European Commission

Leveraging the Power of Location Information and Technologies to Improve Public Services at the Local Level

State of the Art Report

Barker, L.

Claps, M.

Stevens, R.

Crompvoets, J.

Nasi, G.

Vandenbroucke, D.

2021

Contact information
Name: Sven Schade
Address: Via E. Fermi 2749, 21027Ispra (VA), Italy
Email: s.schade@ec.europa.eu

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

JRC126562

PDF	ISBN 978-92-76-41900-6	doi:10.2760/158709
Print	ISBN 978-92-76-41899-3	doi:10.2760/399015

Luxembourg: Publications Office of the European Union, 2021

Editor: Sven Schade

How to cite this report: Barker L., Claps M., Stevens R., Crompvoets J., Nasi G. and Vandenbroucke D. Leveraging the Power of Location Information and Technologies to Improve Public Services at the Local Level - State of the Art Report, Schade S. (ed.), Publications Office of the European Union, Luxembourg, 2021, ISBN 978-92-76-41900-6, doi:10.2760/158709, JRC126562.

Acknowledgements

The production of this report would not have been possible without the input and feedback of stakeholders and experts who were contacted and interviewed through the study. The authors would like to express their gratitude to all of them.

Authors

Louisa Barker (IDC)

Massimiliano Claps (IDC)

Richard Stevens (IDC)

Joep Crompvoets (KU Leuven)

Greta Nasi (Bocconi University)

Danny Vandenbroucke (KU Leuven)

Contents

Executive Summary

Location data and technologies are a foundational component and driver of digital transformation. They can be leveraged to provide policy assessments, digital services and applications for public administrations, businesses and citizens. Location data and technology plays an important role in facilitating data integration, enabling data-driven decision making on where and why things happen and easing communication through intuitive visualisations.[1] However, there are persistent challenges that need to be tackled to realise the benefits of effectively using location data and technology in local and regional governments across the European Union (EU) and creating scalable and replicable high-impact solutions. It is within this context that this study takes place as part of the European Location Interoperability Solutions for e-Government (ELISE) ISA^2 Action.[2]

This report provides an overview of state of the art applications of location data and technology to improve public services, focused specifically on local and regional governments. This report is part of the broader ELISE Lot 1 Project, which aims to provide knowledge and tools to enhance the quality of public services offered by sub-national governments by the meaningful and innovative use of location data and technology.

Chapter 1 provides an overview of the scope of work along with an introduction of key concepts. A definition of state of the art is introduced in order to frame the subsequent analysis. For the purposes of the study, state of the art examples of location-enabled public services are defined as those that leverage location data and technology in a meaningful way to help strengthen public services by driving **public service innovation** and generating **public value**. Frameworks for categorizing public service innovation and public value are also introduced. The chapter then highlights the policy relevance of the research, situating the study in the broader landscape of EU digital government initiatives, including the Infrastructure for Spatial Information in the European Community (INSPIRE) Directive launched in 2007 up to the more recent Open Data Directive, 2019.

The overall approach and methodology for the study are presented in **Chapter 2**. The work is based on three interconnected methods:

- A literature review and desk research: the literature review consisted of selecting and reviewing influential and relevant academic and non-academic sources. In addition, a comprehensive desk review was conducted of EU Commission research and innovation projects, and other local and regional government projects that are developing, piloting or implementing location-enabled public services, as well as the offerings of location data and technology suppliers.
- In-depth interviews: semi-structured interviews were conducted with relevant stakeholders from local and regional governments, subject-matter experts – both academic and practitioners – as well as location data and technology suppliers.
- A quantitative survey: the survey collected information from over 150 local and regional government stakeholders across the EU.

Together, these complementary methods provided quantitative and qualitative information on how location data and technologies are being leveraged to improve public services at the local and regional level, and enabled the identification of state of the art examples. Information was collected on applications across different policy areas, the type of innovations being implemented, the stakeholders involved, the realised or expected public value gained, as well as the main drivers and barriers. The selection criteria for the literature and projects reviewed, as well as the interviewees and survey participants are elaborated in the chapter.

Chapter 3 provides an overview of the evolution of location data and technologies, starting with the more traditional and mainstream before moving to recent innovations and future trends. The information presented in this chapter provides the backdrop against which location-enabled public service innovation is occurring and provides contextual information for subsequent chapters of the report. One of the main findings highlighted is that, over the last decade, there has been a significant increase in the production of more traditional static location data sets, as well as a rise in dynamic location data sets, such as Internet of Things (IoT) data, Mobile Positioning Data (MPD), user-generated data, and high-frequency Earth Observation Data (EOD). These dynamic data sets can be valuable for gaining location intelligence and supporting public service innovation. However, several barriers, currently limit their use - including a high proportion of privately owned data, the

[1] European Commission (a), *About ELISE – European Location Interoperability Solutions for e-Government.* Retrieved from: https://joinup.ec.europa.eu/collection/elise-european-location-interoperability-solutions-e-government/about. Accessed on: 03/06/2021.

[2] Ibid.

human and computing capacity required to process and analyse this data, privacy and ethical considerations and evolving interoperability barriers. The chapter also provides an overview of advances in location technologies across the stages of the data life-cycle, from data collection, management and analytics to visualization.[3] The trends outlined in this chapter may provide the basis for future avenues of research.

Chapter 4 presents findings on how location data and technologies are being leveraged to improve public services, in which policy areas and for what purpose (i.e., strategy, capacity or operational innovations)[4]. The chapter starts with an overview of the application of location data and technologies to public services in local and regional governments across the EU. This provides a landscape view across public service areas. The chapter then provides 'deep dives' into three different policy areas in order to provide more in-depth analysis and highlight state of the art examples. The three policy areas include: transport, tourism and health. The first two policy areas were selected on the basis that these are the areas in which, according to the survey data, location data and technology are used most frequently by local and regional governments to strengthen public services. Health was selected in light of several public service innovations that have occurred in response to the Covid-19 pandemic.

Findings are presented on the types of location data and technology leveraged, stakeholders involved, the main drivers and barriers, as well as the realised or expected outcomes and public value generated. In terms of researching the outcomes of projects, it is important to note that several of the project documents and publications reviewed highlighted expected outcomes and provided little empirical evidence on the public value generated. This lack of available empirical evidence on outcomes is consistent with findings from research conducted on digital transformation projects more broadly.[5] As Barcevičius and others note, "quite often the literature presents the introduction of an innovative service as a positive and valuable development by itself."[6] This finding is also likely related to the limitations of information available through desk research and the fact that several projects reviewed as part of the state of the art analysis, including EU research and innovation projects, are in relatively early stages of maturity and technology readiness.[7]

The chapter concludes by highlighting areas in which location data and technologies are starting to be applied and leveraged but they are either in early stages of research and development, are underexplored, or not widely replicated. According to the survey, the policy areas in which location data and technology are being used the least for public service innovation are social protection and protection of biodiversity and landscape. State of the art examples in these policy areas are presented in order to highlight potential opportunities and avenues for research and development. The chapter also highlights emerging types of public service innovations that can be applied across different policy areas. For example, preliminary research and development are being undertaken to determine whether and how location data and technology can be leveraged to promote and nudge behavioural change as well as pro-active service delivery.

Chapter 5 outlines the conclusions of the State of the Art Report including key takeaways and next steps.

---

[3] Drawn from: Higgins, S., 2012, The lifecycle of data management, in Pryor, G. *Managing Research Data*. London, Facet Publishing, ISBN 978-1-85604-756-2. and Ball, A., Review of Data Management Lifecycle Models. Research Report. Opus: University of Bath Online Publication Store, 2012.

[4] Chen, J. Walker, R, M., Sawhney, M. 'Public Service Innovation: a typology', *Public Management Review*, Vol 22, No 11, 2020, pp. 1674-1695.

[5] A systematic literature review conducted by Barcevičius, and others (2020) found that research on actual effects and impacts of technology in government still lacks comprehensive and conclusive evidence and most literature talk about the transformative effects theoretically and normatively. They also site an earlier systematic literature review conducted by De Vries and others (2016) in which, out of the 181 articles they reviewed focused on innovation in the public sector (between 2014-2014), 40% of studies did not report outcomes.

[6] Barcevičius, E., Cibaitė, G., Codagnone, C., Gineikytė, V., Klimavičiūtė, L., Liva, G., Matulevič, L., Misuraca, G., Vanini, I., Editor: Misuraca, G., Exploring Digital Government transformation in the EU - Analysis of the state of the art and review of literature, EUR 29987 EN, Publications Office of the European Union, Luxembourg, 2019, ISBN 978-92-76-13299-8, doi:10.2760/17207, JRC118857.

[7] European Commission (b), Horizon 2020, Work Programme 2016-2017, 20. General Annexes, 2017. Accessed online at: https://ec.europa.eu/research/participants/data/ref/h2020/other/wp/2016-2017/annexes/h2020-wp1617-annex-ga_en.pdf accessed on: 23/06/2021.

Key takeaways

Trends in Location Data and Technology

- Over the last decade, there has been an increase in the generation of static and dynamic location data. The insights gained from these data sets can be valuable for supporting public service innovation, including strategic, capacity and operational innovations. However, there are persistent barriers to overcome which limit their use.

- The landscape of location data ownership is shifting. Increasingly, valuable dynamic location data sets are created, stored and maintained by the private sector.[8] This is "challenging the role of the public sector as the main producer and owner of geospatial content"[9] and can create barriers for local and regional governments to access this data. This fits into the broader ongoing EU dialogue about Business to Government (B2G) data sharing for public interest[10] as well as the forthcoming creation of common European data spaces (see the EU Data Strategy)[11].

- The capacity of local and regional governments to maintain up-to-date and high-quality location data remains a challenge. This is often driven by a lack of available resources, civil servant capacity and institutional incentives.

- In some cases, the boundary between official and unofficial data is blurring. Several local and regional governments are experimenting with crowdsourcing methodologies to enrich their location data, and, in the future, private sector location data may also be used for this purpose.

- Going forward, additional focus is likely to be given on the legitimacy of using location data for a certain public service. For example, before accessing and utilising location data as part of a public service, first, a public administration, or data controller, should ask (i) what location data is required and necessary to deliver a certain service, and (ii) where does location data add desirable public value. This is aligned with the spirit of the GDPR.

- Advances in positioning technologies and Earth Observation Technologies (EOT) have been, and will continue to be, a key driver in strengthening existing public services and enabling new ones such as ride-hailing, indoor navigation, epidemiological contract tracing and automated environmental monitoring.

- The potential of Geospatial Artificial Intelligence (GeoAI) [12] to drive public service innovation is starting to be demonstrated but projects are generally in early stages of maturity. This is an area that would benefit from additional research focused on the new capabilities GeoAI can enable in local and regional governments, the challenges it can help solve, as well as the risks that need to be navigated.

- Advances in data visualisation such as 3D modelling and immersive technologies (e.g., Augmented Reality (AR), Virtual Reality (VR), MR (Mixed Reality) and Extended Reality (XR)) have the potential to change the ways in which civil servants and citizens interact with location data and are bridging the gap between the digital and physical environment. These advances have also laid the foundations for the development of digital twins.

---

[8] Kotsev, A., Minghini, M., Tomas, R., Cetl, V. and Lutz, M., From Spatial Data Infrastructures to Data Spaces: A Technological Perspective on the Evolution of European SDIs, ISPRS *INTERNATIONAL JOURNAL OF GEO-INFORMATION*, ISSN 2220-9964, 2020, Vol. 9 No. 3, p. 176, JRC120143 and Schade S. and others (2020) Geospatial Information Infrastructures. In: Guo H., Goodchild M.F., Annoni A. (eds) Manual of Digital Earth. Springer, Singapore. https://doi.org/10.1007/978-981-32-9915-3_5.

[9] Kotsev, Minghini, Tomas, Cetl and Lutz (see footnote 8).

[10] European Commission (c), Towards a European Strategy on Business-to-government data sharing for the public interest: Final Report prepared by the High-Level Expert Group on Business-to-Government Data Sharing, 2020, ISBN 978-92-76-11422-2, doi:10.2759/731415.

[11] European Commission (d), *Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions,* Brussels, 2020, A European strategy for data COM/2020/66 final.

[12] Geospatial Artificial Intelligence (GeoAI) is a form of Location Intelligence, that is, "the process of deriving meaningful insights from geospatial data relationships – people, places or things." The following report explores the ways in which location data and technology can support the digital transformation of government and presents case studies, including those focused on GeoAI. Harst, G, V, D. and Valayer, C. ISA2 – Action 10: ELISE Benchmarking Support: Task 2: Location Intelligence. Accessed at: https://joinup.ec.europa.eu/sites/default/files/document/2020-12/Location%20Intelligence-Benchmarking%20Support-Gartner.pdf Accessed on: 23/08/2021 (conducted by Gartner on behalf of the European Commission JRC).

Impact of Location Data and Technology on Improving Public Services

- Location data and technology are being used to strengthen public services across all policy areas in local and regional governments and 96% of survey participants expect that location data and technologies will be used significantly more in the future than they are today. This, in part, reflects the importance of location data as a data integrator and a foundational component of digital transformation programs.
- The policy areas in which location data and technology are most frequently leveraged are transport and tourism. For example, in the area of transport, location data and technology are being used to enable and augment on-demand transport and ride-hailing services, traffic management platforms and connected and autonomous vehicle services, among others. In the area of tourism, they are being used for tourism planning tools and analysis, tourism monitoring platforms (e.g., sentiment analysis and crowd monitoring), tourist navigation apps and digital reality (AR/VR/XR) experiences, among others.
- Location data and technology are being leveraged to drive public service innovation through strategy, capacity and operations.[13] Examples of how these innovations are being driven are presented throughout the report.
- There is limited empirical evidence available on the outcomes and impact of location-enabled public services, including the public value generated. The study found that, when outcomes are measured, they generally focus on operational and productivity gains rather than political or social outcomes.
- Technical, semantic legal, organisational and cultural interoperability were identified as ongoing barriers for replicating and scaling location-enabled public services both within and across borders. These interoperability challenges are dynamic and evolving in line with the trends in location data and technology.
- The potential value to be gained from location-enabled public services need to be balanced with privacy risks and ethical consideration for groups and individuals. Some examples of local and regional governments who have got this right through 'privacy be design principles', as well as examples of those who have got this wrong will be highlighted throughout the report.
- The policy areas in which location data and technology are being used the least to strengthen public services are social protection and protection of landscape and biodiversity. However, over the next two years, there is a high level of expected growth in both these areas.
- Throughout the state of the art report research, examples were identified of types of public service innovation that are starting to be applied but have not yet scaled to their full potential. These span different types of public service innovation - strategic, capacity and operational – and are applicable across several policy areas. These included leveraging location data and technology to:
    - Connect big (location) data with decision making through more immersive data visualisation.
    - Enable remote service administration, for example, using drones for building inspections.
    - Nudge behavioural changes such as increasing physical activity.
    - Facilitate citizen participation in public service design, operation and co-delivery.

The preliminary findings presented in this report highlight potential areas for future in-depth research and provide the basis for subsequent tasks in this Project, particularly:

(i) The development of a conceptual model to critically assess the current and potential impacts of location data and technology on public value creation through public services at the local and regional level.

(ii) The development of detailed case studies to test the validity of the conceptual framework and assess the replicability and scalability of cases.

[13] Chen, Walker and Sawhney (see footnote 4).

1. Introduction

1.1 Scope

This report is deliverable D2 – the State of the Art Report. This deliverable is part of the **European Location Interoperability Solutions for e-Government (ELISE) Lot 1 Project** carried out for the European Commission's Joint Research Centre (JRC).

The ELISE Lot 1 Project aims to explore how location data and technologies are, and can be, leveraged to **improve public services at the local and regional level across the European Union** (EU)**.** The overall objective of the project is to conduct an in-depth mapping and critical analysis of recent initiatives and emerging solutions at the local and regional level to investigate new practices – together with their impact, replicability and scalability potentials – and suggest future pathways for the evolution of public services in the EU. The Project aims to provide practical guidance, convincing value propositions, and a list of priorities for further policy action which will help to improve the quality of public services by the meaningful and innovative use of location data and technology at the local and regional level. Under the ELISE Program, a parallel **Lot 2 Project** is also underway. The objective of this complementary Project is to assess the impact of the adoption of regional and local data ecosystems and digital twins in the EU by exploring several governance and business models and by taking advantage of a sandboxing approach.

This **State of the Art Report** is a culmination of the analysis undertaken as part of ELISE Lot 1, Task 2. The objective of this report is to provide an overview of innovative applications of location data and technology to improve public services in local and regional governments. The report will present public service applications across different policy areas and present available information on the location data and technology leveraged, the stakeholders involved, the realised or expected public value gained, as well as the barriers and drivers. Particular attention will be given to highlighting state of the art location-enabled public services which have resulted in, or have the potential to drive, **public service innovation and digital transformation.**

Task 2 consisted of the following sub-tasks which will be elaborated further in the methodology:

Task 2.1 Literature Review and Desk Research: The literature review consisted of selecting and reviewing (i) the most influential scientific publications on location-enabled public services, (ii) European Commission programs and projects, such as those funded under Horizon 2020 (H2020), which integrate location data and technology (iii) publicly available information on relevant local and regional government strategies, programs and projects and, (iv) the location data and technology solution offerings of major vendors.

Task 2.2 In-depth Interviews: Interviews were conducted with relevant stakeholders in local and regional governments, independent experts, and vendors of location data and technology. These interviews enabled the collection of information on innovative location-enabled public services and focused particularly on identifying the main challenges encountered during project/service implementation, open challenges and lessons learned.

Task 2.3 Quantitative Analysis: A survey was conducted to collect information from a sample of 150 local and regional government stakeholders. Among other areas, information was gathered on the key policy areas where location data and technology are being utilised, the types of public value generated by these applications, and whether Key Performance Indicators (KPIs) are in place to measure the impact.

Task 2.4: Analysis and Systematization of the Main Findings: Together, the complementary information collected through Task 2.1-2.3 provided an overview of how location information and technologies are being leveraged to improve public services at the local and regional level across the EU and enabled the identification of state of the art applications. These findings are presented in this report. The report findings were validated by members of the JRC and an expert panel on **July 5th, 2021,** during a dedicated workshop.

The State of the Art Report presents preliminary findings and recommendations and identifies potential areas for future in-depth research. The analysis undertaken and presented in this report provides the basis for the development of subsequent Lot 1 Project tasks and deliverables, including:

(i) Task 3: the creation of a conceptual model to critically assess in a consistent and scientific manner the current and potential impacts of location data and technology on public value creation through public services at the local and regional level.

(ii) Task 4: the development of detailed case studies to test the validity of the conceptual framework and to assess the replicability and scalability of the cases.

(iii) Task 5: consultation with citizens who are users and potential users of the case studies developed in Task 4 to directly measure attitudes, expectations and user satisfaction. This task will also include consultation with a panel of multi-disciplinary experts to validate the deliverables produced under the Lot 1 Project.

(iv) Task 6: the final report, including a summary of the project and a set of key recommendations and guidelines on the innovative use of location data and technology as well as a visualization tool making available information on all the gathered case studies in an interactive platform.

1.2 Key Definitions and Concepts

As noted above, this report will analyse how location data and technologies are being used to strengthen public services, with particular attention on state of the art location-enabled services. To frame the subsequent analysis, it is necessary to provide definitions of key concepts upfront, including **location data and location-enabled technologies**, **public services**, **public service innovation** and **state of the art**. A glossary is also provided at the end of the report with an extended list of working definitions for key terms.

For the purposes of this Project, the definition of **location data** is drawn from the legal definition provided under the Infrastructure for Spatial Information in Europe (INSPIRE) Directive and includes data with a direct or indirect reference to a specific location or geographical area. While this report will use this term, it can also be interchanged with geospatial data or geo data.[14] In turn, **location-enabled technologies** are defined as geospatial technologies embedded into solutions to deliver services to stakeholders. Different types of location data and technologies, and their evolution, will be described in Chapter 2 of this report.

Public services are defined as: services intended to serve all members of a community. These services can be delivered by the public sector or commissioned by the public sector or delivered, delegated, taken up, by other stakeholders such as businesses, non-governmental organisations or academic institutions. In this report, **public service areas** will be categorized according to the divisions under the Classification of the Functions of Government (COFOG) developed the United Nation's Statistical Division.[15]

Bringing the two aforementioned definitions together, a **location-enabled public service** is a public service that can be linked to a place or position or in which location data and technology is used/embedded. In line with the definition used in the European Union Location Framework (EULF) Blueprint, the service must depend on the effective management or use of location information, that is, the location data or technology must be central to the creation of value.[16]

And finally, it is necessary to define what is meant by **state of the art**. For the purposes of this report, state of the art examples will be assessed as those that leverage location data and technology in a meaningful way to strengthen public services by driving **public service innovation** and generating **public value.** These examples may either drive the innovation and strengthening of an existing public service or enable the creation of a new public service. The report will use the typology of public service innovation developed by Chen and others[17] as a framework for categorising public sector innovation. The typology is comprised of two dimensions: (i) innovation locus (internal or external) (ii) innovation focus (three public value creation processes of strategy, capacity and operations) (see Table 1).

[14] Boguslawski, R., Valayer, C., Van Agansen, K., Keogh, D., Pignatelli, F. *European Union Location Framework Blueprint*, EUR 30374 EN, Luxembourg: Publications Office of the European Union, 2020, ISBN 978-92-76-22068-8, doi:10.2760/096595, JRC117551.

[15] Eurostat (a), *Manual on sources and methods for the compilation of COFOG statistics: Classification of the Functions of Government (COFOG) 2019 Edition*, Luxembourg: Publications Office of the European Union, 2019, ISBN 978-92-76-09695-5, doi:10.2785/110841.

[16] Boguslawski, Valayer, van Gansen, Keogh, Pignatelli, European Union Location Framework Blueprint, EUR 30374 EN, Publications Office of the European Union, Luxembourg, 2020, ISBN 978-92-76-22068-8, doi:10.2760/096595, JRC117551.

[17] Chen, Walker and Sawhney (see footnote 4).

Table 1. A Typology of Public Service Innovation

		Innovation locus	
		Internal	External
Innovation focus	Strategy	Mission innovation	Policy innovation
	Capacity	Management innovation	Partner innovation
	Operation	Service innovation	Citizen innovation

Source: Chen and others (2020)

Public value will be categorized according to three categories of operational value, political value and social value (see Table 2). This framework is largely drawn from Chu and Tseng's (2018)[18] framework for 'public value of e-governance' (See Annex 1) and has been supplemented with additional values from research conducted by Moore (1995)[19], Barcevičius and others (2019)[20], and Osborne and others (2021)[21]. It is important to note that a conceptual framework for assessing the public value created by location-enabled public services does not currently exist within the literature or policy toolkits. Filling this conceptual gap will be the focus of Lot 1 Project Task 3.

Table 2. Public Value Categories

Public Value Category	Public Value
Operational	Collaboration, effectiveness, efficiency, user oriented
Political	Accountability, economic development, equity in accessibility, openness, participation, transparency
Social	Inclusiveness, quality of life, self-development, environmental sustainability, trust

Source: State of the Art Report, 2021 (Drawn from Chu and Seng, 2018; Moore, 1995; Barcevičius and others (2019); and Osborne and others (2021)

1.3 Context

This Project is part of the broader landscape of European Union (EU) Digital Government Initiatives. It is part of the Joint Research Centre's (JRC), and particularly the Digital Economy Unit's, policy and research agenda focused on **digital transformation across the EU**. Most recently, the EU Member States outlined their approach and commitment to a Digital Society and Value Based Government through several mechanisms, including, inter-alia, the Berlin Declaration (2020)[22], the European Data Strategy (2020)[23], and the launch of the Digital Europe Programme (2021).

This Project falls under the ELISE action of the Interoperability Solutions for Public Administrations, Businesses and Citizens (ISA^2) Programme. The ISA^2 Program is comprised of 54 actions which "support the development of digital solutions that enable public administrations, businesses and citizens in Europe to benefit from **interoperable, cross-border and cross-sector public services**."[24] The ELISE action is the only ISA^2 action specifically focused on location data and technology and aims at "enabling digital government through Geospatial Data and Location Intelligence."[25]

[18] Chu, P-Y & Tseng, H-L. (2018). Open Data in Support of E-governance Evaluation: A Public Value Framework. ICEGOV '18: Proceedings of the 11th International Conference on Theory and Practice of Electronic Governance. 338-343. 10.1145/3209415.3209433.
[19] Moore, M. H. (1995). *Creating public value: Strategic management in government*. Harvard university press.
[20] Barcevičius, Cibaitė, Codagnone, Gineikytė, Klimavičiūtė, Liva, Matulevič, Misuraca and Vanini (see footnote 6).
[21] Osborne, S. P., Nasi, G., & Powell, M. (2021). Beyond co-production: value creation and public services. *Public Administration*.
[22] European Union (a), *Berlin Declaration on Digital Society and Value-Based Digital Government,* 2020.
[23] European Commission (d) (see footnote 11).
[24] European Commission (e), *ISA^2 - Interoperability solutions for public administrations, businesses and citizens*. Retrieved from: https://ec.europa.eu/isa2/library_en. Accessed on: 03/06/2021.
[25] European Commission (a) (see footnote 1).

A dedicated action was created focused on location data because of its important role in underpinning policy assessment, digital services and applications. The value of location data for public service innovation is summarised under the ELISE action as follows:

Location data:

1. *Facilitates data integration;*
2. *Allows taking data-driven decisions based on where and why things happen;*
3. *Eases communication through intuitive map representations; and,*
4. *Enables visualisation of sophisticated models and simulation.*[26]

In this context, location intelligence has been identified as an important component and driver of digital transformation. However, as this report will explore, there are persistent challenges that need to be tackled to realise the full potential of effectively using location data and technology in local and regional governments across the EU. The ELISE Action aims to "facilitate **more efficient and effective digital cross-border or cross-sector interaction** and **data re-use** in the domain of location information and services.[27]" The analysis presented in this report, and the subsequent Project deliverables, are aligned with this objective.

The European Union Location Framework Blueprint (EULF) developed under the ISA^2 Programme provides a guiding framework for these efforts including a distillation of good practices in the field of location interoperability, and a series of goals, recommendations, supporting actions and reference materials. See Figure 1 for an overview of the EULF blueprint.

The importance of location data is also recognised in the Open Data and Public Sector Information Directive, 2019, which includes geospatial data as one of five high-value datasets which should be prioritised in the creation of a single market for EU data. High-value data sets are those that hold the potential to (i) generate significant socio-economic or environmental benefits and innovative services, (ii) benefit a high number of users, in particular SMEs (iii) assist in generating revenues, and (iv) be combined with other datasets.[28] It will also be an important cross-cutting data source in the planned Common European data spaces outlined in the European Strategy for Data. These data spaces include, among others, mobility, energy, health and agriculture.[29]

Another EU initiative linked to the ELISE action, and this Project, is the INSPIRE Directive. The INSPIRE Directive, launched in 2007, aims to create a European Union Spatial Data Infrastructure (SDI). The Directive provides a legal basis and blueprint for sharing spatial data among public sector organisations as well as facilitating public access to spatial data across boundaries. The INSPIRE Directive addresses 34 spatial data themes focusing on those which may be needed for environmental applications and is underpinned by implementing rules for metadata, network services, in data and service sharing, spatial data services and monitoring and reporting.[30]

The Significance of INSPIRE has been the promotion of open data and a culture of data sharing, in this regard, it was years ahead of its time." Prof. Joep Crompvoets, KU Leuven Public Governance Institute and Secretary-General of the European Spatial Data Research Network, EuroSDR (State of the Art Report Interviewee and Consortium Member)

Since the launch of the INSPIRE Directive, considerable progress has been made by member states in strengthening their SDI through the creation of centralised spatial databases as well as the implementation of policies and standards to facilitate the access and use of this location data.[31] While member states have appointed national authorities to oversee the implementation of the INSPIRE Directive, local and national governments also have an important role at the frontline of in identifying, producing and sharing spatial data

[26] Ibid.
[27] Ibid.
[28] European Union (b), 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, PE/28/2019/REV/1.
[29] European Commission (d) (see footnote 11).
[30] European Commission (f), *INSPIRE GEOPORTAL, INSPIRE Data Themes.* Retrieved from: [https://inspire-geoportal.ec.europa.eu/theme_selection.html?view=qsTheme.](https://inspire-geoportal.ec.europa.eu/theme_selection.html?view=qsTheme) Accessed on: 03/06/2021.
[31] Cetl, V., Nunes De Lima, M., Tomas, R., Lutz, M., D`Dugenio, J., Nagy, A. and Robbrecht, J., *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.

such as address data, land use data, protected environmental sites and transport network data. While the INSPIRE Directive was focused particularly on spatial data for environmental applications, the SDIs established are relevant, and have been applied, across several policy domains.[32] While full implementation of the Directive is required by the end of 2021, as will be noted later in this report, challenges remain in establishing effective and quality SDIs.

The European Location Framework (EULF) Blueprint is a guidance framework for using location information in policy and digital public services (see also Figure 1, on page 15). It has been developed in the ISA² Programme and the predecessor ISA Programme and is fully aligned with the European Interoperability Framework, through its attention to all aspects of location interoperability. The Blueprint contains recommendations and implementation guidance on how to use location information effectively and innovatively in policy and digital public services (demand-side guidance) and how to create a user-driven SDI that will support the needs of those developing these policies and services (supply-side guidance).

The Blueprint provides guidance across five key focus areas identified by ISA² stakeholders and the wider geospatial community. The table below provides an overview of the good practice guidance principles elaborated through the Blueprint.

1.4 Report Structure

Chapter 1 outlined the scope, the key definitions and how this report and the Lot 1 Project relates to the broader landscape of EU Digital Government Initiatives.

Chapter 2 outlines the methodology behind the State of the Art Report and provides details on the design and implementation of the literature review and desk research, in-depth interviews, survey, analysis and systematisation of main findings. This chapter also provides an explanation of how these different components of Task 2 fit together and the known limitations.

Chapter 3 provides an overview of the evolving landscape of location data and technologies being used to improve public services in regional and local governments and how these have evolved.

Chapter 4 analyses the impact of location data and technologies on improving public services. The chapter starts with a cross-cutting overview of the main policy areas in which location-enabled public services are being adopted, the types of innovations being driven, and the type of public value being generated, and the main challenges experienced.

This chapter then provides a 'deep dive' into three policy areas: transport, tourism, health. The first two policy areas are, according to the survey, those in which innovative uses of location-enabled public services are most frequently being adopted. Health and has been chosen due to innovations occurring in this space linked to the Covid-19 pandemic. The chapter concludes by highlighting areas in which location data and technologies are starting to be applied and leveraged in interesting ways to generate public value, but they are either in early stages of research and development, are underexplored, or not widely replicated.

Chapter 5 outlines the conclusions of the state of the art report including key findings and next steps.

[32] Barbero, M., Lopez Potes, M., Vancauwenberghe, G. and Vandenbroucke, D., *The role of Spatial Data Infrastructures in the Digital Government Transformation of Public Administrations*, Publications Office of the European Union, Luxembourg, 2019, ISBN 978-92-76-09679-5doi:10.2760/324167, JRC117724.

Figure 1. European Location Framework Blueprint

Focus Area	Provider good practices	User good practices
Policy and strategy alignment	• Aligned digital, innovation, and location policies • Interconnected approach to data policy and data governance, incorporating location data in wider data policy implementation, e.g. open data, PSI, GDPR • European data policy alignment • Structured approach to e-reporting	• Cross-sector policy alignment on use of location data • Use location-based evidence to inform policy • Protect personal data, incorporating 'location privacy' measures • Standards based procurement of location data and services
Digital government integration	• Make data easily discoverable and accessible • Publish open core location data and other open location data where possible • Use simple standardised (machine readable) licensing schemes • Build and adapt the SDI according to user needs and priorities (data ecosystems, key services, public and external organisations; analytical support capabilities) • Integration within wider data frameworks, e.g. national, thematic, international	• Optimise use of location data in digital public services • Use authoritative SDI datasets and common access mechanisms • Collaborative agile development • Feedback to providers on data quality • Collaborative business models for location-enabled digital public services • Reusable models for specific data ecosystems based on authoritative open location data (e.g. smart cities) • Use of new technologies to deliver innovation, e.g. digital twins, digital platforms, AI, location intelligence • Integrated location-based statistics
Standardisation and reuse	• Standardised framework for heterogeneous and agile use • Simple cross-sector interoperability models – core datasets, basic multi-purpose models, persistent identifiers, integration with other public sector core data and different thematic / international standards (e.g. road transport, BIM) • Simple modern data access, e.g. metadata, web access, APIs, micro services, event stream processing • Include dynamic (e.g. IoT) and satellite data in the SDI with necessary localised processing and standard access mechanisms • Include relevant external data in the SDI in a structured way (e.g. community-sourced, business data) • Affordable data quality regime, balancing needs and based on agreed standards and service levels	• Use recognised architectural principles and standards in building digital public services • Reuse data, standard access mechanisms (e.g. APIs) and other ICT assets (e.g. software components from sources such as GitHub) • Feedback to providers of tools and services (e.g. APIs) to improve quality.
Return on investment	• Funding agreements for pan-government and open data access • Efficiencies in location data collection and supply • Integration with alternative sources of supply, e.g. private sector / citizens • Providing access to location datasets and expertise for evaluation purposes	• Benchmarking and improvement • ROI case studies • Support location data innovation in relevant communities (e.g. smart cities, energy, health, construction) • Promote innovation in and with the private sector using public sector location data
Governance, partnerships and capabilities	• Cross-sector governance of core data, including location data • Inclusive transparent governance models, involving users • Data supply and data ecosystem partnerships • Geospatial competency framework • Awareness raising and skills programmes	• Partnerships in acquisition and use of data in digital public services • Share learning on digital government innovation

2. Methodology

2.1 Introduction

To conduct the state of the art analysis for this report, three complementary methods of data collection were undertaken: (i) a literature review and desk research (ii) in-depth interviews, and (iii) a quantitative survey. Together, these streams of information allowed for a comprehensive systematisation of the state of the art.

Literature review and desk research: Through the literature review, relevant academic and 'grey literature'[33] were reviewed to collect information on innovations and trends in location data and technology as well as examples, analysis and case studies illustrating how these are being applied to public services across the EU. Through the desk research, a review was undertaken of over 30 European Union funded research and innovation projects, over 100 local and regional government projects and the location data and technology offerings of 40 vendors. Information was collected using a pre-defined analytical framework (see Section 2.2). This review enabled the project team to identify state of the art use cases and analyse aspects such as the ways in which location data and technology are being applied, for what type of uses cases and what are the types of outcomes and public value being documented.

Interviews: Interviews were conducted to collect more in-depth qualitative information on location-enabled public services. The interviews focused on areas which are more difficult to study through desk research such as challenges encountered during project implementation, lessons learned and underexplored opportunities. In total 14 interviews were conducted across three categories: local and regional government experts, independent experts and location data and technology vendors. Interviewees were chosen based on their role, expertise and connection to potentially state of the art projects and location-enabled public services. See Section 2.3 for a matrix of selection criteria.

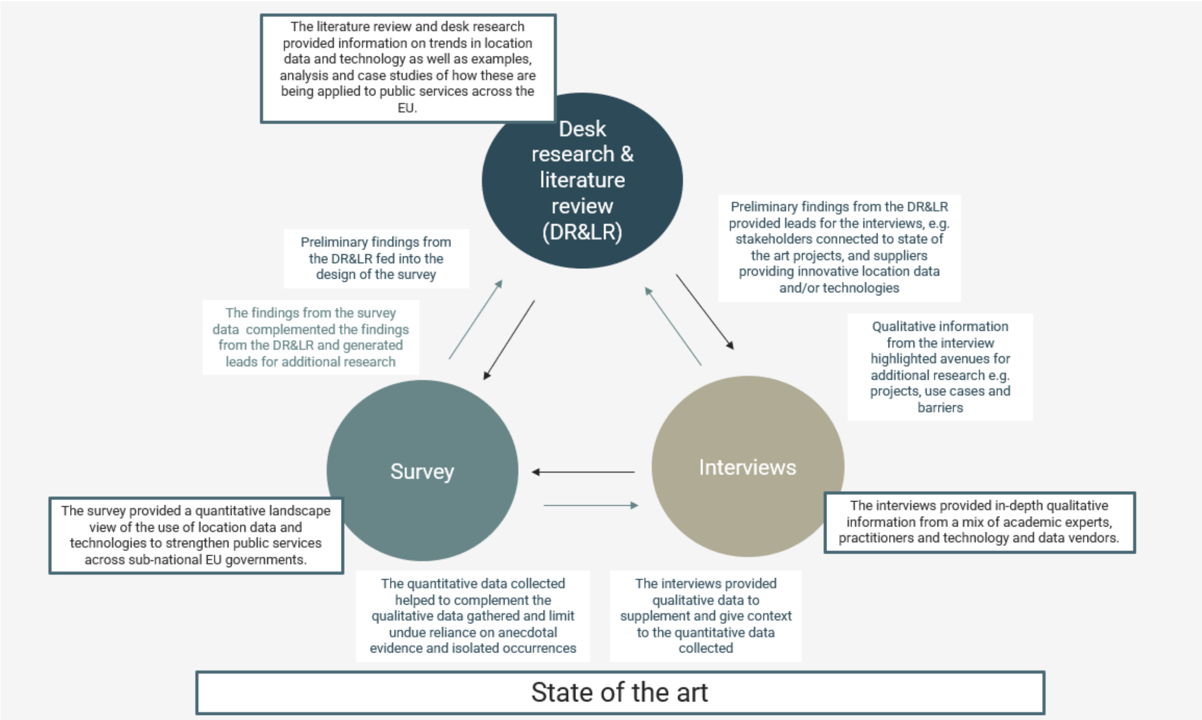
Quantitative survey: Through the survey it was possible to collect quantitative information from a larger sample of local and regional government stakeholders – 158 in total. Data was collected on aspects such as the types of policy areas in which location data and technology are being used to strengthen public services, the types of location-enabled technologies being used, the main barriers for investing in and implementing these project etc. The data collected enabled quantitative analysis to be undertaken to provide additional insights.

These qualitative and qualitative research methods were combined to enable the triangulation of the findings, that is, collecting complementary information accounting for the strengths and limitations of different research methods.[34] Figure 2 provides an overview of how these different components of the research contributed toward the state of the art analysis. These methods, and their respective strengths and limitations, will be described in more detail in the subsequent sections of the methodology chapter.

[33] This included non-academic publications such as reports and articles developed by international organizations, innovation laboratories, journalists and Non-Governmental Organizations (NGOs).

[34] Hammersley M. (2008) "Troubles with Triangulation" in M. M. Bergman (a cura di) Advances in Mixed Methods Research, Sage, London: 22-36.

Figure 2. State of the Art Methodology



Source: State of the Art Report, 2021

2.2 Literature Review and Desk Research

For this part of the research, a review was conducted of:

(i) Relevant literature;
(ii) European Union funded research and innovation projects;
(iii) Local and regional government projects; and
(iv) Location data and technology offerings of major suppliers.

Literature Review

To carry out the state of the art analysis, a review of the most relevant recent publications was conducted. The objective of the review was to identify state of the art examples of location data and technology being applied to public services, the different dimensions of public service innovations being implemented, how the use of location data and technology are evolving, the expected and actual impacts of location-enabled public services, as well as the stakeholders involved, main trend and drivers and barriers. To this end, the following staged approach was adopted including a systematic literature review, a targeted/snowball literature review, and a review of 'grey literature.'

- The first step included a systematic review of literature published in academic journals. The journal articles were identified through an internet search using key words.[35] To narrow the search, the publications were scanned for (i) relevance - to determine whether they focused on an innovative location data and technology and/or a location enabled public service or use case (ii) influence – this was determined by the number of citations as of March 2021.[36] Further, to supplement this, additional desk research was conducted to avoid missing sources that were not identified through the search strings but were still relevant for the study. The academic members of the Consortium also provided additional journal articles based on their expertise and research fields.

[35] Key words included: "geospatial", "GIS", "geographic information system", "spatial", "local government", "regional government", "municipal", "city", "public services", "location data", "location technology."
[36] The threshold applied for the first step of the literature review as articles with more than 10 citations.

- The second step of the literature review included collecting additional sources by using targeted searches and a "snowball" approach, that is, identifying relevant citations in papers selected in the systematic literature review. This enabled more in-depth analysis of emerging trends and findings.

- The review of academic literature was also complemented by desk research on relevant non-academic publications, sometimes referred to as grey literature. This included reports and articles developed by international organizations, innovation laboratories, journalists, Non-Governmental Organizations (NGOs), private consulting firms, among others. This literature was identified through targeted online searches based on emerging trends and findings.

In total, just over 70 academic articles and just over 30 pieces of grey literature were reviewed. A list of this literature is provided in Annex 2. Across all stages of the literature review, publications were included from across several disciplines - including, among others, social science, public administration, political science, information technology, physical planning etc. We included literature published in the last 10 years to reflect the objective of the study to identify state of the art and emerging applications of location data and technology to innovate public services - the majority of literature selected was published in the last 5 years.

Local and Regional Government Projects and European Commission Research and Innovation Projects

The desk research included a review of (ii) local and regional government projects and initiatives and (ii) European Union funded research and innovation projects. Projects were selected on the basis of whether they leveraged location data and technology to help strengthen public services:

- **European Union Research and Innovation Projects:** the majority of projects were selected from the CORDIS H2020 database.[37] Some were also selected from other initiatives such as the Institute for Innovation and Technology's (EIT) Urban Mobility Initiative,[38] the Urban Innovative Actions (UIA) of the European Regional Development Fund (ERDF).[39] Projects were also identified by Lot 1 Consortium members and through the in-depth interviews.

- **Local and regional government projects and initiatives**: projects were identified through: publicly available information published by public sector entities, such as local and regional government strategies, programs and projects; those highlighted by innovation hubs and labs; projects highlighted in communities such as the Institute of Electrical and Electronics Engineers (IEEE) Geoscience and Remote Sensing Society (GRSS) and Geo-Wiki: Earth Observation & Citizen Science; projects identified through the literature review; projects highlighted by interviewees (See Section 2.3); customer references from location data and technology suppliers; and, projects identified by the Lot 1 Consortium members.

In total, 30 European Commission projects and 120 local and regional government projects were selected and reviewed. A full list of European Commission projects can be found in Annex 3 and a full list of local and regional government projects reviewed can be found in Annex 4. Each of the projects that were selected for review were then analysed. The analysis was conducted, and main findings organized, using a pre-defined analytical framework. The core categories of the framework have been summarized in Table 3 below. Other information was also collected, e.g., the stakeholders involved in the project, the geographical scope of the project etc. These have not been elaborated in the table as they are self-explanatory.

[37] European Commission (g), CORDIS Projects and Results. Accessed at https://cordis.europa.eu/projects/en Accessed on: 23/06/2021.

[38] European Union (c), European Institute of Innovation and Technology, EIT Urban Mobility Model. Accessed at: https://eit.europa.eu/our-activities/innovation/eit-urban-mobility-model Accessed on 23/06/2021.

[39] European Regional Development Fund (a), Urban Innovative Actions. Accessed at: https://uia-initiative.eu/en Accessed on: 23/06/21.

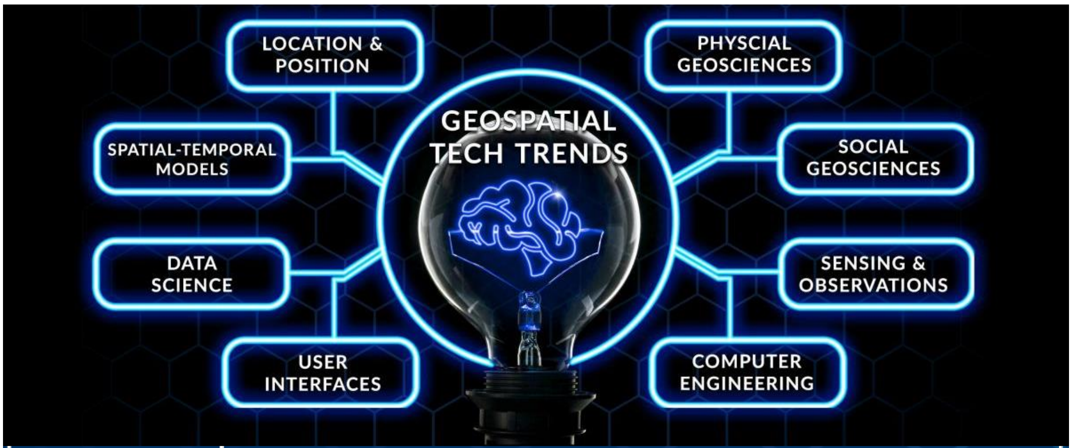
Table 3. Analytical Framework for Researching Projects and Organising Findings

Category	**Approach**	**Purpose**
Theme	Projects were classified into policy areas using the COFOG developed the United Nation's Statistical Division (See Annex 5).[40]	This enabled the consortium to determine in which policy areas location data and technologies are already being used on a regular basis and where opportunities for further enhancement and additional applications lie.
Technology	Available information was reviewed to determine the types of technology used within the project. The types of technology were classified according to the Open Geospatial Consortium's (OGC) Geospatial Tech Trends, 2020 (See Figure 3).[41] Additional information was also collected on the use of other emerging technologies, not explicitly linked to location, for example, 5G, digital twins and edge computing.	This enabled the consortium to determine the types of location technologies being used most frequently in projects to strengthen public services. It also enabled the consortium to determine other emerging technologies that are being integrated into these projects.
Technology Readiness Level	Projects were classified into four stages of technological readiness. These categories were aligned with the Horizon 2020 Technology Readiness Level (TRL) definitions.[42] The 9 TRL definitions were grouped into four categories because sufficient detail was not always available through the desk research to use these more granular definitions. • Research and Innovation (TR1- TR2) • Proof of Concept (TRL3 - TRL4) • Prototype (TRL5 – TRL7) • Production System (TRL8 – TRL9)	Assessing projects against this framework enabled the consortium to determine the maturity of projects, that is, those that can be executed now, those that are being piloted, and those that the public sector can ideate but not implement or pilot. As will be discussed later in the methodology, the level of 'technology readiness' also has an impact on the way in which the impact of the project can be evaluated.
Public Value	A list of public value was developed (See Figure 4). This framework is largely drawn from Chu and Tseng's (2018)[43] framework for 'public value of e-governance' (See Annex 1) and has been supplemented with additional values from research conducted by Moore (1995)[44], Barcevičius and others (2019)[45] and Osborne and others (2021)[46].	Assessing projects against this framework enabled the consortium to determine the types of public value most frequently generated through projects. This framework was not intended to limit the analysis, rather it was used as a foundational framework. When an additional public value was identified that did not fit this framework, they have been documented.

Source: State of the Art Report, 2021

[40] Eurostat (a) (see footnote 15).
[41] Open Geospatial Consortium (a), OGC Technology Trends. Accessed at: https://www.ogc.org/OGCTechTrends Accessed on:23/06/21.
[42] European Commission (b) (see footnote 7).
[43] Chu and Tseng (see footnote 18).
[44] Moore (see footnote 19).
[45] Barcevičius, Cibaitė, Codagnone, Gineikytė, Klimavičiūtė, Liva, Matulevič, Misuraca and Vanini (see footnote 6).
[46] Osborne, Nasi and Powell (see footnote 21).

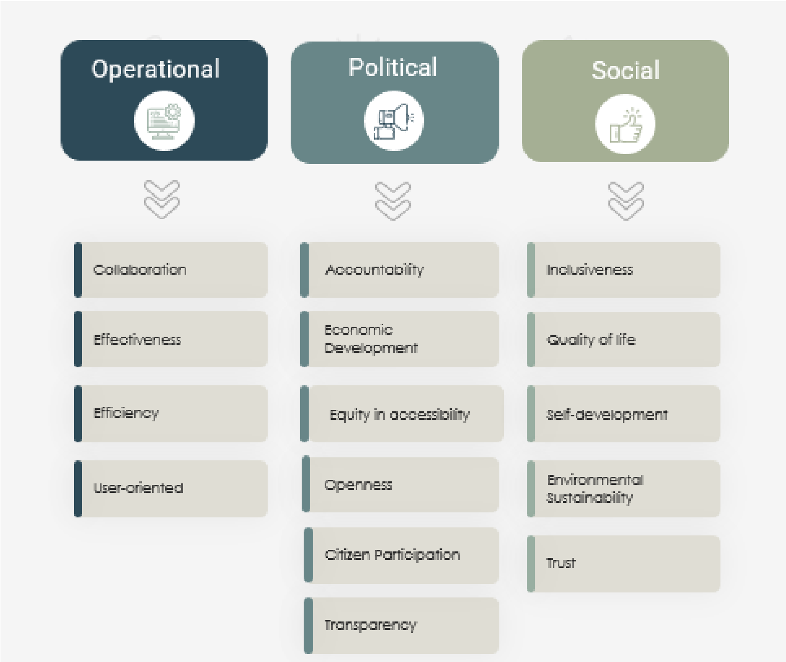
Figure 3. Open Geospatial Consortium's Tech Trends 2020



META TREND	DEFINITION
Location & Position	Determining positions, location and proximity in space and time including spatial thinking and coordinate reference systems and geodesy, GNSS.
Physical Geosciences	Earth's surface, landcover, hydrology, biodiversity, agriculture, geophysics, geosphere, biosphere, oceanography, meteorology, climate.
Social Geosciences	Demographics, society, culture, urban, health, transportation, energy, intelligence, location-based marketing, privacy concerns
Sensing and Observations	Remote and direct sensing and sampling including electromagnetic measurements with radiometric correction; optical, hyperspectral, radar, lidar; from satellites, aircraft, drones, and ground based sensors; and crowdsourcing and Citizen science.
Data Science	Analysis of data to extract insights; using algorithms for graphs, spatial, matrix, dynamic models, machine learning, statistics and visualizations.
Spatial-Temporal Models	Methods for representation and relationships, including geometry, spatial temporal models, map projections.
User Interfaces	Human computer interactions including generating realistic visual images, Display of high-dimensional data from the real scene modeling, simulation and modeling, and natural language interactions.
Computer Engineering	Computer engineering, software, hardware, programming languages, query languages, APIs, internet, databases, network protocols.

Source: OGC, Geospatial Technology Trends, 2020

Figure 4. Public Value Framework



Source: State of the Art Report, 2021 (Drawn from Chu and Seng, 2018; Moore, 1995; Barcevičius et al. 2019; and Osborne et al. 2021)

Review of technology and data offerings by major suppliers

The desk research included a review of location data and technology solutions offered by major suppliers. The objective of this review was to gain an understanding of the current location data and technologies available on the market and identify state of the art and emerging offerings becoming available. It is important to note that not all location-enabled public service projects rely on an external supplier, some projects and solutions are also designed and implemented "in-house."

As part of the review, the following information was collected:

- The type of solution offered, e.g., Geographical Information Systems (GIS) platform, location data marketplace, positioning and tracking, analytics etc.; and
- When available, the main public service areas the data/technology is being applied to, again, using the COFOG classification.[47]

In total, the desk research included a review of the location data and technology offering of 40 major suppliers. A full list of suppliers can be found in Annex 6. This part of the desk research also supported the selection of major suppliers with which in-depth interviews were then conducted (See Section 2.3)

Limitations

One of the main limitations and challenges experienced during the desk research and literature review was the depth of information available on areas such as interoperability, challenges experienced, as well as limited evidence on the impact of location-enabled public service projects and initiatives.

In terms of impact, often, projects reviewed in the literature and through the desk research documented expected outcomes rather than realised outcomes. When evidence was available, generally this focused on operational gains rather than political or social outcomes. Research conducted by Barcevičius and others on the outcomes of digital transformation in the EU more broadly encountered the same challenge, their research also found that "quite often the literature presents the introduction of an innovative service as a positive and valuable development by itself." This is also in line with the findings of the desk research: several projects reviewed focused on the effectiveness of the technology or solution itself rather than the outcome and public value gained.

The lack of information and empirical evidence on impact is likely due to the following factors:

[47] Barcevičius, Cibaitė, Codagnone, Gineikytė, Klimavičiūtė, Liva, Matulevič, Misuraca and Vanini (see footnote 6).

(i) This kind of information is not always documented in publicly available documents.

(ii) Data on the impact of these initiatives is not systematically collected – this hypothesis was verified by the findings on the survey on the use of Key Performance Indicators (KPIS) (see Section 4.1).

(iii) "Productivity gains from technological innovation occur with a time lag."[48]

(iv) The fact that several projects reviewed as part of the state of the art analysis, including EU Commission projects, are in research and development or pilot stage, therefore, several have not been implemented for sufficient time to evaluate the public value generated.

2.3 In-depth Interviews

To supplement the information collected through the desk research, in-depth semi-structured interviews were conducted with relevant stakeholders. The objective of the interviews was to collect more detailed information that it was difficult to collect from the desk research and the survey (see Section 2.2). In this vein, the interviews focused especially on the main challenges encountered during the implementation of location-enabled public service projects, the lessons learned and similar topics which are not often elaborated on in formal, publicly available documents.

Interviews were conducted with three categories of stakeholder: stakeholders in local and regional governments, external experts, and stakeholders from major location data and/or technology suppliers. In total, 14 in-depth interviews were conducted. Table 4 provides information on the number of interviews conducted per category and the selection criteria applied. Annex 7 provides a full list of interviewees. Semi-structured interview guides were developed for each of the stakeholder categories. The interview guides focused on the main areas noted above and were augmented using preliminary findings and leads from the desk research. The semi-structured interview guides were validated by the Consortium and the JRC, and they can be found in Annex 8 of this report.

Table 4. Stakeholder Categories for In-depth Interviews and Selection Criteria

Stakeholder Category	Selection Criteria	Number conducted
Local and regional Government	• Stakeholders with roles such as Chief Information Officer, Chief Digital Officer, and Head of Innovation. • Stakeholders connected to a potentially state of the art project identified through the desk research or via the Consortium.	3
External experts	• External experts with in-depth knowledge related to the application of location data and technologies in the public sector. • A selection of multi-disciplinary expertise. • A selection of practitioners and academic experts.	7
Location data and/or technology suppliers	• Suppliers who offer services/products to multiple public sector institutions across several countries. • Suppliers linked to a potentially state of the art project identified through the desk research or via the Consortium.	4
		14

Source: State of the Art Report, 2021

[48] Barcevičius, Cibaitė, Codagnone, Gineikytė, Klimavičiūtė, Liva, Matulevič, Misuraca and Vanini (see footnote 6).

Limitations

The main limitation was the relatively small sample size of interviewees. This was driven, in part, by the scope and scale of this preliminary deliverable under the Project, but also by the objective of the interviews: to provide complementary qualitative information to the other research methods. To address this, the data collected from the interviews was triangulated with data collected from the survey, desk research and literature review. Further, the findings captured in the State of the Art Report, combining the data from each of the different methods, will be validated by a multi-disciplinary panel of additional subject-matter experts during the remainder of the ELISE Lot 1 Project.

2.4 Survey

A survey was undertaken to collect quantitative data to complement the information gathered through the desk research and interviews. The survey was targeted at local and regional governments, as well as government subsidiaries - who are currently using or plan to use location data and technologies to improve public services. Integrating a survey into the methodology provided a mechanism to cross-check the data gathered during the previous tasks, limiting undue reliance on anecdotal evidence and isolated occurrences, and provided a valuable stream of quantitative data to analyse. The full survey can be found in Annex 9.

The survey was conducted via Computer Assisted Telephone Interviewing (CATI)[49] method in the following languages: English, French, Italian, German, Spanish, Romanian and Polish. The CATI method entails an interviewer running through pre-determined survey questions without editing the questionnaire script: the role of the interviewer is as the intermediary between the respondent and the questionnaire, they can provide explanations when the questions are unclear to improve the response rate and comprehension of the respondent. Some of the advantages of the CATI method include more efficient and accurate questionnaire administration and[50] the ability to conduct surveys with a relatively large sample size. The survey administration was outsourced to an external agency that owns a database of contacts in local and regional governments. They reached out to individuals on this database until the target quotas of participants were met (see below for a discussion on sample size and EU member state quotas).

In terms of the sample size, a total of 158 responses were collected. The survey sample covered key geographies across Europe in a representative manner. Table 5 provides an overview of the sample size and country quotas established. The EU member states selected, and the respective size of their quotas, were based on three variables:

i) Population size of EU member states;[51]

ii) The digital readiness score (using the Digital Economy and Society Index (DESI);[52] and,

iii) EU Regions (Norther, Southern, Western, Central and Eastern).

In total, 82 respondents were from local governments, 16 from regional governments and 60 from government subsidiaries.[53] This will be elaborated at the end of this section in the discussion on limitations. Table 6 provides an overview of the different roles of the participants.

[49] Please find more information on the CATI method here: Mariana, M. Survey methods: Phone survey – CATI, IdSurvey, 2020. Accessed at: https://www.idsurvey.com/en/cati-survey-methodology/ Accessed on: 23/06/2021.

[50] Lavrakas, P., 'Computer-Assisted Telephone Interviewing (CATI)', *Encyclopaedia of Survey Research Methods, Sage, 2008,* http://dx.doi.org/10.4135/9781412963947.n83

[51] Eurostat (b), Population Database, 2021. Accessed at: https://ec.europa.eu/eurostat/web/population-demography-migration-projections/data/database. Accessed on: 23/06/2021

[52] European Commission (h), The digital Economy and Society Index (DESI), 2020. Accessed at: https://digital-strategy.ec.europa.eu/en/policies/desi. Accessed on: 23/06/2021.

[53] Government subsidiaries include agencies such as port authorities and public transit authorities responsible for delivering public services, for the subsidiary to be included in the survey they had to be fully or partially owned by the local or regional government.

Table 6. Survey Sample Targeted and Actual Responses across EU Member States

Country	Number
Germany	*23*
France	*20*
Italy	*15*
Spain	*20*
Netherlands	*10*
Belgium	*10*
Sweden	*10*
Denmark	*10*
Austria	*10*
Poland	*10*
Czech Republic	*10*
Romania	*10*
TOTAL	***158***

Source: State of the Art Report, 2021

Table 5. Roles of Participants (survey responses)

Role	n=	%
Elected Official	2	1%
Chief Information Officer	18	11%
Chief Innovation Officer	3	2%
Chief Digital Officer	6	4%
Chief Data Officer	5	3%
Chief Innovation Officer		0%
Head of IT	39	25%
Head of Sustainability Department	4	3%
Head of Transportation Department	5	3.%
Head of Mayor's Office	1	1%
Head of other Department utilising location data and technologies in service delivery	36	23%
IT Director/ IT Manager	24	15%
GIS Head/ GIS Manager	9	6%
Other	6	4%
TOTAL	**158**	**100**

Source: State of the Art Repot, 2021

Once respondents had been contacted over the phone, a set of screening criteria was used to ensure they were appropriate for the parameters of the study. These included the:

(i) Population size (i.e., had to be over 20,000 participants);
(ii) Principal activity of the organisation (i.e., had to be local government, regional government or a government subsidiary);
(iii) Whether the institution is using or plans to use location data to improve public services; and,
(iv) Whether the respondent is knowledgeable about location data.

The survey included questions on the following areas, among others:

— Policy areas where location data and technologies are currently being leveraged, or plan to be in the near future (i.e., the next 2 years);
— The public values(s) generated, or expected to be generated and if/ how the impact of these projects is measured;
— The types of challenges encountered when investing in and when implementing these projects; and,
— The main types of location data being used, other types of data being used in conjunction, and the use of emerging technologies.

Limitations

The survey was designed to collect standardized quantitative information. The survey included closed questions with a defined list of answers rather than open-ended questions that allow participants to give a free-form answer. The advantage of this approach is that this enables the collection of standardized quantitative data that can be aggregated, compared and analysed. However, the limitation of this approach is that it allows respondent limited space to provide unanticipated answers. To address this, the data collected through desk research, literature and interviews provided an opportunity to identify unanticipated answers and areas of research.

In terms of limitations of the survey sample, due to the scope and scale of the study, it was necessary to select a sub-sample of EU member states: the survey covered 12 of the 27 EU member states. As such, the findings do not integrate data from every member state. To address this, as outlined above, a methodology was developed to select a representative sample based on three variables: population size, digital readiness score and the EU Regions. Further, through the desk research and literature review projects and articles were reviewed from other EU member states to gain a wider regional view. Further, it is also important to note that there were a high percentage of survey participants with IT roles, that is, Head of IT (25%) and IT Director/Manager (15%) (See Table 6 for an overview of the profile of survey participants). This is not a limitation as such, but rather, may have implications on the perspective of survey participants and their responses. For example, some IT departments are not always well connected to those within the public administration working on broader digital transformation strategies.[54]

Finally, a limitation of the survey methodology was the fact that, out of the 158 participants, only 16 respondents were from regional governments. Going forward in the Project, the distinct drivers, challenges experienced, and innovations being driven by local and regional governments respectively will be analysed in more detail, particularly through the development of the case studies.

3. Overview of Location Data and Technologies Enabling the Improvement of Public Services at a Local and Regional Level

This chapter provides an overview of the evolution of location data and technologies starting with the traditional and mainstream and moving to recent innovations and future trends. The chapter is intended as a high-level overview highlighting significant innovations. Some of the drivers and barriers of these location data and technologies will be briefly touched upon but will be elaborated further later in the report. The information presented in this chapter provides an overview of the backdrop against which location-enabled public service innovation and digital transformation is occurring and provide critical context for Chapter 4.

3.1 Evolution of Location Data

3.1.1 Introduction

Over the last decade, there has been a significant increase in the variety and volume of location data produced. As well as an increase in the availability of more traditional static data sets, such as those covered by the INSPIRE Directive, there has been a rise in alternative location data sources such as Internet of Things (IoT) devices, Mobile Positioning Data (MPD), Voluntary Geographic Information (VGI), and high-frequency Earth Observation Data (EOD) from initiatives such as the EU's Copernicus Programme. These alternative data sets are being leveraged to enrich more traditional static data sets. There has been an **increase in the generation of both static and dynamic data sets.** These dynamic data sets tend to have greater volume and velocity, and many are spatio-temporal meaning that they can be linked to a location and a point in time. At a global level, the United Nations Committee of Experts on Global Geospatial Management (UN-GGIM) predicts that the technologies and data creation methods that will have the greatest impact on the geospatial industry are mobile data collection methods, crowdsourcing for real-time data collection, and social-media platforms.[55]

> *"Whereas public sector information (e.g., about cadastral parcels or protected sites) continues to play an important role, increasing amounts of spatial data are produced, owned and provided by the private sector… These changes will significantly affect the role of the public sector in geospatial data management and provision." – Schade et al 2019.*

[54] The profile of survey participants was driven by two main factors. Firstly, the survey administration was outsourced to an external agency that owns a database of contacts in local and regional governments. The participants were targeted on the basis of this contact database. Secondly, once contacted, participants were subject to screening questions, including whether they were directly involved or part of the team making decisions related to geo-location technology.

[55] United Nations Committee of Experts on Global Geospatial Information Management. *Future Trends in geospatial information management: the five to ten year vision – Third Edition*, 2020.

The rise in alternative location data sources is "challenging the role of the public sector as the main producer and owner of geospatial content…[previously] geospatial data and management were an almost exclusive prerogative of the public sector and its contractors."[56] In this context, **the public sector has an increasingly important role as an aggregator and user of third-party location data sets**. An increasing amount of location data is being produced by citizens, such as data from mobile phones, social media and IoT devices, and a significant proportion of this is owned by the private sector. The implications of this change in data ownership and governance are significant and will be touched upon throughout this report.

3.1.2 Static Data

Static location data continues to play an important role in the design and delivery of public services at the local and regional level. Examples of static location datasets include addresses, cadastral parcel, land use, and topography data collected through manual or digital surveying techniques. They are used in a variety of public services provided by regional and local government, such as land management, election management and infrastructure asset management. Several significant static location data sets are covered by the INSPIRE Directive. In the INSPIRE geoportal there are currently approximately 93,000 metadata sets and 43,500 downloadable and viewable location data sets (these numbers fluctuate frequently).[57] Maintaining high-quality and authoritative location data remains an important role for the public sector and is also a continuous challenge.[58] These challenges will be explored further in Chapter 4 of the report.

In the course of this research, three key emerging trends and/or innovations have been identified in the space of static location data:

- The development of **digital underground asset registers**. Over the last 5 years, there have been a few examples of EU jurisdictions developing digital underground registries, for example, the Flanders Underground Utility Location System. However, the majority of local, regional and national governments have not yet established sub-surface datasets. If data is available, it is often fragmented and outdated.[59] A few regional and local governments are in the process of piloting the development of these registers, drawing lessons from the Flanders system.[60]
- There is an increasing demand for **indoor location datasets**. This includes building entry points, floorplans, and facilities for the purposes of indoor navigation. This can be useful for applications such as wayfinding, emergency management, and public health. There has been a particularly high-level of demand in the context of the Covid-19 pandemic. While some governments have accessible data at ground level, less data is available on the layout and floorplans of buildings – and this data is often fragmented.[61]
- The development of an **alternative geocode system** by the company What3Words. What3Words differs from most other encoding system in that it displays 3 words rather than a string of numbers and letters. This geocode system enables users to identify a location, including addresses and property references more accurately and is being applied to several public sector services. Some of the applications of this system include using the system for citizen reporting of emergency and non-emergency events as well as enabling coordination between emergency responders.[62]

---

[56] Kotsev, Minghini, Tomas, Cetl and Lutz (see footnote 8).
[57] European Commission (f) (see footnote 30).
[58] McDougall, K. and Koswatte, S. 'The Future of Authoritative Geospatial Data in the Big Data World – Trends, Opportunities and Challenges,' *Fig Commission 3 Workshop,* Naples, 2018.
[59] United Nations Committee of Experts on Global Geospatial Information Management (see footnote 55).
[60] UK Government, Geospatial Commission, Policy Paper - *National Underground Asset Register Project Update,* 2020. Retrieved from: https://www.gov.uk/government/publications/national-underground-asset-register-project-update/national-underground-asset-register-project-update. Accessed on: 03/06/2021.
[61] Basiri, A., Lohan, E, S., Moore, T., Winstanley, A., Peltola, P., Hill, C., Amirian, P., Figueiredo e Silva, P.
'Indoor location based services challenges, requirements and usability of current solutions', *Computer Science Review*, 2017, Vol. 24, pp 1-12.
[62] What3words, Business, retrieved at: https://what3words.com/business/ Accessed on: 03/06/2021.

3.1.3 Dynamic Data

Mobile Positioning Data

There has been a rapid increase in the generation of MPD. Most smartphones are now equipped with several sensors such as Global Navigation Satellite System (GNSS), Wi-Fi and Bluetooth that can be used to collect information on the location of the device. [63] Mobile network operators (MNO) also automatically collect a large volume of data and metadata created when people make calls, send messages or use the internet. There are two main types of MPD, active positioning data and passive positioning data. For active positioning, a specific request for location is made to the user and a location response is returned. For passive positioning, historical data is collected, and no request is sent to the user. Both passive and active data can be monitored historically or in real time.[64] These 'digital footprints' contains significant value and can provide close to real-time spatio-temporal information on population mobility; this data has a wide range of potential applications such as transport and mobility management, emergency and disaster response, crowd management, tourism flows and urban planning.[65]

While there has been an explosion in the production of MPD, there are persistent barriers that have limited the application of this data to public service innovation. The barriers identified through this research include:

- A lack of business incentives: these data are generally generated and owned by MNOs who may not have an incentive to share this data with regional and local government unless they see a clear monetary value. Further, MNOs also have to consider public opinion and the potential reputational risk of sharing this data.
- Data management and analytics requirements: these data are generally high volume and require large storage capacity. They also require the application of advanced analytics to extract insights.
- Privacy concerns: Given that MPD in its raw form includes personal data and sensitive information the use of MPD is considered ethically and legally complicated in several countries, although a 'privacy by design' approach can ensure anonymization of the data.
- Legal and regulatory requirements: applications have to be in line with General Data Protection Regulation (GDPR) requirements. Some instances were identified where there has been uneven and changing interpretation and application of GDPR to more dynamic location data sources such as MPD. [66]

Internet of Things Devices

Over the last decade, a growing number and variety of digital sensors have been connected to the Internet – the Internet of Things (IoT) – and a growing volume of IoT data generated. Several IoT devices are fitted with GNSS sensors which enable spatio-temporal data to be collected, as well as geo-tagged sensors which collect observation data, for example, observation data collected via an air quality or light sensor. Over the last decade, the precision and spatial resolution of IoT data has increased significantly, and the cost of the hardware has decreased, enabling wider application to several public service domains.[67] IoT devices and systems are often a core component of 'smart city'[68] projects, solutions and services across many different domains complemented by supporting architectures, networking technologies and analytical tools and capabilities.

However, one of the main barriers that is limiting the application of IoT data to public sector innovation is that the velocity and volume of data from IoT devices can make the data more difficult to exploit, from a data

[63] Książek K, Grochla K. 'Aggregation of GPS, WLAN, and BLE Localization Measurements for Mobile Devices in Simulated Environments'. *Sensors (Basel)*, 2019, Vol. 19, No. 7:1694.

[64] Tiru, M. Overview of the Sources and Challenges of Mobile Positioning Data for Statistics, UNstats, 2020. Accessed at: https://unstats.un.org/unsd/trade/events/2014/beijing/Margus%20Tiru%20-%20Mobile%20Positioning%20Data%20Paper.pdf. Accessed on: 23/06/2021.

[65] Ibid.

[66] Kalvet, T., Olesk, M., Raun, J. 'Innovative Tools for Tourism and Cultural Tourism Impact Assessment,' Sustainability, 2020, Vol 12, No. 18, 7470.

[67] Kotsev, Minghini, Tomas, Cetl and Lutz (see footnote 8).

[68] A smart city is a place where traditional networks and services are made more efficient with the use of digital solutions for the benefit of its inhabitants and business. A smart city goes beyond the use of digital technologies for better resource use and less emissions. It means smarter urban transport networks, upgraded water supply and waste disposal facilities and more efficient ways to light and heat buildings. It also means a more interactive and responsive city administration, safer public spaces and meeting the needs of an ageing population. (European Commission, What are Smart Cities? Accessed at: https://ec.europa.eu/info/eu-regional-and-urban-development/topics/cities-and-urban-development/city-initiatives/smart-cities_en#related-policies Accessed on: 09/08/2021)

storage, management, and analytics perspective. As noted by Grannell and others (2020) "despite the existence of tools capable of analysing temporal data in real time, the same does not appear to be true for the spatial component… spatial support for the real-time analysis of IoT data is still in its infancy." [69]

For some IoT enabled applications and services, such as smart infrastructure, health care services and Intelligent Transport Systems (ITS), Edge computing will play an increasingly important role as the underlying system architecture. Edge computing refers to a distributed computing paradigm that brings computation and storage closer to the source of the data, in this case, closer to the "thing" to improve response times and reliability.[70]

User-generated Location Data

User-generated location data has become increasingly prevalent. This is also referred to as Volunteered Geographic Information (VGI), crowdsourced geographic data, and neogeography. User-generated data covers a broad range of different types of data, including, for example, open access participatory mapping. One of the most popular initiatives in this space has been OpenStreetMap (OSM), a crowdsourced vector database that has attracted millions of data contributors; among some EU members states, the public sector is one of the main users.[71] User-generated data is also being collected through citizen science projects such as environmental monitoring (see Section 4.5) as well as civic participation platforms that enable citizens to report non-emergency issues such as potholes. While this data is being widely collected and used there are ongoing debates, both in the literature[72] and public sector institutions[73], on the quality and authority of the data. This will be discussed further in Section 4.1.

An emerging source of data in this field is data generated from social media, for example a georeferenced or geotagged post – these data are increasingly being analysed and visualized through tools such as sentiment mapping and used for applications that the user may not have foreseen, including across various public service domains. The barriers identified for using social media user-generated location data mirror those identified for MPD: access and private-sector ownership, data storage and analytics, and privacy and ethics, on top of this, there is a question relating to how demographically representative the data is.[74]

Earth Observation Data

EOD collected from satellites, aircrafts and drones, has been identified by the EU as another high-value public data set.[75] It is important to note that EOD is distinct from location data as the data generated is digital imagery. Advances and trends in EOD will be discussed briefly here as there are many opportunities to integrate location and earth observation data to gain public value and to acknowledge that there has been a significant growth in the availability of EOD fuelling an increasing number of public service innovations, particularly in the space of environmental and hazard monitoring.[76] Satellite data is now available "at higher resolution and temporal frequency for lower costs."[77] As noted by the Organisation for Economic Corporation and Development (OECD) [78]:

> *"While EOD is not new, it is only recently that investments in satellite capabilities, open and free access to data and tools, and advances in algorithms and data processing have started to enable the widespread use of this information at scale…beyond the scientific community." – OECD, 2021*

[69] Granell, C., Kamilaris, A., Kotsev, A., Ostermann, F, O., Trilles, S. (2020) 'Internet of Things' in Guo, H., Goodchild, M. F., Annoni, A. *Manual of Digital Earth,* Singapore, Springer Open, p404.
[70] United Nations Committee of Experts on Global Geospatial Information Management (see footnote 55) and Syed, A, S. Sierra-Sosa, D., Kumar, A, and & Elmaghraby, A, S. (2021). IoT in Smart Cities: A Survey of Technologies, Practices and Challenges. Smart Cities. 4. 429-475. 10.3390/smartcities4020024.
[71] Interview with Maurizio Napolitano, Researcher at Fondazione Bruno Kessler di Trento, Coordinator for Laboratorio Digit Commons.
[72] Senaratne, H., Mobasheri, A., Ali, A, L., Capineri, C., and Haklay, M. 'A review of volunteered geographic information quality assessment methods' *International Journal of Geographical Information Science*, 2017, Vol. 31, No. 1, pp. 139-167.
[73] Interview with Maurizio Napolitano, Researcher at Fondazione Bruno Kessler di Trento, Coordinator for Laboratorio Digit Commons.
[74] Ibid.
[75] European Commission (d) (see footnote 11).
[76] European Union (d), 2019, *The European Union Earth Observation Programme.* Accessed at: https://www.copernicus.eu/sites/default/files/Brochure_Copernicus_2019%20updated_0.pdf
[77] United Nations Committee of Experts on Global Geospatial Information Management (see footnote 55).
[78] OECD (a), 2017, *Earth Observation for Decision Making*. Accessed at: https://www.oecd.org/environment/indicators-modelling-outlooks/Earth_Observation_for_Decision_Making.pdf Accessed on:2306/2021.

Despite the explosion of available EOD, there are some barriers that limit its uptake, for example:

- Private ownership: some of the most granular satellite image data sets are owned by private companies and can be relatively expensive.
- Data management and analytics requirements: EOD data sets are generally high volume and require sufficient storage and processing capacity. To extract insights, the application of more advanced analytics is often required along with sufficient digital competencies and skills. There have been emerging examples of innovative use cases in the public sector applying AI to EOD; however, these applications are generally not mature or mainstream. To effectively scale knowledge discovery and data mining from satellite images and related geospatial data sets, more advanced analytical tools will need to be developed. There is research and development in this space within the EU, include the Extreme Earth Project. One of the significant barriers noted is the lack of training data sets in the Copernicus context (see quote below).[79]

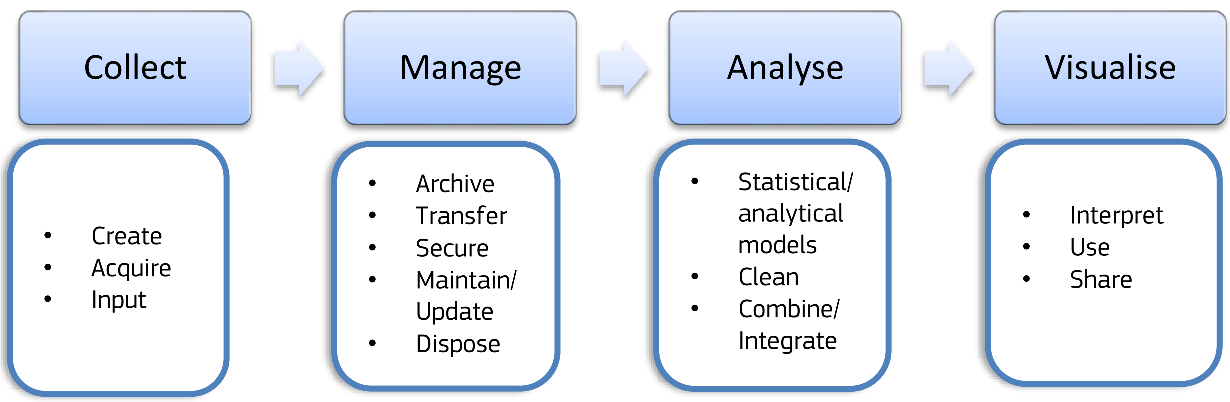
> *"New tools have been developed...for knowledge discovery and data mining from satellite images and related geospatial data sets as well as tools for linked geospatial data integration, querying and analytics. However, none of these tools scale to the many petabytes of data, information and knowledge present in the Copernicus context. Training datasets consisting of millions of data samples in the Copernicus context do not exist today and published deep learning architectures for Copernicus satellite images typically run using one GPU and do not take advantage of recent advances like distributed scale-out deep learning." – Extreme Earth, H2020 Project*

3.2 Evolution of Location Technology

3.2.1 Introduction

Advances in location technologies have been a key driver in strengthening existing public services and enabling new ones, such as ride-hailing, curb side management and Covid-19 track and trace applications. Several of these technological advancements are being driven and/or enabled by other emerging technologies such as cloud and edge computing and 5G. These technological advancements span the data life cycle, from data collection, management and analytics to visualisation. The stages of the data life-cycle – illustrated in Figure 5 – were selected based on a review of relevant literature and have been used as a framework to organise this section of the report.[80]

Figure 5. Stages of the Data Life Cycle



Source: State of the Art Report, 2021 - drawn from Higgins, 2012 and updated by the Project Consortium

[79] Extreme Earth, About, 2019. Accessed at: http://earthanalytics.eu/about.html. Accessed on: 21/06/2021.
[80] Drawn from: Higgins (see footnote 3) and Ball (see also footnote 3).

3.2.2 Data Collection

Positioning Technology

The use of **Global Navigation Satellite Systems** (GNSS) is now ubiquitous in everyday life. As noted by Xin, 2021, "more than ever, we rely on technologies that can determine our location or pinpoint an object's position." [81] Technological developments in GNSS have, and will continue to, advance rapidly. For example, when the European Satellite Programme Galileo's High Accuracy Service (HAS) is complete (target date 2024) it will provide an accuracy of 20 centimetres or better. This level of accuracy will enable the improvement of existing services such as precision farming and infrastructure surveying and is likely to enable several emerging applications and services such as Connected and Autonomous Vehicles (CAVs). While GNSS is not expected to be the primary positioning service for CAVs, sensor networks combined with GNSS are expected to be a potential solution. [82]

Over recent years, there have been significant advances in **indoor positioning** technologies which have, and will continue to, open up opportunities for a wide range of public service innovations such as wayfinding and crowd sensing in transport hubs, libraries and other cultural venues. There are variety of technologies that can enable indoor positioning, including Bluetooth Low Energy (BLE) beacons, ultra-wideband, Wi-Fi, geomagnetism, and near field communication.[83] There have been advances in the accuracy and a reduction in the cost of most of these technologies opening the possibility of wider-spread uptake. The Covid-19 pandemic has been a significant driver for *increasing demand for* indoor positioning technology. Advancements in the accuracy of positioning data are likely to be driven in the long-term by investment in **5G infrastructure**, including enabling a more seamless interaction between indoor and outdoor positioning technologies.[84]

Innovation is also occurring in the field of **underwater positioning**. Devices with radio wave technology can track marine wildlife as well as objects such as drones. However, currently, devices that generate and send sound usually require batteries that require regular charging. Early stage research and development from MIT has led to the creation of a battery-free underwater positioning system. While this is not yet ready to be deployed, it could fuel emerging public service innovations, particularly in the space of environmental monitoring and conservation.[85]

Earth Observation Technology

Earth observation technologies, including satellites, aerial mapping, terrain mapping, have seen, and are expected to continue to see, several innovations and improvements in coverage, resolution, revisit rates, and cost-effectiveness. Copernicus is the EU's Earth Observation Program for the collection of satellite and in-situ EOD. There is also an established ecosystem of private sector providers of earth observation systems and data. At the global level, the UN-GGIM has identified new and improved methods of EOD collection as an important trend for the geospatial community, including Remotely Operated Aerial Systems (ROAS), Autonomous Under-Water Vehicles (AUWS), Autonomous Surface Vehicles (ASVs), small satellites, sensor networks, laser scanning, Synthetic Aperture Radar Interferometry (InSar), and point clouds.[86] An emerging technology that has not yet left the laboratory environment is quantum sensors – these are expected to change how surveying is performed, including underground asset surveys. [87] These technological innovations are driving the quantity, quality and affordability of global remote sensing data available to public and private sector institutions.

[81] Xin, L. 2021, *Hyper-accurate Positioning is Rolling Out Worldwide,* MIT Technology Review. Accessed at: https://www.technologyreview.com/2021/02/24/1017805/hyper-accurate-global-positioning-available-worldwide/ Accessed on: 10/06/2021.

[82] European GNSS Agency, 2020, Galileo High Accuracy Service (HAS) Info Note. Accessed at: https://www.gsc-europa.eu/sites/default/files/sites/all/files/Galileo_HAS_Info_Note.pdf Accessed on: 20/06/2021.

[83] Basiri, Lohan, Moore, Winstanley, Peltola, Hill, Amirian and Figueiredo e Silva (see footnote 61).

[84] United Nations Committee of Experts on Global Geospatial Information Management (see footnote 55).

[85] Ackerman, D. (2020) An Underwater Navigation System Powered by Sound, MIT News. Accessed at: https://news.mit.edu/2020/underwater-gps-navigation-1102 Accessed on: 09/06/2021.

[86] United Nations Committee of Experts on Global Geospatial Information Management (see footnote 55).

[87] Ibid.

3.2.3 Data Management

Data Management Practices

There have been advances in data management linked to the **discoverability, accessibility and interoperability of location data**. In the EU, many of these advances have been driven by the INSPIRE Directive. Since the launch of the INSPIRE Directive, considerable progress has been made by member states in strengthening their SDI through the creation of centralised spatial databases as well as the implementation of policies and standards to facilitate the access and use of this location data.[88] Member states have appointed national authorities to oversee the implementation of the INSPIRE Directive, but local and national governments also have an important role at the frontline in identifying, producing and sharing spatial data such as address data, land use data, protected environmental sites and transport network data. While there have been advances, maintaining high-quality, up-to-date, and interoperable location datasets remains an ongoing challenge for local and regional governments across the EU – this will be discussed further in Chapter 4.

Another EU Directive that has had an influence on the availability and interoperability of location data, and public sector data more broadly, is the Directive on Open Data and the Reuse of Public Sector Information (PSI Directive)[89] and ensuing Open Data Directive.[90] The Directive governs the re-use of public sector information, encourages public and promotes open data policies allowing broad use and reuse of their data. It outlines how the introduction of open and re-usable public datasets allows for the increased development of new value-added applications which can integrate (link) government data without requiring developers to redesign information systems and to centralise data in data silos facilitating collaboration between public sector agencies in the provision of common services, ensure semantic interoperability and facilitates the provision of cross-border public services.

An evolving area of discussion in this context has been the value of **linked location data** – that is, a set of best practices for publishing and connecting structured data on the Web in a way that can be connected and interpreted together. The discussion of Linked Data Principles has become increasingly mainstream in discussions on geospatial information management. [91] As will be discussed in the subsequent chapter of the report, some of the most valuable geospatial intelligence for public service innovation is driven by the integration of multiple datasets, therefore advances in the space of 'linked data' are important. Linked data is data which is structured according to a data model that is interlinked with other data and datasets so that it can be used through semantic queries based on common web standards including HTTP, RDF and URIs so that data can be read by humans and be read automatically by computers. Linked data may also be open data, in which case it is usually described as linked open data.

The use of linked and linked open location datasets is particularly important for public administrations in areas including transport, cadastre/land registry, public infrastructure management and maintenance, environmental monitoring, and emergency management where extensive data has been collected over decades of administration. In many cases, it is difficult to find and use this information if not by the application that was originally planned to manage the particular public service. Applying linked data technologies to these silos of information provides a mechanism to make this information reusable by the administration as it develops new applications as well as leverage datasets and other administrations that have made their data available. It also allows administrations to combine the data in their applications with publicly available location data. Many datasets have either a spatial or temporal identifier and there are increasing examples of governments and government agencies connecting these datasets and publishing their data as Linked Spatiotemporal Data.[92] Schade and Smits (2012) highlight the opportunity of capitalizing on Linked data principles to augment environmental and other spatial-temporal data with information from complementary sectors.[93]

[88] Cetl, Nunes De Lima, Tomas, Lutz, D`Eugenio, Nagy and Robbrecht (see footnote 31).

[89] European Union (e), Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions – Re-use of Public Sector Information of Directive 2003/98/EC.

[90] European Union (b) (see footnote 28).

[91] Janev, Valentina & Mijović, Vuk & Vraneš, Sanja. (2015). Linked data approach to the PSI directive implementation: Supporting tools and lessons learned. 823-826. 10.1109/TELFOR.2015.7377592.

[92] Janowicz, K. Simon, S. Pehle, T. and Hart, G. (2012). Geospatial semantics and linked spatiotemporal data --Past, present, and future. Semantic Web. 3. 321-332. 10.3233/SW-2012-0077.

[93] Schade, S. & Smits, P. (2012). Why Linked Data Should Not Lead to Next Generation SDI. International Geoscience and Remote Sensing Symposium (IGARSS). 10.1109/IGARSS.2012.6350721.

There are many examples of how linked and linked open data can improve public administration service delivery but there are also some limitations. At present, most information systems store data in relational databases often using XML schemas. However, when the data evolve (like the opening of a new highway) these schemas evolve, information systems need to be adapted accordingly. Over time, maintaining these schemas requires significant effort and can be quite inflexible. There are linked data paradigms including Resource Description Framework (RDF) [94] and Geography Markup Language (GML)[95] which allow data merging even if the underlying schemas differ supporting the evolution of schemas over time without requiring all the data consumers to be changed. Although these databases require lower levels of maintenance, adapting systems to the latest Linked Data technologies requires an investment which represents a barrier to many public administrations.

Geographical Information Systems

The evolution of **Geographical Information Systems** (GIS) to aggregate, manage, display and analyse location data has gone hand in hand with the progress of different information technologies. Most recently, advancements and opportunities for GIS innovation have been linked to advances in:

- Big data generation, including real-time data and EOD;
- Data infrastructure, including increased computing and processing power that can be scaled and flexible, including cloud GIS; and,
- Advanced analytics. While data analytics is not an emerging technology, spatial analytics are evolving in sophistication, including advances in machine learning and artificial intelligence (GeoAI).[96]

The ability of GIS platforms to manage, analyse and visualise big data in real time are "transforming the way governments and businesses operate, plan and deliver their services." [97] In terms of emerging and future trends, the majority of GIS products are still linked to desktop applications; it is expected that there will be a significant increase in mobile applications increasing the accessibility and usability of the technology.[98] Going forward, as noted by Schade and others (2019) Geospatial Information Infrastructures, GIS and SDIs have and will continue to need to evolve to become "flexible and robust enough to absorb and embrace technological transformations" including processing and analysis novel data sources.[99]

An emerging area of interest and open challenge in this field is the lack of interoperability of GIS systems with Building Information Management Systems (BIMs). There is a significant body of research focused on addressing the current interoperability challenges, particularly between the following 3D data standards: the International Industry Foundation Class (IFC) standard (developed by Building Smart International) for the built asset industry and CityGML for the geospatial industry (developed by the Open Geospatial Consortium).[100] The interoperability of these systems is also important for the deployment of digital twins which integrate the built environment (see section 3.2.5).

3.2.4 Data Analysis

The field of spatial analytics is constantly evolving to enable deeper location intelligence. The analysis of spatial data has long been undertaken by governments, researchers and businesses to support decision making and operational efficiencies. The UN-GGIM identifies three types of analytics[101]:

- **Descriptive** analytics which describe and visualize aggregated information;
- **Predictive** analytics which model future trends and outcomes; and,
- **Prescriptive** analytics which recommend a course of action to achieve an outcome.

[94] W3C Semantic Web, Resource Description Framework (RDF). Accessed at: https://www.w3.org/RDF/ Accessed on: 09/06/2021.

[95] See Schade, Sven & Cox, Simon. (2010). Linked Data in SDI or How GML is not about Trees for further discussion on the connection and complementarity of standards in the geospatial community and the 'Linked Data Philosophy.'

[96] Song, W., and Wu, C. Introduction to advancements of GIS in the new IT era, Annals of GIS, 2021, Vol 27, No. 1, pp 1-4.

[97] National Geospatial Advisory Committee, *Emerging Technologies and the Geospatial Landscape. Accessed at:* Microsoft Word - NGAC Paper - Emerging Technologies and the Geospatial Landscape.docx (fgdc.gov) Accessed on: 20/05/2021.

[98] United Nations Committee of Experts on Global Geospatial Information Management (see footnote 55).

[99] Schade, Sven & Granell, Carlos & Vancauwenberghe, Glenn & Keßler, Carsten & Vandenbroucke, Danny & Masser, Ian & Gould, Michael. (2020). Geospatial Information Infrastructures. 10.1007/978-981-32-9915-3_5.

[100] United Nations Committee of Experts on Global Geospatial Information Management (see footnote 55).

[101] Ibid.

These three categories also reflect a scale of maturity. Advances in predictive and prescriptive analytics are, to a large extent, being driven by Artificial Intelligence – **GeoAI.** As will be discussed later in the report, there are state of the art examples of public service innovations leveraging GeoAI, but these examples are in the minority and are generally in a developmental stage. Innovation is occurring particularly in the space of automatic processing, cleaning and interpretation of data, including image recognition and classification of EOD and IoT data; for example, the classification of buildings, solar panels and street furniture from aerial and satellite imagery and the identification of people and objects (e.g., street furniture and street markings) from video imagery.[102]

"Most location data is still human read. There are exciting prospects in the space of machine read and analysed geospatial data to support automated analysis and prediction." Miranda Sharp, Chief Executive of METIS DIGITAL and previous Director of Innovation at UK Ordnance Survey (State of the Art Report Interview)

The main technological drivers of GeoAI include the reduction in cost of IoT and earth observation technology, and the subsequent volume and variety of data available, new algorithms that can run across several data sources, and lower-cost of cloud-based data processing.[103] As will be discussed later in the report, the main barriers for uptake, particularly in the public sector, are linked to discussions on algorithm confidence, trust, ethics and governance as well as a digital skills gap – particularly acute in local and regional governments. [104]

3.2.5 Data visualization

Advances in visualisation and immersive technology have been changing the ways in which people interact with location data and have been bridging the gap between the digital and physical environment. Technological advancements are enabling a move from 2D to 3D visualisations of location data. Governments, particularly city governments, are increasingly investing in 3D city models as an essential component of their SDI, including the development of Open 3D City Models through CityGML.[105] Advances in immersive technologies such as virtual reality (VR) and augmented reality (AR) are also transforming the ways in which users can interact with digital information by merging real world location data with computer generated virtual layers.

In terms of future innovations, the concept of digital twins has gained significant traction in recent years and is subject to extensive research and preliminary piloting. This technology brings together data collection, management, analytics and visualization to enable the creation of a virtual replica of something in the physical world constructed through data rather than physical materials. In comparison to 3D static models, digital twins are directly fed by multiple data sources and continuously updated.[106] Pilots and models are being built across multiple scales from single facilities to whole cities with the objective of providing richer decision support capabilities for both planning and operational processes. Static location data will be and important basis of digital twins and communities which can then be enhanced with dynamic data such as EOD and IoT data.

4. The Impact of Location Data and Technologies on Improving Public Services

This chapter of the report will start by providing a cross-cutting overview of the policy areas in which location-enabled public services are being adopted, the types of public value being generated, as well as some of the challenges experienced. These cross-cutting findings are primarily based on the findings from the survey but have also been complemented with findings from the other research methods. The chapter will then provide a

[102] Analysis from the review of EC and regional and local government projects as part of the desk research as well as findings from interviews with experts.

[103] United Nations Committee of Experts on Global Geospatial Information Management (see footnote 55).

[104] Fatima, S., Desouza, K, Dawson, G, S. and Denforc, J, S. Analyzing Artificial Intelligence Plans in 34 Countries. Brookings Institute, TechTank, 2021. Accessed at: https://www.brookings.edu/blog/techtank/2021/05/13/analyzing-artificial-intelligence-plans-in-34-countries/ Accessed on: 15/05/2021.

[105] Prandi, F., Devigili, F., M., Soave, M. Staso, U, D., De Amicis, R. '3D Web Visualization of Huge CityGML models' The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, Vol. cL-3/W3, La Grande Motte, 2015.

[106] GIS-Enabled Digital Twin System for Sustainable Evaluation of Carbon Emissions: A Case Study of Jeonju City, South Korea

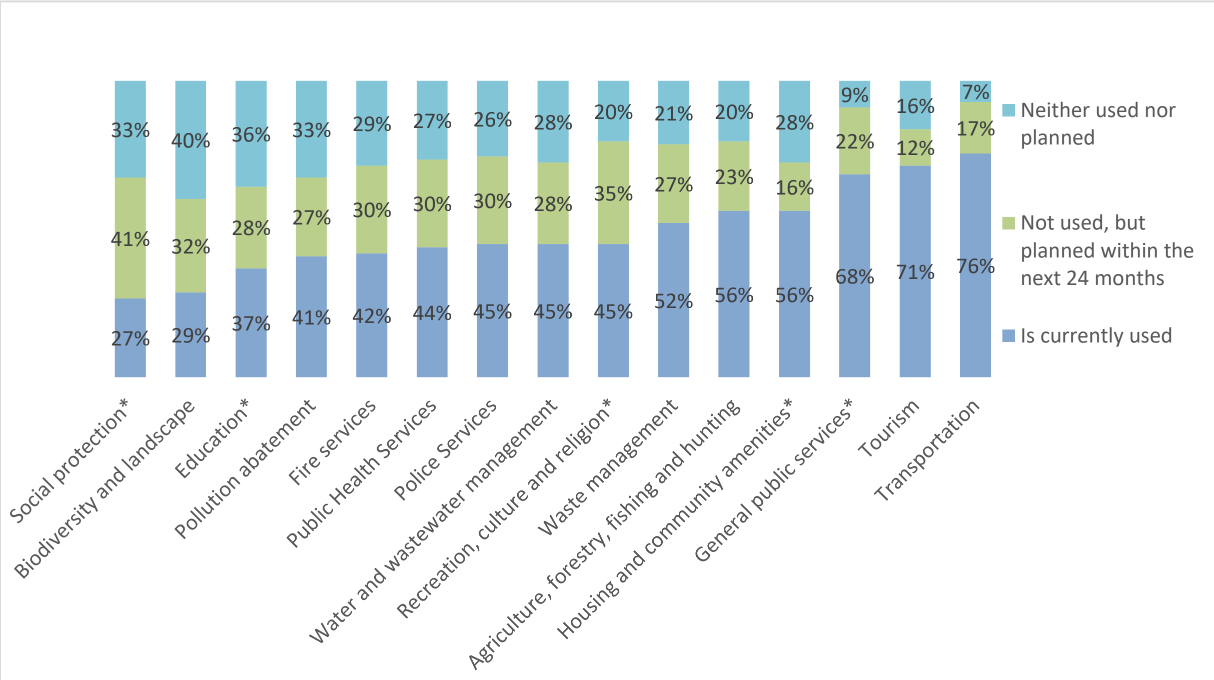
'deep dive' into three policy areas in which innovative uses of location-enabled public services are being adopted: transport, tourism and health. Finally, the chapter will conclude by highlighting policy areas in which location data and technologies are starting to be applied and leveraged in interesting ways to generate public value, but they are either in early stages of research and development, are underexplored or are not widely replicated. This final section of the chapter will highlight emerging examples of types of innovations which can be enabled by location data and technology which could be applicable to several policy areas.

4.1 Overview of Location-Enabled Public Services

4.1.1 Public service areas

The data from the survey demonstrates that location data and technologies are being used by local and regional governments across all the policy areas included in the survey (see Figure 6). The policy areas included in the survey are based on the COFOG classification.[107] In part, this reflects the fact that a large percentage of data collected by the public sector has a location component; for example, in the United Kingdom it is estimated that address data underpins 80% of all local government data.[108] It also reflects the fact that location data plays an important role in data integration, allowing data-driven decisions based on where and why things happen across all public service areas. [109]

Figure 6. Public Service Areas in which Location Data and Technologies are Currently Leveraged in Local and Regional Governments



Source: State of the Art Report, 2021, Survey Data (n=98)

The top two public services areas in which location data are most frequently being leveraged include: (i) transportation and (ii) tourism. On this basis, the subsequent sections of this chapter will provide 'deep dives' into these areas. The decision was also taken to conduct a 'deep dive' into public health in the context of the rapid increase in the use of location data and technologies as a result of the Covid-19 pandemic. The pandemic has driven the strengthening of existing location-enabled public services and the creation of new public services in response to the health crisis.

[107] Following Eurostat (a) (see footnote 15). The classification is comprised of top-level divisions, e.g., public order and safety, each of which is broken down into between 6-9 groups e.g., police services, fire protection services, law courts, prisons etc. In the survey, some 'top-level divisions' were included, and, for areas that were identified as having a high-prevalence of location-enabled public services, 'groups' were included in order to provide more granular detail. This decision was made based on the preliminary findings from the desk research, literature review and interviews.

[108] Symons, T. *Using data to make services more personalised, effective and efficient: Discussion Paper*, Nesta, 2016.

[109] European Commission (a) (see footnote 1).

Looking ahead, the significance of location data and technologies for public service innovation is expected to increase in the future. **96% of survey participants expect that location data and technologies will be used significantly more than they are today**, with 67% indicating that its use will be in new areas and 29% indicating that its use will primarily be in areas where they are already used.

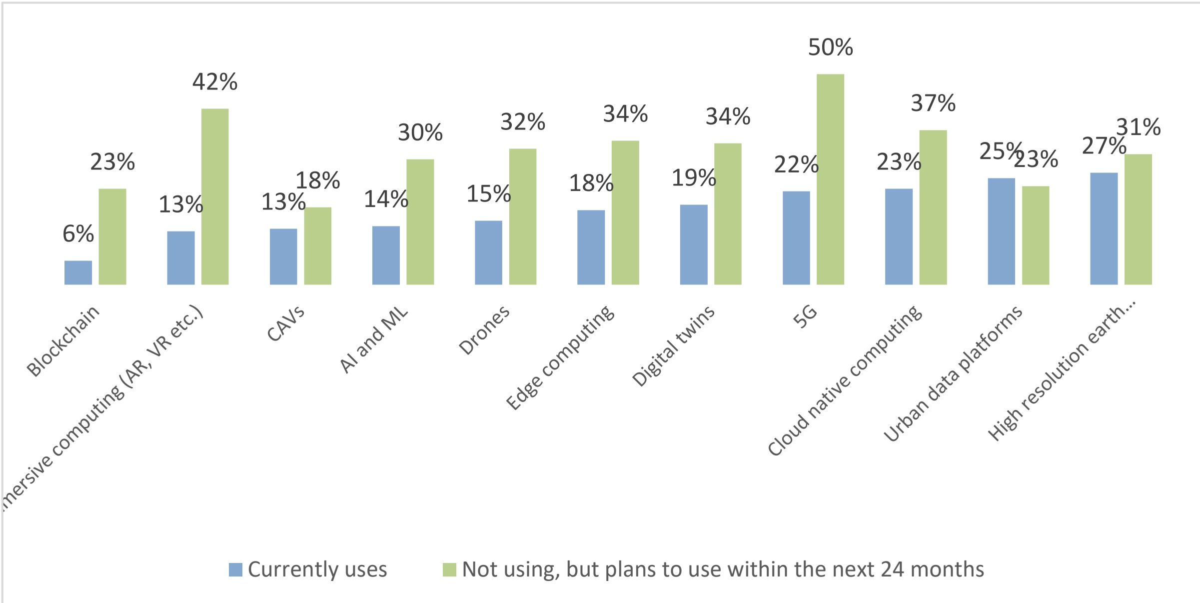
4.1.2 Emerging Technologies

In the survey, local and regional governments and government subsidiaries were also asked whether they are using emerging technologies in their location-enabled public service projects. The results, outlined in Figure 7, demonstrate that there is relatively low uptake of emerging technologies in these projects. These results are consistent with the findings from the desk research and interviews which highlighted that that several of the projects using location data and technology are relatively traditional in scope; for example, using static data layers to manage public sector assets. They are, for the large part, not currently leveraging some of the emerging dynamic data sources and location technologies elaborated in Chapter 3 of the report. However, the survey results indicate that **there is expected to be a significant increase in the uptake of emerging technologies over the next 2 years**.

High resolution earth observation technology/imagery is the emerging technology currently used most frequently as part of these projects. Throughout the desk research several examples were identified of projects using high-frequency and high-resolution earth observation technology to enable public service innovation, particularly in the area of environmental monitoring (see also Section 4.5) and agriculture. However, the majority of the use cases reviewed in the desk research were still in pilot phase and have not yet matured or scaled. As demonstrated by the survey results and desk review findings, it is expected that the use of high-frequency and high-resolution earth observation technology in local and regional governments will increase significantly in the short-medium term, driven in part by advances in data storage, computational capacity and GeoAI.

The emerging technologies which have the highest expected growth potential – that is, those expected to be deployed in the next 2 years – include 5G technology (at 50%) and immersive computing (at 42%). As discussed in Chapter 3 of the report, investments in 5G infrastructure will be a foundational technology for advancing the accuracy of outdoor and indoor positioning technologies.[110] The high proportion of local and regional governments and subsidiaries that plan to use immersive computing in the next 2 years – 42% – is also consistent with the findings of the desk research. Several early-stage pilots were identified across several domains, particularly in the area of community planning, public order and safety, and tourism.

Figure 7. Use of Emerging Technologies in Location Data and Technology Projects Aimed at Improving Public Services



Source: State of the Art Report, 2021, Survey Data (n=158)

[110] United Nations Committee of Experts on Global Geospatial Information Management (see footnote 55).

Interestingly, when reviewing the use of emerging technologies relative to population size of local and regional governments, there is no significant variance.[111] In the desk research, more innovative and state of the art examples of location-enabled public services were primarily identified in urban areas – often linked to smart city initiatives. The findings of the desk research may be a result of the sample of literature and projects selected, and linked to this, likely also reflect the projects which are most frequently documented and researched.

4.1.3 Stakeholders and Innovation Ecosystems

Local and regional government bodies are only one of the stakeholders involved in projects and initiatives to drive and deliver public service innovation. The majority of public service digital transformation projects include the involvement of a broad ecosystem of stakeholders. As noted by Chen and others (2020), new models of public governance generally include more of an "external innovation locus;" they observe that an ecosystem of actors has become increasingly important for public service innovation "due to the complexity of modern, wicked problems that require cross-sectoral collaboration.[112]"

This trajectory is consistent with the literature on, and models of, digital government transformation. The OECD, for example, has developed a digital government framework comprised of six dimensions that make up a fully digital government. One of these principles – Government as a platform - is linked to the increasing involvement of an ecosystem of actors in public service innovation and delivery.[113] Further, one of the central tenants of the "Vision for Public Services," developed by the Public Services Unit in the Directorate-General for Communications Networks, Content and Technology (DG CONNECT), is an open and collaborative government which, can rely on citizens, companies and others to perform completely, or in part, government tasks. The Vision notes that this type of public service innovation has been driven by the increased connectivity of citizens and businesses as well as the increasing availability of closed information and data.[114]

From government as a service provider to ***government as a platform*** for public value co-creation [where] governments build supportive ecosystems that support and equip public servants to design effective policy and delivery quality services. That ecosystem enables collaboration with and between citizens, businesses, civil society and others to harness their creativity, knowledge and skills in addressing challenges facing a country." – OECD Digital Government Framework, 2019.

As will be outlined in the subsequent policy area 'deep dives,' location-enabled technologies have been a key enabler for the expansion of different models of public service delivery, including public-citizen, private-citizen, citizen-citizen and citizen-business. Take for example, the burgeoning number of transport options available to citizens including ride-hailing, car sharing, and on-demand public transport.

The survey data presented in Figure 8 page provides insights into how local and regional governments and their subsidiaries are engaging with the wider ecosystem of location data and technology providers and users to support project implementation, including the types of partnerships being made as well as the actions taken to create an enabling environment for 'government as a platform.'

Partnerships – During project implementation, the survey demonstrated that several local and regional governments and subsidiaries coordinate with external stakeholders. Data from the survey highlighted that 66% of the surveyed regional governments have coordinated with other regional and local governments, 32% with Non-Governmental Organisations (NGOs) and 21% with research institutions. 15% of survey participants have also coordinated with private sector stakeholders for public private partnerships and 21% for data sharing arrangements. An interesting avenue for future research would be to explore the types of cooperation and exchanges that are occurring between regional and local governments during the implementation of these projects, whether it be knowledge sharing, data exchange, scaling up existing products and services etc.

[111] The following population size categories were used in the survey: 20,000-100,000; 200,000-250,000; 250,000- 1,000,000; more than 1,000,000.

[112] Chen, Walker and Sawhney (see footnote 4).

[113] OECD (b), Strengthening Digital Government, 2019. Accessed at: strengthening-digital-government.pdf (oecd.org) Accessed on: 09/06/2021.

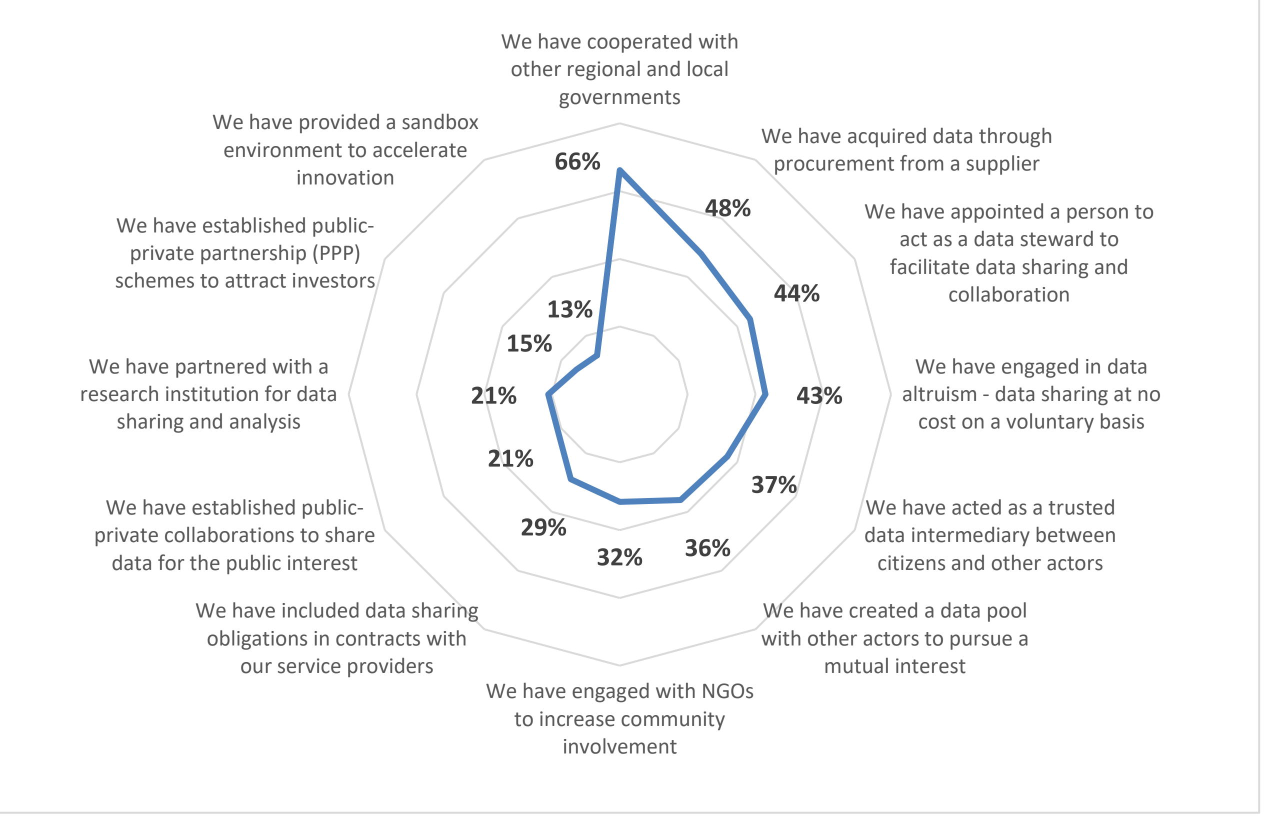
[114] European Commission (i), A Vision for Public Services: Draft Version dated 13/06/2013. Accessed at: https://ec.europa.eu/newsroom/dae/document.cfm?doc_id=3179 Accessed on: 23/08/2021.

Government as a platform for public value and co-creation –

The survey data highlight the ongoing trend of governments opening data to citizens, businesses, civil society and starting to put in place mechanisms and governance structures to support data sharing. GISs are often core components of government's open data portals, take for example Smart City Valencia's GIS portal, many layers of which are open to the public including information on mobility, economy, social services and other areas.[115] Over 40% of local and regional governments and their subsidiaries are sharing data at no cost on a voluntary basis and have appointed someone within the institution to act as a data steward to facilitate data sharing and collaboration. Allocating a data steward is one of several steps that public administrations can take to help create an enabling environment for data sharing both within and between institutions. However, findings from the interviews indicated that, in several instances, even if a data steward is appointed, they may not have a dedicated position with an allocated budget and defined objectives; rather, in some instances, the data steward may be a more informal position, a 'go to' individual with expertise in data management or policy.

As will be discussed later in the chapter, one of the cross-cutting challenges experienced by governments in these projects is the increasing amount of location data owned by the private sector and limited business to government (B2G) data sharing.[116] Interestingly, nearly 30% of survey participants are already including data sharing obligations in contracts with service providers - this will be discussed further in Section 4.1.5.

Figure 8. Engagement with wider ecosystem of providers and users during the implementation of projects which leverage location data and technologies



Source: State of the Art Report, 2021, Survey Data (n=142)

4.1.4 Multi-level Governance for Location-enabled Public Services

While the scope of this Project is on location enabled public services at the sub-national level, the legal, institutional, cultural and technical conditions of national governments and the EU are critical contextual factors which can drive or limit the viability and effectiveness of these services. The importance of national

[115] Smart City Valencia, Geoportal: All the data, street to street. Accessed at: http://smartcity.valencia.es/vlci/gis-portal/ Accessed on: 11/07/2021.

[116] European Commission (c) (see footnote 10).

and cross-border conditions for the creation of sub-national public services will be elaborated briefly below, however, in-depth research or analysis on this area is beyond the scope of this study.

In terms of legal conditions, for example, in order for sub-national governments, or other stakeholders within the ecosystem, to use and share location data, they must comply with the EU's legal framework for data governance, including the GDPR regulation under the 2018 Data Protection Act, as well as pre-existing legal frameworks of member states. The significance of the national legal context is exemplified by a case in Estonia where, in 2019, the national data protection agency changed its interpretation of privacy regulations meaning that mobile operators were no longer allowed to share anonymized and aggregated MPD with private data analytics companies. For more than a decade prior, a private company had regularly analysed mobility patterns and tourism flows based on MPD data and provided these analytics to national and sub-national governments to support their strategic planning. [117] While the interpretation has since been updated to allow the sharing of MPD, this case highlights the significance of national context for the viability of certain location-enabled public services.

The effectiveness of member state's Spatial Data Infrastructures (SDIs) can also be key enablers or barriers for the creation of location-enabled public services in local and regional governments. The INSPIRE Directive has been a key driver of the establishment of SDIs across EU member states over the last decade. Yet, the extent of implementation of the INSPIRE Directive varies across member states. The latest implementation evaluation of the Directive found that 90% of spatial data sets are reported by only 5 countries.[118] This demonstrates the varying operating conditions for local and regional governments when establishing location-enabled public services.

"An SDI is developed for the purpose of supporting ready access to spatial information to support decision making at different scales for multiple purposes, and is based on partnerships at corporate, local, state/provincial, national, regional (multi-national) and global levels. This enables users to save resources, time and effort when trying to acquire new datasets by avoiding duplication of expenses associated with the generation and maintenance of data and their integration with other datasets." - Rajabifard and others (2006)

Coordination between national and sub-national governments is a critical factor in the success of SDIs. While national mapping agencies, or other delegated national authorities, have the overarching responsibility for maintaining SDIs, much of the spatial data is administered by sub-national governments. Therefore, the role of the national government as a coordinator across different local governments is key, for example, in establishing clear workflows for data collection, reporting sharing, and publication, and in some instances, providing funding to local and regional governments.[119]

"For Local and regional governments, maintaining up-to-date location data is particularly challenging when there is not a national agency that plays an active role in coordinating data collection."- Fabio Cartolano, Intelligent Transport Expert (State of the Art Report Interview)

Finally, in order for location data to be shared and re-used across borders, and location-enabled public services to be replicated or scaled, the conditions and frameworks between countries must also be interoperable. The ELISE action of the ISA[2] Program, under which this Project is being conducted, is focused on supporting the development of foundational frameworks and solutions, including legal and policy solutions, to enable effective digital cross-border of cross-sector interaction and location data re-use. One of the frameworks developed for this purpose is the EULF Blueprint which provides a framework of guidance and actions to foster interoperability (see Section 1.3 of the report for additional details on the framework).

[117] Ibid.
[118] Cetl, Nunes De Lima, Tomas, Lutz, D`Eugenio, Nagy and Robbrecht (see footnote 31).
[118] Ibid.
[119] Cetl, Nunes De Lima, Tomas, Lutz, D`Eugenio, Nagy and Robbrecht (see footnote 31).

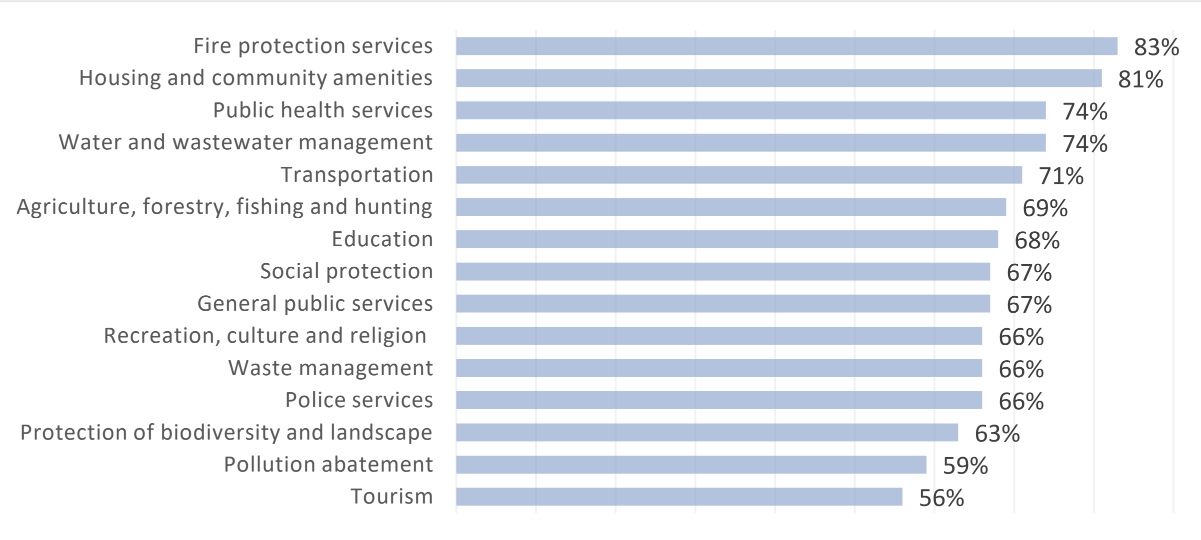
4.1.5 Public Service Innovation

Location data and technologies are being used to strengthen and innovate public services in several ways and are also a "major factor in the latest wave of digital transformation."[120] Digital government transformation, as defined by Barcevičius and others (2019)[121], includes implementing reforms to government operations, enabled by the introduction of existing and/or new technologies and applications and organisational reforms. These reforms can include radical changes alongside more incremental changes. This section will explore the types of public service innovation being driven by location data and technologies.

The majority of local and regional governments find location data and technology either very useful or extremely useful for improving public services (see Figure 9). Survey participants were asked to evaluate the usefulness of location data and technology for improving public services across different policy areas.

> *"[Digital Government Transformation] may encompass different forms of public sector innovation across different phases of the service provision and policy cycle to achieve key context-specific public values and related objectives such as, among others, increasing efficiency, effectiveness, accountability and transparency, to deliver citizen-centric services and design policies that increase inclusion and trust in government." - Barcevičius and others (2019)*

Figure 9. Usefulness of Location Data and Technology for Improving Local and Regional Public Services by Policy Area *(graph combines participant responses for those that found it extremely and very useful)*



Source: State of the Art Report, 2021, Survey Data (n=98)

The evaluation of usefulness is relatively similar for several policy areas – ranging from between 65-75% – but there are a few outliers with a relatively high or low evaluation. For example, 83% for improving fire protection services compared with only 56% for tourism services. The comparatively low score for tourism is interesting given that tourism has the second highest usage of location data and technologies. This signifies that there is an opportunity to improve the current usage of location data in tourism services to drive more effective digital transformation and there is an opportunity to draw on lessons learned from the application of location data and technologies to improve fire protection services.

As noted in the introduction and methodology, the State of the Art Report is using Chen and others (2020) typology of public service innovation as a framework of analysis. The typology is comprised of two dimensions: (i) Innovation locus and (ii) innovation focus (Figure 10, below).[122] The desk research findings

[120] Ethical Geo, Locus Charter, 2021. Accessed at: https://ethicalgeo.org/wp-content/uploads/2021/03/Locus_Charter_March21.pdf Accessed on: 09/06/2021.
[121] Barcevičius, Cibaitė, Codagnone, Gineikytė, Klimavičiūtė, Liva, Matulevič, Misuraca and Vanini (see footnote 6).
[122] Chen, Walker and Sawhney(see footnote 4).

highlighted that location data and technologies are being used to create public value through all categories of public service innovation.[123]

Figure 10. A Typology of Public Service Innovation

		Innovation locus	
		Internal	External
Innovation focus	Strategy	Mission innovation	Policy innovation
	Capacity	Management innovation	Partner innovation
	Operation	Service innovation	Citizen innovation

Source: Chen, J. Walker, R, M., Sawhney, M, 2020.

1. ***Strategy focus**: "involves the authorizing process for an organization in defining its domain, mission and guiding principles working with/out stakeholders."*[124]

Internal strategy innovation (mission innovation) involves an organization responding to the requirements of political actors who set mandates and boards of governors that outline the organizational mission. Whereas external strategy innovation (policy innovation) involves an organization engaging multiple ecosystem stakeholders to meet their needs and obligations.[125]

The importance of location data for strategic planning and evaluation has increased significantly. In part, this is being driven by the unprecedented availability of open and big data and the availability of geospatial analytical tools. There are myriad of examples of location data and technologies being leveraged to support strategic decision making in local and regional governments across different policy areas. However, many projects still rely on more traditional data sources and there are gaps in digital literacy, which limit the extent of public service innovation.[126] State of the art examples of 'strategy focus' public service innovations identified through this study are:

- Utilising **dynamic data sources** – for example, in the space of tourism planning, traditional data sources are still heavily relied on to monitor and assess the impact of tourism (e.g., household surveys and business surveys for accommodation). State of the art examples are emerging from governments leveraging big data sources to support tourism development strategic planning. For example, Tartu County in Estonia is using anonymized and aggregated MPD to map tourism flows – this data source enables the county to gain much larger samples of more granular data at more regular intervals. MPD can also be used to monitor cross-border mobility patterns; a pilot project based on Chemin d'Arles – a medieval pilgrim route running between France and Spain – is using MPD to analyse tourism flows between the two countries.[127] (Mission innovation)

- Integrating multiple data sets to gain **location intelligence** – this can include integrating different location data sets (e.g., combining crowdsourced data with IoT data), different types of data (such as EOD), as well as cross-sectoral data (e.g., healthcare data). For example, in the City of Vaasa in Finland, a city-level decarbonization platform has been established to help reduce the city's carbon emissions. The platform brings together diverse data sets from the city's three biggest emission sources – transportation, heating and electricity consumption. This tool enables decision-makers to simulate the impact of different policies on city-wide emissions and make **place-based rather than sector-specific decisions**. (Mission innovation)

- Leveraging **immersive visualisation technologies** to support more **intuitive data-driven decision making.** Under the Horizon 2020 PoliVisu Project, carried out jointly in Ghent, Belgium, Plzen, Czech Republic, and Issy-les Molyneaux, France, urban policy makers were equipped with the skills and tools –

[123] Ibid.
[124] Ibid.
[125] Ibid.
[126] McAleer S.R., Kogut P., Raes L. (2018) The Case for Collaborative Policy Experimentation Using Advanced Geospatial Data Analytics and Visualisation. In: Diplaris S., Satsiou A., Følstad A., Vafopoulos M., Vilarinho T. (eds) Internet Science. INSCI 2017. Lecture Notes in Computer Science, vol 10750. Springer, Cham.
[127] Kalvet, Olesk and Raun (see footnote 61).

from open location data processing to advanced visualisations – to enhance public involvement in collaborative policy experimentation. As noted by the team working on the project, across the public sector, there are persistent data gaps that have impeded policy making, particularly when it comes to big data.[128] They identify two major challenges that need to be addressed (i) data literacy, helping policy makers outside of specialist data teams appreciate the benefits and risks of geographic information, and (ii) advanced technology, policymakers require easy to use tools to extract trusted intelligence from data. In order to help address these challenges, the project has developed interactive and customizable maps, 3D maps and story-telling visualizations to support more intuitive and collaborative data decision policy making.[129] This project has concluded but is being taken forward through a complementary project – Digital Urban European Twins (DUET)[130] (Policy innovation)

The ability to detect unexpected trends and changes may give planning the opportunity to become more contingent… continuous monitoring may provide opportunities for more trial and error approaches to policymaking, with data giving continuous feedback. This may help facilitate policies that encourage gradual changes based on a series of 'nudges' rather than sudden step-changes." - Milne, D. and Watling, D. 2019

In terms of future trends, there is some academic research that explores and hypothesises how the availability of big data, including location data, will impact policy and planning systems. For example, Milne and Watling, 2019 review the implications of big data for transport planning systems. They hypothese that**, over time, access to big data and new analytical approaches have the potential to make planning and policy making more "contingent" and experimental**.[131]

2. ***Capacity focus***: *"instituting a process that provides an organisation with the administration, structure, expertise, management, technology and resources necessary to accomplish its politically mandated mission."*[132]

This can include a public administration improving its internal organizational procedures (management innovation) and improving its external relationship with partners (partner innovation). Partnerships are developed with a view to improve the organization's ability to meet its goals and to access a wider set of capacities and resources.

Location data and technologies are also being leveraged to create additional capacity within public sector institutions. For example, location data and technology are providing public administrators with easier access to the information they need to perform their functions more efficiently, and tools such as mobile-entry devices to collect real-time crowdsourced information into centralised GIS systems. State of the art examples of 'capacity focus' public service innovations identified through the study are:

- Leveraging **advanced analytics to automate the processing and analysis of data to increase efficiency and minimise repetitive tasks**. For example, in South Tyrol (Italy), the AgriML Proof of Concept Project demonstrated the feasibility of using machine learning to detect the type of crops present in satellite images of cultivated fields. The project is expected to enable the administration to disburse contributions for agriculture in a more efficient way to allow better management of provincial budget.[133] (Management innovation)
- Utilising **location-enabled technologies to undertake work remotely** for example building permit and planning inspections. For example, in Scotland a local authority contracted a local drone company to provide aerial inspection by Unmanned Aerial Vehicle (UAV) of over 600 council owner proprieties as part of a larger scale program to bring them into line with energy efficiency requirements. Leveraging this location-enabled technology meant that the inspection took weeks rather than years and also saved

[128] PoliVisu, Accessed at: https://www.polivisu.eu/ Accessed on: 20/08/2021.
[129] McAleer, Kogut and Raes (see footnote 126).
[130] DUET, Digital Urban European Twins, About Us. Accessed at: https://www.digitalurbantwins.com/ Accessed on: 10/08/2021.
[131] Milne, D. and Watling, D. 'Big data and understanding change in the context of planning transport systems', *Journal of Transport Geography*, Science Direct, 2019, Vol. 76, pp 235-244.
[132] Chen, Walker and Sawhney (see footnote 4).
[133] Informatica Alto Adige, 2020, The AgriML SIAG project awarded by the IDC. Accessed at: https://www.siag.it/it/news/il-progetto-agri-ml Accessed on: 23/05/2021.

resources – an estimated cost saving of £4.5 million.[134] In EU, further research is being undertaken in this space including combining Galileo dual frequency navigation, 5G, IoT devices and drones for remote asset management.[135] (Partner innovation)

3. *Operations focus: "The process that an organisation uses to put its strategic decisions and policies into action for the sake of its mission. An organisation can launch new programs or services or can reorganise its resources to improve existing ones."*[136]

In internal operational innovation, the public administrator is focused on the organization and offers new services to achieve the politically mandated mission or policies (service innovation). Whereas external operational innovation (citizen innovation) public administrators can invite citizens to engage in service delivery moving from a passive recipient to an active co-creator (e.g., a neighbourhood watch program).[137]

Location data and technologies are being utilised to strengthen existing public services and launch new public services. These innovations are both internally facing and externally facing to citizens and businesses. Previous research conducted by the JRC has pointed to the role of location data and SDIs in delivering better and more user-friendly services to citizens.[138] Following Bekker's categorization of 5 types e-government services, the desk research demonstrated that location data and technology are being leveraged to innovate across each type of digital service: information services, contact services, transaction services, participation services and data transfer services.[139] State of the art examples of 'operational focus' public service innovations identified through this study are:

- Integrating **different sources of real-time data** to enable more **pro-active and targeted service provision**. For example, in the City of Eindhoven in the Netherlands, a CityPulse model was piloted in a street with a high crime rate. The model drew on existing sources of information of pedestrian walking patterns from Closed-circuit television (CCTV) camera, plus additional data from audio sensors, social media data and weather data to provide early warnings to a police control room. The police service then used this information to better target patrols. The city also experimented with other de-escalating techniques such as pre-emptively adjusting the street lighting. While the model was built to ensure citizens were not identifiable, this project also raises important questions of trust, privacy and ethics which will also be discussed later in the report.[140] (Service innovation)
- Providing **location data in online applications to help people access the information they need online** rather than over the phone or in person. For example, in Northern Ireland, the Education Authority has built an application based on its SDI to help parents and guardians check if their children are eligible for school transport. 80% of applicants receive an immediate decision on eligibility – previously, the paper-based process took between 3-6 weeks. Emerging innovations in this space include **providing real-time information** to citizens to enable their decision making. For example, in the context of Covid-19, some train operators are providing real-time information on the business of particular services and specific carriages[141] and some city governments are providing information on the business of certain areas of town. [142] (Citizen innovation)
- **Leveraging crowdsourced citizen data** to improve public services. This can include information directly submitted by citizens or data from social media generally intended for a different audience. For some time, local and regional governments have experimented with platforms and applications to report

[134] Government Business, The View from Above: Drones and Public Services. Accessed at: https://governmentbusiness.co.uk/features/view-above-drones-and-public-services Accessed on: 04/06/2021

[135] European Union Agency for the Space Program, GEONAV IoT: Galileo dual frequency 5G, IoT devices and services for Drones, Assets Management and Elite sport. Accessed at: https://www.euspa.europa.eu/galileo-dual-frequency-5g-iot-devices-and-services-drones-assets-management-and-elite-sport Accessed on: 04/06/2021.

[136] Chen, Walker and Sawhney (see footnote 4).

[137] Ibid.

[138] Barbero, Lopez Potes, Vancauwenberghe and Vandenbroucke (see footnote 32).

[139] Bekkers, V. (2007a). Modernization, public innovation and information and communication Technologies: The emperor's new clothes? Information Polity. 12:103–107 in Vandenbroucke, D, Vancauwenberghe, G, Boguslawski, R, Pignatelli, F. Design of location-enabled e-government services, EUR 30220 EN, Publications Office of the European Union, Luxembourg, 2020, ISBN 978-92-76-18939-8, doi:10.2760/860082, JRC119730.

[140] Galic, M., and Gellert, R. 'Data protection law beyond identifiability? Atmospheric profiles, nudging and the Stratumseind Living Lab' *Computer Law and Security Review, Elsevier,* 2021, Vol. 40, 105486.

[141] Loughran, J., Train operator displays social distancing capacity by measuring carriage weight, Engineering and Technology. Accessed at: https://eandt.theiet.org/content/articles/2020/08/train-operator-displays-social-distancing-capacity-by-measuring-carriage-weight/ Accessed on: 09/06/2021.

[142] Fix my Street, About. Accessed at: https://www.fixmystreet.com/ Accessed on: 09/06/2021

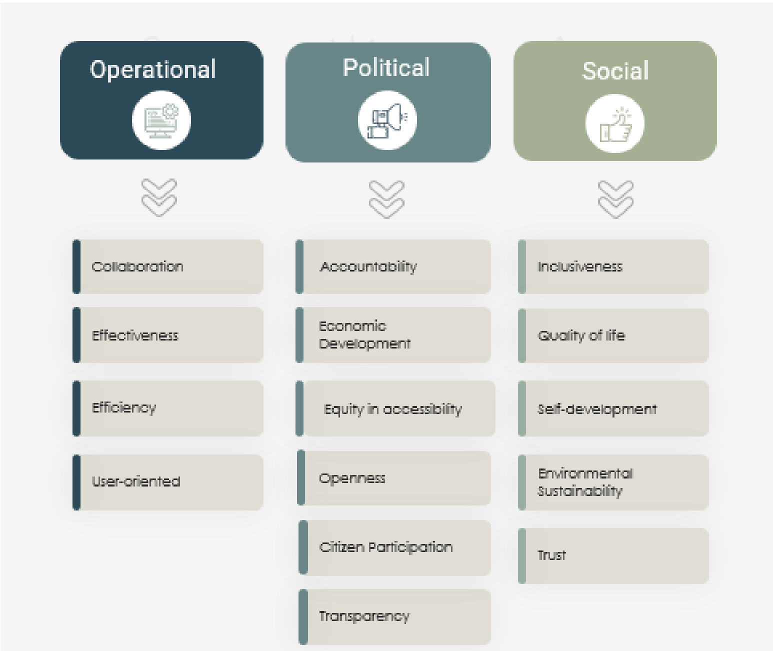
non-emergency issues. For example, local and regional governments across 9 countries are using the Fix My Street internet platform or phone application to allow citizens to report problems such as fly tipping and potholes.[143] Several local and regional governments are also connecting their GIS platforms with the what3words API to enable citizens to report incidents, ranging from forest fires to fly tipping, to an accuracy of $3m^2$. (Citizen innovation)

- However, some research undertaken on applications to report non-emergency issues to governments highlighted the need to create better incentives and feedback mechanisms for citizens to generate more systemic impacts from this citizen innovation. Innovative local governments are exploring whether emerging technologies such as AI and ML can be used to achieve this goal.[144] The municipality of Vilnius launched the Tvarkau Vilniu platform in 2012 to streamline the process of gathering information from citizens. Research on the implementation of the Tvarkau app highlighted that, while citizens are often willing to collaborate and provide information, systemic impacts such as building trust and legitimacy only occur if there is a feedback loop in place where citizens can monitor their contribution. Further, from an efficiency perspective, these platforms create a new stream of information for local and regional governments to process. While this provides valuable information, although sometimes of varying quality, the right workstreams need to be in place to process this. In line with this, the municipality of Vilnius is considering the introduction of AI and ML to process and prioritize issues, so they can react more quickly. (Citizen innovation)[145]

4.1.6 Public Value

Public service innovations undertaken as part of digital government transformation aim to drive a range of context-specific public value.[146] For the purposes of this study, public value has been broadly drawn into three main categories (Figure 11).

Figure 11. Public Value Framework



Source: State of the Art Report, 2021 (Drawn from Chu and Seng, 2018; Moore, 1995; Barcevičius and others (2019); and Osborne and others (2021).

The data from the survey provides an overview of the types of operational, political and social public value being generated most frequently through projects that leverage location data and technologies to strengthen public services. The European Union is striving to strengthen the role of public administrations in driving a

[143] How Busy is Toon, About. Accessed at: https://howbusyistoon.com/ Accessed on: 09/06/2021
[144] Barcevičius, Cibaitė, Codagnone, Gineikytė, Klimavičiūtė, Liva, Matulevič, Misuraca and Vanini (see footnote 6)
[145] Ibid.
[146] Ibid.

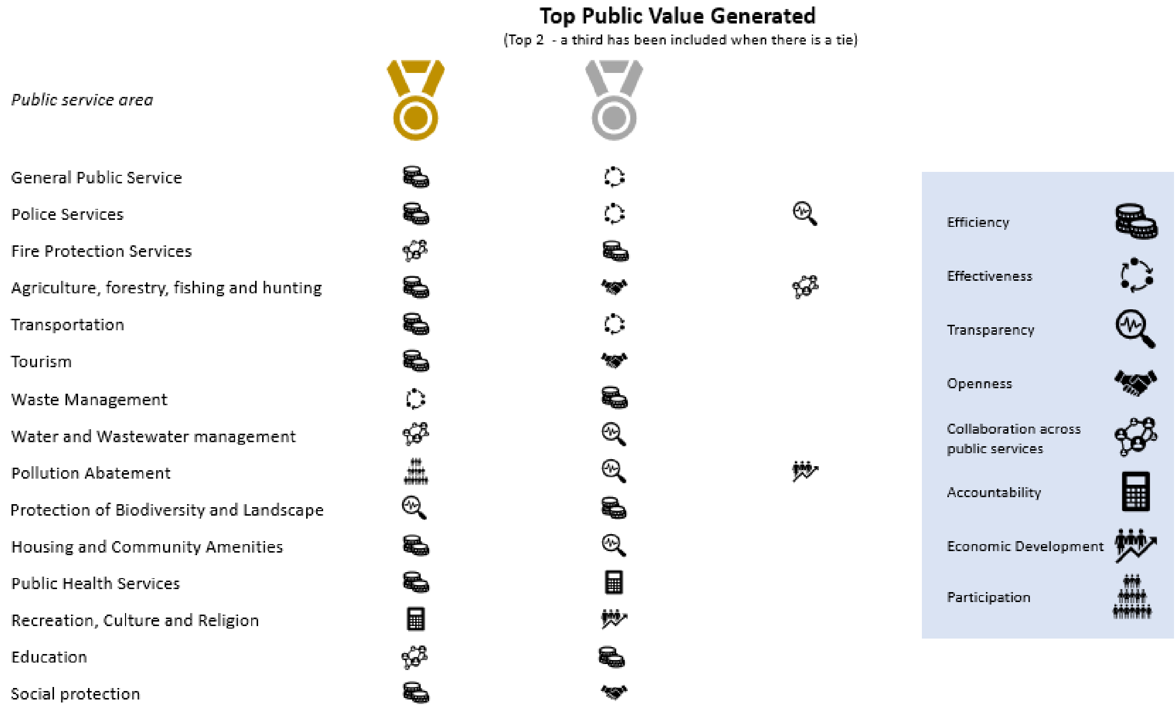
value-based digital public services and digital transformation of societies. This value-based approach to public services has been encapsulated in the Berlin Declaration on Digital Society and Value-Based Digital Government.[147]

Figure 12 provides an overview of the top two types of public value generated in these projects across different policy areas. The results show that, across almost all policy areas, operational public value is the most frequently generated, particularly efficiency, which is in the top two for 80% of the public service areas. This is consistent with research conducted on digital government transformations more broadly, where, efficiency, productivity gains and cost savings have been identified as the main drivers and documented outcomes of introducing digital innovations.[148]

Political public value was also reported in the top two in over two thirds of the policy areas, with transparency as the most frequently sited public value. The generation of greater transparency links to the broader objectives and trajectory of digital government transformation. One of the six dimensions of digital government in the OECD's Digital Government Framework is 'open by default.' [149] The types of public value generated will be explored in more detail in the subsequent 'deep dives.'

Principle 3 – "From closed to open by default: Government is committed to disclosing data in open formats, collaborating across organisational boundaries and involving those outside of government in line with the principles of transparency, integrity, accountability and participation that underpin digital ways of working..." – [OECD, 2019]

Figure 12. Top public values gained from using location data and technologies to improve public services by public service area



Source: State of the Art Report, 2021, Survey Data (n=98)

However, it is important to note that this assessment of public value creation is based on the assessment of the public administration rather than the service user. A survey of service users would likely generate different results. Task 5 of this Project will explicitly focus on the citizen experience of public services. The

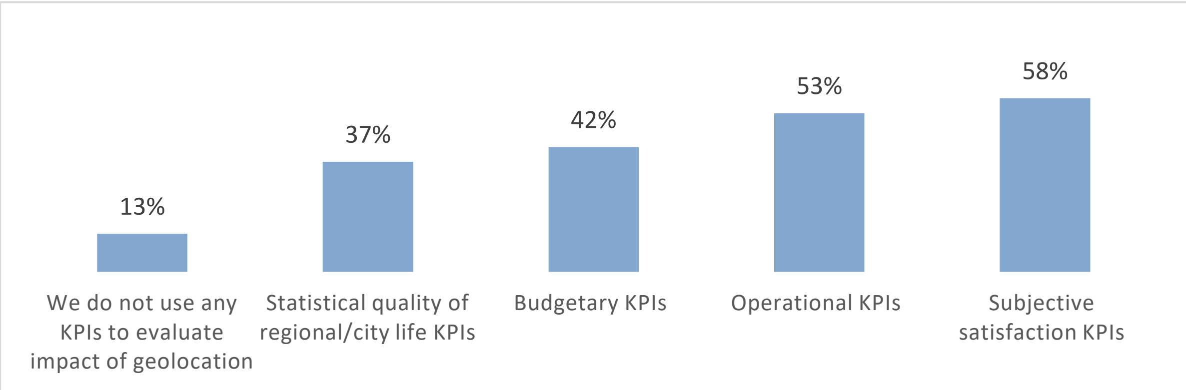
[147] European Union (a) (see footnote 22).
[148] Barcevičius, Cibaitė, Codagnone, Gineikytė, Klimavičiūtė, Liva, Matulevič, Misuraca and Vanini (see footnote 6).
[149] OECD (b) (see footnote 113).

task will entail consultation with citizens to understand public attitudes and needs related to public service innovation with location data and technology in relation to the case studies developed in Task 4.

Further, the public value gained from these projects may not always be systematically measured or well documented or certain types of value/outcomes are measured more frequently than others. This means that the types of value presented in Figure 12 may reflect *expected* values, rather than values determined by empirical evidence.

Through the survey, data was also collected on the KPIS that local and regional governments, and their subsidiaries, use to evaluate the impact of location data and technologies on public services. The data highlighted that the majority do use Key Performance Indicators (KPIs) to evaluate the impact of location data and technologies on public services (see Figure 13). The data also provides insights into the types of KPIs are used most frequently: 58% use subjective satisfaction KPIs (e.g., the measurable satisfaction with services increased), 53% use operational KPIs (e.g., project timeline met, increased volume of services rendered), 42% use budgetary KPIs (e.g., project within budget, cost savings achieved, increased income) and 37% use statistical quality (e.g., decreased commuting time, decreased missions, decreased crime rates). While nearly 60% of survey respondents use subjective KPIs to measure the effectiveness, the other most used KPIs are focused on operational KPIs and budgetary KPIs. Local and regional government respondents were least likely to measure KPIs focused on quality-of-life outcomes, in this regard, they are less likely to capture some types of political and social outcomes.

Figure 13. Use of Key Performance Indicators to Evaluate the Impact of Location Data and Technology on Public Services.



Budgetary KPIs	e.g., project did not exceed budget, costs savings achieved, income increased
Operational KPIs	e.g., project time has been met, volume of services rendered increased
Subjective Satisfaction KPIs	e.g., the measurable satisfaction with services increased
Statistical Quality KPIs	e.g., commuting time decrease, percentage of crimes solved increase, percentage if timely interventions in social services increase

Source: State of the Art Report, 2021, Survey Data (n=142)

These findings are consistent with the findings of the desk research and literature review, where several of the projects and papers reviewed documented *expected* outcomes and provided little empirical evidence; when outcomes were measured, these were often focused on operational outcomes. Research conducted by Barcevičius and others (2020) on the outcomes of digital transformation in the EU more broadly came to the same conclusion.[150]

These findings may also be due to:

(i) Limitations of information available through desk research.

(ii) The fact that several projects reviewed as part of the state of the art analysis, including EU Commission projects, are in relatively early stages of maturity, therefore, several have not been implemented for sufficient time to evaluate the public value generated.

[150] OECD (b) (see footnote 113).

(iii) The fact that "productivity gains from technological innovation occur with a time lag."[151]

Further, the research of Barcevičius and others (2020) also highlighted that "quite often the literature presents the introduction of an innovative service as a positive and valuable development by itself." This is also in line with the findings of the desk research: several projects reviewed focused on the **effectiveness of the technology or solution itself rather than the overarching outcome and public value gained**. For example, if a technological solution is introduced with the objective of reducing traffic congestion and increasing environmental sustainability through emission reductions, e.g., a network of road traffic sensors, the focus of evaluation should be on whether this technology is effective, i.e., how effective are the sensors at measuring and mapping congestion, as well as whether it has supported the overall project objective i.e., reducing the level of congestion and reduced emissions. The project documents reviewed often focused on the former and not the latter. It is important to ask whether the overall objective of the project has been met if the data generated is not then used to generate public value. In some instances, measurement of these outcomes may be more complicated if the technological solution is part of a broader package of policy and strategic measures, in these instances attribution of impact can be a challenge.

In this context, it is important to note that a conceptual framework for assessing the public value created by location-enabled public services does not currently exist within the literature or policy toolkits. Filling this conceptual gap will be the focus of Lot 1 Task 3.

4.1.7 Cross-cutting Challenges

The findings from the survey provide an overview of the main challenges for local governments, regional governments, and their subsidiaries, when *investing* in location data and technologies to improve public services and when *implementing* projects that leverage location data and technologies to improve public services (see also Figure 14).

Figure 14 shows that, for the survey participants, the top challenges experienced, or expected to be experienced, by local and regional governments, and their subsidiaries are very similar when *investing* and *implementing* these projects.[152] The common top challenges include: a lack of leadership and resistance within the organisation, interoperability, digital skills among government employees, strategic plans in relation to adopting and developing location data and technologies. When investing in these projects, a lack of legal frameworks is also identified as one of the biggest challenges and when implementing these projects, budget and financial constraints were also identified. While some of these challenges are the same for the investment and implementation stage the prioritisation is different: the number one challenge when investing in these projects is a lack of leadership and organisational resistance, whereas, during project implementation the lack of digital skills amongst government employees becomes the most significant challenge.

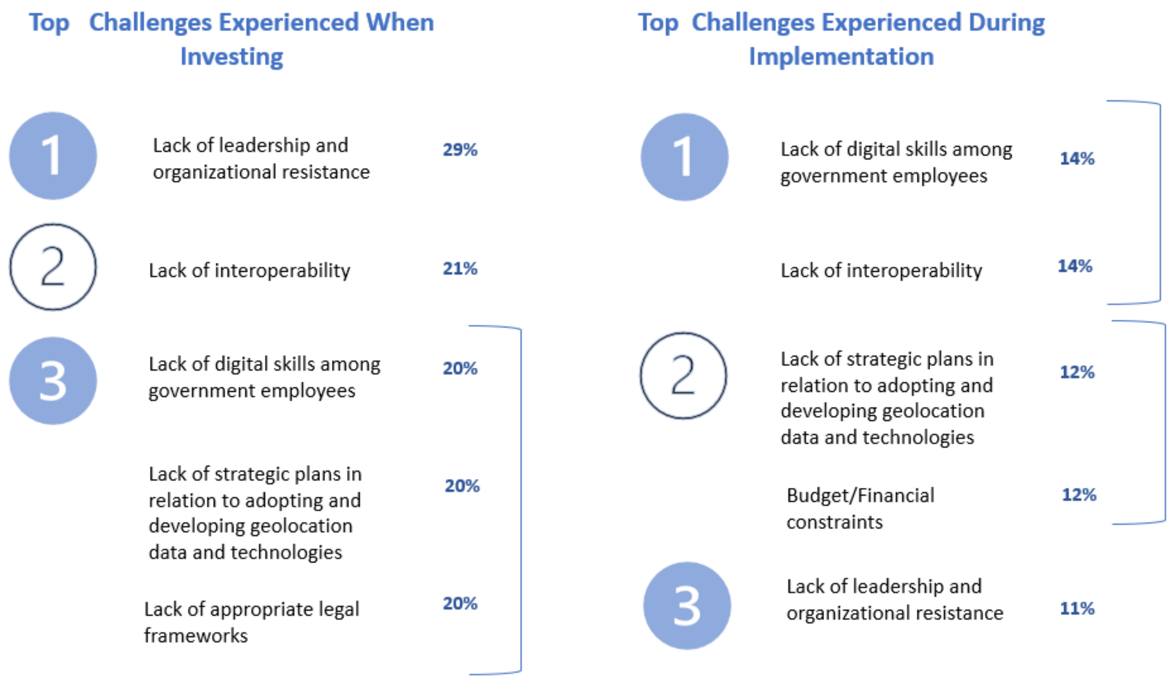
Through the desk research and interviews, interoperability and a lack of digital skills among government employees were also identified as some of the main challenges experienced. However, the findings of the literature review and interviews gave a greater emphasis to the challenge of citizen trust and privacy and data quality and less emphasis to the lack of strategic plans and leadership. Further, an additional challenge of private sector data ownership was identified. Data ownership was not included in the survey as an option for participants – see Chapter 2 for a discussion on methodological limitations.

A selection of cross-cutting challenges is elaborated below, including **location data quality and digital skills**, **interoperability and legal frameworks**, **budget and financial constraints**, **data ownership** and **citizen trust and data privacy**. These challenges will also be further illustrated through the policy area 'deep dives.' While the survey findings also highlight a lack of **strategic plans, leadership and organizational resistance** as significant barriers for local and regional governments, limited information was identified on these challenges through the desk research and interviews – this signals an important avenue for further research through the remainder of the Project. Further, as noted above, **citizen trust and data privacy** and **data ownership** did not feature in the top challenges in the survey data; however, these were identified as main challenges through the literature review, desk research and interviews, they have, therefore, been included for discussion.

[151] Barcevičius, Cibaitė, Codagnone, Gineikytė, Klimavičiūtė, Liva, Matulevič, Misuraca and Vanini (see footnote 6).

[152] The options given in the survey included: ageing and outdated IT< lack of interoperability, lack of access to reliable geolocation data, lack of access to granular geolocation data, lack of strategic plans in relation to adopting and developing geolocation data and technologies, lack of legal frameworks, citizen trust and confidence issues, budget/financial constraints, other.

Figure 14. Biggest Challenge Experienced in Projects that Leverage Location Data and Technologies to Improve Public Services



Source: State of the Art Report, 2021, Survey Data (n=158)[153]

Location Data Quality and Digital Skills

Reliable, high quality and up-to-date static location data are foundational for many location-enabled public services whether the location data is used in isolation or is augmented with dynamic location data. However, through the interviews and desk research, the capacity of governments, particularly local and regional governments, to maintain up-to-date and high-quality location data was identified as a persistent challenge driven by a lack of available resources, capacity, and incentives. This includes data themes covered by the INSPIRE Directive.

"Having access to the right data and at the right time is crucial to good decision making. It is data that provides new levels of insight into our past, present and future. For this reason, governments, businesses and the community need to know they are using the most accurate and authoritative data for planning, analysis, navigation and visualization – good data underpins good decisions." UN-GGIM Integrated Geospatial Information Framework, 2019

In an interview, Veiko Lember (PhD and Senior Research Fellow)[154] noted that, in local and regional governments, there are every day persistent challenges of updating, uploading and sharing data underpinned by data capacity gaps. He explained that maintaining up-to-date address data and population registry is a particular challenge for the public sector across Estonia. In light of this challenge, he noted that there is an ongoing research project in Estonia to strengthen the accuracy of location and contact data in delivering public services. One of the questions being asked through the research is **whether there are public service areas where location data is currently being used but may not be required to deliver the service**; for example, is address data required to administer taxes or can digital contact data replace this? This research is aligned well with the principles of the GDPR, that is, first, a public administration, or data

[153] Questions asked: What are, or will be, the top one or two key challenges related to investing in geolocation data and technologies for improving public services? [Choose up to 2] What is the biggest challenge you have experienced, or do you expect to experience, when implementing geolocation data and technologies to improve public services?

[154] Veiko Lember, PhD, Senior Research Follow Ragnar Nurkse Department of Innovation and Governance, Tallinn University of Technology and Visiting Professor at the Public Governance Institute, KU Leuven.

controller, should ask (i) what location data is required and necessary to deliver a certain service, and (ii) where does location data add desirable public value.

In an interview with Fabio Cartolano, an expert in intelligent transportation and previous employee of the Municipality of Bologna, he noted that maintaining up-to-date location data is particularly challenging when there is not a national agency that plays an active role in coordinating sub-national location data collection, including maintaining a central data set, establishing workflows and reporting for data collection and reporting, and, in some instances, providing funding to local and regional governments.

In light of this cross-cutting challenge, there has been some research into mechanisms to supplement public sector location data with other sources. For example, research to determine whether and how crowdsourcing methods can be used to enhance existing public data sets, and in some instances, create new data sets.[155] This brings to the fore important questions about authoritative data and the boundary between official and unofficial data. Veiko Lember[156] also predicted that the "next idea on the horizon" is whether and how private data sets, such as address data from utility companies, post offices or MNOs, could be used to feed authoritative government location datasets such as address and population registries. This raises several questions around data privacy as well as the incentives for private companies and private citizens to share this data. This interaction between public and private data is related to the subsequent challenge that will be discussed – data ownership.

Location Data and Technology Interoperability and Legal Frameworks

The interoperability of location and technologies was identified through the desk research and literature review and interviews as a common challenge. This was identified as both **a challenge that affects individual projects at investment and implementation stage**, as well as the **replicability of solutions across and between EU Member States**. The European Interoperability Framework (2017) identifies four main types of interoperability: technical, semantic, organisational and legal. More recently, as part of the European Interoperability Framework (EIF) with Smart Cities and Communities (EIF4SCC), which aims to support primarily local administrations in providing interoperable services to citizens and businesses, a fifth facet of interoperability was also identified: cultural interoperability.[157]

During the desk research of location-enabled public service projects, it was not possible to systematically assess the interoperability maturity of public services, for example using the European Commission Interoperability Maturity Assessment of Public Service (IMAPS) framework, as this level of information is not readily available. This more detailed research will be conducted in subsequent stages of this Project. However, preliminary findings from the desk research, literature review and interviews indicated barriers related to technical and semantic interoperability, organizational and cultural interoperability and legal interoperability.[158]

Technical and Semantic Interoperability

Technical and semantic interoperability have been combined as it was not always possible to determine whether the barrier was linked to technological or semantics interoperability, most likely the barriers noted combine both elements.

- The interoperability of location data was highlighted as one of the challenges of implementing solutions across borders. In the transport domain, for example, an expert working on the EU IMOVE Project noted that the "data landscape" is different in each country, so each required a different architecture: this limits scalability.[159]
- Through the review of local and regional government projects, the challenges of combining diverse streams of dynamic location data were highlighted as a challenge, both from an interoperability perspective as well as a storage and analytics perspective.[160] As well as the challenge of integrating

[155] McDougall and Koswatte (see footnote 58).
[156] Veiko Lember, PhD (see footnote 154).
[157] European Commission (j), Connecting the European Interoperability Framework (EIF) with Smart Cities and Communities (WIF4SCC), 2021. Accessed at: https://joinup.ec.europa.eu/collection/nifo-national-interoperability-framework-observatory/news/connecting-eif-smart-cities-communities-eif4scc. Accessed on: 11/07/2021.
[158] European Union (g), About IMAPS (Interoperability Maturity Assessment of a Public Service). Accessed at: https://joinup.ec.europa.eu/collection/imaps-interoperability-maturity-assessment-public-service/about Accessed on: 10/06/2021.
[159] Interview with an Intelligent Transport Expert and Previous Employee of the Municipality of Bologna.
[160] European Commission (k), Horizon 2020, Variety, Veracity, Value: Handling the Multiplicity of Urban Sensors. Accessed at: https://cordis.europa.eu/project/id/688380/reporting Accessed on: 10/06/2021.

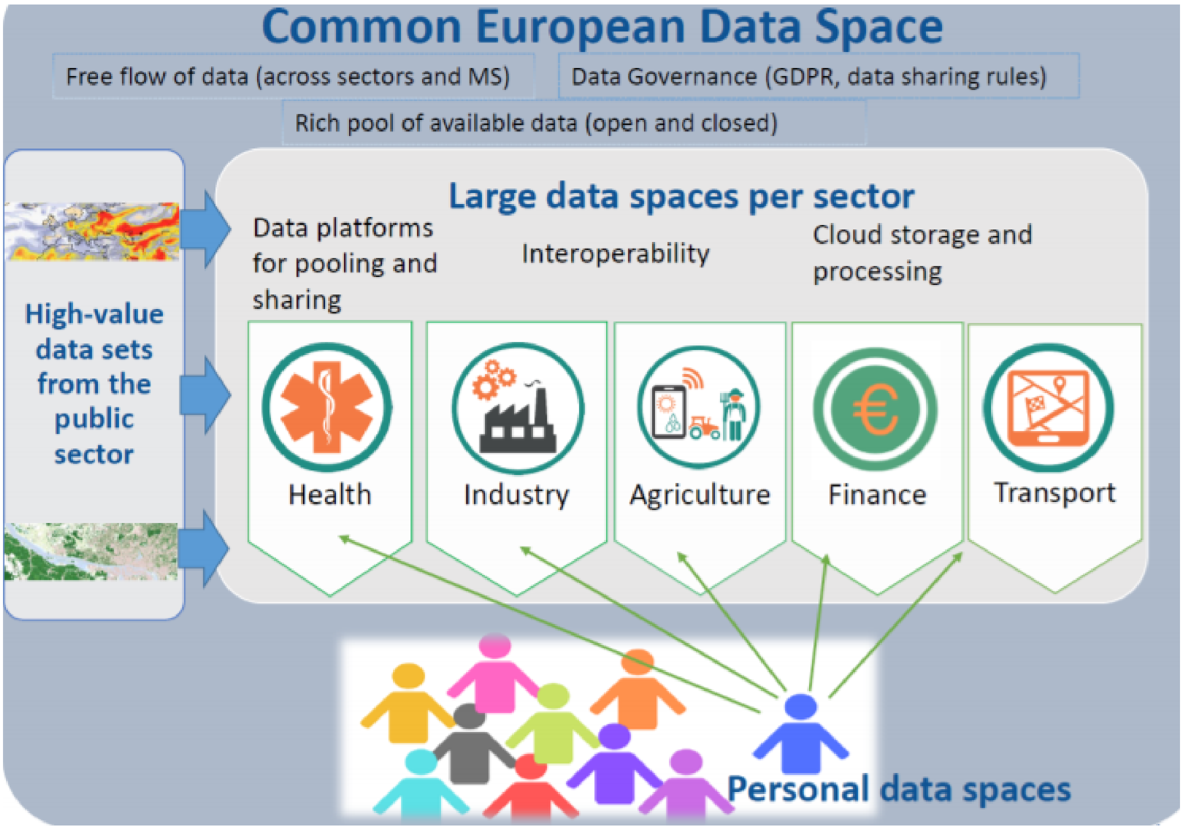
location data with (i) other types of data, for example, earth observation data and (ii) data from different sectoral data spaces e.g., health.

Legal Interoperability

— While open data and public sector information policies and frameworks, such as the INSPIRE Directive, support open government principles, they often do not have specifications for a data policy. This has often resulted in location data sets being published under 'a heterogenous set of licenses' with varying rules as to what users can and cannot do with the data and metadata.[161] This can create a barrier and disincentive as it makes it more complicated for internal public sector departments and external bodies such as academic institutions and entrepreneurs to determine whether and how the data can be used, merged and published.[162]

— Going forward, under the EU Data Strategy, plans have been set in motion for the establishment of common European data spaces across key sectors such as health, public administration, agriculture, mobility etc. Several of these data spaces will feature location data sets (See Figure 15). These data spaces will be subject to a horizontal framework for data governance and data access as well as a Data Space Support Centre to support with data licensing and legal queries. Going forward this governance framework will help to support the aforementioned legal interoperability challenges. [163]

Figure 15. Common European Data Spaces



Source: European Commission, 2018.

Organizational and Cultural Interoperability

— Organizational interoperability was also identified as a challenge in supporting the replicability and scalability of location-enabled public services and solutions. Organizations often develop organisational structures to serve specific user communities, each with their own business processes, technologies (including legacy IT systems) and ways to collect and process data; this creates barriers for sharing

[161] Kotsev, Minghini, Tomas, Cetl and Lutz (see footnote 8).

[162] Cabinet Office, An Initial Analysis of the Potential Geospatial Economic Opportunity, UK, 2018. Accessed at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/733864/Initial_Analysis_of_the_Potential_Geospatial_Economic_Opportunity.pdf Accessed on: 23/05/2021.

[163] European Commission (d) (see footnote 11).

information and scaling or replicating services within and across different organisations. For example, as discussed with an emergency response expert at what3words, many local governments use GIS to help them manage the large areas they administer (facilities, transport network etc.) However, sharing the specific location of assets, particularly if they do not have an address, can be a challenge both internally within the authority but also with other organisations e.g., sharing the location of assets with constructions firms but also other public sector organisations such as police and fire services. The location of assets is generally stored within the private GIS system for which external organisations do not have access and do not share a common reference. To support inter-organisational collaboration, what3words is being integrated into GIS systems to provide a common georeferencing system within and between the organisations.[164]

- Cultural interoperability was also identified as a challenge throughout the desk research. Cultural interoperability is an area that is receiving increasing attention through the EIF4SCC initiative. The EIF4CC defines cultural interoperability as the "steps taken by individuals and organisations to take into consideration their social and cultural differences and, if applicable, organisational cultural differences." [165] For example, in Amsterdam, a Crowd Insights Monitor (CIM) project was established in response to the Covid-19 pandemic. The project involved installing cameras with lights that indicate when citizens are not respecting social distancing. When discussing the project with an expert from Amsterdam Smart City, they noted that initially there was some resistance to the introduction of the project due to citizen concerns over privacy, however, acceptance of the project has increased, in part due to the "privacy by design" and "citizen centric" approach the city has taken to protect digital rights. **In this instance, the project is only possible because of the social and cultural public values and the citizen's trust of the public sector.** This may not be the same in another city or community, therefore, the replicability of scalability of the solution is, in part, contingent on cultural interoperability. See the following sub-section for a discussion on citizen trust and privacy.

  Another interesting cultural dynamic at play in the CIM project is driven by the culture of the local administration itself. As noted above, "privacy by design" and a "citizen centric" approach is central to the city's approach to digital services and solutions. On this basis, the city has made the source code for CIM available to partner cities if they adhere to some terms and conditions related to citizen privacy, including joining the coalition of Cities for Digital Rights. Therefore, in this instance, **the local administration's public and cultural values determine which cities can replicate this public service**.[166]

In the context of these cross-cutting challenges, there are a few international and regional (EU-level) initiatives underway which aim to support local administrations and other actors related with challenges that relate to providing interoperability services to citizens and businesses. Internationally, the Open and Agile Smart Cities (OASC) network aims to help build a global market for solutions, services and data base on the needs of cities and communities; one of the core aims of the network is to develop Minimal Interoperability Mechanisms (MIMs) based on open technical specifications that allow cities and communities to replicate and scale solutions globally.[167] In parallel, at the EU level, EIF4SC aims to support primarily local administrations in providing interoperable services to citizens and businesses. The EIF4SCC will include initiative such as developing common standards and technical specifications such as MIMS.[168]

Citizen Trust and Location Data Privacy

The use of location data for strengthening public services, and the potential public value that can be generated, needs to be balanced with the privacy risks and ethics. The use of location data within public services, and the associated privacy concerns, are very different depending on the type of location data e.g., the location of an asset versus the location of a citizen. The use of location data that is directly or can in-directly be linked back to an individual is particularly sensitive and subject to additional ethical and legal concerns and requirements. As noted under the ELISE Action, "While location data privacy has many aspects in common with general data protection principles, particular characteristics of location need to be considered.

[164] Interview with Joshua Rayner, what3words.
[165] European Union (f) (see footnote 30).
[166] Ibid.
[167] Open and Agile Smart Cities, Minimal Interoperability Mechanisms – MIMS, 2020. Accessed at: https://oascities.org/minimal-interoperability-mechanisms/ Accessed on: 10/08/2021.
[168] European Union (g) (see footnote 158).

Actions can be taken to mitigate the potential risks associated with using (personal) location data, keeping these characteristics in place mind."[169]

> *"One person can be at the same time the user of a mobile map, and the object of tracking in digital mapping by many organizations they are not aware of… Ubiquitous digital mapping can service individual freedoms but can also intensify imbalances of power." Ethical Geo, Locus Charter, 2021*

In the implementation of location-enabled public services, privacy must be considered from the perspective of public opinion, potential risks to citizens, and the regulatory environment. These three spheres are intimately connected and the first two play a crucial role in influencing and driving the latter.[170]

In the regulatory space, in the European Union's General Data Protection Regulation (GDPR), location data is determined to be personal data if it can be used to identify a person. Some instances were identified where there has been uneven and changing interpretation and application of GDPR to more dynamic location data sources such as MPD. [171] As highlighted by Kalvet and others (2020), for more than a decade, a private company in Estonia has analysed mobility and tourism flows based on pseudonymised data from MNOs. However, in 2019, it was determined that MNOS were no longer allowed to provide data due to a change in the national data protection agency's interpretation of privacy regulations.[172] While this regulatory challenge has now been overcome in Estonia, the ambiguity and inconsistency between member states may act as a disincentive for MNOs to share data and for public sector organizations to experiment with its use. It may also act as a disincentive for public sector institutions to use MPD for applications such as official statistics as they need to know that the systems and processes, they are investing in are sustainable, that is their access to MPD data from MNOs will not be disrupted.[173]

When discussing barriers with a vendor and expert in this space, they noted that **public opinion was a more important challenge for MNOs than the regulatory environment** as the former drives the later and they are reticent to risk their relationship of trust with their customers.

Best practices in this space are emerging, including incorporating 'privacy by design principles' in projects throughout the lifecycle of a project. Some examples of projects that have incorporated this best practice principles, but also, importantly, those that have got this wrong will be highlighted in the subsequent deep dives.

Location Data Ownership

The landscape of location data ownership is shifting. Increasingly, valuable location data sets are created, stored and maintained by the private sector - this applies to both static and dynamic location data but particularly to the latter category. [174] This is "challenging the role of the public sector as the main producer and owner of geospatial content"[175] and can create barriers for local and regional governments to access this data. As discussed earlier in this report, **data-driven insights gained from these 'upper layers' of data can be very valuable for gaining location intelligence and supporting public service innovations**. This can create a barrier to accessing valuable location data. For example, both in the literature and according to interviews, the primary barrier identified for the usage of MPD in public sector projects is gaining access to anonymized MPD data from MNOs.[176] Currently, there are limited incentives or obligations for private sector companies to share data with the public sector; further, they also need to navigate the regulatory

[169] European Union (h) ELISE- European Location Interoperability for e-Government: Location data privacy, 2021. Accessed at: https://joinup.ec.europa.eu/collection/elise-european-location-interoperability-solutions-e-government/location-data-privacy Accessed on: 10/08/2021.

[170] Interview with Veiko Lember, PhD, Senior Research Follow Ragnar Nurkse Department of Innovation and Governance, Tallinn University of Technology and Visiting Professor at the Public Governance Institute, KU Leuven and Erki Saluveer, the CEO of Positium - a company that specializes in MPD statistics.

[171] Kalvet, Olesk and Raun (see footnote 127).

[172] Ibid.

[173] Interview with Erki Saluveer, CEO of Positium (company that specializes in MPD statistics)

[174] Kotsev, A., Minghini, M., Tomas, R., Cetl, V. and Lutz, M., From Spatial Data Infrastructures to Data Spaces: A Technological Perspective on the Evolution of European SDIs, ISPRS *INTERNATIONAL JOURNAL OF GEO-INFORMATION*, ISSN 2220-9964, 2020, Vol. 9 No. 3, p. 176, JRC120143 and Schade S. and others (2020) Geospatial Information Infrastructures. In: Guo H., Goodchild M.F., Annoni A. (eds) Manual of Digital Earth. Springer, Singapore. https://doi.org/10.1007/978-981-32-9915-3_5

[175] Kotsev, Minghini, Tomas, Cetl and Lutz (see footnote 8).

[176] Kalvet, Olesk and Raun (see footnote 127).

environment for sharing potentially personal data – e.g., compliance with GDPR – as well as be responsive to public opinion.[177]

> *"The Inspire Directive focuses mainly on 'unlocking' data from the public sector, there is need to address emerging technological trends, and consider the role of other actors such as private sector and citizen science initiatives." Kotsev and others (2020)*

This has implications on the way all levels of government interact with location data. There is increasing dialogue about how to encourage and structure business-to-government data-sharing partnerships. For example, the European Commission has convened a high-level expert group on business-to-government data sharing and has recently published *Towards a European Strategy on Business-to-Government Data Sharing for the Public Interest.* The study highlighted that "business-to-government data-sharing partnerships are still largely isolated, short-term collaborations."[178] However, there are some concrete examples of emerging models in this space (see, for example the JRC publication developed through the Digitranscope Project on the Governance of Digitally-Transformed Society."[179]

There is increasing experimentation and innovation in this space by local and regional governments. For example, in Los Angeles, the Los Angeles Department of Transport (LADOT) introduced a new system whereby, to gain a license, shared use mobility providers (such as scooters and bikes) must provide their data to the city government including real-time information about how many of their vehicles are in use, where they are and in what condition. They created a Mobility Data Specification based on an Application Programming Interface (API) to standardise this information. This same requirement has now been introduced in several cities globally including cities in the EU such as Bergen, Norway, and Hamburg and Ulm in Germany.[180] Other regional and local governments are considering mandating telecom operators to share some of the data as a condition to be granted a permit to install or expand 5G antennas in a jurisdiction.

This signals a shift from unlocking data from the public sector to unlocking data from the private sector. As noted above, this will require the right incentives and regulations for the private sector, but this will also require the right incentives to be in place within local and regional governments. This point was raised in an interview with Ben Hawes (see quote on the following page).

> *"Local data, including location-enabled data, can have huge potential collective value, that could be realised locally in the public interest much more than it is now. As an example of where it does happen, local governments already seek access to ride-hailing platform data, as part of negotiations to allow Uber to operate in a city, because that data has potential local public value (for urban planning and management). This is value that only a local public body can realise for the community. Individuals cannot, a central government is too far away, and private entities do not have the incentives to use data for collective societal outcomes. There may be many other domains in which an active approach by local government to local data held by external organisations could realise public value locally, including by operating data trusts. Currently, local governments do not have in in their stated duties to go out and seek value from external data about the areas they manage. In an increasingly datafied world, perhaps we need to give them that responsibility." – Ben Hawes, Benchmark Initiative on responsible use of location data, Lot 1 Interview*

The forthcoming common data spaces, and Data Act, introduced earlier in this report will also play a key role in facilitating data sharing in a trusted environment across the data ecosystem of public administration, private companies and citizens.[181]

---

[177] Interview with Veiko Lember, PhD, Senior Research Follow Ragnar Nurkse Department of Innovation and Governance, Tallinn University of Technology and Visiting Professor at the Public Governance Institute, KU Leuven and the Erki Saluveer, the CEO of Positium a company that specializes in MPD statistics.

[178] European Commission (c) (see footnote 10).

[179] Micheli, M., Ponti, M., Craglia, M., and Berti Suman, A. Emerging models of data governance in the age of datafication. Big Data & Society, 2020. 7.

[180] LADOT, Mobility Data Specification: Information Briefing, 2018. Accessed at: https://ladot.io/wp-content/uploads/2018/12/What-is-MDS-Cities.pdf. Accessed on: 10/06/2021.

[181] European Commission (d) (see footnote 11).

4.2 Transport Deep Dive

Within the transport sector, location data and technologies have been central to public service innovation and digital transformation. As highlighted in the survey, 76% of the contacted local and regional governments are currently using location data and technology to strengthen transport public services. Advances in location technology, and the diversification and expansion of available location data, are driving **internal innovations** (e.g., fleet management, route planning and scheduling, demand-modelling, real-time traffic management etc.) and have also underpinned several **external innovations** resulting in smarter mobility services for citizens and businesses (e.g., on-demand transport, micro-mobility and smart journey planning).

Advances in location data and technology will also be critical drivers for future public service innovations; for example, more granular and interoperable location data, as well as more accurate GNSS, will be required for autonomous vehicle services to be deployed and will also support the scale-up of unmanned aerial drones.

Based on the findings from the desk research, the main public value driven by location-enabled transport services include **operational value** – including effectiveness, efficiency, and user-orientation –and **social value** – including quality of life, inclusiveness, and environmental sustainability.

This section will focus on two use cases within the domain of transport: on-demand transport services and journey planning and transport planning and management.

New and more sophisticated techniques for route optimisation, along with the use of unmanned drones, could realise up to £1.9 billion per year – An Initial Analysis of the Potential Geospatial Economic Opportunity, UK Cabinet Office

4.2.1 On-demand Transport Services and Journey Planning

Description of Use Case

This use case covers the provision of smart and multi-modal services to citizens. Location data and technology have enabled the proliferation of:

- **On-demand mobility service models** including peer-peer car rental, modern car clubs or modern car sharing, demand-responsive public transport, ride-hailing, ride-sourcing, ride-sharing and micro-transit.
- **Smart journey planning** platforms and applications. These platforms generally integrate various forms of transport services into a single platform to facilitate travellers to plan their journeys more easily.

Location data and technology have **enabled the creation of new public service delivery models** such as citizen to citizen (C2C) ride-hailing but have also **enabled the strengthening of existing public services** such as car-pooling and demand-responsive transport. New location-enabled transport services and delivery models are frequently emerging on the market expanding the selection of services available for citizens.

Together, on-demand mobility and smart journey planning are part of an ongoing paradigm shift from traditional operator-led public transport environment to **Mobility as-a Service** (Maas). MaaS refers to the integration of various forms of public and private transport services through a single application providing users with information on optimal routes and recommended multi-modal transport services with a single payment channel instead of multiple ticketing and payment options. MaaS represents a vision; in reality, transport services are often fragmented across different proprietary platforms. [182]

Location Data and Technology Enabling Innovative Public Services

Innovations in on-demand transport and smart journey planning services have both been enabled by advances in GNSS technology. This includes **GNSS trackers integrated into mobile devices and GNSS transponders located in vehicles** such as buses, shared scooters and car club fleets. Driven by the increasing accuracy of GNSS positioning technology and the decreasing cost of sensors, GPS trackers are now fitted in a significant proportion of transport fleets; in the UK, for example, 97% of buses are now fitted with GPS trackers.[183] Mobile and IoT GNSS sensors enable users to track the location of vehicles in real-time –

[182] MaaS Alliance, What is Maas? Accessed at: https://maas-alliance.eu/homepage/what-is-maas/ Accessed on: 10/06/2021.

[183] SmartCitiesWorld, UK wants to use location data to empower more passengers, 2019. Accessed at: https://smartcities.world.net/uk -wants-to-use-data-to-empower-more-bus-passengers. Accessed on: 10/06/2021.

whether on demand or scheduled services – and providers to track the location of users in real-time to deliver services based on their location.

The location data generated by these devices is an important **source of real-time data to feed into journey planning applications and on-demand service applications**. As will be discussed in the subsequent section, the location data generated by these services is also a valuable resource to support governments in transport and traffic planning and management.

For this use case, examples of innovative and emerging location data and technology include:

- Utilising **artificial intelligence and machine learning to improve and personalize service delivery**. For example, BusUp, an on-demand crowdsourced private bus provider, operational in territories across Spain and Portugal, is using AI algorithms to determine optimal pick-up times, locations and vehicle routes.[184]
- Piloting **Connected and Autonomous Vehicles** (CAVs) for on-demand and scheduled transport services. It is expected that most automated vehicles in the future will be offered via shared vehicles or ride-hailing services. While there are no CAV deployments with full automation there are several prototypes being piloted including through the EU funded projects, like Fabulos.[185] CAVs rely on a combination of different location data and technologies including the availability of granular road and street maps, high-accuracy positioning services (including the Galileo HAS due to be operational in 2024)[186] and IoT sensor networks alongside Cloud and Edge Computing and 5G.
- Leveraging **advances in IoT devices**. For example, some on-demand mobility providers such as modern car clubs and peer-peer car rental have integrated Near-Field Communication or Bluetooth Low Energy (BLE) sensors into their fleets to enable proximity authentication for their users.[187]
- Using **geofencing** to enable MaaS. Geofencing is a location-based service which uses radio frequency identification (RFID), Wi-Fi, GNSS or cellular data to identify when a mobile device or RFID tag enters or exits a virtual geographic boundary. For example, Deutsche Bahn has developed a ticketless journey application, Tickin, with a 'pay as you go' option based on distance travelled. The app detects the end of a journey automatically through the user's mobile GNSS.[188]

Stakeholders

The proliferation of location-enabled on-demand and smart journey planning applications has been accompanied with a **significant shift in the stakeholders involved in the provision of transport services and the role of local and regional governments:**

- **Location-enabled Service User:** The end-user of these services are citizens finding a means of transportation that is aligned with their priorities, for example, convenience, affordability and sustainability.
- **On-demand transport service/platform provider:** The proliferation of location-enabled on-demand transportation has led to a transformation and expansion of the models of public service delivery now in operation: public-citizen, private-citizen, citizen-citizen, citizen-private. Several models of service delivery include a separation between the transport service provider and the owner of the platform on which it is accessed.

  In this ecosystem, there are four main roles that local and regional governments can play:

  (i) Owner and operator of the service

  (ii) Owner of the service but outsourced to a third party

[184] European Commission (l), Horizon 2020, BusUp: Multi-platform On-demand Crowdsourced Bus Transportation for Smart City Mobility. Accessed at: https://cordis.europa.eu/project/id/757004 Accessed on: 10/06/2021.

[185] Fabulos, Fabulos Project. Accessed at: https://fabulos/eu/ Accessed on: 10/06/2021.

[186] European Global Navigation Satellite Systems Agency, Galileo High Accuracy Service (HAS) Info Note, 2020. Accessed at: https://www.gsc-europa.eu/sites/default/files/sites/all/files/Galileo_HAS_Info_Note.pdf Accessed on:10/06/2021.

[187] European Commission (m), Horizon 2020, Smart Sharing. Accessed at: https://cordis.europa.eu/project/id/738441 Accessed on: 10/06/2021.

[188] Deutsche Bahn, Gunstig reisen im VRN: die neue Ticket-App "Tickin", 2020. Accessed at: https://www.deutschebahn.com/pr-stuttgart-de/aktuell/presseinformationen/104-pm_vrn_ticket_app_tickin-5458690 Accessed on: 10/06/2021.

(iii) Orchestrators (e.g., providing a journey planning application for public and private transport services)

(iv) Regulators of private services

- **Data provider:** These can include public authorities and their subsidiaries (e.g., public transit providers providing real-time public transit data to smart journey planning platforms, whether public or privately orchestrated) as well as private firms such as HERE, Inrix and TomTom providing location-based mobility data to public and private sector service providers (for example, TomTom providing traffic data to support the functionality of a journey planning or on-demand transport service).

In most projects and services reviewed, the role of local and regional governments is as the service regulator. In terms of emerging trends, there is an increasing recognition that data collected from journey planners by 'service orchestrators' is **a valuable data set for transport planning and operations.** As such, there has been a move by local authorities and transport operators in many European regions to adopt this role and develop their own multimodal journey planners.[189] However, as will be discussed in the subsequent section, this also has implications on the potential impact and scalability.

Public Value Generated from Public Service Innovation

> *"The transformation towards a sustainable mobility future relies on data. Data provides grounds for decision-making in many urban geographies today, and data-sharing models between public and private stakeholders will create value through innovative, and likely real-time, analysis tomorrow." – World Business Council for Sustainable Development, 2020*

Analysis from the desk research and interviews highlighted that these location-enabled services generally drive operational and social public value.

In terms of **operational value**, the main public value type identified was '**user-oriented**.' The proliferation of on-demand transport services, particularly in urban areas, have created a wider selection of services available to citizens. This has expanded citizen's ability to choose a service based on their priorities, e.g., cost, convenience and sustainability. Further, these services are often more convenient and flexible because services can be chosen or delivered based on the user's location, e.g., ride-hailing services or car sharing. A more traditional demand-responsive transport experience, which does not leverage location technologies, generally consists of passengers calling a contact centre to request a rise, often well in advance. For example, the Regionalbus Rostock GmbH operates a call-line bus, ALF, that required booking by 4:00pm the day before the trip.[190]

More innovative and high-impact services in this space are **increasing the convenience and personalization of services using artificial intelligence and machine learning**. For example, KAROS a carpooling application, in operation in several local and regional territories across France, has integrated a predictive algorithm based on user's mobility habits to predict upcoming trips and connect them to users who match their itinerary and commute time. Looking to future developments in this space, it is also expected that CAV car-sharing and ride-hailing services will generate additional operational efficiency as well as improvements to safety.[191]

Smart, multi-modal journey planners also create 'user oriented' value as they enable users to access information from multiple providers from one platform. The most convenient examples of these services include:

(i) The integration of services from multiple providers across different modes, including scheduled and flexible transport. This requires the sharing of real-time location data, generally through APIs.

(ii) Seamless and integrated ticketing. The most innovative examples in this space include applications which enable ticketless travel, utilising emerging location technologies such as MPD and geofencing.

---

[189] CityGo, Transportation Planner and Intelligent Mobility Solution. Accessed at: http://www.city-go.eu/sites/default/files/city-go/public/content-files/pages/CityGO_factsheet.pdf Accessed on: 10/06/2021.
[190] Claps, M. Mobility as a Service: Demand-Based Business Models in European Cities, IDC, 2021.
[191] Ibid.

In terms of emerging trends, there is an increasing recognition that data collected from journey planners is a valuable data set, which can in turn be used to **strengthen the operational efficiency of transport planning and operations**. As such, there has been a move by local authorities and transport operators in many European regions to adopt the role of 'service orchestrator' and develop their own multimodal journey planners.[192] However, it can be a challenge for governments to identify a business model to financially sustain these platforms and to incentivise providers to share their and integrate their mobility data and services. Further, while a government orchestrated platform can improve public sector access to location and mobility data, it can also result in fragmentation of services for citizens by promoting geographically specific applications that can only be used in one place.

In response to this challenge, an EU funded project developed and piloted the CityGO journey planning application. The app has been developed with a 'scalability by design' approach, including reusable architecture, software components and templates, as well as customizable city features to reduce the cost of developing and deploying city-specific applications.[193] The app is also connected directly to a CityDash web-based dashboard for transport planning and operation. To date, the app has been piloted in Malaga; the scalability of the solution is yet to be determined.

The public services and projects reviewed in this space are also expected to generate social value including **quality of life**, and **environmental sustainability** as well as political value through **equity in accessibility**. However, the information available through the desk research often documented the expected impact of the solution with limited qualitative or quantitative analysis of impacts available. The impact on **quality of life** is generally linked to the reduction in travel times generated through on-demand flexible services and smart-multi modal journey planning. The impact on **equity in accessibility** is generally linked to carpooling and on-demand bus services providing services for underserved areas of cities, namely suburban areas resulting in greater service coverage. Finally, the impact on environmental sustainability is generally linked to the reduced reliance on private cars.

One EU funded project that documented the public value generated is the carpooling application KAROS. On average, users save €97 per month and reduce their travel time by 26 minutes per trip. From an environmental perspective, the carpooling solution helps to increase the load factor of cars, resulting in fewer cars on the road. At the time of the implementation of the EC Commission Project, the company estimated a reduction of C02 emissions by 202 tonnes and No2 emissions by 248kg – the service has scaled significantly since this time.

However, it is also important to consider the potential negative externalities of this revolution in mobility, particularly in urban areas which have been inundated with emerging start-ups. Ride-hailing services, for example, at their best have been found to reduce vehicle ownership and complemented public services and at their worst increase pollution, vehicle ownership, congestion, and reduce use of public transport. Literature highlights that **the impact of these services is heterogenous across territories** depending on, for example, the size of public transit agencies and population distribution.[194] To better manage the potential negative externalities, some local and regional governments are using location data generated from these services to research and simulate the impacts of emerging mobility solutions.[195] These examples will be explored further in the next section on transport management and planning.

Key Drivers and Barriers linked to Location Data and Technology

Table 7 provides a high-level overview of drivers and barriers related to location-enabled on-demand transport and journey planning solutions; however, it is important to note that, for each local and regional government, these will depend on the local context.

Table 7. Key Drivers and Barriers for On-demand Transport and Journey Planning Location-enabled Services

Political	***Drivers:*** Policies are changing at the EU and national level to create the conditions for data-centric innovation in the transportation space. For instance, one of the European Common Data Spaces proposed by the European Data Strategy is centered on mobility.

[192] CityGo (see footnote 190).

[193] Ibid.

[194] Hall, D. H., Palsson, C. and Price, J. 'Is Uber a substitute or complement for public transit?' Journal of Urban Economic, Elsevier, 2018, Vol. 108, pp 36-50.

[195] CityGo (see footnote 190).

Elected official's desire to respond to citizen expectations for services that align with their priorities, whether convenience, cost or environmental sustainability can also be a driver for the creation or innovation of these services. There is research that indicates that transportation policy instruments, and subsequent service delivery, is highly dependent on political ideology.[196]

Barriers: The political ideology and priorities for transportation public services can also act as a barrier for the creation of new publicly administered or outsourced public services.

Economic	***Drivers:*** The main driver for innovation in this space has been the profitability of emerging business models for service providers and orchestrators, whether through the cost of the service or the value generated from the location data created. Advances in location technology will also continue to drive economic benefits; for example, the higher precision and accuracy of location data can strengthen route optimization and result in fuel and cost savings for users and providers. ***Barriers:*** It can be a challenge for governments to identify a business model to financially sustain smart journey planning platforms and to incentivize providers to share and integrate their mobility data and services. This links to barriers related to data governance and ownership – see the discussion on cross-cutting challenges in Part 3 of the report. Further, The EU lacks a framework aimed at both safeguarding fair competition among transport modes through ensuring the effective integration of different transport means, including emerging mobility forms such as car-sharing, ride hailing, scooter-sharing, etc.[197] Finally, the survey data showed that, across all policy areas, the costs local and regional governments struggle with the most when investing in location-enabled public services are, new hardware, software licenses, additional data sets (either licensed or acquired) and extra staff.[198]
Social	***Drivers:*** Within the urban context, people are changing their consumption habits; they prefer to consume and share services within a community rather than simply own assets such as cars. Further, following the introduction of ride-hailing services over the last decade, citizens have greater expectations for on-demand and convenient services oriented around their location. ***Barriers:*** Not all citizens can use location-enabled on-demand transit services and smart journey planning platforms. Using these services requires citizens to have a smartphone and a sufficient level of digital literacy. As of 2019, almost three-quarters quarters (73%) of the adult population in the EU used mobile devices to connect to the internet.[199] While this is a sizeable proportion, use varies according to different demographics and local and regional authorities need to be cognisant that a digital divide does not map onto accessibility to transport service provision.
Technological	***Drivers:*** GPS mobile and IoT devices have enabled the proliferation of on-demand mobility solutions and smart journey planning applications. Emerging location technologies such as geo-fencing and GeoAI are also being leveraged for public service innovations. ***Barriers:*** Challenges of technical and semantic interoperability were identified as a challenge during project implementation and also as a barrier for replicating solutions and services. To enable the prototypes of on-demand CAVs to reach maturity, more accurate positioning technology will be required through both GNSS positioning but primarily through IoT devices, along with 5G networks, Cloud and Edge Computing.

[196] Christiansen, P. The effects of transportation priority congruence for political legitimacy. Transportation Research Part A Policy and Practice. 2019. 132. 61-76. 10.1016/j.tra.2019.11.005.

[197] European Parliament, Research for TRAN Committee- Eu funding of transport projects, 2019. Accessed at: https://www.europarl.europa.eu/RegData/etudes/STUD/2019/629199/IPOL_STU(2019)629199_EN.pdf Accessed on: 10/08/2021.

[198] Based on State of the Art Survey Data. The response is not specific to one policy area. N=29.

[199] Eurostat (c), File: People who used mobile devices to access the internet away from home or work, Eu-27, 2019 (%) BYIE20.png. Accessed at: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=File:People_who_used_mobile_devices_to_access_the_internet_away_from_home_or_work,_EU-27,_2019_(%25)_BYIE20.png Accessed on:10/06/2021.

Environmental	***Drivers:*** Increasing numbers of citizens are interested in taking more environmentally friendly transportation, whether carpooling, car clubs, or micro-mobility solutions to reduce the use or need for private vehicles. Location technologies and data have been critical to enabling the provision of these flexible services. Further, at the intersection of environmental and economic drivers, 200 cities in 10 countries across Europe are operating Low Emission Zones to reduce air pollution where the most polluting vehicles are either banned or charged an access fee. These fees make using private cars a less attractive proposition for many citizens.[200] ***Barriers:*** There is mixed evidence on the efficacy of some on-demand mobility services on increasing environmental sustainability and lowering emissions.[201] To better manage the potential negative externalities, some local and regional governments are using location data generated from these services to research and simulate the impacts of emerging mobility solutions.[202]
Legal	***Drivers:*** The European Data Governance Act proposal and the European Commission report on Business-to-Government (B2G) data sharing will be driving further investment in this location-enabled transportation services. ***Barriers:*** The legal and regulatory environment for location-enabled shared mobility services is heterogenous across and between EU member states and in several countries it is ambiguous.[203] In the space of smart mobility, significant value can be derived from tracking routes of public transport passengers, private vehicles, cyclists and pedestrians. The advent of CAVS will expand the volume, velocity and variety of data available. But such granular data collection risk not being compliant with GDPR laws that prohibit profiling individual citizens. Technology could offer a partial solution by being designed to collect masses of data anonymized at the source, such as have intelligent sensors that count the number of cars at an intersection, rather than collecting the location of individual cars and then sending them to a central server that sums up the cars with the same GPS coordinates. However, the same technologies are making it easier to de-anonymize data. Therefore, smart mobility services must find a way, within the legal framework of GDPR, to combine security, innovation and ethics. Finally, given the trend for increasing use of AI to predict passenger's journey preferences and patterns, consideration must also be given to the ethical use of AI and the EU proposal for a regulation laying down harmonized rules for AI.[204]

Source: State of the Art Report, 2021

4.2.2 Transport Planning and Management

Description of Use Case

This use case covers the application of location data and technologies to support both:

- **Transport planning:** this includes preparing, assessing and implementing policies, plans, and projects to improve and manage transport systems. For example, route planning and network maintenance.
- **Transport management**: this includes a set of applications and management tools to improve the overall traffic efficiency and safety of the transport system. For example, fleet and driver management, logistics optimization and traffic enforcement.

---

[200] AA, European Low Emission Zones. Accessed at: https://www.theaa.com/european-breakdown-cover/driving-in-europe/european-low-emission-zones#:~:text=LEZ%20rules%20could%20mean%20access,or%20charged%20an%20access%20fee Accessed on: 10/06/2021.

[201] Hall, D. H., Palsson, C. and Price, J. 'Is Uber a substitute or complement for public transit?' Journal of Urban Economic, Elsevier, 2018, Vol. 108, pp 36-50.

[202] CityGo (see footnote 190).

[203] Ride2Rail Consortium, State-of-the-Art of Ride-sharing in target Eu countries, Deliverable D2.2, 2020.

[204] European Union (h), Proposal for a REGULATION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL LAYING DOWN HARMONISED RULES ON ARTIFICIAL INTELLIGENCE (ARTIFICIAL INTELLIGENCE ACT) AND AMENDING CERTAIN UNION LEGISLATIVE ACTS COM/2021/206 final.

In this use case, the application of location data and technologies have enabled the **strengthening of existing public services** through providing more granular, comprehensive and dynamic information, and have also enabled **the creation of new public services** for transport and logistics management such as in-car features to alert drivers of upcoming conditions and curb-side management applications.

Location Data and Technology Enabling Innovating Public Services

Transport planning and management tools and systems rely on collecting, analysing and visualising location and mobility data. There has been an evolution and continuous experimentation in the types of location data and technologies that can be integrated into these tools to support better decision making. Advances in location data and technology have enabled access to more dynamic, granular, comprehensive and real-time insights for decisions transport planning and operations. Examples of more dynamic location data integrated into these systems and tools include:

- **Mobile Positioning Data**, including cellular data generated by MNOs, Mobile GNSS data collected via on-demand transport and smart journey planning applications, and WIFI connection data. For example, in London, the transport authority partnered with an MNO to provide free WIFI and uses WIFI connection data to track mobility patterns on the underground.[205]
- **IoT Device data,** including a variety of geo-located sensors, such as automated traffic counters, GPS-enabled sensors in vehicles, and video detection. As noted in the previous section, GPS trackers are now fitted in a significant proportion of transport fleets.[206]
- **Crowdsourced data,** including data collected from social media as well as navigation applications. Future innovations in this space will be linked to user-generated data from CAVs on driving and mobility patterns.
- **Earth Observation Data**, emerging and innovative location data and technology in this space include the use of satellite data to monitor ground movement[207] and the use of LIDAR technology and edge computing.[208]

While most of these location data sets have been successfully integrated into mature tools and services, it is important to note that: (i) several local and regional governments still use more traditional location data sets for transport planning and management (ii) more dynamic data sets are still integrated with static data sets so the quality of these base layers remains important. [209] Figure 16 highlights the types of data used in a project in Tartu, Estonia to help create a new bus network.

Utilising and integrating these big data sets requires greater data storage and processing capacity and more advanced analytics. Integrating diverse streams of big data can also create challenges around interoperability; this will be discussed further in the drivers and barriers section. Some of the most innovative systems and tools in this space are using advanced analytics such as AI and ML to:

(i) Automatically interpret the location data collected, for example, image recognition of different road users via video streams and unusual ground movement recognition from satellite imagery; and,

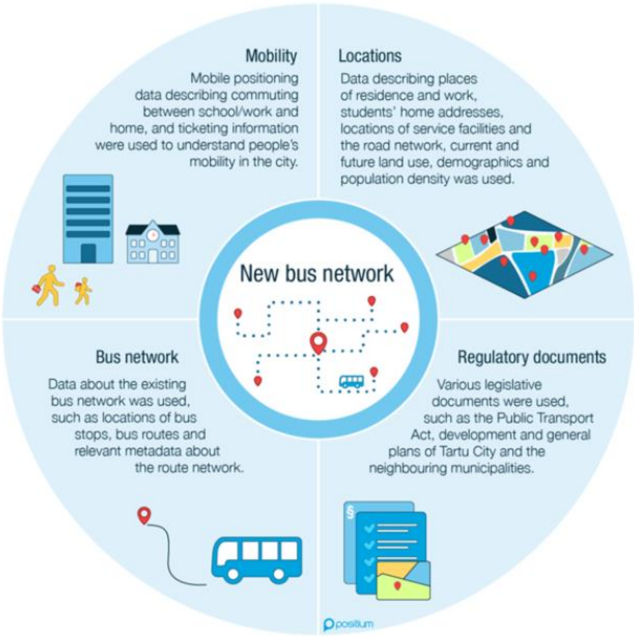
(ii) Predict future scenarios, for example predictive future road maintenance systems and AI-led optimized traffic light control.

The location data collected for transport planning and management is generally collected, analysed and visualized through a GIS. **Emerging innovations in this space are related to the development of digital twins**: digital twins bring together advanced data analytics and immersive simulations. These projects are still in the research and development or piloting phase. For example, a project funded by the UK Geospatial Commission is building a digital twin of three cities, Leeds, York and Hull. The digital twin will be an immersive 3D model that integrates ground movement data from satellite data and MPD from MNOs and

[205] Transport For London, Wi-Fi data collection. Accessed at: https://tfl.gov.uk/corporate/privacy-and-cookies/wi-fi-data-collection Accessed on: 10/06/2021.
[206] SmartCitiesWorld (see footnote 184).
[207] Satsense, Infrastructure. Accessed at: https://satsense.com/our-sectors/infrastructure/ Accessed on: 10/06/2021.
[208] Stone, T. Velodyne and Qualcomm team up to deploy lidar for city and traffic management, Traffic Technology Today, 2021. Accessed at: https://www.traffictechnologytoday.com/news/machine-vision-alpr/velodyne-and-qualcomm-team-up-to-deploy-lidar-for-city-and-traffic-management.html Accessed on: 10/06/2021.
[209] Positium (a), Blog: Building the future of public transport with mobile phone data and Remix. Accessed at: https://positium.com/blog/future-public-transport-mobile-phone-data-remix Accessed on: 10/06/2021.

uses advanced analytics for city and transport modelling. The digital twin is being built to enable planners to test different ways to boost the capacity of the existing network, reduce congestion, air pollution and improve logistics..[210] Further, an EU H2020 Project, *Low-Emission Adaptive Last Mile Logistics Supporting the On-demand Economy Through Digital Twins (LEAD)* digital twins are being developed to improve the operation and efficiency of parcel delivery, and the negative externalities (e.g., congestion) in Budapest, Lyon, Madrid, Oslo, Porto and the Hague. [211] The digital twins are being built to establish data-driven decisions as well as co-design of value cases by suppliers, shippers, policymakers and urban planners.

Figure 16. Data used for Creating the New Bus Network of Tartu



Source: Positium, Use Case: building a smart city with data-driven solutions, inclusivity and innovation in Tartu[212]

Stakeholders

- **Data and Technology Users:** The primary end users of these public services innovations are transport authorities. Citizens can also be the direct user of services through applications such as CAV traffic and road safety alerts.
- **Data provider:** Location data providers can include local, regional and national governments, transport providers (public and private), telecommunications companies, social media companies etc., sensor data (public and private), OEMs and CAV users.
- **Data aggregator**: Some local and regional government transport authorities play a primary role in coordinating the collection and integration of multiple location data sets. In other instances, the location technology and service provider play this role.

Public Value Generated from Public Service Innovation

Analysis from the desk research and interviews highlighted that the main value delivered from these location-enabled services is **operational value** including increased **efficiency, effectiveness and user-centricity.** Transport planners and operators can use the location intelligence generated from these systems to drive data-driven decision making and, on this basis, pursue objectives such as boosting network capacity, increasing network coverage, route optimization, cost reduction, reducing travel times.

[210] Slingshot Simulations, Press Release: Government Invests in UK's Largest Digital Twin Program: Leeds-based start-up to deliver one of the world's largest digital twin projects. Accessed at: https://www.slingshotsimulations.co.uk/news/digital-twins/government-invests-in-uks-largest-digital-twin-platform/ Accessed on: 10/06/2021.

[211] LEAD, Digital Twins for Low Emission Last Mile Logistics. 2021. Accessed at: https://www.leadproject.eu/ Accessed on: 20/08/2021.

[212] Positium (b), Blog: Use case: building a smart city with data-driven solutions, inclusivity and innovation in Tartu. Accessed at: https://positium.com/blog/smart-city-data-driven-solutions-innovation-in-tartu Accessed on: 10/06/2021

Some solutions reviewed also drove **social value** including increased **environmental sustainability** through reduced congestion and air pollution reduction and **quality of life**, mostly linked to improved air quality and reduced travel times. Another social; public value identified that was not included in the preliminary public value framework (see methodology) is safety; for example, traffic management systems can enable incident monitoring enabling the transport authority to act and/or communicate the risk to the public. Other solutions also drove **political value** through **equity in accessibility** through better transport service coverage.

Big location data sets and analytical approaches are helping to create operational value by equipping transport authorities with more dynamic and granular data to make decisions. For example, in 2019, in Tartu, Estonia, MPD was leveraged along with a variety of mobility and static location data to redesign the bus network. As a result of the updated network, the use of public transport increased by 10%, the frequency of bus arrivals increased from 14-10 to 10 minutes per bus and the public stakeholders consulted were satisfied with the changes.[213]

The future is where you combine different data sets. Each data set have their own benefits and limitations. And when you combine them, you discover new opportunities to generate value – Erki Saluveer, Positium (State of the Art Report Interview)

In the space of traffic management, adaptive traffic management systems, based on IoT based traffic flow data have been in operation over the last few decades. More innovative, and potentially high-impact, solutions are integrating a variety of dynamic data sets. For example, as part of the Variety, Veracity Value: Handling the Multiplicity of Urban Sensors Project (VaVeL) funded by the European Commission, a traffic management prototype system was developed which integrates traffic volume information from sensors, BUS GPS real time locations, Twitter messages, tram location information, crowdsourcing data, weather and pollution data, and CCTV data. The system was developed to enable more effective and efficient public transport and support a reduction in air pollution. In this project, and in other projects reviewed through the desk research, limited qualitative and quantitative data was available on the impact of these solutions. However, it is expected that these solutions will enable transport authorities to deploy **more proactive rather than responsive solutions, provide more real-time situational awareness and provide more holistic insights for transport planning**.[214]

Advances in digital twin technologies are expected to further increase operational efficiencies. For example, The Sensors4Rail project being implemented by the Deutsche Bahn will equip a Hamburg S-Bahn train with high accuracy sensors that locate the train and monitor surrounding; this data will be visualized on a high-definition 3D map.[215]

AT Deutsche Bahn, we are going to use the advantages of digital technologies to increase the capacity and quality of the railway system. The HERE HD map helps us to locate our trains more precisely. This way we can run more trains, at shorter intervals, on our existing infrastructure." Dr. Kristian Weiland, Head of Program Digital Rail for Germany, 2021

Innovative and potentially high impact projects in this space are integrating advanced analytics, such as **AI and ML** to predict future scenarios and **deploy proactive rather than responsive solutions.** For example, the ongoing EU-funded Urbanite Project[216] is building a mobility data platform that integrates data from public and private providers, including sharing-economy and micro-mobility providers to enable more holistic public sector management of transport and integrated policy making. The platform will use AI and predictive algorithms to simulate the impacts, including unforeseen impacts, of 'disruptive' on-demand transport

[213] Positium (b), Blog: Use case: building a smart city with data-driven solutions, inclusivity and innovation in Tartu. Accessed at: https://positium.com/blog/smart-city-data-driven-solutions-innovation-in-tartu Accessed on: 10/06/2021

[214] Milne and Watling (see footnote 131).

[215] RailTech.com, Deutsche Bahn to test HD mapping, creating railway Digital Twin, 2021. Accessed at: https://www.railtech.com/digitalisation/2021/01/18/deutsche-bahn-to-test-hd-mapping-creating-railway-digital-twin/ Accessed on: 10/06/2021

[216] European Commission, Horizon 2020, Supporting the decision-making in URBAN transformation with the use of disruptive Technologies. Accessed at: https://cordis.europa.eu/project/id/870338 Accessed on: 10/06/2021.

providers and create tools to help policy makers come to informed decisions. Interestingly, this project integrates **research on stakeholder's trust in AI and other emerging technologies for decision making**. While the pilot is occurring in Amsterdam, Bilbao, Helsinki and Messina, the project is also taking an 'replicability by design' approach by design approach and developing the system on European open standards.

In this use case, there are also several examples of projects which leverage location data and technology to **provide new and improved citizen-facing services**. For example, several cities are implementing **digital curb side management applications** which share the location of free parking spots and loading zones with a variety of potential users such as freight and logistics operators and cyclists. These applications can be used to drive operational value through more efficient use of urban space and the provision of user-centric services, as well as social values such as environmental sustainability and quality of life through the reduction of congestion. The most innovative pilots in this space provide **dynamic curb side management applications**; for example, Parkunload, an EU-funded project has developed a platform for dynamically regulated loading zones to pilot in Dublin. The innovative aspect of this solution is that the city can adjust the price and availability of loading zones based on several criteria including vehicle emissions, traffic, tonnage and time of day.[217]

There are also emerging dynamic and **potentially high impact** location-enabled solutions in this space linked to CAVs. For example, under the NordicWay2Geofence Pilot, **dynamic control zones** are being implemented. Through these dynamic zones, transport authorities can set real-time rules related to access, speed and pricing. The system works through geo-fencing technology and establishing a two-way communication network from the vehicle to surrounding infrastructure using GNSS and mobile networks. In the City of Gothenburg, a pilot was established for green adjustable zones. These zones are unavailable to diesel and gasoline vehicles and when hybrid vehicles enter a 'green zone' the electric motor is automatically activated. One of the core elements of the project is focused on creating replicable and connected Cooperative and Intelligent Transport Systems (CITS) solutions across Scandinavian countries. The services are being developed using a 'scalability by design' approach; including, inter alia, a cloud2cloud concept with an interchange network building on standards and open solutions.[218]

Key Drivers and Barriers linked to Location Data and Technology

Table 8 provides a high-level overview of drivers and barriers related to location-enabled transport planning and management solutions; however, it is important to note that, for each local and regional government, these will depend on the local context.

Table 8. Key Drivers and Barriers for Transport Planning and Management Location-enabled Services

Political	***Drivers and Barriers:*** Consistent with barriers outlined on page 70.
Economic	***Drivers:*** Local and regional authorities and network operators are driven by the need to increase efficiency, including cost-efficiency of transport services provided. There is also a cost to the negative externalities created by traffic congestion, for example the cost of time spent commuting, and health and wellbeing damages linked to GHG emissions. ***Barriers:*** EU resources for transport projects may be affected by political pressures to reduce the EU budget and other budgetary priorities gaining importance (such as pandemic response, immigration, and security).[219] The survey data showed that, across all policy areas, the costs local and regional governments struggle with the most when investing in location-enabled public services are, new hardware, software licenses, additional data sets (either licensed or acquired) and extra staff.[220]
Social	***Drivers:*** The high use of car in certain local and regional territories for work and leisure has driven elevated levels of congestion and the challenges associated. Further, several of the innovative transport planning and management systems

[217] European Commission, Smart Loading Zones in EU and Global market to regulate, control and monitor City Logistics - Last Mile Delivery in dense urban areas, based on Bluetooth devices and mobile apps for commercial drivers. Accessed at: https://cordis.europa.eu/project/id/886990 accessed on: 24/05/2021.

[218] Nordic Way, Protecting the environment with dynamic environmental zones. Accessed at: https://www.nordicway.net/demonstrationsites/dynamic-environmental-zones Accessed on: 10/06/2021.

[219] European Parliament (see footnote 198).

[220] Based on State of the Art Survey Data. The response is not specific to one policy area. N=29.

	automate more manual processes, e.g., a transition from manual to automated traffic and pedestrian counting. ***Barriers:*** There is ongoing discussion about the attitudes of civil servants and the public to advanced analytics, such as AI, being used to inform decision making.
Technological	***Drivers:*** The increasing availability of static and dynamic location data have underpinned several of these public service innovations. Collection, analysis and visualization of big location data has also been underpinned by increasing adoption and advances in cloud computing and advanced analytics. This can be both a driver and barrier depending on the interest, capacity and budget of transport authorities. ***Barriers:*** One of the main barriers identified is the challenge of integrating heterogeneous data sets, including location data but also complementary data sets such as environmental data sets. Challenges include technical, legal, semantic and organizational interoperability as well as the challenge of analysis and processing large data streams. As noted by Milne and Watling, 2019,[221] "These big data are often not specifically captured for transport applications but have relevance to its understanding. It takes additional work to manage, integrate, analyse and visualise this data in a way that is useful to gain insights."[222]
Environmental	**Driver:** Many of the rationales given for implementing traffic and transport management systems included increasing environmental sustainability through reducing GHG emissions. Air quality is gaining particular attention in the wake of the Covid 19 pandemic.
Legal	***Drivers and Barriers:*** Consistent with barriers outlined on page 72.

Source: State of the Art Report, 2021

4.3 Tourism Deep Dive

As highlighted in the survey, 71% of the participating local and regional governments are currently using location data and technology to strengthen tourism public services. Advances in location data and technology are driving internal innovations linked to tourism planning and management (e.g., tourist flow and monitoring, demand-modelling, studies of tourist experience and impact evaluation) as well as external innovations focused on tourist services and products (e.g., recommender and navigation apps sharing location-based information on the nearest tourist attractions, accommodation and facilities, as well as interactive and immersive experiences and guides). These location-enabled services are part of a movement toward the increasing application of ICT and data to the tourism sector, captured in the term 'smart tourism.'[223] This section will focus on uses cases related to tourism planning and management.

Description of Use Cases

This use case covers the application of location data and technologies to support both:

- Tourism planning: this includes activities related to preparing, implementing and evaluating policies and plans to strengthen the tourism sector; and,
- Tourism management: this includes tools to monitor tourist flows as well as tourist assets, for example, the condition of cultural heritage assets and natural assets for the purposes of operational management.

In this use case, location data and technologies are generally being leveraged to provide greater insights into tourist mobility patterns across different geographical scales – whether across one tourist attraction site, or multiple regions or countries – insights related to the tourist experience, and insights into the impact of tourism on the local economy, environment and society.

[221] Milne and Watling (see footnote 131).
[222] Ibid.
[223] Gretzel, U.; Sigala, M.; Xiang, Z.; Koo, C. 'Smart tourism: Foundations and developments', *Electronic Markets,* 2015, Vol. 25, pp 179-188.

"It is very difficult for governments to get detailed insights to plan for tourist related economic development." Erki Saluveer, Positium (State of the Art Report Interview)

Location Data and Technology Enabling Innovative Public Services

For many local and regional governments, traditional data sources and technologies are still heavily relied on to monitor and assess the impacts of tourism. For example, as noted by Kalvet and others (2020)., a common source of information for measuring the mobility patterns of tourists are household and business surveys.[224] However, they note that data from these surveys are often not consistently available, the data set provided is static and they can be time consuming and expensive to conduct.[225] State of the art research and applications are emerging of governments leveraging big and dynamic location data sources, as well as advanced analytics, to provide location intelligence, more granular insights at more regular intervals to support tourism planning and management. For example, some governments are using:

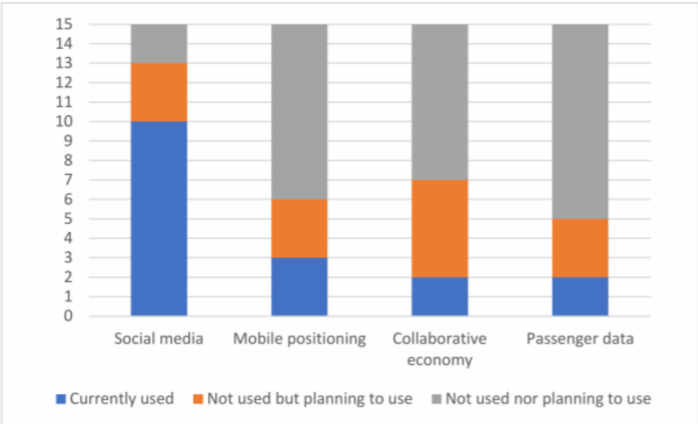
- **Mobile Positioning Data**: This can include the use of network data, and data generated from Bluetooth, Wi-Fi or GNSS to monitor tourist movements. When Bluetooth and Wi-Fi data are collected for this purpose, they are generally collected for fixed geographical areas, such as museums or points of interest, for a defined time period and generally require a user's permission. [226] Cellular network data, generated by MNOs, is also increasingly being applied to study tourism flows. For example, the Departments of Haute-Garonne and Aveyron in France are using a tourism vision flow dashboard that converts large, anonymized MNO datasets into statistical indicators to monitor tourism flows both for general trends and specific events.[227] There has also been experimentation in using passive MPD to generate tourism statistics; so far two countries in the world use this data for official tourism statistics - Estonia and Indonesia. However, as discussed in Chapter 2 and 4.1, there are barriers related to access, data privacy and regulation which are limiting the more mainstream use of MPD.[228]
- **IoT device data**: including a variety of geo-located sensors. For example, as part of the Smart Heritage City Project, funded by the ERDF, a system was piloted that integrates pedestrian counting cameras and sensors to collect data on the condition and occupancy of the historical complex. The data was used to feed a self-diagnostic web tool that generated recommendations for management intervention. The data was also integrated into a mobile application for tourist and citizens recommending routes based on event schedules and occupancy indicators.[229]
- **User-generated data:** including data collected from social media, web traffic and search data and online travel reviews. This data can provide insights on *tourist experience*, and what tourists are doing at specific locations. For example, with support from the ERDF, the region of Aragon in Spain has developed a platform for tourist profiling which collects social media data on a regular basis, combined with tourist statistics, to conduct place-based sentiment analysis. The platform is being used to support policy development.[230] To improve the platform, the next steps of the project will include integrating more advanced analytics and other data sources to provide more detailed insights and reports.[231] Kalvet et. al note that, increasingly, data and insights from the shared and collaborative economy, e.g., from Airbnb, TripAdvisor, Uber will be important for understanding the impact of tourism – a significant proportion of this data has a geospatial component.[232]
- **Environmental Observation data:** Some preliminary research and pilots are taking place using Unmanned Aerial Vehicles (UAVs) (i.e., drones) to monitor both the flow and impact of tourists. For example, a study focused on the Jotunheimen National Park in south-central Norway is using drones to

[224] Kalvet, Olesk and Raun (see footnote 127).
[225] Ibid.
[226] Ibid.
[227] Ibid.
[228] Ibid.
[229] European Union (j), Smart Heritage City. Accessed at: https://keep.eu/projects/18139/Smart-Heritage-City-EN/ Accessed on: 23/05/2021.
[230] Interreg Europe, Smart Tourism Platform. Accessed at: https://www.interregeurope.eu/policylearning/good-practices/item/4297/smart-tourism-platform/ Accessed on 23/05/2021.
[231] Ibid.
[232] Kalvet, Olesk and Raun (see footnote 127).

monitor the impact of tourists on protected areas.[233] The EU is also funding a research and innovation project, Deep Cube, which will use Copernicus satellite data, along with social media data, to compute the environmental impact of different tourist packages/ trips both at the time and over time. The satellite imagery will be used to gather information on environmental conditions such as human pressure, water pressure, ecological potential and air quality.[234]

However, while these dynamic location data are available, several local and regional governments are not currently leveraging them to gain insights for tourism planning and management. This can be demonstrated through research undertaken as part of the ongoing H2020 Research and Innovation Project, *Improving Sustainable Development Policies and Practices to Assess, Diversify and Foster Cultural Tourism in European Regions and Areas* (IMPACTOUR). The project is focused on developing advanced and adaptable methods to measure the impact of tourism and will include 15 Pilots Sites across Europe.[235] One of the first steps of the project included conducting a baseline assessment of the 15 pilot sites to determine their current and planned usage of selected dynamic data sets for tourism planning and management. The results are presented in Figure 17 below and demonstrate the general low usage of more 'novel' dynamic data sets. The research found that, while the current use of social media data is high, this is currently used mostly for marketing but there is interest to use it more for planning purposes in the future.[236]

Figure 17. Number of IMPACTOUR Pilot Participants who are currently using, and intend to use, novel data sources for tourism management and planning



Source: Kalvet and others (2020)

Going, forward, the IMPACTOUR project will help to develop methodologies that integrate more dynamic data and advanced technologies, many of which have a geospatial component, to better measure the social, economic and environmental impact of tourism.

"CT [Cultural Tourism] has been recognized as one of the divers of growth, jobs and economic development, as well as intercultural understanding and social development in European regions and urban areas. However, there is still a knowledge gap on methods to measure different types of CT impacts and to assess multilevel and cross-border strategies, policies and practices contribution to sustainable development." – IMPACTOUR H2020 Project, 2020

[233] Ancin-Murguzur, F, J., Munoz, L., Monz, C., Hausner, V, H. 'Donres as a tool to monitor human impacts and vegetation changes in parks and protected areas', *Remote Sensing in Ecology and Conservation,* ZSL, 2019, Vol. 6, (1), p105-113. https://doi.org/10.1002/rse2.127

[234] Deep Cube, Copernicus Services for Sustainable and Environmentally-friendly Tourism: Use Cases. Accessed at: https://deepcube-h2020.eu/use-cases/copernicus-services-for-sustainable-and-environmentally-friendly-tourism/ Accessed on: 20/06/2021.

[235] IMPACTOUR, Improving Sustainable Development Policies and Practices to Access, Diversity and Foster Cultural Tourism in European Regions and Areas: About. Accessed at: https://www.impactour.eu/ Accessed on: 19/06/2021.

[236] Kalvet, Olesk and Raun (see footnote 127).

Stakeholders

Data and technology users: The primary end users of these public service innovations are local and regional government tourism authorities. In some instances, the insights being shared on tourist flows are also shared with other departments to foster collaboration, including local police departments, transport departments and fire and rescue services.

Data providers: location data providers can include local, regional and national governments, e.g., Point of Interest data collected by mapping/survey authorities or generated by IoT devices purchased by local authorities, as well as MNOs, social media companies, shared and collaborative economy platform/service providers, credit card companies etc.

Data aggregators: Some local and regional governments play a role in integrating multiple location data sets from different sources, however, as noted above, to date, the integration of multiple dynamic location data sets is not common practice.

Data generators: Tourists play an important role as co-creators of location data that can be valuable for tourism planning and management. This brings to the fore questions of data privacy, ownership and ethics. See Section 4.1 for a discussion on location data privacy.

> *"An important part of the smart tourism concept is that it regards tourists as co-creators of valuable data, e.g., by uploading hash-tagged photos of tourism destinations on s0cial media, crowd mapping points of interest, generating data through the sensors in their wearables etc." Kalvet et al, 2020.*

Public Value Generated from Public Service Innovation

Analysis from the desk research and interviews highlighted that these location-enabled services can generate:

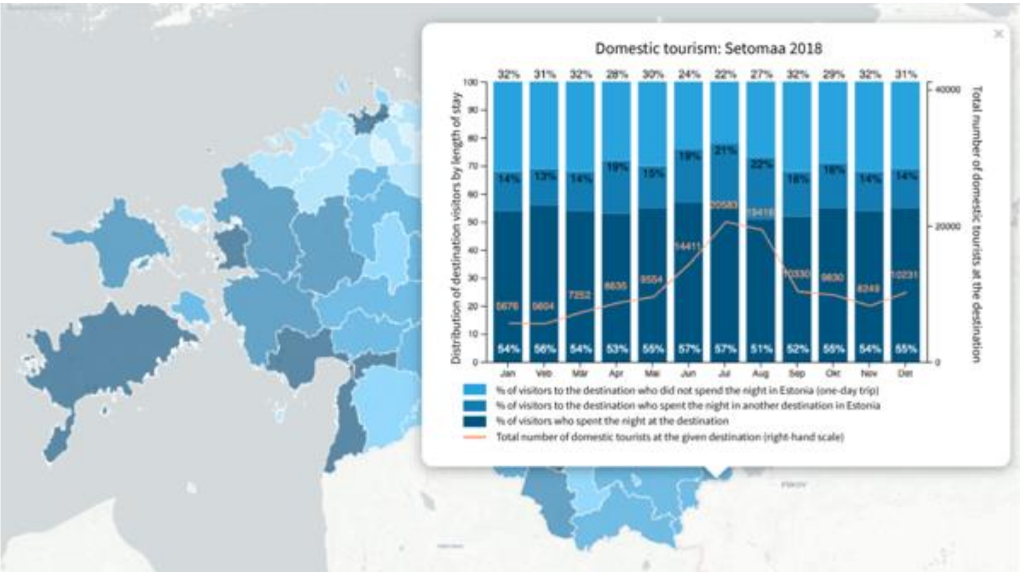
- Operational value, mainly through increasing the effectiveness and efficiency of tourism policy, planning and operations, and in some instances, collaboration between different levels of government and departments, such as the police and fire and rescue.
- Political value, through the promotion of economic development, and, in some instances, openness; and,
- Social value, through quality of life, mostly linked to the experience of the tourist, but also, in some instances focused on local residents, as well as some initiatives that promote environmentally sustainable tourism.

In terms of **operational value**, tourism planners can use location intelligence to drive data-driven decision making and to **improve the effectiveness of their policies and strategies**. For example, as noted earlier in this section, in Estonia, the national Government uses MPD to monitor the flow of tourists in the country, including their start and end destination, nationality and their length of trip. This data is captured by the Estonian Tourist Board in a Tourism Dashboard, and, at the national level, is used to support strategic planning. The Board also gives access to the dashboard to local and regional tourism organisations to support their planning and operations. For example, in the region of Setomaa, the local tourism organisation has used the dashboard to better understand tourist flows, target marketing and measure the impact of their policies (see Figure 18). Before they had access to this data, VisitSetomaa had been relying on accommodation data which did not capture a lot of tourists, as many of the businesses in the rural tourism communities were too small to have to register visitor numbers and many tourists stay in camping vehicles. It is expected that this location intelligence will also drive **political value** through the **promotion of economic development**.[237]

[237] Positium (c), Blog, Local Tourism Insights from MPD – Setomaa in South Estonia. Accessed at: https://positium.com/blog/local-tourism-insights-from-mpd-setomaa-in-south-estonia Accessed on: 21/03/2021.

Those managing the operation of tourist sites can also use location intelligence to strengthen the **effectiveness** and **efficiency** of various maintenance activities and services. The availability of real-time location data, whether collected from IoT devices, mobile devices, social media or EOD, can increase the capacity of local and regional governments to respond pro-actively. For example, in response to the Covid-19 pandemic, the Tourism and Planning Body for Costa del Sol, part of the Malaga Provincial Council, established a GIS platform to manage the capacity of its beaches. The solution was designed to provide information to the 14 different municipalities that collectively manage over 124 beaches. For each beach, a polygon map was developed, along with a calculation of maximum capacity based on moveable assets, fixed facilities and the social distancing restrictions of municipalities. Counting applications were developed to feed information on occupancy into the platform. This information was provided to municipalities as well as to tourists and residents via an online dashboard. As part of the same project, a pilot was launched with two municipalities to use drones to capture images of beaches, and using AI, automatically calculate occupancy percentages. One of these municipalities was Mijas (see Figure 19).[238]

Figure 18. Estonian Tourist Board's Dashboard: Number of Domestic Tourists



Source: Positium, Local Tourism Insights from MPD – Setomaa in Estonia, 2020.

This GIS solution has also enabled **collaboration** between municipalities. In this regard, one of the documented challenges to overcome was creating a solution compatible with the budgetary requirements of different municipalities as well as their work and management flows. It has also enabled collaboration within municipalities, for example, as part of the Mijas pilot, the information collected via drones is shared with the police and rescue services. It is also expected that this solution will drive **social value** through promoting public health and safety and enabling the continuation of recreation and tourism.[239]

It is important to note that the promotion of one of these public value through location-enabled services can result in trade-offs and negative externalities for other areas of public value. For example, using location intelligence to better target marketing and increase tourist flows may support economic development of a local area of region; however, depending on how this strategy is managed, it may also create social, and indeed economic, challenges for local residents who may find prices rising and have less access to local facilities.

[238] ESRI Espana, Solucion Aforos Playas, 2021. Accessed at: https://www.esri.es/es-es/descubre-los-gis/casos-de-exito/administracion-/solucion-aforos-playas-cs Accessed on 19/03/2021. and Merion, I., Three drones control the capacity on the beaches, Mijas News, 2021. Accessed at: https://turismo.mijas.es/images/ocio/eventos/2020/DRON%20INGL%C3%89S.pdf Accessed on: 20/06/2021.

[239] Ibid.

"Local Communities all over Europe today feel that touristic activity, until recently regarded as a source of prosperity and pride for, is turning into a threat for their way of life." SMARDEST Project, Cities as Mobility Hubs: Tackling Social Exclusion through Smart Citizen Engagement, 2020

As noted earlier in this section, there is a methodological gap on how to effectively measure the social and economic impacts of tourism, including evaluating the impact of different strategies, policies and practices.[240] The European Commission H2020 is funding several projects in this space focused on developing methodologies and tools to measure the socio-economic impact of tourism, including:

- The IMPACTOUR Project - *Improving Sustainable Development Policies and Practices to Assess, Diversify and Foster Cultural Tourism in European Regions and Areas*[241]
- The SMARtCulTour Project - Smart *Cultural Tourism as a Driver of Sustainable Development of European Regions*[242]
- The SMARTDEST Project – *Cities as Mobility Hubs: Tackling Social Exclusion through Smart Citizen Engagement.*[243]

Figure 19. Mijas Municipality Pilot to Monitor Beaches via Drone Imagery

Source: ESRI Espagne, 2020.

Each of these three ongoing projects will use geo-statistical, big-data mining methods and advanced analytics, including AI and ML, to examine the impact of tourists, socially, economically and spatially. These projects aim to equip decision makers with the tools and data required to promote more sustainable tourism practices focusing on the experience of tourists as well as citizens.

The SMARtCulTour Project, which will be piloted in 6 living labs across Europe, will include the development of a Platform aggregating multiple sources of data, including several big geospatial datasets such as MPD and user-generated data from social media, to evaluate the socio-economic impact of tourism. The project focuses particularly on peripheral tourist areas, particularly rural areas in which, if managed correctly, tourism could bring socio-economic benefits. In terms of social impact, the platform will focus on both the experience

[240] IMPACTOUR (see footnote 236).
[241] Ibid.
[242] European Commission (n), Smart Cultural Tourism as a Driver of Sustainable Development of European Regions. Accessed at: https://cordis.europa.eu/project/id/870708. Accessed on: 18/06/2021.
[243] European Commission (o), Cities as mobility hubs: tackling social exclusion through 'smart' citizen engagement. Accessed at: https://cordis.europa.eu/project/id/870753. Accessed on: 18/06/2021.

of citizens and tourists. AI will be integrated into the prototype platform to support data mining and integration, forecasting of future trends and clustering of regions/destinations in terms of similar characteristics and subsequent benchmarking.[244]

Key Drivers and Barriers linked to Location Data and Technology

Table 9 provides a high-level overview of drivers and barriers related to location-enabled tourism planning and management solutions. However, it is important to note that, for each local and regional government, these will be dependent on the local context.

Table 9. Key Drivers and Barriers for Tourism Planning and Management Location-enabled Services

Political	***Drivers:*** The literature suggests that the importance of quantitative data has increased considerably in policy planning, implementation and evaluation, including in the tourism sector. [245] On the edge of political and economic, public service innovations are driven by politician's and the public's priorities and expectations related to the tourism sector. Depending on the political priorities of the local and regional organization, this could also be a **Barrier**.
Economic	***Drivers:*** Public service innovations are driven by the objectives of local and regional governments to support economic development through tourism, whether in areas which already have a high-level of tourism or in under-developed regions. The objective of some local and regional governments to re-start/maintain tourist activities in the wake of the Covid-19 pandemic has been one of the drivers for the introduction of several location-enabled services to monitor tourist flows and activities in real-time. Another driver in this space is the growing pressure for governments to deliver more quality services for less.[246] ***Barriers:*** The survey data showed that, across all policy areas, the costs local and regional governments struggle with the most when investing in location-enabled public services are, new hardware, software licenses, additional data sets (either licensed or acquired) and extra staff.[247]
Social	***Drivers:*** Tourists need and expectation for effective tourism management and, increasingly, residents needs and expectations for the negative externalities of tourism to also be managed. **Barriers:** On the edge of social, economic and legal, there are several barriers surrounding the usage of some dynamic location datasets, particularly MPD. These relate to incentives for private sector companies to give access to valuable data, public opinion, data ethics and a shifting regulatory environment (see legal). In part related to these barriers, the study by Kalvet and others (2020) of 15 local and regional governments found that several still do not plan to use dynamic data sources for tourism planning and management.[248] This may also be linked to factors such as budget availability and digital skills and capacity.
Technological	***Drivers:*** The increasing availability of static and dynamic location data have underpinned several of these public service innovations. Collection, analysis and visualization of big location data has also been underpinned by increasing adoption and advances in cloud computing and advanced analytics. This can be both a driver and barrier depending on the interest, capacity and budget of tourism authorities. **Barriers:** Collection, analysis and visualization of heterogenous data, particularly mobile positioning data, crowdsourced data and high-volume satellite imager pose data interoperability, storage, analysis and data quality challenges. One of the

[244] European Commission (l) (see footnote 185).
[245] IMPACTOUR (see footnote 236).
[246] Kalvet, Olesk and Raun (see footnote 127).
[247] Based on State of the Art Survey Data. The response is not specific to one policy area. N=29.
[248] Kalvet, Olesk and Raun (see footnote 127).

	greatest challenges for the use of satellite imagery is the lack of training data sets available (see discussion in Chapter 2).
Environmental	**Driver:** In light of the Sustainable Development Goals and other related policies, there has been an increasing focus on sustainable tourism, which includes limiting the impact on the environment. This has been a driver behind some of public service innovations related to environmental impact assessments and monitoring. ***Barrier:*** The increasing focus on the negative externalities of tourism activities and public values of citizens, including potential for environmental degradation may also create a barrier for the creation of services which prioritize tourist activities.
Legal	***Driver:*** Enabling legal, policy and strategy documents at the EU and national level can be important drivers and enabler of these services, including, for example, the European Data Strategy and the forthcoming European Data Governance Act. ***Barriers:*** The use of more accurate and granular location data, such as MPD creates a concern over the ability to protect citizen's privacy. As elaborated in 4.1, there has also been some ambiguity and inconsistency between member states in their legal and regulatory approach to the use of MPD; this can be disincentive for MNOs to share data and for public sector organizations to experiment with its use.[249]

Source: State of the Art Report, 2021

4.4 Health Deep Dive

COVID-19 demonstrated more than ever the value of data and information technology, including location data and technology to strengthen public health services. From visualizing information on websites that externally helped make public health surveillance more transparent for citizens to predicting the spread of the disease that increased the speed of internal decision making. However, the pandemic also brought to the fore dialogue about data privacy and ethics, particularly related to track and trace applications, as countries across the world experimented with different uses of mobile positioning to track the movement of their citizens.

Actionable insights from location data help national and international health institutions to prevent what is preventable and prepare for what is imminent. They enable healthcare authorities to take proactive measures, including mobilizing resources, training staff, and preparing hospital facilities and infrastructures to meet the challenges of the epidemic. At an individual hospital level, location data and technologies are essential to ensure healthcare service continuity and redundancy, by rapidly setting up additional capabilities, such as ICUs, bedside monitoring tools, and triage systems to treat more critical patients faster. The lessons learned from the pandemic on the application of location data and technologies to innovate public health can be extended to non-communicable diseases, such as diabetes, pulmonary disease and cancer, or to efficiently and effectively manage day-by-day emergencies to improve health operational and social outcomes.

Over the last 10 months we have seen location data play an important role in supporting the public sector's response to Covid-19. The pandemic has highlighted how vital that high quality geospatial data is easily and quickly accessible to all users – Chris Chambers, Head of the Public Sector Geospatial Agreement at the UK Ordnance Survey, 2021.

Description of Use Cases

Public health consists of the integrated cycle of sense-predict-respond ecosystem that underpins health preparedness and management strategies.

- **Sense and detect** includes ongoing public health surveillance, and emergency preparedness activities.
- **Predict and prevent** entails the ability to produce proactive insights for early detection, epidemiological modelling and forecasting, and preparation of resilience systems.

[249] Kalvet, Olesk and Raun (see footnote 127).

- **Respond** entails data-driven epidemic monitoring and surveillance, risk communication and community engagement, and care service delivery continuity.

Location Data and Technology Enabling Innovative Public Services

Location data has been used to **detect** causes of disease, track its spread and monitor the recovery of patients since the 19th century, when John Snow mapped cholera outbreaks in London in 1854, by tracking down the source of the infection to a specific street[250].

With the wider availability of data about the location of patients and clusters of disease outbreaks, as well as the location of resources needed for response, location technology can now produce insights to track and manage diseases, such as the current coronavirus pandemic, in near real-time, enabling improved responses.

Location data can be used to model the transmission of disease, **predict** communities more likely to be vulnerable to its spread and identify and assign appropriate healthcare resources to **respond** to the needs of those communities**.** For instance, in the UK static location data, such as Unique Property Reference Numbers play a role in helping health and social care workers plan and target their services more effectively. Address API has been providing the NHS with accurate addressing information. Sharing UPRNs between organisations has helped combine insights to help target interventions where needed the most[251]. Existing real-time, location-based technology is being repurposed to support the national response such as the newly created *NHS Volunteer Responders*. This initiative uses a platform to enable project coordinators to remotely assign tasks to individuals in the field depending on need and prioritisation. Already 750,000 volunteers have signed up to participate in the scheme.

Location data is also used to prepare and **prevent** so that healthcare systems are made more resilient. In the UK, Ordnance Survey data has been used, in Somerset, to assess travel times and potential implications of closing stroke services at a hospital and centralising.[252] In Scotland, NHS used OS Points of Interest and Highways data to help identify safe locations for a mobile team to take blood samples.[253]

Location data and technology helped **democratize public health surveillance** during COVID-19. At the global level, John's Hopkins University COVID-19 map is the quintessential example[254] but in Europe, many more localized and actionable insights have been made available for the public.

Location data and technology enabled also internal innovation to **respond** by ensuring continuity of care delivery. For example, the city of Cascais set up an operational control room to efficiently manage its resources available and have a real-time view of the situation and disease's spread and manage the crisis in an integrated manner, through real-time data visualization, and integrating information from the Civil Protection, Firefighters, and other actors of the Health System. The operational control room was also used to optimize COVID19 test scheduling and results management and to monitor resources, as well as their capacity (total and available); and currently is being used to optimize vaccine distribution. The Lisbon Metropolitan Area (AML) used location data and technology to speed up the response time to critical needs around products, equipment and services, for example, protective masks, gloves, disinfectant gel, cooked meals, availability of accommodation for isolation, quarantine or treatment, medical supplies.[255]

The expansion of more dynamic datasets has enriched the ability to **sense and detect** more rapidly. For instance, the German government aggregated county level mobile positioning data (MPD) as part of a prototype project to identify successful counties (positive deviants) and analyse their strategies during the pandemic,[256] MPD data (in partnership with telecom companies and MPD analytics specialist Teralytics) was used to develop a general understanding of mobility patterns in Germany during different phases of the pandemic, the relevant factors in pandemic developments, potential positive deviants that have performed

[250] Rogers, S. John Snow's data journalism: the cholera map that changed the world. The Guardian, 2013. Accessed at https://www.theguardian.com/news/datablog/2013/mar/15/john-snow-cholera-map Accessed on: 10/06/2021.

[251] GeoPlace, Bridging central and local government with UPRNs to respond to COVID-19. Accessed at: https://www.geoplace.co.uk/case-studies/bridging-central-and-local-government-with-uprns-to-respond-to-covid-19 Accessed on: 10/06/2021.

[252] Ordnance Survey (a) OS Data helps keep hospital open in Somerset, 2014. Accessed at: https://www.ordnancesurvey.co.uk/business-government/products/case-studies/stroke-nhs. Accessed on: 10/06/2021.

[253] Ordnance Survey (b), Cross-referencing data so NHS Lothian can look after shielding patients during Covid-19. Accessed at: https://www.ordnancesurvey.co.uk/business-government/products/case-studies/nhs-lothian-covid-datasets Accessed on: 10/06/2021.

[254] John Hopkins, University of Medicine, COVID-10 Dashboard by the Center for Systems Science and Engineering (CSSE) at John Hopkins University (JHU). Access at: https://coronavirus.jhu.edu/map.html Accessed on: 10/06/2021.

[255] Deloitte, Smart City Solution Centre, 2020. Accessed at: https://www2.deloitte.com/content/dam/Deloitte/pt/Documents/public-sector/Smart%20City%20Solution%20Center.pdf Accessed on: 10/06/2021.

[256] Heeks, R and Albanna, B. Positive Deviance: A Data-Powered Approach to the Covid-19 Response, GIZ Data Lab, 2020. Accessed at: https://www.blog-datalab.com/home/a-data-powered-approach-to-the-covid-19-response/ Accessed on: 10/06/2021.

particularly well. The data included structural data and data on the infection spread of COVID-19. Structural data included factors such as population density, hospital capacities, nursing homes, etc. per district and was primarily extracted from Landatlas. The project team also added data on average age and average household size. The data on the infection spread encompassed the number of COVID-19 infections per district provided by the Robert Koch Institute and data on the connectedness of districts with early COVID-19 hotspots measured by the frequency of travelling between the districts. Behavioural data from social media or mobility data was also analysed.

The most controversial application of location data and technologies in public health sensing and detection was mobile-enabled **contact tracing**.[257] Traditionally most public health systems have managed contact tracing through phone interviews of citizens who have tested positive for a disease. In the case of Covid-19, this requires the patient to be able to accurately recall all the locations and people they have been in contact with for the last 2 weeks. The high penetration of smartphones offered the opportunity to experiment with various approaches to more accurate contact tracing; the most widely adopted in Europe was based on Bluetooth. However, the results were underwhelming, either because of low take up, or because the process was not integrated with the public health operators in charge of conducting phone follow ups. Other countries are using mobile phone triangulation to identify the comings and goings of infected persons, but unfortunately this does not cover places with the biggest risk indoor spaces. You can use GPS or a QR-code check-in to determine the location of an individual but cannot determine which area of the facility they have visited. This means that everyone who visited the building would need to go into quarantine. Some companies offer contact tracing with wearables to achieve indoor positioning but often require substantial investment, including beacon installation. State of the art geomagnetic indoor positioning offering are available on the market as hardware-free solutions; Orient Indoor GPS can collect data within 3ft/1m of accuracy – analysis of individual data only processed in the case of a positive Covid test.

COVID-19 triggered European local and regional governments to invest in systems for pro-active crowd management of crowded urban spaces. Pilots are ongoing in Amsterdam, Milan, and Barcelona, based on various crowd monitoring sensor types: automatic counting & flow/speed/density detection systems; RFID tags and sensors; Wi-Fi & Bluetooth sensors; GPS trackers and smartphone applications. The EIT-KIC project CityFlows, which aims to improve the liveability of crowded pedestrian spaces through the provision of decision-support for the management of pedestrian flows, was extended to crowd management for COVID-19 social distancing management.[258]

Crowd management applications raise questions of privacy and ethics and the distinction between counting and tracking citizens. The CityFlows Project was developed with a privacy-by-design approach to ensure GDPR compliance and the privacy of citizens (See Figure 20 for more information). There are also examples of where local and regional governments have implemented crowd management tools and have not sufficiently accounted for privacy concerns and regulatory requirements. For example, through the interviews, an example was identified where a city government used WI-FI data and sensors for a crowd counting application in the city centre. An investigation was conducted by the national data protection agency and the municipality was fined for not properly protecting citizen's privacy. It was determined that, as the data was being collected over time, this was considered to constitute 'tracking' rather than 'counting.' Examples such as these highlight important lessons learnt.

Figure 20. City Flows Project, Privacy by Design Approach

City Flows' Crowd Monitoring Dashboard (CMD) was developed using a privacy-by-design framework. This means that the data gathered by the CM-DSS is, as much as possible, already encrypted at the source in a way that it is impossible to recreate the original data without the exact encryption algorithm, which changes dynamically over time. Besides that, only data which is essential to evaluate the crowd's movements is captured by the CM-DSS and transmitted from the sensor towards the CM-DSS mainframe. Most importantly, the CM-DSS only stores anonymized aggregated statistics regarding the crowd, which cannot be traced back to any one individual. First and foremost, the CityFlows CM-DSS only accepts GPS traces from providers/applications that have explicitly asked permission to their users to distribute the data (anonymously) to third parties, such as the CityFlows CM-DSS. Secondly, the original identification

[257] De Nigris, S., Gomez-Gonzales, E., Gomez Gutierrez, E., Martens, B., Iglesias Portela, M., Vespe, M., Schade, S., Micheli, M., Kotsev, A., Mitton, I., Vesnic Alujevic, L., Pignatelli, F., Hradec, J., Nativi, S., Sanchez Martin, J.I., Hamon, R. and Junklewitz, H., Artificial Intelligence and Digital Transformation: early lessons from the COVID-19 crisis, Craglia, M. editor(s), EUR 30306 EN, Publications Office of the European Union, Luxembourg, 2020, ISBN 978-92-76-20802-0, doi:10.2760/166278, JRC121305.

[258] European Union, CityFlows, EIT Urban Mobility, 2020. Accessed at: https://www.eiturbanmobility.eu/projects/cityflows/ Accessed on: 10/06/2021.

information is hashed, cut and re-hashed before it is stored in the database of the CityFlows CM-DSS. Moreover, GPS traces of individual smartphones are only used in the analysis, but never visualized in a way that a GPS track can be traced back to a specific individual.

Source: European Union, City Flows Project, 2020

Stakeholders

The complexity of the healthcare ecosystem, which includes public health authorities, patients, public and private hospitals and other care providers, payers, pharma and life science companies, and so forth, results into different roles that each of them can play:

- **Data users**: this can include public health authorities that use location data to detect patients at risk, predict the evolution of diseases in a certain community, but it can also include hospitals that need to organize resources and citizens who want transparent access to public health surveillance data.
- **Data aggregators**: public health authorities play a primary role here, because they are accountable for coordinating the whole sensing-predicting-responding life cycle, therefore have more opportunities to realize the benefit of integrating multiple location data sets.
- **Data providers:** this can include public health and other public authorities, but also telecom companies in case of MPD and eventually patients themselves that through mobile devices, fitness devices and other tools generate personal health data with related location attributes.

Public Value

Across the sense-predict-respond public health management life cycle, the main values delivered by location data and technology include:

- Operational values, like efficient allocation of care resources, resiliency in case of emergency and personalization of care. For instance, during the COVID-19 emergency, the Rhein-Neckar-Kreis County in Germany faced the need for its emergency rooms to route ambulance cars running emergency transports with COVID-19 patients to clinics with available (bed) capacities, replacing the manual and time-consuming processes. District offices also had to continuously report to the state and federal authorities how many COVID-19 intensive care beds were available with or without ventilation options in the region. They deployed a cloud application to report and actively manage capacity and availability of different fully functional bed types — including information about protective gear, staff, doctors, ventilators, and more — in the COVID-19 departments of all 25 hospitals across the Rhein-Neckar-Kreis County. The solution had to ensure the timely routing of emergency transports to suitable clinics by central coordination and distribution of patients across the county's 45 COVID-19 wards in those 25 clinics. Using this data, users can determine capacity levels and decide which hospital can best care for the patient in question. The information was also shown on an interactive map enabling medical and emergency staff to see where each hospital is located, pinpoint a facility where beds are available, and coordinate directly with the team there[259].
- Political values, like increased transparency of information from public health surveillance activities, participation, because for example citizens actively contribute as data providers, and equity in accessibility, because more efficient allocation of healthcare resources translates into more affordable services. For instance, Valencia Smart City Office has deployed a new municipal website coronavirus.valencia.es that brought together data on the evolution of the health crisis including positive cases detected, fatalities number of people hospitalized and discharged (from the regional health board). The data is represented through graphs and maps. The website integrates GIS mapping and spatial analytics software to create and share location intelligence. Taking advantage of the capabilities of the existing VLCi (FIWARE-based) Platform, a series of graphs have been publicly shown as a small extract of the Smart City Dashboards with relevant information on the state of the city of Valencia during the state of alarm by Covid-19 regarding matters such as mobility, urban waste management, pollution

[259] SAP, Managing COVID-10 Hospital Bed Capacity and Availability with SAP Cloud Platform and SAP Fiori. Accessed at: https://www.sap.com/documents/2020/08/48de8f76-aa7d-0010-87a3-c30de2ffd8ff.html Accessed on: 11/08/2021.

and water consumption. This kind of information allows for monitoring of the crisis evolution and delivering transparent and relevant information to citizens on a daily basis.[260]

- Social values, such as quality of life, because of saved lives or extension of healthy life years, when health services function well. For instance, in Birmingham, the city's public heath team used Ordnance Survey's data to tackle childhood obesity crisis to slow spread of unhealthy fast-food outlets near schools.[261]

Drivers and Barriers

Table 10 provides a high-level overview of drivers and barriers related to location-enabled health services; however, it is important to note that, for each city and municipality and region, these will depend on the local context.

Table 10. Key Drivers and Barriers for Public Health Location-enabled Services

Political	**Drivers:** elected officials' desire to respond to citizen expectations for improved and more affordable and personalized public health to be re-elected. **Barriers:** the complexity and dynamic nature of the health ecosystem makes difficult to align incentives to share location data for the public good. This can be a political barrier in terms of the mandates and policies of public sector institutions and also be a result of organizational and cultural interoperability barriers.
Economic	**Drivers:** improving efficiency of public health so that services become more affordable and accessible for a large part of the population. Further, improving quality of healthcare outcomes, so that citizens are healthy and productive. **Barriers:** budget constraints limit the ability of public health authorities to invest in location data collection, aggregation and analysis.
Social	**Drivers:** Public need and expectation for improved and more affordable and personalized public health. **Barriers:** concerns over the ethical use of data, including location data, and advanced technologies like AI, which could restrict the choices that citizens can make about their health.[262]
Technological	**Drivers:** Collection, analysis and visualization of heterogenous data can enhance the speed, accuracy and personalization of health interventions. **Barriers:** Collection, analysis and visualization of heterogenous data, particularly mobile positioning data and crowdsourced data that pose both data interoperability and data quality challenges. Further, limited processing capabilities at the edge, where more intelligence could cut the latency of response to health risks to almost real-time, which means saving lives.
Legal	***Drivers:*** Enabling legal, policy and strategy documents at the EU and national level can be important drivers and enabler of these services, including, for example, the European Data Strategy and the forthcoming European Data Governance Act. The European Data Strategy has outlined plans to develop common European data spaces for key sectors including health care. This will provide a data governance framework and enhance data access. This driver is on the edge of a political and legal driver. **Barriers:** Data protection: healthcare data are the most sensitive (and valuable data[263]), so, the expansion of more accurate and granular location data, such as MPD, creates a concern over the ability to protect patient privacy

Source: State of the Art Report, 2021

[260] Ajuntament De Valencia, COVID19 Valencia. Accessed at: http://smartcity.valencia.es/vlci/covid19-information-website-for-citizens/ Accessed on: 10/06/2021.

[261] Ordnance Survey (c), NHS and OS battle obesity in Birmingham. https://www.ordnancesurvey.co.uk/business-government/products/case-studies/birmingham-nhs-mapping Accessed on: 10/06/2021.

[262] European Commission (p), Press Release: Europe fit for the Digital Age: Commission proposes new rules and actions for excellence and trust in Artificial Intelligence. Accessed at: https://ec.europa.eu/commission/presscorner/detail/en/ip_21_1682 Accessed on: 10/06/2021.

[263] Neveux, E. Healthcare data: The new prize for hackers, SecureLink, 2020. Accessed at: https://www.securelink.com/blog/healthcare-data-new-prize-hackers/ Accessed on: 10/06/2021.

4.5 Trends for the Evolution of Location-enabled Public Services

This section will highlight areas in which location data and technologies are starting to be applied to public services in innovative ways, but they are either in early stages of research and development, are underexplored, or not widely replicated. The section will include:

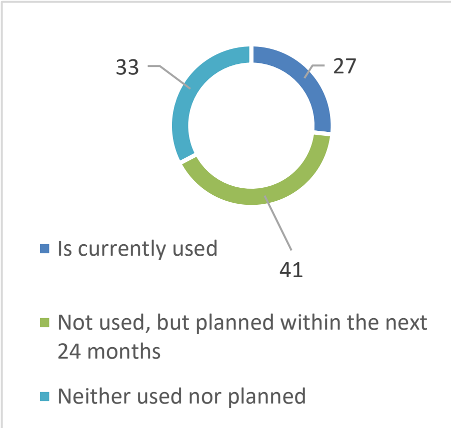
- Specific policy areas in which location data and technology are underutilised for public service innovation. These public service areas have been selected on the basis of the survey findings; they are the public service areas where location data and technology are being used the least frequently by local and regional governments to strengthen public services.
- Types of **public service innovations** (i.e., strategic, capacity, services) that could be applied across several different public service areas - the trends and opportunities highlighted here were identified through the desk research, literature review and interviews.

4.5.1 Policy Areas

Social Protection

Social protection includes government functions related to sickness and disability, old age, survivors, family and children, unemployment, housing and social exclusion.[264] The findings from the survey highlighted that social protection is the policy service area in which location data and technologies are least frequently leveraged: only 27% of local and regional governments are using location data and technologies to strengthen social protection public services. However, it is also the area with the highest increase in planned usage: just over 40% of local and regional governments surveyed plan to use location data and technology in this area within the next 2 years (see Figure 21). It would be interesting to conduct further research on the reason behind the high planned increase in usage and the expected use cases; one hypothesis for this significant increase is the impact of the Covid-19 pandemic and the vulnerabilities exposed in social protection mechanisms[265] as well as the ageing population across the EU.[266]

Figure 21. Use of Location Data and Technologies for Improving Social Protection Services



There are several examples of location data and technology being used to improve public services in this area across the EU that could potentially be replicated or scaled up, as well as several opportunities for new services and products to be developed. For example, in the space of geospatial demography, the European Space Agency partnered with the University of Vienna, World Data Lab and GeoVille to develop an algorithm called *AgeSpot* which sorts through satellite imagery and census data to find correlations between a location's physical surroundings and the age of its inhabitants. The model has been piloted in Vienna, Austria and projects population shifts over a 12-years span.[267] Applications of geospatial demography are also relevant across a range of public service applications, including in the areas of unemployment, housing and social exclusion.

There is also research and innovation in the space of assistive technologies, such as wayfinding applications and devices for citizens with disabilities and GPS devices to help locate senior citizen's suffering from dementia.[268] In the last example, there are important ethics and privacy questions that need to be addressed

[264] Eurostat (a) (see footnote 15).

[265] Razavi, S., Behrendt, C., Bierbaum, M., Orton, I. and Tessier, L. 'Reinvigorating the social contract and strengthening social cohesion: Social protection responses to COVID-19', *International Social Security Review*, 2020, Vol. 73, No. 3, pp 55-80.

[266] Eurostat (d), Population Structure and Ageing: Increase in the share of the population aged 65 years or over between 2009 and 2019, 2020. Accessed at: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Population_structure_and_ageing Accessed on: 15/06/2021.

[267] ESA, Space to help support us as we get older, 2017. Accessed at: https://business.esa.int/news/space-to-help-support-us-we-get-older. Accessed on: 20/06/2021.

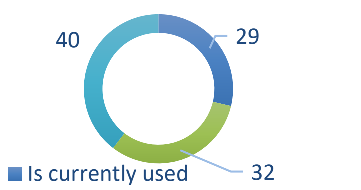
[268] Microsoft, A map delivered in 3D Sound. Accessed at: https://www.microsoft.com/en-us/research/product/soundscape/ Accessed on: 20/06/2021.

before more mainstream deployment.[269] These are a few illustrative examples which highlight the potential for location-enabled public services in the space of social protection.

Protection of Biodiversity and Landscape

The findings from the survey highlighted that protection of biodiversity and landscape[270] is the public service area in which location data and technologies are leveraged the second least frequently: **only 29% of local and regional governments are currently using location data and technologies to strengthen public services in this area.** However, an additional 30% of local and regional governments surveyed plan to within the next 2 years (see Figure 22). This signals a high rate of expected short-term growth in this space.

Figure 22. Use of Location Data and Technologies for Protection of Biodiversity and Landscape Services



Protection of biodiversity and landscape is a domain covered by the INSPIRE Directive, including several relevant data themes such as protected sites, bio-geographical regions, habitats and biotypes and species distribution, and sea regions. Knowing the geographical location of a species is important for many elements of biodiversity conservation and protection. As highlighted by an Interreg Europe Policy Brief, location data, earth observation data and spatial visualisation tools such as GIS "play a key role in ensuring efficient management of protected areas as they provide reliable information for decision making processes." The policy brief also notes that this is an area in which local and regional governments play a key role, including, supporting the implementation of the EU nature and biodiversity policy.[271]

There are several examples of location data and technologies being leveraged to provide location-enabled public services in this space, **including projects and initiatives that have been effectively undertaken at the regional level in collaboration with local governments**. A number of these projects have received funding through Interreg Europe through the European Regional Development Fund (ERDF). For example, the Regional Government of Catalonia has partnered with research institutions and local governments to undertake the SITXell project.[272] The SITXell project is a cartographic database and GIS which integrates scientific data on the ecological and socio-economic values of natural areas (geology, hydrology, botany, zoology, ecology, socio-economic, agronomy and town planning). The data is publicly accessible and can serve many purposes, but it has been specifically designed to support integrated land planning; that is, public bodies developing plans, from territorial organisation plans, master plans, town plans and management plans, using the same common multidisciplinary information. The Regional Government is responsible for updating land cover and habitat maps, data is then added based on partnerships with research organizations, NGOs/citizen science, and local governments. The tool has been used by more than 100 municipalities and has been reported to drive public values across each three categories of the public value framework: operational, through increased collaboration, political through openness, and social through environmental sustainability. Research by Interreg Europe concluded that this tool can be easily transferred and adapted to

[269] Wood, E., Ward, G, E., and Woolham, J. 'The development of safer walking technology: a review', *Journal of Assistive Technologies,* 2015, Vol. 9. 2. Pp 100-115. DOI:10.1108/JAT-07-2014-0017

[270] Protection of Biodiversity and Landscape is one of the categories of the COFOG – Eurostat (a) (see footnote 15). This category covers activities relating to the protection of fauna and flora species (including the reintroduction of fauna and flora species (including the reintroduction of extinct species and the recovery of species menaced by extinction), the protection of habitats (including the management of natural parks and reserves) and the protection of landscapes for their aesthetic values (including reshaping of damaged landscapes for the purpose of strengthening their aesthetic value and the rehabilitation of abandoned mines and quarry sites). Climate change mitigation objectives and policies, such as the policy initiatives set out in the European Green Deal, are in part covered by the category of 'pollution abatement.' It is also important to note that the COFOG classification does not cover these recently developed priorities.

[271] Interreg Europe (d), A Policy Brief from the Policy Learning Platform on Environment and Resource Efficiency: Use of technologies for better protection and management of nature and biodiversity, 2019. Accessed at: http://www.interregeurope.eu/fileadmin/user_upload/plp_uploads/policy_briefs/2019-02-28_TO6_policy_brief_on_natural_heritage_and_technologies.pdf Accessed on: 20/06/2021.

[272] ESRI Espana (b), Barcelona Provincial Council: SITxell Ecosystem Service. Accessed at: https://www.esri.es/es-es/descubre-los-gis/casos-de-exito/medio-ambiente/sitxell-servicios-ecosistemicos-caso-exito-infraestructura-verde Accessed on: 20/06/2021.

other regions.[273] There are several other examples of cartographic biodiversity databases and GIS platforms across the EU including the Seascape Charter Assessment conducted through a participatory approach in Donegal County Ireland[274] the Biodiversity Data Bank of the Generality of Valencia.[275]

As highlighted in the SITXell project, services related to the protection of biodiversity and landscape often involve stakeholders from research and academic institutions, NGOs, and, in some instances, citizen scientists. An important driver and outcome of several of the projects researched is the integration of data into a consolidated GIS platform to enable collaboration and open data to the ecosystem of governmental and non-governmental organizations who can leverage this to support their mission. Some applications have been developed specifically to enable citizens to capture and share crowdsourced data on biodiversity; for example, at a European-wide level, the Joint Research Centre developed an 'Invasive Alien Species Europe' app, which aims to collect information on (currently) 66 alien species of concern for the EU which can have a harmful effect on biodiversity and ecosystems. Users of the app have the option to use their phones' GPS system and camera to capture images of these species. Once checked for accuracy, this information is fed into the European Alien Species Information Network (EASIN, including a species mapper tool, to complement existing information.[276] These examples provide illustrative cases of the potential of location-enabled public services in this domain.

The volume of environmental knowledge generated by citizen science initiatives across the EU offers a unique opportunity to help deliver on the European Green Deal and other EU (and global) priorities, and to involve the public in EU policy making… Official monitoring alone could never give us (at reasonable costs) the number of observations and geographical and temporal coverage currently provided by thousands of volunteers – Best Practices in Citizen Science for Environmental Monitoring, 2020

Looking forward, research and innovation in this space is particularly focused on the use of EOD and AI to support environmental monitoring. The Copernicus Program includes a wide range of data that can be, and is being, leveraged for this purpose. The Program includes, among other services, a Marine Environment Monitoring Service (CMEMS)[277] which provides regular and systematic references information on the physical and biogeochemical state of the ocean and marine ecosystem for the global ocean and European seas, and a Land Monitoring Service (CLMS) which provides geographical information on land cover and its change, land us, vegetation state, and water cycle. [278] In the space of EOD and AI, as noted in Chapter 2 of the Report, "the availability of the growing volume of environmental data from space represents a unique opportunity for science and applications, it also poses a major challenge to achieve its full potential in terms of data exploitation." Once this barrier has been overcome, this will unlock potential for a myriad of location-enabled public services in this space.

4.5.2 Types of Public Service Innovation

Strategic Innovation

Connecting Big Location Data with Decision Making

There are myriad of examples of location data and technologies being leveraged to support strategic and operational decision making in local and regional governments across different domains. However, many projects still rely on more traditional data sources and there are gaps in digital literacy which limits the extent of public service innovation.[279] There are some interesting examples of projects that are **leveraging**

[273] Interreg Europe (b), Good practice: Use of Biodiversity data in decision making the SITxell Project. Accessed at: https://www.interregeurope.eu/policylearning/good-practices/item/679/use-of-biodiversity-data-in-decision-making-the-sitxell-project/ Accessed on: 20/06/2021.

[274] Interreg Europe (c), Good practice: Seascape Character Assessment. Accessed at: https://www.interregeurope.eu/policylearning/good-practices/item/821/seascape-character-assessment/ Accessed on: 20/06/2021.

[275] ESRI Espana (c), Biodiversity Data Bank, Accessed at: https://www.esri.es/es-es/descubre-los-gis/casos-de-exito/medio-ambiente/banco-de-datos-de-la-biodiversidad Accessed on: 20/06/2021.

[276] European Commission (q) EASIN – European Alien Species Information Network. Accessed at: https://easin.jrc.ec.europa.eu/easin Accessed on 20/08/2021. and Schade, S., Kotsev, A., Cardoso, A., 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. 2019. 78. 10.1016/j.compenvurbsys.2019.101384.

[277] European Union (l), Copernicus Marine Environment Monitoring Service. Accessed at: https://www.copernicus.eu/en/copernicus-services/marine Accessed on: 20/06/2021.

[278] European Union (m), Copernicus Land Monitoring Service. Accessed at: https://www.copernicus.eu/en/copernicus-services/land Accessed on: 20/06/2021.

[279] McAleer, Kogut P and Raes (see footnote 126).

immersive visualisation technologies to support more intuitive decision making and are bridging the gap between big data generation and big data application.[280] For example, as highlighted earlier in the report, as part of the Horizon 2020 *PoliVisu Project* carried out jointly in Ghent, Belgium, Plzen, Czech Republic, and Issy-les Molyneaux, France, interactive and customizable 3D maps and story-telling visualizations have been developed to support collaborative data driven policy making in the fields of smart mobility and urban planning. This project has concluded but is being taken forward through a complementary project – Digital Urban European Twins (DUET). Several digital twin projects being piloted or deployed are also creating innovations in this space, making data driven decision making more intuitive through more dynamic data visualization.

Another example is the H2020 funded project, *Extended Reality for Disaster Management and Media Planning* which is currently being implemented. The objective of the project is to enhance the situational awareness of those who are managing disasters, manmade crises or public events by using immersive technologies, such as VR, integrated with systems fed by live sensor data.[281] The use of more immersive data visualization to bring location data to life for decision makers is expected to remain an area of experimentation. This is supported by the findings of the survey which demonstrated that, **while only 13% of local and regional governments are currently using immersive technologies such as VR and AR in location-enabled public services projects, an additional 42% plan to use it within the next 2 years**.

Capacity Innovation

Remote Administration

There are increasing examples, and research and development, focused on utilising location-enabled technologies to undertake public service administration remotely. This includes the use of unmanned aerial vehicles to conduct activities such as building control inspections, development control inspections and environmental impact assessments and the use of satellite imagery to monitor environmental changes and agricultural practices. For example, as noted earlier in the report:

- In Scotland, a local authority contracted a local drone company to provide aerial inspection by Unmanned Aerial Vehicle (UAV) of over 600 council owned proprieties as part of a larger scale program to bring them into line with energy efficiency requirements. Leveraging this location-enabled technology meant that the inspections took weeks rather than years and also saved resources – an estimated cost saving of £4.5 million.[282]
- In South Tyrol, Italy, the AgriML Proof of Concept Project demonstrated the feasibility of using machine learning to detect the type of crops present in satellite images of cultivated fields. The project will allow the administration to disburse contributions for agriculture in a more efficient way to allow better management of provincial budget.[283]

These technologies have the potential to enable public administrations to undertake tasks such as asset management more efficiently and get more frequent data from the field. During the Covid-19 pandemic, there was an increasing drive for using location-enabled technologies for remote administration.

To enable more mainstream use of these technologies, there are barriers which need to be navigated. For the use of drones, governments need to establish a safe and enabling regulatory environment for their air spaces, there is a need to take privacy concerns into consideration, and for some applications there is a need to improve the precision of positioning and navigation technology. In the EU, research is being undertaken in this space including combining Galileo dual frequency navigation, 5G, IoT devices and drones for more precise remote asset management systems.[284] For the increases use of satellite imagery for remote and automated monitoring, additional research, development and tools are needed to scale the use of AI for interpreting high-frequency satellite data (See discussion in Chapter 2).

Service Innovation

Behavioural Change

[280] See: DUET (see footnote 130), LEAD (see footnote 213), PoliVisu (see foornote128).
[281] European Commission (r), Extended Reality for Disaster Management and Media Planning, 2020, Accessed at: https://cordis.europa.eu/project/id/952133 Accessed on: 15/06/2021.
[282] Government Business (see footnote 134).
[283] Informatica Alto Adige (see footnote 133).
[284] European Union Agency for the Space Program (see footnote 135).

Preliminary research and development are being undertaken to determine whether and how **location data and technology can be leveraged to promote and nudge behavioural change**. For example, Belfast City Council, in Northern Ireland, is piloting a mobile phone application that incentivises users to spend time in local parks. The Civic Dollars app will track users' location using mobile phone positioning technology and provide a reward for each half an hour spent in local parks. The 'dollars' will be a local digital currency that can be spent on transport passes, tickets to local attractions or can be donated to community groups in the city. As well as encouraging healthy behaviours on an individual level, the location data collected will be used by the city government to better understand how people use green spaces for planning and operational purposes and will also provide a promotion platform for local businesses, services and events.[285]

This example is part of a broader trend in the public sector to try and leverage technology to promote behavioural change. For example, the Government in the UK is planning a £5 million trial of apps that reward healthy behaviours, particularly focused on harder to reach groups that experience higher rates of obesity.[286]

> *A government becomes more user-driven by awarding a central role to people's needs and convenience in the shaping of processes, services and policies; and by adopting inclusive mechanisms for this to happen – The OECD Digital Government Policy Framework, 2020*

While these examples are both linked to public health, there are opportunities to extend these types of applications to other public service areas and to support other objectives, for example, encouraging and incentivizing more environmentally sustainable behaviours. There is an opportunity for further research and development in this space. The main barrier to overcome to enable these applications to be scaled up will most likely be related to public trust and data privacy.

Citizen Participation in the Design, Operation and Co-delivery of Public Services

There is also some interesting research and development **using location data and technology to enable citizen engagement and co-creation of public service design, operation and co-delivery**. For some time, local and regional governments have experimented with crowdsourcing information to improve the design and operation of public services. For example, as noted earlier in the report, local and regional governments used platforms and applications to report non-emergency and emergency issues from fly tipping to forest fires through map-based websites and applications. [287] However, research conducted by Barcevičius and others (2020). has highlighted that there are opportunities to create higher impact through these initiatives, such as building a greater level of trust, by ensuring a feedback loop with citizens once they have reported an issue. [288] Location technologies could be leveraged for this purpose, i.e., enabling the public sector to provide updates based on the geo-tagged citizen report.

There are also examples of local and regional governments using in-direct crowdsourced data from online platforms, such as social media, online reviews etc. to gain place-based insights and inform the design and delivery of public services. Some innovative examples of using sentiment analysis for public health services emerged during the Covid-19 pandemic. For example, a selection of cities across the US used sentiment analysis software for a variety of objectives including tracking place-based public opinion on restrictions, adjustments to public services such as waste collection, and the spread of misinformation related to Covid-19 vaccines.[289] The use of direct and indirect crowdsourced information, and indeed a combination, to improve service design and operation across multiple public service areas is an area where there is further untapped potential.[290]

[285] Public Technology, Belfast trials app-based rewards for visiting park, 2021. Accessed at: https://www.publictechnology.net/articles/news/belfast-trials-app-based-rewards-visiting-park-0?utm_medium=email&utm_campaign=Daily%20email%204th%20of%20June&utm_content=Daily%20email%204th%20of%20June+CID_c3c3cca84213447e60d431e4ebde8da0&utm_source=Email%20newsletters&utm_term=Belfast%20trials%20app-based%20rewards%20for%20visiting%20park Accessed on: 10/06/2021.

[286] Trendall, S, Government plans £5m trial of apps that reward healthy behaviour, 2021, accessed at: https://www.publictechnology.net/articles/news/government-plans-%C2%A35m-trial-apps-reward-healthy-behaviour accessed on: 10/06/2021.

[287] Fix my Street (see footnote 142).

[288] Barcevičius, Cibaitė, Codagnone, Gineikytė, Klimavičiūtė, Liva, Matulevič, Misuraca and Vanini (see footnote 6).

[289] Zencity, Case Studies. Accessed at: https://zencity.io/case-studies/ Accessed on:15/06/2021

[290] Analysis from desk research and insights from interview with Ben Hawes, Associated Director of the Connected Places Catapult, UK and Engagement Director at the Benchmark Initiative, Geovation.

Preliminary pilots and prototypes are also emerging where location data and technology are being used to enable the co-delivery of public services. For example, in the city of Heerlen, in the Netherlands, the local government is piloting an application, 'Heerlens Heitje' through the European Regional Development Fund Urban Innovative Action (UIA) fund. Through the application, citizens are being rewarded for undertaking public space maintenance tasks such as removing stickers from trash cans or weeding public gardens. The tasks that are included on the app are those that the government does not currently have sufficient funds to procure on a regular basis; it is not intended to replace existing jobs of government employed maintenance workers and contractors. Citizens are paid in a local digital currency which they can use in Heerlen to help stimulate the local economy – See Figure 23 for more information. Currently, while still in the development stage, the tasks are linked to addresses and GPS coordinates with photographs, but the next step will be to integrate an embedded map. The project is still in the early stages of piloting; therefore, it is too early to assess the impact and public value gained.[291]

Another example of engaging citizens in public service delivery, albeit at the national level, is the UK National Health Service's Volunteer Responder's Application run in partnership with the Royal Voluntary Service highlighted earlier in the report. A platform was rapidly developed, using existing real-time location-based technology, which enables project coordinators to remotely assign tasks to citizen volunteers in the field depending on need and prioritisation. 750,000 have volunteered to participate in the scheme to date and are undertaking 'micro-volunteering opportunities' such as stewarding at vaccination centres and by making phone calls to people who have been shielding.[292] The program is evolving in line with changing needs, for example, Covid-19 spikes, winter flu season etc. and, nearly 60% of healthcare workers surveyed would like to continue the Program year-round.[293] Preliminary outcomes identified through survey research included a variety of social public value including for the patients, nearly 85% of whom reported their basic needs were met and that the service was very important to them,[294] and for the volunteers, who reported improvements to their wellbeing and community spirit.[295] **There are opportunities to extend research and development of citizen participation in location-enabled public service delivery across multiple public service areas.**

Figure 23. City of Heerlen: Heerlens Heitje – a Crowdtasking Platform for Governments

The City of Heerlen, a former mining centre in the Southeast of the Netherlands, is struggling with four main inter-related challenges:

- Economic decline following the closure of mining sites and shop closures driven by the rise in e-commerce;
- Population decline, to the extent that housing is being demolished leaving additional public spaces that need to be maintained;
- Low civil engagement and social capital, including a lack of community engagement and pride of place; and,
- A lack of government funds to maintain public spaces.

In response to these challenges, in 2021, the city council started piloting a mobile and web application, Heerlens Heitje, derived from the Dutch for 'bob-a-job'. The application enables citizens to be rewarded for undertaking maintenance tasks such as painting a bench, removing stickers and weeding flower beds. The users are then paid in local digital currency which can only be used in the local economy. The application is focusing on jobs which the council currently cannot afford to contract regularly, therefore, it is intended to provide an additional means of flexible income, and not to replace the contracts of existing maintenance

[291] Interview with Senior Project Leader for Digital Innovation - Gemeente Heerlen; UIA, Heerlen Digital transition; WESH – We-Service. Heerlen. Accessed at: https://uia-initiative.eu/en/uia-cities/heerlen Accessed on: 10/06/2021

[292] Royal Voluntary Service (a), NHS Volunteer Responders, Accessed at: https://www.goodsamapp.org/NHSvolunteerresponders?_ckplc=y&_ga=2.91201177.2036620802.1622624035-417951280.1622624035 Accessed on: 14/06/2021.

[293] Royal Voluntary Service (b), Findings from Those Referring into the NHS Volunteer Responder Programme During Covid-1, Working Paper Three, 2021. Accessed at: https://www.royalvoluntaryservice.org.uk/Uploads/Documents/About%20us/NHSVR_Working_Paper_Three_Referrer_Findings.pdf Accessed on: 14/06/2021.

[294] Royal Voluntary Service (c), Findings: Patients Supported by the NHS Volunteer Responder Programme during Covid-19 – April to August 2020: Working Paper One, 2020, Accessed at: https://www.royalvoluntaryservice.org.uk/Uploads/Documents/Our%20impact/NHSVR_working_paper_one_patient_findings.pdf Accessed on: 14/06/2021.

[295] Royal Voluntary Service (d), Findings from Volunteers Participating in the NHS Volunteer Responder (NHSVR) Programme During Covid-19 – April to August 2020: Working Paper Two, 2020, Accessed at: https://www.royalvoluntaryservice.org.uk/Uploads/Documents/About%20us/Working_Paper_Two_Patient_Findings_271120.pdf Accessed on: Accessed on: 14/06/2021.

workers hired by the council. Further, there is a maximum of 1,500 euros earnings to avoid oppression of the employment market.

Currently, while still in the development stage, the tasks are linked to addresses and GPS coordinates with photographs, but the next step will be to integrate an embedded map. The project is still in the early stages of piloting; therefore, it is too early to assess the impact and public value gained.

The project is being conducted by the Municipality of Heerlen in partnership with CoTown (SME), Statistics Netherland (national public authority), Brightlands Smart Services Campus, the City Centre Organization Heerlen Mijn Stad (NGO), Buurtoganisatie GMS (NGO) and the Association of Netherlands Municipalities Realisation (sectoral agency). The project is being conducted through the European Regional Development Fund's Urban Innovative Actions (UIA).

Source: Interview with Senior Project Leader for Digital Innovation - Gemeente Heerlen and UIA 2021, WESH – We.Service.Herleen.

Pro-active Public Service Delivery

"A proactive government pre-empts requests from citizens, instead providing answers or solutions to their needs through the adoption of push vs pull delivery models (Linders, Liao and Wang, 2018) that limit to the minimum the burdens and frictions interacting with public sectors organisations." – The OECD Digital Government Policy Framework, 2020

There are opportunities to further leverage location data and technologies to enable proactive public services.[296] For example, the Flemish Agency for Innovation & Entrepreneurship has developed a Hindrance Premium tool in Flanders. The Hindrance Premium is a financial subsidy for small enterprises who face serious hindrance from roadworks. Enterprises automatically receive a letter if they qualify for the premium. This tool has been developed using data on public works and road register integrated with the enterprise register, including address information.[297] This is an illustrative example using more traditional static data sets. Through the desk research, limited comparable examples were identified and no examples leveraging advances in location data and technology. This is consistent with the insights provided through an interview with Prof. Janssen (see quote below).

"The area where I see innovation taking place is in proactive services that empower and connect people to services where they are eligible without having to look for them. This is an area which is emerging, there are not many examples being implemented at scale" – Prof. Marijn Jansen, Professor of ICT & Governance and Head of the ICT Section of the Faculty of Technology, Policy and Management, Delft University of Technology (State of the Art Report Interview).

This is an area that has several potential applications across public service areas. For example, as highlighted earlier in the report, there is a project being undertaken by the Flemish regional government to create a solar potential map of more than 2.5 million Flemish rooftops using remote sensing technology, a digital topographical reference map and meteorological data. The service is pro-active in as much as citizens can type in their address and see whether their roof is ideal, usable or limited for solar and calculate the cost price and repayment time. However, this type of program could be made more pro-active by automatically notifying citizens of the suitability of their property, without having to seek out this information, and be informed of their eligibility for related government programs such as energy efficiency loans and subsidies (see Chapter 4.2.4).[298] There is an opportunity for additional research and development in this area.

[296] OECD (b) (see footnote 113).
[297] Barbero, Lopez Potes, Vancauwenberghe and Vandenbroucke (see footnote 32).
[298] Vito, Solar Potential on Flemish Rooftops. Accessed at: https://vito.be/en/solar-potential-flemish-rooftops Accessed on: 15/06/21

5. Key Findings and Conclusions

5.1 Key Findings

By combining the results emerging from the three streams of the study, namely the desk research, interviews and survey, the following main findings have been identified. The preliminary findings provide a basis for subsequent Lot 1 Project tasks and highlight potential areas for future in-depth research.

5.1.1 Trends in Location Data and Technology

There has been an increase in the generation of static and dynamic location data

Over the last decade, there has been a significant increase in the volume and variety of location data produced. [299] As well as an increase in the availability of more traditional static data sets, including those covered by the INSPIRE Directive, there has been a rise in dynamic location data sources such as IoT data, MPD, user-generated data and high-frequency EOD. These dynamic data sets, sometimes referred to as big geodata,[300] are being leveraged to enrich more traditional static data sets. As demonstrated in Chapter 4 of the report, data-driven insights gained from these 'upper layers' of data can be very valuable for gaining location intelligence and supporting public service innovation. This study identified barriers which limit the use of dynamic data, including a high proportion of privately owned data, the human and technical capacity needed to process and analyse 'big geodata', data privacy and ethics considerations, evolving interoperability challenges and legal and regulatory requirements. These barriers have been explored throughout the report and will be further elaborated in subsequent key findings.

Increasingly, high value dynamic location data sets are owned by the private sector

Increasingly, valuable location data is generated and owned by the private sector – this applies to both static and dynamic location data but particularly to the latter category. [301] This is "challenging the role of the public sector as the main producer and owner of geospatial content"[302] and can create barriers for local and regional governments to access this data. For example, both in the literature, and according to interviews, the primary barrier identified for the usage of MPD in public sector projects is gaining access to this data from MNOs.[303] Currently, there are limited incentives or obligations for private sector companies to share data with the public sector; further, they also need to navigate the regulatory environment for sharing potentially personal data – e.g., compliance with GDPR – as well as be responsive to public opinion.[304]

In Chapter 4 of the report, examples were given of local and regional governments experimenting in this space, for example, transport authorities only providing licensing to shared micro-mobility providers that share real-time data. The survey also demonstrated progress in this area, nearly 30% of local and regional governments reported that they have included data sharing obligations in contracts with service providers. However, the desk research findings highlighted that B2G data sharing arrangements are still largely isolated and short-term collaborations.[305] Further exploration is needed into best practices and lessons learned in this space as well as the policy and regulatory levers that can be applied to incentivize B2G location data sharing. This fits into the broader EU dialogue about B2G business sharing, but also has distinct characteristics in that a significant proportion of dynamic location data is generated from citizens (e.g., MPD, data from CAVS) and, depending on its use, can also be defined as sensitive data under the GDPR. Going forward, forthcoming data spaces and the Data Governance Act could be important enablers in this space.

In some cases, the boundary between official and unofficial data is blurring

Reliable, high quality and up-to-date static location data are foundational for many location-enabled public services whether the location data is used in isolation or is augmented with dynamic location data. Several local and regional governments are experimenting with crowdsourcing methodologies to enrich their location

[299] Kotsev, Minghini, Tomas, Cetl and Lutz (see footnote 8).

[300] Pei, T., Song, C., Shu, H. Liu, Y., Du, Y., Ma, T., Zhou, C. 'Big geodata mining: Objective, connotations and research issues', *Journal of Geographic Sciences*, Volume 20, 2020, pp 251-266.

[301] Kotsev, A., Minghini, M., Tomas, R., Cetl, V. and Lutz, M., From Spatial Data Infrastructures to Data Spaces: A Technological Perspective on the Evolution of European SDIs, ISPRS *INTERNATIONAL JOURNAL OF GEO-INFORMATION*, ISSN 2220-9964, 2020, Vol. 9 No. 3, p. 176, JRC120143 and Schade S. and others (2020) Geospatial Information Infrastructures. In: Guo H., Goodchild M.F., Annoni A. (eds) Manual of Digital Earth. Springer, Singapore. https://doi.org/10.1007/978-981-32-9915-3_5

[302] Kotsev, Minghini, Tomas, Cetl and Lutz (see footnote 8).

[303] Kalvet, Olesk and Raun (see footnote 127).

[304] Interview with Veiko Lember, PhD, Senior Research Follow Ragnar Nurkse Department of Innovation and Governance, Tallinn University of Technology and Visiting Professor at the Public Governance Institute, KU Leuven and the Erki Saluveer, the CEO of Positium a company that specializes in MPD statistics.

[305] European Commission (c) (see footnote 10).

data sets. However, many public authorities are still cautious about integrating crowdsourced data with authoritative data. A future trend identified in the desk research is the potential use of private data sets, such as address data from utilities companies, post offices or mobile network operators, to augment authoritative government location datasets such as address and population registries. To scale this, several open questions like data privacy, the incentives to share this data and data quality need to be addressed.

Going forward, additional focus is likely to be given on the legitimacy of using location data for a certain public service. For example, research is being undertaken in Estonia to determine whether address data is required to administer taxes. While this research project is mainly driven by challenges in maintain an up-to-date address register, this research is also aligned well with the principles of the GDPR, that is, first, a public administration, or data controller, should ask (i) what location data is required and necessary to deliver a certain service, and (ii) where does location data add desirable public value.

Advances in positioning and earth observation technologies have been a key driver of public service innovation

Advances in positioning technologies have been a key driver in strengthening existing public services and enabling new ones, such as ride-hailing, epidemiological contact tracing and non-emergency citizen reporting platforms. Technological developments in positioning technology are expected to continue to advance rapidly. Innovations and trends in this space include the increasing accuracy of GNSS (including Galileo's High Accuracy Service), indoor positioning and underwater positioning. These developments will provide new opportunities for public service innovations, for example, autonomous driving, indoor wayfinding, and oceanic monitoring, respectively.

Earth observation technologies, including satellite, aerial and terrain mapping, have seen and are expected to continue to see innovations and improvements in coverage, resolution, revisit rates and cost-effectiveness.[306] The use of high-frequency OD data to enable public service innovation, in conjunction with location data, has increased in several public service areas, particularly environmental monitoring; however, the majority of the use cases reviewed in this study were still in pilot phase and have not yet matured or scaled. It is expected that the use of high-frequency EOD in local and regional governments will increase significantly in the short-medium term, driven in part by advances in computational capacity and GeoAI.

The potential of GeoAI to drive public service innovation is starting to be demonstrated but projects are generally in early stages of maturity

Across each of the three public service area 'deep 'dives' conducted as part of this study, the use of GeoAI was identified as an emerging and high potential trend. While there are state of the art examples of public service innovations leveraging GeoAI at the local and regional level, these examples are in the minority and generally in a developmental stage. As demonstrated by the survey, only 14% of local and regional governments are currently using AI and ML in projects aimed at strengthening public services through location data and technology; however, an additional 30% plan to use it within the next 2 years - this signals an almost 2-fold increase. Innovation is occurring particularly in the space of automatic processing and interpretation of data, including image recognition and classification of EOD and IoT data.[307] The main barriers to the uptake of GeoAI, particularly in the public sector, are linked to digital skills and capacity, algorithm confidence, data ownership, ethics and processing power.[308] GeoAI is an area that would benefit from additional research, focusing on the new capabilities and public service innovations that GeoAI can enable at the local and regional level as well as the potential risks that need to be navigated.

Advances in data visualization are changing the ways in which people interact with location data and are bridging the gap between the digital and physical environment

Advances in 3D modelling and immersive technologies such as VR and AR are transforming the ways in which users can interact with location information by merging real world location data with computer-generated virtual layers. Governments, particularly city governments, are increasingly investing in 3D city models as an essential component of their SDI. [309]The survey demonstrated that, while only 13% of local and regional governments are currently using immersive technologies in location-enabled public services projects, an additional 42% plan to use it within the next 2 years. This is one of the highest projected increases in uptake of emerging technologies across these projects.

[306] United Nations Committee of Experts on Global Geospatial Information Management (see footnote 55).

[307] Analysis from the review of EC and regional and local government projects as part of the desk research as well as findings from interviews with experts.

[308] Fatima, Desouza, Dawson and Denforc (see footnote 104).

[311] Prandi, F., Devigili, F., M., Soave, M. Staso, U, D., De Amicis, R. (see footnote 105).

As highlighted in Chapter 4, there are innovative examples of immersive technologies being used by local and regional governments *internally* to make location data and analytics more understandable and to connect data to decision and policy making processes as well as *externally* to share information with the public in a more dynamic way and support the greater participation of citizens in the co-creation of public services. In terms of future innovations, digital twin technology has gained significant traction in recent years. Pilots and models are being built across multiple scales from single facilities to whole cities with the objective of providing richer decision support capabilities for both planning, operational and citizen engagement processes.

5.1.2 Impact of Location-enabled Public Services

Location data and technology are being used to strengthen public service across all public service areas

Location data and technologies are being used across all public service areas in local and regional governments.[310] This reflects the fact that a large percentage of data collected by the public sector has a location component. For example, in the United Kingdom it is estimated that address data underpins 80% of all local government data.[311] It also reflects that location data plays an important role in data integration, allowing data-driven decisions based on where and why things happen across all public service areas. [312] The public services areas in which location data are most frequently being leveraged include: (i) transportation (ii) tourism (iii) general public services, (iv) housing and community amenities and (v) agriculture, forestry, fishing and hunting. Looking ahead, the significance of location data and technologies for public service innovation is expected to increase in the future. 96% of local and regional governments, and their subsidiaries, expect that location data and technologies will be used significantly more than they are today.[313]

Location data and technology are being leveraged to drive public service innovation through strategy, capacity and operations

Location data and technologies are being used in myriad ways across each of the three dimensions of public service innovation identified by Chen et al: strategy, capacity and operations.

Strategy – The importance of location data for policy and strategy planning, implementation and evaluation has increased significantly. In part, this is being driven by the unprecedented generation of open and big geodata and the availability of geospatial analytical tools. However, it is important to note that many projects still do not leverage dynamic location data sets to unlock additional value. This is not to say that these are required to create value in every project, more traditional data sets may be sufficient to meet the project objectives.

Capacity – Location data and technologies are being leveraged to create additional capacity within public sector institutions, particularly by providing public administrators with additional information and expertise to conduct their functions more effectively and efficiently. Several examples highlight that certain functions can now be conducted remotely due to the application of location data and technologies, e.g., remote planning inspections and agricultural monitoring. It is expected that advanced analytics will be increasingly leveraged to automate the processing and analysis of location data to gain additional insights and reduce repetitive tasks for public administrators.

Operations – Location data and technologies are being utilised to strengthen existing public services and launch new public services. These innovations are both internally facing and externally facing to citizens and businesses.

There is limited empirical evidence available on the impact of location-enabled public services, including the public value generated

The results of the survey show that across almost all public service areas, the most frequently generated public value is related to operational improvements, particularly efficiency gains. This is consistent with research conducted on digital government transformations more broadly, where, efficiency, productivity gains and cost savings have been identified as the main drivers and documented outcomes of introducing digital innovations.[314]

However, it is important to note that the public value gained from these projects are not always systematically measured or well documented. This means that the public value reported may reflect expected

Following the Classification of the Functions of Government (COFOG): Eurostat (a) (see footnote 15).

[311] Symons (see footnote 108).

[312] European Commission (a) (see footnote 1).

[313] Findings from the State of the Art Report survey.

[314] Barcevičius, Cibaitė, Codagnone, Gineikytė, Klimavičiūtė, Liva, Matulevič, Misuraca and Vanini (see footnote 6).

values, rather than values supported by empirical evidence. This is consistent with the findings of the desk research: several of the projects and papers reviewed highlighted expected outcomes and provided little empirical evidence. Research conducted by Barcevičius and others (2020) on the outcomes of digital transformation in the EU more broadly came to the same conclusion. The research also highlighted that "quite often the literature presents the introduction of an innovative service as a positive and valuable development by itself."[315]

The study found that there is particularly low measurement of the political and social outcomes of these projects. This is, in part, demonstrated by the fact that only 27% of local and regional governments, and their subsidiaries, use statistical quality of regional/city life KPIs (e.g., commuting time decrease, reduction in crime rates) to evaluate the impact of location-enabled public services. In this context, it is important to note that a conceptual framework for assessing the public value created by location-enabled public services does not currently exist within the literature or policy toolkits. Filling this conceptual gap will be the focus of Lot 1 Task 3.

Interoperability challenges remain an ongoing barrier and are evolving in line with the location data landscape

Technical, semantic legal, organizational and cultural interoperability was identified as ongoing barriers for replicating and scaling location-enabled public services both within and across borders.[316] Local and regional governments identified lack of interoperability as one of the main challenges experienced when investing in and implementing projects using location data and technology to improve public services.[317] It was not possible to systematically assess the 'interoperability maturity' of location-enabled public services and initiatives through the desk research – for example using the European Commission Interoperability Maturity Assessment of Public Service (IMAPS) framework – as this level of information is not readily available. This more detailed research will be conducted in subsequent stages of the broader Project. However, preliminary findings from the desk research indicated that interoperability challenges are dynamic and evolving in line with trends in location data and technology outlined in Chapter 2 of the report.

Local and regional governments experience challenges in maintaining high quality and up-to-date location data

Through the interviews and desk research, the capacity of governments, particularly local and regional governments, to maintain up-to-date high-quality location data was identified as a persistent challenge driven by a lack of available resources, digital skills, and incentives. This includes data themes covered by the INSPIRE Directive. For this reason, in many member states, national governments play a key role in partnering and coordinating with local and regional governments to support the creation and maintenance of location data. The research indicated that maintaining up-to-date location data is particularly challenging when there is not a national agency that plays an active role in coordinating sub-national location data collection, including maintaining a central data set, establishing workflows and reporting, and, in some instances, providing funding to local and regional governments. Additional capacity needs to be built to maintain SDIs and enable effective digital transformation.

Location-enabled public services need to balance the potential public value to be gained with the privacy risks and ethics for groups and individuals

The use of location data for strengthening public services, and the potential public value that can be generated, needs to be balanced with the privacy risks and ethics for individuals and groups. In the implementation of location-enabled public services, privacy must be considered from the perspective of public opinion, potential risks to citizens, and the regulatory environment (including GDPR). These three spheres are intimately connected and the first two play a crucial role in influencing and driving the latter.[318] Some examples of local and regional governments who have got this right, through 'privacy by design principles', as well as examples of those who have got this wrong have been highlighted throughout the report. These examples provide valuable lessons learned. In the regulatory sphere, the report found that greater clarity is needed on the implementation of GDPR to location data. Some instances were identified where there has

[315] Ibid.

[316] European Commission (n) (see footnote 243).

[317] Ibid.

[318] Interview with Veiko Lember, PhD, Senior Research Follow Ragnar Nurkse Department of Innovation and Governance, Tallinn University of Technology and Visiting Professor at the Public Governance Institute, KU Leuven and the Erki Saluveer, the CEO of Positium a company that specializes in MPD statistics.

been uneven and changing interpretation and application of GDPR to more dynamic location data sources such as MPD.[319]

5.1.3 Underexplored Areas

The two policy areas in which location data and technology are being used the least to strengthen public services are social protection and protection of landscape and biodiversity.

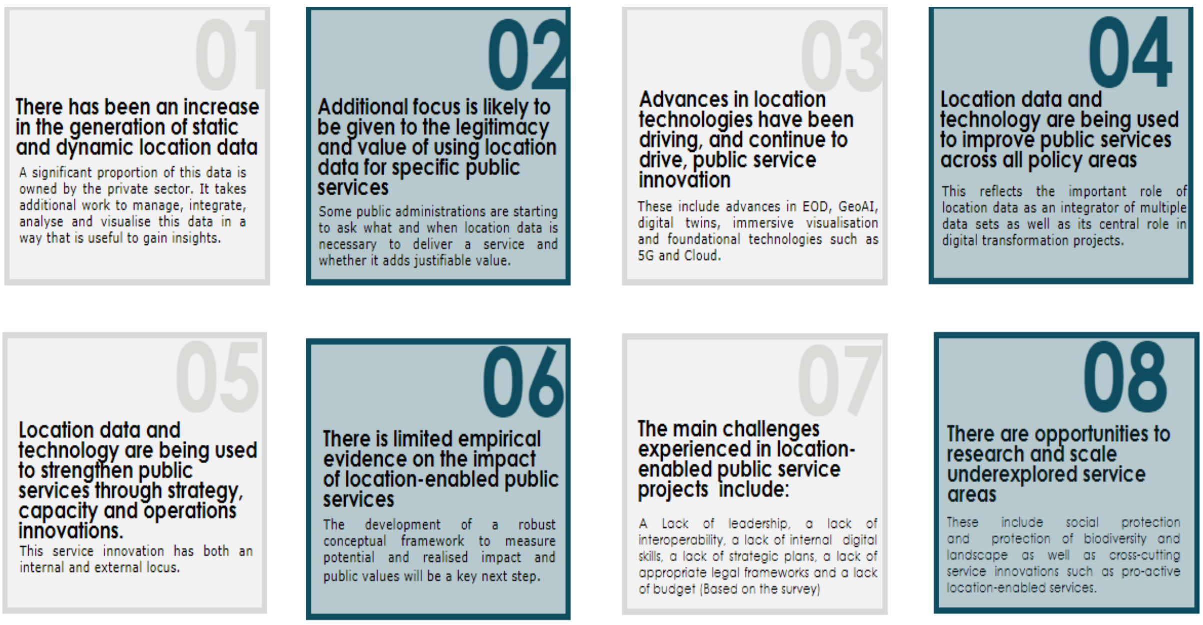
However, over the next two years, there is a high level of expected growth in both these areas. For social protection, just over 40% of local and regional governments surveyed plan to use location data and technology in this area within the next 2 years and for protection of landscape and biodiversity, 30%. The report highlighted examples of local and regional governments effectively applying location data and technologies to improve existing and create new public service areas. Both these areas would benefit from additional research and development focusing on the use cases with the highest potential impact as well as the potential barriers for uptake and replication.

Cross-cutting trends were also identified of emerging types of public service innovations that can be enabled by location data and technology

Throughout the state of the art research, examples were identified of types of public service innovation that are starting to be applied but have not yet scaled to their full potential. These span different types of public service innovation- strategic, capacity and operational (Chen and others (2020)) – and are applicable across several policy areas. These included leveraging location data and technology to:

- Connect big (location) data with decision making through more immersive data visualization;
- Enable remote service administration, for example, using drones for building and planning inspections and automated environmental and agricultural monitoring;
- Nudge behavioural changes such as increasing physical activity; and,
- Facilitate citizen participation in public service design, operation and co-delivery.

Figure 24. Overview of Main Findings



Source, State of the Art Report, 2021
Note: This summary is intended to provide an overview and does not include all findings from the report.

[319] Kalvet, Olesk and Raun (see footnote 127).

5.2 Conclusions

The key findings of this State of the Art Report uncovered multiple opportunities advance knowledge and applicability of location data and technology to drive public service innovation:

- **Given the increasing importance of dynamic data sets owned by the private sector, it is important to investigate, test and scale governance models for business to government location data sharing.** Some European local and regional governments have been experimenting with different incentives and mandatory B2G data sharing models for location data. For example, the cities which have predicated issuing licenses to micro-mobility operators based on a data-sharing agreements. Others are working to build data exchanges. The lessons learned from these practices should be documented and shared across member states to develop standard policies and principles to harmonize licenses for data use, integration and publication. The variety of stakeholders involved in generating, sharing and using location data would benefit from a common framework to map the location data ecosystem to facilitate discussions about data access, sharing and monetization and can feed into the establishment of data sharing priorities.

- **The increased granularity of location data and the data protection concerns arising from it should be analysed and transparently discussed with all stakeholders, including citizens.** Global best practices on the ethical and responsible use of location data should be considered; for example, the Locus Charter, led by the American Geographical Society, provides a proposed set of common international principles to support ethical and responsible practice when using location data. Striking the right balance could also help overcome resistance in B2G data sharing for instance for MNOs that are concerned about public opinion and public trust. A consistent application of GDPR to location data across member states and local and regional governments should also be promoted. Some instances were identified where there has been uneven and changing interpretation and application of GDPR to more dynamic location data sources such as MPD. For example, in one member state, there was a ruling that mobile operators are no longer allowed to provide data to analyse mobility and tourism patterns based on the national data protection agency's interpretation of privacy regulations.320 At the time of writing this report, this challenge has been resolved; however, it exemplifies the need for consistent application.

- **To address location data technical, legal, organizational and semantic interoperability the European Commission and member states should collaborate to define how Spatial Data Infrastructures should evolve.** The implementation deadline for the INSPIRE Directive this year (2021) provides the opportune moment to evaluate the effectiveness and potential gaps in the INSPIRE Directive; including how to integrate SDIs with other high value data sets such as earth observation data, health data and mobility data and data platforms that have/are being created for other data domains and sectors. For example, under the European Commission Horizon 2020, the *Open DEI Project* is focusing on the implementation of the next generation of digital platforms across four industrial domains: manufacturing, agriculture, energy and health care.

- **It is necessary to nurture the geospatial capacity of local and regional governments to enable successful digital transformation**. Local and Regional Governments must have the budget, expertise and mandate to maintain high quality and up-to date location data. Improving their capacity will be particularly important if SDIs evolve to reflect the current location data landscape, that is, integrating dynamic location data and private sector location data.

- **From a technological innovation standpoint, research should be incentivized to further explore the potential of location technologies such as GeoAI for public service innovation, starting with using these new tools to augment the quality of location data across public, private and crowdsourced data sets.** This research should focus on the potential types of public service innovation, the potential applications, and public value that can be generated as well as the potential risks. Research should draw upon principles such as Explainable AI - this refers to creating projects and services that

[320] Kalvet, Olesk and Raun (see footnote 127).

allow humans to take decisions alongside AI or adapt if something goes wrong. This research should include broad stakeholder engagement.

The technological, legal and organizational developments listed above should be investigated not only for public service areas where location data and technology are already making an impact, such as transport and tourism, but also by taking into account the emerging need for location data and technology in the underexplored areas analysed in this report.

5.3 Next Steps

The State of the Art Report has presented preliminary findings and recommendations and identified potential areas for future in-depth research. The analysis undertaken and presented in this report will provide the basis for the development of subsequent Lot 1 tasks and deliverables, including:

(i) Task 3: the creation of a conceptual model to critically assess in a consistent and scientific manner the current and potential impacts of location data and technology on public value creation through public services at the local and regional level

(ii) Task 4: the development of detailed case studies to test the validity of the conceptual framework and to assess the replicability and scalability of the cases

(iii) Task 5: consultation with citizens who are users and potential users of the case studies developed in Task 4 to directly measure attitudes, expectations and user satisfaction. This Task will also include consultation with a panel of multi-disciplinary experts to validate all the deliverables produced under Lot 1.

(iv) Task 6: the final report, including a summary of the project and a set of key recommendations and guidelines on the innovative use of location data and technology, as well as a visualization tool making available information on all the gathered case studies in an interactive platform.

References

AA, European Low Emission Zones. Accessed at: https://www.theaa.com/european-breakdown-cover/driving-in-europe/european-low-emission-zones#:~:text=LEZ%20rules%20could%20mean%20access,or%20charged%20an%20access%20fee Accessed on: 10/06/2021.

Ackerman, D. (2020) An Underwater Navigation System Powered by Sound, MIT News. Accessed at: https://news.mit.edu/2020/underwater-gps-navigation-1102 Accessed on: 09/06/2021.

Ajuntament De Valencia, COVID19 Valencia. Accessed at: http://smartcity.valencia.es/vlci/covid19-information-website-for-citizens/ Accessed on: 10/06/2021.

Ancin-Murguzur, F, J., Munoz, L., Monz, C., Hausner, V, H. 'Donres as a tool to monitor human impacts and vegetation changes in parks and protected areas', *Remote Sensing in Ecology and Conservation,* ZSL, 2019, Vol. 6, (1), p105-113. https://doi.org/10.1002/rse2.127

Barcevičius, E., Cibaitė, G., Codagnone, C., Gineikytė, V., Klimavičiūtė, L., Liva, G., Matulevič, L., Misuraca, G., Vanini, I., Editor: Misuraca, G., Exploring Digital Government transformation in the EU - Analysis of the state of the art and review of literature, EUR 29987 EN, Publications Office of the European Union, Luxembourg, 2019, ISBN 978-92-76-13299-8, doi:10.2760/17207, JRC118857.

Barbero, M., Lopez Potes, M., Vancauwenberghe, G. and Vandenbroucke, D., *The role of Spatial Data Infrastructures in the Digital Government Transformation of Public Administrations*, Publications Office of the European Union, Luxembourg, 2019, ISBN 978-92-76-09679-5doi:10.2760/324167, JRC117724.

Basiri, A., Lohan, E, S., Moore, T., Winstanley, A., Peltola, P., Hill, C., Amirian, P., Figueiredo e Silva, P.

'Indoor location based services challenges, requirements and usability of current solutions', *Computer Science Review*, 2017, Vol. 24, pp 1-12.

Bekkers, V. (2007a). Modernization, public innovation and information and communication Technologies: The emperor's new clothes? Information Polity. 12:103–107 in Vandenbroucke, D, Vancauwenberghe, G, Boguslawski, R, Pignatelli, F. Design of location-enabled e-government services, EUR 30220 EN, Publications Office of the European Union, Luxembourg, 2020, ISBN 978-92-76-18939-8, doi:10.2760/860082, JRC119730.

Boguslawski, R., Valayer, C., Van Agansen, K., Keogh, D., Pignatelli, F. *European Union Location Framework Blueprint*, EUR 30374 EN, Luxembourg: Publications Office of the European Union, 2020, ISBN 978-92-76-22068-8, doi:10.2760/096595, JRC117551.

Cabinet Office, An Initial Analysis of the Potential Geospatial Economic Opportunity, UK, 2018. Accessed at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/733864/Initial_Analysis_of_the_Potential_Geospatial_Economic_Opportunity.pdf Accessed on: 23/05/2021.

Cetl, V., Nunes De Lima, M., Tomas, R., Lutz, M., D`Eugenio, J., Nagy, A. and Robbrecht, J., *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.

Chen, J. Walker, R, M., Sawhney, M. 'Public Service Innovation: a typology', *Public Management Review*, Vol 22, No 11, 2020, pp. 1674-1695.

Christiansen, P. The effects of transportation priority congruence for political legitimacy. Transportation Research Part A Policy and Practice. 2019. 132. 61-76. 10.1016/j.tra.2019.11.005.

Chu, P-Y & Tseng, H-L. (2018). Open Data in Support of E-governance Evaluation: A Public Value Framework. ICEGOV '18: Proceedings of the 11th International Conference on Theory and Practice of Electronic Governance. 338-343. 10.1145/3209415.3209433.

CityGo, Transportation Planner and Intelligent Mobility Solution. Accessed at: http://www.city-go.eu/sites/default/files/city-go/public/content-files/pages/CityGO_factsheet.pdf Accessed on: 10/06/2021.

Claps, M. Mobility as a Service: Demand-Based Business Models in European Cities, IDC, 2021.

Deep Cube, Copernicus Services for Sustainable and Environmentally-friendly Tourism: Use Cases. Accessed at: https://deepcube-h2020.eu/use-cases/copernicus-services-for-sustainable-and-environmentally-friendly-tourism/ Accessed on: 20/06/2021.

Deloitte, Smart City Solution Centre, 2020. Accessed at: https://www2.deloitte.com/content/dam/Deloitte/pt/Documents/public-sector/Smart%20City%20Solution%20Center.pdf Accessed on: 10/06/2021.

Deutsche Bahn, Gunstig reisen im VRN: die neue Ticket-App "Tickin", 2020. Accessed at: https://www.deutschebahn.com/pr-stuttgart-de/aktuell/presseinformationen/104-pm_vrn_ticket_app_tickin-5458690 Accessed on: 10/06/2021.

De Nigris, S., Gomez-Gonzales, E., Gomez Gutierrez, E., Martens, B., Iglesias Portela, M., Vespe, M., Schade, S., Micheli, M., Kotsev, A., Mitton, I., Vesnic Alujevic, L., Pignatelli, F., Hradec, J., Nativi, S., Sanchez Martin, J.I., Hamon, R. and Junklewitz, H., Artificial Intelligence and Digital Transformation: early lessons from the COVID-19 crisis, Craglia, M. editor(s), EUR 30306 EN, Publications Office of the European Union, Luxembourg, 2020, ISBN 978-92-76-20802-0, doi:10.2760/166278, JRC121305.

De Vries, H., Bekkers, V., & Tummers, L. (2016). Innovation in the public sector: A systematic review and future research agenda. Public administration, 94(1), 146-166.

DUET, Digital Urban European Twins, About Us. Accessed at: https://www.digitalurbantwins.com/ Accessed on: 10/08/2021.

ESA, Space to help support us as we get older, 2017. Accessed at: https://business.esa.int/news/space-to-help-support-us-we-get-older. Accessed on: 20/06/2021.

ESRI Espana (a), Solucion Aforos Playas, 2021. Accessed at: https://www.esri.es/es-es/descubre-los-gis/casos-de-exito/administracion-/solucion-aforos-playas-cs Accessed on 19/03/2021.

ESRI Espana (b), Barcelona Provincial Council: SITxell Ecosystem Service. Accessed at: https://www.esri.es/es-es/descubre-los-gis/casos-de-exito/medio-ambiente/sitxell-servicios-ecosistemicos-caso-exito-infraestructura-verde Accessed on: 20/06/2021.

ESRI Espana (c), Biodiversity Data Bank, Accessed at: https://www.esri.es/es-es/descubre-los-gis/casos-de-exito/medio-ambiente/banco-de-datos-de-la-biodiversidad Accessed on: 20/06/2021.

Ethical Geo, Locus Charter, 2021. Accessed at: https://ethicalgeo.org/wp-content/uploads/2021/03/Locus_Charter_March21.pdf Accessed on: 09/06/2021.

European Commission (a), *About ELISE – European Location Interoperability Solutions for e-Government.* Retrieved from: https://joinup.ec.europa.eu/collection/elise-european-location-interoperability-solutions-e-government/about. Accessed on: 03/06/2021.

European Commission (b), Horizon 2020, Work Programme 2016-2017, 20. General Annexes, 2017. Accessed online at: https://ec.europa.eu/research/participants/data/ref/h2020/other/wp/2016-2017/annexes/h2020-wp1617-annex-ga_en.pdf accessed on: 23/06/2021.

European Commission (c), Towards a European Strategy on Business-to-government data sharing for the public interest: Final Report prepared by the High-Level Expert Group on Business-to-Government Data Sharing, 2020, ISBN 978-92-76-11422-2, doi:10.2759/731415.

European Commission (d), *Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions,* Brussels, 2020, COM (2020) 66 final.

European Commission (e), *ISA² - Interoperability solutions for public administrations, businesses and citizens*. Retrieved from: https://ec.europa.eu/isa2/library_en. Accessed on: 03/06/2021.

European Commission (f), *INSPIRE GEOPORTAL, INSPIRE Data Themes.* Retrieved from: https://inspire-geoportal.ec.europa.eu/theme_selection.html?view=qsTheme. Accessed on: 03/06/2021

European Commission (g), CORDIS Projects and Results. Accessed at https://cordis.europa.eu/projects/en Accessed on: 23/06/2021.

European Commission (h), The digital Economy and Society Index (DESI), 2020. Accessed at: https://digital-strategy.ec.europa.eu/en/policies/desi. Accessed on: 23/06/2021.

European Commission (i), A Vision for Public Services: Draft Version dated 13/06/2013. Accessed at: https://digital-strategy.ec.europa.eu/en/news/vision-public-servicesf Accessed on: 23/08/2021.

European Commission (j), Connecting the European Interoperability Framework (EIF) with Smart Cities and Communities (WIF4SCC), 2021. Accessed at: https://joinup.ec.europa.eu/collection/nifo-national-interoperability-framework-observatory/news/connecting-eif-smart-cities-communities-eif4scc. Accessed on: 11/07/2021.

European Commission (k), Horizon 2020, Variety, Veracity, Value: Handling the Multiplicity of Urban Sensors. Accessed at: https://cordis.europa.eu/project/id/688380/reporting Accessed on: 10/06/2021.

European Commission (l), Horizon 2020, BusUp: Multi-platform On-demand Crowdsourced Bus Transportation for Smart City Mobility. Accessed at: https://cordis.europa.eu/project/id/757004 Accessed on: 10/06/2021.

European Commission (m), Horizon 2020, Smart Sharing. Accessed at: https://cordis.europa.eu/project/id/738441 Accessed on: 10/06/2021.

European Commission (n), Smart Cultural Tourism as a Driver of Sustainable Development of European Regions. Accessed at: https://cordis.europa.eu/project/id/870708. Accessed on: 18/06/2021.

European Commission (o), Cities as mobility hubs: tackling social exclusion through 'smart' citizen engagement. Accessed at: https://cordis.europa.eu/project/id/870753. Accessed on: 18/06/2021.

European Commission (p), Press Release: Europe fit for the Digital Age: Commission proposes new rules and actions for excellence and trust in Artificial Intelligence. Accessed at: https://ec.europa.eu/commission/presscorner/detail/en/ip_21_1682 Accessed on: 10/06/2021.

European Commission (q) EASIN – European Alien Specices Information Network. Accessed at: https://easin.jrc.ec.europa.eu/easin

European Commission (r), Extended Reality for Disaster Management and Media Planning, 2020, Accessed at: https://cordis.europa.eu/project/id/952133 Accessed on: 15/06/2021.

Eurostat (a), *Manual on sources and methods for the compilation of COFOG statistics: Classification of the Functions of Government (COFOG) 2019 Edition*, Luxembourg: Publications Office of the European Union, 2019, ISBN 978-92-76-09695-5, doi:10.2785/110841.

Eurostat (b), Population Database, 2021. Accessed at: https://ec.europa.eu/eurostat/web/population-demography-migration-projections/data/database. Accessed on: 23/06/2021

Eurostat (c), File: People who used mobile devices to access the internet away from home or work, Eu-27, 2019 (%) BYIE20.png. Accessed at: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=File:People_who_used_mobile_devices_to_access_the_internet_away_from_home_or_work,_EU-27,_2019_(%25)_BYIE20.png Accessed on:10/06/2021.

Eurostat (d), Population Structure and Ageing: Increase in the share of the population aged 65 years or over between 2009 and 2019, 2020. Accessed at: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Population_structure_and_ageing Accessed on: 15/06/2021.

European Parliament, Research for TRAN Committee- Eu funding of trabsport projects, 2019. Accessed at: https://www.europarl.europa.eu/RegData/etudes/STUD/2019/629199/IPOL_STU(2019)629199_EN.pdf Accessed on: 10/08/2021.

European Union Agency for the Space Program, GEONAV IoT: Galileo dual frequency 5G, IoT devices and services for Drones, Assets Management and Elite sport. Accessed at: https://www.euspa.europa.eu/galileo-dual-frequency-5g-iot-devices-and-services-drones-assets-management-and-elite-sport Accessed on: 04/06/201.

European Global Navigation Satellite Systems Agency, Galileo High Accuracy Service (HAS) Info Note, 2020. Accessed at: https://www.gsc-europa.eu/sites/default/files/sites/all/files/Galileo_HAS_Info_Note.pdf Accessed on:10/06/2021.

European GNSS Agency, 2020, Galileo High Accuracy Service (HAS) Info Note. Accessed at: https://www.gsc-europa.eu/sites/default/files/sites/all/files/Galileo_HAS_Info_Note.pdf Accessed on: 20/06/2021.

European Regional Development Fund(a), Urban Innovative Actions. Accessed at: https://uia-initiative.eu/en Accessed on: 23/06/21.

European Union(a), *Berlin Declaration on Digital Society and Value-Based Digital Government,* 2020.

European Union(b), 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, PE/28/2019/REV/1.

European Union(c), European Institute of Innovation and Technology, EIT Urban Mobility Model. Accessed at: https://eit.europa.eu/our-activities/innovation/eit-urban-mobility-model Accessed on 23/06/2021

European Union(d), 2019, *The European Union Earth Observation Programme.* Accessed at: https://www.copernicus.eu/sites/default/files/Brochure_Copernicus_2019%20updated_0.pdf. Accessed on: 16/06/2021.

European Union(e), Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions – Re-use of Public Sector Information of Directive 2003/98/EC

European Union (h) ELISE- European Location Interoperability for e-Government: Location data privacy, 2021. Accessed at: https://joinup.ec.europa.eu/collection/elise-european-location-interoperability-solutions-e-government/location-data-privacy Accessed on: 10/08/2021.

European Union (i), About IMAPS (Interoperability Maturity Assessment of a Public Service). Accessed at: https://joinup.ec.europa.eu/collection/imaps-interoperability-maturity-assessment-public-service/about Accessed on:10/06/2021.

European Union (i), Smart Heritage City. Accessed at: https://keep.eu/projects/18139/Smart-Heritage-City-EN/ Accessed on: 23/05/2021.

European Union (j), Copernicus Land Monitoring Service. Accessed at: https://www.copernicus.eu/en/copernicus-services/land Accessed on: 20/06/2021.

European Union (k), Copernicus Marine Environment Monitoring Service. Accessed at: https://www.copernicus.eu/en/copernicus-services/marine Accessed on: 20/06/2021.

European Union Agency for the Space Program, GEONAV IoT: Galileo dual frequency 5G, IoT devices and services for Drones, Assets Management and Elite sport. Accessed at: https://www.euspa.europa.eu/galileo-dual-frequency-5g-iot-devices-and-services-drones-assets-management-and-elite-sport Accessed on: 04/06/2021.

Extreme Earth, About, 2019. Accessed at: http://earthanalytics.eu/about.html. Accessed on: 21/06/2021.

Granell, C., Kamilaris, A., Kotsev, A., Ostermann, F, O., Trilles, S. (2020) 'Internet of Things' in Guo, H., Goodchild, M. F., Annoni, A. *Manual of Digital Earth,* Singapore, Springer Open, p404.

Fabulos, Fabulos Project. Accessed at: https://fabulos/eu/ Accessed on: 10/06/2021

Fatima, S., Desouza, K, Dawson, G, S. and Denforc, J, S. Analyzing Artificial Intelligence Plans in 34 Countries. Brookings Institute, TechTank, 2021. Accessed at: https://www.brookings.edu/blog/techtank/2021/05/13/analyzing-artificial-intelligence-plans-in-34-countries/ Accessed on: 15/05/2021.

Fix my Street, About. Accessed at: https://www.fixmystreet.com/ Accessed on: 09/06/2021.

Galic, M., and Gellert, R. 'Data protection law beyond identifiability? Atmospheric profiles, nudging and the Stratumseind Living Lab' *Computer Law and Security Review, Elsevier,* 2021, Vol. 40, 105486.

GeoPlace, Bridging central and local government with UPRNs to respond to COVID-19. Accessed at: https://www.geoplace.co.uk/case-studies/bridging-central-and-local-government-with-uprns-to-respond-to-covid-19 Accessed on: 10/06/2021.

Government Business, The View from Above: Drones and Public Services. Accessed at: https://governmentbusiness.co.uk/features/view-above-drones-and-public-services Accessed on: 04/06/2021.

Gretzel, U.; Sigala, M.; Xiang, Z.; Koo, C. 'Smart tourism: Foundations and developments', *Electronic Markets,* 2015, Vol. 25, pp 179-188.

Hall, D. H., Palsson, C. and Price, J. 'Is Uber a substitute or complement for public transit?' Journal of Urban Economic, Elsevier, 2018, Vol. 108, pp 36-50.

Hammersley M. (2008) “Troubles with Triangulation” in M. M. Bergman (a cura di) Advances in Mixed Methods Research, Sage, London: 22-36.

Harst, G, V, D. and Valayer, C. ISA2 – Action 10: ELISE Benchmarking Support: Task 2: Location Intelligence. Accessed at: https://joinup.ec.europa.eu/sites/default/files/document/2020-12/Location%20Intelligence-Benchmarking%20Support-Gartner.pdf Accessed on: 23/08/2021 (conducted by Gartner on behalf of the European Commission JRC)

Heeks, R and Albanna, B. Positive Deviance: A Data-Powered Approach to the Covid-19 Response, GIZ Data Lab, 2020. Accessed at: https://www.blog-datalab.com/home/a-data-powered-approach-to-the-covid-19-response/ Accessed on: 10/06/2021.

Higgins, S., 2012, The lifecycle of data management, in Pryor, G. *Managing Research Data*. London, Facet Publishing, ISBN 978-1-85604-756-2.

Ball, A., Review of Data Management Lifecycle Models. Research Report. Opus: University of Bath Online Publication Store, 2012.

How Busy is Toon, About. Accessed at: https://howbusyistoon.com/ Accessed on: 09/06/2021

IMPACTOUR, Improving Sustainable Development Policies and Practices to Access, Diversity and Foster Cultural Tourism in European Regions and Areas: About. Accessed at: https://www.impactour.eu/ Accessed on: 19/06/2021.

Informatica Alto Adige, 2020, The AgriML SIAG project awarded by the IDC. Accessed at: https://www.siag.it/it/news/il-progetto-agri-ml

Interreg Europe, Smart Tourism Platform. Accessed at: https://www.interregeurope.eu/policylearning/good-practices/item/4297/smart-tourism-platform/ Accessed on 23/05/2021.

Interreg Europe (b), Good practice: Use of Biodiversity data in decision making the SITxell Project. Accessed at: https://www.interregeurope.eu/policylearning/good-practices/item/679/use-of-biodiversity-data-in-decision-making-the-sitxell-project/ Accessed on: 20/06/2021.

Interreg Europe (c), Good practice: Seascape Character Assessment. Accessed at: https://www.interregeurope.eu/policylearning/good-practices/item/821/seascape-character-assessment/ Accessed on: 20/06/2021.

Interreg Europe (d), A Policy Brief from the Policy Learning Platform on Environment and Resource Efficiency: Use of technologies for better protection and management of nature and biodiversity, 2019. Accessed at: http://www.interregeurope.eu/fileadmin/user_upload/plp_uploads/policy_briefs/2019-02-28_TO6_policy_brief_on_natural_heritage_and_technologies.pdf Accessed on: 20/06/2021.

Janev, Valentina & Mijović, Vuk & Vraneš, Sanja. (2015). Linked data approach to the PSI directive implementation: Supporting tools and lessons learned. 823-826. 10.1109/TELFOR.2015.7377592.

Janowicz, K. Simon, S. Pehle, T. and Hart, G. (2012). Geospatial semantics and linked spatiotemporal data -- Past, present, and future. Semantic Web. 3. 321-332. 10.3233/SW-2012-0077.

John Hopkins, University of Medicine, COVID-10 Dashboard by the Center for Systems Science and Engineering (CSSE) at John Hopkins University (JHU). Access at: https://coronavirus.jhu.edu/map.html Accessed on: 10/06/2021.

Kalvet, T., Olesk, M., Raun, J. ‘Innovative Tools for Tourism and Cultural Tourism Impact Assessment,’ Sustainability, 2020, Vol 12, No. 18, 7470.

Kotsev, A., Minghini, M., Tomas, R., Cetl, V. and Lutz, M. ‘From Spatial Data Infrastructures to Data Spaces: A Technological Perspective on the Evolution of European SDIs’, *ISPRS INTERNATIONAL JOURNAL OF GEO-INFORMATION*, ISSN 2220-9964, 9 (3), 2020, p. 176, JRC120143.

Książek K, Grochla K. ‘Aggregation of GPS, WLAN, and BLE Localization Measurements for Mobile Devices in Simulated Environments’. *Sensors (Basel)*, 2019, Vol. 19, No. 7:1694.

LADOT, Mobility Data Specification: Information Briefing, 2018. Accessed at: https://ladot.io/wp-content/uploads/2018/12/What-is-MDS-Cities.pdf. Accessed on: 10/06/2021

Lavrakas, P., ‘Computer-Assisted Telephone Interviewing (CATI)’, *Encyclopaedia of Survey Research Methods, Sage, 2008,* http://dx.doi.org/10.4135/9781412963947.n83

LEAD, Digital Twins for Low Emission Last Mile Logistics. 2021. Accessed at: https://www.leadproject.eu/ Accessed on: 20/08/2021.

McAleer S.R., Kogut P., Raes L. (2018) The Case for Collaborative Policy Experimentation Using Advanced Geospatial Data Analytics and Visualisation. In: Diplaris S., Satsiou A., Følstad A., Vafopoulos M., Vilarinho T. (eds) Internet Science. INSCI 2017. Lecture Notes in Computer Science, vol 10750. Springer, Cham.

MaaS Alliance, What is Maas? Accessed at: https://maas-alliance.eu/homepage/what-is-maas/ Accessed on: 10/06/2021. Mariana, M. Survey methods: Phone survey – CATI, IdSurvey, 2020. Accessed at: https://www.idsurvey.com/en/cati-survey-methodology/ Accessed on: 23/06/2021.

McDougall, K. and Koswatte, S. 'The Future of Authoritative Geospatial Data in the Big Data World – Trends, Opportunities and Challenges,' *Fig Commission 3 Workshop,* Naples, 2018.

Merion, I., Three drones control the capacity on the beaches, Mijas News, 2021. Accessed at: https://turismo.mijas.es/images/ocio/eventos/2020/DRON%20INGL%C3%89S.pdf Accessed on: 20/06/2021.

Micheli, M., Ponti, M., Craglia, M., and Berti Suman, A. Emerging models of data governance in the age of datafication. Big Data & Society, 2020. 7.

Microsoft, A map delivered in 3D Sound. Accessed at: https://www.microsoft.com/en-us/research/product/soundscape/ Accessed on: 20/06/2021.

Milne, D. and Watling, D. 'Big data and understanding change in the context of planning transport systems', *Journal of Transport Geography,* Science Direct, 2019, Vol. 76, pp 235-244.

National Geospatial Advisory Committee, *Emerging Technologies and the Geospatial Landscape. Accessed at:* Microsoft Word - NGAC Paper - Emerging Technologies and the Geospatial Landscape.docx (fgdc.gov) Accessed on: 20/05/2021.

Neveux, E. Healthcare data: The new prize for hackers, SecureLink, 2020. Accessed at: https://www.securelink.com/blog/healthcare-data-new-prize-hackers/ Accessed on: 10/06/2021.

Nordic Way, Protecting the environment with dynamic environmental zones. Accessed at: https://www.nordicway.net/demonstrationsites/dynamic-environmental-zones Accessed on: 10/06/2021.

OECD(a), *Earth Observation for Decision Making, 2017*. Accessed at: https://www.oecd.org/environment/indicators-modelling-outlooks/Earth_Observation_for_Decision_Making.pdf

Accessed on: 15/06/2021.

OECD(b), Strengthening Digital Government, 2019. Accessed at: strengthening-digital-government.pdf (oecd.org) Accessed on: 09/06/2021

Open and Agile Smart Cities, 2020, Minimal Interoperability Mechanisms – MIMS. Accessed at: https://oascities.org/minimal-interoperability-mechanisms/ Accessed on: 10/08/2021.

Open Geospatial Consortium(a), OGC Technology Trends 2020. Accessed at: https://www.ogc.org/OGCTechTrends Accessed on:23/06/21.

Ordnance Survey (a) OS Data helps keep hospital open in Somerset, 2014. Accessed at: https://www.ordnancesurvey.co.uk/business-government/products/case-studies/stroke-nhs. Accessed on: 10/06/2021.

Ordnance Survey (b), Cross-referencing data so NHS Lothian can look after shielding patients during Covid-19. Accessed at: https://www.ordnancesurvey.co.uk/business-government/products/case-studies/nhs-lothian-covid-datasets Accessed on: 10/06/2021.

Ordnance Survey (c), NHS and OS battle obesity in Birmingham. https://www.ordnancesurvey.co.uk/business-government/products/case-studies/birmingham-nhs-mapping Accessed on: 10/06/2021.

Pei, T., Song, C., Shu, H. Liu, Y., Du, Y., Ma, T., Zhou, C. 'Big geodata mining: Objective, connotations and research issues', *Journal of Geographic Sciences*, Volume 20, 2020, pp 251-266.

PoliVisu, About. Accessed at: https://www.polivisu.eu/ Accessed on: 20/08/2021.

Positium, Blog: Building the future of public transport with mobile phone data and Remix. Accessed at: https://positium.com/blog/future-public-transport-mobile-phone-data-remix Accessed on: 10/06/2021.

Positium, Blog: Use case: building a smart city with data-driven solutions, inclusivity and innovation in Tartu. Accessed at: https://positium.com/blog/smart-city-data-driven-solutions-innovation-in-tartu Accessed on: 10/06/2021

Positium (c), Blog, Local Tourism Insights from MPD – Setomaa in South Estonia. Accessed at: https://positium.com/blog/local-tourism-insights-from-mpd-setomaa-in-south-estonia Accessed on: 21/03/2021.

Prandi, F., Devigili, F., M., Soave, M. Staso, U, D., De Amicis, R. '3D Web Visualization of Huge CityGML models' *The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, Vol. cL-3/W3, La Grande Motte, 2015.*

Public Technology, Belfast trials app-based rewards for visiting park, 2021. Accessed at: https://www.publictechnology.net/articles/news/belfast-trials-app-based-rewards-visiting-park-0?utm_medium=email&utm_campaign=Daily%20email%204th%20of%20June&utm_content=Daily%20email%204th%20of%20June+CID_c3c3cca84213447e60d431e4ebde8da0&utm_source=Email%20newsletters&utm_term=Belfast%20trials%20app-based%20rewards%20for%20visiting%20park Accessed on: 10/06/2021.

RailTech.com, Deutsche Bahn to test HD mapping, creating railway Digital Twin, 2021. Accessed at: *https://www.railtech.com/digitalisation/2021/01/18/deutsche-bahn-to-test-hd-mapping-creating-railway-digital-twin/* Accessed on: 10/06/2021

Razavi, S., Behrendt, C., Bierbaum, M., Orton, I. and Tessier, L. 'Reinvigorating the social contract and strengthening social cohesion: Social protection responses to COVID-19', *International Social Security Review*, 2020, Vol. 73, No. 3, pp 55-80.

Rogers, S. John Snow's data journalism: the cholera map that changed the world. The Guardian, 2013. Accessed at https://www.theguardian.com/news/datablog/2013/mar/15/john-snow-cholera-map Accessed on: 10/06/2021.

SAP, Managing COVID-10 Hopsital Bed Capacity and Availability ith SAP Cloud Platform and SP Firorit. Accessed at: https://www.sap.com/documents/2020/08/48de8f76-aa7d-0010-87a3-c30de2ffd8ff.html Accessed on: 11/08/2021.

Satsense, Infrastructure. Accessed at: https://satsense.com/our-sectors/infrastructure/ Accessed on: 10/06/2021.

Schade, S. & Smits, P. Why Linked Data Should Not Lead to Next Generation SDI. International Geoscience and Remote Sensing Symposium (IGARSS). 2012. 10.1109/IGARSS.2012.6350721.

Schade, S., Kotsev, A., Cardoso, A., 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. 2019. 78. 10.1016/j.compenvurbsys.2019.101384.

Smart City Valencia, Geoportal: All the data, street to street. Accessed at: http://smartcity.valencia.es/vlci/gis-portal/ Accessed on: 11/07/2021.

Senaratne, H., Mobasheri, A., Ali, A, L., Capineri, C., and Haklay, M. 'A review of volunteered geographic information quality assessment methods' *International Journal of Geographical Information Science*, 2017, Vol. 31, No. 1, pp. 139-167.

Slingshot Simulations, Press Release: Government Invests in UK's Largest Digital Twin Program: Leeds-based start-up to deliver one of the world's largest digital twin projects. Accessed at: https://www.slingshotsimulations.co.uk/news/digital-twins/government-invests-in-uks-largest-digital-twin-platform/ Accessed on: 10/06/2021.

SmartCitiesWorld, UK wants to use location data to empower more passengers, 2019. Accessed at: https://www.smartcitiesworld.net/news/news/uk-wants-to-use-location-data-to-empower-more-bus-passengers-4026#:~:text=UK%20wants%20to%20use%20location%20data%20to%20empower%20more%20bus%20passengers,-News02%20Apr&text=The%20platform%20will%20enable%20app,97%20per%20cent%20of%20buses.

Song, W., and Wu, C. Introduction to advancements of GIS in the new IT era, Annals of GIS, 2021, Vol 27, No. 1, pp 1-4.

Stone, T. Velodyne and Qualcomm team up to deploy lidar for city and traffic management, Traffic Technology Today, 2021. Accessed at: https://www.traffictechnologytoday.com/news/machine-vision-alpr/velodyne-and-qualcomm-team-up-to-deploy-lidar-for-city-and-traffic-management.html Accessed on: 10/06/2021.

Symons, T. *Using data to make services more personalised, effective and efficient: Discussion Paper,* Nesta, 2016.

Transport For London, Wi-Fi data collection. Accessed at: https://tfl.gov.uk/corporate/privacy-and-cookies/wi-fi-data-collection Accessed on: 10/06/2021.

Trendall, S, Government plans £5m trial of apps that reward healthy behaviour, 2021, accessed at: https://www.publictechnology.net/articles/news/government-plans-%C2%A35m-trial-apps-reward-healthy-behaviour accessed on: 10/06/2021

UK Government, Geospatial Commission, Policy Paper - *National Underground Asset Register Project Update,* 2020. Retrieved from: https://www.gov.uk/government/publications/national-underground-asset-register-project-update/national-underground-asset-register-project-update. Accessed on: 03/06/2021.

United Nations Committee of Experts on Global Geospatial Information Management. *Future Trends in geospatial information management: the five to ten year vision – Third Edition*, 2020.

Ride2Rail Consortium, State-of-the-Art of Ride-sharing in target Eu countries, Deliverable D2.2, 2020.

Royal Voluntary Service (a), NHS Volunteer Responders, Accessed at: https://www.goodsamapp.org/NHSvolunteerresponders?_ckplc=y&_ga=2.91201177.2036620802.1622624035-417951280.1622624035 Accessed on: 14/06/2021.

Royal Voluntary Service (b), Findings from Those Referring into the NHS Volunteer Responder Programme During Covid-1, Working Paper Three, 2021. Accessed at: https://www.royalvoluntaryservice.org.uk/Uploads/Documents/About%20us/NHSVR_Working_Paper_Three_Referrer_Findings.pdf Accessed on: 14/06/2021.

Royal Voluntary Service (c), Findings: Patients Supported by the NHS Volunteer Responder Programme during Covid-19 – April to August 2020: Working Paper One, 2020, Accessed at: https://www.royalvoluntaryservice.org.uk/Uploads/Documents/Our%20impact/NHSVR_working_paper_one_patient_findings.pdf Accessed on: 14/06/2021.

Royal Voluntary Service (d), Findings from Volunteers Participating in the NHS Volunteer Responder (NHSVR) Programme During Covid-19 – April to August 2020: Working Paper Two, 2020, Accessed at: https://www.royalvoluntaryservice.org.uk/Uploads/Documents/About%20us/Working_Paper_Two_Patient_Findings_271120.pdf Accessed on: Accessed on: 14/06/2021.

SmartCitiesWorld, UK wants to use location data to empower more passengers, 2019. Accessed at: https://smartcities.world.net/uk -wants-to-use-data-to-empower-more-bus-passengers. Accessed on: 10/06/2021.

Syed, A, S. Sierra-Sosa, D., Kumar, A, and & Elmaghraby, A, S. (2021). IoT in Smart Cities: A Survey of Technologies, Practices and Challenges. Smart Cities. 4. 429-475. 10.3390/smartcities4020024.

Tiru, M. Overview of the Sources and Challenges of Mobile Positioning Data for Statistics, UNstats, 2020. Accessed at: https://unstats.un.org/unsd/trade/events/2014/beijing/Margus%20Tiru%20-%20Mobile%20Positioning%20Data%20Paper.pdf. Accessed on: 23/06/2021.

Vito, Solar Potential on Flemish Rooftops. Accessed at: https://vito.be/en/solar-potential-flemish-rooftops Accessed on: 15/06/21

What3words, Business. Accessed at: https://what3words.com/business/ Accessed on: 03/06/2021.

Wood, E., Ward, G, E., and Woolham, J. 'The development of safer walking technology: a review', *Journal of Assistive Technologies,* 2015, Vol. 9. 2. Pp 100-115. DOI:10.1108/JAT-07-2014-0017

W3C Semantic Web, Resource Description Framework (RDF). Accessed at: https://www.w3.org/RDF/ Accessed on: 09/06/2021

Xin, L. 2021, *Hyper-accurate Positioning is Rolling Out Worldwide,* MIT Technology Review. Accessed at: https://www.technologyreview.com/2021/02/24/1017805/hyper-accurate-global-positioning-available-worldwide/

Zencity, Case Studies. Accessed at: https://zencity.io/case-studies/ Accessed on:15/06/2021

List of abbreviations and definitions

Abbreviations

AI	Artificial Intelligence
API	Application Programming Interface
AR	Augmented Reality
AUWS	Autonomous Under Water Vehicles
BIM	Building Information Modelling
BLE	Bluetooth Low Energy
CAV	Connected and Autonomous Vehicle
CITS	Cooperative and Intelligent Transport Systems
CIM	Crowd Insights Monitor
COFOG	Classification of the Functions of Government
DG CONNECT	Directorate-General for Communications Networks, Content and Technology
EC	European Commission
EIF	European Interoperability Framework
EIF4SCC	European Interoperability Framework with Smart Cities and Communities
ELISE	European Location Interoperability Solutions for e- Government
EOD	Earth Observation Data
EOT	Earth Observation Technologies
ERDF	European Regional Development Fund
ERP	Enterprise Resource Planning
EU	European Union
EULF	European Location Framework Blueprint
FAIR	Findable Accessible Interoperable and Reusable
GEO AI	Geographical Artificial Intelligence
GDPR	General Data Protection Regulation
GIS	Geographical Information System
GNSS	Global Navigation Satellite System
GRSS	Geoscience and Remote Sensing Society
HTTP	Hypertext Transfer Protocol
H2020	Horizon 2020
IEEE	Institute of Electrical and Electronics Engineers
INSPIRE	Infrastructure for Spatial Information in Europe
IDC	International Data Corporation
InSar	Synthetic Aperture Radar Interferometry
IoT	Internet of Things
ITS	Intelligent Transport Systems
JRC	Joint Research Centre
KPI	Key Performance Indicator
ML	Machine Learning
MR	Mixed Reality
MNO	Mobile Network Operator
MPD	Mobile Positioning Data
NGO	Non-Governmental Organisation
OASC	Open and Agile Smart Cities
OECD	Organisation for Economic Corporation and Development
OSM	Open Street Map
RDF	Resource Description Framework
RFID	Radio Frequency Identification
ROAS	Remotely Operated Aerial Systems
SDI	Spatial Data Infrastructure
UN GGIM	United Nations Committee of Experts on Global Geospatial Information
URI	Uniform Resource Identifier
VGI	Voluntary Geographic Information
VR	Virtual Reality
XR	Extended Reality

Definitions

- **Case study**: According to Yin (2008), case studies can be used to explain, describe or explore events or phenomena in the everyday contexts in which they occur. These can help to understand and explain causal links and pathways resulting from the adoption of location information and technologies to improve local public services.
- **Context:** refers to specific features of the local environment that must be considered for the transformation and value creation of local public services. Various attributes affecting the choices for planning and implementing public services at local level, such as:
  - Values: Economic, Social, Environment, Governance
  - Drivers: History of the city/municipality, development focus of the solutions (such as levering on the deployment of ICT for local development, leveraging on human capital, attracting investments, etc.), and local dimensions to be improved (such as economic, social, environment, mobility, health, living and governance
  - Challenges: economic, social, environmental, technological, service delivery, financial, governance, legal, ethical, and institutional
  - Risks: economic, social, environmental, technological, financial and strategic
  - Region: comprising more cities/municipalities sharing similar problems and opportunities
- **Co-production:** regular, long-term relationships between professionalized service providers… and service users… where all parties make substantial resource contributions" (Bovaird, 2007 p. 847).
- **Digital Government transformation:** "a notable change, modernisation effort or innovation, introducing digital technologies in government's business processes, service delivery models and culture, restructuring how the government performs basic functions and governs. [… It is] the abandonment of analogue operating models (e.g., manual, paper) in favour of the new digital systems", not in a gradual manner. Other key aspects of Digital Government Transformation are:
  - Transformation as a process with different degrees of maturity (traditional government, e-government, digital government)
  - "The new, 'transformed', technology-based systems should not only be consumer-friendly, strategy-driven, and capable of providing a better experience for those interacting with the government, but, more importantly, should also improve the way the government systems operate".[321]
- **Dynamic Location Data:** For the purposes of the report, dynamic data refers to data that is updated at more frequent intervals, may relate to a dynamic entity (e.g., a moving individual or vehicle), is often spatio-temporal (i.e., relating to both a specific location and point in time), and can be generated from a dynamic ecosystem of data producers, whether citizens, public or private entities.
- **Geography**: The selected case studies will span various global geographies, however applicability to EU Member States will be noted.
- **Geospatial Application**: Broadly classified as data sharing platform; wayfinding; real-time decision making, planning and simulation; data collection; indoor location; alternative geospatial mapping.
- **Innovative aspect of the solution:** including the focus on the outputs/attributes of the solution, interoperability, openness, scalability and re-usability; application of leading-edge technologies, such as IoT, edge computing, AI/ML, quantum, digital twin
- **Innovative use of data**: Data used in a novel manner in reference to an organization, a sector or a policy
- **Inputs:** refer to elements that the transformation process of a local public service delivery can use. Two main input attributes can be identified: location technologies and data.
- **Interoperability:** A key factor in making a digital transformation possible. It allows administrative entities to electronically exchange meaningful information in ways that are understood by all parties. (ELISE Glossary)
- **Local and regional governments:** Territorial public authorities within a sovereign state. In the context of the European Union, local and regional governments correspond to NUTS-2, NUTS-3 and LAU (Local Administrative Units) in the EU common nomenclature of territorial units for statistics.
- **Location data**: geospatial information embedded into the solution to deliver services to the stakeholders. Data with a direct or indirect reference to a specific location or geographical area (cf. the legal definition in the INSPIRE directive, Directive 2007/2/EC). This term can be interchanged with location data, geospatial data or geodata.
- **Location-enabled (public) services:** Services provided by public authorities which depend on effective management or use of location information. Their location component is essential to create value. It refers to services that regularly use location-enabled technologies and to the ones that make an innovative use of them.[322]

[321] Barcevičius, E., Cibaitė, G., Codagnone, C., Gineikytė, V., Klimavičiūtė, L., Liva, G., Matulevič, L., Misuraca, G., Vanini, I., Editor: Misuraca, G., Exploring Digital Government transformation in the EU - Analysis of the state of the art and review of literature, EUR 29987 EN, Publications Office of the European Union, Luxembourg, 2019, ISBN 978-92-76-13299-8, doi:10.2760/17207, JRC118857.

- **Location-enabled technologies**: geospatial technologies embedded into the solution to deliver services to the stakeholders. The focus is both on data and technology.
- **Location information:** Any piece of information that has a direct or indirect reference to a specific location or geographical area, such as an address, a postcode, a building or a census area. Most information from diverse sources can be linked to a location. This term can be interchanged with spatial, geospatial, place or geographic information.
- **Location intelligence:** The process of deriving meaningful insight from geospatial data relationships — people, places or things — to solve particular challenges such as demographic or environmental analysis, asset tracking, and traffic planning [Gartner Research]
- **Maturity:** digital maturity refers to the extent to which digital technologies have transformed an organization's processes, talent engagement, and citizen service models. (Deloitte, 2015)
- **Outcomes:** refer to results produced by transformation processes of public services at local level. The outcome of these processes is the creation of public value.
- **Policy/Service area:** including energy, transport, health, housing, education, etc.
- **Public sector:** any type of organisation delivering public services, acting within a local or regional territory. Examples include public organizations as municipalities, non-profit organizations, public companies, private sector firms, port authorities, transportation and utility companies. Ref. Brown, K., & Osborne, S. P. (2012). Managing change and innovation in public service organizations. Routledge.
- **Public service:** a service intended to serve all members of a community. It is commissioned by the public sector or delegated/taken up/delivered by others and is a solution that serves a purpose for its stakeholders. The taxonomy "European taxonomy for public services" developed by ISA2 will inform the project's activities. According to this taxonomy, public services can be defined as a combination of themes (e.g., Education, Health Care) and patterns (e.g., Information, Financing, Production).
- **Public value (creation) / generated value**: results of the activities the public sector has achieved. It is a multi-dimensional concept that embraces several dimensions of value including efficiency, effectiveness, output, quality, responsiveness, democracy that are relevant to the different stakeholders of public services. The team acknowledges that value may also destroyed for some stakeholders. The focus will be on cases where the overall public value is positive. According to Osborne, Nasi and Powell (2020) identify three *loci* of value creation:
    - Individuals/Citizens, as end-users, stakeholders, communities;
    - Society, because the public service is expression of societal values or addresses systemic societal problems;
    - Public Sector Organizations because of learning and consequent change implemented in public services.

  While Osborne (2018) distinguishes between
    - Value-in-use: the customer utilization of the offer generates value to the customers themselves;
    - Value-in-context: customers create value because the utilization of the offer interacts with their experiences of life and social environment.
- **Public values:** beliefs and ideologies in the context. Public values represent a contextual variable that informs the project. Public values should be addressed among the determinants of the external environment in providing recommendations for upscaling and diffusion of location-enabled services. Ref. Osborne, S. P. (2018). From public service-dominant logic to public service logic: are public service organizations capable of co-production and value co-creation? Public Management Review, Vol. 20, N.2, p. 225-231
- **Public-value of e-governance:** According to Pin-Yu & Chu (2017), it can be operational (efficiency, user-oriented service), political (transparency/accountability, citizen participation, equity in accessibility), social (trust, self-development, quality of life, environmental sustanability).
- **Readiness:** methods for determining the maturity of technology during the acquisition phase.
- **Solutions:** means to create value. They include the technology, but also the data/digital components.
- **Stakeholders:** all actors with an interest/expectation in the need for which the service represents a solution. The team will use the power and interest stakeholder matrix and it will mainly focus on stakeholders with a high power and a high interest.
- **Static Location Data:** in the context of the report, we use the term static data to refer to data which relates to a static element of the environment, e.g., a property or parcel of land. These data sets tend to be more persistent and are updated less frequently. These datasets tend to be provided and managed by a single public sector entity with a limited role played by the broader ecosystem.

[322] Boguslawski, Valayer, van Gansen, Keogh, Pignatelli, European Union Location Framework Blueprint, EUR 30374 EN, Publications Office of the European Union, Luxembourg, 2020, ISBN 978-92-76-22068-8, doi:10.2760/096595, JRC117551.

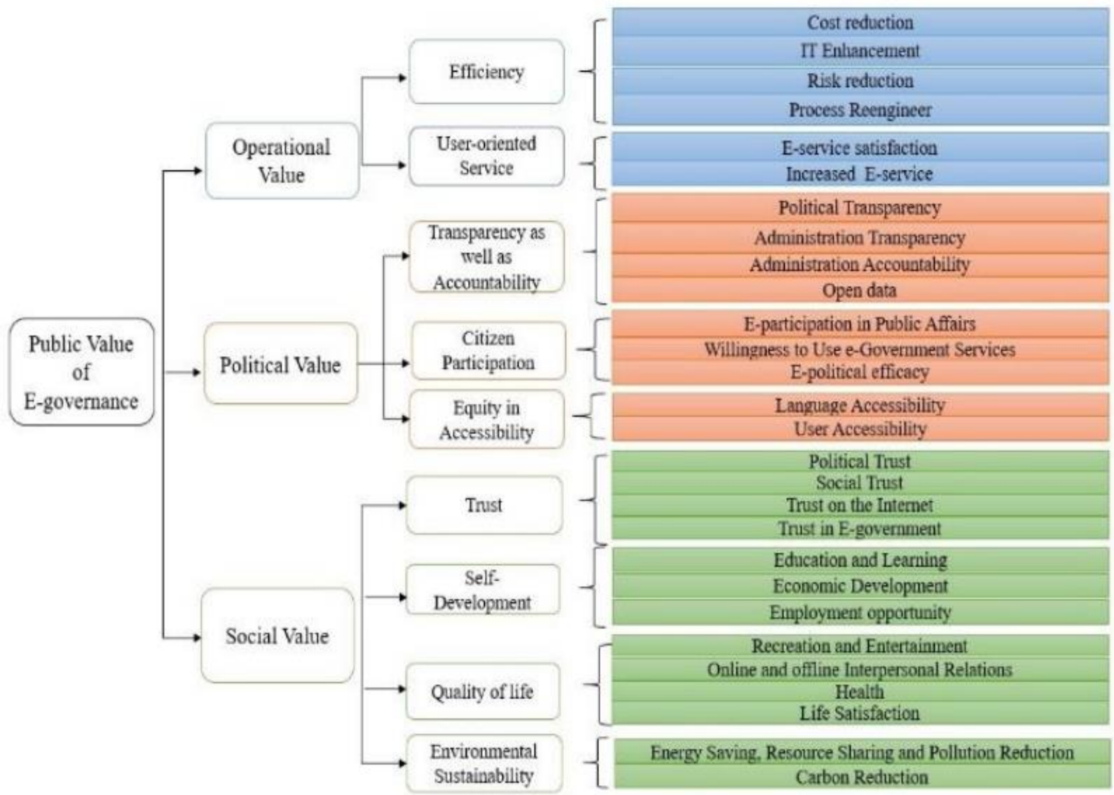
- **Transformation:** refers to the processes of re-designing and improving public services and of delivering new, innovative services. This study focuses on transformation driven by or enabled by location data and technologies. Transformation could refer to new, innovative approaches for the design and delivery of public services and/or for the governance of services. Looking at the existing literature on digital transformation and innovative public services, various specific attributes relevant to the transformation process could be identified: approaches, stakeholders, governance and maturity models. Each of these attributes could be classified into relevant sub-attributes
    - Approaches: top-down and bottom-up
    - Stakeholders' attributes: Types, Roles, and Partnerships
    - Governance: requirements, principles, vision, resource management, models and government roles
    - Maturity models for measuring and monitoring the level of progress: eGEP2.0 model (Salvoldelli and others (2013)), scorecards (Meynhardt and Gomez, 2013

List of figures

List of tables

Annexes

Annex 1. Public Value of E-Governance Framework



Source: Chu, P. and Tseng, H, L. 2018.

Annex 2. List of Literature Reviewed

	Academic Literature Reviewed
1.	Ahas, Rein & Aasa, Anto & Silm, Siiri & Tiru, Margus. (2007). Mobile Positioning Data in Tourism Studies and Monitoring: Case Study in Tartu, Estonia. Information and Communication Technologies in Tourism 2007. 119-128. 10.1007/978-3-211-69566-1_12.
2.	Ahmed, Aminah & Zanotti Fragonara, Luca. (2021). ADAPTIVE INTELLIGENT TRAFFIC CONTROL SYSTEMS FOR IMPROVING TRAFFIC QUALITY AND CONGESTION IN SMART CITIES. International Journal for Quality Research. 15. 139-154. 10.24874/IJQR15.01-08.
3.	Angelidou, Margarita. (2014). Smart city policies: A spatial approach. Cities. 41. S3-S11. 10.1016/j.cities.2014.06.007.
4.	Barbero, M., Lopez Potes, M., Vancauwenberghe, G. and Vandenbroucke, D., The role of Spatial Data Infrastructures in the Digital Government Transformation of Public Administrations, Publications Office of the European Union, Luxembourg, 2019, ISBN 978-92-76-09679-5doi:10.2760/324167, JRC117724.
5.	Barcevičius, E., Cibaitė, G., Codagnone, C., Gineikytė, V., Klimavičiūtė, L., Liva, G., Matulevič, L., Misuraca, G., Vanini, I., Editor: Misuraca, G., Exploring Digital Government transformation in the EU - Analysis of the state of the art and review of literature, EUR 29987 EN, Publications Office of the European Union, Luxembourg, 2019, ISBN 978-92-76-13299-8, doi:10.2760/17207, JRC118857.
6.	Basiri, A., Lohan, E, S., Moore, T., Winstanley, A., Peltola, P., Hill, C., Amirian, P., Figueiredo e Silva, P. 'Indoor location based services challenges, requirements and usability of current solutions', Computer Science Review, 2017, Vol. 24, pp 1-12.
7.	Bekkers, V. (2007a). Modernization, public innovation and information and communication Technologies: The emperor's new clothes? Information Polity. 12:103–107 in Vandenbroucke, D, Vancauwenberghe, G, Boguslawski, R, Pignatelli, F. Design of location-enabled e-government services, EUR 30220 EN, Publications Office of the European Union, Luxembourg, 2020, ISBN 978-92-76-18939-8, doi:10.2760/860082, JRC119730.
8.	Boguslawski, R., Valayer, C., Van Agansen, K., Keogh, D., Pignatelli, F. European Union Location Framework Blueprint, EUR 30374 EN, Luxembourg: Publications Office of the European Union, 2020, ISBN 978-92-76-22068-8, doi:10.2760/096595, JRC117551.
9.	Bruzza, Mariuxi & Tupia, Manuel & Vancauwenberghe, Glenn. (2020). State-of-the-Art Applications of Spatial Data Infrastructure in the Provision of e-Government Services in Latin America. 10.1007/978-3-030-40690-5_13.
10.	Cetl, V., Nunes De Lima, M., Tomas, R., Lutz, M., D`Eugenio, J., Nagy, A. and Robbrecht, J., 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.
11.	Chen, J. Walker, R, M., Sawhney, M. 'Public Service Innovation: a typology', Public Management Review, Vol 22, No 11, 2020, pp. 1674-1695.
12.	Chmielewski, Szymon & Samulowska, Marta & Lupa, Michał & Lee, Danbi & Zagajewski, Bogdan. (2018). Citizen science and WebGIS for outdoor advertisement visual pollution assessment. Computers Environment and Urban Systems. 67. 97–109. 10.1016/j.compenvurbsys.2017.09.001.

13.	Chung, Kyusuk & Yang, Duck-Hye & Bell, Ralph. (2004). Health and GIS: Toward Spatial Statistical Analyses. Journal of medical systems. 28. 349-60. 10.1023/B:JOMS.0000032850.04124.33.
14.	Consoli, S., Presutti, V., D, Reforgiato Recupero., and Peroni, S. 'Producing Linked Data for Smart Cities: The Case of Catania' *Big Data Research* 2017, Vol. 7, pp.1-15 DOI:10.1016/j.bdr.2016.10.001
15.	Cos, Olga & Castillo, Valentín & Cantarero, David. (2020). Facing a Second Wave from a Regional View: Spatial Patterns of COVID-19 as a Key Determinant for Public Health and Geoprevention Plans. International Journal of Environmental Research and Public Health. 17. 8468. 10.3390/ijerph17228468.
16.	Dasgupta, A. & Ghosh, S. (2018). A Volunteered Geographic Information (VGI) Framework for Disaster Management Based on Mobile Services and SDI. 10.1007/978-981-13-2330-0_10.
17.	Demertzis, Konstantinos & Bougoudis, Ilias & Liadis, Lazaros. (2015). HISYCOL a Hybrid Computational Intelligence System for Combined Machine Learning: The case of Air Pollution Modeling in Athens. Neural Computing and Applications. 27. 10.1007/s00521-015-1927-7.
18.	Erdélyi, Ján & Kopacik, Alojz & Kyrinovic, Peter. (2020). Spatial Data Analysis for Deformation Monitoring of Bridge Structures. Applied Sciences. 10. 8731. 10.3390/app10238731.
19.	Estrada, Elsa & Martinez, Martha & Gómez, Judith & Peña Pérez Negrón, Adriana & López, Graciela & Maciel, Rocio. (2019). Smart Cities Big Data Algorithms for Sensors Location. *Applied Sciences*. 9. 4196. 10.3390/app9194196.
20.	Ferguson, Matilda & Boovaraghavan, Sudershan & Agarwal, Yuvraj. (2020). Vista: Spatial Data Representation for Smart Buildings. 342-343. 10.1145/3408308.3431112.
21.	Galic, M., and Gellert, R. 'Data protection law beyond identifiability? Atmospheric profiles, nudging and the Stratumseind Living Lab' Computer Law and Security Review, Elsevier, 2021, Vol. 40, 105486.
22.	Gallo, Jason & Bernknopf, Richard & Lev, Steven. (2017). Measuring the Socioeconomic Value of Data and Information Products Derived from Earth Observations and Other Geospatial Data. 10.1201/9781315154640-2.
23.	Garcia Alvarez, Manuel & Morales, Javier & Kraak, Menno-Jan. (2019). Integration and Exploitation of Sensor Data in Smart Cities through Event-Driven Applications. *Sensors.* 19. 10.3390/s19061372.
24.	Granell, C., Kamilaris, A., Kotsev, A., Ostermann, F, O., Trilles, S. (2020) 'Internet of Things' in Guo, H., Goodchild, M. F., Annoni, A. Manual of Digital Earth, Singapore, Springer Open, p404.
25.	Gretzel, U.; Sigala, M.; Xiang, Z.; Koo, C. 'Smart tourism: Foundations and developments', Electronic Markets, 2015, Vol. 25, pp 179-188.
26.	Guney, Caner. (2016). Rethinking GIS Towards the Vision of Smart Cities Through CityGML. ISPRS - International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences. XLII-2/W1. 121-129. 10.5194/isprs-archives-XLII-2-W1-121-2016.
27.	Hall, D. H., Palsson, C. and Price, J. 'Is Uber a substitute or complement for public transit?' Journal of Urban Economic, Elsevier, 2018, Vol. 108, pp 36-50.

28.	Higgins, S., 2012, The lifecycle of data management, in Pryor, G. Managing Research Data. London, Facet Publishing, ISBN 978-1-85604-756-2. and Ball, A., Review of Data Management Lifecycle Models. Research Report. Opus: University of Bath Online Publication Store, 2012.
29.	Hofer, Barbara & Casteleyn, Sven & Aguilar-Moreno, Estefanía & Missoni-Steinbacher, Eva-Maria & Albrecht, Florian & Lemmens, Rob & Lang, Stefan & Albrecht, Jochen & Stelmaszczuk-Gorska, Martyna & Vancauwenberghe, Glenn & Monfort-Muriach, Aida. (2020). Complementing the European earth observation and geographic information body of knowledge with a business-oriented perspective. Transactions in GIS. 24. 10.1111/tgis.12628.
30.	Idrizi, Bashkim. (2016). Volume 6 – International Scientific Journal: Micro Macro & Mezzo Geo Information. 10.13140/RG.2.1.4461.5287.
31.	Jasny, Johannes. (2020). Spatial data analysis in economics.
32.	Kalvet, Tarmo, Maarja Olesk, Marek Tiits, and Janika Raun. 2020. "Innovative Tools for Tourism and Cultural Tourism Impact Assessment" Sustainability 12, no. 18: 7470. https://doi.org/10.3390/su12187470
33.	Kita, Jaroslav & Keresty, Jan & Dano, Ferdinand & Kita, Pavol & Kollar, Patricia. (2020). Possible uses of spatial data in the geographic information system. 10.2478/9788395720475-018.
34.	Kotsev, A., Minghini, M., Tomas, R., Cetl, V. and Lutz, M., From Spatial Data Infrastructures to Data Spaces: A Technological Perspective on the Evolution of European SDIs, ISPRS INTERNATIONAL JOURNAL OF GEO-INFORMATION, ISSN 2220-9964 (online), 9 (3), 2020, p. 176, JRC120143.
35.	Kourtit, Karima. (2021). Cities and Spatial Data in the New Urban World: A Data-Analytic Exploration. 10.1007/978-981-33-4098-5_6.
36.	Kovacs, Zoltan & Vida, György & Elekes, Ábel & Kovalcsik, Tamás. (2021). Combining social media and Mobile Positioning Data in the Analysis of Tourist Flows: A Case Study from Szeged, Hungary. Sustainability. 13. 2926. 10.3390/su13052926.
37.	Książek K, Grochla K. 'Aggregation of GPS, WLAN, and BLE Localization Measurements for Mobile Devices in Simulated Environments'. Sensors (Basel), 2019, Vol. 19, No. 7:1694.
38.	Maris, Martin. (2020). Municipal changes in Slovakia. The evidence from spatial data. European Journal of Geography. 11. 58-072. 10.48088/ejg.m.mar.11.1.58.72.
39.	Martin, Raubal. (2020). Spatial data science for sustainable mobility. Journal of Spatial Information Science. 10.5311/JOSIS.2020.20.651.
40.	Maschio, Giuseppe & Ancione, Giuseppa & Lisi, Roberto & Milazzo, Maria Francesca. (2021). A GIS tool for the emergency management of terrorist actions in the transport of hazardous substance.
41.	Masser, Ian. (2005). The future of spatial data infrastructures.
42.	Merodio Gómez, Paloma & Limones, Efrain & Ramírez Santiago, Andrea & García, Efrain. (2020). Strengthening resilience in the Caribbean region through the Spatial Data Infrastructures Strengthening resilience in the Caribbean region through the Spatial Data Infrastructures. International Journal of Cartography. 7. 10.1080/23729333.2020.1830467.
43.	Michel, Gregorio & Guzmán Javier, Vladimir & Tapia, Santiago & Crompvoets, Joep. (2020). IDENTIFYING USERS' REQUIREMENTS OF GEOGRAPHIC INFORMATION FOR DISASTER RISK MANAGEMENT IN THE DOMINICAN REPUBLIC. ISPRS Annals of Photogrammetry, Remote Sensing and Spatial Information Sciences. VI-3/W1-2020. 10.5194/isprs-annals-vi-3-w1-2020-99-

	2020.
44.	Milne, D. and Watling, D. 'Big data and understanding change in the context of planning transport systems', Journal of Transport Geography, Science Direct, 2019, Vol. 76, pp 235-244.
45.	Naidu, Dadi Sanyasi. (2018) "GIS Applications to Smart Cities." International Journal of Advanced Multidisciplinary Scientific Research (IJAMSR), Volume 1(1): 1- 7.
46.	Noori, Negar & Jong, W MARTIN & Janssen, Marijn & Schraven, Daan & Hoppe, T. (2020). Input-Output Modelling for Smart City Development Input-Output Modelling for Smart City Development. Journal of Urban Technology. 27. 1-22. 10.1080/10630732.2020.1794728.
47.	Pei, T., Song, C., Shu, H. Liu, Y., Du, Y., Ma, T., Zhou, C. 'Big geodata mining: Objective, connotations and research issues', Journal of Geographic Sciences, Volume 20, 2020, pp 251-266.
48.	Peiris, Samadhi. (2020). Geographical Information System (GIS) for Disaster Management.
49.	Prandi, F., Devigili, F., M., Soave, M. Staso, U, D., De Amicis, R. '3D Web Visualization of Huge CityGML models' The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, Vol. cL-3/W3, La Grande Motte, 2015.
50.	Raun, J., Shoval, N. and Tiru, M. (2020), "Gateways for intra-national tourism flows: measured using two types of tracking technologies", International Journal of Tourism Cities, Vol. 6 No. 2, pp. 261-278. https://doi.org/10.1108/IJTC-08-2019-0123
51.	Razavi, S., Behrendt, C., Bierbaum, M., Orton, I. and Tessier, L. 'Reinvigorating the social contract and strengthening social cohesion: Social protection responses to COVID-19', International Social Security Review, 2020, Vol. 73, No. 3, pp 55-80.
52.	Schade, Sven & Granell, Carlos & Vancauwenberghe, Glenn & Keßler, Carsten & Vandenbroucke, Danny & Masser, Ian & Gould, Michael. (2020). Geospatial Information Infrastructures. 10.1007/978-981-32-9915-3_5.
53.	Senaratne, H., Mobasheri, A., Ali, A, L., Capineri, C., and Haklay, M. 'A review of volunteered geographic information quality assessment methods' International Journal of Geographical Information Science, 2017, Vol. 31, No. 1, pp. 139-167.
54.	Sjoukema, Jaap-Willem & Samia, Jalal & Bregt, Arnold & Crompvoets, Joep. (2021). Governance interactions of spatial data infrastructures: an agent-based modelling approach. International Journal of Digital Earth. 10.1080/17538947.2020.1868585.
55.	Song, W., and Wu, C. Introduction to advancements of GIS in the new IT era, Annals of GIS, 2021, Vol 27, No. 1, pp 1-4.
56.	Stepniak, C. and Turek, T. 'Possibilities of Using GIS Technology for Dynamic Planning of Investment Processes in Cities' *Procedia Computer Science,* 2020, Vol 176, pp 3225-3234 https://doi.org/10.1016/j.procs.2020.09.126
57.	Tan, Evrim & Pattyn, Valérie & Casiano Flores, Cesar & Crompvoets, Joep. (2021). A capacity assessment framework for the fit-for-purpose land administration systems: The use of unmanned aerial vehicle (UAV) in Rwanda and Kenya. Land Use Policy. 102. 10.1016/j.landusepol.2020.105244.
58.	Tao, Wang. (2013). Interdisciplinary urban GIS for smart cities: Advancements and opportunities. Geo-spatial Information Science. 16. 25-34. 10.1080/10095020.2013.774108.
59.	Tararin, A.M. & Belyaev, Valery. (2020). Spatial data in urban planning. Geodesy and Cartography. 965. 29-39. 10.22389/0016-7126-2020-965-11-29-39.
60.	Tosta, Nancy & Domaratz, Michael. (2020). The US National Spatial Data Infrastructure. 10.1201/9781003062691-3.

61.	Unger, Eva-Maria & Bennett, Rohan & Lemmen, Christiaan & Zeeuw, Kees & Zevenbergen, J. & Teo, CheeHai & Crompvoets, Joep. (2020). Global policy transfer for land administration and disaster risk management. Land Use Policy. 99. 104834. 10.1016/j.landusepol.2020.104834.
62.	United Nations Committee of Experts on Global Geospatial Information Management. *Future Trends in geospatial information management: the five to ten year vision – Third Edition*, 2020.
63.	Vancauwenberghe, Glenn & Loenen, B. (2018). Exploring the Emergence of Open Spatial Data Infrastructures: Analysis of Recent Developments and Trends in Europe. 10.1007/978-3-319-59442-2_2.
64.	Vancauwenberghe, Glenn & Loenen, B. (2019). Governing Open Spatial Data Infrastructures: The Case of the United Kingdom. 10.1007/978-3-030-14446-3_2.
65.	Vancauwenberghe, Glenn & Valečkaitė, Kotryna & Loenen, B. & Welle Donker, Frederika. (2018). Assessing the Openness of Spatial Data Infrastructures (SDI): Towards a Map of Open SDI. International Journal of Spatial Data Infrastructures Research. 13. 88-100. 10.2902/1725-0463.2018.13.art9.
66.	Wang, Yanxin & Li, Jian & Zhao, xi & Feng, Gengzhong & Luo, Robert. (2020). Using Mobile Phone Data for Emergency Management: A Systematic Literature Review. Information systems frontiers: a journal of research and innovation. 22. 1-21. 10.1007/s10796-020-10057-w.
67.	Wood, E., Ward, G, E., and Woolham, J. 'The development of safer walking technology: a review', Journal of Assistive Technologies, 2015, Vol. 9. 2. Pp 100-115. DOI:10.1108/JAT-07-2014-0017
68.	Xie, Y., Gupta, J., Li, T., and Shekhar, S. Transforming Smart Cities with Spatial Computing. *IEEE, International Smart Cities Conference,* 2019 DOI: 10.1109/ISC2.2018.8656800
69.	Zaragozí, Benito, Sergio Trilles, and Aaron Gutiérrez. 2021. "Passive Mobile Data for Studying Seasonal Tourism Mobilities: An Application in a Mediterranean Coastal Destination" ISPRS International Journal of Geo-Information 10, no. 2: 98. https://doi.org/10.3390/ijgi10020098
	Grey Literature Reviewed
70.	AA, European Low Emission Zones. Link. Accessed on: 10/06/2021.
71.	Ackerman, D. (2020) An Underwater Navigation System Powered by Sound, MIT News. Link. Accessed on: 09/06/2021.
72.	Cabinet Office, An Initial Analysis of the Potential Geospatial Economic Opportunity, UK, 2018. Link. Accessed on: 23/05/2021.
73.	European Commission (n), Press Release: Europe fit for the Digital Age: Commission proposes new rules and actions for excellence and trust in Artificial Intelligence. Link. Accessed on: 10/06/2021.
74.	Eurostat(c), File: People who used mobile devices to access the internet away from home or work, Eu-27, 2019 (%) BYIE20.png. Link. Accessed on:10/06/2021.
75.	Eurostat (d), Population Structure and Ageing: Increase in the share of the population aged 65 years or over between 2009 and 2019, 2020. Link. Accessed on: 15/06/2021.

76.	European Global Navigation Satellite Systems Agency, Galileo High Accuracy Service (HAS) Info Note, 2020. Link. Accessed on:10/06/2021.
77.	European Union(d), 2019, The European Union Earth Observation Programme. Link. Accessed on: 16/06/2021.
78.	European Union(g), About IMAPS (Interoperability Maturity Assessment of a Public Service). Link Accessed on:10/06/2021.
79.	European Union (j), Copernicus Land Monitoring Service. Link. Accessed on: 20/06/2021.
80.	European Union (k), Copernicus Marine Environment Monitoring Service. Link. Accessed on: 20/06/2021.
81.	European Union Agency for the Space Program, GEONAV IoT: Galileo dual frequency 5G, IoT devices and services for Drones, Assets Management and Elite sport. Link. Accessed on: 04/06/2021.
82.	Fatima, S., Desouza, K, Dawson, G, S. and Denforc, J, S. Analyzing Artificial Intelligence Plans in 34 Countries. Brookings Institute, TechTank, 2021. Link Accessed on: 15/05/2021.
83.	GeoPlace, Bridging central and local government with UPRNs to respond to COVID-19. Link. Accessed on: 10/06/2021.
84.	Government Business, The View from Above: Drones and Public Services. Link. Accessed on: 04/06/2021.
85.	Interreg Europe (d), A Policy Brief from the Policy Learning Platform on Environment and Resource Efficiency: Use of technologies for better protection and management of nature and biodiversity, 2019. Link. Accessed on: 20/06/2021.
86.	LADOT, Mobility Data Specification: Information Briefing, 2018. Link. Accessed on: 10/06/2021
87.	MaaS Alliance, What is Maas? Accessed at: Link. Accessed on: 10/06/2021.
88.	Mariana, M. Survey methods: Phone survey – CATI, IdSurvey, 2020. Link. Accessed on: 23/06/2021.
89.	McDougall, K. and Koswatte, S. 'The Future of Authoritative Geospatial Data in the Big Data World – Trends, Opportunities and Challenges,' Fig Commission 3 Workshop, Naples, 2018.
90.	National Geospatial Advisory Committee, Emerging Technologies and the Geospatial Landscape. Accessed at: Microsoft Word - NGAC Paper - Emerging Technologies and the Geospatial Landscape.docx (fgdc.gov) Accessed on: 20/05/2021.
91.	Neveux, E. Healthcare data: The new prize for hackers, SecureLink, 2020. Accessed at: https://www.securelink.com/blog/healthcare-data-new-prize-hackers/ Accessed on: 10/06/2021.
92.	OECD(a), Earth Observation for Decision Making, 2017. Link. Accessed at: 10/06/2021.
93.	OECD(b), Strengthening Digital Government, 2019. Link. Accessed on: 09/06/2021

94.	Positium, Blog: Building the future of public transport with mobile phone data and Remix. Link. Accessed on: 10/06/2021.
95.	Rogers, S. John Snow's data journalism: the cholera map that changed the world. The Guardian, 2013. Link. Accessed on: 10/06/2021.
96.	SmartCitiesWorld, UK wants to use location data to empower more passengers, 2019. Link. Accessed at: 10/06/2021.
97.	Symons, T. Using data to make services more personalised, effective and efficient: Discussion Paper, Nesta, 2016.
98.	UK Government, Geospatial Commission, Policy Paper - National Underground Asset Register Project Update, 2020. Link. on: 03/06/2021.
99.	Tiru, M. Overview of the Sources and Challenges of Mobile Positioning Data for Statistics, UNstats, 2020. Link. Accessed on: 23/06/2021.
100.	Xin, L. 2021, Hyper-accurate Positioning is Rolling Out Worldwide, MIT Technology Review. Link. Accessed on: 23/06/2021.
101.	Unlocking the Power of Location Data: The UK Geospatial Strategy 2020-2025. Link. Accessed on: 23/06/2021.
102.	Extreme Earth, About, 2019. Link. Accessed on: 21/06/2021.
103.	UK Government, Unlocking the Power of Location: The UK's Geospatial Strategy, 2020 to 2025. 2020. Link. Accessed on: 13/06/2021.

Annex 3. List of European Commission Projects Reviewed

	Project Name	COFOG classification(s)	Link
1	Mobile Positioning Data as a Source for Aggregated Human Mobility Statistics (MOBPOSSTAT)	Transport; Community Development; Other Industries (tourism)	Link
2	Variety, Veracity, Value: Handling the Multiplicity of Urban Sensors (VaVeL)	Transport	Link
3	Extended Reality for Disaster management And Media planning (xR4DRAMA)	Civil Defence	Link
4	Transforming Cellular Network Data into the Next Generation of Mobility Management Platform (TrafficWise)	Transport	Link
5	Smart Sharing (SMASH)	Transport	Link
6	Disrupting the Car-Sharing Market in Smart Cities through a Unified Cross-Border Platform	Transport	Link
7	Disrupting Logistics in Smart Cities and Regions through an Advanced Logistics Platform	Transport	Link
8	Everything Local, On-line (LocaLine)	General economic, commercial and labour affairs	Link
9	BusUp: Multi-platform On-demand Crowdsourced Bus Transportation for Smart City Mobility	Transport	Link
10	Making CO2-free City Logistics a Reality	Transport	Link
11	KAROS – Integration of a Dynamic and Predictive Short Distance Carpooling Offer into Route Planner Services	Transport	Link
12	Enhanced Buying Experiences in SMART CITIES	General economic, commercial and labour affairs	Link
13	Federating IoT and Cloud Infrastructures to Provide Scalable and Interoperable Smart Cities Applications, by Introducing Novel IoT Virtualization Technologies (Fed4IoT)	Waste management; Police Services; Transport; Protection of Biodiversity and Landscape; Police Services; Multi-functional	Link
14	Managing Crop Water Saving with Enterprise Services (MOSES)	Agriculture, forestry, fishing and hunting	Link
15	CityFlows - Decision-support System for Pro-active Crowd Management of Crowded Urban Spaces	Other industries (tourism); Public health services; Recreational and sporting events; cultural services	Link
16	Supporting the Decision-making in Urban	Transport	Link

	Transformation with the use of Disruptive Technologies (URBANITE)		
17	Improving Sustainable Development Policies and Practices to Access, Diversify and Foster Cultural Tourism in European Regions and areas (IMPACTOUR)	Other industries (tourism)	Link
18	Smart Heritage City (ShCity)	Other industries (tourism)	Link
19	Smart Cultural Tourism as a Driver of Sustainable Development of European Regions (SmartCulTour)	Other industries (tourism)	Link
20	Cities as Mobility Hubs: Tackling Social Exclusion Through 'Smart' Citizen Engagment (SMARTDEST)	Other industries (tourism)	Link
21	Policy Development based on Advanced Geospatial Data Analytics and Visualisation (PoliVisu)	Community Development; Transport; Waste Management	Link
22	Pre-Commercial Procurement of Future Autonomous Bus Urban Level Operation Systems (Fabulos)	Transport	Link
23	CityGo and CityDash Dashboard	Transport	Link
24	Smart Loading Zones in EU and Global market to regulate, control and monitor City Logistics - Last Mile Delivery in dense urban areas, based on Bluetooth devices and mobile apps for commercial drivers	Transport	Link
25	Smart Tourism Platform	Other industries (tourism)	Link
26	AgeSpot	Old age	Link
27	SITXell - Territorial Information System for the Network of Open Areas in the Province of Barcelona	Protection of Biodiversity and Landscape	Link
28	ELISE Energy Pilot	Fuel and energy; Pollution abatement	Link
29	Digital Urban European Twins for smarter decision making (DUET)	Community Development; Multi-functional	Link
30	A Citizen Observatory and Innovation Marketplace for Land Use and Land Cover Monitoring (LandSense)	Community development; Protection of biodiversity and landscape; Agriculture, forestry, fishing and hunting	Link
31	Heerlens Heitje – a Crowdtasking Platform for Governments	General economic, commercial and labour affairs	Link

Annex 4. List of Local and Regional Government Projects Reviewed

	Project Name	COFOG classification(s)	Link
1	Mirador GIS Platform in Valencia	Community development; Multi-functional	Link
2	SPRO Parking and Unloading Application in Barcelona	Transport	Link
3	Bus Network Planning in Tartu	Transport	Link
4	Sustainable and Smart City Planning Using Spatial Data in Wallonia	Community Development	Link
5	Thessaloniki -Shared Taxis in Greece	Transport	Link
6	Helsinki Smart Mobility Ecosystem	Transport	Link
7	WebGIS in Torfaen County	Community development; Multi-functional	Link
8	Smart City Valencia: Municipal Web COVID 19	Public Health	Link
9	City Synergy: COVID War Room in Cascais	Public Health	Link
10	Mobi Cascais Journey Planning App and Transport Management System	Transport	Link
11	AgriML: Machine Learning in South Tyrol	Agriculture, forestry, fishing and hunting	Link
12	Decarbonisation Platform Project in Vaasa	Fuel and energy; Pollution abatement	Link
13	Humberside Fire Rescue Service GIS Platform	Fire protection services	Link
14	Thames Estuary Story Map	Protection of biodiversity and landscape	Link
15	Severn Trent Water Crowdsourcing App and GIS platform	Water supply	Link
16	Northern Ireland Spatial National Infrastructure	Community development; General economic, commercial and labour affairs; Multi-functional	Link
17	Oxfordshire County Council and Oxfordshire Fire and Rescue Service GIS Platform	Fire protection services	Link
18	Transport for West Midlands: COVID-19 Response	Transport	Link
19	Dwe Cymru Welsh Water: Safer Drinking Water for Smarter Catchment Management	Water management	Link
20	City of London Police: Preventing Crime Through Evidence-based Policing	Police services	Link

21	Oxfordshire County Council Adult Care Services	Sickness and disability; Old age	Link
22	Worcestershire County Council Adult Social Care	Sickness and disability; Old age	Link
23	Broads Authority: Improving the Efficiency of National Park Maintenance	Protection of biodiversity and landscape	Link
24	Northumberland National Park Authority: Inspiring Visitors at a Digital Landscape Exhibition	Protection of biodiversity and landscape	Link
25	Passenger Experience at Dublin Airport	Transport	Link
26	Cork County Council: Responding More Effectively to Extreme Weather Events	Civil defence	Link
27	Donegal County Council: Crowd Sourcing Information to Improve Local Planning	Community development	Link
28	Norther Ireland Water GIS Platform for Operations and Customer Experience	Water management	Link
29	Greater London Authority: Collaborative Infrastructure Planning	Community Development; Transport; Water management; Housing	Link
30	Lambeth Council: Open Spatial Data	Community development; Multi-functional	Link
31	Sports Wales: Improving Access to Sporting Facilities in Wales	Recreation, sports, culture	Link
32	Avon & Somerset Constabulary: Neighbourhood Policing Design	Police services	Link
33	Loch Lomond: Protecting the Natural Park	Protection of biodiversity and landscape	Link
34	Westcountry Rivers Trust: Leading a Collaborative Approach to River Conservation	Protection of biodiversity and landscape	Link
35	Norfolk County Council: Improving the Commissioning of School Transport for Vulnerable Children	Transport; family and children; pre-primary and primary education; secondary education	Link
36	South Ayrshire Council: Citizen Engagement with Policy Making	Community development; Multi-functional	Link
37	Carlow County Council: Planning Application Process	Community development	Link
38	Starnberg District Office: Geoinformation for Development Plans	Community development	Link
39	Starnberg District Office: Solar Roof Cadastre	Community development; Pollution abatement	Link

40	GIS Platform for Construction Projects in the City of Cologne	Community development; Transport; Construction; Fuel and Energy; Housing	Link
41	Road Traffic Accidents in Hessen	Transport	Link
42	Danish Public Transit Agency: Bus Operations and Maintenance	Transport	Link
43	The Digitalization of the Port of Rotterdam	Transport; General economic, commercial and labour affairs	Link
44	Water Asset Management in Northern Tuscany	Water management	Link
45	The integration of the Inventory of Landslide Phenomenon in Italy in a Geoportal (IFFI project)	Civil Defence	Link
46	The Municipality of Milan Geoportal	Community development; Multi-functional	Link
47	Regional Territorial Information System of Puglia	Community development; Multi-functional	Link
48	GIS Platform for Road Surveillance in Rome	Transport	Link
49	Open data: Rome Mobility Agency	Transport	Link
50	GIS Parking Solutions in Rome	Transport	Link
51	Smart Airport Rome	Transport	Link
52	Road Traffic Management in Helsinki	Transport	Link
53	Road Traffic Management in Berlin	Transport	Link
54	Mostoles City Council GIS Platform	Community development; Multi-functional	Link
55	Valladolid Street Map	Community development; Multi-functional	Link
56	Granada Human Smart City	Community Development; Tourism; Transport; Multi-functional	Link
57	Xeoportal IDE Sanitago de Compostela	Community development; Multi-functional	Link
58	Analysis of Threats to Wildlife in the Badajoz Province	Protection of biodiversity and landscape	Link
59	GIS for Fire Management in the Donana National Park	Fire protection services	Link
60	The use of GIS for the Control and Response to the Tiger Mosquito in Madrid	Public Health	Link
61	Impulso VLCi: Smart Tourism Valencia	Other industries (tourism)	Link

62	Monitoring of Solid Waste Hauling and Street Sweeping Vehicles: Smart City Valencia	Waste management	Link
63	Smart Heritage Management: Smart City Valencia	Other industries (tourism)	Link
64	Smart Parking: Smart City Valencia	Transport	Link
65	Geoportal Smart City Valencia	Community development; Multi-functional	Link
66	Environmental Sensors on Buses: Smart City Valencia	Transport	Link
67	Management of Urban Noise: Smart City Valencia	Pollution abatement	Link
68	Smart Lighting: Smart City Valencia	Street lighting	Link
69	Operational Mobility Center: Smart City Amsterdam	Transport	Link
70	Parksharing: Smart City Amsterdam	General economic, commercial and labour affairs	Link
71	Urban Nature Amsterdam	Protection of biodiversity and landscape	Link
72	EyeBeacons, Wayfinding in Public Spaces: Smart City Amsterdam	Transport; Sickness and Disability	Link
73	App to Locate Nearest EV Charger: Smart City Amsterdam	Transport	Link
74	StreetSense: Smart City Amsterdam	Transport	Link
75	Public Transit Map: Malaga	Transport	Link
76	EasyWay Public Transport Map: Krakow	Transport	Link
77	Public Transit Map: Rennes	Transport	Link
78	Flanders Cooperative Intelligent Transportation System	Transport	Link
79	Citizen Location Services for Police: Scotland	Police Services	Link
80	**Local tourism insights from MPD – Setomaa in South Estonia**	Other industries (tourism)	Link
81	Sohjoa Last Mile Project: Forum Virium Helsinki	Transport	Link
82	RIDE2RAIL: Forum Virium Helsinki	Transport	Link
83	ITRACK Real-time Monitoring of the Rail Network: Forum Virium Helsinki	Transport	Link
84	Last Mile Autonomous Delivery (LMAD) Pilots:	Transport; General economic,	Link

	Forum Virium Helsinki	commercial and labour affairs	
85	Carbon Neutral Drone Services: Forum Virium Helsinki	Transport; General economic, commercial and labour affairs; Protection of biodiversity and landscape; Police Services	Link
86	GIS Platform and AI for Roads and Highways in Bavaria	Transport	Link
87	City Pulse: Stratumseind Living Lab	Police services	Link
88	Drones for Social Housing Surveying	Housing	Link
89	MPD to track tourist mobility in Chemin d'Arles	Other industries (tourism)	Link
90	How Busy is Toon: City Occupancy in Glasgow	Public Health	Link
91	Fix My Street Platform	Transport; Street lighting; Waste management; Water Management	Link
92	Geocode System to Crowdsource Information on Fly-tipping in Northamptonshire	Waste management	Link
93	Tvarkau Vilniu Platform: Non-emergency Citizen Reporting App	Transport; Street lighting; Waste management; Water Management	Link
94	Tickin App, Journey Planning in Rhein Neckar	Transport	Link
95	Rail Network Monitoring in Kent	Transport	Link
96	Digital Twin for Mobility Monitoring	Transport; Environmental Protection	Link
97	Sensors4Rail Pilot Project: Digital Twin of Railway in Hamburg	Transport	Link
98	NordicWay Dynamic Environmental Zones in Gothenburg	Transport	Link
99	Environmental Monitoring in Jotunheimen National Park	Protection of biodiversity and landscape	Link
100	Capacity Management Solution for the Beaches of the Costa del Sol	Other industries (tourism)	Link
101	Locating Mobile Blood-testing Units in Lothian	Public health	Link
102	Reducing Obesity through mapping Fast Food Vendors in Birmingham	Public health	Link
103	Hospital Location Planning in Somerset	Public Health	Link
104	Belfast Civic Dollar App	Public Health	Link
105	Hindrance Premium Tool in Flanders	Construction; General economic, commercial and labour affairs	Link

106	Underground Asset Register in Northumbria and London	Fuel and Energy; Water management; Waste management; Wastewater management; communication	Link
107	Flanders Underground Utility Location System (KLIP)	Fuel and Energy; Water management; Waste management; Wastewater management; communication	Link
108	Spotbooking in Flanders	Community development	Link
109	MijnTuinLab: Citizen Science Platform	Protection of environment and biodiversity	Link
110	AirBezen: Air Quality Map in Antwerp	Pollution abatement	Link
111	IssueDoc: Non-emergency Citizen reporting	Transport; Street Lighting; Waste Management; Water Management	Link
112	PARKTRACK: Smart Parking	Transport	Link
113	Heidelberg Smart Waste	Waste management	Link
114	Amsterdam Beacon Mile	Muti-functional; Other industries (tourism); General economic, commercial and labour affairs; Tourism	Link
115	Normandy GIS platform to manage COVID-19 Impacts	Public Health; General economic, commercial and labour affairs; Police Service	Link
116	Mapping of Species in Cergy-Pontoise	Protection of environment and biodiversity	Link
117	Loiret Interactive Tourism Map	Other industries (tourism)	Link
118	Monitoring of the COVID-19 epidemic in Île-de-France	Public health	Link
119	Regio 2N Regional Train Pilot in the North of France	Transport	Link
120	Reef Check Reunion in La Saline	Protection of environment and biodiversity	Link

Annex 5. Classification of Functions of Government

Table 3: COFOG classification structure

01 - General public services
- 01.1 - Executive and legislative organs, financial and fiscal affairs, external affairs
- 01.2 - Foreign economic aid
- 01.3 - General services
- 01.4 - Basic research
- 01.5 - R&D General public services
- 01.6 - General public services n.e.c.
- 01.7 - Public debt transactions
- 01.8 - Transfers of a general character between different levels of government

02 - Defence
- 02.1 - Military defence
- 02.2 - Civil defence
- 02.3 - Foreign military aid
- 02.4 - R&D Defence
- 02.5 - Defence n.e.c.

03 - Public order and safety
- 03.1 - Police services
- 03.2 - Fire-protection services
- 03.3 - Law courts
- 03.4 - Prisons
- 03.5 - R&D Public order and safety
- 03.6 - Public order and safety n.e.c.

04 - Economic affairs
- 04.1 - General economic, commercial and labour affairs
- 04.2 - Agriculture, forestry, fishing and hunting
- 04.3 - Fuel and energy
- 04.4 - Mining, manufacturing and construction
- 04.5 - Transport
- 04.6 - Communication
- 04.7 - Other industries
- 04.8 - R&D Economic affairs
- 04.9 - Economic affairs n.e.c.

05 - Environmental protection
- 05.1 - Waste management
- 05.2 - Waste water management
- 05.3 - Pollution abatement
- 05.4 - Protection of biodiversity and landscape
- 05.5 - R&D Environmental protection
- 05.6 - Environmental protection n.e.c.

06 - Housing and community amenities
- 06.1 - Housing development
- 06.2 - Community development
- 06.3 - Water supply
- 06.4 - Street lighting
- 06.5 - R&D Housing and community amenities
- 06.6 - Housing and community amenities n.e.c.

07 - Health
- 07.1 - Medical products, appliances and equipment
- 07.2 - Outpatient services
- 07.3 - Hospital services
- 07.4 - Public health services
- 07.5 - R&D Health
- 07.6 - Health n.e.c.

08 - Recreation, culture and religion
- 08.1 - Recreational and sporting services
- 08.2 - Cultural services
- 08.3 - Broadcasting and publishing services
- 08.4 - Religious and other community services
- 08.5 - R&D Recreation, culture and religion
- 08.6 - Recreation, culture and religion n.e.c.

09 - Education
- 09.1 - Pre-primary and primary education
- 09.2 - Secondary education
- 09.3 - Post-secondary non-tertiary education
- 09.4 - Tertiary education
- 09.5 - Education not definable by level
- 09.6 - Subsidiary services to education
- 09.7 - R&D Education
- 09.8 - Education n.e.c.

10 - Social protection
- 10.1 - Sickness and disability
- 10.2 - Old age
- 10.3 - Survivors
- 10.4 - Family and children
- 10.5 - Unemployment
- 10.6 - Housing
- 10.7 - Social exclusion n.e.c.
- 10.8 - R&D Social protection
- 10.9 - Social protection n.e.c.

Source: Eurostat (a), 2019

Annex 6. List of Location Data and/or Technology Suppliers Reviewed

	Location Data and Technology Vendor Name	Service	Link
1.	Arizona State University GEOspatial Data Library	Data	Link
2.	Back4App	Data	Link
3.	Cambridge, MA, US, GIS data on GitHub	Data	Link
4.	Copernicus	Data	Link
5.	Enel X	Technology	Link
6.	Esri	Technology	Link
7.	Eurogeographics	Data	Link
8.	Factual	Data & technology	Link
9.	Foursquare	Data	Link
10.	Galileo	Data	Link
11.	Geo Maps		Link
12.	Geo Wiki Project - Citizen-driven Environmental Monitoring	Data	Link
13.	GeoFabrik - OSM data extracted to a variety of formats and areas	Data	Link
14.	GeoNames Worldwide	Data	Link
15.	Global Administrative Areas Database (GADM)	Data & Technology	Link
16.	Google	Data & Technology	Link
17.	Greendex	Data & technology	Link
18.	Geographica	Technology	Link
19.	Here	Data & technology	Link
20.	Hexagon	Technology	Link
21.	Homeland Infrastructure Foundation-Level Data	Data	Link
22.	IEEE Geoscience and Remote Sensing Society DASE Website	Data	Link
23.	Inrix	Data & technology	Link
24.	IP2LOCATION	Data	Link
25.	Landsat 8 on AWS	Data	Link

26.	Loqate GBG	Data	Link
27.	Natural Earth - vectors and rasters of the world	Data	Link
28.	Openaddresses	Data	Link
29.	Openstreetmap	Data	Link
30.	Orange Business Services	Data &Technology	Link
31.	Pleiades - Gazetteer and graph of ancient places	Data	Link
32.	Positium	Technology	Link
33.	Slingshot Simulations	Technology	Link
34.	Teralytics	Technology	Link
35.	TomTom	Data & technology	Link
37.	UN Environmental Data	Data	Link
38.	What3words	Data & technology	Link
39.	W-Locate	Technology	Link
40.	Zencity	Technology	Link

Annex 7. List of Interviewees

Interview Type	Total	Name(s)	Position and Institution	Other relevant experience	Date
Local/ Regional Government	3	Pieter Bonnema	Senior Project Leader for Digital Innovation - Gemeente Heerlen	Independent advisor for city innovation projects	12/04/2021
		Jukka Talvi	Director of Municipal Infrastructure - City of Vaasa		26/05/2021
		David Bueno Vallejo	Previous CIO - City of Malaga; Associate Professor – University of Malaga School of Computer Science and Telecommunications.	CIO at the city of Malaga for 10 years, leading the Municipal Information Technology Centre (CEMI).	08/04/2021
Independent Experts	7	Frans-Anton Vermast	International Smart City Ambassador and Senior Strategy Advisor for Low Carbon and Connected Urban Planning - Amsterdam Smart City		05/05/2021
		Miranda Sharp	Member – Smart London Board; Member- Mayor of London Infrastructure Advisory Panel; Member – National Digital Twin Program	Previous Director of Innovation at Ordnance Survey	08/04/2021
		Fabio Cartolano	Innovation Manager and Transport Expert	Previous Expert Evaluator for EU H2020 Programs; Transport Expert	26/04/2021
		Maurizio Napolitano	Head of Unit of Digital Commons Lab Fondazione Bruno Kessler (FBK)	Represents the Open Knowledge Foundation in Italy and is an expert in Open Data and Open Street Map.	16/04/2021
		Prof. Marijn Janssen	Professor in ICT and Governance, Head of ICT at the Faculty of Technology, Policy and Management, Delft University		06/05/2021
		Veiko Lember (PhD)	Senior Research Follow Ragnar Nurkse Department of Innovation and		15/05/2021

			Governance, Tallinn University of Technology and Visiting Professor at the Public Governance Institute, KU Leuven		
		Ben Hawes	Associate Director, Connected Places Catapult; Engagement Director Benchmark Initiative Geovation	Contributor to the Locus Charter – a proposed set of international principles for the ethical use of location data	25/05/2021
		Joshua Rayner	Partnerships Manager – What3Words		28/05/2021
Vendor	4	Erki Saluveer	Director – Positium		25/05/2021
		Tamara Ciullo	Senior Product Marketing Specialist & Urban Mobility Specialist – HERE Technologies		10/06/2021
		Pratik Desai	Senior Product Marketing Manager (Global Public Sector Lead) – HERE Technologies	Public Safety Specialist	15/06/2021
Total	14				

Annex 8. Semi-structured Interview Guides

Qualitative Interview

Discussion Guide – Regional and Local Governments

+

Project "ELISE Lot 1 - Leveraging the power of location information and technologies to improve Public Services at Local Level: An EU-wide Analysis" aims to conduct an in depth mapping and critical analysis of recent initiatives, emerging solutions and their possible impacts, thereby organically structuring the information available at local and regional level, and investigating new practices - together with their replicability and scalability potentials - and suggest possible future pathways for the evolution of public services in the EU.

In-depth interviews conducted with relevant stakeholders in **regional and local governments** are especially focusing on identifying the main drivers and challenges which were encountered during the implementation, lessons learned in terms of governance and stakeholder management, and similar topics which are unlikely to be elaborated on in formal, publicly available documents.

The interviewer will not read all the questions systematically but will use this as a guide for the conversation to collect all the necessary information.

Name of interviewee	
Title	
Organization	
Country and location	
Contact info	**Email:** **Tel:**
Sector	
Company size	
Date of interview	
Place of interview	
Name of interviewer	
Does the interviewee wish to be quoted or prefer to be anonymous? **During the interview, please specify any data or content that cannot be quoted, if any**	
Yes, you can quote my name and organization	

Yes, you can quote my organization not my name	
No, I prefer to remain anonymous	

Questions

1. Please describe the most important services in your region/city/authority which leverage location data and technologies.
    a. Please elaborate on which location data and technology enabled services you have already implemented, which ones you are piloting and which ones you are considering for the next 3 to 5 years, but have not made any investment yet
2. How has the role of location data and technology changed over the past 3 to 5 years, for example in terms of sources of data, or location data sourced from the private sector. Or are you using location data and technologies to improve public services in new areas?
3. What is your region/city/authority key drivers for investing, implementing and adopting location data and technologies to improve public services?
4. What is your region/city/authority challenges that you are facing when investing, implementing and sustaining in location data and technology enabled services?
    a. In particular, please elaborate on the topic of interoperability (technical, semantic, organizational legal) and re-usability of solutions
5. Looking at your location data and technology-enabled projects, what are the key stakeholders of the project?
6. What lessons do you draw from stakeholder management and governance that you have so far?
7. Was it difficult to secure executive sponsorship and uptake among government employees? If so, how did you overcome organizational and cultural challenge?
8. What other main challenges did you encounter?
9. With the benefit of hindsight, what would you have done differently during the planning phase, through procurement, implementation and post-implementation in your latest location data and technology enabled public service improvement project?
10. Could you describe the impact of location data and technology-enabled services that you implemented? How did it impact concepts like equity of access, efficiency, transparency; and collaborative spirit across and within organization(s), re-use and interoperability?
11. How did you evaluate the impact of location data and technologies? Do you have a public value framework that you apply consistently? How do you select KPIs to assess the project ex ante and ex post? Please elaborate.
12. How did you approach your cooperation with local data and technology suppliers? What are the main gaps in the market?

Qualitative Interview

Discussion Guide - Experts

+

Project "ELISE Lot 1 - Leveraging the power of location information and technologies to improve Public Services at Local Level: An EU-wide Analysis" aims to conduct an in depth mapping and critical analysis of recent initiatives, emerging solutions and their possible impacts, thereby organically structuring the information available at local and regional level, and investigating new practices - together with their replicability and scalability potentials - and suggest possible future pathways for the evolution of public services in the EU.

In-depth interviews conducted with **experts** are especially focusing on identifying location data and technology enabled public service innovations, and their impact on public services.

The interviewer will not read all the questions systematically but will use this as a guide for the conversation to collect all the necessary information.

Name of interviewee	
Title	
Organization	
Country and location	
Contact info	**Email:** **Tel:**
Sector	
Company size	
Date of interview	
Place of interview	
Name of interviewer	
Does the interviewee wish to be quoted or prefer to be anonymous? **During the interview, please specify any data or content that cannot be quoted, if any**	
Yes, you can quote my name and organization	

Yes, you can quote my organization not my name	
No, I prefer to remain anonymous	

Questions

1. What are the latest trends that you see in the market regarding location data and technology enabled public services?
   a. Please elaborate on the most promising projects and initiatives that you have heard of in the European regional and local government space
   b. In your experience are there cross-sector applications of location data and technologies? Or are they emerging?
   c. In your experience are there cross-border applications of location data and technologies? Or are they emerging?
2. What are key drivers for regions, cities and other local authorities investing in location data and technologies?
   a. In particular, please elaborate on the topic of interoperability (technical, semantic, organizational legal) and re-usability of solutions as a key criteria for investing and implementing location data and technology.
3. What are key challenges for regions, cities and other local authorities investing in location data and technologies?
   a. Please elaborate on technical challenges, such interoperability, organizational, such as leadership and cultural change, financial, and other types of challenges
4. In your experience, what governance models are working to deliver successful location data and technology projects in regional and local government, from the planning phase, to procurement, to implementation and post-implementation?
5. Please elaborate on the way to conceptualize public value, the methodology, and KPIs to evaluate the success of location data and technology project for improving public services.
6. In your experience, what is the replicability of location data and technology solutions for improving public services? Are they context dependent or can they be successfully re-used by other regional and local governments? Including in different EU member states?

+

Project "ELISE Lot 1 - Leveraging the power of location information and technologies to improve Public Services at Local Level: An EU-wide Analysis" aims to conduct an in depth mapping and critical analysis of recent initiatives, emerging solutions and their possible impacts, thereby organically structuring the information available at local and regional level, and investigating new practices - together with their replicability and scalability potentials - and suggest possible future pathways for the evolution of public services in the EU.

In-depth interviews conducted with **vendors** are especially focusing on identifying location data and technology enabled public service innovations, and how vendors are working with the public sector to successfully implement those innovations.

The interviewer will not read all the questions systematically but will use this as a guide for the conversation to collect all the necessary information.

Name of interviewee	
Title	
Organization	
Country and location	
Contact info	**Email:** **Tel:**
Sector	
Company size	
Date of interview	
Place of interview	
Name of interviewer	
Does the interviewee wish to be quoted or prefer to be anonymous? **During the interview, please specify any data or content that cannot be quoted, if any**	
Yes, you can quote my name and organization	
Yes, you can quote my	

organization not my name	
No, I prefer to remain anonymous	

Questions

1. What kind of location data and technology does your company offer?
    a. Are your technologies interoperable?
    b. Is your company reusing existing data and technologies?
    c. Is your company applying international standards in the development of your location data and technologies? Please elaborate with examples
2. How has the role of location data and technology changed over the past 3 to 5 years, for example do your regional and local government customers use new sources of data, such as crowdsourced location data, or location data sourced from the private sector. Or are they using location data and technologies to improve public services in new areas?
3. What are the key target users and use cases in regional and local government that you provide your solutions to?
4. What are some of the most promising use cases that regional and local governments have started to ask you to pilot or investigate with them for future investments?
    a. From your experiences, what are the most promising improvements that location data and technology can bring to public services?
5. What are key drivers of investment for regions, cities and other local authorities buying your location data and technologies?
6. In your experience what are the key criteria that regional and local government apply when purchasing location data and technology?
    a. Are they asking explicitly for interoperability and reuse?
    b. Are location data and tech as stand-alone solutions, or as an integral part of larger IT system
7. What are key challenges for regions, cities and other local authorities investing in location data and technologies?
    a. Please elaborate on technical challenges, such interoperability, organizational, such as leadership and cultural change, financial, and other types of challenges
8. Considering those challenges, what are the critical success factors for actually improving public services with location data and technology?
    a. Please elaborate on the critical success factors from the technical, project management, organizational change, benefit realization, supplier-client relationship point of view

Annex 9. Quantitative Survey

INTRODUCTION:
We are looking to speak to representatives of regional governments, local governments, and local government subsidiaries who make, or help make, decisions related to the use of location information and geolocation technologies.

Geolocation technologies provide, manage, use, or deliver data and/or services that relate to a location or space on Earth; for example, the use of Geographical Information Systems (GIS) for asset management or the use of mobile location data to enable traffic and transport management.

The survey should take approximately 30 minutes to complete, depending on the answers you provide.

[DO NOT READ]
If you have any questions relating to the content or validity of the survey, please contact ….

Screeners

S1. Where is your organization located?

Please select one response:

1) Austria
2) Czech Republic
3) Denmark
4) Finland
5) France
6) Germany
7) Italy
8) Netherlands
9) Poland
10) Romania
11) Spain
12) Sweden
13) Other [TERMINATE]

CEE (2,9,10) WE (1,5,6,7,8,11) Nordics (3,4,12)

S2a. Which of the following industry classifications best represents the principal business activity of your company/organization?

Please select one response.

1) Regional government
2) Local government
3) **A subsidiary of regional or local government**, dealing with**:**
   a. Transportation
   b. Ports, stations, airports
   c. Bridges, tunnels, highways
   d. Tourism
   e. Public health and social care
   f. Arts, culture, museums
   g. Local fire and rescue
   h. Local police
   i. Economic development
   j. Resilience/Disaster risk management
   k. Waste management
   l. Housing

m. Parks and other recreational facilities
n. Other [TERMINATE]

S2b. (ASK about subsidiaries if S2a = 3–15)

Which one of the following best describes your organization?

1) Fully owned by regional or local government
2) Partly owned by regional or local government
3) Privately owned [TERMINATE]

S3. Which one of the following titles most closely represents your current position within your organization?

1) Elected official
2) Chief information officer
3) Chief innovation officer
4) Chief digital officer
5) Chief data officer
6) Chief innovation officer
7) Head of IT
8) Head of sustainability
9) Head of transportation
10) Head of the Mayor's Office
11) Head of another department that utilizes geolocation data and technologies in its delivery of services
12) Other; please specify
13) IT Director/ IT Manager *
14) GIS Head / GIS Manager *

*Added after FW ended, recoded from Other please specify

Q1c. Does your organization currently use, or plan to use, geolocation data and technologies to improve public services?

1) Currently uses
2) Not using but plans to use within the next 24 months
3) Neither uses nor plans to use

Q1d. (ASK if Q1c = 3) Are you knowledgeable about the concept of geolocation data and technologies?

1) Yes, I am very knowledgeable about it.
2) Yes, to a degree.
3) No, I have never heard of it. [TERMINATE]

S4. (ASK if Q1c = 1, 2) Which one of the following statements best reflects your role regarding your organization's utilization of geolocation data and technologies?

Please select one response.

1) I am the primary decision maker, and I am responsible to a large degree for either the implementation of geolocation data and technologies or for final service delivery or for both.
2) I am a part of a team that makes these decisions, and I understand well the impact of geolocation data and technologies on service delivery.
3) I have no or limited influence over decisions regarding geolocation data and technologies, or I have no visibility into how geolocation data and technologies influence our service delivery. [TERMINATE]

S5a. (ASK if S2a = 1 or 2) What is the population size of the geographic area (city or region) that your organization serves?

Please select one response.

1) Fewer than 20,000 inhabitants [TERMINATE]
2) 20,000 to 49,999 inhabitants
3) 50,000 to 99,999 inhabitants
4) 100,000 to 249,999 inhabitants
5) 250,000 to 499,999 inhabitants
6) 500,000 to 1 million inhabitants
7) More than 1 million inhabitants

S5b. (ASK if S2a = 3–15) What is the population size of the geographic area (city or region) where your organization has its headquarters?

Please select one response.

1) Fewer than 20,000 inhabitants [TERMINATE]
2) 20,000 to 49,999 inhabitants
3) 50,000 to 99,999 inhabitants
4) 100,000 to 249,999 inhabitants
5) 250,000 to 499,999 inhabitants
6) 500,000 to 1 million inhabitants
7) More than 1 million inhabitants

Questions

Q1a. (ASK if S2a = 1 or 2) In which policy areas does your organization currently use or plan to use geolocation data and technologies to improve public services?

Answer options:

(a) Currently uses
(b) Not using but plans to use within the next 24 months
(c) Neither uses nor plans to use

1) General public services (including all major sectors: executive and legislative organs, financial and fiscal affairs, foreign affairs)
2) Public order and safety — police services
3) Public order and safety — fire services
4) Economic affairs — agriculture, forestry, fishing and hunting
5) Economic affairs — transportation
6) Economic affairs — tourism
7) Environmental protection — waste management
8) Environmental protection — water and wastewater management
9) Environmental protection — pollution abatement
10) Environmental protection — biodiversity and landscape
11) Housing and community amenities (including all major sectors: housing development, community development, water supply, street lighting)
12) Health — public health services
13) Recreation, culture, and religion (including all major sectors: recreational and sporting events, cultural activities)
14) Education (including all major sectors: pre-primary, primary, secondary, tertiary)
15) Social protection (including all major sectors: sickness and disability, old age, survivors, family and children, unemployment)
16) Others; please specify
17) None [EXCLUSIVE]

Q1b. (ASK if S2a = 1 or 2) In which other policy areas does your organizations foresee that geolocation data and technologies will improve public services in the long term?

Use the same list as that used for Q1a, where Q1a = c (neither uses nor plans to use).

Q1acc. (ASK if S2a = 1 or 2 for more than 3 areas) **Please select the three policy areas in which geolocation data and technologies are used most frequently.**

Q2a. (ASK if Q1a = a, b). For each policy area in which you utilize geolocation data and technologies, please evaluate on 1–5 scale (on which 1 = not at all useful and 5 = extremely useful) its usefulness for improving public services. [List those items selected in Q1c or randomly selected if planes only (more than 3).]

1) Not at all useful
2) Slightly useful
3) Moderately useful
4) Very useful
5) Extremely useful

Q2aSubsidi. (ASK if Q1c = a, b). For the areas in which you do utilize location data and technologies please evaluate on 1-5 scale (one being not at all useful) its usefulness for improving public services.

1) Not at all useful
2) Slightly useful
3) Moderately useful
4) Very useful
5) Extremely useful

Q2b. (ASK only if Q2a = 3–5) For each policy area in which you have just indicated that geolocation data and technologies are useful, what public value has your organization achieved?

YES/NO answer for each item

1) Efficiency
2) Effectiveness
3) Accountability
4) Participation
5) Inclusiveness
6) Openness
7) Transparency
8) Economic development
9) Collaboration across public services

Q2bSubsidi. (ASK only if Q2aSubsidi = 3–5) You have just indicated that geolocation data and technologies are useful. What public value has your organization achieved from them?

YES/NO answer

1) Efficiency
2) Effectiveness
3) Accountability
4) Participation
5) Inclusiveness
6) Openness
7) Transparency
8) Economic development

9) Collaboration across public services

Q3. (ASK only if Q1a = a or Q1c = a) What key performance indicator (KPI) types do you use to evaluate the impact of geolocation data and technologies on your public services?

Please select all that apply.

1) Budgetary KPIs (e.g., project within budget, cost savings achieved, increased income)
2) Operational KPIs (e.g., project timeline met, increased volume of services rendered)
3) Subjective satisfaction KPIs (e.g., increased satisfaction with services)
4) Statistical quality of regional/city life KPIs (e.g., decreased commuting time, increased percentage of crimes solved, increased percentage of timely interventions in social services)
5) Others; please specify
6) We do not use any KPIs to evaluate the impacts of geolocation technologies. [EXCLUSIVE]

Q4. (ASK ALL) What are, or would you expect to be, the key benefits behind the use of geolocation data and technologies in your region/city?

1) Improved quality and responsiveness of citizen services
2) Increased citizen trust and engagement
3) Improved quality of life
4) Environmental sustainability
5) Improved public-service-mission outcomes (e.g., relating to transportation, public health)
6) Reduced cost of operations/Increased efficiency
7) Increased revenues (e.g., taxes, fees)
8) Innovation and smart solutions
9) Regulatory compliance
10) Other; please specify

Q5. (ASK if Q1a and Q1c = a, b) Which activities do geolocation data and technologies support? (Multiple choices allowed)

1) Structured activities
2) Monitoring and planning
3) Forecasting and strategic decision making

Q6. (ASK if Q1a and Q1c = a, b) What data types do you use in your geolocation data and technology projects aimed at improving public services?

Please select all that apply.

1) Geospatial
2) Cadastral
3) Earth observation and environment
4) Meteorological
5) Statistics
6) Company and company ownership
7) Mobility
8) Others; please specify

Q7. (ASK ALL) What is your view in general of the future development of geolocation data and technologies for public services?

Please select one response.

1) Geolocation technologies will be in use significantly more than they are today, with more areas where they will improve public services.
2) Geolocation technologies will be used more than they are today — primarily, in areas where they are already used.
3) Geolocation technology usage will remain more less at the level it is now.

4) We will see less usage of geolocation technologies.
5) I do not know.

Q8. (ASK if Q1a and Q1c = a) How has your organization engaged with the wider ecosystem of geolocation data and technology providers and users during the implementation of such initiatives?

[SELECT ALL THAT APPLY]

1) We have cooperated with other regional and local governments.
2) We have established PPP schemes to attract investors.
3) We have provided a sandbox environment to accelerate innovation.
4) We have engaged with NGOs to increase community involvement.
5) We have established public-private collaborations to share data for the public interest.
6) We have acted as a trusted data intermediary between citizens and other actors.
7) We have created a data pool with other actors to pursue a mutual interest.
8) We have engaged in data altruism — data sharing at no cost on a voluntary basis.
9) We have acquired data through procurement from a supplier.
10) We have partnered with a research institution for data sharing and analysis.
11) We have included data sharing obligations in contracts with our service providers.
12) We have appointed a person to act as a data steward to facilitate data sharing and collaboration.
13) Others; please specify
14) None of the above [EXCLUSIVE]

Q9. (ASK if Q1a and Q1c = a, b) What emerging technologies does your organization currently use or plan to use in your geolocation data and technology projects aimed at improving public services?

Answer options:

a. Currently uses
b. Not using but plans to use within the next 24 months
c. Neither uses nor plans to use

1) Machine learning and artificial intelligence
2) Edge computing
3) Cloud native computing
4) Blockchain
5) Immersive computing, such as augmented reality, virtual reality, and wearables
6) Connected and autonomous vehicles
7) High resolution earth observation/imagery
8) Drones
9) 5G
10) Digital twins
11) Urban data platforms

Q10. (ASK if Q1a and Q1c = a, b) What are, or will be, the top one or two key challenges related to investing in geolocation data and technologies for improving public services?

Please select 2 at most

1) Ageing and outdated IT
2) Lack of interoperability
3) Lack of access to reliable geolocation data
4) Lack of access to granular geolocation data
5) Lack of strategic plans in relation to adopting and developing geolocation data and technologies
6) Lack of leadership and resistance within the organization
7) Lack of digital skills among government employees
8) Lack of appropriate legal frameworks
9) Citizen trust and confidence issues

10) Budget/Financial constraints
11) Others; please specify

Q10a [ASK if Q10 = "Budget/Financial constraints"] What cost types do you struggle with the most?

[SELECT UP TO 2]

1) New hardware
2) Software licenses
3) Additional datasets — either licensed or acquired
4) Extra staff
5) Staff training
6) Professional services

Q11. (ASK if Q1a and Q1c = a, b) What is the biggest challenge you have experienced, or do you expect to experience, when implementing geolocation data and technologies to improve public services? Challenges stemming from:

1) Ageing and outdated IT
2) Lack of interoperability
3) Lack of access to reliable geolocation data
4) Lack of access to granular geolocation data
5) Lack of strategic plans in relation to adopting and developing geolocation data and technologies
6) Lack of leadership and resistance within the organization
7) Lack of digital skills among government employees
8) Lack of appropriate legal frameworks
9) Citizen trust and confidence issues
10) Budget/Financial constraints
11) Others; please specify

KJ-01-21-275-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:10.2760/158709

ISBN 978-92-76-41900-6