European Commission

JRC TECHNICAL REPORT

Quantifying the Benefits of Location Interoperability in the European Union

Ulrich, P., Duch Brown, N., Kotsev, A., Minghini, M., Hernandez Quiros, L., Boguslawski, R., Pignatelli, F.

2022

Joint Research Centre

EUR 31004 EN

Contact information
Name: Peter Ulrich
Address: Joint Research Centre, Edificio Expo, C. Inca Garcilaso, 3, 41092 Sevilla, Spain
Email: peter.ulrich@ec.europa.eu

EU Science Hub
https://ec.europa.eu/jrc

JRC127330

EUR 31004 EN

PDF ISBN 978-92-76-48846-0 ISSN 1831-9424 doi:10.2760/72064

Luxembourg: Publications Office of the European Union, 2022

How to cite: Ulrich, P., Duch Brown, N., Kotsev, A., Minghini, M., Hernandez Quiros, L., Boguslawski, R. and Pignatelli, F., *Quantifying the Benefits of Location Interoperability in the European Union*, EUR 31004 EN, Publications Office of the European Union, Luxembourg, 2022, ISBN 978-92-76-48846-0, doi:10.2760/72064, JRC127330.

Contents

Foreword

The ISA and ISA^2 programmes have given a strong stimulus to promoting and supporting better interoperability in European digital public services over the last ten years, echoing and amplifying the steps being taken in Member States. The many different aspects of interoperability are embedded in the principles and levels of the European interoperability framework (EIF). While interoperability factors are recognised as beneficial, understanding the contribution of interoperability to benefits can be difficult, measuring that contribution even more so.

As the ISA^2 programme draws to a close and transition is made to support Europe's new digital strategy, 'Europe Fit for the Digital Age', an impact assessment of the programme is being undertaken and proposals considered for a future interoperability strategy and an EIF that can contribute to achieving the targets set for Europe's Digital Decade to 2030. Another key element of the EU's digital strategy, the European data strategy envisages setting up a series of demand-driven common European data spaces supported by a federated cloud infrastructure in thematic policy areas such as health, mobility and environment, with a "High Impact Project" planned from 2021-27. To support this, the Data Governance Act aims to foster the availability of data by increasing trust in data intermediaries and by strengthening data-sharing mechanisms for data voluntarily made available by public administrations, businesses, individuals and researchers.

The aim of this report is to support the assessment by demonstrating how interoperability benefits can be better understood and quantified. This is done by focusing on one aspect of interoperability, location interoperability, where the Joint Research Centre has many years of expertise, including support to the INSPIRE Directive and responsibility for the geospatial actions in ISA (EULF and ARE3NA) and ISA^2 (ELISE).

Benefits for public administrations, businesses and citizens in relation to digital public services can be understood, for example, in terms of improved productivity, better public services, improved policy outcomes (e.g. health, environmental), and market opportunities. Interoperability in its many forms is an important enabler but it is the policies and public services that are actually delivering the benefits. Consequently, while there are many examples demonstrating the beneficial outcomes from particular policies or services, there are very few studies that focus purely on the contribution of interoperability.

This report aims to get closer to that understanding by, firstly, narrowing the focus to location data, secondly, by drawing on examples (through INSPIRE and other initiatives) and, thirdly, by recognising and mitigating the challenges in developing broad assessments of this type. Location data is a good starting point because it is widely used across multiple sectors, it needs to be linked to other data to deliver value and it offers no value without being interoperable. Numerous geospatial case studies are examined to understand the applications, types of data, and assessment techniques used (including the assumptions applied in making generalisations). This learning has then been applied in developing an illustrative pan-European econometric model demonstrating the benefits of geospatial data and, in particular, the associated interoperability factors associated with the data.

We welcome feedback on the analysis and hope it adds to the body of knowledge on this important and elusive topic. If we can get a better understanding of potential benefits, we can put in place mechanisms to measure those benefits and better support the ambitious goals set out for European digital public services over the next ten years.

Francesco Pignatelli, Project Leader, European Commission Joint Research Centre

Acknowledgements

The authors would like to acknowledge the support of many friends and colleagues across the JRC, the Commission at large, and beyond. This report addresses a very complex question, and it does so in an interdisciplinary manner and through a great team effort. Our gratitude goes to Eric van Capelleveen, Michel Grothe, Friso Penninga, Ton Zijlstra and Jan Bruins (Geonovum), as well as Marijn Janssen (TU Delft) for helping us build the evidence base for this report. Andy Coote of ConsultingWhere who helped us shape the direction of this report early on. Our colleagues Sven Schade and Uros Kostic at the JRC, for an excellent review and for taking on the task of verifying a decade old urban myth respectively. Lastly, our special thanks go out to the colleagues at DG DIGIT (among them Isa von Kalben and Cristina Cosma), who keep pushing the importance of interoperability in Europe, and who provided us with this challenge.

Authors

ULRICH Peter; European Commission, Joint Research Centre

DUCH BROWN Nestor; European Commission, Joint Research Centre

MINGHINI Marco; European Commission, Joint Research Centre

KOTSEV Alexander; European Commission, Joint Research Centre

HERNANDEZ QUIROS Lorena; European Commission, Joint Research Centre

BOGUSLAWSKI Raymond; Geotonic Limited; London, United Kingdom

PIGNATELLI Francesco; European Commission, Joint Research Centre

Abstract

Interoperability, of location data as well as in digital public services generally, is one of the key enablers of the digital transformation of the public sector. However, as an enabling horizontal factor, its exact contribution is hard to measure. This report quantifies the impact of location interoperability in the European Union. The report does so by first discussing the context of policy developments and technological developments relevant for location interoperability. It continues by developing and analyzing an extensive collection of cases of location interoperability. The report complements the case collection with an economic impact assessment of public sector interoperability in general, and more specifically in terms of location interoperability. Lastly, the report concludes by developing policy recommendations based on the evidence compiled in the previous sections.

Executive Summary

This report quantifies the impact of location interoperability in the European Union. It does so by first discussing the context of policy developments and technological developments relevant for location interoperability. It continues by developing and analysing an extensive collection of cases of location interoperability. The report complements the case collection with an economic impact assessment of public sector interoperability in general, and more specifically in terms of location interoperability.

1. The context of policy and technological developments relevant for location interoperability

Digital transformation has been a long-standing priority of the European Commission. Recently, this has been further strengthened by the Commission's digital strategy **Shaping Europe's Digital Future.** A cross cutting challenge of the digital transformation is interoperability. To address this challenge, especially for the public sector, the Commission is developing an **enhanced interoperability strategy for EU governments.** This should ensure coordination and common standards for secure and borderless public sector data flows and services. Location interoperability is an important element of overall public sector interoperability.

This increased emphasis on interoperability in the public sector is necessary for example due to continuous technological developments. Technologies such as **location intelligence** (exploitation and analysis of location data), **Internet of Things** (sensors) and **Artificial Intelligence** (simulation of human intelligence in machines) are increasingly explored to assess the possibility of using alternative sources of data to reduce administrative reporting burden and get access to more exhaustive and timely, if not real-time, data to build our evidence bases and enhance digital public services. These developments increase the data volume, data availability, and diversity of sources of data in the public sector. They therefore necessitate a **more ambitious approach to interoperability,** for location interoperability as well as interoperability overall.

2. Identifying quantifiable benefits of location interoperability through case studies

The report undertakes an extensive analysis of case studies of location interoperability. Through literature review and expert consultation, **the report identifies 20 cases** of location interoperability for which analyses with quantifiable benefits are available. Analysing those cases reveals that most quantifiable benefits of location interoperability fall into the following categories.

1. Public sector efficiency
2. Effective public services
3. New market opportunities

The case studies show a very **rich image of the benefits of location interoperability**. Benefits could be identified across all levels of government, across a large variety of sectors, and in a diverse range of applications. This diverse picture of the benefits of location interoperability however also leads to **fragmentation of evidence**. This is turn makes it challenging to extrapolate benefits of location interoperability from the level of individual cases to national or European level.

3. Calculating economic impact of location interoperability

Following the analysis of the case studies, the report conducts an economic impact analysis of location interoperability in the EU. This impact analysis **first calculates the economic impact of interoperability generally** in the EU. In a second step, it identifies the **share of location interoperability** as part of interoperability in general. It does so for the impact on citizens, businesses, and public sector.

Impact of improved interoperability on citizens

This report assumes that improved interoperability would lead to a reduction in the time citizens spend every year with the administration by 25%, and that better services due to improved interoperability would increase the number of citizens using online public services by 15%. This would translate into **time savings of 24 million hours per year for citizens**. Taking average hourly wages as a basis, this would represent **monetary savings in the order of EUR 543 M**.

Impact of improved interoperability on businesses

In 2019, EU businesses spent 172 billion hours in order to complete a number of core interactions with the administration – such as paying taxes, registering property, and more. This report assumes that improved interoperability would, similar to the impact on citizens, lead to a reduction of time necessary to interact with the administration as well as increase the number of firms using online public services. Based on these assumptions, improved interoperability would lead to **time savings of 30 billion hours**. In monetary terms, this **translates into savings of EUR 568 billion annually**.

Impact of improved interoperability on the public sector

For calculating the impact of improved interoperability on the public sector, this report assumes that improvements in interoperability can affect public sector performance in a variety of areas. Different indices measure overall government performance. The United Nations' E-Government Development Index (EGDI) for example is a composite measure of three important dimensions of e-government, namely: provision of online services, telecommunication connectivity and human capacity. This report calculates that **improvements in interoperability that would increase the EGDI by 1%** are associated with:

- an increase of **0.4% in GDP**
- a reduction in general government production costs in 0.3 percentage points of GDP
- an increase of general government revenues in 0.07 percentage points of GDP
- a reduction of general government expenditures of 0.6 percentage points of GDP
- a reduction of the inputs required for the government to be able to produce and implement good policies and deliver public goods of 0.2%
- an increase in policy performance of 0.3%

Total impact of improved interoperability in the EU

Summing up, the overall impact of enhanced interoperability in the EU27 considering all three dimensions will **range from EUR 432 billion to EUR 625 billion**.

Total impact of enhanced location interoperability

Assuming that the share of location data in the public sector lies between 50% and 80% of all public sector data, the estimated impact of improved location interoperability ranges **from EUR 272 billion to EUR 500 billion**, depending on the proportion of location data in the public sector and also on the scenario considered.

1 Introduction

In March 2021, the European Commission presented an ambitious plan for the digital transformation of the EU by 2030: Europe's Digital Decade. Location data held by the public sector has long been an enabler for digital transformation in the EU, especially but not limited to, transforming businesses and public services. In the Netherlands alone, the economic impact of geolocation technologies, fostering or relying on location interoperability, was estimated to be EUR 35.5 Bn (Geospatial Media and Communications, 2021). In order to reap the benefits of technological innovations and location data, this data and the ways the data is used need to be interoperable, meaning that from a technical, semantic, legal, and organisational point of view, data can be exchanged and used without barriers.

While experts and practitioners generally agree that there are significant benefits from making location data interoperable, quantifying those benefits is a complex and challenging task. Estimations are typically made of a complete investment (e.g. digital public service improvement, product development) rather than individual enablers such as location data interoperability or organisational interoperability. This can help explain the relatively limited availability and scattered nature of quantifiable evidence of location interoperability benefits. However, due to its central importance for the digital transformation of the EU, and many other policy developments, this lack of a structured evidence base is a significant shortcoming. Only if we have a reliable overview of the benefits of location interoperability, including in a quantifiable manner, can we design relevant policies and make investments accordingly. In this regard, the report contributes with a location perspective to the development of an enhanced EU interoperability strategy currently under discussion[1].

What is location interoperability?

The European Union Location Framework (EULF) Blueprint guidance framework, developed under the ISA and ISA[2] programmes, defines geospatial or location interoperability as follows:

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

A common example is the use of post codes and address data in daily life. All users of such data benefit from a common understanding of the data (**semantic interoperability**). Address and post code data is typically generated, collated and shared within and across multiple organisations (local councils, postal services, mapping and cadastral agencies) collaborating (**organisational interoperability**). There may be legislation surrounding the responsibilities and obligations relating to the provision and sharing of data (**legal interoperability**). Such data is typically associated with other data (e.g., property owners, residents) and it is equally important to manage the links with related data (semantic interoperability). The high volumes associated with such data and the associated links, the large number of changes needed in a given time period, and the distributed nature of data generation all require integrated, performant and resilient technical capabilities to manage the data (**technical interoperability**). Address and post code data is the backbone of multiple public and private services and applications. Easy, reliable access to the data is therefore needed to enable the efficient operation of these services (technical interoperability).

This report establishes a structured overview of the quantifiable benefits of location data interoperability. To do so, we first provide more context on the relevance of location data interoperability, including the policy context, as well as emerging trends in terms of data sources and technological developments (Section 1). This is followed by a section dedicated to case studies on location interoperability (Section 2). This includes a presentation of the methodological approach, a deep dive into the case studies, and a discussion on the challenges encountered in this approach. The subsequent section (Section 3) calculates the economic impact of location interoperability across Europe. Also, this chapter will provide an explanation of the methodological approach, followed by a presentation of the results. Finally, the report draws a brief conclusion (Section 4).

1 https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/12579-Interoperable-digital-public-services-European-Interoperability-Framework-evaluation-&-strategy_en

1.1 Policy context of location interoperability

Location data provides a foundation for delivering added value in combination with other data, both geospatial and non-geospatial, connected e.g. with services, stakeholders or technologies. Location data is used in many fields, including environment, agriculture, regional and local planning, transport, energy, health, tourism and culture. To enable this added value, interoperability of location data is fundamental to more effective data ecosystems, services, products and communication with stakeholders, and is a condition for effective use and analysis of location data to deliver efficiency gains. Public administrations increasingly recognise the value of location information, the interoperability thereof and the role they play in the digital transformation of government, business and society.

The EU has recently embarked on a green and digital transition. The two dimensions are closely interrelated, and the Commission has taken the lead to drive these transitions and to focus investments on recovery and resilience efforts in these areas. The 2019 European Green Deal[2] recognises the potential of digitalisation to achieve the environment and climate aims and the necessity to explore sustainable digital technologies as essential enablers of the changes needed for a just green transition. In February 2020, the Commission adopted its new digital strategy titled 'Shaping Europe's Digital Future' (European Commission, 2020a) along with its first two pillars: the **European Strategy for Data** (European Commission, 2020b) and a **White Paper on Artificial Intelligence** (European Commission, 2020c). The European Strategy for Data (European Commission, 2020a) sets a vision for a transition to a healthy planet and a new digital world. It emphasises the need for the twin challenge of a green and digital transformation to go together, and points to the digital component as a key in reaching the ambitions of the European Green Deal. Interoperability plays a key role in the strategy for the exploitation of the data value within the envisioned common European data spaces in all the EU strategic sectors. Together with data availability, quality, governance and literacy, the strategy identifies interoperability as a key barrier holding the EU back from realising its full potential in the data economy.

Under the headline ambition 'Europe fit for the digital age', the Communication Shaping Europe's digital future[3] also presents an enhanced interoperability strategy for EU governments to ensure coordination and common standards for secure and borderless public sector data flows and services. The need for action in this area was identified by the Council of the European Union in its June 2019 Conclusions on the future of a highly digitised Europe beyond 2020[4] and has come to the fore as the COVID-19 crisis and the response to it have unfolded.

The development of a new EU interoperability strategy and the associated revision of the European Interoperability Framework (EIF) go hand in hand with other initiatives at the EU level that are crucial for the world of location data. Those include:

- the **INSPIRE Directive** (European Union, 2007), which is currently under evaluation with a possible revision in 2022. Through a complex legal, technical and organisational framework, the Directive has identified interoperability requirements for location data sharing across all components (data, metadata and services) to establish an EU-wide Spatial Data Infrastructure (SDI) to support environmental policies. INSPIRE most probably represents the largest location data sharing effort ever undertaken and has been, and is still today, seen as a reference example by many countries and organisations all over the world that intend to establish SDIs from the local to the national and international level (Kotsev et al., 2021).
- the **Directive on public access to environmental information** (European Union, 2003b), which can be reviewed together with the INSPIRE Directive in 2022.
- the **Open Data Directive** (European Union, 2019), aims at maximally reusing the INSPIRE Directive, introducing the notion of high-value datasets (to be fully identified and described in an upcoming implementing act), and addressing the aspect of legal interoperability through the focus on the (open) licensing of data.
- the above-mentioned **European Strategy for Data** (European Commission, 2020b) and its common European data spaces as an overarching data sharing framework, including data from public administrations, businesses, research, and citizens; and

2 https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal_en

3https://ec.europa.eu/info/sites/default/files/communication-shaping-europes-digital-future-feb2020_en_4.pdf

4 https://www.consilium.europa.eu/media/39667/st10102-en19.pdf

- **Copernicus**[5], the EU's Earth Observation programme managed by the European Commission, which on a daily basis delivers an immense amount of location data and products, all provided free of charge and under an open access licence to maximise the reuse; Copernicus services target six key areas (atmosphere, marine, land, climate change, security and emergency) with direct impacts on several EU policies.

1.2 The context of technological developments and changes in location data

In line with the policy developments mentioned above, technologies such as location intelligence (exploitation and analysis of location data), Internet of Things (sensors) and Artificial Intelligence (simulation of human intelligence in machines) are increasingly explored to assess the possibility of using alternative sources of data to reduce administrative reporting burden and get access to more exhaustive and timely, if not real-time, location data to build our evidence bases and enhance digital public services. These developments also necessitate a more ambitious approach to interoperability, in the location domain and in general. One general trend we can observe that creates a need for more location interoperability is the increase in the data volume, data availability, and diversity of sources of data. The main trends in terms of new sources of location data and new approaches for (location) data sharing are briefly presented below.

1.2.1 Internet of Things (IoT)

An ever-increasing number of **heterogeneous devices are connected to the Internet** and are capable of producing increasing volumes of different data (Swan, 2012). With the rise of 5G networks and a low cost of hardware components, the number of sensors and the data they produce are only expected to grow. This provides unprecedented opportunities for densifying existing monitoring networks and collecting data with a precision and spatial resolution that were unthinkable only several years ago. That is why, the rise of the Internet of Things (IoT) has a direct influence on data ecosystem dynamics, architectures, tools and standards, and ultimately poses new challenges and opportunities for the use and interoperability of the data. A debate on the advantages and issues related with the uptake of the IoT concretely within the context of location applications is provided by Granell et al. (2020).

1.2.2 Citizen-generated location data

Major technological changes occurred in the location domain during the first decade of the 2000s, mainly the spread of GPS-enabled mobile devices and the availability of high-resolution satellite imagery at low cost, have seen a new player – the crowd – become a major producer of location information, thus **challenging the traditional role of the public sector**. Citizen-generated location data is nowadays referred to through multiple terms. The first one to be coined was Volunteered Geographic Information (VGI) (Goodchild, 2007), followed by a plethora of other terms which are overall summarised by the umbrella expression *crowdsourced geographic information* (See et al., 2016).

The most popular VGI project to date is certainly **OpenStreetMap** (OSM)[6]. Started in 2004, it consists of a crowdsourced database of vector data (points, lines and polygons) covering the whole world and available under the open access Open Database License (ODbL). To date more than 1.7 million contributors have performed at least one change to the database, with about 50 thousand active contributors performing approximately 120 million edits every month[7]. The simplicity of the OSM data model (Ramm et al., 2010) and the availability of multiple APIs to access the data[8] make it extremely easy to download and consume OSM data in mainstream GIS software or via third-party applications. This is – together with the open licence – the reason why OSM is currently used by an increasing number of actors (Mooney and Minghini, 2017), including, among others: humanitarian organisations, private companies, including tech giants such as Facebook, Apple and Amazon, and even governments, using OSM to integrate, complement or update authoritative data[9]. Recent studies were performed by the JRC on how the legal, technical, organisational and semantic interoperability could be preserved when combining location data from INSPIRE and OSM (Minghini et al., 2019; Sarretta and Minghini, 2021).

5 http://www.copernicus.eu

6 https://www.openstreetmap.org

7 https://wiki.openstreetmap.org/wiki/Stats

8 https://wiki.openstreetmap.org/wiki/API

9 https://wiki.openstreetmap.org/wiki/Import

A significant portion of citizen-generated location data also derives from **Citizen Science** (CS) initiatives. CS is a more general and historically older term pertaining to the involvement of non-professionals in scientific activities, mainly data collection but also quality assurance, data analysis and dissemination of results (Irwin, 1995). In contrast to OSM where contributors can add any type of location data, the objectives of CS projects usually target a specific thematic area, for example biodiversity (Schade et al., 2016). CS was demonstrated to be a viable way to engage and empower the public in EU policymaking, particularly to support the European Commission objectives connected to the Green Deal (European Commission, 2020d). Crowdsourced geographic information and citizen science data add to the diversity of sources of location data, and to be of value rely on interoperability.

1.2.3 Satellite data

In addition to allowing citizens to produce new data, **remotely-sensed observations** are themselves a valuable data source for many location applications. The domain of satellite remote sensing is currently characterised by the presence of big industry players such as Planet[10] and Maxar[11], which directly control hundreds of satellites and offer an impressive number of products ranging from high-resolution imagery to derived datasets and services. In the public sector, a prominent role is played by **Copernicus**[12], the EU's Earth Observation programme managed by the European Commission and delivering services targeting six key areas (atmosphere, marine, land, climate change, security and emergency) with direct impacts on several EU policies. Through the family of Sentinel satellites, Copernicus – though still under development – already delivers an immense amount of location data, all provided free of charge and under an open access licence to maximise the reuse. When fully operational, Copernicus will generate more than 25 PB of data per year, thus becoming the largest satellite system in history (Bai et. al, 2017). The public sector needs to be prepared to be able to digest these large amounts of data for developing policies and providing public services. Interoperability plays an important role in this effort.

Some more recent developments include affordable small satellites, which provide opportunities for mass deployment and establishment of dense Earth Observation constellations at the fraction of the price of traditional (military, government and private) systems and low-cost unmanned aerial vehicles (UAV), which have also become mature and reliable systems to generate valuable data for several disciplines and applications. Such trends further diversify the origin and nature of location data and, in addition to challenging the public sector in its role as the main producer and holder of location data, adds further challenges to location interoperability.

1.2.4 Private sector location data

Private entities in many application domains and of varied sizes ranging from small and medium enterprises to hyperscalers now **hold increasing amounts of location data**, which is collected, stored, and used often without the awareness or explicit consent of those who contributed it. Location data from the private sector is of critical importance for the success of a growing number of commercial endeavours as well as an important strategic asset. The reuse of private-sector data is at present difficult, as companies are very often not willing to share them with the rest of the world and are in a few cases only sharing them on a voluntary basis. Considering that data are an important asset of companies, they are very often not willing to share them with the rest of the world. In the absence of a clear regulatory framework requiring the private sector across multiple domains to contribute their data, societal benefits from their possible reuse remain limited. The envisioned Data Act described above will address those shortcomings and lead to a fairer business data sharing. This in turn will lead to more location data entering the public sector and having to be integrated into interoperable systems.

1.2.5 From data collection to data connection (APIs)

Since the early conceptualisation of INSPIRE, the web has been used as the means for exposing location data. However, this was done using technical approaches that required specific knowledge to interact with the data. The service interfaces in traditional SDIs, including INSPIRE, e.g., Web Map Service (WMS), Web Feature Service (WFS), Web Coverage Service (WCS) and Sensor Observation Service (SOS) are well known and supported by client applications, but they use the Web as a 'tunnel' and are difficult to interact with in the absence of up-

10 https://www.planet.com

11 https://www.maxar.com

12 https://www.copernicus.eu

front knowledge of the query logic. In contrast, modern web-based Application Programming Interfaces (APIs) provide a means for developers to easily create value-added products with limited preliminary knowledge (Vaccari et al., 2021). Recently developed standards of the Open Geospatial Consortium (OGC) have a strong focus on establishing **APIs for sharing location data**. For instance, the OGC API - Features[13] and the OGC SensorThings API[14] standards provide standardised APIs for ensuring modern access to spatial and observation data. This trend also needs to be acknowledged and considered by the public sector in its role as a data provider. The choice of which standards to use for a public sector API crucially influences the interoperability of public sector data.

1.2.6 Novel architectures

Traditionally, the exchange of data in an SDI follows a request-response pattern, which extracts requested data from a database and delivers them to the users. With the rise of the IoT as a major source of information, the **streaming of data** is playing an increasingly important role. A stream provides a sequence of digitally encoded signals with a certain frequency and payload that are transmitted and/or received. Often, there is no need to store the streamed data, e.g., in cases where data is useful only in certain circumstances and within the right context.

In addition, the polling of data which is inherent to the service-oriented architecture of SDIs as we know them might lead to the generation of excessive traffic and is not necessarily well-suited for data intensive use-cases, or when data is needed only as result of the occurrence of a particular event, for example when a threshold value is reached, or when new data is made available. Standards such as the Message Queue Telemetry Transport (MQTT)[15] are well established and fit for such purposes. That is why Rieke et al. (2018) recommend the establishment of "**Event-driven SDI's**". This might be achieved in an evolutionary manner that complements and does not substitute existing approaches. Such an approach would provide users with a choice of a solution tailored to their needs. This possibility becomes feasible from a technological point of view, as the emergence of cloud-based solutions can address the user demand in a flexible and scalable manner (Kotsev et al., 2020).

Also relevant in this context are Meshed App and Service Architecture (MASA) approaches. With such an architecture, the constituent parts (apps, mini services, micro services and mediated APIs) deliver increased agility and enable application innovations to support IoT integration, automated decision making, third-party interoperability and omni-channel business models. A mediated API is a design pattern in which an API is virtualised, managed, protected and enriched by a mediation layer to support specific client requirements. Such an approach will become increasingly important in location-based applications, reflecting the transition from largely static SDI models to increasingly dynamic models, e.g. smart cities, smart grids and intelligent transport systems (Boguslawski et al, 2021).

These new architectures have an impact on public sector interoperability further on and need to be monitored and considered for adoption by public administrations.

1.3 Standardisation for location interoperability

Standards play an essential part in interoperability, in the location domain and in general. INSPIRE for example, one of the main drivers so far of location interoperability in the EU public sector, is strongly influenced by international standards such as the ones developed by the **Open Geospatial Consortium (OGC)**, the **ISO Technical Committee 211 - Geographic Information (ISO TC/211)** and the **World Wide Web Consortium (W3C)**. Any effort to further improve interoperability in the location domain needs to consider and build on the standards developed by these organisations so far. **1** below provides an overview of the most popular standards used in INSPIRE, classified according to the specific component (metadata, data encoding, and type of service) each of them refers to.

13 https://ogcapi.ogc.org/features

14 https://www.ogc.org/standards/sensorthings

15 https://mqtt.org

Table 1. Standards used in INSPIRE

Standard	**Description**	**Application**
ISO 19115/19119 - Geographic information — Metadata	Schema for describing geographic information and services	Metadata
ISO 19139	XML Schema implementation derived from ISO 19115	Metadata
GeoDCAT-AP	Extension to the DCAT application profile for European data portals for the representation of geographic metadata.	Metadata
OGC Geography Markup Language (GML)	XML-based encoding for geographical features	Data encoding
GeoJSON	JSON-based encoding for geographical features	Data encoding
ISO 19156 Observations and Measurements (O&M)	Conceptual schema encoding for spatio-temporal observations	Data encoding
OGC Catalogue Service for the Web (CSW)	Web interface for discovery, browsing, and query of metadata	Discovery service
OGC Web Map Service (WMS)	Web service for requesting spatially-referenced images	View service
OGC Web Map Tile Service (WMTS)	Web service for spatially-referenced map tiles	View service
Atom Syndication Format	XML-based data and metadata syndication format	Download service
OGC Web Feature Service (WFS)	Download service for access to feature data	Download service
OGC Web Coverage Service (WCS)	Download service for access to coverage data	Download service
OGC API - Features	Multi-part API-based standard for sharing geospatial features	Download service
OGC SensorThings API	API-based standard for sharing of spatially-enabled IoT data	Download service

2 Identifying quantifiable benefits through case studies

The starting point for this research was an extensive review of white and grey literature on location data and interoperability. The publications were identified based on a consultation of experts, a follow-up of references and sources mentioned within already identified reports, complemented by a web search. Annex 1 contains a list of all 47 publications reviewed for this analysis.

The literature review followed three steps:

1. Identifying cases with quantifiable benefits of location interoperability.
2. Assessing and categorising the benefits in those cases.
3. Structuring the cases along categories of benefits and other attributes.

Identified cases

The literature review identified **20 cases** of location interoperability for which analyses with quantifiable benefits were available. Those cases came from **11 different countries**, of which four were not from the EU-27. The majority of 9 cases was at country level, followed by 6 at regional level, 2 at local level, 2 cases with a European scope and 1 case at global scale.

The table below gives an overview of the cases this report identified through literature review and expert consultation.

Table 2: Cases identified for analysis

#	Case	Country	Scale
1	National availability of geodata in the community building process in Sweden.	Sweden	country
2	The value of the geolocation economy in the Netherlands.	Netherlands	country
3	Evaluation of the INSPIRE implementation in Lithuania.	Lithuania	country
4	Evaluation of the INSPIRE implementation in Spain.	Spain	country
5	Evaluation of regional Spatial Data Infrastructure in Catalonia.	Spain	region
6	Evaluation of regional Spatial Data Infrastructure in Lombardy.	Italy	region
7	Impact of the open geographical data in Denmark.	Denmark	country
8	Evaluation of the INSPIRE implementation in the Netherlands.	Netherlands	country
9	Value of Danish address data.	Denmark	country
10	The Use of Spatial Data for the Preparation of Environmental Reports in Europe	Europe wide	supranational
11	Benefits of e-cadastres	Europe wide	supranational
12	Economic Value of Spatial Information in New South Wales.	Australia	region
13	Use of location data in the Glasgow Operations Centre.	UK	local
14	Potential Geospatial Economic Opportunity in the UK.	UK	country

#	Case	Country	Scale
15	Cost Benefit Analysis of Address and Street Data for Local Authorities and Emergency Services in England and Wales.	UK	region
16	Value of Transport for London's open data and digital partnerships.	UK	local
17	Benefits from use of geographic information systems by King county, Washington	USA	local
18	The Value of OS OpenData™ to the Economy of Great Britain	UK	country
19	Socioeconomic benefits of exchanging surface-based observational data internationally	global	global
20	Hectares BC Pilot: A system for geospatial data analysis in the natural resource sector.	Canada	region

Many of the examples above are also referenced in the **European Union Location Framework (EULF) Blueprint**, which includes guidance on optimising return on investment and contains benefits illustrations for 15 types of location applications, with 34 case studies (qualitative and quantitative analysis). The information is available online in Joinup[16] and in a published report[17].

Categorising benefits

On the basis of the above, we scanned these cases to identify what kind of quantifiable benefits the related analyses are referring to. At this point it needs to be stressed again that the focus here is on quantifiable benefits. In the literature reviewed for this report, we found many claims for other benefits of interoperability in the location domain, including transparency, democracy and many more. While it is possible to quantify those elements as well, they often rely on proxy indicators and require dedicated data collection for example through opinion surveys. The focus here, however, is on **benefits that can more readily be measured** and counted, which means they usually rely on direct indicators such as time and money. Across the different cases we found many quantifiable benefits of location interoperability, which we clustered into three categories.

1. Public sector efficiency

Location interoperability can help increase public sector efficiency. This usually refers to a reduction of working time per task of public sector employees. If data collected by a public administration follows a commonly accepted and used standard, then this data does not have to be reformatted before sharing with external agents (e.g. for reporting), therefore saving working time. If location data is made available through an API, a public administration does not have to deal with individual requests for accessing this data.

2. Effective public services

Effectiveness in public services refers to achieving the expected outcomes of those services. Location interoperability can greatly increase effectiveness of public services. It can for example increase the accessibility of data for businesses and citizens, therefore saving time and eventually money in the economy. Furthermore, location interoperability can help make more informed decisions due to better data. This is for example instrumental in effective environmental management and can lead to less greenhouse gas emissions or more biodiversity.

3. New market opportunities

Making interoperable location data available can also lead to new and better market opportunities. By making location data interoperable, larger and integrated datasets can be created that allow entrepreneurs to develop new services. Interoperable land use data or property registers can for example benefit real estate developers.

16https://joinup.ec.europa.eu/collection/elise-european-location-interoperability-solutions-e-government/solution/eulf-blueprint/about

17 https://joinup.ec.europa.eu/node/704723

Open and interoperable address data might be useful for mobility and delivery services. The possibilities for new market opportunities through location interoperability are only limited by the imagination of entrepreneurs.

Structuring cases along benefits

Following the categorisation of benefits into the three categories, we analysed the identified cases again to understand which benefits had been found for which case. This attribution helps to understand were the main impact of interoperability benefits lie. Of the 20 cases identified, 9 showed claims of location interoperability contributing to increased public sector efficiency, 13 to improved public service effectiveness and 7 to creating market opportunities, while for one case we could not attribute a specific category of benefits.

2.1 Case studies on location interoperability – a deep dive

In this section we take a deep dive into the cases identified by this report and provide a closer look at the evidence of quantifiable location benefits these cases exhibit. We present each case following a common structure, starting with cases from EU Member States followed by cases from outside the EU.

2.1.1 Case studies from EU Member States

<table>
<tr><td colspan="2">#1 - National availability of geodata in the community building process in Sweden.</td></tr>
<tr><td>Country: Sweden</td><td>Scale: country</td></tr>
<tr><td>Benefits category:
Public sector efficiency
Effective public services</td><td>Source:
Lantmäteriet (2019) Ekonomisk nytta av ett samlat nationellt tillgängliggörande av geodata i samhällsbyggnadsprocessen. Retrieved online 20.09.2021 from https://www.lantmateriet.se/contentassets/50c7b8feec4744e5a0fa2ffaf0ea07ec/519-2018_2889-bilaga-2-ekonomisk-nytta-rattelse-190514.pdf

Spatineo & GIS-kvalitet i Norden (2019) Ekonomisk nytta av geodata i samhällsbyggnadsprocessen i Sverige. Retrieved online 20.09.2021 from https://www.spatineo.com/the-economic-benefits-of-geodata-in-digital-urban-planning-and-building-process/</td></tr>
<tr><td colspan="2">Description:
The National Land Survey of Sweden (Lantmäteriet) conducted a study in 2019 to estimate the potential economic benefit of the use of geodata in the digital urban planning and building process in Sweden. A comprehensive assessment of the economic value of the use of spatial data and digital tools in urban planning and building, including all its sub-processes, was not possible. The study nevertheless concludes that an uninterrupted flow of information in this area could save billions of Swedish krona (SEK). The study identifies direct benefits and indirect benefits. Direct benefits refer to making the location data available nationally in a standardized form. Indirect benefits are related to tools and processes that would be developed based on the availability of standardized location data. The estimated annual economic value is 22,6 – 42,2 billion SEK. Part of this is based on estimated 60% savings of the total man-time spent on inquiry and investigation. Municipalities would receive 256 million SEK in direct benefits, government agencies 538 million SEK, and construction companies (private or public) 22,000 million SEK.</td></tr>
</table>

#2 - The value of the geolocation economy in the Netherlands.	
Country: Netherlands	**Scale**: country
Benefits category: • Effective public services • New market opportunities	**Source**: Geospatial Media and Communications (2021) Netherlands Geolocation Economy Report. Retrieved online 20.09.2021 from https://geospatialmedia.net/reports/the-netherlands-geolocation-economy-report/
Description: In 2021, the Ministry of the Interior and Kingdom Relations of the Netherlands and Geonovum, the National Spatial Data Infrastructure (NSDI) executive committee, commissioned a study to estimate the economic impact of geolocation technologies in the Netherlands. The report estimates this impact to be EUR 35.5 Bn. This can be broken down into benefits for businesses of EUR 31 billion, benefits for consumers of EUR 4.5 billion. The benefits for consumers can further be split into the time saved by commuters by using digital maps (estimated at EUR 2.5 bn) and fuel savings due to improved navigation (estimated at EUR 1.95 bn). Although the report goes significantly beyond assessing the impact of location interoperability, it also clearly emphasises its importance. The report for example mentions interoperability as a crucial precondition for the development of Digital Twins. Furthermore, the report recommends setting up standards and interoperability frameworks to further support the development of the geolocation economy.	

#3 - Evaluation of the INSPIRE Directive implementation in Lithuania.	
Country: Lithuania	**Scale**: country
Benefits category: • Public sector efficiency • Effective public services	**Source**: V. Cetl, V. Nunes de Lima, R. Tomas, M. Lutz, J. D'Eugenio, A. Nagy, J. Robbrecht, Summary Report on Status of implementation of the INSPIRE Directive in EU, EUR 28930 EN, Publications Office of the European Union, Luxembourg, 2017, ISBN 978-92-79-77058-6, doi:10.2760/143502, JRC109035. Retrieved online 20.09.2021 from https://publications.jrc.ec.europa.eu/repository/handle/JRC109035
Description: The INSPIRE Directive, 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, entered into force in May 2007. It is one of the main pillars of location interoperability in Europe. In 2017, the Commission's Joint Research Centre published a report, summarising the status of implementation of INSPIRE. The report takes a specific look at the implementation of the directive in Lithuania. It finds that, through the implementation of INSPIRE, Lithuania was able to achieve public service savings of around 1.2 million € in working days. The total socio-economic benefits are estimated at 0.9 million € in the year 2014 and at an average of 1.8 million € annually in the following years.	

#4 - Evaluation of the INSPIRE implementation in Spain.	
Country: Spain	**Scale**: country
Benefits category: • Effective public services	**Source**: V. Cetl, V. Nunes de Lima, R. Tomas, M. Lutz, J. D'Eugenio, A. Nagy, J. Robbrecht, Summary Report on Status of implementation of the INSPIRE Directive in EU, EUR 28930 EN, Publications Office of the European Union, Luxembourg, 2017, ISBN 978-92-79-77058-6, doi:10.2760/143502, JRC109035. Retrieved online 20.09.2021 from https://publications.jrc.ec.europa.eu/repository/handle/JRC109035
Description: The benefits of the implementation of INSPIRE, as one of the main pillars of location interoperability in Europe, can be assessed at national level (see case on Lithuania above) or in more specific use cases. The JRC Summary Report on Status of implementation of the INSPIRE Directive in the EU finds one such specific use case for Spain. Here, the geoportal for hydrocarbons of the ministry of industry, commerce and tourism enables savings for citizens of up to EUR 60 million / year. This is in line with other specific use cases from Denmark and Poland for example.	

#5 - Evaluation of regional Spatial Data Infrastructure in Catalonia.	
Country: Spain	**Scale**: region
Benefits category: • Public sector efficiency • Effective public services	**Source**: M. Craglia, M. Campagna (2010) Advanced Regional SDI in Europe: Comparative cost-benefit evaluation and impact assessment perspectives. In International Journal of Spatial Data Infrastructures Research. Retrieved online 20.09.2021 from https://www.researchgate.net/publication/215591771_Advanced_Regional_SDIs_in_Europe_comparative_cost-benefit_evaluation_and_impact_assessment_perspectives
Description: The early 2000s saw the establishment of Spatial Data Infrastructures across Europe, including those at regional level. A 2010 study undertook a comparative cost-benefit analysis of two regions in the EU. One of them was Catalonia. The study found that the total direct cost of establishing and operating the regional spatial data infrastructure, the Infraestructura de Dades Espacials de Catalunya (IDEC), over a five-year period (2002-06) was €1.5 million. Regarding benefits, the study extrapolates findings from 20 local authorities (from a total of 100 municipalities that participate in the IDEC). The internal efficiency benefits account for over 500 hours saved per month. Using an hourly rate of €30 these savings exceed €2.6 million per year. In addition, the study estimates effectiveness savings of another 500 hours per month.	

#6 - Evaluation of regional Spatial Data Infrastructure in Lombardy.	
Country: Italy	**Scale**: region
Benefits category: • Effective public services	**Source**: M. Craglia, M. Campagna (2010) Advanced Regional SDI in Europe: Comparative cost-benefit evaluation and impact assessment perspectives. In International Journal of Spatial Data Infrastructures Research. Retrieved online 20.09.2021 from https://www.researchgate.net/publication/215591771_Advanced_Regional_SDIs_in_Europe_comparative_cost-benefit_evaluation_and_impact_assessment_perspectives
Description: Lombardia was among the regions that implemented regional spatial data infrastructures in Europe in the early 2000s. The study, Advanced Regional SDI in Europe: Comparative cost-benefit evaluation and impact assessment perspectives, analysed the costs and benefits of this development. With a specific focus on the effort required to do environmental impact assessments (EIA) or strategic environmental assessments (SEA), the study found the following net benefits to companies doing these studies: € 3 m/year in this application domain alone. Net benefits in this case refer to savings in time and cost to find and access the data needed for the EIAs/SEAs. This stands in contrast to total investments of the Lombardia SDI development and operation for the first three years (2004-2006) of € 1.36 million per annum.	

#7 - Impact of the open geographical data in Denmark.	
Country: Denmark	**Scale**: country
Benefits category: • Public sector efficiency • Effective public services • Market opportunities	**Source**: SDFE (2017) The impact of the open geographical data – follow up study. Retrieved online 20.09.2021 from https://sdfe.dk/data-skaber-vaerdi/nyheder/nyhedsarkiv/2017/mar/stor-stigning-i-vaerdien-af-de-frie-geografiske-grunddata/
Description: In 2013, as part of the country's digitalisation strategy, the Danish government opened up the country's geographical data. Open location data depends greatly on standardised and interoperable data formats. In 2017, the Danish Agency for Data Supply and Efficiency (SDFE) conducted a follow-up study on the impact of opening up its location data. The total socio-economic value of the open geodata in 2016 is estimated at DKK 3.5 billion, which is more than twice as much as estimated in 2012. The increase in socio-economic value is calculated partly as efficiency gains of approx. 1 billion DKK, and partly as so-called productivity gains of approx. 2.5 billion DKK. The study also finds that for the public sector, the most significant development is that the free spatial data is increasingly contributing to more efficient internal work processes and more efficient solution of government tasks.	

#8 - Evaluation of the INSPIRE implementation in the Netherlands.	
Country: Netherlands	**Scale**: country
Benefits category: unclear	**Source**: Geonovum (2016) Actualisatie KBA INSPIRE. Retrieved online 20.09.2021 from https://www.geonovum.nl/uploads/documents/Actualisatie_KBA_INSPIRE.pdf
Description: The European INSPIRE Directive was adopted into Dutch law in 2009 by royal decree. In 2016 Geonovum, a government funded foundation working on geolocation data, conducted a cost benefit analysis of the first years of the INSPIRE implementation. The study shows that over the total time horizon of the cost benefit analysis, the costs exceed the benefits by approximately EUR 50 to 60 million (2016 net value). More specifically, the costs during that time period amount to 64 million euros and the benefits in total from 4 to 14 million euros. However, the study also specifies there are several strategic effects of the implementation of INSPIRE that cannot be quantified. In addition, the study estimates that an expansion of the INSPIRE model to better meet the needs of actors in the Netherlands would offset its costs rather quickly. The costs to be incurred for the expansion of INSPIRE are expected to be recovered in a relatively short time of about 8 years.	

#9 - Value of Danish address data.	
Country: Denmark	**Scale**: country
Benefits category: • Market opportunities	**Source**: Danish Enterprise and Construction Authority (2010) The value of Danish address data: Social benefits from the 2002 agreement on procuring address data etc. free of charge. Retrieved online 20.09.2021 from https://docplayer.net/21079505-The-value-of-danish-address-data.html
Description: Address data is a crucial building block for many public and private services. Having this data available in a standardised and interoperable manner can be highly beneficial. Therefore, in 2002, the Danish government made the country's address data available openly and free of charge. In 2010, the Danish Enterprise and Construction Authority commissioned a study to evaluate the benefits that had been created by this policy. The study found that the direct financial benefit to society of opening the country's address data amounted to roughly DKK 471m (€62m) between 2005 and 2009. This stands in contrast to relatively small costs of DKK 15m (€2m) across the same period.	

#10 - The Use of Spatial Data for the Preparation of Environmental Reports in Europe	
Country: Europe wide	**Scale**: supranational
Benefits category: • Effective public services	**Source**: Craglia M, Pavanello L, Smith R. The Use of Spatial Data for the Preparation of Environmental Reports in Europe. EUR 24327 EN. Luxembourg (Luxembourg): Publications Office of the European Union; 2010. JRC58006. Retrieved online 20.09.2021 from https://publications.jrc.ec.europa.eu/repository/handle/111111111/13603
Description: Environmental Impact Assessments (EIAs) and/or Strategic Environmental Assessments (SEAs) are an important part of many policy developments. A study by the Commission's Joint Research Centre in 2010 found that practitioners working on producing these assessments were facing problems related to availability and interoperability of spatial data. Issues mainly relate to finding and accessing data of the quality needed for the purpose. The report further estimates that every year savings of 100-230 million Euro would be achieved if additional costs and time due to problems with the use of spatial data were removed.	

#11 - Benefits of e-cadastres	
Country: Europe wide	**Scale**: supranational
Benefits category: • Effective public services	**Source**: Maria Teresa Borzacchiello, Massimo Craglia, Estimating benefits of Spatial Data Infrastructures: A case study on e-Cadastres, Computers, Environment and Urban Systems, Volume 41, 2013, Pages 276-288, ISSN 0198-9715. Retrieved online 20.09.2021 from https://doi.org/10.1016/j.compenvurbsys.2012.05.004. https://www.sciencedirect.com/science/article/pii/S019897151200052X
Description: Spatial data infrastructures have been a crucial driver for location interoperability over the past decade. They have significantly contributed to providing online public services. A study in 2013 surveyed 44 European Cadastral Agencies to assess the benefits of providing services online. The result was that efficiency for users increased in terms of both time and costs by providing services online. The study further estimated that users could save up to €7 billion, with a complete shift to online services.	

2.1.2 Case studies outside the European Union

#12 - Economic Value of Spatial Information in New South Wales.	
Country: Australia	**Scale**: region
Benefits category: • Public sector efficiency • Effective public services • Market opportunities	**Source**: CRCSI (2017) Economic Value of Spatial Information in NSW. Retrieved online 20.09.2021 from https://www.crcsi.com.au/assets/Consultancy-Reports-and-Case-Studies/Value-of-NSW-Spatial-Information-final.pdf
Description: A report for the Spatial Information and the Spatial Services Division of the Department of Finance, Services and Innovation of New South Wales, Australia, estimates the economic value of spatial information in that region. The report acknowledges the role of interoperability through an emerging spatial data infrastructure. The report calculates net benefits in 2017 from improvements in productivity attributed to the use of spatial information for ten areas: • Land and property administration: 4.4 M AUD • Building construction and infrastructure: 13,5 M AUD • Smart buildings and infrastructure: 360 M AUD • Asset management: 43,2 M AUD • Utilities: 57,1 M AUD • Smart cities and local government: 7 M AUD • Emergency services, insurance and ambulance services: 17,5 M AUD • Agriculture: 21 M AUD • Forestry: 5,5 M AUD • Planning and Environment: 5 M AUD • Logistics: 70,5 M AUD	

#13 - Use of location data in the Glasgow Operations Centre.	
Country: UK	**Scale**: local
Benefits category: • Public sector efficiency	**Source**: D. Di Giacomo, B. Kudzmanaite, A. Zamboni, G. Cacciaguerra Ranghier (2018) Assessment of economic opportunities and barriers related to location data in the context of the Digital Single Market. European Commission, DG Joint Research Centre, Retrieved online 20.09.2021 from https://joinup.ec.europa.eu/collection/elise-european-location-interoperability-solutions-e-government/document/report-assessment-economic-opportunities-and-barriers-related-geospatial-data-context-digital-single
Description: Glasgow Operations Centre is an integrated traffic and public safety management system. It brings together Public Space CCTV, security for the city council's museums and art galleries, Traffic Management and Police Intelligence. An underlying enabler for such an integrated management approach is interoperability of the data that is used. A 2018 report for the Commission's Joint Research Centre estimates that the use of location data to enhance process efficiency has led to savings of up to £20 million for the centre since its inception.	

#14 - Potential Geospatial Economic Opportunity in the UK.	
Country: UK	**Scale**: country
Benefits category: • Effective public services • Market opportunities	**Source**: UK Cabinet Office (2018) An Initial Analysis of the Potential Geospatial Economic Opportunity. Retrieved online 20.09.2021 from https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/733864/Initial_Analysis_of_the_Potential_Geospatial_Economic_Opportunity.pdf
Description: A 2018 study for the UK Geospatial Commission analysed the economic potential of location data for the private sector in the UK. The study focussed on productivity gains, such as reduced time needed to complete a process or reduced fuel consumption due to route optimisation. In addition, the analysis considers material savings such as reduced error rates in the construction sector. The report finds that government, through more accessible and better-quality location data, could unlock up to £6-11 bn per year, of which over £4bn per year fall on the construction sector. The report emphasises the role of interoperability for unlocking this economic potential.	

#15 - Cost Benefit Analysis of Address and Street Data for Local Authorities and Emergency Services in England and Wales.	
Country: UK	**Scale**: region
Benefits category: • Public sector efficiency • Effective public services	**Source**: GeoPlace (2016) Cost Benefit Analysis of Address and Street Data for Local Authorities and Emergency Services in England and Wales. Retrieved online 20.09.2021 from https://www.geoplace.co.uk/case-studies/geoplace-identifies-4-1-roi
Description: Address and street data are among the core of location data and offer a wide range of applications. In the UK, a study commissioned by the publicly owned company GeoPlace, conducted a cost benefit analysis of address and street data for local authorities and emergency services in England and Wales. The study from 2016 estimated net benefits up to £202 million by 2020 from better use of the address and street data that councils create and maintain. This would represent a return on investment after discounting of 4:1.	

#16 - Value of Transport for London's open data and digital partnerships.	
Country: UK	**Scale:** local
Benefits category: • Market opportunities.	**Source**: TFL (2017) Assessing the value of TfL's open data and digital partnerships. Retrieved online 20.09.2021 from http://content.tfl.gov.uk/deloitte-report-tfl-open-data.pdf
Description: Transport for London (TFL) is a local government body responsible for most of the transport network in London. As such the company owns and generates large amounts of location data, and provides this data in open formats. This includes for example the locations of rail lines, embarkation points and facilities, and georeferenced data – such as timetables, transit status, and updates about disruptions and scheduled works. In 2017, a study assessed the value of TFL's open data and digital partnerships. It found that Transport for London generates economic benefits and savings of up to £130m each year, by opening access to location data. This stands in contrast to a relatively small estimated cost of around £1m per year for publishing the data openly.	

#17 - Benefits from use of geographic information systems by King county, Washington	
Country: USA	**Scale**: local
Benefits category: • Public sector efficiency	**Source**: Zerbe, Richard & Fumia, D. & Reynolds, T. & Singh, P. & Scott, T. & Babinski, Greg. (2015). An analysis of benefits from use of geographic information systems by King county, Washington. 27. 13-28. Retrieved online 20.09.2021 from https://www.researchgate.net/publication/298697965_An_analysis_of_benefits_from_use_of_geographic_information_systems_by_King_county_Washington
Description: A geographic information system (GIS), now widely used in the public and private sector, is a system that creates, manages, analyses, and maps all types of data. A precondition for using GIS is that data is available in standardised and interoperable formats. King County in Washington state, with the county seat in Seattle, conducted a return on investment study regarding the use of GIS in its administration. To do so, they created a model of King County's outputs and public services with and without the use of GIS. The study concludes that GIS appears to be an efficient, highly beneficial investment for King County. The most conservative estimate finds that GIS produced $775 million in net benefits from 1992 to 2010.	

#18 - The Value of OS OpenData™ to the Economy of Great Britain	
Country: UK	**Scale**: country
Benefits category: • Market opportunities	**Source**: Assessing the Value of OS OpenData™ to the Economy of Great Britain – Synopsis. Retrieved online 20.09.2021 from https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/207692/bis-13-950-assessing-value-of-opendata-to-economy-of-great-britain.pdf
Description: The UK Ordnance Survey (OS) is Great Britain's mapping agency. The OS Open Data Initiative, started in 2010, initially provided eleven Ordnance Survey digital datasets in standardized and interoperable formats. The data was delivered through an open data portal. In 2013, the OS commissioned a study assessing the economic impact of opening up those eleven datasets for free use and re-use by anyone. The study, in a conservative estimate claimed that by 2016, the country's real GDP would have increased by between a lower bound of £13.0 million, and an upper bound of £28.5m as a direct result of the open data initiative. The net increase in real taxation revenue would have been between a lower bound of £4.4million and an upper bound of £8.3million, according to the estimates. The study argues that while the economic impact was modest, it gave an indication of the positive net economic impact of a relatively small policy change.	

#19 - Socioeconomic benefits of exchanging surface-based observational data internationally	
Country: global	**Scale**: global
Benefits category: • Public sector efficiency • Effective public services • Market opportunities	**Source**: Kull, Daniel; Riishojgaard, Lars Peter; Eyre, John; Varley, Robert A.. 2021. The Value of Surface-based Meteorological Observation Data. World Bank, Washington, DC. © World Bank, WMO, and British Crown, Met Office. Retrieved online 20.09.2021 from https://openknowledge.worldbank.org/handle/10986/35178
Description: Meteorological observations based on data are behind many crucial services, such as weather forecasts, warning of life-threatening hazards, and long-term climate change projection. This creates significant societal benefits. However, data such as surface-based observation data is not sufficiently available for some regions of the world. A further sharing of such data in interoperable formats could lead to further societal benefits. A study by the World Bank, the World Meteorological Organisation and the Met Office (UK), estimates that improving the collection and international exchange of surface-based observational data would deliver additional socioeconomic benefits worth more than US $5bn a year.	

#20 - Hectares BC Pilot: A system for geospatial data analysis in the natural resource sector.	
Country: Canada	**Scale**: Regional
Benefits category: • Public sector efficiency • Effective public services	**Source**: Geospatial Return on Investment Case Study: Hectares BC. Retrieved online 20.09.2021 from https://ftp.maps.canada.ca/pub/nrcan_rncan/publications/STPublications_PublicationsST/288/288867/cgdi_ip_18.pdf
Description: Hectares BC was a pilot project in British Colombia, Canada. The collaboration between several government entities developed a system for geospatial data analysis in the natural resource sector. Hectares BC granted anyone with web access the ability to view, download or analyse large volumes of data with a query tool. Such a common platform requires underlying interoperability of data. An evaluation in 2010 found that the cumulative costs for this ten-year project ($903,767) were amortized after three years with an annual return on investment of 108%. The study found that the greatest benefit of this system was increased productivity of staff, followed by a reduction in costs to acquire data for environmental assessments.	

2.2 Conclusions from analysing the case studies

Analysing these cases can shed light on location interoperability and help us understand its value. The first take away is that interoperability in the location domain paints a **very diverse picture.** This is due to the cross-cutting nature of location data in many sectors of the economy and in the public sector, as well as the **horizontal nature of interoperability as an enabling factor**. The cases we collected and analysed in this report come from ten different countries, across all levels of government, and include applications as diverse as transport and urban planning, meteorology, and open data. This, as just explained, speaks to the very strong cross-cutting nature of location interoperability. However, it leads also to a strong **fragmentation of the evidence base**, which makes it difficult to extrapolate benefits of location interoperability from the level of individual cases to, for example, the EU level.

The analysis of the case collection has also revealed another trend regarding the evidence base on location interoperability. Of the twenty cases analysed, six are ex-ante projections, three are global estimates and approximations about the value of geodata in a specific area, and only eleven, **about half, are concrete ex-post policy or project evaluations**. Of those eleven ex-post evaluations, many are related to the implementation of the INSPIRE Directive. While the first two categories do have their place and purpose, their data carry more methodological uncertainties. Furthermore, all the studies, whether ex-ante or ex-post contain caveats in the assumptions made which are usually explained but may or may not have been factored into the calculations to an appropriate degree. These uncertainties place other limitations on the explanatory power of the case study collection and the possibility to extrapolate to a higher level.

There may be value however in exploring underlying cases below the macro level that most of these studies cover and using **individual illustrations to communicate best practices** and encourage similar actions across stakeholder communities. For example, in the UK both Ordnance Survey and GeoPlace publish extensive libraries and map-based views of case studies using their products, highlighting the outcomes and benefits for their customers.

In addition to the diversity and quality of the evidence that can be taken from a case collection of location interoperability, there are further learnings we can take from analysing this case collection. Those additional learnings concern the **challenges of conceptualising interoperability** and how this poses a challenge for identifying quantifiable interoperability benefits.

Interoperability - in the location domain or generally - is **never an aim in itself, but always an enabling precondition** for achieving other goals and creating value. In environmental policy, for example, the aim might be protecting and nurturing the environment. To achieve this aim, interoperability might be necessary because it standardises environmental reporting. This is, for example, the case of the INSPIRE Directive. In the same way, interoperability measures are rarely a stand-alone action. In order to achieve their objectives, policy initiatives will have to combine interoperability measures with other elements to further legal, organisational, semantic,

technical, interoperability. For example, interoperable data will not lead to impact unless it is also findable and accessible by those who need it. Interoperability is therefore **a necessary, but not a sufficient condition to achieving policy goals**.

This also manifests itself in the case studies. All of them relate to the use of data for particular purposes and not the existence of the data nor the interoperability aspects of the data, or ways of accessing the data. None of the studies is solely about location interoperability. However, this does not take away the importance of location interoperability in deriving benefits. On the contrary, in this context it is **important to reflect on the cost of non-interoperability**. Few if none of the cases we analysed would have been possible without underlying interoperability.

Because it is **challenging to isolate interoperability measures from other input factors**, further down the line, it is even more difficult to attribute specific outputs or outcomes to interoperability measures. The narrower the policy or action, the easier its output and outcome can be measured. On the other hand, the broader the policy or action, the more difficult it is to pinpoint the output and outcome that can be specifically attributed to interoperability elements. The clearest examples are those at a project level in single administrations. In the circumstances, where broad-ranging policies sit within a highly complex landscape of external factors and varying degrees of history and maturity in dealing with a topic in different administrations (nationally) or different Member States (at an EU level), in these it is more difficult to assess the quantifiable benefits of interoperability.

3 Calculating the economic impact of location interoperability

So far, we looked at case studies as a way to identify the benefits of location interoperability. This approach led to a rich and informative landscape of diverse use cases. However, this diversity in the use cases has also brought a limitation for the aims of this report. Based on the cases we collected, and due to the diverse landscape they create, it is difficult to extrapolate and make general statements about – and calculate the economic impact of- the benefits of location interoperability at the European level. Therefore, in this chapter, we are complementing the case study approach with an economic impact assessment of location interoperability. To do so, we are following a two-step approach. First, we are calculating the **impact of public sector interoperability overall.** In a second step, we are **breaking down this calculation for the location sector.**

3.1 Economic impact of interoperability in the EU overall

Governments perform many tasks and roles, such as the provision of services and goods for citizens, the maintenance of the social and economic order and the stabilisation of the economy, among others. Moreover, public administrations must transform the way they function by using more information and communication technologies in order to remain responsive and efficient. This challenge was further revealed during lockdowns in individual countries due to COVID-19, which affected their social and economic development. The solution to that challenge is the impulse of digital government, increasing innovation in governance processes as well as efficiency and effectiveness by offering more participative opportunities to citizens. To provide citizen-centric, efficient operations and services, governments must challenge the traditional way of cooperation, and improve technical, legal, semantic, as well as organisational interoperability. **Interoperability is thus an essential component of digital government**.

In order to fulfil their missions, governments require natural persons (citizens) and legal entities (firms) to carry out a series of administrative procedures. The bureaucracy associated with these requirements imposes costs to these economic and social agents in terms of time, effort and money spent in carrying out these tasks. In addition, the way these requirements are organised, also implies an investment of resources from the public sector. The adoption of information and communication technologies to facilitate the relationship with the public sector can reduce the resources necessary to perform the required procedures. However, there is little information and data that can be used to calculate an appropriate economic impact of this "administrative burden" and how advances in digital government solutions may reduce it. In the first step, we look at the impact of **increased interoperability of public services for citizens, firms and the public sector itself**, as well as the total expected impact.

3.1.1 The impact on Citizens

Citizens are required to perform a series of administrative procedures vis á vis the public sector during their life that vary in frequency, complexity, and effort required. For instance, new-borns need to be registered only once, but taxes must be paid every year. The different procedures have changed with the adoption of technology, and the associated resources required to fulfil them have been decreasing over time. From the citizens' perspective, we assume that the benefits of enhanced interoperability of public services will manifest as time savings in their relationship with the administration.

In order to proceed with the calculations, from the Harmonised Time Use Survey (HTUS18,19), we extract information about how much time European citizens devote to their relationships with public administrations by country. The information provided is the average time (in minutes) per individual[20]. The average time spent of every adult citizen in the EU-27 in the year 2019 was 25 minutes[21]. These figures imply that in the EU-27 in 2019, **152 million hours were needed** to fulfil the requirements of the administration in terms of administrative procedures.

18 https://ec.europa.eu/eurostat/web/time-use-surveys/data/database

19 The Harmonised European Time Use Surveys (HETUS) are national surveys conducted in European countries to quantify how much time people spend on various activities, including paid work, household chores and family care, personal care, voluntary work, social life, travel and leisure. HETUS is held about once a decade on the basis of a gentlemen's agreement between participating countries and Eurostat. The last wave corresponds to the year 2010 and the new one was planned for 2020, although delayed due to Covid-19.

20 This is an extrapolation as not all individuals report having relationships with the administration. HTUS also provides information about the real time spend with the administration and the share of individuals reporting this variable.

21 The information is available for 18 EU-27 countries only. In order to complete the information, we have performed a simple extrapolation using population data.

However, not all individuals interact with the administration in the same way. Some citizens use digital technologies to carry out some –if not all- their interactions with the administrations while others prefer more traditional methods. To take this fact into account, from the statistics on ICT usage in households and by individuals[22], we obtain information about the proportion of the population that use the internet to interact with public authorities. In 2019, the EU-27 average was 53%, with important differences by Member State.

In order to calculate the economic impact of increased interoperability of public sector information systems, we assume two scenarios. In the first one, we consider that an increase in interoperability would reduce exclusively the time devoted by those individuals already using the internet to deal with the administration. In the second one, we conjecture that enhanced interoperability, due to improved accessibility and service quality, would also motivate some individuals to engage with the administration online[23]. Due to the lack of relevant data, the assumptions for the analysis are ad-hoc and correspond to a hypothesised reduction in the number of hours required for citizens to interact with the administration (respectively an increase in the number of people using the internet to interact with the government) of 25% (respectively, an increase of 15% with a ceiling of 100%[24]). Comparing each of these two scenarios with the baseline number of hours per year devoted to the relationship with the administration, we are able to compute time savings from enhanced interoperability. Moreover, using the hourly wage rate as a measure of the value of time, we can put a monetary value to these time savings. Table 3 provides the results of the calculations of the two scenarios, both in terms of hours saved and economic impact, by country. As the table shows, the **time saved from enhanced interoperability of the public sector information systems ranges from 21 to 24 million hours per year.** Further improvements in interoperability, or changes in the proportion of individuals using the internet to interact with the public sector, would change these estimates. Similarly, by multiplying the number of hours saved by the hourly wage rate per country, we obtain the economic value of the time savings observed in each scenario. In this case, the **monetary savings can be in the order of EUR 473 to 543 M**. Figures 1 and 2 present the results graphically.

22 https://ec.europa.eu/eurostat/web/digital-economy-and-society/data/database

23 In this case, this proportion cannot exceed the maximum of 100%.

24 This only happens in the case of Denmark and Finland.

Table 3. Citizens: time saved and economic impact from enhanced interoperability in 2019, by country

	Time saved (M hours)		**Economic Impact (M EUR)**	
	Scenario 1	**Scenario 2**	**Scenario 1**	**Scenario 2**
Belgium	0.6	0.7	18.7	21.5
Bulgaria	0.1	0.1	0.5	0.6
Czechia	0.4	0.5	4.3	4.9
Denmark	0.5	0.5	18.7	20.3
Germany	5.4	6.2	151.6	174.3
Estonia	0.1	0.1	0.8	0.9
Ireland	0.2	0.3	5.8	6.7
Greece	0.3	0.4	3.9	4.4
Spain	2.3	2.7	36.4	41.8
France	4.0	4.6	101.1	116.3
Croatia	0.1	0.1	0.8	0.9
Italy	1.2	1.3	23.0	26.5
Cyprus	0.0	0.0	0.4	0.5
Latvia	0.1	0.1	0.8	1.0
Lithuania	0.1	0.1	1.0	1.1
Luxembourg	0.0	0.0	1.1	1.3
Hungary	0.3	0.4	2.8	3.3
Malta	0.0	0.0	0.2	0.3
Netherlands	1.4	1.6	38.6	44.4
Austria	0.5	0.6	13.5	15.6
Poland	1.3	1.5	10.8	12.5
Portugal	0.3	0.3	3.1	3.5
Romania	0.1	0.1	0.9	1.1
Slovenia	0.1	0.1	1.3	1.4
Slovakia	0.2	0.3	2.3	2.6
Finland	0.4	0.5	11.3	12.9
Sweden	0.7	0.9	19.5	22.5

Figure 1: Citizens: time saved in million hours per year from enhanced interoperability, 2019

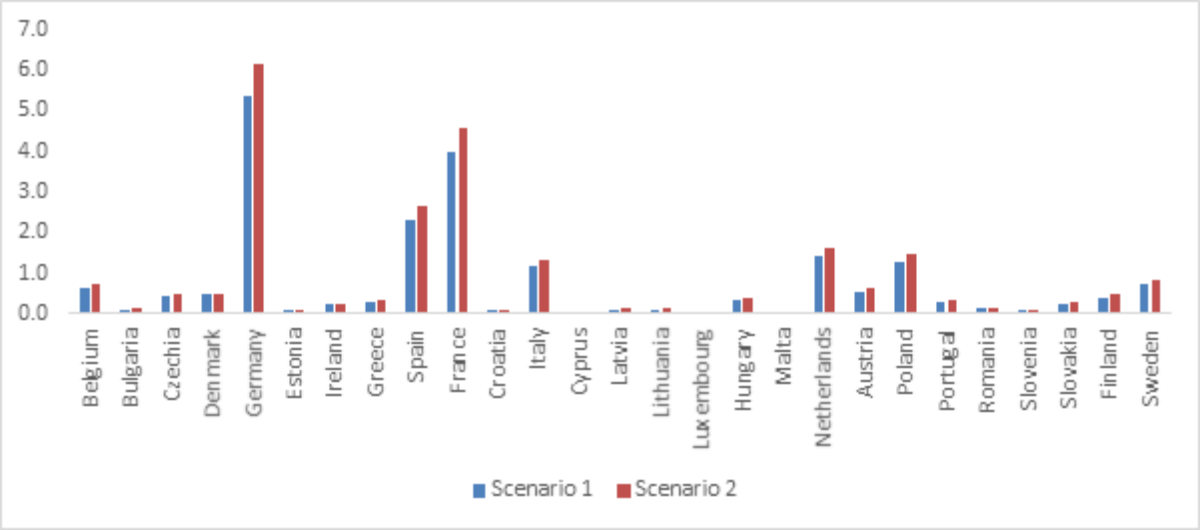
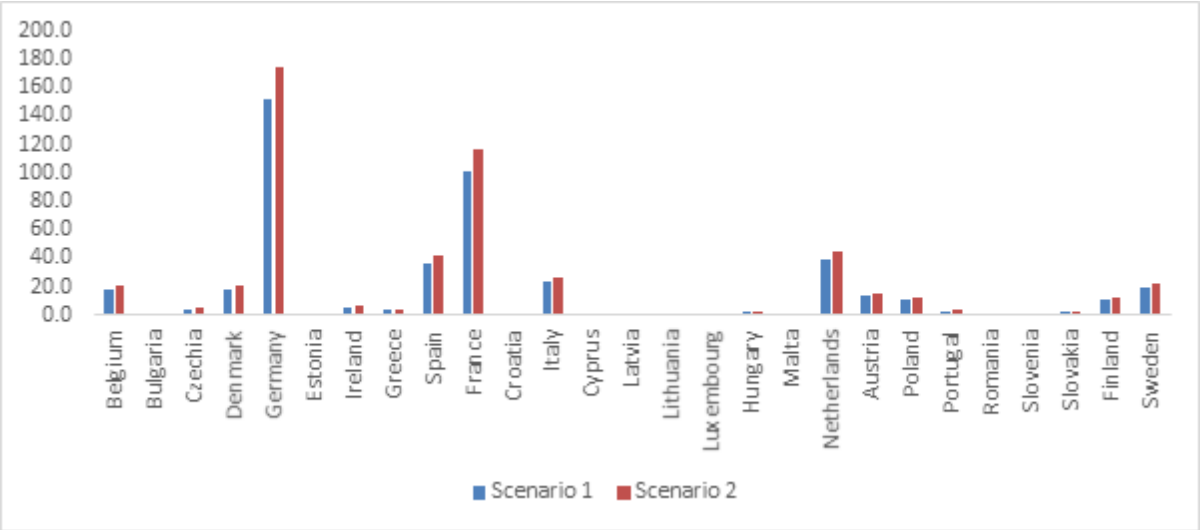


Figure 2: Citizens: economic impact (in M EUR) per year from enhanced interoperability, 2019



3.1.2 The impact on firms

Firms also deal with the administration in several ways, from collecting information to filling forms and taking care of administrative procedures. The Doing Business[25] report by the World Bank, presents quantitative indicators on business regulations and the protection of property rights that can be compared across 190 economies and over time. More specifically, this source offers information about the total number of steps and the time needed to fulfil all of them in eleven different categories of activities. Since three of them are referred to firms' relationships with the financial sector and another one with utilities, we focus on the remaining eight. These activities are:

- Starting a Business
- Dealing with Construction Permits
- Registering Property
- Paying Taxes
- Trading across Borders (both importing and exporting)
- Enforcing Contracts
- Contracting with the Government

25 https://www.doingbusiness.org/en/doingbusiness

From the referred source, we get information on the time required to carry out each of these activities in the 27 different EU MS. In order to calculate the total time per country, we need to identify a precise reference to use in each of the cases. The references used are the following:

Table 4: Business events requiring interaction with the administration

Concept	**Reference**	**Source**
Starting a Business	Firms created in year t	Eurostat
Dealing with Construction Permits	Number of residential property construction starts per 1,000 citizens	Deloitte, Property Index 2021: Overview of European Residential Markets
Registering Property	Number of housing transactions	European Central Bank
Paying Taxes	All firms active in the economy in year t	Eurostat
Trading across Borders (both importing and exporting)	Importers and exporters in year t	Eurostat
Enforcing Contracts	10% of the firms active in year t	Eurostat
Contracting with the Government	Number of annual tenders	Global Public Procurement Database, World Bank

A final assumption is that not all firms use the internet in their interactions with the administration. Hence, after computing all the time required to deal with the administration each year in each country, we split these hours in terms of those susceptible to be more affected by interoperability (corresponding to the share of firms using the internet to deal with the administration) and those that are not (the rest). This information comes from the OECD[26]. As in the case of citizens, a second scenario assumes that a proportion of firms would prefer to switch to internet-based transactions with the public sector as a result of improvements in interoperability, with a maximum of 100%.

As before, we proceed by multiplying the time required to fulfil each task by the number of firms that are assumed to carry out that specific activity, or the events that happened in the corresponding year that would justify the time requirements. After these calculations are done, we get a baseline scenario of all the hours required to perform all these business events in a given year. In 2019, **172 billion hours were required in the EU27 to perform all the operations listed in the previous table**.

Then, we assume, first, that improvements in interoperability of the public sector systems would allow reductions in the time required to perform all these activities and, second, that also a fraction of firms not using digital technologies in their relationships with the administration would adopt them, and compute the time required again.

Then, we can compare the number of hours required in each scenario with the baseline scenario and calculate the time savings, as well as the monetary savings assuming that each hour has a price equivalent to the wage we would need to pay the workers involved in the selected activities. The results are presented in the following table, as well as in figures 3, for time savings, and 4, in monetary terms. As the table and the figures show, the first scenario would imply a **reduction in the time required** to fulfil the selected administrative transactions of about **27.6 billion hours**, whereas in scenario 2 the figure would be **30 billion hours.** If we translate this into monetary terms, **savings would be of EUR 521 and 568 billion in scenario 1 and 2, respectively.**

26 https://www.oecd.org/gov/government-at-a-glance-22214399.htm

The number of hours required in 2019 to perform all the business events considered might look high. Considering the number of employed individuals in the EU27 in that same year, and the total number of hours worked, dealing with the administration would represent around 35% of worked hours. Although this seems like a high proportion, we estimate that it is close to reality. According to the World Bank[27], the proportion of senior management time spent dealing with the requirements of government regulation was 9%. If this is the proportion of senior management time devoted to dealing with government, 35% on average for a typical firm does not seem too unrealistic. Moreover, informal evidence[28] also suggests that the average worker spends around 50% on administrative tasks, of which more than half are related to government regulations. More research would be needed to better understand how much time is devoted to fulfil the public administration requirements. However, for the purposes of this report they represent a good estimate.

Table 5: Improved interoperability and its impact on businesses in terms of time and money saved

	Time saved (M hours)		**Economic Impact (M EUR)**	
	Scenario 1	**Scenario 2**	**Scenario 1**	**Scenario 2**
Austria	672.7	736.4	17.2	18.8
Belgium	663.5	767.8	19.8	23.0
Bulgaria	317.7	367.5	1.6	1.8
Croatia	60.5	75.5	0.6	0.7
Cyprus	25.3	28.3	0.3	0.4
Czech Republic	1434.3	1496.7	14.2	14.8
Denmark	375.9	382.7	15.0	15.3
Estonia	122.6	131.7	1.2	1.3
Finland	341.8	358.5	9.5	10.0
France	4682.9	5116.4	119.4	130.5
Germany	1212.1	1363.1	34.3	38.6
Greece	151.4	162.8	1.9	2.0
Hungary	536.4	634.8	4.6	5.4
Ireland	71.3	78.7	1.9	2.1
Italy	4914.7	5577.5	97.3	110.4
Latvia	257.7	272.3	2.1	2.2
Lithuania	646.6	651.7	5.8	5.8
Luxembourg	31.0	35.7	1.1	1.3

27 https://www.enterprisesurveys.org/en/data/exploretopics/regulations-and-taxes

28 https://www.humanresourcesonline.net/managers-how-many-hours-a-day-do-you-spend-on-admin-tasks

Malta	68.5	68.9	0.9	0.9
Netherlands	1429.5	1451.3	38.9	39.5
Poland	1143.6	1194.9	9.7	10.2
Portugal	2263.0	2293.0	24.0	24.3
Romania	71.0	71.3	0.5	0.5
Slovak Republic	672.3	731.4	6.3	6.8
Slovenia	255.6	299.9	4.1	4.8
Spain	4525.0	4971.9	71.0	78.1
Sweden	698.1	734.5	18.4	19.3

Figure 3: Business: time saved in million hours per year from enhanced interoperability, 2019

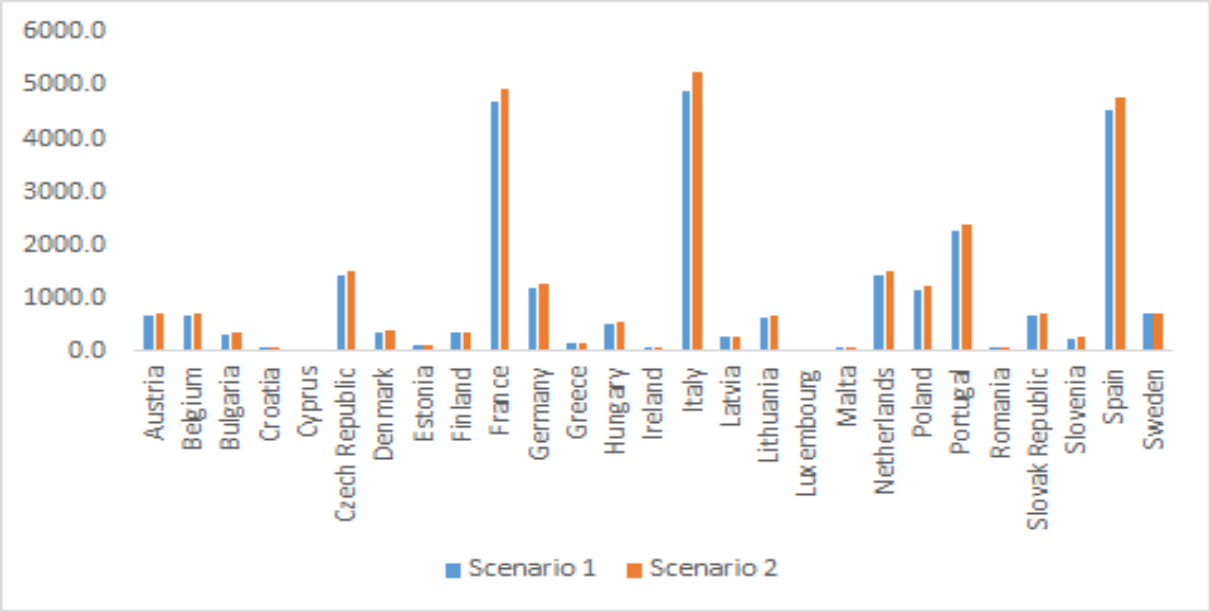
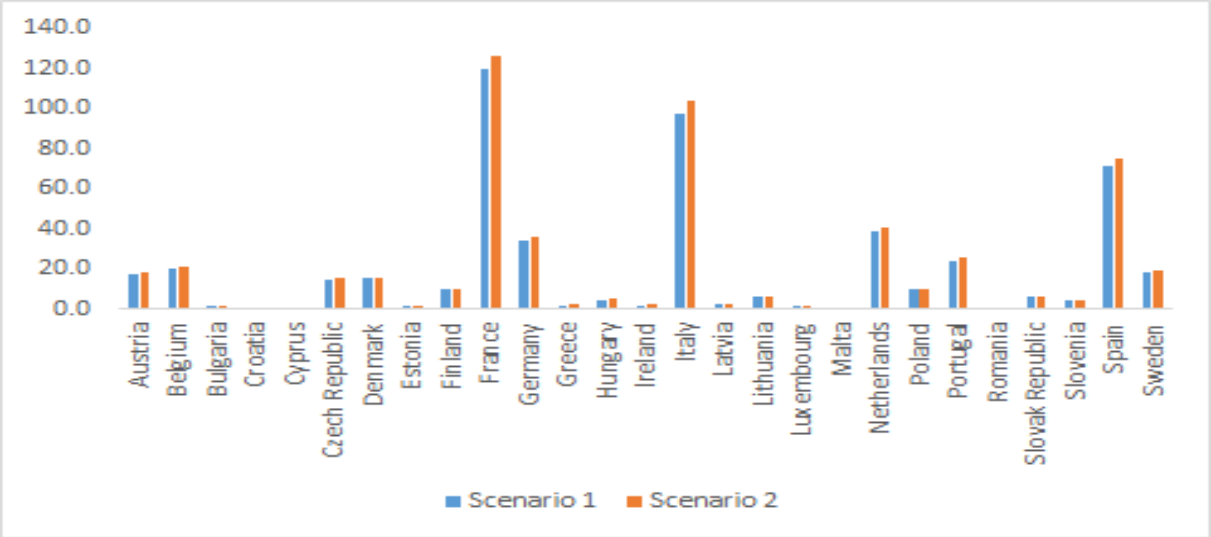


Figure 4: Business: economic impact (in M EUR) per year from enhanced interoperability, 2019



3.1.3 Impact on the public sector

To analyse how improvements in interoperability impact the public sector, we adopt a slightly different approach. In this case, we will relate changes in e-government readiness, measured by well-known international indicators- with changes in public sector performance indicators. In this setting, an implicit assumption is that the changes in e-government readiness are the result of enhanced interoperability in public sector systems. Hence, we will assess to what extent changes in interoperability that would imply an increase in 1% in the e-government indicator would imply changes in the selected indicators of public sector performance.

As a measure of e-government readiness, we use the **E-Government Development Index** (EGDI) published by the United Nations. The main advantage of this indicator over others is that it is available for a relatively long period of time, which allows an analysis that is more robust. Along with an assessment of the website development patterns in a country, this index incorporates the access characteristics, such as the infrastructure and educational levels, to reflect how a country is using information technologies to promote access and inclusion of its people. The index is a composite measure of three important dimensions of e-government, namely: provision of online services, telecommunication connectivity and human capacity. In a separate set of results, we will look at the relationship between the changes in the provision of online services (online service index) and changes in the public sector performance indicators. We assume that this sub-component of the EGDI reflects better the changes due to increased interoperability[1]. EGDI is published every two years. We will look at the period 2010-2020 with biennial information, for the EU27 MS.

We will use a battery of public sector performance indicators to study the potential impacts of increased interoperability. In addition, we will also look at the impact on GDP, to account for the potential gains in terms of value added in the EU economy as a whole. GDP is a basic measure of the overall size of a country's (or region's) economy. As an aggregate measure of production, GDP is equal to the sum of the gross value added of all resident institutional units engaged in production, plus any taxes on products and minus any subsidies on products. It can also be defined as the difference between output and intermediate consumption.

We will use several indicators to take account of the performance of the public sector. First, we will look at **general government production costs**. These come from decisions about the amount and type of goods and services governments produce, as well as on how best to produce them. They are often political in nature and based on a country's social and cultural context. Governments use a mix of their own employees, capital, and outside contractors (non-profit institutions or private sector entities) to produce goods and services. Government production costs include: compensation costs of general government employees; goods and services used and financed by general government (including intermediate consumption and social transfer in kind via market producers paid for by government); and other costs, including depreciation of capital and other taxes on

production less other subsidies on production. The data include government employment and intermediate consumption for output produced by the government for its own use, such as roads and other capital investment projects built by government employees. This indicator is published by the OECD and is measured as a percentage of GDP.

Second, we look at **Government Revenues**. Governments collect revenues mainly for two purposes: to finance the goods and services they provide to citizens and businesses, and to fulfil their redistributive role. Comparing levels of government revenues across countries provides an indication of the importance of the government sector in the economy in terms of available financial resources. The total amount of revenues collected by governments is determined by past and current political decisions. This indicator, also produced by the OECD, is measured as a percentage of GDP.

Third, **General government spending** provides an indication of the size of government across countries. The large variation in this indicator highlights the variety of countries' approaches to delivering public goods and services and providing social protection, not necessarily differences in resources spent. This indicator is measured in terms of percentage of GDP.

Fourth, **Government Effectiveness** indicates the quality of public service provision, the quality of the bureaucracy, the competence of civil servants, the independence of the civil service from political pressures, and the credibility of the government's commitment to policies. The main focus of this index is on inputs required for the government to be able to produce and implement good policies and deliver public goods.

Finally, we also look at some governance indicators, which examine each country's policy performance in terms of three dimensions of sustainable development. If the goal of politics is to promote sustainable development, and if citizens are to be empowered to live their lives in accordance with their own individual talents, then governments must be able to establish and maintain the social, economic and environmental conditions for such well-being and empowerment. The conditions for social progress must be generated by suitable outcomes in certain policy fields. Such outcomes are examined by the **Policy Performance indicator**.

Table 6: Impact of enhanced interoperability in public sector performance, EGDI

	(1)	(2)	(3)	(4)	(5)	(6)
	GDP	Costs	Revenues	Expenditure	Government Effectiveness	Policy performance
E-government index	0.418***	-0.346***	0.0772*	-0.596***	-0.200**	0.286***
	(0.0565)	(0.0799)	(0.0458)	(0.117)	(0.0943)	(0.0360)
Constant	10.91***	3.006***	3.685***	3.469***	2.004***	1.870***
	(0.0333)	(0.0484)	(0.0277)	(0.0710)	(0.0557)	(0.0212)
Observations	162	132	132	132	162	162
R-squared	0.998	0.834	0.927	0.680	0.965	0.937

Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

From table 6 we observe that **improvements in interoperability that would increase the EGDI by 1%** are associated to:

- an increase of **0,4% in GDP**
- a reduction in general government production costs in 0.3 percentage points of GDP
- an increase of general government revenues in 0.07 percentage points of GDP
- a reduction of general government expenditures of 0.6 percentage points of GDP
- a reduction of the inputs required for the government to be able to produce and implement good policies and deliver public goods of 0,2%
- an increase in policy performance of 0,3%

Similar results (with the exception of the positive effect on government revenues) are obtained if we replace the EGDI with the Online Service Index (OSI), as shown in table 7.

Table 7: Impact of enhanced interoperability in public sector performance, OSI

	(1)	(2)	(3)	(4)	(5)	(6)
	GDP	Costs	Revenues	Expenditure	Government Effectiveness	Policy performance
Online service index (log)	0.158***	-0.127***	0.0240	-0.206***	-0.0678*	0.113***
	(0.0234)	(0.0320)	(0.0182)	(0.0476)	(0.0384)	(0.0147)
Constant	14.50***	3.075***	3.667***	3.595***	2.399***	1.820***
	(0.0292)	(0.0397)	(0.0226)	(0.0592)	(0.0478)	(0.0183)
Observations	162	132	132	132	162	162
R-squared	0.998	0.830	0.926	0.663	0.964	0.935

Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 7 shows that a 1% increase in the Online Service Index due to improved interoperability would imply:

- an increase of **0,16% in GDP**
- a reduction in general government production costs in 0.13 percentage points of GDP
- an increase of general government revenues in 0.02 percentage points of GDP
- a reduction of general government expenditures of 0.2 percentage points of GDP
- a reduction of the inputs required for the government to be able to produce and implement good policies and deliver public goods of 0,07%
- an increase in policy performance of 0,1%

These results indicate that the potential positive benefits derived from increased interoperability for the public sector in the EU are considerable. For instance, converting these estimates to monetary terms, a 1%

improvement in the indicators used because of better interoperability would imply an **increase of the EU GDP in the range of EUR 21 to 56 billion.**

3.1.4 Total expected impact of improved interoperability

Summing up, the overall impact of enhanced interoperability in the EU27 considering all three dimensions will **range from EUR 432 billion** (adding up EUR 0,47 billion for citizens, EUR 521,6 billion for firms and EUR 21,2 billion for the public sector) **to EUR 625 billion** (the sum of EUR 0,54 billion for citizens, EUR 568,8 billion for firms and EUR 56 billion for the public sector). These figures should be interpreted with care due to the lack of more detailed and precise data to apply a more specific and sophisticated methodology[29].

3.2 Economic impact of location interoperability

After calculating the economic impact of interoperability overall, we are now looking at location interoperability specifically. To do so, we are introducing a few additional methodological steps, in order to break down the results above for their location dimension. In the world of geospatial data, one will often encounter the claim that 80% of all data is geographic. This claim however is rarely backed up with concrete evidence. Caitlin Dempsey[30] very illustratively shows the background of this claim and describes attempts to verify it. Due to the uncertainty surrounding this number, we are first attempting to examine it for the public sector before using it as a basis for further calculations. To do so, we analysed the data on the European data hub. The webpage data.europa.eu provides the counts of datasets based on file formats, which we used to establish how many data sets are geographic in nature. To do so, we compared the datasets of the portal with two reference lists[31] [32] of geospatial file formats. Our results show that 59% of all datasets on the European data portal come in file formats that are geographic based on these reference lists. We then further refined this search, since the two reference lists on file formats we used contain formats that might or might not be geographic. This means the 59% might be an overestimation. On the other hand, the reference lists we used in the first step are missing file formats that are clearly geographic e.g. ArcGIS Map Service, arcgis geoservices rest api, and more. This could mean the 59% are an underestimation. Hence, we further classified the file formats into 1. clearly geographic, 2. possibly geographic, and 3. not geographic. The analysis shows that **49% of all datasets on the European data portal are clearly geographic, 50% are possibly geographic, and only 1% is clearly not geographic.** Therefore, we assume the total number of location related data in the public sector to be between 49% and 99%. Which means the 80% claim could be close to the truth in the end. A more precise result would require checking each dataset's description using more advanced search techniques. For the purposes of our analysis though, this result is sufficient, since also many of the business events, and life events we used for our calculations above can be linked to location data.

In order to approximate the gains in overall interoperability that would come from location data, we combine our overall economic impacts with information about the proportion of location data in the public sector. Given the lack of more precise information, we simply apply a direct proportionality rule to the data. The results are shown in figure 5. **The estimated impact of improved location interoperability ranges from EUR 272 billion to EUR 500 billion**, depending on the proportion of location data in the public sector and also in the scenario considered.

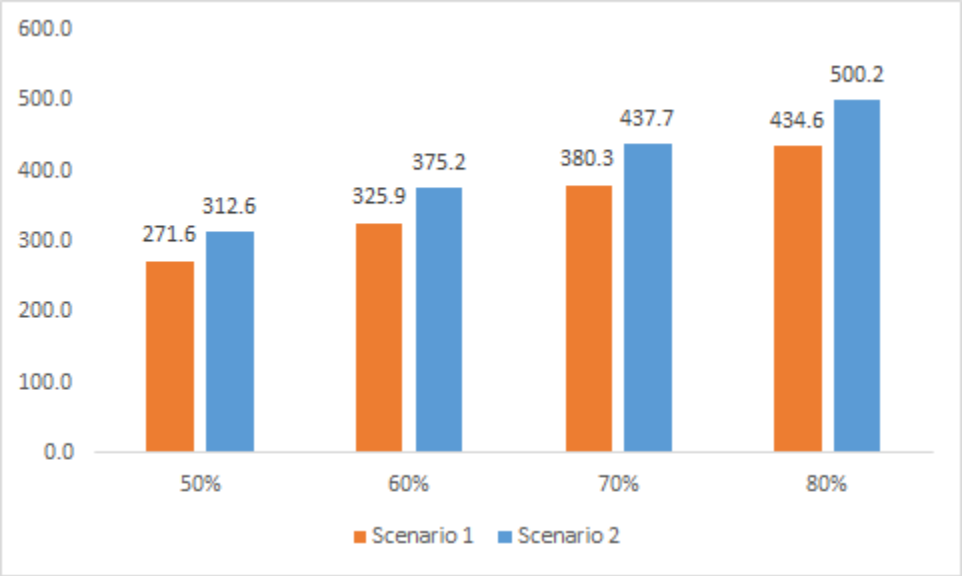
29 For details of the methodology used to construct these indictors, please see https://publicadministration.un.org/egovkb/Portals/egovkb/Documents/un/2016-Survey/Annexes.pdf

30 https://www.gislounge.com/80-percent-data-is-geographic/

31 sites.udel.edu/gis/file-formats-for-gis

32 gisgeography.com/gis-formats

Figure 5: Estimation of the economic impact of location interoperability in the EU27 (EUR billion)



The methodology used in this report has some limitations. The most important comes from the lack of appropriate data to evaluate with a higher degree of precision the different effects and impacts of location data in the structure of the public sector and the different competences attributed to its various levels. Another limitation comes from the fact that the methodology employed does not consider the uses of location data, just its availability. The fact that location data is available does not necessarily mean that it will be used. Hence, a more detailed methodology should control for the demand side of location data. Finally, the complexity of the public sector, in terms of its organisational structure, is relevant. All these elements in an enhanced methodological proposal are left for future research. The results presented here should be interpreted as an approximation to the real economic impact.

4 Conclusion

This report set out to quantify the benefits of location interoperability in Europe. It provided answers through two different research methodologies: one bottom up through case studies, one top down through an economic impact assessment of interoperability. The report has shown the great diversity in which interoperability of location data in the public sector can create benefits, be it for fostering public sector efficiency, developing better services, or creating new market opportunities. Furthermore, it shows the great potential impact that improved interoperability, of location data or in general, could have in Europe.

However, the report also points to the challenges of isolating the role interoperability plays in different policies. This is because interoperability is an enabler cutting across many policy fields. While doing so, it is never an aim in itself. Furthermore, interoperability is not likely to create impact by itself. It is the policies that are enabled and improved by interoperability that eventually create impact for citizens and businesses in Europe. This leads to three overall messages that we can take from this report:

1. In terms of methodologies, we need to get better at understanding the influence different factors have in creating policy impact.
2. We need to rigorously evaluate the impact of policies, not just ex-ante but especially ex-post.
3. Despite the methodological uncertainties, this report underlines the importance of further strengthening interoperability, of location data and generally, to create public value in Europe.

References

Boguslawski, Valayer,Mazzoli Kronborg , Pignatelli, European Union Location Framework Blueprint, EUR 30872 EN, Publications Office of the European Union, Luxembourg, 2021, ISBN 978-92-76-42641-7, doi:10.2760/367025, JRC126653.

European Commission, *Shaping Europe's Digital Future*, KK-03-20-102-EN-N, Publications Office of the European Union, Luxembourg, 2020a (https://ec.europa.eu/info/sites/default/files/communication-shaping-europes-digital-future-feb2020_en_4.pdf) (accessed 12 August 2021).

European Commission, Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, *A European Strategy for Data*, COM (2020) 66 final, 2020b, pp. 1–34 (https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1593073685620&uri=CELEX%3A52020DC0066) (accessed 9 August 2021).

European Commission, *White Paper on Artificial Intelligence – A European approach to excellence and trust*,COM (2020) 65 final, 2020c, pp. 1–26 (https://ec.europa.eu/info/sites/default/files/commission-white-paper-artificial-intelligence-feb2020_en.pdf) (accessed 12 August 2021).

European Commission, Best Practices in Citizen Science for Environmental Monitoring, Commission Staff Working Document, SWD (2020) 149 final, 2020d, pp. 1–75 (https://ec.europa.eu/environment/legal/reporting/pdf/best_practices_citizen_science_environmental_monitoring.pdf) (accessed 18 October 2021).

European Union, Directive (EU) 2019/1024 of the European Parliament and of the Council of 20 June 2019 on open data and the re-use of public sector information, Official Journal of the European Union, L 172, 2019, pp. 56–83 (https://eur-lex.europa.eu/eli/dir/2019/1024/oj) (accessed 9 August 2021).

Goodchild, M.F. 'Citizens as sensors: the world of volunteered geography'. *GeoJournal*, Vol. 69, No. 4, 2007, pp. 211-221, doi:10.1007/s10708-007-9111-y.

Granell, C., Kamilaris, A., Kotsev, A., Ostermann, F.O. and Trilles, S., 'Internet of things'. In: *Manual of Digital Earth*, Springer, Singapore, 2020, pp. 387–423, doi:10.1007/978-981-32-9915-3_11.

Kotsev A., Minghini M., Cetl V., Penninga F., Robbrecht J., Lutz M., INSPIRE – A Public Sector Contribution to the European Green Deal Data Space: A vision for the technological evolution of Europe's Spatial Data Infrastructures for 2030, EUR 30832 EN, Publications Office of the European Union, Luxembourg, 2021, ISBN 978-92-76-41564-0, doi:10.2760/8563, JRC126319.

Minghini, M., Kotsev, A. and Lutz, M., 'Comparing INSPIRE and OpenStreetMap data: how to make the most out of the two worlds'. *The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, Vol. XLII-4, No W14, 2019, pp. 167–174, doi:10.5194/isprs-archives-XLII-4-W14-167-20.

Mooney, P. and Minghini, M., 'A Review of OpenStreetMap Data'. In: *Mapping and the Citizen Sensor*, Ubiquity Press, London, 2017, pp. 37–59, doi:10.5334/bbf.c.

Sarretta, A. and Minghini, M., 'Towards the integration of authoritative and OpenStreetMap geospatial datasets in support of the European Strategy for Data'. *The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, Vol. XLVI-4, No W2-2021, 2021, pp. 159–166. doi:10.5194/isprs-archives-XLVI-4-W2-2021-159-2021.

Schade, S., Kotsev, A., Cardoso, A.C., Tsiamis, K., Gervasini, E., Spinelli, F., Mitton, I. and Sgnaolin, R., 'Aliens in Europe. An open approach to involve more people in invasive species detection'. *Computers, Environment and Urban Systems*, Vol. 78, No 101384, 2019, pp. 1–14. doi:10.1016/j.compenvurbsys.2019.101384.

See, L., Mooney, P., Foody, G., Bastin, L., Comber, A., Estima, J., Fritz, S., Kerle, N., Jiang, B., Laakso, M., Liu, H.-Y., Milcinski, G., Nikšic, M., Painho, M., Podör, A., Olteanu-Raimond, A.-M. and Rutzinger, M., 'Crowdsourcing, citizen science or volunteered geographic information? The current state of crowdsourced geographic information'. *ISPRS International Journal of Geo-Information*, Vol. 5, No 55, 2016, pp. 1–23, doi:10.3390/ijgi505005.

Swan, M., 'Sensor mania! the Internet of Things, wearable computing, objective metrics, and the quantified self 2.0'. *Journal of Sensor and Actuator networks*, Vol. 1, No 3, 2012, pp. 217–253, doi:10.3390/jsan1030217.

List of tables and figures

Annexes

Annex 1. Publications in literature review

1	Lantmäteriet (2019) Ekonomisk nytta av ett samlat nationellt tillgängliggörande av geodata i samhällsbyggnadsprocessen. Retrieved online 20.09.2021 from https://www.lantmateriet.se/contentassets/50c7b8feec4744e5a0fa2ffaf0ea07ec/519-2018_2889-bilaga-2-ekonomisk-nytta-rattelse-190514.pdf
2	Geospatial Media and Communications (2021) Netherlands Geolocation Economy Report. Retrieved online 20.09.2021 from https://geospatialmedia.net/reports/the-netherlands-geolocation-economy-report/
3	Joint Research Centre (2021) INSPIRE Monitoring and Reporting 2020: Process, results and way forward. 13thMIG meeting –June 17-18, 2021
4	V. Cetl, V. Nunes de Lima, R. Tomas, M. Lutz, J. D'Eugenio, A. Nagy, J. Robbrecht, Summary Report on Status of implementation of the INSPIRE Directive in EU, EUR 28930 EN, Publications Office of the European Union, Luxembourg, 2017, ISBN 978-92-79-77058-6, doi:10.2760/143502, JRC109035. Retrieved online 20.09.2021 from https://publications.jrc.ec.europa.eu/repository/handle/JRC109035
5	M. Craglia, M. Campagna (2010) Advanced Regional SDI in Europe: Comparative cost-benefit evaluation and impact assessment perspectives. In International Journal of Spatial Data Infrastructures Research. Retrieved online 20.09.2021 from https://www.researchgate.net/publication/215591771_Advanced_Regional_SDIs_in_Europe_comparative_cost-benefit_evaluation_and_impact_assessment_perspectives
6	Cetl, Vlado & Tomas, Robert & Kotsev, Alexander & Nunes de Lima, Vanda & Smith, Robin & Jobst, Markus. (2019). Establishing Common Ground Through INSPIRE: The Legally-Driven European Spatial Data Infrastructure. 10.1007/978-3-319-72434-8_3.
7	European Commission (2020) Impact Assessment study on the list of high-value datasets to be made available by the Member States under the PSI Directive. Luxembourg: Publications Office of the European Union, 2020
8	Wilkinson, M. D.et al.The FAIR Guiding Principles for scientific datamanagement and stewardship. Sci. Data3:160018 doi: 10.1038/sdata.2016.18 (2016).
9	CRCSI (2017) Economic Value of Spatial Information in NSW. Retrieved online 20.09.2021 from https://www.crcsi.com.au/assets/Consultancy-Reports-and-Case-Studies/Value-of-NSW-Spatial-Information-final.pdf
10	Kotsev, Alexander & Minghini, Marco & Tomas, Robert & Cetl, Vlado & Lutz, Michael. (2020). From Spatial Data Infrastructures to Data Spaces-A Technological Perspective on the Evolution of European SDIs. International Journal of Geo-Information. 9. 10.3390/ijgi9030176.
11	Minghini, Marco & Kotsev, Alexander & Lutz, M.. (2019). Comparing INSPIRE and OpenStreetMap data: how to make the most out of the two worlds. ISPRS - International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences. XLII-4/W14. 167-174. 10.5194/isprs-archives-XLII-4-W14-167-2019.
12	SDFE (2017) The impact of the open geographical data – follow up study. Retrieved online 20.09.2021 from https://sdfe.dk/data-skaber-vaerdi/nyheder/nyhedsarkiv/2017/mar/stor-stigning-i-vaerdien-af-de-frie-geografiske-grunddata/

13	Di Giacomo, D. (2018) Assessment of economic opportunities and barriers related to geospatial data in the context of the Digital Single Market. European Commission Specific contract 395 under Framework Contract n° DI/07172 – ABCIII March 2018
14	Geonovum (2016) Actualisatie KBA INSPIRE. Retrieved online 20.09.2021 from https://www.geonovum.nl/uploads/documents/Actualisatie_KBA_INSPIRE.pdf
15	Toth K, Smits P. Cost-Benefit Considerations in Establishing Interoperability of the Data Component of Spatial Data Infrastructures. In Conference Proceedings: Alejandra Coll, editor. 24th International Cartographic Conference - The World`s Geo-Spatial Solutions - ISBN 978-1-907075-02-5. Vol. XXIV. Santiago de Chile (Chile): International Cartographic Association and Escuola Militar de Santiago; 2009. JRC53133
16	Flego, G., Vitiello, S., Fulli, G., Marretta L., Stromsather J., Cost-benefit analysis of Smart Grid projects: Isernia - Costs and benefits of Smart Grid pilot installations and scalability options, EUR 29222 EN, Publications Office of the European Union, Luxembourg, 2018, ISBN 978-92-79-88762-8, doi:10.2760/698571, JRC111852
17	Ministerie Verkeer en Waterstaat (2010) Audit Business Case NDOV - Op weg naar een Nationale Databank Openbaar Vervoer. Retrieved online 21.12.2021 from https://zoek.officielebekendmakingen.nl/blg-69857.pdf
18	Forum Standaardisatie (2012) Grenzeloze Standaardisatie. Retrieved online 21.12.2021 from https://www.forumstandaardisatie.nl/sites/default/files/BFS/4-basisinformatie/publicaties/Ondersteunend/Handreiking-grenzeloze-standaardisatie.pdf
19	Ytrehus, L., O'neill, G., Hernandez Quiros, L. and Vrecar, S., Sharing and using geospatial data across borders, EUR 30801 EN, Publications Office of the European Union, Luxembourg, 2021, ISBN 978-92-76-40991-5, doi:10.2760/877497, JRC126053.
20	Joint Research Centre (2021) Evolution of the access to spatial data for environmental purposes. Webinar 04/02/2021
21	Boguslawski, Valayer,Mazzoli Kronborg , Pignatelli, European Union Location Framework Blueprint, EUR 30872 EN, Publications Office of the European Union, Luxembourg, 2021, ISBN 978-92-76-42641-7, doi:10.2760/367025, JRC126653.
22	EULF Blueprint - Benefits - National data programmes ; part of Boguslawski, Valayer,Mazzoli Kronborg , Pignatelli, European Union Location Framework Blueprint, EUR 30872 EN, Publications Office of the European Union, Luxembourg, 2021, ISBN 978-92-76-42641-7, doi:10.2760/367025, JRC126653.
23	EULF Blueprint - Benefits - Geospatial strategic reviews; part of Boguslawski, Valayer,Mazzoli Kronborg , Pignatelli, European Union Location Framework Blueprint, EUR 30872 EN, Publications Office of the European Union, Luxembourg, 2021, ISBN 978-92-76-42641-7, doi:10.2760/367025, JRC126653
24	EULF Blueprint - Benefits - Integration of data from external sources; part of Boguslawski, Valayer,Mazzoli Kronborg , Pignatelli, European Union Location Framework Blueprint, EUR 30872 EN, Publications Office of the European Union, Luxembourg, 2021, ISBN 978-92-76-42641-7, doi:10.2760/367025, JRC126653
25	EULF Blueprint - Benefits - Address data; part of Boguslawski, Valayer,Mazzoli Kronborg , Pignatelli, European Union Location Framework Blueprint, EUR 30872 EN, Publications Office of the European Union, Luxembourg, 2021, ISBN 978-92-76-42641-7, doi:10.2760/367025, JRC126653
26	EULF Blueprint - Benefits - Planning and construction; part of Boguslawski, Valayer,Mazzoli Kronborg , Pignatelli, European Union Location Framework Blueprint, EUR 30872 EN, Publications Office of the European Union, Luxembourg, 2021, ISBN 978-92-76-42641-7, doi:10.2760/367025, JRC126653

27	EULF Blueprint - Benefits - Routing applications; part of Boguslawski, Valayer,Mazzoli Kronborg , Pignatelli, European Union Location Framework Blueprint, EUR 30872 EN, Publications Office of the European Union, Luxembourg, 2021, ISBN 978-92-76-42641-7, doi:10.2760/367025, JRC126653
28	EULF Blueprint - Benefits - Public transport; part of Boguslawski, Valayer,Mazzoli Kronborg , Pignatelli, European Union Location Framework Blueprint, EUR 30872 EN, Publications Office of the European Union, Luxembourg, 2021, ISBN 978-92-76-42641-7, doi:10.2760/367025, JRC126653
29	EULF Blueprint - Benefits - Catchment area and transport planning; part of Boguslawski, Valayer,Mazzoli Kronborg , Pignatelli, European Union Location Framework Blueprint, EUR 30872 EN, Publications Office of the European Union, Luxembourg, 2021, ISBN 978-92-76-42641-7, doi:10.2760/367025, JRC126653
30	EULF Blueprint - Benefits - Asset maintenance; part of Boguslawski, Valayer,Mazzoli Kronborg , Pignatelli, European Union Location Framework Blueprint, EUR 30872 EN, Publications Office of the European Union, Luxembourg, 2021, ISBN 978-92-76-42641-7, doi:10.2760/367025, JRC126653
31	EULF Blueprint - Benefits - Agriculture and fisheries; part of Boguslawski, Valayer,Mazzoli Kronborg , Pignatelli, European Union Location Framework Blueprint, EUR 30872 EN, Publications Office of the European Union, Luxembourg, 2021, ISBN 978-92-76-42641-7, doi:10.2760/367025, JRC126653
32	EULF Blueprint - Benefits - Environment; part of Boguslawski, Valayer,Mazzoli Kronborg , Pignatelli, European Union Location Framework Blueprint, EUR 30872 EN, Publications Office of the European Union, Luxembourg, 2021, ISBN 978-92-76-42641-7, doi:10.2760/367025, JRC126653
33	EULF Blueprint - Benefits - Healthcare; part of Boguslawski, Valayer,Mazzoli Kronborg , Pignatelli, European Union Location Framework Blueprint, EUR 30872 EN, Publications Office of the European Union, Luxembourg, 2021, ISBN 978-92-76-42641-7, doi:10.2760/367025, JRC126653
34	EULF Blueprint - Benefits - Fix My Street applications; part of Boguslawski, Valayer,Mazzoli Kronborg , Pignatelli, European Union Location Framework Blueprint, EUR 30872 EN, Publications Office of the European Union, Luxembourg, 2021, ISBN 978-92-76-42641-7, doi:10.2760/367025, JRC126653
35	EULF Blueprint - Benefits - Meteorological services; part of Boguslawski, Valayer,Mazzoli Kronborg , Pignatelli, European Union Location Framework Blueprint, EUR 30872 EN, Publications Office of the European Union, Luxembourg, 2021, ISBN 978-92-76-42641-7, doi:10.2760/367025, JRC126653
36	Joint Research Centre (2021) Location Interoperability Framework Observatory (LIFO). Retrieved online 21.12.2021 from https://joinup.ec.europa.eu/collection/elise-european-location-interoperability-solutions-e-government/location-interoperability-framework-observatory-lifo
37	Das, A., Study on Opportunities and Challenges of Collaboration for Geospatial Services, Cetl, V. editor(s), Publications Office of the European Union, Luxembourg, 2021, ISBN 978-92-76-40674-7, doi:10.2760/070456, JRC126087.
38	Craglia M, Pavanello L, Smith R. The Use of Spatial Data for the Preparation of Environmental Reports in Europe. EUR 24327 EN. Luxembourg (Luxembourg): Publications Office of the European Union; 2010. JRC58006
39	Borzacchiello M, Craglia M. Socio-Economic Benefits from the Use of Earth Observations . EUR 24951 EN. Luxembourg (Luxembourg): Publications Office of the European Union; 2011. JRC66935
40	Ulla Kronborg Mazzoli (2012) Business cases in DK INSPIRE in the Danish E-government. Cost/Benefits of implementing the INSPIRE Directive Workshop, JRC, Ispra 15-16 October 2012

41	Pignatelli F; Boguslawski R; Borzacchiello M; Bigagli E. European Union Location Framework References - version 2. EUR 28414 EN. Luxembourg (Luxembourg): Publications Office of the European Union; 2016. JRC105229
42	Stewart, M.A. (2012) Geospatial Return on Investment Case Study: Hectares BC. Retrieved online 20.09.2021 from https://ftp.maps.canada.ca/pub/nrcan_rncan/publications/STPublications PublicationsST/288/288867/cgdi_ip_18.pdf
43	Jaana Mäkelä (2012) Costs and benefits of implementing the INSPIRE, experiences from Finland. Cost and Benefits of implementing the INSPIRE Directive Workshop, JRC, Ispra 15.10.2012
44	Maria Teresa Borzacchiello, Massimo Craglia, Estimating benefits of Spatial Data Infrastructures: A case study on e-Cadastres, Computers, Environment and Urban Systems, Volume 41, 2013, Pages 276-288, ISSN 0198-9715
45	Craglia, M. (2003) Contribution to the extended impact assessment of INSPIRE. Environment Agency for England and Wales
46	Parcher, J. (2012) Benefits of Open Availability of Landsat Data. Retrieved online 21.12.2021 from http://www.unoosa.org/pdf/pres/stsc2012/2012ind-05E.pdf
47	Assessing the Value of OS OpenData™ to the Economy of Great Britain – Synopsis. Retrieved online 20.09.2021 from https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/207692/bis-13-950-assessing-value-of-opendata-to-economy-of-great-britain.pdf

GETTING IN TOUCH WITH THE EU

In person

All over the European Union there are hundreds of Europe Direct information centres. You can find the address of the centre nearest you at: https://europa.eu/european-union/contact_en

On the phone or by email

Europe Direct is a service that answers your questions about the European Union. You can contact this service:

-by freephone: 00 800 6 7 8 9 10 11 (certain operators may charge for these calls),

-at the following standard number: +32 22999696, or

-by electronic mail via: https://europa.eu/european-union/contact_en

FINDING INFORMATION ABOUT THE EU

Online

Information about the European Union in all the official languages of the EU is available on the Europa website at: https://europa.eu/european-union/index_en

EU publications

You can download or order free and priced EU publications from EU Bookshop at: https://publications.europa.eu/en/publications. Multiple copies of free publications may be obtained by contacting Europe Direct or your local information centre (see https://europa.eu/european-union/contact_en).

KJ-NA-31004-EN-N

The European Commission's science and knowledge service

Joint Research Centre

JRC Mission

As the science and knowledge service of the European Commission, the Joint Research Centre's mission is to support EU policies with independent evidence throughout the whole policy cycle.

EU Science Hub

ec.europa.eu/jrc

@EU_ScienceHub

EU Science Hub - Joint Research Centre

EU Science, Research and Innovation

EU Science Hub

Publications Office of the European Union

doi:10.2760/72064

ISBN 978-92-76-48846-0