.1.1 What are the relevant processes that underpin and enable the sharing/use of data across borders? | *Interviewee information/perception on:*<br>• Technical, legal and organisational processes applied<br>• (the magnitude of) benefits associated with sharing data across borders | • Desk research and literature review, including:<br>▪ European Commission website, particularly:<br>▪ INSPIRE Directive<br>▪ PSI and Open Data Directive<br>▪ Copernicus<br>▪ IoT and citizen science<br>▪ FAIR Principles<br>▪ GDPR<br>▪ Other sources, i.e. Eurogeographics and related studies such as the Open ELS study and the study on the role of SDIs for Digital Government Transformation.<br>• Semi-Structured interviews |
| | SQ.1.2 What is the impact of GDPR, INSPIRE Directive, PSI and Open data Directive in enabling data sharing across borders? | *Interviewee perspectives on:*<br>• The EU policy environment as an enabling factor to sharing data. | |
| | SQ.1.3 What is the impact of Copernicus in enabling data sharing across borders? | *Interviewee perceptions on:*<br>• The role of Copernicus<br>• Earth Observation data as an enabler for the relevant project | |
| | SQ.1.4 What is the impact of IoT, citizen science in enabling data sharing across borders? | *Interviewee perceptions on:*<br>• Relevance and impact of IoT and citizen science in enabling data sharing | |
| | SQ.1.5. What is the impact of the FAIR principles (findable, comparable, accessible or affordable) in enabling data sharing across borders? | *Interviewee perceptions on:*<br>• The availability of findable and comparable cross-border data<br>• Completeness of data quality<br>• Availability and affordability of licenses that offer service level agreement | |
| | SQ.1.6 How should the cross-border data-sharing be to enable data-driven innovation? | *Interviewee perceptions and mention of:*<br>• New approaches to using and share data across borders enabling better policy design and/or service delivery | |

| Second level research Question | Third level research question | Indicators | Sources of information |
|---|---|---|---|
| | | • New approaches to use and share data across borders enabling better service delivery.<br>• Potential benefits of interoperability efforts necessary for sharing data across borders | |
| | SQ.1.7 How raw data vs services (on top of the data) impact in enabling data sharing and use across borders? Are services (on top of the data) such as API fostering the reuse of cross-border data? | *Interviewee opinion on:*<br>• whether their project/initiative, moving beyond raw data, fosters reuse of data or not | |
| **Q.2: What are the key obstacles for sharing geospatial data across borders?** | SQ.2.1 What are the aspects that current SDI's need to look at/ modify to allow better data access and sharing across borders? | *Interviewee information and perception related to:*<br>• Legal, organisational, economic and technical challenges encountered<br>• (the magnitude of) costs associated with data sharing across borders<br>• How to address such challenges | • Desk research and literature review, including:<br>▪ European Commission website, particularly:<br>▪ INSPIRE Directive<br>▪ PSI and Open Data Directive<br>▪ Copernicus<br>▪ IoT and citizen science<br>▪ FAIR Principles<br>▪ GDPR<br>▪ Other sources, i.e. Eurogeographics and related studies such as the Open ELS study and the study on the role of SDIs for Digital Government Transformation.<br>• Semi-Structured interviews |
| | SQ.2.2 What is the impact of the INSPIRE Directive, PSI, Open data Directive and GDPR in hindering data sharing across borders? | *Interviewee perspectives on:*<br>• Potential obstacles in the EU policy environment to sharing data across borders | |
| | SQ.2.3 How does the availability or lack of "high quality" data impacts in hindering data sharing across borders? | *Interviewee perceptions on:*<br>• Availability of relevant, high-quality datasets<br>• Its impact on the ability to share data across borders | |
| | SQ.2.4 What are the potential blocking factors for developing cross-border services? | *Interviewee assessment of most impactful challenge experienced, especially pertaining to:*<br>• Potential lack of legal, technical administrative and organisational framework conditions to develop cross-border services<br>• Potential budgetary restrictions to develop cross-border services | |

| Second level research Question | Third level research question | Indicators | Sources of information |
|---|---|---|---|
| **Q3: What is the role of the public and private sector in sharing geospatial data across borders?** | SQ.3.1 How important is it to have a trusted environment for sharing and analysing data? | *Interviewee perceptions of:*<br>• The importance of a trusted environment | • Desk research and literature review, including:<br>▪ European Commission website, particularly:<br>▪ INSPIRE Directive<br>▪ PSI and Open Data Directive<br>▪ Copernicus<br>▪ IoT and citizen science<br>▪ FAIR Principles<br>▪ GDPR<br>▪ Other sources, i.e. Eurogeographics and related studies such as the Open ELS study and the study on the role of SDIs for Digital Government Transformation.<br>• Semi-Structured interviews |
| | SQ.3.2 How and in what context do public and private organisations exchange data in cross-border scenarios? | *Interviewee information on:*<br>• *Collaboration between public and private actors in their relevant project/initiative*<br>• *In which context such potential collaboration occurs* | |
| | SQ.3.3 Would a European Data market help enabling data-driven innovation? How could cross-border data sharing/will look like in 5 years? How should the future European data spaces be to allow for better cross-border data sharing and use? | *Interviewees' views/ perceptions on:*<br>• *Potential enabling factors of the European Data market*<br>• *How this may look and play out in the future to allow for better cross-border data sharing and use* | |
| | SQ.3.4 Would the availability of pan European datasets help in enabling data-driven innovation? Would the availability of pan-European datasets help in expanding – scaling to other EU- countries? | *Interviewees' views/ perceptions on:*<br>• The benefits of pan-European datasets<br>• Their potential role in enabling better policy design and service delivery | |
| | SQ.3.5 Are there specific standards or specification that support best the exchange and use of data in cross-border scenarios? | • Mapping of standards and specifications mentioned by interviewees<br>• Interviewees' perceptions on whether such standards support the objective of sharing and using data across borders | |
| | SQ.3.6 Do third party sources such as Google Maps, OpenStreetMap, others… bring more added value compared to other sources? If so, which ones? | *Interviewees' views/perceptions on:*<br>• Whether third party sources bring added value<br>• Mention of specific third party sources engaged with or exploited as part of the project/initiative | |

Afterwards, **the mapping indicators** for case studies were selected. There was a need to obtain a comprehensive representation within a limited number of case studies. In this context, the study team decided to emphasise the diversity of domain, geographical scope and ownership. To encompass this, the following indicators were established for the first mapping exercise of potential case studies:

- Ownership (public, private, non-profit)
- Domain
- Actor(s) involved
- Business model
- Geographical scope
- Datasets/services/apps
- Purpose
- Contact information

The **selection of case studies** was made in the following way. Initially, the study team developed a first mapping of relevant projects from various fields based on the above indicators. For all initiatives included in the mapping, the project/company/organisation in question had to work with location data across borders or in multiple European countries. In other words, the study spans beyond projects/companies operating in cross-border regions.  A total of 42 projects were eventually included in the mapping.

Then, the study team developed a selection matrix (see Annex 2. Selection matrix

). The selection matrix was established to apply some key criteria to ensure a diverse selection of case studies. Creating a selection matrix was of added value as it allowed the study team to compare the case studies and identify any potential gaps in coverage. The criteria of the matrix were the following:

Private/public sector

- Private/public sector
- Business model
- Geographical scope/coverage
- EU policy area
- Data type
- Data source
- Infrastructure
- Value of geospatial data
- Challenges and costs of non-interoperability.

Based on these criteria, eight case studies were selected, ensuring diversity across all the above indicators and covering the information needs determined by the methodological approach.

### *Data collection*

The data collection process consisted of the following activities:


Firstly, the **desk research/literature** review activity aimed to obtain an overview of the current state of cross-border data-sharing and use in the EU. The primary sources were ELISE Action studies, journal articles, EU legal instruments, and materials linked to projects, initiatives or services relevant to the study. While the activity resulted in finding relevant research and vast numbers of projects and initiatives working (directly or indirectly) with sharing and using geospatial data across borders, there is limited data available on cross-border sharing of data experiences. However, the exercise was highly useful in informing the context in which the case studies operate.

Secondly, to conduct the case studies, the study team commenced drafting Interview Guidelines

the Interview Guidelines.

The guidelines consist of complete sets of questions designed to cover the methodological framework indicators and provide ready-to-use documents for carrying out case study interviews on the topic. The study team prepared case study briefing documents based on desk research.

Once the interview guidelines had been completed, the study team scheduled individual one-hour interviews with each case study owner. The interviews were semi-structured, covering the relevant questions for the study. The semi-structured interview approach allowed the study team to adapt to the needs by focusing on those questions that were particularly relevant to each case study. It also let the interviewer go deeper into certain aspects of interest.

Lastly, the study team decided to conduct a **validation workshop** on "*Cross-border sharing of geospatial data*" with a broader range of stakeholders. The purpose of this workshop was to collect stakeholder opinions and validate findings from the case studies. The benefit of conducting a workshop is that it allows for collecting both individual and collective views. As part of the workshop, the study team organised polls, breakout sessions and presented findings. A summary of the workshop can be found in Annex 3 .

### *Data analysis*

In order to reply to the overall research question of "what is the current state of play on sharing and using (geospatial) data across European borders and what can we learn from these practices to support the evolution of Spatial Data Infrastructures (SDIs)?" the study team developed a table of contents for the study and conducted a data analysis exercise.

The results gathered from each data collection technique was compared to assess whether the results can be cross-checked. The process of comparing different data sources in this way is known as data triangulation. In the case of trends gathered through interviews, it can be advantageous to challenge this data against the views and opinions expressed by stakeholders during the workshop.

The data triangulation exercise included the following steps:

- Firstly, the study team assembled data from the various sources to identify key input and trends across inputs.
- Then, the hypotheses and findings generated from each source were checked for consistency by comparing them against the other sources.

— Lastly, when necessary, the study team approached the various information sources to obtain additional data to analyse and explain possible contradictions and/or differences in the findings.

### *Interview Guidelines*

**Date:**
**Interviewee:**
— **Name:**
— **Organisation:**
— **Contact details:**
**Interviewers:**

Background information on the case/initiative and approach to cross-border data exchange and usage

*(Information on the background of the case/initiative will be collected, as much as possible, by the study team through desk research/literature review. These questions will only aim at validating and completing the evidence gathered).*

*For this part of the questionnaire, the team will have to differentiate between interviews with public authorities (in the context of cross-border government services) and with businesses (for apps/services using data from multiple countries).*

### *Interviews with Public authorities for cross-border public services*

— Could you please explain the objective of your initiative and what role geospatial data play in it?

— What type of (geospatial) data do you use to provide your service? From which data sources and from how many countries?

— Can you please elaborate more on how your initiative is organised and who are the key stakeholders and beneficiaries?

— How important is it for you to access/share geospatial data across borders?

— What added value does cross-border data exchange and use have to the services you provide?

— …

### *Interviews with businesses delivering services cross-border/using geospatial data from different countries*

— Could you please elaborate further on your business model and how geospatial data play a role in it?

— What type of (geospatial data) do you use and from which sources? (i.e. authoritative sources only or rather a mix of authoritative and other sources, Google Maps, OpenStreetMap etc.[26])

— Do you offer your service/product in multiple European countries? If yes, which ones? Does the choice of the countries reflect the availability of data?

— How important is it for you to access/share geospatial data across borders?

— …

[26] See survey from Eurogeographics as a background for this question, https://openels.eu/wp-content/uploads/2019/05/Open-ELS-SME-Engagement_report.pdf

### *Key aspects and enablers of data sharing/data use across borders*

— Organisational/legal aspects:

  - What is the process underpinning the data sharing/use across borders?
  - What are the major process steps, and what is their sequence (order);
  - Who are the major actors? (public actors, private actors, citizens etc. and what are their roles)
  - What triggers the process, what ends the process?
  - What existing information and datasets are used, and from what sources (organisations/actors)?
  - What new information/data or other outputs are created throughout the process, and by whom?
  - In which process steps are location data used and/or created?
  - How is the output distributed or used in other processes, and by whom?
  - How is this organised in terms of collaboration between stakeholders? How do you ensure smooth access to the data? (i.e. in the context of public services, do you have Service Level Agreements/Cooperation agreements with the other public authorities; in the context of businesses, do you have to accept terms and conditions for the reuse/sharing the data)?
  - …

— Technical aspects:

  - Which type of infrastructure is underpinning your initiative/is your business using to access/share data across borders (i.e. APIs, web services)? How did this infrastructure enable data sharing? (use case vs in general)
  - To what extent data and metadata from the different sources are interoperable? Do you have to invest considerably in data cleaning and integration (i.e. in cases of varying data granularity etc.)? What was the role of standards in ensuring interoperability? What are important technical aspects which are necessary due to the cross-border nature of your initiative/your service?
  - Are there any advancements in IoT, citizen science or other technologies you see as particularly impactful enablers for data sharing?
  - …

— Policy aspects:

  - How do you perceive the EU policy environment (i.e. GDPR, INSPIRE, Public Sector Information Directive (PSI), Open Data Directive, Copernicus) as enabling/restricting your activity in sharing data across borders?
  - Would you believe a European Data market[27] or the availability of pan-European datasets would help to enable data-driven innovation? How should the future European data spaces look to allow for better cross-border data sharing and use?

— Other aspects:

  - What are the key elements you have to pay attention to due to the cross-border nature of your initiative/service? (i.e. compatibility of licenses, etc.)

[27] More data becomes available for use in the economy and society, while keeping companies and individuals who generate the data in control. European Data Economy: https://ec.europa.eu/digital-single-market/en/policies/building-european-data-economy

- What are the benefits of the processes you employ (as described by the interviewee) to share data across borders? How important is it to have a trusted environment to share and analyse data?
- In what ways does the project foster/encourage the reuse of data?

### *Challenges of data sharing/data use across borders*

— Which challenges do you encounter more often when using/sharing data across borders? (We expect some of these challenges to be more relevant for businesses than for public authorities and vice versa).

— Does licensing constitute a key challenge for your initiative/business, and if so, how? (public/private, authentication, cost)

— Legal challenges: other than the above elements, i.e. terms and conditions, intellectual property, the liability of data…

— Organisational challenges: i.e. gathering the data from multiple sources which provide data in different ways, liaising with various organisations and their terms and conditions…

— Economic challenges: i.e. collection of data from different sources is too labour intensive and costs too much

— Technical challenges: i.e. data access, interoperability (integration, data format, metadata, lack of standards), data infrastructure… Is the challenge/obstacle valid for single-use cases or in general?

— What are the most impactful amongst these challenges and those that constitute the highest-burden to your initiative/your company?

— How do you address them? What best practices have you encountered in this respect?

— Are there new challenges that emerged only recently and/or have these challenges remained the same over time (i.e. did efforts in terms of standardisation of data and metadata under INSPIRE helped)?

— Would you use/share cross-border data more should these challenges be partially or totally addressed?

### *Lessons learned*

— Are there any lessons learned from your experience with cross-border data sharing/use that you want to share?

— Are there any recommendations on the socio-economic, legal, organisational or technical approach for Public authorities, standardisation bodies, data providers, or other actors involved that would improve or facilitate cross-border data sharing?

— What do you see in terms of cross-border sharing/use of data for the near future? i.e. is it likely to increase or remain the same, which new trends are emerging?

— …

## Annex 2. Selection matrix

| Case | Demographics | | | | | Key characteristics (flows, assets, value and challenges) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **Private/public sector** | **Business Model** | **Geographical scope/coverage** | **EU funded?** | **EU policy[28]** | **Data type** | **Data Source** | **Infrastructure** | **Value of geospatial data for business model/initiative[29]** | **Challenges and cost of non-interoperability[30]** |
| **the Locator** | Public/Private | G2B | Euregio Meuse-Rhine (Maastricht, Aachen and Liège) | Yes (2010-2014) | Interreg A | Addresses and location data concerning industrial sites, real estate and other economic data | Public administrations - each city have their own system/method, self-generated data (contacting businesses who fill-in form) and third-party provider (paid). | Open-source database | Economic (allows for a common solution to provide companies with the possibility of easily identifying settlement opportunities and industrial sites available) and organisational/cultural (need for collaboration drives partners from competition to cooperation) | Economic (need to attract business to the region), technical (the difficulty in mapping, obtaining data, updates and non-harmonisation of data remains a key cost of non-interoperability in the region, also regarding updates of datasets), linguistic (obstacle to harmonisation) |

[28] mentioned in the interview
[29] economic, legal, technical, organisational
[30] economic, legal, political, technical, organisational

| Case | Demographics | | | | | Key characteristics (flows, assets, value and challenges) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **Private/public sector** | **Business Model** | **Geographical scope/coverage** | **EU funded?** | **EU policy[28]** | **Data type** | **Data Source** | **Infrastructure** | **Value of geospatial data for business model/initiative[29]** | **Challenges and cost of non-interoperability[30]** |
| **Grande Region (SIG-GR)** | Public | G2G (but the user group is also private companies, researchers etc.) | Luxembourg, Rhénanie-Palatinat, Sarre, Grand Est, Wallonie | Yes (2010-2013) | Interreg A | Geospatial base data and thematic data | Regional offices, institutes and EU sources (thematic data). Geographic institutes (geospatial base data) and other stakeholders/partners. | Web service providing thematic maps | Organisational (geospatial data informing decision-makers, EIA) and technical (advancing regional spatial planning), security (delivery of public services, especially in crises.) | Political efforts needed in putting on the agenda cross-border data sharing for reuse and to enable sustainability, legal (expensive licensing), technical (non-comparable data and formatting required for spatial planning, time-consuming), organisational (they help partners connect to obtain data which is a necessary prerequisite) |

| Case | Demographics | | | | | Key characteristics (flows, assets, value and challenges) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **Private/public sector** | **Business Model** | **Geographical scope/coverage** | **EU funded?** | **EU policy[28]** | **Data type** | **Data Source** | **Infrastructure** | **Value of geospatial data for business model/initiative[29]** | **Challenges and cost of non-interoperability[30]** |
| **FAIRway Danube** | Public | G2X (industry and authorities) | Austria, Slovakia, Hungary, Croatia, Bulgaria and Romania | Yes | INEA (CEF, Horizon2020, the Innovation Fund), TEN-T Network Regulation, RIS Directive | Rainfall levels, the status of infrastructure, depth of river (river bed) in conjunction with other reference data | National authorities and self-generated data. | Platform | Technical (allows for timely maintenance, improves conditions for river navigations and operations for data provision), organisational (need for data sharing improved cooperation between EU and non-EU countries), the safety of navigation and economic (geospatially informed system improving the infrastructure of trade route) | Economic (need for interoperability to support to the logistics sector), technical and organisational (lack of standards and harmonised open data sharing traditions across countries), sustainability (ensuring continued updates, financing), legal (especially liability concerns regarding next steps) |

| Case | Demographics | | | | | Key characteristics (flows, assets, value and challenges) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **Private/public sector** | **Business Model** | **Geographical scope/coverage** | **EU funded?** | **EU policy[28]** | **Data type** | **Data Source** | **Infrastructure** | **Value of geospatial data for business model/initiative[29]** | **Challenges and cost of non-interoperability[30]** |
| **NordicSmart Government** | Public | G2B | Norway, Sweden, Denmark, Finland | No | No | Bookkeeping data (revenue and other financial reporting) | National tax authorities | API | Not exploited | Legal barriers and legal interoperability are critical challenges for public authorities to cooperate and share this data across borders and organisational difficulties in changing private companies' behaviours. |
| **Esri** | Private | B2x | Global | No | INSPIRE, European Data Strategy | Geospatial data (++) | Private companies, public authorities, citizens | Data, analytics, solutions (APIs) | Economic, technical, organisational. Pillar of their business model, further strengthened by an internal data sharing ecosystem. | None mentioned |

| Case | Demographics | | | | | Key characteristics (flows, assets, value and challenges) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **Private/public sector** | **Business Model** | **Geographical scope/coverage** | **EU funded?** | **EU policy[28]** | **Data type** | **Data Source** | **Infrastructure** | **Value of geospatial data for business model/initiative[29]** | **Challenges and cost of non-interoperability[30]** |
| **Seapilot** | Private | B2C | Europe, US, Canada and Australia | No | PSI | Hydrographic data (nautical maps), weather information | National hydrographic offices | App | Economic and technical. Obtaining geospatial data (in the form of hydrographic maps) is essential for this SME. Open and easily accessible datasets present the opportunity to expand their application into new geographies and provide new solutions for hobby boaters all over Europe and beyond. | Technical: Key challenge is data access, i.e. finding the right access points and obtaining data. Economic: disparity in pricing models |

| Case | Demographics | | | | | Key characteristics (flows, assets, value and challenges) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **Private/public sector** | **Business Model** | **Geographical scope/coverage** | **EU funded?** | **EU policy[28]** | **Data type** | **Data Source** | **Infrastructure** | **Value of geospatial data for business model/initiative[29]** | **Challenges and cost of non-interoperability[30]** |
| **European Rail Agency** | Public | G2x | Europe | Yes | TIN-Directive | Data related to rail (technical specifications, timing and routes) | Rail operators, producers and wagon keepers | Platform | Technical, organisational and economic. Value is the possibility to link data, independently of data models, to create an interoperable routing system across Europe. | Technical: Key challenge is data access from intermediaries and the organisational aspect of raising awareness amongst non-technical audiences on the importance of creating interoperable systems "by birth". |

| Case | Demographics | | | | | Key characteristics (flows, assets, value and challenges) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **Private/public sector** | **Business Model** | **Geographical scope/coverage** | **EU funded?** | **EU policy[28]** | **Data type** | **Data Source** | **Infrastructure** | **Value of geospatial data for business model/initiative[29]** | **Challenges and cost of non-interoperability[30]** |
| **Eurobird** | Non-profit | NP2x | Europe | No | No | Bird data in the form of casual records, complete lists and protocol data (if any) | NGOs, volunteers | Knowledge graph, platform | Technical and organisational. Allows tracking bird migration patterns across Europe, presenting unique data for natural preservation. | Economic sustainability (in terms of long term funding) and organisational challenges related to local capacity building. |

# Annex 3. Summary of workshop findings

**Date**: 01/12/2020

**Place**: Virtual (Zoom meeting)

**Participants**: Representatives from academia/research, EU, small and medium-sized companies, international organisations, large companies, data providers and project coordinators (18).

### *Introduction and background*

This workshop was carried out in the context of the ELISE action team's study on cross-border (geospatial) data sharing.

The key research question of the study is as follows:

> *What is the current state of play on sharing and using geospatial data across European borders?*

> *What can we learn from these practices to support the evolution of Spatial Data Infrastructures (SDIs)?*

To answer this question, the study team had conducted desk research and interviewed several private and public actors working specifically with the cross-border sharing of location data.

The workshop objectives were to:

- Validate findings from past case study interviews, especially challenges and lessons learned;
- Explore the future of SDIs, needs and tools for innovation;
- Raise awareness and inspire partnerships, showcasing key drivers, opportunities and challenges for cross-border sharing and use of location data between public and private actors.

Discussion amongst participants took place in the framework of four breakout rooms, which are briefly summarised hereafter.

### *FAIR principle: state of play and impact*

The breakout session aimed to explore participants' perceptions on the findability, availability, interoperability, and reusability of location data across borders in their specific context.

Regarding the importance of cross-border data sharing, some key points raised by the participants were:

- There is evidence of increased use of (geospatial) data leading to a higher return of investments from the business perspective. Data is key for companies to generate new business applications, also for the benefit of the public sector and wider society;
- The existence of transborder challenges (i.e. environmental issues, COVID-19) calls for data sharing to support efficient and effective policy design, disaster response and more;
- There is a need for cooperation between neighbouring countries, which remains fundamental to realise the European project.

When discussing the "FAIRness" of data in the participants' current context, the availability of findable and comparable cross-border data was discussed at length. To make data findable, it needs to become findable through search engines. It was also pointed out that finding the appropriate access points to obtain data from national data providers is not always straightforward.

Disparities in licensing, language and terminologies were pointed out as key issues. Some participants representing end-users argued that data is hard to find and that the Member States do not publish data to a satisfactory extent. Member State representatives did not necessarily share this opinion. It was pointed out that the national geoportals are up-to-date but that the transnational infrastructures are "too complex", making it challenging for data providers to integrate their data. As a result, it deters data providers from making their data more readily available in a cross-border context.

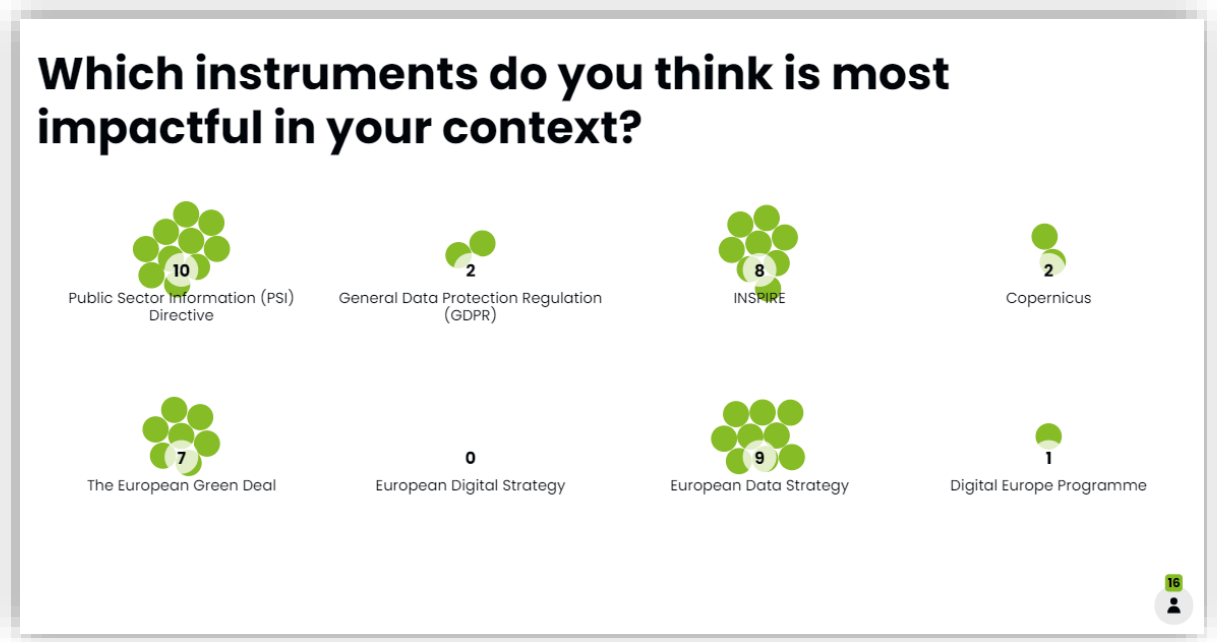
Regarding discussions on interoperability, the participants mentioned that while INSPIRE formats are useful and there has been immense progress in the past years, data models and guidance are still lacking and necessary to ensure interoperability. Edge-matching[31] is mentioned as a necessity to incorporate into cross-border data production.

### *EU perspective: policy mapping and tools for the future*

The breakout session aimed to explore participants' perception of the current EU policy environment on sharing data across borders and inspire thinking on future supportive policies.

Interactive polling was performed to determine those policy instruments which are considered most impactful by the participants, with regards to their context.

**Figure 8** - Policy poll




**Source: Deloitte (2020)**

When asked to describe their perception of the role of EU policy with regards to data sharing across borders, participants highlighted that the EU should:

[31] Edge-matching is the process to determine which edges (lines) should be linked among candidates. For some cases, one edge will join with only other one and for some other cases, more than two edges will be linked together. It depends on the features (attributes) represented by data. Process of contour data is the former case and process of river or boundary is the later. (Geocomputation.org)

— Ensure cross-border policy and strategic direction in view of tackling cross-border issues/challenges (e.g. in the context of COVID). It was mentioned that the INSPIRE Directive already provides a solid basis but more needs to be done to lay down sound building blocks for open and harmonised data sharing;

— Ensure coherence of policy initiatives around data sharing, thereby supporting the once-only principle and alignment between instruments at a European level. For example, in the field of transport, data sharing is legislated through a number of instruments (most notably the PSI Directive, the ITS Directive and the INSPIRE Directive), which may lead to different interpretations and applications in practice.

— Complement national policy goals notably by supporting the implementation of INSPIRE at the national level (through funding and support of longer-term cross-border data exchange initiatives) and the ability to share data between actors at national levels, including at regional and local level where both resources and use cases for data sharing may be limited;

— Facilitate and enable organisations to collect and share data across Europe through a number of measures. First, by providing a clear governance structure for data sharing. Second, by harmonising aspects related to costs of data, which are considered as significantly varying across the Member States. Finally, by harmonising semantic issues, thereby focusing on the actual usability of data which is shared.

The participants said that EU policy can be used to support the sharing and use of location data across borders in several ways. These include providing clear use cases, funding opportunities, providing visibility to local and national initiatives, and supporting EU data spaces to ensure smooth data sharing.

Participants also described EU policy as having gaps when it comes to several aspects. These include tackling barriers related to local/national governance and ensuring the existence of formal cooperation platforms for cross-border data sharing as well as local/regional data sharing. In addition, there are gaps when it comes to providing necessary resources, ensuring a "give and get" data sharing culture and attributing accountability (including considering penalties) for reluctance to make data available.

### *Spatial Data Infrastructures: Where are we now?*

The breakout session aimed to explore participants' perceptions of current challenges, opportunities, insights, and needs regarding Spatial Data Infrastructures (SDIs).

When asked about the main challenges experienced by the participants and the magnitude of these, the following elements were mentioned:

— The strategic direction must be made more evident so owners have a clear idea of the benefits of sharing data. This is also why INSPIRE must continue to be given strategic importance;

— Funding, visibility and findability of portals is essential to ensure the sustainability of cross-border initiatives, and we are not yet there;

— Classification of data attributes must be further harmonised across borders;

— Legal challenges, legal harmonisation (harmonised licensing), language (linked data) and edge-matching are key challenges that need attention;

— With the increased availability of spatial data and SDIs being more affordable today than ever before (much due to cloud and webGIS), we are still awaiting applications to apply for even more specific needs.

The key opportunities presented by SDIs is the potential of provision of data from private third party actors and combining them with data from multiple sources. For example, connecting SDIs with other core registers and interoperable frameworks and merging them with open data catalogues and INSPIRE. In addition, an unprecedented scaling of applications and delivery of these has recently been witnessed in the context of the COVID-19 crisis. It may be considered whether it is time to move from Spatial Data Infrastructures to simply Data Infrastructures because "*spatial is no longer special*". We are at a maturity level where location data is not necessarily analysed in isolation.

The challenges and needs seen concerning SDIs are the readiness of technology and the need to make information available via search engines. Capacity building and compliance at all levels are essential for SDIs to be created and maintained.

### *Emerging tech trends and new challenges*

The breakout session aimed to explore participants' opinion on how we might best leverage technological trends to support the sharing of location data across borders.

Interactive polling was performed to determine which technological trends are perceived as most impactful in their context:

— Artificial intelligence (+ML, DL) (9/14);

— Citizen Science (9/14).

When asked how technological trends may be leveraged upon to support cross-border data sharing, the participants mentioned:

Regarding citizen science, supporting policies are seen as instrumental in enhancing this development. Citizen science-driven data should be incorporated into overall data collected by and available from the public sector, ensuring all data gaps currently identified would be filled. Further to this, participants highlighted the importance of ensuring that a feedback loop exists, e.g. for private sector companies who use public sector data to re-share the result of their processing/interpretation of the original data.

When asked how to best leverage artificial intelligence, machine learning and deep learning, the participants mentioned that:

— Standards and standard interfaces will help make data available to the public (and across borders);

— Technology can have an impact on the harmonisation of semantic aspects to ensure compatibility in different countries;

— AI is foreseen to continue to have a significant impact of improving both data collection and quality, although this progress is mainly seen at national levels;

— AI changes the way private sector organisations providing geospatial data services communicate and exchange with their users: the latter is not only 'using the service, but expected to contribute to it, through the further provision of data;

— Use cases will drive technological trends and data sharing. Currently, ongoing projects use real-time translation to support the reuse of (meta) data from different countries);

— Moreover, cross-border data usage is demand-driven and technological trends depend on this demand. That being said, it was pointed out that data sharing is a policy issue rather than a technological one as it depends on ways of collaborating of entities.

Lastly, it was mentioned that supercomputing could also be seen as an enabler. It supports the increased processing possibilities related to the collection and sharing of data across borders.

# Annex 4. Mapping of relevant case studies

| Case | Ownership Public/Private/Mixed | Business model | Geographical scope | Datasets/Services/apps | Link |
|---|---|---|---|---|---|
| **The Lake Constance Project (2016)** | Public | G2G | Baden-Wuerttemberg (Germany), Bavaria (Germany), Austria and Switzerland | Dataset | https://seewandel.org/en/startseite/ |
| **Rail Data Space** | Private | B2B | Europe | Dataset | https://internationaldataspaces.org/knorr-bremse-establishing-data-sovereignty-and-data-ecosystems-in-the-rail-industry/ |
| **The locator** | Private | B2B | Europe | Dataset | http://www.the-locator.eu/72EMR_Frontend/home.xhtml?mode=home |
| **Seapilot** | Private | B2x | Europe, Oceania, North America | App | https://www.seapilot.com/ |
| **ALBINA project** | Public | G2x | Tyrol, South Tyrol and Trento | Service | https://avalanche.report/more/about |
| **ITI project (2013)** | Public | G2G | Italy-Slovenia | Regulatory and territorial instrument | https://euro-go.eu/en/programmi-e-progetti/progetti-iti-salute-zdravstvo/ |
| **FAIRway Danube (2015-2020)** | Public | G2x | Austria, Slovakia, Hungary, Croatia, Bulgaria and Romania under the umbrella of the Innovation and Networks Executive Agency (INEA) of the European Commission. | Policy cooperation, operation and pilot activities in data collection and harmonisation. | http://www.fairwaydanube.eu/ |
| **Do-Tours** | Private | B2C | French company - global scope | Application | https://www.do-tours.com/ |
| **Open Data Soft** | Private | B2B | French company - global scope | Services | https://www.opendatasoft.com/ |

| Case | Ownership Public/Private/Mixed | Business model | Geographical scope | Datasets/Services/apps | Link |
|---|---|---|---|---|---|
| **Trafi** | Private | B2C | Berlin, Prague, Vilnius and Jakarta | Application | https://www.trafi.com/ |
| **Strong Lek Dyke Project** | Public | G2x | the Netherlands, but also potentially Belgium and Germany | Digital Twin | https://iro.nl/nl/nieuws-en-pers/sustainable-dyke-reinforcement-emission-free-and-innovative-through-unique-collaboration/ |
| **Cross-forest project** | Public | G2x | Spain, Portugal | DSI | https://crossforest.eu/ |
| **HARMO-DATA** | Public | G2G | Friuli-Venezia-Giulia (Italy), Veneto (Italy) and Slovenia | Dataset | http://www.harmo-data-geoportal.eu:8080/geoportal/search/ |
| **Geo-Rhena**<br><br>Note: this is a project of SIG-GR | Public | G2x | France, Germany, Switzerland (Rhine Area) | Dataset | https://www.georhena.eu/ |
| **CentropeMAP/STATISTICS** | Public | G2x | The Czech Republic, Slovakia, Hungary and Austria | service | https://www.centropemap.org/index.php?id=1&L=0 |
| **IDEOTALEX** | Public | G2x | Alentejo - Extremadura | service | http://www.ideotalex.eu/OtalexC/ |
| **SIGN II** | Public | G2x | Galicia- North of Portugal | service | https://www.sig-gr.eu/fr/sig-gr/objectifs.html |
| **SIG-GR** | Public | G2x | Luxembourg, Rhénanie-Palatinat, Sarre, Grand Est, Wallonie | service | https://www.sig-gr.eu/fr/sig-gr/objectifs.html |
| **NordicSmartGovernment** | Public - Private | G2B | Nordic Region (Denmark, Finland, Iceland, Sweden, Norway)<br><br>Note: probably some statistical offices are providing geodata too | service | https://nordicsmartgovernment.org/ |

| Case | Ownership Public/Private/Mixed | Business model | Geographical scope | Datasets/Services/apps | Link |
|---|---|---|---|---|---|
| **ESPON2020** | Public | G2G mainly but also G2x | EU wide - covering the entire territory of the 28 EU Members States and 4 Partner States of Iceland, Liechtenstein, Norway and Switzerland. | Service (provides many tools as the Territorial Impact Assessment tool that could be in scope for Study 1) | https://www.espon.eu/news-events/news/videos/espon-tools-introduction |
| **Repowermap** | Non-profit | Network of NGOs, renewable energy and energy efficiency associations, local authorities and regions gathering sources for citizens | Europe (initial focus Austria, Belgium, Bulgaria, Finland, France, Germany, Italy, Liechtenstein, Slovakia, and Poland) | Dataset | http://www.repowermap.org/ |
| **U42** | Private | B2B | Global | API | https://up42.com/use-cases/ |
| **EIA transboundary projects:**<br><br>**Construction and reconstruction of railway line corridor 8- Eastern Part on Bulgarian Territory (2013)** | Public | G2G | Bulgaria (EIA → Macedonia) | EIA | https://www.moew.government.bg/static/media/ups/tiny/TrBP/JP_linia-Radomir-Gueshevo_en.pdf |
| **EIA transboundary project:**<br><br>**Track-quadrupling of the Fortezza-Verona line southern access to the Brenner Base Tunnel**<br><br>**Additional information: FS Italiane** | Public | G2G | Italy - Austria<br><br>Map | EIA | https://va.minambiente.it/en-GB/Oggetti/Info/47 |
| **EIA transboundary project:**<br><br>**Resolution of February 14, 2020 «Oriol photovoltaic installation of 327.57 MW, and evacuation** | Public | G2x | Spain - Portugal | | n/a |

| Case | Ownership Public/Private/Mixed | Business model | Geographical scope | Datasets/Services/apps | Link |
|---|---|---|---|---|---|
| **infrastructure in the town of Ceclavín (Cáceres)** | | | | | |
| **Slovenia-Austria Karawanke Tunnel** | Public | G2G | Slovenia-Austria | EIA | https://ec.europa.eu/inea/sites/inea/files/fiche_2014-at-ta-0156_s_final.pdf |
| **Slovenia- Hungary gas pipeline** | Public | G2G | Slovenia-Hungary | EIA | https://ec.europa.eu/inea/sites/inea/files/cefpub/summary_6.23-0019-si-s-m-14_final.pdf |
| **Baltic Geodata Marketplace** | Private | B2x | Latvia- Estonia | | https://estlat.eu/en/estlat-results/baltic-geodata-marketplace.html |
| **Esri Location Data** | Private | B2x | Global | | https://www.esri.com/en-us/arcgis/products/data/overview |
| **Windy** | Private | B2c | Europe (based in CZ) | App | https://www.windy.com/ |
| **CARTO** | Private | B2x | Global | | https://carto.com/ |
| **Wetransform** | Private | B2B | Germany (Europe) | Consulting services and product development | https://www.wetransform.to/ |
| **Geograma** | Private | B2B | Spain | | https://www.geograma.com/en/ |
| **Bilbomatica** | Private | B2B | Spain (European clients) | Consulting services in digital transformation (GIS) | https://www.bilbomatica.es/en#/ |
| **European Union Agency for Railways** | Public | B2x | European | single safety certificates and vehicle (type) authorisations valid in multiple European countries and to ensure an interoperable European Rail Traffic Management System | https://www.era.europa.eu/ |

| Case | Ownership Public/Private/Mixed | Business model | Geographical scope | Datasets/Services/apps | Link |
|---|---|---|---|---|---|
| **Eurobird** | Public | C2x | European (Dutch org.) | Data portal | https://eurobirdportal.org/ebp/en/#home/HIRRUS/r52weeks/CUCCAN/r52weeks/ |
| **GEBCO** | Public | C2x | Hosted by British Oceanographic Data Center | Map | https://www.gebco.net/about_us/ |
| **Sixfold** | Private | B2B | European (7 locations) | Analytics platform | https://covid-19.sixfold.com/ |
| **Tmrow's open-source electricity map** | Private | B2x | Danish maps Europe | Map | https://www.electricitymap.org/map?solar=false&remote=true&wind=false |
| **DRINKADRIA** | Public | G2x | Slovenia | Map | http://drinkadria.fgg.uni-lj.si/water-supply/cross-border-water-supply-map/ |
| **Geoplasma (Interreg)** | Public | G2x | Germany, Poland, Czech Republic, Slovakia, Austria and Slovenia. | Web portal | https://portal.geoplasma-ce.eu/ |
| **HERE Technology's Covid border restrictions map** | Private | B2x | the Netherlands | Map | https://app.developer.here.com/covid19-travel-restrictions/ |

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Photo by Joyce McCown on Unsplash

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# Acronyms

AI – Artificial Intelligence

API – Application Programming Interface

DaaS – Data as a Service

EIF – European Interoperability Framework

ELISE – European Location Interoperability Solutions for e-Government

FAIR – Findable, Accessible, Interoperable, Reusable

GDPR – General Data Protection Rules

G2G - Government-to-Government

G2B - Government-to-Business

G2C - Government-to-Citizen

G2x - Government-to-all

ISA$^2$ – Interoperability Solutions for European Public Administrations, Businesses and Citizens

NGO – Non-Governmental Organisation

SDI – Spatial Data Infrastructure

SLA – Service Level Agreement

SME – Small and Medium-sized Company

# Glossary

**Data as a Service (DaaS)** is a design approach that contributes to an information architecture by delivering data on demand via consistent, prebuilt access, with the aid of standard processing and connectivity protocols. Originating data remains local to its storage platform and, following various steps to access, format, evaluate and possibly even contextualize it, is presented as output for use in a subsequent process or delivery endpoint. (ELISE Glossary, 2021)

**Data ecosystem** (or 'data-driven digital ecosystem') is where a number of actors interact with each other and their environment for a specific purpose, generating value from the network by producing, exchanging and consuming data in a collectively governed and operated way. (ELISE Glossary, 2021)

**Data portability.** The term comes from Article 20, GDPR: "The data subject shall have the right to receive the personal data concerning him or her, which he or she has provided to a controller, in a structured, commonly used and machine-readable format and have the right to transmit those data to another controller without hindrance from the controller to which the personal data have been provided (..)" Available at: https://gdpr-info.eu/art-20-gdpr/

**Digital government** is government designed and operated to take advantage of the information in creating, optimising, and transforming government services. (ELISE Glossary, 2021)

**Edge-matching** is the process to determine which edges (lines) should be linked among candidates. For some cases, one edge will join with only other one and for some other cases, more than two edges will be linked together. It depends on the features (attributes) represented by data. (Geocomputation.org)

**European data space** is defined by COM (2018) 232 as "A seamless digital area with the scale that will enable the development of new products and services based on data", The European strategy for data envisages domain-specific data spaces for Industry, Green Deal (including evaluating the INSPIRE and Environment Information Directives), Mobility, Health, Financial, Energy, Agricultural, Public administration and Skills. (ELISE Glossary, 2021)

**Gazetteer** is a directory of instances of a class or classes of features containing some information regarding position. (JRC, "Feasibility study for an EU Gazetteer common service," 2017)

**Geography/geographies,** in the context of this study, refers to the area in which an actor operates.

**Geospatial or Location data** is data with a direct or indirect reference to a specific location or geographical area (cf. the legal definition in the INSPIRE directive, Directive 2007/2/EC). This term can be interchanged with location data, geospatial data or geodata. (ELISE Glossary, 2021)

**Geodata** is data with a direct or indirect reference to a specific location or geographical area (cf. the legal definition in the INSPIRE directive, Directive 2007/2/EC). This term can be interchanged with location data, geospatial data or geodata. (ELISE Glossary, 2021)

**High-Value Dataset.** The Open Data Directive introduces the concept of 'high-value datasets' as datasets holding the potential to (i) generate significant socio-economic or environmental benefits and innovative services, (ii) benefit a high number of users, in particular, SMEs, (iii) assist in generating revenues, and (iv) be combined with other datasets. Given this, the Directive requires that such datasets are available free of charge, are provided via Application Programming Interfaces (APIs), and as a bulk download, where relevant, and are machine-readable. The Directive does not include the specific list of high-value datasets—which is expected in the future—but only their thematic categories, one of which is 'Geospatial'. (ELISE Glossary, 2021)

**INSPIRE** refers to Directive 2007/2/EC establishing an infrastructure for spatial information in Europe to support Community environmental policies and policies or activities which may have an impact on the environment. (ELISE Glossary, 2021)

**Interoperability** is a key factor in making a digital transformation possible. It allows administrative entities to electronically exchange meaningful information in ways that are understood by all parties. (ELISE Glossary, 2021)

**Linked data** is defined as relationships or connections between data from different data sources such as databases and the Web (Science Direct)

**Location information** is any piece of information that has a direct or indirect reference to a specific location or geographical area, such as an address, a postcode, a building or a census area. Most information from diverse sources can be linked to a location. This term can be interchanged with spatial, geospatial, place or geographic information. (ELISE Glossary, 2021)

**Location intelligence** is the process of deriving meaningful insight from geospatial data relationships — people, places or things — to solve particular challenges such as demographic or environmental analysis, asset tracking, and traffic planning [Gartner Research] (ELISE Glossary, 2021)

**Location Interoperability** is the ability of organisations, systems and devices to exchange and make use of location data with a coherent and consistent approach. (ELISE Glossary, 2021)

**Platform** refers to a place for exchanges of information, goods, or services to occur between producers and consumers as well as the community that interacts with said platform (BMC, 2021)

**Spatial Data Infrastructures (SDI)** may be defined as a framework of policies, institutional arrangements, technologies, data, and people that enable the effective sharing and use of geographic information' [Bernard et al., 2005]. (ELISE Glossary, 2021)

**Standard.** In the context of this study, standard refers to a common technical specification for how information is described, processed, or transmitted (Inspired by definition by US GOV)

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