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Artificial Intelligence for Interoperability in the European Public Sector

An exploratory study

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Abstract

This report provides the result of a research study conducted within the context of the Public Sector Tech Watch, an observatory developed by DG DIGIT, with the support of the Joint Research Centre (JRC), that provides a knowledge hub and a virtual space where public administrations, civil society, GovTech companies and researchers can find and share knowledge and experience. The report's primary goal is to offer an analysis of how Artificial Intelligence (AI) systems are improving interoperability in the European Public Sector. The findings are based on three pillars: (i) a literature and policy review on the synergies between AI and interoperability; (ii) a quantitative analysis of a selected set of 189 use cases fitting the purpose of the research question; and (iii) a qualitative study going deeper into some illustrative cases. The findings highlight that the one-fourth of the cases collected are using AI techniques to support interoperability through a varied set of applications. Moreover, the semantic interoperability layer is fundamental in most of the cases. In addition, ontologies and taxonomies combined with AI can help in establishing interoperability between different systems. The solutions analysed classify, detect and provide structure, among other actions performed on data. Hence, AI has the capability to standardise, clean, structure and increase the usage of large volumes of data, thus improving overall quality and making it easier to use and share between different systems.

Foreword

In today's rapidly evolving world, where technology continues to shape our daily lives and reshape entire industries, digital transformation is having a profound effect on the way public services are delivered to citizens. Governments are accelerating their digital transition in order to become more efficient and deliver a better citizen experience.

The European Union has placed digital government transformation at the core of its policy agenda and backs its implementation through various initiatives. Europe's Digital Decade policy programme encompasses all digital aspects that will steer Europe through this transformative journey. The European Commission aids Member States in this journey through multiple funding programs, notably the digital Europe programme, the Recovery and Resilience Facility and the Technical Support Instrument.

Interoperability plays a key role in this context. Public administrations need to become increasingly interoperable to ensure seamless delivery of public services and faster and more efficient exchange

of data and information. It is in this context that the European Commission has proposed the Interoperable Europe Act, a new piece of legislation that aims at fostering cross-border public sector interoperability.

The advent of Artificial Intelligence (AI) has opened up a world of possibilities for promoting and improving interoperability in the public sector. Thanks to its ability to analyse and process large amounts of data, AI has the potential to bridge the gaps and break down the silos that often hinder effective collaboration and information sharing within government institutions and with their stakeholders, thereby improving their interoperability.

This exploratory study examines European practices in the use of AI to promote and improve interoperability. You will find in it elaborated analyses of AI-based solutions that effectively structure and link data and information, providing benefits such as identifying regulatory inconsistencies, streamlining processes, building vocabulary, and facilitating data linkage in specific domains. The research provides a glimpse of the enormous opportunity that AI can offer to improve service delivery and the overall efficiency of government operations.

By leveraging AI to foster interoperability, policymakers can harness the power of emerging technologies to drive transformational change in the public sector. This approach can lead to more robust and automated systems capable of sharing information consistently and securely, enabling governments to work together more effectively and providing citizens with better access to information and services.

To realise these benefits, there is a need to share theory, practice and experience, and to promote peer learning across the public sector. This is why this work is part of a broader initiative, the Public Sector Tech Watch, an observatory run by DG DIGIT with the support of the Joint Research Centre, which aims to create a knowledge hub and a virtual space where public administrations, civil society, GovTech companies and researchers can find, share and develop knowledge and experience.

We welcome and endorse the final results for assisting policymakers in the development of AI-based solutions for promoting interoperability in the public sector. Let's embrace AI-based solutions to manage and deliver better public services to our citizens and businesses, and to create public value in Europe.

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Executive summary

Objectives

Among the numerous benefits of Artificial Intelligence (hereinafter AI) for the public sector, one of the most relevant ones, due to its capabilities, is the use of AI to foster public sector interoperability (hereinafter AI4IOP). In other words, AI can be an essential tool for better structuring, curating, standardising and linking public administration data, in order to make them more interoperable within and outside a single organisation.

The report's primary goal is to offer an analysis of how AI systems are improving interoperability in the European public sector. The idea is to analyse AI-based solutions that better structure, link and interconnect data and information and which benefits these efforts bring for legal, organisational, semantic and technical interoperability.

Policy context

The policy context is rapidly evolving, concerning both interoperability and AI. With respect to interoperability, in November 2022, the European Commission published the Interoperable Europe Act, presently under negotiation. The aim of the act is to ensure a consistent EU approach to interoperability, establish an EU-wide interoperability governance structure, and to set up an ecosystem of reusable and interoperable solutions for public administration. In particular, Chapter 3 of the Act sets out measures to support the implementation of the Regulation. These include support for innovation and innovative solutions. With regard to AI, the first crucial step was taken in 2018 with the Coordinated Plan on the Development and Use of Artificial Intelligence COM (2018). Since then, several policy documents have been published. The main recent legislative step took place in April 2021, when the European Commission released the proposal for a regulation of the European Parliament and of the Council laying down harmonised rules on AI – the Artificial Intelligence Act – the first legal framework to regulate AI. This proposal aims to promote transparency and compliance with ethical requirements for systems that interact with humans by following a risk-based approach.

Key conclusions

The report offers a fresh view, adding new dimensions of analysis and some new insights in the existing body of knowledge on the use of AI systems to support interoperability in the public sector. Moreover, it illustrates with a clear picture how the capabilities of AI technology can improve interoperability by operating across different layers: technical, semantic, legal and organisational. Hence, AI can become be an essential tool for better structuring, curating, standardising and processing public administration data and enhancing interoperability within and outside public sector organisations.

However, public administration must take many steps to leverage the full capabilities of AI technology to support interoperability. Implementing an AI4IOP solution is a complex project that often requires cross-organisational collaboration. Moreover, there is a significant distance to cover in terms of approach to interoperability and awareness of the benefits that AI-based solutions can offer in terms of data or system interoperability. Creating awareness inside the public administration regarding the potential of this technology along with experimentation seems to be the way forward. In this direction, further research should gather and analyse additional practices that promote sharing experiences among public organisations. Furthermore, greater emphasis must be placed on ensuring the sustainable implementation in everyday operations by examining how technological inno-

vation is transforming organisational practices, procedures, processes and approaches in the public sector.

Main findings

The study includes a literature and policy review on the synergies between AI and interoperability, as the ability of organisations to interact towards mutually beneficial goals, a quantitative analysis of a selected from a list of 189 use cases, out of 720 cases fitting the purpose of the research question, and a qualitative study going deeper into some illustrative cases. The main results from the quantitative analysis are:

- About 26% of the cases collected in the public sector are using AI to support interoperability, confirming the relevance of the topic.
- The semantic layer of interoperability is relevant in 91% of the AI4IOP cases selected. Moreover, the usage of ontologies and taxonomies to create a common language and shared understanding of data, combined with AI technology, can help in establishing semantic interoperability between different systems.
- The most common area of application of AI-based services that support interoperability is internal management processes, with 36% of the cases.
- The main European Interoperability Framework (hereinafter EIF) principle that is driving the development and adoption AI-based solutions that support interoperability is administrative simplification, with 59% of the cases being by far the most relevant principle, followed by assessment of effectiveness and efficiency with 35% of the cases. Moreover, this indicates that these types of AI-based solutions provide a wide range of tools and services useful to reduce the administrative burden and at the same time comply with EU, national, regional or local obligations.
- The three most common actions that AI-based systems perform to boost data interoperability are: Detect (42%), Structure (22%) and Classify (16%). Moreover, these actions, taking advantage of the capability of AI technology to automatically process large volumes of data, help to increase the usage of standardised data formats, clean and structure large volumes of data, thereby improving its overall quality and making it easier to use and share between different systems.

In addition, the report includes an analysis of seven in-depth case studies. The main takeaways from this analysis are:

- The benefits are significant and diverse, ranging from the elimination and automation of repetitive tasks, to easier replicability and reusability of the service. This has a direct impact on the cost and quality of public services.
- The cases analysed have identified a number of challenges: (i) lack of skills and expertise, (ii) cross-border interoperability, (iii) complexity, (iv) system integration issues (v) compliance with laws and regulations, (vi) budget constraints, and (vii) quality of data.
- There is a significant distance to cover in terms of the approach to interoperability and awareness of the benefits that AI-based solutions can offer in terms of data or system interoperability.
- Public organisations need to move from a sporadic use of AI for interoperability to a more structured use based on specific and defined strategies for a more interoperable European public sector.
- Public organisations need to move towards a comprehensive, cross-organisational approach.

Policy recommendations

Thanks to the evidence collected it was possible to formulate some recommendations for policymakers and public managers dealing with AI4IOP solutions and implementation. The recommendations focus on which elements public organisations should consider when approaching the implementation of AI-based solutions that support interoperability in the public sector.

The recommendations are:

- Public administration should raise internal awareness regarding the possibilities of AI to improve interoperability, experimenting and discovering the benefits and potential to be exploited.
- Public administration should treat the adoption of a sustainable AI-based solution to support interoperability as a complex project with a special focus, both collaboratively and individually, on system integration, law compliance and data quality.
- Public administration should create the best environmental conditions for an effective collaboration between public agencies: this is based on a common understanding of the problems in order to facilitate data exchange and the integration of different systems and services.
- Public administration should promote the use of uniform and standardised ontologies and taxonomies to create a common language and shared understanding of data that, combined with AI technology, can help in establishing semantic interoperability between different systems.
- Public administrations should assess current legislations at early stages of the experimentation phase and regularly after the implementation of an AI4IOP solution.
- Public administration should support the upskilling of AI and interoperability specialists within the public administration, internalising in this way critical supervision tasks of AI systems that support interoperability.

Related and future JRC work

The report is written by the INNPULSE Team at the JRC. The Team is conducting research to provide in-depth scientific knowledge that is required to understand the ongoing digital transitions of the public sectors[1], digital governance[2], the use of new technologies to innovate public services and policymaking[3], trustworthy AI[4], location interoperability[5], and much more. For years, the JRC has developed high-level in-house expertise on digital government and the surrounding transformations in the public and private spheres. This includes contribution to the development and implementation of the Digital Single Market Strategy, the Interoperable Europe ACT, building evidence for regulatory intervention for a fair data economy, developing interoperability solutions and standards for data access, studying, and assessing the impacts of digital technologies on the economy, the society and the public sector, and identifying possible scenarios for Digital Governance. This report, conducted within the context of the Public Sector Tech Watch, an observatory developed by DG DIGIT, promotes and supports the digital transition of the public sector in Europe, especially the new interoperability policy, the implementation of the Digital Europe Programme, and the revised EC Digital Strategy.

1. https://joint-research-centre.ec.europa.eu/jrc-science-and-knowledge-activities/digital-transition_en

2. Millard, J., Impact of digital transformation on public governance, Manzoni, M. and Schade, S. editor(s), Publications Office of the European Union, Luxembourg, 2023, doi:10.2760/355723, https://publications.jrc.ec.europa.eu/repository/handle/JRC133975

3. https://joint-research-centre.ec.europa.eu/scientific-activities-z/innovations-public-governance_en

4. https://joint-research-centre.ec.europa.eu/jrc-science-and-knowledge-activities/trustworthy-artificial-intelligence-ai_en

5. https://joinup.ec.europa.eu/collection/elise-european-location-interoperability-solutions-e-government/about

1 Introduction

Governments have invested significant efforts over decades in designing tools and processes developed in line with standards for data exchange to increase interoperability between different public organisations. However, this process is still hindered by many challenges and blocking factors, such as administrative silos, a multitude of existing standards, etc.

The advent of AI has opened up a realm of possibilities for fostering interoperability among public organisations. Thanks to its capability of analysing and processing large amounts of data, AI has the potential to bridge the gaps and break down the silos that often hinder effective collaboration and information sharing within governmental institutions, hence **improving their interoperability**.

For example, one of the most challenging aspects regarding interoperability is the requirement to transition unstructured documents to structured data. Doing these tasks manually is nearly impossible, especially given the exponential growth in the volume, types and sources of data. In this regard, AI systems can be extremely useful, as they are capable of quickly processing and restructuring copious amounts of data, automating processes and creating standard formats that other participants of the workflows can access and use.

Moreover, with AI, workflows can be improved, and different users of the system can receive documents with automatically identified information. This way, AI can facilitate the integration, harmonisation and exchange of information, enabling stakeholders to access, apply and collaborate on critical data sets.

In other words, AI can be an essential tool for better structuring, curating, standardising and linking public administration data, in order to make it more interoperable within and outside the single organisation.

The understanding and use of AI as an interoperability enabler holds the promise of transforming the public sector in Europe into a connected, agile and efficient ecosystem, capable of delivering improved services, enhancing decision-making, and ultimately delivering better outcomes for citizens. By leveraging AI technologies, the public sector can overcome barriers such as incompatible systems, data fragmentation and varying standards, thereby promoting seamless interoperability across different departments, agencies and regions.

The report's primary goal is to offer an analysis of **how AI systems are improving interoperability in the European Public Sector**. The idea is to analyse AI-based solutions that better structure, link and interconnect data and information and what benefits these efforts bring for legal, organisational, semantic and technical interoperability. The study focuses on answering the following research question:

How can Public Administrations benefit from the use of AI to enhance interoperability?

To answer this question, the research follows an exploratory approach based on three different highlighted aspects:

- A literature review about what we know from the existing literature and the existing public sector policies in the field, looking at the synergies between AI and interoperability, starting from the IEF.
- A quantitative analysis of a selected set of 189 use cases fitting the purpose of the research question to gain a view on how public administrations are now using AI to enhance interoperability.
- A qualitative study going deeper into seven illustrative cases, to better observe which challenges, barriers and benefits derive from the use of these technologies.

Furthermore, this report contributes to the increasing body of knowledge about the adoption of AI in the public sector based on analysing original evidence on how AI is being used in this environment and how it is affecting interoperability. The report presents the state of play of AI for interoperability in the public sector in Europe, and identifies the challenges, drivers and also the risks of AI in the public sector and how to address them.

Chapter 2 provides an overview of the state of play in research and policies to provide both the background and context guiding the research conducted in the report. Chapter 3 reports the results of a quantitative analysis, in which the selected cases were categorised and described with the focus on how these cases are fostering interoperability. Chapter 4 includes a comparative-analysis of seven in-depth case studies describing how public administrations have experimented with AI-based solutions to support interoperability. Chapter 5 proposes a list of policy recommendations derived from the analysis, as well as recommendations for future research activities. An additional annex is included giving a more detailed description of each of the seven cases analysed as part of the in-depth case studies from in Chapter 4.

Finally, the entire AI use cases database (overall 720 cases), from which 189 cases have been selected, has been updated with the new cases and is now available in open data in the JRC data portal, to give policymakers and the research community access to the raw data in the hope of fostering further research based on the information collected by the AI Watch team over the years.

2 Scientific and policy background

2.1 The definition of interoperability

In the public sector, interoperability has been a crucial concept for many years. Its evolution can be traced back to the emergence of e-government in the late 1990s, which aimed to deliver public services online. At that time, interoperability was mainly viewed as a technical issue, focused on ensuring that different systems could communicate with each other (Casiano Flores et al., 2021).

However, as e-government matured and became more complex, the scope of interoperability expanded to include not just technical aspects but also data, processes and organisational structures. While some may view interoperability solely as a technical issue involving systems that need to communicate with each other, it is also vital to consider interoperability in terms of **data and processes**. This broader understanding of interoperability allows for more effective implementation of digital government, as it enables the breaking down of silos and the integration of different elements. Interoperability is, in fact, one of the key drivers of digital government, as it enables the seamless exchange of data and processes, promoting horizontality and collaboration between different departments and public institutions.

In 2004, the European Commission published the first EIF to promote the interoperability of European public services, followed by a 2010 version and the most recent one published in 2017. In the EIF, interoperability is defined as ***the ability of disparate and diverse organisations to interact towards mutually beneficial and agreed common goals, involving the sharing of information and knowledge between the organisations, through the business processes they support, by means of the exchange of data between their respective ICT systems.*** Moreover, it identifies legal, organisational, semantic and technical interoperability as the four pillars of integrated public service governance (European Commission, 2017) (See 3.2.2).

As digital government continues to evolve, the concept of interoperability is likely to become even more complex and multifaceted. Emerging technologies such as AI and blockchain have the potential to transform the ways in which data are exchanged and processed, presenting new challenges and opportunities for interoperability (Gad et al., 2022; Taeihagh, 2021).

2.2 Interoperability in the public sector: Potential benefits and challenges

As previously mentioned, the digitalisation of public administrations can be greatly enhanced by improving interoperability. Interoperability is expected to be a key factor to consider in the day-to-day operations of public administrations, as public service owners are facing several challenges when it comes to delivering public services that are digital by default. These include:

- Improving interoperability of digital public services and bringing their maturity to a higher level.
- Optimising the customer experience by providing "one-click" or proactive digital public services.
- Redesigning and standardising procedures to make digital public services more efficient, effective and transparent.
- Enabling seamless interaction of shared public services and promoting a culture of collaboration.

Given this context, significant efforts have been undertaken by international organisations and various governments around the world towards realising the potential benefits that come with embracing an open architecture for digital infrastructure via standard-setting frameworks (Ubaldi et al., 2019). Interoperability can also enable seamless communication and data sharing between different public sector organisations, resulting in more efficient and effective service delivery. Interoperability can facilitate innovation and the development of new services, as it enables the integration of existing systems and data (Borgogno and Colangelo, 2019; Campmas et al., 2022b; European Commission, 2017).

In addition to these advantages, interoperability is a critical factor in tackling societal issues including energy efficiency, healthcare provision, climate change mitigation and urban mobility. Although it is challenging to achieve full interoperability between different systems or organisations, its absence often results in unsatisfactory service delivery by public entities (Casiano Flores et al., 2022; Tambouris and Tarabanis, 2021).

Overall, interoperability in the public sector can lead to:

- **Improved service delivery**: Interoperability can enhance the quality and timeliness of public services. For instance, interoperable systems can provide citizens with a single point of access to different public services, making it easier for them to access the services they need.
- **Increased transparency and accountability**: Interoperability can lead to greater transparency in the delivery of public services by making it easier to track and monitor processes and outcomes.
- **Enhanced data quality**: Interoperability can improve the quality of data used in public service delivery by different systems ensuring data exchange and integration seamlessly, making it easier to identify and correct errors and inconsistencies and reducing manual data entry and processing.
- **Greater efficiency and cost savings**: Interoperability can help public sector organisations to optimise resources, avoid duplication of efforts and reduce costs associated with manual processes.
- **Facilitated cross-sectoral collaboration**: Interoperability can break down silos and foster collaboration across different sectors, enabling a more holistic approach to addressing complex issues such as digital transformation, and leading to innovative and effective solutions.

Despites its potential benefits, the implementation of interoperability in the public sector is still a significant challenge. The **lack of generally agreed/mandatory data formats** and **standards** is one of the main challenges, making it difficult for different systems to communicate with each other (Ray et al., 2011). For instance, different public organisations may use different data formats for the same type of information, such as names and addresses. This can lead to errors and inconsistencies when exchanging information, making it difficult to aggregate and analyse data from different sources (Casiano Flores et al., 2020).

Another challenge is the **complexity of integrating different systems** and services, which requires significant investments in time, resources and expertise. However, traditional approaches to interoperability, which rely solely on technical standards and specifications, still need to address the complexity of these challenges effectively (Casiano Flores et al., 2020). Therefore, there is a need to adopt a more inclusive approach that considers the needs and preferences of all stakeholders involved in developing and implementing interoperability solutions. Furthermore, interoperability requires a **coordinated effort among different stakeholders**, including public organisations, citizens and businesses (European Commission, 2017). Stakeholders may have different priorities and interests, which can create conflicts and hinder the adoption of common standards and approaches. Therefore, it is essential to involve all stakeholders in the interoperability initiatives and ensure that their concerns and needs are adequately addressed (Casiano Flores et al., 2020).

Historical legacies, such as the use of legacy systems and technologies, pose another obstacle for interoperability. In addition, many public organisations still need to use updated systems and software compatible with modern interoperability standards. Therefore, migrating to newer technologies and adopting common standards require substantial investments, resources and time (Peoples, 2018; Pradhan, 2019).

Privacy and security concerns are also crucial challenges to interoperability implementation in the public sector. The exchange of sensitive data and information across different systems and organisations may expose individuals' privacy and security (Chaturvedi and Kolbe, 2019). Therefore, ensuring the protection of personal data and maintaining robust security mechanisms are critical for interoperability. Govern-

ments need to establish clear policies and regulations to ensure the proper handling and protection of sensitive information (European Commission, 2017).

The **rapid pace of technological advancements** presents another challenge to interoperability implementation. New technologies emerge regularly, and public organisations must keep up with the latest trends to maintain compatibility with other systems. However, adopting new technologies requires significant training and capacity-building efforts to ensure public officials can use them effectively (Fortino et al., 2018).

In conclusion, the implementation of interoperability in the public sector faces various challenges, including the need for common data formats and standards, integration complexity, historical legacies, conflicting interests among stakeholders, privacy and security concerns, and the rapid pace of technological advancements. To overcome these challenges, governments must establish clear policies and regulations, invest in capacity-building and training, involve all stakeholders, and adopt common standards and approaches, as recommended by the EIF (European Commission, 2017).

Key challenges in interoperability could be summarised into eight clusters:

- Heterogeneous Systems: Variations in data formats, protocols and standards across different systems.
- Semantic Differences: Diverse interpretations and meanings of data elements.
- Scalability: Managing large volumes of data and complex interactions between systems.
- Real-Time Integration: Ensuring timely and continuous data exchange between systems.
- Legacy Systems: Historical use of outdated technologies that are incompatible with current interoperability standards.
- Security and Privacy: Balancing the need for data sharing with the need to protect sensitive information and maintain robust security protocols.
- Rapid Technological Advancements: Keeping pace with emerging technologies to ensure continued interoperability and exploit new opportunities.
- Organisational Culture: Overcoming resistance to change, and fostering a culture of collaboration and innovation is critical for the success of an interoperability initiative.

2.3 The European Commission's interoperability strategy

Recognising the pivotal role of interoperability among Member States, the European Union (EU) established the 'Interoperability Solutions for European Public Administrations' (ISA) funding program that ran between 2010 and 2015. This initiative was designed to foster the creation and interoperability of eGovernment services, enhancing their accessibility for European public administrations, businesses and citizens. To build on this momentum, the EU launched the ISA[2] program in 2016, which ran till 2020. This program sought to streamline the development of digital solutions, promoting interoperability across borders and sectors within public services.[6]

The digital single market, one of the EU's fundamental objectives, lies at the heart of these efforts. By nurturing this digital ecosystem, the EU aims to boost the European data economy, fostering benefits for citizens, public authorities, companies and researchers.[7]

In 2017, as a part of the digital single market strategy, the EU adopted the new EIF. This framework not only underscores the public sector's critical role as a regulator, service provider, and employer in the digital single market, but also offers models, guidance and recommendations to enhance the quality of European public services (European Commission, 2017).

Today, thanks to the 'Interoperable Europe' initiative[8] and the Interoperable Europe Act proposal[9], the EU aims to promote and foster interoperability at large in the European Union.

6. https://ec.europa.eu/isa2/isa2_en
7. https://ec.europa.eu/commission/priorities/digital-single-market_en#policy-areas
8. https://joinup.ec.europa.eu/interoperable-europe
9. https://commission.europa.eu/publications/interoperable-europe-act-proposal_en

2.4 The Interoperable Europe Act

The Interoperable Europe Act[10] is a legislative proposal put forward by the European Commission to promote interoperability in the public sector across the EU. The Act, together with its accompanying Communication[11], were recently adopted by the European Commission with the goal of strengthening cross-border interoperability and cooperation in the public sector throughout the EU. This Act is an essential step towards achieving Europe's digital targets for 2030 and supporting trusted data flows. Moreover, it aligns with and complements other key digital policies and initiatives of the EU, such as the Digital Services Act, the Digital Markets Act, the EU Digital Strategy, and the European Data Strategy (as discussed further in section 2.7).

The Act will support the creation of a network of sovereign and interconnected digital public administrations, accelerating the digital transformation of Europe's public sector. This will enable public administrations across the EU to cooperate more effectively, exchange information, and ensure the seamless delivery of public services across borders, sectors and organisational boundaries. It will also stimulate public sector innovation and public-private 'GovTech' projects.

To achieve this goal, the Interoperable Europe Act introduces a cooperation framework for public administrations across the EU that facilitates building a secure cross-border exchange of data and agreeing on shared digital solutions. These solutions may include open-source software, guidelines, checklists, frameworks, and IT tools. Moreover, it will help remove administrative burdens, including legal, organisational, semantic and technical obstacles, which might reduce costs and time for companies, citizens, businesses and the public sector itself.

The cooperation framework that the Interoperable Europe Act introduces will consist of structured EU cooperation, where public administrations, supported by public and private actors, come together in the framework of projects co-owned by Member States, as well as regions and cities. The Act also mandates assessments to evaluate the impact of changes in information technology systems on cross-border interoperability in the EU. To facilitate the sharing and reuse of solutions, often open-source, the Act proposes the creation of an 'Interoperable Europe Portal' that will serve as a one-stop-shop for solutions and community cooperation. The Act also includes innovation and support measures, including regulatory sandboxes for policy experimentation, GovTech projects to develop and scale up solutions for reuse, and training support. The Interoperable Europe Board will steer the future interoperability cooperation framework. The Board will be composed of representatives from the EU Member States, the Commission, the Committee of the Regions, and the European Economic and Social Committee. The Board will have the mandate to agree on common reusable resources, support and innovation measures, and update the EIF, which is Europe's widely recognised conceptual model for interoperability.

The European Commission has pledged to provide training materials on the use of EIF and Interoperable Europe solutions and implement a 'peer review' system to aid Member States in performing interoperability assessments. They have already published a slide-deck training material in English and four other European languages as a reference document to assist the 27 EU Member States, Iceland, Liechtenstein, Norway and Ukraine in improving the interoperability of their public services. Additionally, they plan to hold dedicated working meetings with certain Member States to boost their digitalisation and interoperability, enhance their scores on the EIF, and improve interoperability more generally.

Moreover, the Commission's proposal involves creating an Interoperable Europe portal to develop the necessary knowledge on interoperability and solutions, particularly for non-IT professionals. Communication and cooperation are critical factors for interoperability, and having a one-stop-shop to facilitate reliable exchanges of information in a common location where all public administrations can access supporting materials is essential. The proposal also

10. https://commission.europa.eu/system/files/2022-11/com2022720_0.pdf

11. https://commission.europa.eu/system/files/2022-11/com2022710_0.pdf

suggests establishing an Interoperable Europe Board that would be co-owned by Member States and the European Commission and supported by public and private entities.

2.5 The European Interoperability Framework

The European Interoperability Framework (EIF)[12] is a guidance document that sets out the principles and recommendations for achieving interoperability among European public administrations. Initial considerations and reflections on the interconnectivity of digital public services started in the 1990s and the first version of the EIF was published in 2004. It has since been updated and revised to reflect the changing technological landscape and the evolving needs of European public administrations (European Commission, 2017).

The original version of the EIF focused primarily on technical interoperability, providing guidance on the use of open standards and specifications to ensure that different systems and services could communicate with each other. However, over time, the EIF has evolved to include other aspects of interoperability, such as organisational and legal interoperability. In 2010, the EIF was updated to include a focus on semantic interoperability, which involves ensuring that data is shared in a way that can be understood and interpreted by different systems and services. This version of the EIF also emphasised the importance of cross-border interoperability, as European public administrations were increasingly working together to provide services to citizens across borders. In 2017, the EIF was updated again, with a focus on promoting the digital transformation of European public administrations. This version of the EIF emphasised the importance of citizen-centricity and the need to design and deliver digital public services that meet the needs and expectations of citizens. It also introduced the concept of interoperability by default, which means that interoperability should be considered from the outset of any digital project (European Commission, 2017).

The EIF serves as a guide, providing definitions, recommendations and insights to facilitate interoperability across diverse public administrations in Europe. Its purpose is to support the development of digital public services that are accessible, efficient and effective. By adhering to the principles and recommendations outlined in the framework, public administrations can enhance their capacity to collaborate, share information and provide improved services to citizens and businesses.

Considering the evolving digital landscape and the identified areas for improvement, the Interoperable Europe Act proposes a revision of the EIF. The Act emphasises the importance of publishing the EIF on the Interoperable Europe portal in open, machine-readable, accessible, findable and reusable formats, along with their metadata. Additionally, the Interoperable Europe Board is tasked with developing and updating the EIF as needed and proposing it to the Commission. These developments underscore the need for an updated EIF that aligns with current requirements and leverages opportunities presented by the European Digital Strategy and the Interoperable Europe Act. The revision process aims to address identified areas for improvement, enhance interoperability and foster effective collaboration among European public administrations.

2.5.1 Interoperability principles

The essential features of behaviour that must be considered while developing interoperability programs are referred to as interoperability principles. In order to create interoperable European public services, the EIF has defined some general interoperability rules. They provide a description of the environment in which European Public Services are designed and implemented. It is possible to merge 12 EIF principles9 in four categories that might be utilised in any solution development:

- The guiding principle for interoperability-related EU activities (principle 1).
- Interoperability's core values (principles 2 to 5).
- General guidelines for user requirements and expectations (principles 6 to 9).
- Guidelines for intergovernmental collaboration (principles 10 to 12).

12. https://joinup.ec.europa.eu/collection/nifo-national-interoperability-framework-observatory/european-interoperability-framework-detail

Interoperability principles of the EIF[13]:

1. **Subsidiarity and Proportionality:** The level of governance at which services are delivered should be the lowest that is competent to deliver them effectively, and action taken should not exceed what is necessary to achieve the objectives.
2. **Openness:** Public services should be designed and delivered in a way that ensures that they are open and can support multiple platforms, technologies and devices as user needs evolve, unless restrictions apply.
3. **Transparency:** Providing clear visibility into the administrative processes, rules, data, services and decision-making of public administrations. This includes ensuring accessibility to interfaces within their diverse and disparate information systems, while also safeguarding the protection of personal data in compliance with the relevant legal framework.
4. **Reusability:** Public administrations should prioritise the reuse of existing components when developing or deploying digital public services to avoid duplicating work, promoting cost-effectiveness and efficiency, which contribute significantly to the development of the EU's digital single market.
5. **Technological Neutrality and Data Portability:** Public administrations should prioritise functionality over specific technologies to minimise dependencies and ensure data can be easily transferred and reused across various systems and applications, facilitating the smooth operation of the digital single market.
6. **User-centricity:** User needs and requirements should guide the design and development of public services, in accordance with the following expectations.
7. **Inclusion and Accessibility:** Digital public services must be inclusive and accessible for everyone, including people with disabilities.
8. **Security and Privacy:** Digital public services must ensure a high level of security, protect privacy, and provide transparent information about how personal data is processed.
9. **Multilingualism:** Given the multilingual nature of the EU, digital public services should be designed to work in multiple languages whenever possible.
10. **Administrative Simplification:** Procedures and processes should be as simple as possible to make digital public services easy to use and understand.
11. **Preservation of Information:** Information must be preserved for future use in a way that takes into account long-term access, readability and integrity.
12. **Assessment of Effectiveness and Efficiency:** The value of interoperable public services must be assessed through several possible KPI (key performance indicators) like: ROI (Return on Investment), TCO (Total Cost of Ownership), level of flexibility and adaptability, reduced administrative burden, efficiency, reduced risk, transparency, simplification, improved working methods, and level of user satisfaction.

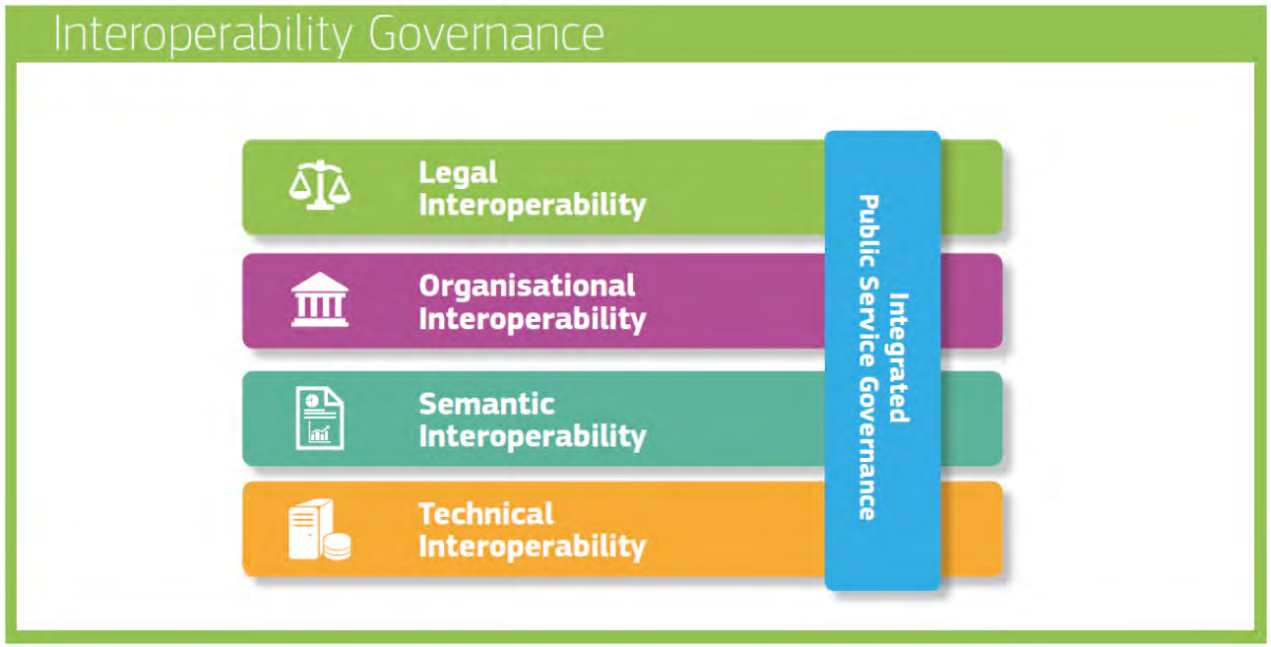
13. For a detailed description of the EIF principles, see https://joinup.ec.europa.eu/collection/nifo-national-interoperability-framework-observatory/2-underlying-principles-european-public-services.

The 12 EIF principles are used inside the EIF guidelines to represent the context in which European public services are designed and implemented. Interoperability is endorsing and facilitating the adoption of these principles in the implementation of Public Services. This exploratory research aims to identify the most commonly exploited EIF principles that are driving the adoption of AI technology in different public sector contexts.

2.5.2 Interoperability layers

The interoperability governance within an organisation or system is primarily shaped by an interoperability model that consist of four interoperability layers that are applicable to all digital public services and may also be considered as an integral element of the interoperability-by-design paradigm. They provide a structured approach to managing the complexities associated with interoperability (European Commission, 2017).

Figure 1. The EIF interoperability layers



Source: European Commission

- **Legal interoperability** refers to the ability of different legal systems to work together in a harmonised way to enable the provision of seamless services across borders and sectors. Legal interoperability involves establishing common legal frameworks and agreements to ensure that different organisations, systems and services can interact and exchange data while complying with legal requirements and respecting data protection and privacy regulations. This includes the need for standardisation and harmonisation of legal frameworks and regulations, such as data protection, security, intellectual property rights and access to information. It also involves the use of common standards, contracts and agreements to ensure consistency and facilitate interoperability across different legal systems. Legal interoperability is critical in enabling cross-border and cross-sector services, such as e-government, e-health, and e-business, and in facilitating the exchange of data and information between different organisations and sectors, while ensuring compliance with legal and regulatory requirements.
- **Organisational interoperability** refers to the ability of organisations to cooperate and share information to achieve common objectives. It involves coordination between different organisations, as well as the alignment of their policies, proce-

dures and business processes. Organisational interoperability is a key factor in achieving interoperability across different public administrations and government agencies. It includes aspects such as shared governance models, mutual recognition of data and common approaches to data management. To achieve organisational interoperability, it is important to have a clear understanding of the roles and responsibilities of different organisations, as well as their business processes, data requirements and technical infrastructures. This can be facilitated using standard frameworks and methodologies, as well as through the establishment of formal agreements and partnerships between organisations.

- **Semantic interoperability** refers to the ability of different systems and services to exchange and interpret data and information based on a common understanding of the meaning of that data. To achieve semantic interoperability, it is necessary to use common vocabularies, data models and ontologies that enable systems to understand the semantics of the data being exchanged. This means that the data must be structured and labelled in a consistent way, using standard formats and metadata, to ensure that it can be understood by both human users and machines. Semantic interoperability is particularly important in the public sector, where different organisations and systems need to exchange information in order to deliver services to citizens and businesses. By using common standards and semantic models, public sector organisations can reduce duplication of effort, improve data quality and enhance the efficiency and effectiveness of service delivery. In the EIF, semantic interoperability covers both semantic and syntactic aspects.
- **Technical interoperability** is about enabling the exchange of data in a seamless and secure way. This involves various aspects such as interface specifications, interconnection services, data integration services, data presentation and exchange, and secure communication protocols. Interface specifications refer to the standardised methods and formats used for communication between systems, which can ensure that data is understood and processed correctly. Interconnection services are the tools and methods used to establish connections between different systems and services. Data integration services are used to transform and combine data from different sources to ensure that they are consistent and usable across different systems. Data presentation and exchange refers to the ability of systems to present and share data in a meaningful way, using common standards and formats. Finally, secure communication protocols are essential for ensuring that data are transmitted and stored securely, protecting it from unauthorised access or modification. Overall, technical interoperability plays a crucial role in enabling different systems and services to work together effectively and efficiently, allowing for seamless data exchange and collaboration across different organisations and sectors.

These four layers of interoperability are interdependent and must be considered together to achieve true interoperability in the public sector. For example, a technical solution that allows for data exchange between two systems will not be sufficient if the data are not understood in the same way by both systems, or if the legal and regulatory framework does not allow for the exchange of the data. Therefore, it is important to consider all four layers of the EIF when implementing interoperability solutions in the public sector.

2.5.3 The proposal of a European Interoperability Framework for Smart Cities and Communities

The European Interoperability Framework for Smart Cities and Communities (EIF4SCC)[14] is a proposal built on the EIF and other EU initiatives that specifically addresses the challenges of in-

14. https://op.europa.eu/en/publication-detail/-/publication/f69284c4-eacb-11eb-93a8-01aa75ed71a1/language-en

teroperability in the context of smart cities and communities. Smart cities and communities are an increasingly important aspect of urban development, as they leverage technological advancements to enhance the quality of life for citizens and promote sustainable growth.

The EIF4SCC was developed in 2021 as part of the EC commitment to support the development of smart cities and communities across Europe. It is based on the same principles and recommendations as the EIF, but with a specific focus on the needs and requirements of smart cities and communities. The framework aims to equip local administration leaders with definitions, principles, recommendations, practical use cases, and a common model that can streamline public service delivery across domains, cities, regions and borders.

In addition to the four layers of the EIF – legal, organisational, semantic and technical – the EIF4SCC adds a fifth 'cultural' layer, which emphasises the importance of citizen engagement and co-creation in smart city projects. This cultural layer encourages the development of solutions that consider the diverse needs and expectations of citizens and promotes their participation in the design and implementation of those solutions. Furthermore, the EIF4SCC promotes the use of open standards and specifications to ensure interoperability and avoid vendor lock-in.

Public administrations, businesses and other stakeholders involved in the development of smart cities and communities could use the EIF4SCC as a valuable tool to design and implement interoperable digital solutions that are both effective and citizen centric. By promoting interoperability, the EIF4SCC aims to facilitate the development of innovative and sustainable digital solutions that contribute to the development of smart cities and communities across Europe.

2.5.4 Study on the development of a European Framework for Interoperability Skills and Competences in the public sector

The study on the development of a European Framework for Interoperability Skills and Competences (EFISC)[15] was developed to provide a standardised approach for identifying and developing the necessary skills and competences to support interoperability in the public sector. The framework builds on the EIF and aims to support its implementation by defining the necessary skills and competences required by public sector employees, service providers and other stakeholders to achieve interoperability (European Commission, Directorate-General for Informatics, 2021).

The EFISC provides a common language and understanding of the skills and competences necessary for achieving interoperability in the public sector. It was funded by the ISA[2] programme in response to the need for a coherent approach to developing interoperability skills and competences across the European Union. In particularly, it proposes four pillars: attitudes, skills, values and knowledge elements. Moreover, it serves as a reference framework for training and development programs for public sector professionals, as well as for the assessment and certification of interoperability skills and competences.

2.5.5 The EIF Toolbox

The EIF Toolbox[16] is a comprehensive and dynamic guidance tool developed by the European Commission to facilitate national public administrations in aligning their National Interoperability Frameworks (NIFs) with the EIF, with the aim of promoting interoperability at both the national and European levels. The toolbox offers a complete and holistic approach to interoperability, providing access to information, guidance and reusable solutions or components that can be used to tackle specific aspects of interoperability when designing a new digital solution.

The structure of the toolbox provides support for all aspects of the EIF, including the 12 principles and 47 recommendations. It contains guidance documents that offer a theoretical background on the framework's pillars, as well as operation-

15. https://op.europa.eu/en/publication-detail/-/publication/4e07a84f-abbf-11eb-927e-01aa75ed71a1

16. https://joinup.ec.europa.eu/collection/nifo-national-interoperability-framework-observatory/solution/eif-toolbox/eif-toolbox

al solutions for the alignment and implementation of the EIF. Additionally, to provide a comprehensive support and guidance experience, the EIF Pillars section of the toolbox includes a range of interactive elements, such as EU legal/policy initiatives, good practices and concrete examples, and open standards and specifications related to the implementation of the EIF.

The EIF Toolbox is a dynamic and evolving tool that emphasises practical implementation success stories, thereby bridging the gap between public administrations and interoperable digital public services. Its resources and tools are continually updated to ensure its relevance and effectiveness in promoting interoperability at the national and European levels. Overall, the EIF Toolbox could be a valuable resource for national public administrations, providing guidance and tools to align their NIFs with the EIF and promote interoperability among their systems and services. By using the tools provided in the toolbox, public administrations can develop digital public services that might be more accessible and effective, ultimately contributing to a more connected and interoperable Europe.

2.5.6 The European Interoperability Reference Architecture (EIRA)

The European Interoperability Reference Architecture (EIRA)[17], developed by the ISA² Programme, is an essential tool in modernising public administrations and facilitating interoperable public services. Its objectives are to aid in the design of eGovernment solutions, provide a reference model for assessing architectures, assist in communication and sharing of interoperable elements, and facilitate the discovery and reuse of interoperable solutions. EIRA© targets public administration stakeholders such as architects, business analysts and portfolio managers. Architects can leverage it for solution architecture design, business analysts for assessing the impact of changes on IT systems, and portfolio managers for maintaining an asset catalogue and making investment decisions.

The benefits of EIRA© are manifold. It fosters network effects, enhances coordination between EU and Member States' public administrations, and leverages Enterprise Architecture principles, leading to more efficient business and IT operations, better returns on investment, and faster, simpler, cheaper procurement. EIRA© also promotes awareness and use of EIF principles and recommendations.

While interoperability implies reusability, the scope of EIRA© extends beyond this, facilitating interoperability at different organisational and geographical levels, thereby enabling efficient business processes, and transitioning from traditional channels to digital service delivery.

2.5.7 The Interoperable Europe (IOPEU) Academy[18]

The IOPEU Academy, part of the European Commission's Interoperable Europe initiative and funded under ISA², was established in 2019. It aims to enhance advanced digital skills in interoperability in public administrations. It provides a range of online, self-paced Massive Open Online Courses that are accessible to anyone interested in this field. The primary focus is on empowering public servants involved in digital transformation for policy support, service delivery improvement and impact assessment.

The IOPEU Academy offers resources through two platforms: Joinup[19] and the EU Academy[20]. On the Joinup page, you can find various resources aimed at enhancing advanced digital skills and promoting interoperability. In addition to this, the EU Academy hosts Interoperable Europe Academy eLearning courses on its Community Page.

For the years ahead, the IOPEU Academy has set reusability as its main objective. This will involve sharing instructions and support for users in order to facilitate the reuse and creation of learning materials. Furthermore, the curriculum of the IOPEUA will be developed based on the latest

17. https://joinup.ec.europa.eu/collection/european-interoperability-reference-architecture-eira/about

18. https://joinup.ec.europa.eu/collection/digital-skills-public-sector/solution/interoperable-europe-academy

19. https://joinup.ec.europa.eu/

20. https://academy.europa.eu/

trends and requirements in digital skills training within the public sector. In order to enhance user engagement and promote community collaboration, starting from 2023, efforts will include establishing an Academic/Event Calendar hosted by the EU Academy's space, publishing more eLearning content such as courses, events, lecture series and seasonal schools. To foster a stronger sense of community around advanced digital skills and promote exchange among participants, multilingualism will be emphasised. With this goal in mind, the IOPEU Academy aims to translate all courses into every language spoken across the EU.

2.6 Relation of the Interoperable Europe Act to other digital policies

The Interoperable Europe Act is a significant addition to the European Union's efforts to improve the governance of digital services (European Commission, 2021). It complements the Digital Services Act[21] and the Digital Markets Act,[22] which were previously agreed upon by the European Commission, European Parliament and European Council (European Parliament, 2020). The Act is part of the broader **Digital Single Market Strategy**, which aims to establish a single market for digital goods and services within the EU, recognising the importance of digital technologies such as AI to achieve this objective (European Commission, 2020a). The Act promotes the development and use of AI and other digital technologies to enhance the delivery of public services across Europe (European Commission, 2020b).

Furthermore, the Interoperable Europe Act recognises the importance of interoperability in the development and deployment of AI applications, both within and between organisations, to ensure that they can effectively and efficiently communicate and exchange data with other systems (European Commission, 2021). This is crucial to ensure that AI can fulfil its potential in enhancing public services in healthcare, education and transport, among other areas.

The Act is closely linked to the **Digital Decade**, which is the EU's strategy for digital transformation over the next decade, aiming to create a sustainable, inclusive and secure digital single market and to make the benefits of digital transformation accessible to all EU citizens and businesses (European Commission, 2021). Interoperability is a key priority of the Digital Decade, and the Interoperable Europe Act is a crucial part of its strategy to achieve interoperability across the EU's public sector. The Act supports other key priorities of the Digital Decade, including the development of digital skills, deployment of digital infrastructure, and promotion of digital innovation (European Commission, 2021).

Other key initiatives related, some already mentioned, are:

- **Digital Services Act** (DSA) package, which aims to update the existing EU legal framework for digital services provided by the private sector and create a safer online environment for users. The DSA proposal would introduce new obligations for digital services providers, including increased transparency and accountability measures, such as obligations to publish information about how they moderate content, as well as clear rules on online advertising and targeted content.
- **Digital Markets Act** (DMA), which aims to establish new rules to address the dominant position of large online platforms and promote fair competition in the digital market. The DMA proposal would set out new obligations for large online platforms, including transparency measures for online advertising and obligations to allow users to switch to alternative service providers easily.
- The EU has also laid out an EU **Digital Strategy**[23], which sets out a comprehensive approach to foster the development and uptake of digital technologies, including AI and the Internet of Things (IoT). The strategy includes initiatives to boost digital skills and literacy, encourage

21. https://digital-strategy.ec.europa.eu/en/policies/digital-services-act-package

22. https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/europe-fit-digital-age/digital-markets-act-ensuring-fair-and-open-digital-markets_en

23. https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/europe-fit-digital-age/digital-markets-act-ensuring-fair-and-open-digital-markets_en

investment in digital infrastructure, and promote the use of digital technologies in public services.

- Additionally, the EU has proposed the **European Data Strategy**[24], which aims to create a single market for data, while also ensuring that data privacy and security are protected. The strategy includes proposals to establish common European data spaces, improve data interoperability, and increase investment in research and innovation in the field of data.
- **eGovernment benchmark**[25]: The eGovernment Benchmark is an initiative that assesses the digital performance of EU Member States in providing online public services. It measures aspects such as human-centricity, transparency and cross-border usability, with the goal of driving improvements in eGovernment services across Europe.
- **Sustainable Development Goals** (SDGs)[26]: The EU aligns its digital policies with the United Nations' SDGs. These goals address various global challenges, and digital transformation plays a crucial role in achieving them. The EU strives to ensure that digital initiatives contribute to, for instance, sustainable development, societal well-being and environmental sustainability.

2.7 AI in the public sector and its relevance for interoperability

The emergence of AI has unlocked a range of possibilities for promoting interoperability among public organisations. By harnessing its ability to analyse and process vast amounts of data, AI has the potential to bridge gaps and dismantle the barriers that often impede effective collaboration and information sharing within government institutions. This fusion of AI and interoperability holds the potential to transform the European public sector into a connected, agile and efficient ecosystem, capable of delivering enhanced services, improving decision-making and ultimately achieving better outcomes for citizens. By leveraging AI technologies, the public sector can overcome obstacles such as incompatible systems, fragmented data and varying standards, thereby promoting seamless interoperability across different departments, agencies and regions.

For better understanding the role of AI in fostering interoperability, it is first worth positioning the topic within the broader context of the policy landscape of AI in Europe and the current body of research on AI in the public sector.

2.7.1 AI policy landscape

The definition of artificial intelligence is a complex and much-debated topic, with various perspectives and approaches. This ongoing discourse has resulted in the overuse of the term 'AI' as a buzzword without precise understanding or definition. Nevertheless, recent developments in regulatory frameworks pertaining to AI technology have underscored the urgent need for clarity on its definition – such as demonstrated by the proposed Artificial Intelligence Act[27] by the European Commission (Hupont et al., 2022).

Despite several attempts to reach a consensus on what exactly AI is, there is still no universal agreement. At the EU level, there is still an open debate especially now that the European Commission wants to regulate the use of AI (the so-called AI Act, which will be described in more detail below). At the time of writing there are still proposed changes to the definition[28] that are going through the EU trilogue interinstitutional negotiation process[29]. In the research described in this report, we will not delve into the proposed changes and we will refer mainly to the definition proposed in the initial AI act[30] proposal.

24. https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/europe-fit-digital-age/european-data-strategy_en

25. https://digital-strategy.ec.europa.eu/en/library/egovernment-benchmark-2022

26. https://international-partnerships.ec.europa.eu/policies/sustainable-development-goals_en

27. https://digital-strategy.ec.europa.eu/en/library/proposal-regulation-european-approach-artificial-intelligence

28. https://www.euractiv.com/section/artificial-intelligence/news/ai-act-spanish-presidency-sets-out-options-on-key-topics-of-negotiation

29. https://eur-lex.europa.eu/EN/legal-content/glossary/trilogue.html

30. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52021PC0206

> *Artificial intelligence system (AI system) means software that is developed with one or more of the techniques and approaches listed in Annex I and can, for a given set of human-defined objectives, generate outputs such as content, predictions, recommendations, or decisions influencing the environments they interact with.*

Despite this choice, the research has taken into account the new AI definition proposals expressed in the 3 different EU institutions mandates[31, 32] published the 20 June 2023. What emerges from these documents and from the ongoing public debate is a need for a new AI definition that is more harmonised with other international policies (e.g. OECD and extra-EU policies on AI), that achieves a wider acceptance of the act and that takes into account the rapid technological developments in the field (e.g. generative AI).

Therefore, we can consider the chosen definition as a good one for the purpose of our study, because if it changes, it will be to have a more generic one. Our cases, selected with the above definition, will not be excluded, not affecting the research results of this report.

The Proposal for a Regulation of the European Parliament and of the Council Laying Down Harmonised Rules on Artificial Intelligence (**Artificial Intelligence Act**) in April 2021 is one of the most significant legislative actions regarding AI. This regulation aims to foster transparency and compliance with ethical requirements for AI systems through a risk-based approach.

Yet, the landscape of AI-related regulations and policies in the EU has been shaped by several pivotal actions. One of the initial building blocks was the **Declaration of Cooperation on AI**[33] adopted by all EU Member States, as well as Norway, Switzerland and the United Kingdom, in April 2018. The Declaration sought to augment Europe's industrial and technological capacity in AI and its adoption.

This was soon followed by the **Communication 'Artificial Intelligence for Europe'** (COM/2018/237),[34] approved by the European Council in June 2018. The Communication outlined an overarching AI strategy for Europe, laying down policy foundations that would foster optimal conditions for the development and deployment of AI within Europe. In essence, it aimed to create an environment conducive to capitalising on the opportunities AI could offer to the private sector and civil society.

The AI strategy was further supported by the Communication on a Coordinated Plan on the Development and Use of Artificial Intelligence (COM (2018) 795 final)[35]. This plan provided a shared policy collaboration framework and encouraged all Member States to establish national AI strategies. The plan received an update in 2021, which entailed a detailed set of joint actions to foster the EU's global leadership in trustworthy AI. One of these actions was aimed at positioning the public sector as a pioneer in AI adoption.

Moreover, the recommendations of the **High-Level Expert Group (HLEG) on AI**[36] provided several insights for the development, deployment and scaling of trustworthy AI. The goal was to enable the creation of AI-based public services that prioritise human-centric values and uphold the fundamental rights of those who benefit from AI-driven public services.

Furthermore, the **Berlin Declaration** on Digital Society and Value-Based Digital Government[37] underscored the importance of developing value-oriented, human-centric AI systems for use by the public sector. The Declaration emphasised the need for responsible, transparent and explainable AI usage, while also minimising unlawful discrimination in public sector applications of AI. These values were reiterated by The

31. https://www.europarl.europa.eu/doceo/document/TA-9-2023-0236_EN.html

32. https://www.europarl.europa.eu/cmsdata/272920/AI%20Mandates.pdf

33. https://ec.europa.eu/jrc/communities/en/node/1286/document/eu-declaration-cooperation-artificial-intelligence

34. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM%3A2018%3A237%3AFIN

35. https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:52018DC0795&from=EN

36. https://digital-strategy.ec.europa.eu/en/policies/expert-group-ai

37. https://www.bmi.bund.de/SharedDocs/downloads/EN/eu-presidency/berlin-declaration-digital-society

Lisbon Declaration on Digital Democracy with a Purpose,[38] which acknowledged the role of green and digital technologies, including AI, in balancing innovation, competitiveness, social development and environmental preservation.

Financial support for AI in the public sector has been included in programs such as the **Digital Europe**[39] and the **EU Recovery and Resilience Facility (RRF)**.[40] These initiatives offer funding opportunities through the European Digital Innovation Hubs, Testing and Experimentation facilities, AI skills and awareness raising, and AI procurement. The **Digital Europe Programme**[41] also supports AI experimentation within cities through initiatives such as the Large-Scale Pilots. Additionally, the **2024 Flagship Technical Support Project 'AI-ready public administration'**[42] is an initiative designed to accelerate the adoption of AI by supporting Member States' public administrations for leveraging AI in a safe and trustworthy manner. The support will mainly prioritize a human-centric approach and key factors of the preparatory phase before implementation, such as the relevance of interoperability, IT and data governance, and digital skills.

The **White Paper on Artificial Intelligence** – A European approach to excellence and trust (COM/2020/65)[43] outlined policy options to ensure trustworthy, secure and value-aligned development of AI, and includes a specific section on the adoption of AI by the public sector. Moreover, the **Communication on a European Strategy for Data** (COM/2020/66)[44] highlighted the necessity of utilising data for improved decision-making and public services. It also stressed the importance of adopting cloud technologies to deploy AI in the public sector. In terms of practical implementation, the European Commission launched several initiatives such as the **AI Watch initiative**[45] and **Adopt AI programme** to monitor AI development and facilitate public procurement of AI. Moreover, The **Digital GovTech Incubator cooperation framework call**,[46] published in February 2022, is aimed at discovering new interoperable solutions, including AI, which can be adopted by EU Member States.

Moreover, in December 2021, the Commission adopted **new rules on Open-Source Software** to facilitate public accessibility of its software solutions whenever it would be beneficial for citizens, companies or other public services. The recently released Data Act is one of the last horizontal building blocks of the Commissions' data strategy that will ensure fairness in the digital environment, stimulating competitive data markets, and fostering data-driven innovation. Finally, recent initiatives such as the **Digital Services Act** and the **Digital Markets Act** add to the building blocks upgrading governing digital services in the EU, which provide the right infrastructure for building high-performance and robust AI systems.[47]

2.7.2 Transformative role of AI in/for the public sector

The emergence of AI offers a revolutionary technology that holds the capacity to transform public service delivery (Maragno et al., 2023; Medaglia et al., 2021). Governments are increasingly utilising AI as a tool for enhancing efficiency, by automating both physical and digital tasks (Tangi et al., 2022). This move also enables better policymaking and improved outcomes through better predictive capabilities. The adoption of AI also bolsters responsiveness to user needs, as it facilitates the delivery of personalised and human-centred services through human-centric interface design. The implementation of AI has already initiated transformational effects on multiple aspects within the public sector such

38. https://digital-strategy.ec.europa.eu/en/news/berlin-declaration-digital-society-and-value-based-digital-government

39. https://eur-lex.europa.eu/eli/reg/2021/694/oj

40. https://ec.europa.eu/info/business-economy-euro/recovery-coronavirus/recovery-and-resilience-facility_en

41. https://digital-strategy.ec.europa.eu/en/activities/digital-programme

42. https://reform-support.ec.europa.eu/tsi-2024-flagship-ai-ready-public-administration_en

43. https://ec.europa.eu/info/sites/info/files/commission-white-paper-artificial-intelligence-feb2020_en.pdf

44. https://commission.europa.eu/publications/white-paper-artificial-intelligence-european-approach-excellence-and-trust_en

45. https://ai-watch.ec.europa.eu/index_en

46. https://joinup.ec.europa.eu/collection/interoperable-europe/news/call-digital-govtech-incubator-open

47. https://digital-strategy.ec.europa.eu/en/policies/european-approach-artificial-intelligence

as efficiency, effectiveness and responsiveness. The automation of both physical and digital tasks has led to increased efficiency, allowing for quicker and more accurate completion of tasks. The improved predictive capabilities of AI have enabled better policymaking and delivered better outcomes. Additionally, AI has allowed for more personalised and human-centred services to be delivered to users, resulting in increased responsiveness to user needs. Overall, the implementation of AI has the potential to transform the public sector in various ways, for example, in predictive analytics in healthcare and chatbots for customer service (Følstad and Brandtzæg, 2017). With advancements in computational power, unprecedented growth in data availability, and breakthrough algorithmic techniques, employing AI technology is becoming increasingly feasible. Governments worldwide are therefore acknowledging the potential benefits that incorporating AI into their operations could provide for the public sector at large (Tangi et al., 2022).

The potential benefits of AI in the public sector are vast (Tangi et al., 2022). It can help organisations work more effectively, reduce costs and improve the quality of services provided to citizens. By using AI to automate tasks that would otherwise require human intervention, public sector organisations can free up resources to focus on more pressing issues. AI can also help public sector organisations make more informed decisions by analysing large amounts of data and identifying patterns and trends that would be difficult to detect manually (Ishengoma et al., 2022). Moreover, AI can enable public sector organisations to work more efficiently, make better decisions, and deliver better services (Kuziemski and Misuraca, 2020). For example, AI-powered chatbots can provide faster and more accurate responses to citizens' queries, freeing up staff to focus on more complex tasks. Predictive analytics can help healthcare providers predict and prevent health issues, resulting in better outcomes for patients. AI can also improve public procurement by automating repetitive tasks, identifying potential suppliers, and analysing contracts for compliance. However, the adoption of AI in the public sector poses several challenges, ranging from technological to organisational and legal (Tangi et al., 2023), and it is hindered or driven by a number of factors, such as the existence of a suitable infrastructure (van Noordt and Tangi, 2023), the right competences and skills (Maragno et al., 2022; Tangi et al., 2023) as well as a fruitful collaboration with the supplier (Maragno et al., 2023)

Governments across the world are giving increased attention to the potential of AI. For instance, The European Commission has recognised the potential of AI in the public sector and has included a specific section in its recent White Paper on AI[48] to promote its adoption. The plan mainly focuses on four key areas: increasing investment, making more data available, fostering talent, and ensuring trust. Also, in the 2021 Review of the Coordinated Plan on Artificial Intelligence,[49] the public sector is pointed out as a 'trailblazer for using AI', and the Commission remarks that it is essential that public administrations, hospitals, utility and transport services, financial supervisors, and other areas of public interest rapidly begin to deploy products and services that rely on AI in their activities.

2.8 How AI could improve interoperability in the public sector

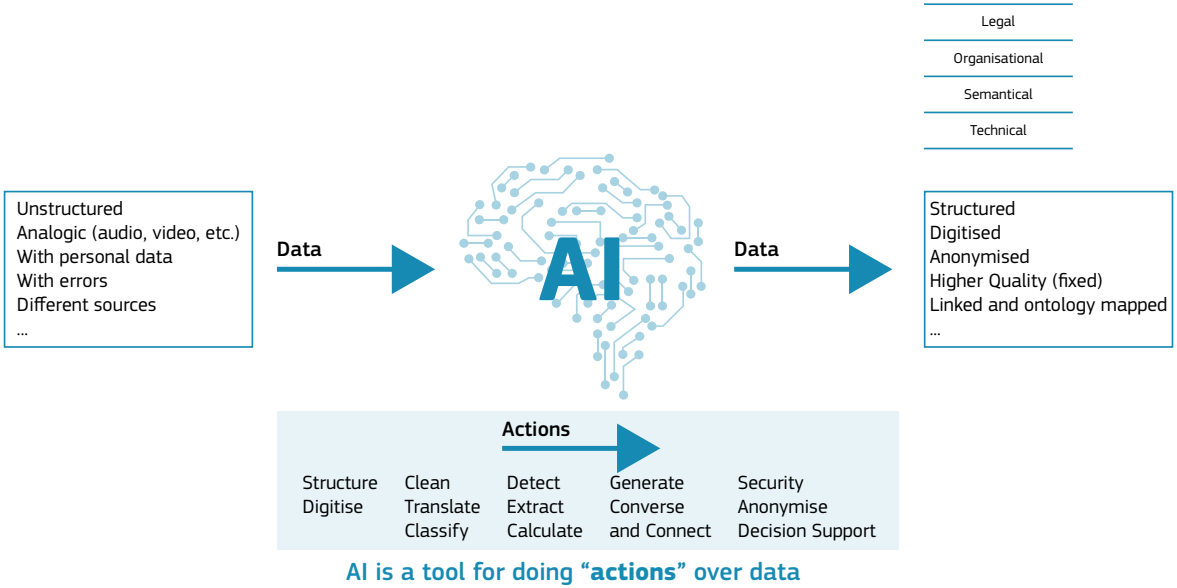
AI can be used to adapt data into a tangible format or structure, facilitating the harmonisation, mapping, transformation, and standardisation of data across heterogeneous sources and formats improving in this way facilitating its **interoperability**.

To better understand how this is happening, **Figure 2** offers a more complete view, distinguishing the elements that participate in the process. The AI system receives **input data** from one or many sources, this data may have some 'weaknesses' that require a preliminary processing before is further analysed.

48. https://ec.europa.eu/info/sites/info/files/commission-white-paper-artificial-intelligence-feb2020_en.pdf

49. https://commission.europa.eu/publications/white-paper-artificial-intelligence-european-approach-excellence-and-trust_en

Figure 2. How AI supports interoperability



Source: JRC's own elaboration

For example, the input data may be unstructured, analogic or with errors. These issues prevent these data from being fully interoperable and further analysed. The AI system has the capability of acting on any of the **EIF interoperability layers** (technical, semantical, legal and organisational) over the input data, performing specific ***actions*** to obtain the desired results in the **output data**.

These AI solutions are leveraging AI techniques such as Natural Language Processing, Machine Learning, and semantic modelling to extract, transform and reconcile data, ensuring compatibility and consistency for efficient data sharing and integration. AI algorithms can analyse and understand the content and context of data, enabling the identification of patterns, relationships and similarities between different datasets (Valle-Cruz et al., 2019). This capability allows for the development of automated processes that can adapt data into a concrete format or structure, making it easier to integrate and exchange information across heterogeneous sources. Moreover, AI can help to automate the process of data integration across different systems, enabling seamless data exchange and reducing the need for manual input. This can improve the quality and timeliness of data, as well as reduce errors and redundancies. It could also enable predictive modelling, which can support public sector organisations in anticipating and addressing potential interoperability challenges before they arise. This can include predicting future demand for services or identifying potential data conflicts that may impact interoperability.

Furthermore, AI supports the development of more **human-centric** public services by enabling more personalised and targeted service delivery. This can be achieved by using AI to analyse user data and preferences, and tailoring service delivery accordingly. AI-based Natural Language Processing (NLP) can also help to standardise the meaning of terms and concepts across different systems, allowing improved understanding between systems and an easier exchange of data. Additionally, AI can help to automate the processing and analysis of data, which can reduce the need for manual intervention and improve the accuracy and speed of data exchange.

Overall, AI can be an essential tool for better structuring, curating, standardising and processing public administration data and enhancing interoperability within and outside public sector organisations.

This exploratory study aims to showcase the potential of AI to play a key role in enabling interoperability between different systems and applications in the public sector and beyond, leading to more efficient and effective exchange of information and communication in a responsible and ethical manner, taking into account issues such as privacy, bias and transparency.

3

Exploration of case collection, interoperability and AI dynamics

This section aims at exploring use cases on the employment of AI for fostering interoperability. It analyses a subset of the case collection on AI already published in open data and presented in a previous report (Tangi et al., 2022).

The exponential growth of data is affecting society and the economy overall – this also includes public administrations. Managing large volumes of data requires adequate infrastructures and workflows in order to prevent organisations from being overwhelmed with large amounts of unmanageable data. In this respect, one of the major challenges for organisations in improving the management of the data generated is data interoperability. In this context, it is interesting to observe how public administrations are using AI as a tool for enhancing interoperability. This chapter aims at answering the following questions:

- How are public administrations using AI for enhancing interoperability?
- In which contexts are public administrations using these types of AI solutions?

3.1 Methodology

This analysis took advantage of the inventory of use cases Artificial Intelligence published in 2022 in the JRC data catalogue and described in a report titled 'AI Watch. European Landscape on the Use of Artificial Intelligence by the Public Sector' (Tangi et al., 2022). The previous research offered an overview of the use of AI in the European public sector by analysing a set of 686 use cases. The current research conducts a deep-dive into a narrower topic – AI for interoperability.

Compared with the previous AI Watch report (Tangi et al., 2022), the present report uses an updated version of the dataset, containing 720 use cases. Contextually, with the publication of this report, the new dataset has also been published and is available in open data in the JRC data catalogue.[50]

Additionally, the taxonomy for analysing the cases has been enriched in order to characterise each case in relationship with the interoperability model described in the European Interoperability Guidelines (see Figure 4).

3.1.1 Case selection

The first step of the analysis was based on selecting, among all the cases collected, **the ones that are relevant for the study, in particular, the AI-based cases that enhance interoperability** (hereinafter referred to as AI4IOP).

The selection has been made following the criteria reported in **Table 1**. Criterion 1 is linked with the limitation of the data source, while criteria 2 and 3 are related with the selection of the cases enhancing interoperability.

50. https://data.jrc.ec.europa.eu/collection/id-00330

Table 1. Case selection criteria

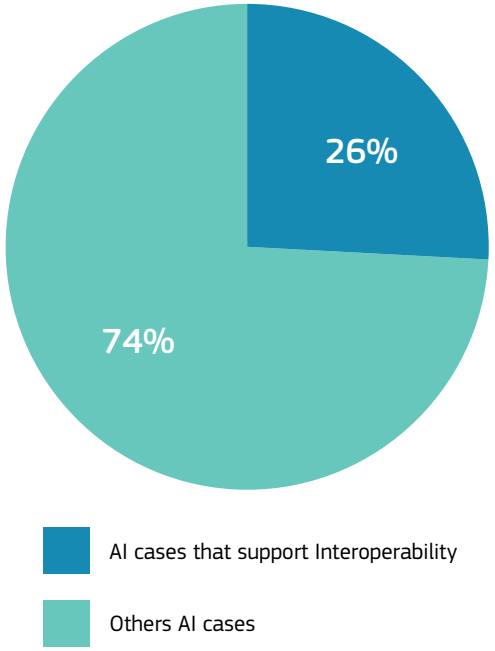
Criteria	Explanation
1. Completeness of the information	The cases have been collected mainly through web search and secondary sources (see Tangi et al., (2022) for a more detailed explanation). Hence the information available is limited. Given the specific need of the analysis, we limit to the cases where there was enough information available to be able to assess if the case was aiming at enhancing IOP. We adopted a conservative approach, i.e., in case of doubts we tended towards excluding the case.
2. Assignment of EIF principles	As a theoretical understanding of interoperability, the work is based on the definition and categorisation of the topic done under the EIF. For this reason, to ensure that the case was effectively supporting interoperability, we assign to each case at least one interoperability principle, and we selected only cases where this assignment was doable.
3. Assignment of EIF layers	Using the same logic, we included only cases where the assignment of at least one EIF layer was doable.

Source: JRC's own elaboration

The selection is based on an expert analysis made by a pool of JRC experts, all of them authoring this report. All experts have an in-depth knowledge of the interoperability regulation and are technical experts on different aspects related to interoperability and AI for the public sector. Two experts assessed each case independently. Individual reviews were based on a custom-made list of questions to prompt the expert to reflect on how the case fulfils a series of relevant criteria, guiding the process and establishing a common protocol for all cases in order to promote objectivity and reproducibility in the obtained results. Moreover, the experts discussed the results of the work to arrive at a consensus on a unique list of cases. This process ensured a larger validity and robustness of the selection. For the more controversial cases, other experts stepped in with additional opinions on the case.

The analysis resulted in the identification of 189 AI4IOP cases among a total of 720, approx. 26%, shown in Figure 3. This is already an initial interesting result of the study, highlighting the relevance of the topic, given that one fourth of all the AI solutions detected, to some extent, enhance interoperability.

Figure 3. Classification of selected AI cases that support interoperability in the public sector



Source: JRC's own elaboration

The selected cases are considered homogeneous with the set of cases adopted in the AI Watch report (Tangi et al., 2022), in particular considering the geographical extent and development status of the cases.

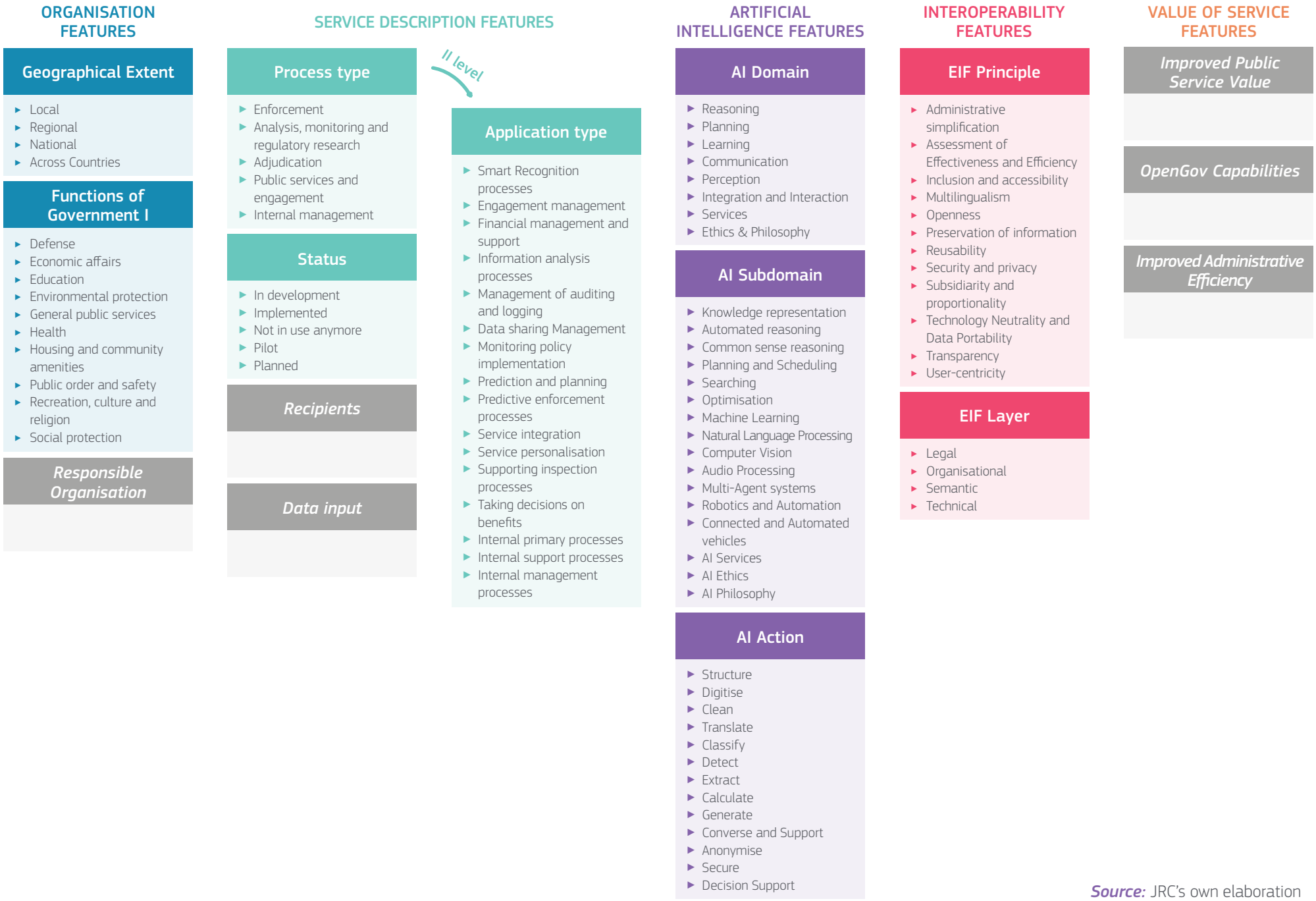
One of the most important elements of the research is the design and application of an adequate taxonomy to categorise and analyse the collected cases. For this reason, we designed a taxonomy that, on the one hand, could reflect the value that AI technology can create supporting interoperability, and on the other hand, building on the taxonomy used in the AI Watch report (Tangi et al., 2022) to create consistency and potentially an easier comparison among data collection activities. Furthermore, the taxonomy is available to the research community for reuse, as all the data are available in open data. The taxonomy is reported in Figure 4. The figure also highlights which fields are taken from the previous report and which are novel ones, designed ad hoc for the current study. The following **Table 2** provides a brief explanation and the main classification references. The taxonomy includes:

- **Organisation Features:** part of the organisation information is contextual public sector-related information. In particular, for this study we have used the geographical area and the policy domain in which the system is being used (following the COFOG[51] classification), and the main purpose of the AI system.
- **Service description features:** service information of the AI use case, including process and application type, targeted by the AI case, and status of known use of the AI system, either planned, in development, implemented or not used any longer (in case of dismissed AI solutions).
- **AI features:** concepts that are specific to the AI technology domain. In particular, the research introduced a new concept 'AI action' required to map one or more specific AI enabling features (see section 3.2.6) with the impacted/improved interoperability layer of the cases.
- **Interoperability features:** interoperability-specific concepts extracted from the EIF such as the EIF layers, EIF principles and interoperability assessment aspects (IMAPS).

Figure 4 and **Table 2** describe the overall taxonomy used for the purpose of this analysis.

51. https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Glossary:Classification_of_the_functions_of_government_(COFOG)

Figure 4. Taxonomy for AI case categorisation



Source: JRC's own elaboration

Table 2. Description and sources of the taxonomy's features

	Features	Description	Source
Organisation	Geographical area	This indicator follows the administrative tiers identified by Nomenclature of Territorial Units for Statistics (NUTS).	Nomenclature of Territorial Units for Statistics (NUTS)
	Functions of Government (COFOG I)	The Organisation for Economic Co-operation and Development (OECD) developed the COFOG classification as a standard for classifying the purposes of government activities. It is published by the United Nations Statistical Division. This report uses the version from 1999.	OECD
Service	Process type	Classification of five high-level types of government decision-making tasks commonly implemented with basic processes/tools and potentially governed by AI.	Engstrom, Ho, Sharkey, & Cuéllar, 2020
	Application type	This category refers to a particular purpose or use of technology in solving a problem or performing a specific function. It is a mean between different cases collection sources (not standardised). It is a sub-level of Process Types.	JRC's own elaboration
	Status	This category refers to the implementation status of the cases: pilot, in development, implemented, no longer in use or planned.	JRC's own elaboration
AI Features	AI domain	List of representative core and transversal AI domains and subdomains will assist us in classifying R&D and industrial agents and their activities. Therefore, it encompasses the main theoretical AI scientific areas, and AI-related non-technological issues from industrial and R&D AI Activities, as well as ethical and philosophical issues.	Samoili et al., 2021
	AI subdomain		
	AI Actions	This list provides a set of different kind of possible actions ('act') that AI can perform in the design of a digital system for the public administration.	JRC's own elaboration
Interoperability Features	EIF Principle	The EIF principles are fundamental behavioural aspects to drive interoperability actions. There are 12 principles relevant to the process of establishing interoperable European public services. They describe the context in which European public services are designed and implemented.	EIF Framework
	EIF Layer	EIF describes an interoperability model which is applicable to all digital public services and may also be considered as an integral element of the interoperability-by-design paradigm. This model defined four main layers of interoperability.	EIF Framework

Source: JRC's own elaboration

The taxonomy features 'AI Action' and 'Application type' require a more in-depth explanation.

The 'AI Action' classification (see **Table 3**) provides a set of possible applicable actions performed by AI solutions and answers the question: 'What type of action does the AI system perform to support interoperability?'. The aim of this classification is to cluster the potential of AI into a limited number of actions in order to provide and even better understanding of the ways AI systems can support interoperability. It should be considered an experimental proposal achieved following a pragmatic trial and error process. The third column of **Table 3** provides a few application examples to better understand the description of the actions – it should not be considered an exhaustive list.

Table 3. 'AI Action' feature description

AI Action	Description	Examples
Structure	Organising and formatting data into a specific structure, such as a database, spreadsheet, or other formats that can be more easily analysed	Parse unstructured data Data/structure transformation Entity/feature extraction Text-2-Media (speech, images, video)
Digitise	Converting non-digital data, such as images or documents, into a digital format that can be more easily processed by AI systems	Document Digitisation Smart OCR Process Automation
Clean	Removing errors, duplicates or irrelevant data from a dataset to improve its quality and accuracy	Data Matching/Profiling Grammar Correction Outlier detection
Translate	Converting data from one language to another using natural language processing (NLP) techniques	Natural language translation Source/Query code translation Movie subtitling translation
Classify	Categorising data based on specific criteria, such as assigning images to different categories or grouping texts based on their topics	Document classification Data/Text/Token classification Image/audio/speech classification Spam Filtering
Detect	Identifying specific objects, patterns or anomalies in data, such as detecting fraud or identifying specific objects in an image	Video detection Speech/sound detection Sensors/IoT detection
Extract	Locate entities, features or keywords inside data. It can be used for various purposes such as data analysis, data mining, and NLP	Entity naming/Feature Extraction Summarise/Keywords extraction Code Explanation
Calculate	Performing calculations or mathematical operations on data, such as calculating statistical measures or predicting values	Calculate Time/Complexity ESRB Rating Calculation Taxes/Benefits Calculation
Converse and connect	Providing support for natural language conversations with humans, such as chatbots or virtual assistants	Development companion/tutor General/Specialised Q&A, chatbots Online form fills tutoring Information search support/tutoring
Anonymise	Removing identifying information from data to protect privacy and confidentiality	Data Anonymisation Third person converter/paraphraser
Decision Support	Providing insights and recommendations based on data analysis, such as providing insights for business decision-making	Data-driven DSS Knowledge-driven DSS Document-driven DSS

Source: JRC's own elaboration

The information sources referenced by the study to build the AI Action taxonomy are the following:

1. AI Watch[52] AI categories (17) and AI keywords (about 150) as a pivotal classification to cross-map and reduce the number of items of the heterogeneous classifications considered and listed hereafter.
2. OECD.AI Classification Framework[53] is a list of seven AI tasks (Recognition, Event Detection, Forecasting, Personalisation, Interaction Support, Goal-driven optimisation, Reasoning with knowledge structures).
3. Open Neural Network Exchange (ONNX[54]), an open standard format to represent machine learning models, three main AI categories (Vision, Language, Other) are defined in its repository, underlying ten underlying subcategories.
4. AI Tasks[55] classification available in the Hugging Face[56] community portal. It is composed of six main AI usage categories (Computer Vision, NLP, Audio and Multimodal, Tabular and Reinforcement Learning) and it underlies four subsets composed of 32 sub-tasks. This classification is used to expose in a structured and searchable way the catalogue of most the common machine learning-based applications, models, training datasets and learning documentation.
5. AI Examples classification on the OpenAI[57] website. It is composed of seven main AI categories (Answers, Classification, Code, Conversation, Generation, Translation, and Transformation) and it underlies seven subsets composed of 48 sub-categories of AI examples. This classification is used to publish a wide range of exemplificative machine learning-based applications.

The Application Type classification is a sub-classification of Process Type and seeks to offer more detail regarding the activity for which the solution was developed (Table 4). The design of this classification aims to answer the question, 'What governmental activity does the AI technology support?' This classification is taken from the previous report (Tangi et al., 2022). In addition, the Application Type classification is an experimental proposal achieved following a pragmatic trial and error process.

52. https://publications.jrc.ec.europa.eu/repository/handle/JRC126426
53. https://oecd.ai/en/classification
54. https://github.com/onnx/models
55. https://huggingface.co/tasks
56. https://huggingface.co/about
57. https://openai.com/about/

Table 4. Application Type descriptions

Application Type	Description
Service personalisation	Delivery of a customised service considering the needs of the citizen, business or public servant.
Engagement management	This category refers to the creation of connections with citizens and business to build trust along the different interactions with the public administration.
Service integration	Service integration is the management of the integration of multiple service suppliers and information sources in order to provide a tailored new specific service to citizens, other organisations or even for internal purposes.
Data sharing management	Data sharing processes that support accesses to data, consider interoperability and data licensing (e.g., open data).
Smart Recognition processes	Processes that can identify objects, people, places, writing, situations and actions in images, video, audio and other basic or complex physical measurement.
Predictive enforcement processes	This category involves algorithms to analyse amounts of information in order to predict and support the prevention of potential future crimes.
Supporting inspection processes	Processes to identify irregular practices in administrative procedures (e.g., tax payments, property or businesses registrations).
Management of auditing and logging	Collection of records, that might include destination and source, to provide documentary evidence of the activities sequence that have affected, at any time, a specific operation, procedure, event or device.
Prediction and planning	Processes for management of resources based on prediction models in order to support planning.
Information analysis processes	Process of inspecting, transforming, and modelling information. It is made by converting raw data into actionable knowledge in order to support the public administration decision-making process.
Monitoring policy implementation	Processes that follow and assess policies implementation to ensure they are developed, endorsed and implemented.
Internal support processes	This category refers to the operational processes within an administration that provide support to other functions or processes within the administration. These processes are designed to enable effective communication, coordination and collaboration among different departments or functions within the public administration.
Internal primary processes	This category refers to the core operational processes within an administration that are directly involved in creating and delivering public value. These processes are typically focused on the creation, production, and delivery of services to citizens and businesses.
Taking decisions on benefits	Processes within the public sector used to take decisions regarding approvals, validations or revocation of benefits (e.g., social).

Source: JRC's own elaboration

3.1.2 Limitations of the approach

Before going through the result of this analysis, it is important to state the limitations of the study for a better understanding what can and cannot be explained by the analysis. The current inventory is by no means a complete overview of the use of AI in order to solve interoperability-related issues in the public sector. In other words, the data are not and do not aim to be representative of the situation regarding this topic in the European public sector.

Furthermore, as explained, the analysis is based on the inventory described in a previous report (Tangi et al., 2022). As also stated in the previous report, despite the width and depth of the case collection provided, it is not an exhaustive overview and the information gathered from public data was clearly limited by the research team's searching capacity. Therefore, there are limitations related to the data collection process of the previously mentioned report in terms of availability and intelligibility of the information, lack of information of the evolution of some projects over time, definitional issues surrounding AI, and definitional issues surrounding the concept of public sector.

This means that despite the best efforts of the research team, looking at the single case, further analysis might be needed to better categorise some cases. However, given the large number of cases collected, it is assumed that no systematic error has been introduced.

Some important considerations can therefore be drawn from the case collection that represents a unique attempt at the European level of offering an overview of the current situation with respect to the use of AI in public services to solve interoperability related problems.

3.2 Results

Overall, 720 use cases of AI in the public sector have been analysed. Among these use cases, 189 have been identified as cases where the AI system is somehow supporting interoperability.

Moreover, the analysis provides some interesting insights that help to show the different aspects of how AI can support interoperability, taking advantage of its capability to analyse and process large amounts of data, automating in this way tasks and processes and, at the same time, reducing costs and improving efficiency. Our research has identified many cases in different functions of government.

In the coming sections, a quantitative analysis of the use case inventory is presented with the objective of better understanding how AI systems are supporting interoperability, and which are the most common tasks in the public sector where AI systems are supporting data interoperability in one way or another.

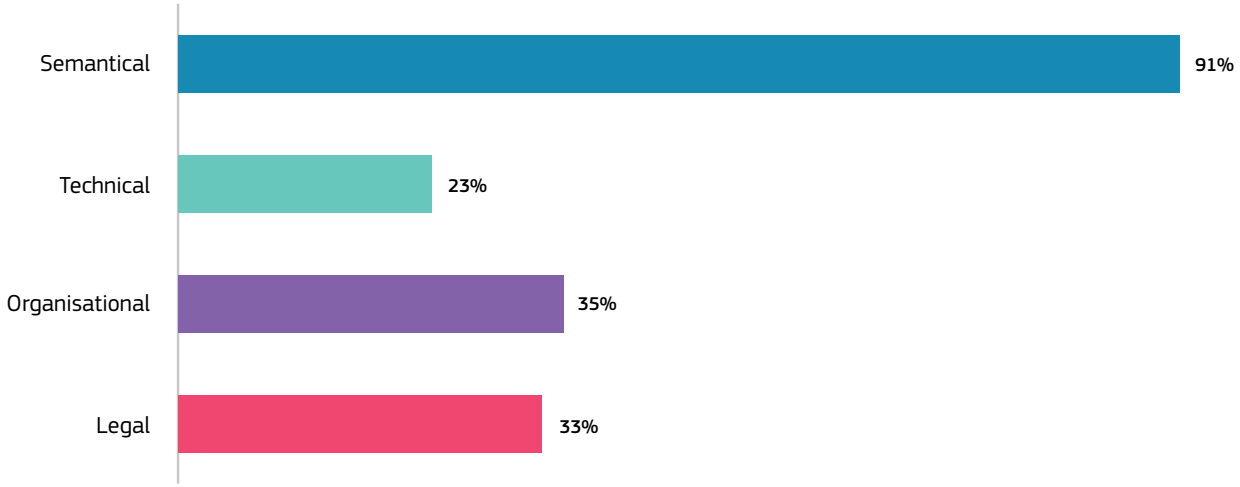
3.2.1 Main EIF layers involved by cases

First, the analysis links the cases with the **interoperability layers**. The four layers considered for this study (technical, semantic, legal and organisational) are defined in the EIF and are applicable to all the public services.

Only the most relevant interoperability layers have been assigned. For example, an NLP-based solution for automatically anonymising court documents by removing personal data should take into account all four of the EIF layers in the design phase. The semantic layer is the most impacted when it comes to the implementation of AI solutions. The ability to provide a consolidated view of data across the process is fundamental in ensuring that public service-related tasks are executed correctly using AI technologies. By enriching the data model using the semantic layer, algorithms can better understand and execute the required task. While legal and organisational factors may have a minor impact, it is important to be aware that the solution ensures data interoperability and complies with the existing legal framework by removing personal data in the text. This also has an impact on internal organisational processes. The results (**Figure 5**) show that a quite large number of the cases are solutions that impact the **semantic (91%)** interoperability layer.

The results show how AI4IOP developments seem driven by **semantic** data interoperability issues. In addition, the data show how ontologies and taxonomies combined with AI technology can help in establishing semantic interoperability between different systems. The other interoperability layers are less relevant: **legal (35%) and organisational (33%) and technical (23%)**.

Figure 5. Main EIF layers addressed by the use cases



Source: JRC's own elaboration

For a better understanding of the logic behind the classification, in the following is a list a use case example for each EIF layer:

- **Technical layer:** A good example of improvement on this layer is the work by the VITO research centre, which is part of the policy area of the Department of Economy, Science and Innovation (EWI) of the Flemish government.[58] The case uses AI-based encoding/decoding (e.g., compression) and data transportation techniques.[59] It provides similar reconstruction accuracies while preserving information details for downstream applications with compressed features corresponding to meaningful image representations that can be used as input for other lightweight AI applications with less training data required.
- **Semantic layer:** In Portugal, the EPISA[60] project uses NLP, entity recognition and automatic learning methods in order to explore the records of documents and documents themselves if they are in digital form. From the descriptions produced by archivists, entities and relationships are extracted and populate a description model that is semantically richer than the current one and easier to deal with automatically.
- **Legal layer:** European Commission is developing a LEOS case study[61] to explore how AI can be used to verify the transposition of EU laws by Member States. The plan involves taking the transposition of some directives into Italian domestic legislation and to compare them with the help of AI in order to measure the relationships between the different articles and so identify where the two document diverge, also considering the legal aspect of the interoperability, beside the syntactical and semantical.
- **Organisational layer:** The Ministry of Justice in Austria implemented the JustizOnline[62] project to reduce the necessity of physically appearing in court in many

58. https://www.bloomberg.com/profile/company/1554630D:US

59. Data Compression:The Complete Reference | Guide books (acm.org)

60. https://episa.inesctec.pt/

61. https://joinup.ec.europa.eu/collection/justice-law-and-security/solution/leos-open-source-software-editing-legislation/document/drafting-legislation-era-ai-and-digitisation

62. https://justizonline.gv.at/jop/web

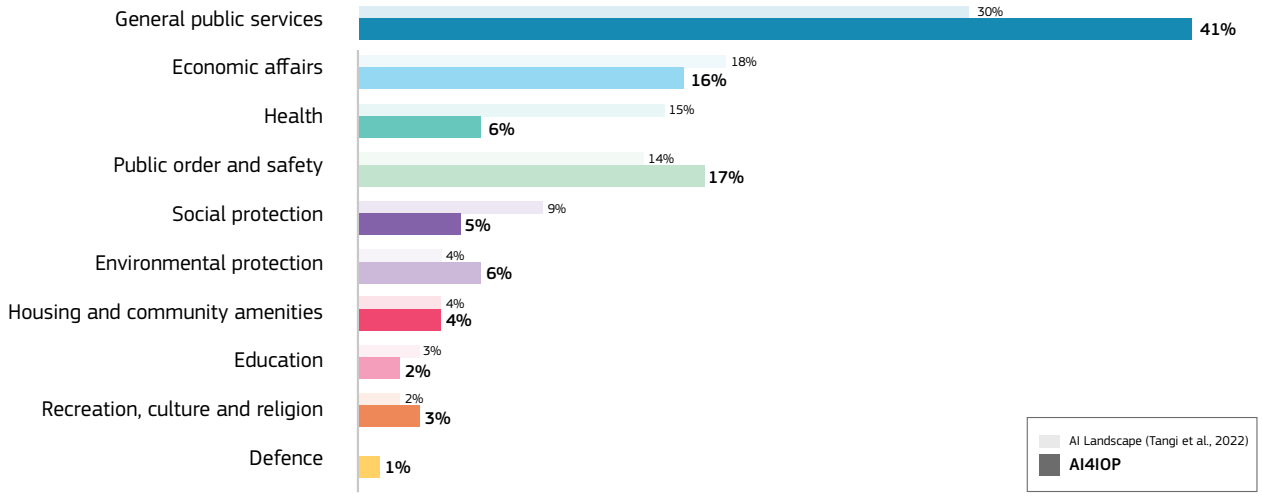
cases and, secondly, that information and answers are provided quickly through a chatbot that guides people in search of information directly to the information and functions that are relevant to them. This solution focuses on the organisational aspects of integrating various systems and processes within an organisation. It provides a structured approach to aligning technology solutions with the organisation's goals, strategies and business processes.

3.2.2 Cases by governmental function

The analysis identifies the main functions of public administration where AI-based services are supporting interoperability. For this purpose, we use the COFOG (Classification of the Functions of Government) classification.[63] The research maps cases for the first level – the public sector division. **Figure 6** presents the results, including a comparison of the distribution of the 189 AI4IOP cases among the main sectors of public administration with the distribution for the entire AI-based use cases collection, published in the previous AI Watch landscape report (Tangi et al., 2022).

63. COFOG Classification: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Glossary:Classification_of_the_functions_of_government_(COFOG)

Figure 6. Percentage of AI4IOP use cases in the public administration main sectors (COFOG Level I) and comparison with AI Watch landscape, 2022



Source: JRC's own elaboration

The main governmental function for the AI4IOP cases is **General Public Services, accounting for 41% of cases**. This is followed by **Public Order and Safety (17%) and Economic Affairs (16%)**. Fewer cases focus on Health (6%), Social Protection (5%) and Environmental Protection (4%). AI4IOP cases seem to have a similar distribution as with the overall sample, despite that they find their application more in the delivery of General Public Services, and less in other sectors, such as the health sector. A deep dive into the General Public Services category by AI can be a fundamental asset for several activities related to service management and delivery, through:

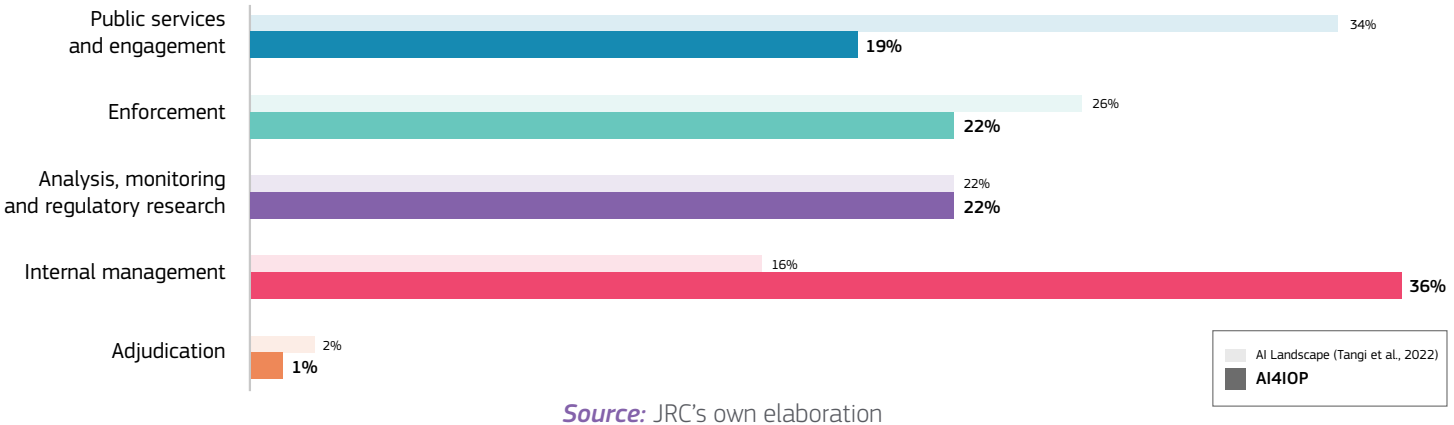
- comparison detection, and management of misinformation;
- classification, storage and search of documents (even hand-written), videos, and/or recorded speeches with automatic extraction of metadata and information;
- detection of various types of data anomalies or potential frauds.

Overall, the findings suggest that AI could support interoperability across a wide range of governmental functions, with a focus on improving public services and public order and safety.

3.2.3 Cases by process type

The Process Type indicator aims to measure with a coarse granularity the type of AI governance process inside the public sector for each specific case. **Figure 7** reports the result of the analysis. Figure 7 also includes a comparison of the distribution of the 189 AI4IOP cases among the Process Type categories with the distribution for the entire AI-based use cases collection, published in the previous AI Watch landscape report (Tangi et al., 2022).

Figure 7. Percentage of AI4IOP use cases in the public administration main sectors (COFOG Level I) and comparison with AI Watch landscape, 2022



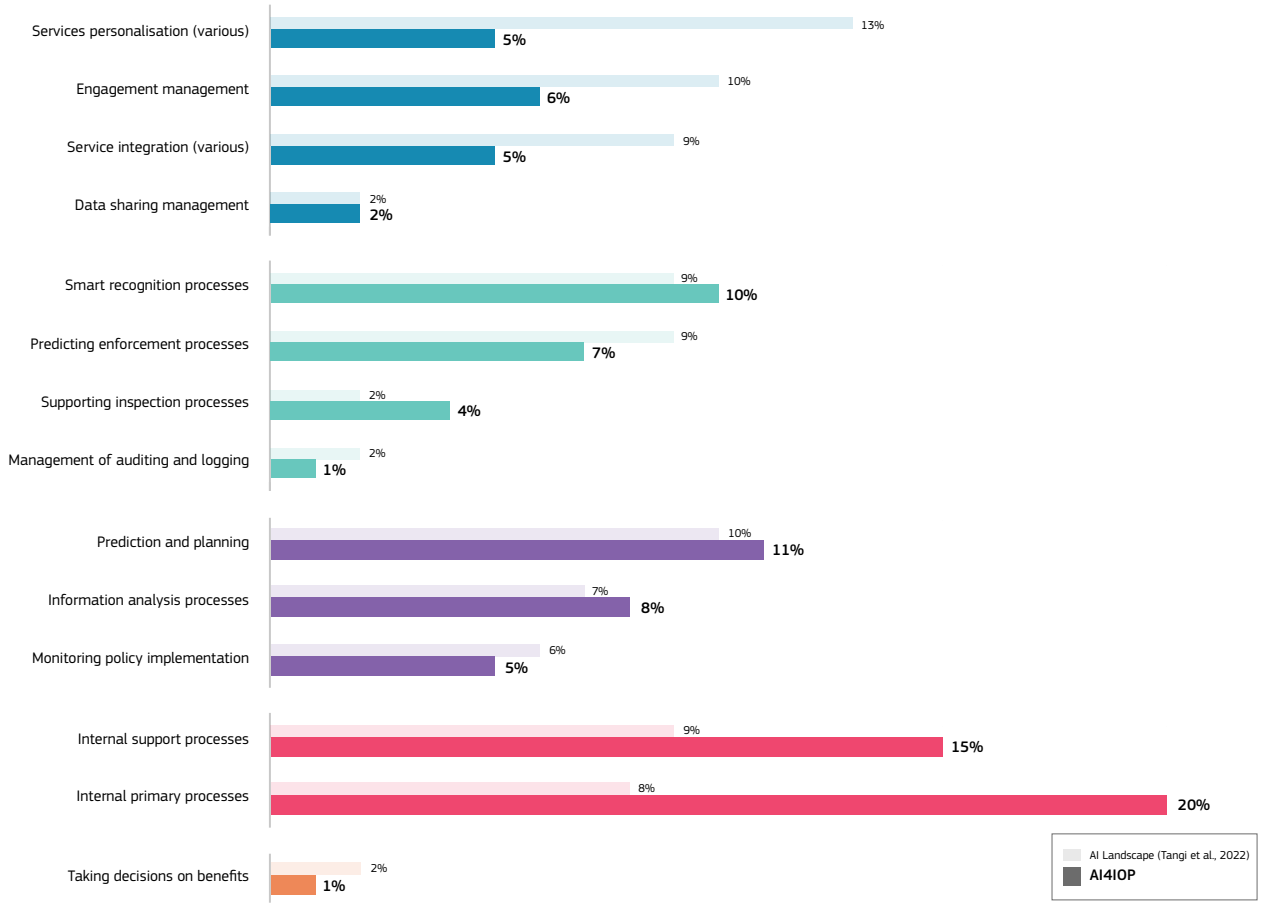
Source: JRC's own elaboration

Compared with the overall sample of AI cases in the public sector (Tangi et al. 2022), the subset of AI4IOP cases shows a lower percentage of cases relating to the direct delivery of public services, while the presence of use cases connected to the support of internal functions is considerably higher. This is not surprising as the support for interoperability mainly refer to internal activities for connecting data and systems that do not have a direct effect to the service delivery, while mainly focusing on ensuring all the preconditions that indirectly make the service more efficient and effective.

3.2.4 Cases by application type

To understand the actual purposes of using AI to support interoperability, we complemented the COFOG classification with the application type of the cases, an ad hoc feature developed in the AI Watch report (Tangi et al., 2022) that is a sub-level of Process Type. This classification is not mutually exclusive, i.e., multiple associations are allowed for a single case. **Figure 8** reports the results of the analysis. Figure 8 also includes a comparison of the distribution of AI4IOP cases among the Application Type categories with the distribution for the entire AI-based use cases collection published in the previous AI Watch landscape report (Tangi et al., 2022).

Figure 8. Percentage of AI4IOP cases by Application Type and comparison with AI Watch landscape, 2022



Source: JRC's own elaboration

Some potentially relevant elements emerge from the selected sample of cases. Within the 'Public Service and Engagement' process type, the percentage of AI cases connected to a personalisation of public services is lower than those in the same category related to the creation and maintenance of connections with citizens and business to build trust along the different interactions with the public administration. The few AI cases explicitly classified under the data sharing management application type are all connected to interoperability improvement.

The chart shows that a large portion of AI cases in the public sector fall under the category of **Internal primary processes (20%)** followed by **Internal support processes (15%)**. More concretely, **internal primary processes** refer to the core operational processes within the public administration that are directly involved in creating and delivering public value. Examples of these applications are translation, transcription or handwritten text recognition tools used by the administration to improve services, management of health documentation, tax assessment tools or court related services to assist magistrates. More precisely, internal support processes refer to the operational processes within the public administration that provide support to other functions or processes within the administration. Examples of these applications are knowledge organisation related tools, such as: search engines, classification systems and tools to extract and restructure information used by administration departments that need to automatically analyse large amounts of data. The percentage of internal primary and support process applications is much higher when looking at AI4IOP cases compared to the overall sample of AI solutions. This is in line with the results of the process type above. The other categories of application types for AI-based use cases that support interoperability are also interesting.

Prediction and planning (11%) refer to the processes of resource management based on prediction models to support planning. Many

examples of this type of AI application to support interoperability are related to environmental protection, such as mapping of tree density using satellite images or weather warning systems. Moreover, other examples are found in the economic affairs sector, such as insolvency prediction systems or intelligent transport systems in ports, including forecasting services that combine information from sensors, collected in real-time that can be later interpreted by IoT algorithms to effectively predict traffic patterns.

Smart recognition (10%) is another application type with many cases that support interoperability. This category refers to the identification of objects, people or situations and actions in images, video, audio and other basic or complex physical measurements. Most of the examples are in the Public Order and Safety sector, such as detection using images from mobile-phone usage on vehicles, licence plates, speeding violations or illegal substances. Furthermore, another sector that has many examples that support interoperability in this category is economic affairs, with road safety or rail safety applications that use data from cameras or IoT sensors.

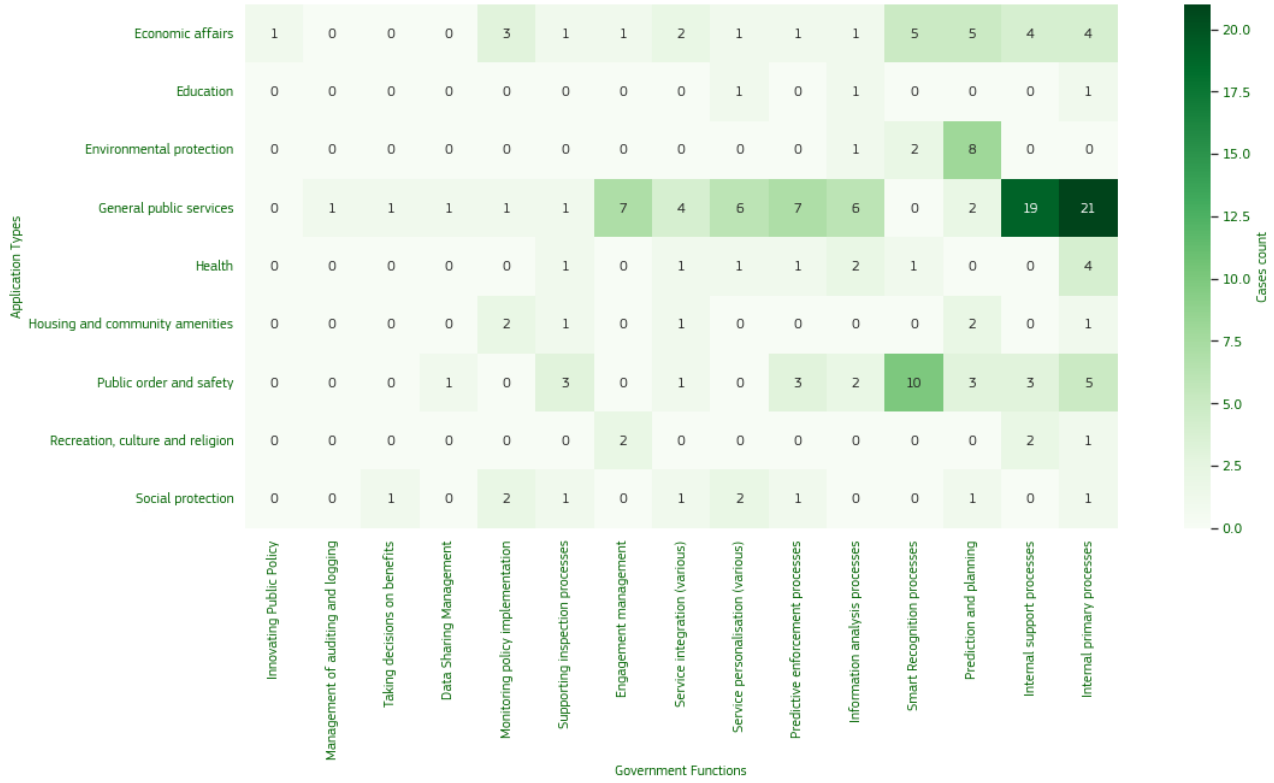
Information analysis processes (7%) refers to the processes of inspecting, transforming and modelling information. We find examples of this category in very diverse sectors of public administration. Moreover, in the general public services sector there are more cases, for example, detecting anomalies and incidents in the data exchange layer or integrating multiple data sources for validating or analysing data.

The remaining 4 application types (Predictive Enforcement, Service Personalisation, Service Integration and Engagement Management) have a smaller number of cases that support interoperability and are in smaller percentages.

3.2.5 Government functions by application type

The selection of a subset of cases constitutes a particular set of cases aimed at identifying recurring practices of the use of AI in a more or less explicit way to increase the exchange of information between different systems and organisations. For that reason, it could also be of interest to have different views on the application types crossed with the public administration functions. **Figure 9** reports the cross analysis between the application type and the governmental functions.

Figure 9. Government functions by application type



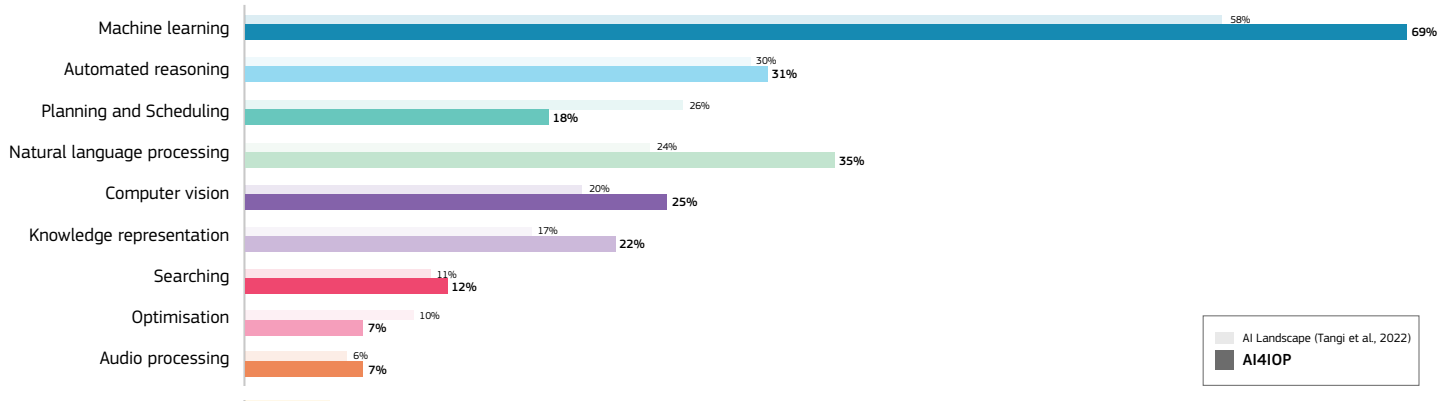
Source: JRC's own elaboration

Most of the selected cases reviewed by the research are related to AI applications supporting the provision of General Public Services through an automation of **internal processes**, mainly primary processes but also supporting processes. The governance function General Public Services is also heavily featured in Information Analysis, Predictive Enforcement, Engagement Management and Service Personalisation. Much more specific than some government sectors are **Smart Recognition** processes, which are essentially divided into Economic Affairs, Public Order and Safety and Environment Protection. The latter clearly stands out as it is also the most relevant in the cases catalogued as **Prediction and Planning**. Surprisingly enough 'Data Sharing' is an Application Type not significantly present, as well as Management of Auditing and Logging.

3.2.6 AI technology

The classifications AI domain and subdomain of all collected cases also sought to characterise functional and technological aspects in several ways based on the AI classification used in the AI Watch report (Tangi et al., 2022). These classifications are not mutually exclusive, i.e., multiple associations are allowed for a single case. The case classification has been made using the AI Watch taxonomy (Samoili et al., 2021) that is composed of two levels, the second of which focuses on the technology itself. For this reason, the research has only considered the second level. It should be noted that this classification is a simplification of the complex ecosystem of possible AI techniques. However, the research considered this to be a fair balance between having a detailed classification and a manageable number of items. Moreover, the AI Actions taxonomy also connects the research to some specific AI technologies and could be considered to see which AI technologies are the most used for these purposes. For the most part, cases have been categorised with multiple values. **Figure 10** reports the result of the analysis. It also includes a comparison of the distribution of AI4IOP cases among the AI technology categories, with the distribution for the entire AI-based use cases collection published in the previous AI Watch landscape report (Tangi et al., 2022).

Figure 10. Percentage of AI4IOP cases by AI Technologies and comparison with AI Watch landscape, 2022



Source: JRC's own elaboration

Approximately **69%** of AI solutions fall under the category of **Machine Learning (ML)**. ML is a broad type of AI solution that enables systems to learn, make decisions, predict, adapt and react to changes by improving from experience without the need for explicit programming. It is the foundation of AI systems, which is why it represents such a large percentage of cases. Examples of this type include the use of ML to identify fraud and highlight material errors in financial statements, e.g., the Corpus Viewer platform that uses ML to analyse structured metadata and unstructured textual data in large corpus of textual documents.

35% of cases involve the use of **Natural Language Processing (NLP)** techniques. NLP is a more focused category of AI solutions. It gives systems the ability to identify, process, understand and/or generate information in written and spoken human communications. Examples of this type include the use NLP to analyse and classify reports from other public service organisations or pre-processing work on the handwritten documents to improve the quality of the input data and then using handwritten text recognition (HTR) to extract information from the handwritten documents.

The third most common category, accounting for **31%** of usage, is **Automated Reasoning** techniques, which include logic-based and knowledge-based approaches, inference, deductive engines, symbolic reasoning and expert systems. These AI systems focus on inferring facts from knowledge represented in different forms of information and data and use symbolic rules to provide solutions. Examples of this type include: adopting automatic reasoning at certain level to ensure smooth and efficient operation and the interaction of sensor technology, analysis, forecasting and information systems that has led to significant increases in efficiency; adopting automated reasoning in smart control rooms in order to detect automatically all kind of vehicles or boats moving/cruising, calculate the speed limit, traffic allowance, etc.

Computer Vision (CV) accounts for **25%** of cases. This category refers to AI solutions that identify objects in digital images, as a part of object-class detection (also known as machine perception). In some cases, it refers to image pattern recognition for specific tasks, or in a broader sense, as machine vision, with applications in facial and body recognition, video content recognition, 3D reconstruction, public safety and security, health, and others.

Examples of this type include: a semi-supervised training technique to improve detection for satellite images; using AI to extract topographical objects from aerial images, thereby making it possible to detect new buildings and roads with a view to identifying construction areas, and consequently to reduce State officials' workload and increase the quality and rapidity of updating the databases held by the Land Registry and Topography Administration.

Knowledge representation accounts for **22%**. This category refers to a type of technology used in conjunction with other technologies (e.g., Machine Learning and Automated Reasoning) focusing the building of an adequate machine-readable information repository required to run the selected algorithm.

An example of this type is found in the judiciary: based on case law data from several agencies (e.g. Court of Cassation, Courts of Appeal, etc.), AI is making it possible to reconcile decisions dealing with the same subject matter and to detect divergent interpretations of the law in order to guarantee an interpretation.

Planning and Scheduling (PS), accounts for **18%** of cases. This category involves different forms of smart processing automation and often involves robotics. It is concerned with the design and execution of a set of actions to carry out an activity, performed by intelligent agents, autonomous robots and unmanned vehicles. Unlike classical control and classification problems, solutions in this subdomain are more complex and, in most cases, require optimisation in a multidimensional space.

Examples of this type are: use of past Court of Justice decisions to assist magistrates when receiving inquiries or documents from lawyers enabling to speed up the process, helping doctors improve the planning of operations; addressing data quality through data analysis in Personal Records Databases (BRP).

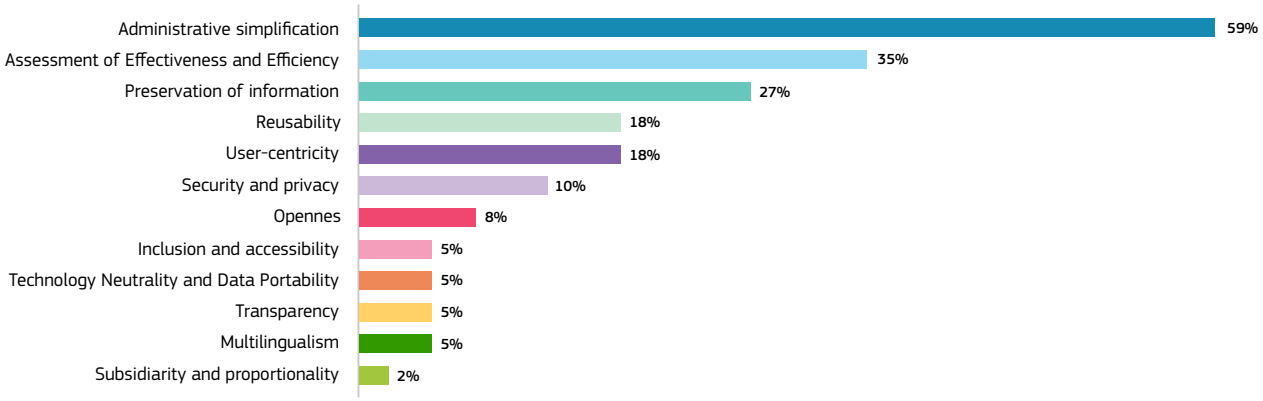
3.2.7 Interoperability principles alignment

As a result of the stand-alone review of the AI4IOP cases, in **Figure 11** the research team has mapped the 12 EIF principles[64] according to the available information of each case. This mapping aims to characterise how the selected AI cases are aligned with the 12 interoperability principles as fundamental behavioural aspects to drive interoperability actions. The interoper-

64. https://joinup.ec.europa.eu/collection/nifo-national-interoperability-framework-observatory/2-underlying-principles-european-public-services

ability principles are relevant to the process of establishing interoperable European public services, and its mapping over the selected AI use cases points out the slight connection between AI and the interoperability requirements of digital systems. This classification is considered not mutually exclusive, and a maximum of two principles were allowed for each case.

Figure 11. Classification of AI cases by the EIF principles



Source: JRC's own elaboration

Administrative simplification (59%) is by far the most relevant principle that could be applied to most of the cases. It responds to the need of public administrations to streamline and simplify their administrative processes by improving them or eliminating the ones that provide no public value. In this respect, AI-based solutions provide a wide range of tools and services useful to reducing the administrative burden of complying with EU, national, regional or local obligations. For example, chatbots to automatically process public services requests or to answer frequently asked questions from citizens, or systems that interpret or compare different regulations.

Assessment of Effectiveness and Efficiency (35%) comes next and is complementary to Administrative simplification. It includes considerations such as return on investment, total cost of ownership and user needs. Examples of AI-based solutions that are aligned with this principle include law enforcement or fraud detection systems, optimisation of energy consumption or quality control of the water.

Preservation of Information (27%) refers to the preservation and, where necessary, conversion to new media of the digital records and information held by public administrations, when old media become obsolete, for the purpose of documenting procedures and decisions. Examples include, AI-based speech-to-text services and text analytics systems, handwriting recognition, transcription, and searches in historic documents of national archives or tools to improve the data quality.

Reusability (18%) is another principal enabler of interoperability and improves quality because it extends operational use, as well as saving money and time. Examples of AI-based solutions that are aligned with this principle are related to restructuring or labelling data to improve further data searches and interoperability.

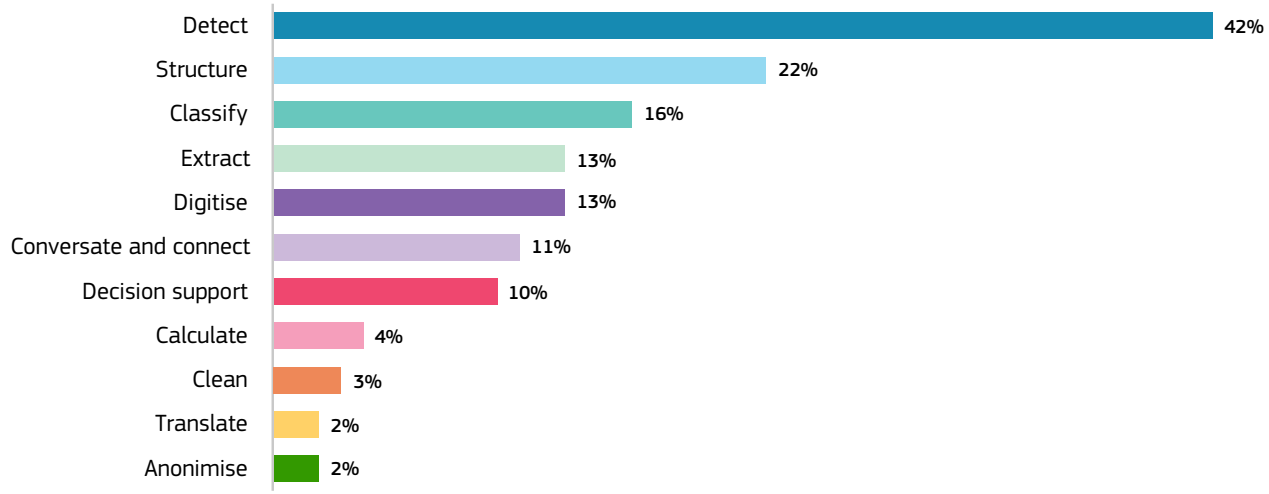
User/Human-centricity (18%) is highly relevant even if the set of selected cases focus primarily on internal management issues in public administration (see Process Type in par. 3.3.4)

Beside these five main principles, other relevant principles are **Security and Privacy (10%)** and Inclusion and **Accessibility (8%)**.

3.2.8 AI Actions

One of the pillars of this study is to understand how AI can improve interoperability in the public sector and, more concretely, what its potential is in performing specific tasks on data. In this respect, the research team has developed an ad-hoc taxonomy to better understand, through the examination of the use cases, the types of 'actions' AI-based solutions can perform to support interoperability. **Figure 12** shows the results of the case categorisation, which are not mutually exclusive: all use cases have been mapped with a maximum of two AI actions forcing the authors to highlight the main ones.

Figure 12. Classification of cases by AI Actions



Source: JRC's own elaboration

Detect (42%) is the most common action category. The systems included in this category detect data structure or patterns in digital data input flows. This category is closely aligned to application types related to smart recognition, inspection processes or monitoring policy implementation. Some examples are related to detection of patterns using images, such as detecting agriculture or forest areas using satellite imagery, or diseases in plants. Other examples are based on the detection of patterns in text, such as divergent interpretations of the law or searches for similar lawsuits.

Structure (22%) is the second action category with more cases. The systems included in this category restructure data, proposing a well-defined data structure as an output, thereby improving interoperability. Examples from this category include systems to analyse, structure and interpret medical information; solutions that enhance metadata for unstructured, textual information and hence increase the quality of search and automatic reasoning; and tools that structure digitised or transcribed data (from audio or handwriting sources) in standard formats, etc.

Classify (16%) is the third most relevant action implemented through an AI-based solution. This category includes systems that automatically classify documents, e-mails, incoming phone calls, company data, citizen inquiries or complaints, etc. This classification can be done through coding or labelling the data.

Other noteworthy categories are **Extract (13%)** which refers to the location of entities, features or keywords contained in data (e.g., summaries, knowledge extraction); and **Digitise (13%)**, which supports the digital transformation of physical media (e.g., documents) into digital data using techniques such as Optical Character Recognition (OCR). This category also includes automated speech translation tools.

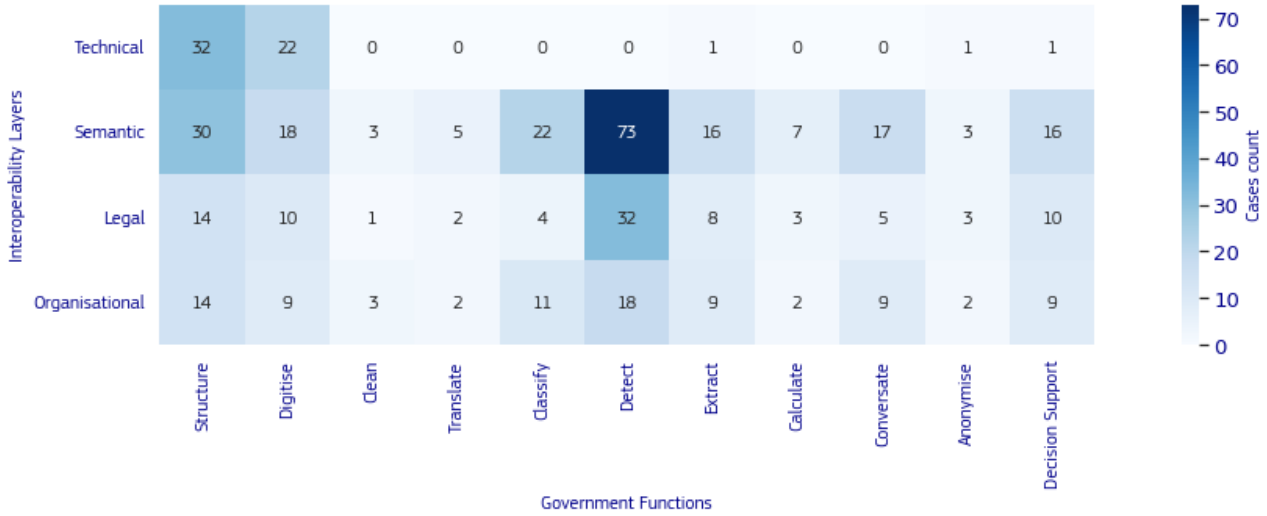
Other relevant categories but with a lower percentage of cases are **Converse and connect (11%)** supporting interoperability of information (e.g., in chatbots, searches, writing code or online forms) and information delivery to the correct level and correct digital address. **Decision support (10%)**, supporting the exchange of higher-level information, enabling decision-making processes. **Calculate (4%)**, supporting complex calculations with a large set of variables and contextual requirements and standards (e.g., detection of fraud with value declarations). Finally, other categories with fewer cases are **Translate (3%)**, **Clean (2%)** and **Anonymise (2%)**.

3.2.9 Interoperability layers by AI Actions

Besides the quantitative analysis concerning each specific AI action described in the previous section, in this section we have crossed the AI actions with the EIF interoperability layers (**Figure 13**) to highlight some additional interesting

points. Each AI case has been classified, highlighting which of the EIF layers is more relevant. Each AI case could range from a minimum of one EIF layer impacted to all four EIF layers. Figure 13 shows the number of cases (Y) affecting a certain EIF layer grouped by AI action.

Figure 13. Interoperability layers by AI Actions



Source: JRC's own elaboration

It is possible to observe that the most frequent action, **Detect** is strongly characterised by improving interoperability through the **semantic layer**. More concretely, the related cases are based on the detection of specific data structures or patterns using for example video images, photos, satellite imagery, textual data, etc. Combining AI capabilities with the use of ontologies and taxonomies creates a more accurate format and meaning of exchanged data and information, preserving them throughout exchanges between parties, and covers both semantic and syntactic aspects. The second relevant layer for the detection cases is the legal layer, noting that in many cases the detection of certain information is used for law enforcement and often requires that organisations work together under different legal frameworks, policies and strategies. These factors bring us to the third relevant layer for the detection cases, the organisational layer. The technical layer is not relevant in this category because by detecting patterns or specific data structures in a collection of data elements, the source data formats are not modified.

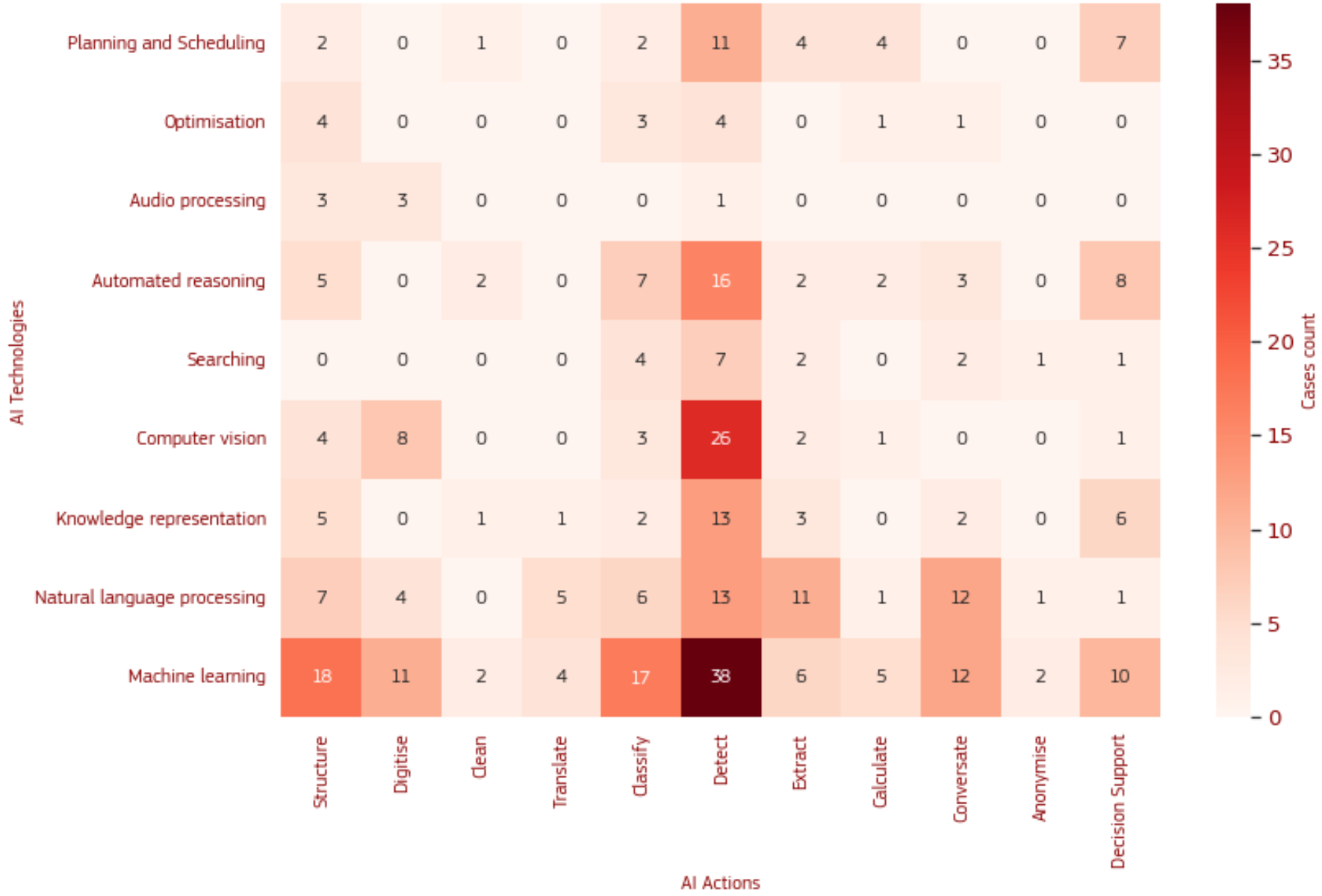
The cases that perform **classification**, **translation**, **calculation**, **anonymisation**, **decision support** and **extraction** actions have a similar pattern as the detection cases, which feature a strong focus on the semantic layer and with almost no relevance with regard to the technical layer with only some exceptions (AI-based compression for extraction cases and generation of synthetic test data for anonymisation cases).

On the other hand, the **technical layer** is slightly predominant in specific actions such as **Structure** and **Digitise** where technical interfaces are more relevant – more concretely by digitising and/or structuring the output data in defined data formats.

3.2.10 AI technologies by AI Actions

Beside the analysis of each specific AI action and the relationship with the interoperability layers, in this section the research has crossed the AI actions with the AI technologies (**Figure 14**) to investigate possible dependencies between these two important features available in the AI cases set.

Figure 14. AI technologies by AI Actions



Source: JRC's own elaboration

Some elements to be highlighted include:

- In all AI actions, **Machine Learning is the prevailing AI technology** confirming that ML is a technology widely used even in very different use cases and with different requirements;
- In AI actions such as **Detect, Extract, Converse and Connect** there is a large use of **Natural Language Processing (NLP)** technology in order to process and exchange information through natural language;
- In AI actions like **Detect and Digitise** there is a remarkable adoption of **Computer Vision technologies**, in order to digitally integrate physical information and physical contents in the applications;
- **Digitise** is the most relevant AI action for **Audio Processing** technologies, often to transform speech into interoperable information within public services;
- **Detect and Decision Support** are the most important AI actions where **Planning and Scheduling** AI technologies have been adopted.

3.2.11 AI Actions and interoperability layers map

In this section, we have crossed the 'AI Actions' layer with the EIF interoperability layer (**Tables 5 and 6**). The main objective of this analysis is to identify the relationships and dependencies between different interoperability layers and the AI actions performed to better understand how AI operates in the different layers to support interoperability. Moreover, we have identified particular use cases and/or specific areas of usage that illustrate how the AI systems support each interoperability layer depending on the action that is performed.

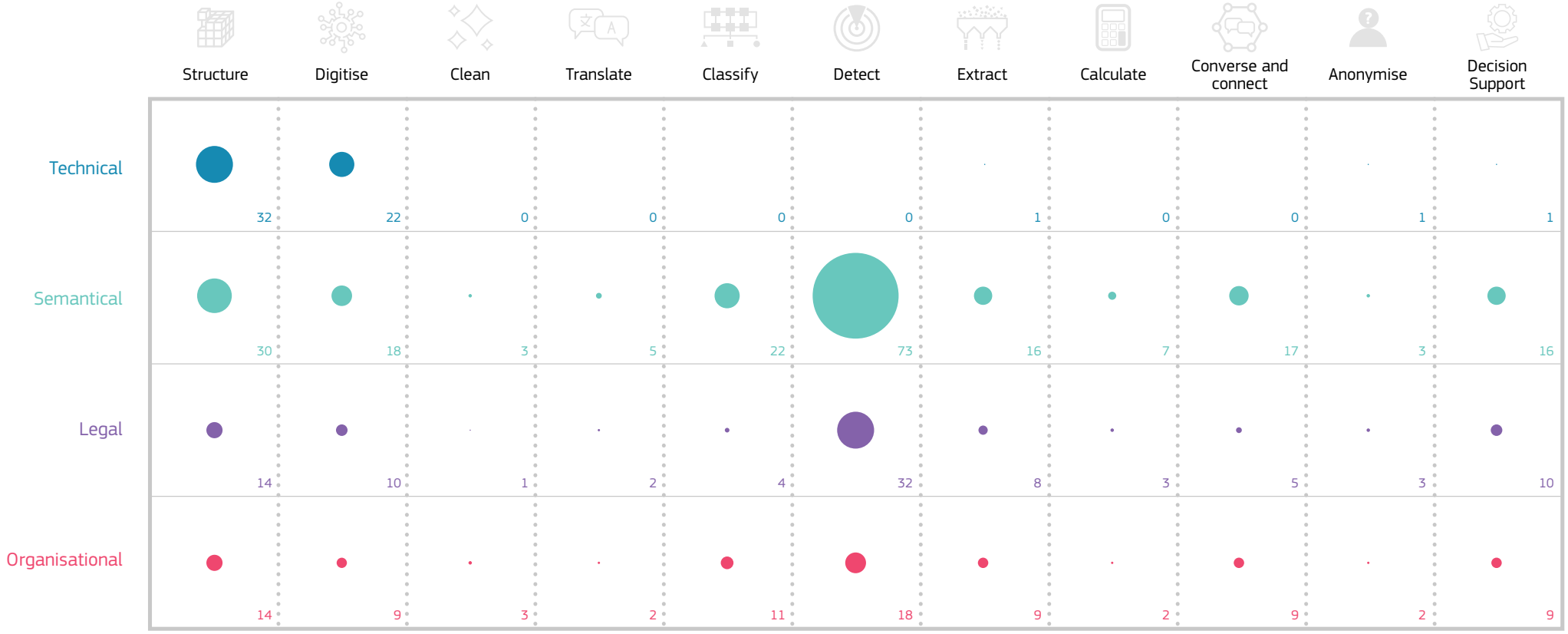
The actions that the AI systems perform on data can interact with each interoperability layer in different ways, for example, interacting with the technical layer by changing data formats, interacting with the semantical layer by adding metadata, interacting with the legal layer by modifying data or interacting with the organisational layer by verifying data from different sources. Hence, by understanding how AI systems support each interoperability layer depending on each AI action performed can be useful to better understand where the value of the AI systems is and its suitability to solve interoperability needs of the different public services.

Table 5 gives an idea of cases per 'AI action' that support each of the interoperability layers. Each case could have assigned relevance on a certain interoperability level for each of the four interoperability layers considered.

Differing slightly from the previous paragraph, there is a confirmation that the cases interacting with the **technical layer** are mainly related to the **Structure** and **Digitise** actions. Moreover, the layer with more cases is the **semantic layer**, and breaking down these cases by actions, the **Detect** cases are by far the most common.

Another interesting aspect concerns the distribution of interaction with the legal and organisational layers, which have similar frequency. In fact, the **legal layer** is more related to the **Detect** action and less with **Structure** and **Digitise** actions, by contrast, the **organisational layer** is much more distributed over mostly all AI actions.

Table 5. Cross mapping results of AI Actions with the EIF



Source: JRC's own elaboration

Starting from the quantitative data reported above, we propose a more detailed view in **Table 6**. In particular, this table describes the role that AI plays in each of the EIF layers. Each of the cells describes how a specific action can support each layer (in bold letters), including examples of concrete areas of usage.

In completing this table, the research team assumed that the actions **Classify, Detect, and Calculate do not interact with the technical layer** by definition, because performing these actions does not bring about any modification of the technical aspects of the datasets (e.g., data format).

Some important considerations and highlights of **Table 6** are:

- The interaction with the **technical layer** is mainly relevant only to the systems **Structure** (32 cases) and **Digitise** (22 cases). In those cases, there is a modification or creation of data structures affecting in this way the technical specifications. Furthermore, our study identified interesting singular cases:
  - A case related to AI-based data compression. We considered that in this case there is an action performed based on data **extraction** and a consequent modification of the data format to produce compressed files as output.
  - An **anonymisation** case consisting in the AI-based generation of new synthetic test data for a dedicated test environment, allowing in this way tests in system integration processes without using authentic personal data.
  - A **decision-support** case based on data collected from different sources, creating a new dataset.
- As stated in previously, **the interaction with the semantic layer is the most relevant**. In this respect, worthy of note are the number of **detection** cases identified that interact with the semantic layer (73 cases).
- Regarding the interaction with the **legal layer**, worthy of note are the number of **detection** cases that are mainly oriented towards law enforcement, for example, detection of fraud, crime or finance supervision based on AI.
- Finally, the main number of cases identified that interact with the **organisational layer** relate to the improvement of organisational aspects through **detection** (e.g., inter-departmental fraud detection), **restructuring** data exchange among administrations (e.g., collection and structuring of data from different departmental silos), and automatic data **classification** to reduce the response time of the administration (e.g., classification of legal documents for decision-making).

Table 6. Cross mapping highlights of AI Actions with the EIF layers

	Structure	Digitise	Clean	Translate	Classify	Detect	Extract	Calculate	Converse and connect	Anonymize	Decision Support
Technical	**Restructure the data in defined data formats/ structures:** structure relevant documents, structure data from different data sources in datasets. 32	**New data formats through the digitisation of analogue media:** document digitisation, licence plate recognition, speech recognition, Handwritten Text Recognition (HTR). 22	0	0	0	0	**Output data format after extraction of data elements:** AI-based data encoding and decoding integration services (e.g., compression services). 1	0	0	**Anonymisation in the creation of new data formats:** generation of rich synthetic test data in a dedicated test environment . 1	**Decision support with data collected:** different estimates and insights from the integration platform (sensors). 1
Semantical	**Restructure data based on semantics:** transcription, automatic analysis of linguistic data, unstructured textual data analysis, NLP to make text content machine readable. 30	**Semantics for the digitisation of analogic media:** transcription, semantic assistance in HTR, automated subtitling services, automated creation of inventories, indexation. 18	**Data cleaning by identifying issues and correcting mistakes based on semantics:** automated editing and imputation. 3	**Translation services based on semantics:** Machine translation services, website automated translation. 5	**Semantics for automatic assessment and classification:** text or audio classification, labelling/tagging by keywords, documents mapping, classification of linguistic data, knowledge classification. 22	**Semantics for the detection of specific data structures/patterns:** in video, images, text, data streams from sensors, financial statements, registries, seals and signatures, audio signals, statistical data, software coding. 73	**Semantics for the extraction of information elements:** knowledge/topographical objects/NER entities extraction from images, text, unstructured sources, summarization. 16	**Semantics for calculation and predictive analysis:** predictive analysis of business difficulties, automatic calculation of property value, bid prediction, rail trespassers prediction. 7	**Semantics for conversational agents:** search support, source code co-pilots, online forms assistant, Q&A. 17	**Semantics for anonymization:** anomalies/incidents detection in document publishing; security compliancy process automation. 3	**Semantics for support in the decision-making process:** enabling semantical and ontological links between data . 16
Legal	**Restructuring data to be compliant with current regulation:** structuring legal documents for legal assessment, data reconstruction for the optimisation of law enforcement . 14	**Digitisation of analogue media to fulfil legal obligations:** automated transcription of proceedings or calls, speech-to-text services on the accessibility of websites and mobile applications of public sector bodies. 10	**Data cleaning by identifying issues and correcting mistakes according to legal requirements:** publication procedure assessment for anonymised open datasets to be compliant with the GDPR. 1	**Translation services to fulfil legal requirements:** quick, raw machine translations from and into any official EU language for administrations. 2	**Classification services to fulfil legal framework:** assessment and classification of legal documents, automatic classification of images for law enforcement, documents classification for investigative activities. 4	**Detection of specific data structures/patterns for law enforcement:** mobile phone usage in vehicles, fraud/crime detection, water quality monitoring, finance supervision. 32	**Extraction of information elements supporting current regulations:** entities, concepts, keywords and features for GDPR fulfilment; management of innovation policies; fraud/crime detection; summarisation of regulations. 8	**Calculation and predictive analysis for supporting current regulations:** taxation, property evaluation, digital-readiness of policies and legislative acts assessment. 3	**Conversational services supporting current regulations:** Collection or distribution of legal sensitive information, transparency and civic issues. 5	**Anonymization to fulfill current laws:** blurring images and anonymising children's identity according to child protection law, removing personal data before publishing according to data protection law. 3	**Support decision-making over sensitive legal data processing:** automatic verification of submitted declarations, support of the financial supervisory authority. 10
Organisational	**Restructuring data exchanged among administrations and towards the users:** harvesting and restructuring data from silos of different administrations or departments, document structuring in transcription related services. 14	**Improving organisational aspects through digitisation of analogic media:** speech recognition in public speaking, transcribing calls of crisis or other public services. 9	**Improving processes through data cleaning:** automated editing and imputation tasks, improving timelines of statistical results or improving the data quality of registrations to deliver services. 3	**Improving organisational aspects through translation services:** time-critical language translations, through conversational agents. 2	**Improving organisational aspects through classification reducing the response time of the administration:** classification of audio, text, images or legal documents for decision-making, benefits applications, cultural management or investigative purposes. 11	**Improving organisational aspects through detection:** inter-departmental fraud/crime/complex economic or social situations detection, user friendly interfaces for the detection of names or places; land structure and ownership detection. 18	**Extraction of information elements improving procedures:** extracting entities, concepts, keywords and features in investigations, administrative processes simplification, report processing for law enforcement. 9	**Improving organisational aspects through calculation:** predictive analysis of business difficulties, rail trespassers prediction. 2	**Improving organisational aspects through conversational agents:** cross-organisation data exchange guidance, citizen-centric services guidance. 9	**Improving organisational aspects through anonymisation:** pseudonymisation of case law data for legal tech startups, generation of synthetic test data for enterprises. 2	**Improving organisational aspects through decision-making support:** aligning business processes and relevant information exchanged. 9

Source: JRC's own elaboration

3.3 Results analysis

The evidence collected is mainly based on the quantitative analysis made in the previous sections and on observations of the research team on concrete examples and cases. 720 use cases of AI in the public sector have been analysed. Among these use cases, 189 have been identified as cases where the AI system is somehow supporting interoperability.

The subset of cases gathered represents a relevant portion of the total AI usage (26%), highlighting the large potential of AI in support of interoperability. The insights are summarised in the following sections.

The first general statement that can be derived from this analysis is that AI has the capability to significantly improve interoperability through a varied set of applications. Below are some insights that summarise the results of this chapter:

- **Semantic layer interoperability is relevant in 91%** of the cases selected, being one of the pillars of AI-based cases that support interoperability. Moreover, the usage of ontologies and taxonomies to create a common language and shared understanding of data, combined with AI technology, can help in establishing semantic interoperability between different systems. The other layers are less relevant: **legal (35%), organisational (33%) and technical (23%)**.
- The most common area of application of AI-based services that support interoperability is **internal management processes, with 36% of cases**. Moreover, this percentage is significantly higher compared with the results obtained by analysing the overall sample (16%, see Tangi et al., 2022). This can indicate a clear suitability of AI-based solutions for supporting interoperability in applications related to the internal processes of public administration.
- The main EIF principle driving the development and adoption AI-based solutions that support interoperability is **administrative simplification with 59% of the cases**. This is by far the most relevant principle, followed by **assessment of effectiveness and efficiency with 35% of cases**. Moreover, this indicates that this type of AI-based solutions provides a wide range of tools and services useful in the reduction of **administrative burdens** and at the same time complying with EU, national, regional or local obligations.
- The three most common actions that AI-based systems perform to boost interoperability are: **Detect (42%), Structure (22%) and Classify (16%)**. Taking advantage of the capability of AI technology to automatically process large volumes of data, these actions help to increase the usage of standardised data formats, clean and structure large volumes of data, improving overall quality and making it easier to use and share between different systems.

Other interesting points observed are:

- **AI actions support multiple EIF layers:** AI can operate across all the different interoperability layers – i.e., technical, semantic, legal and organisational. For example, in a context related to certificate classification to apply for benefits, the classification services can automatically classify incoming documents based on text data, supporting the semantic layer of interoperability, and at the same time fulfilling the legal requirements. This also applies to other types of use cases related to law enforcement, such as automatic classification of certified electronic mail, images containing illegal substances, and documents with a focus on investigative activities.
- **AI can facilitate the integration of different systems and services:** AI can play a vital role in the ability of different information technology systems and software applications to communicate, exchange data, and use the information that has been exchanged, by identifying patterns and creating links between them. For instance, AI-powered recommendation systems can connect citizens with relevant services, based on their search history, preferences and past interactions.

- **AI can improve data quality and accuracy:** AI can enhance the quality and accuracy of data by automating data cleansing, matching and validation processes. This can help ensure that the data are reliable and can be effectively used for decision-making purposes.
- **AI can enable better decision-making:** AI can provide valuable insights and predictions, enabling better decision-making at different levels with data from multiple sources and with different formats. For example, AI-powered analytics tools can help governments identify trends, patterns and anomalies in large and distributed data lakes, allowing for proactive policymaking and resource allocation.

Regarding the methodology adopted, the **AI action** classification proposal is a necessary **starting point** to describe how AI could help interoperability tasks, and to **simplify the mapping of the AI technology in business processes and tasks** that are quite **common**, typically encountered in the implementation of public services.

4

Comparative-analysis of in-depth case studies

This section explores seven use cases of **AI-based solutions that are enhancing interoperability in the public sector in Europe**. It focuses on the challenges and factors associated with AI adoption in the public sector, ensuring ethical, transparent and accountable use of these technologies.

AI can be an essential tool for better structuring, curating and standardising data to make them more interoperable within and outside a single organisation. There is a growing need for interoperability. Technologies such as IoT combined with the deployment of 5G networks are enlarging the volume of the datasets that administrations manage. In addition, innovative public services (taxes, social security, environment ...) often require cross-domain and cross-border integration.

However, AI adoption for enhancing interoperability in the public sector is very challenging. Exploring this topic requires a full understanding of the complex relationships between government, society and technology, and consideration of the expected benefits and the most relevant challenges.

4.1 Methodology

4.1.1 Case selection and description

This chapter is based on an in-depth analysis of seven case studies of AI-based solutions that are enhancing interoperability in different ways.

The selection of the case studies was done starting from the identification of the potentially relevant cases with detailed available public information. Afterwards, the list was reduced by only including the cases where the contact details of at least one person working on the project was available.

Given the described methodology, it is important to state that the seven resulting selected cases do not represent best practices in Europe but allow to extract some useful insights on how to deal with interoperability challenges and how AI-based solutions can help, learning from the experience of those cases. In fact, the purpose of the research is exploratory, with the aim of collecting 'intangible' information related to this context. Such information can be collected only by listening to field experience.

The selected cases are listed and described in **Table 7** including a mapping of the **AI actions performed** by each use case analysed, based on the taxonomy developed in section 3.

All of the cases are using Machine Learning (ML) jointly with some other AI techniques. The adoption of Natural Language Processing (NLP) is worthy of note, being a widely adopted technology to read information that is not structured, and which is also pointed out in the quantitative analysis described section 4. Each case is further described on a dedicated page in the annex to the report.

For each selected case, all the information available was reviewed, followed by an interview with a person involved in its development. All the interviews were conducted online and transcribed.

Table 7. Cross mapping highlights of AI Actions with the EIF layers

#	Case	Country	Org	AI	Short description	AI actions	Further details
1	BÜROKRATT – A virtual assistant for Public Administration	Estonia	Estonian Information System Authority	ML NLP AR	The idea of BÜROKRATT is to allow an end-user (citizens, businesses) from any device and through a virtual assistant to have access to any service needed in one communication session. BÜROKRATT is thus an interoperable network of public sector agencies attached to national information systems, as well as those provided by the private sector, which, from the user's point of view, acts as a single channel for obtaining public direct and information services from the Estonian public administration.	Converse and connect	The solution supports the interoperability of information by being a single conversational channel for all the questions of the citizens or businesses regarding most of the digital services that Estonia provides and giving access to any service needed in one communication session.

2	SAFERS - Structured Approaches for Forest fire Emergencies in Resilient Societies	Italy Cross-country	Fondazione LINKS (Regione Piemonte) SAFERS consortium	ML CV NLP AR	SAFERS developed an innovative platform to improve the management of forest fires. Their impact has greatly increased due to climate change. In addition to damaging the natural ecosystem as well as the social and productive fabric, forest fires also release a large quantity of greenhouse gasses and many pollutants that contribute to the deterioration of air quality. With the objective of reducing the impact of future forest fires, SAFERS developed a new Big Data platform based on AI, coupled with other information systems, making use of different data sources such as the Copernicus Sentinel satellites. In addition to satellite data, the system analyses, in real time, data from ad hoc monitoring cameras, social media as well as mobile phones of professional users, volunteers and citizens who, through chatbots, may report the situation they are observing.	Detect	SAFERS automatically detects fire events by combining different types of input data (e.g., ground-based cameras, social networks or satellite data) that have different formats, validating, classifying and correcting information, and in this way, creating more accurate data. In addition, the system seeks to calculate measurement indices, such as the firewater index, a vulnerability indicator of the area to fires. Finally, it suggests actions to citizens on what to do and what not to do.
3	Energy Vulnerability – automated evaluation of the energy poverty report	Spain	Administració Oberta de Catalunya (AOC)	PS AR KR	According to the law in Spain, the citizens who are facing complex economic or social situations cannot be cut off from basic supply services such as gas, water or electricity. When the suppliers detect unpaid bills, before cutting off the service, they must consult with the municipality to determine if the citizen or family is facing a situation of social vulnerability. The municipalities receive monthly lists from the companies in different formats and have to go through a costly bureaucratic manual process in order to validate if a citizen is at social or economic risk. The solution developed by the AOC automates this complex process of data verification by improving the interoperability between the companies and the municipalities and between the municipalities and other administrations to verify the data.	Detect	The solution improves the interoperability between the companies and the municipalities and between the municipalities and other administrations to verify the relevant data to automatically detect if a citizen is facing complex economic or social situations.
4	Evaluate science and business cooperation in terms of knowledge usage efficiency	Lithuania	Lithuania Innovation Agency	ML OP	The solution is an AI-based tool that will allow the collection, processing and systematisation of relevant data on the knowledge generated by the Institutions of Science and Studies (ISS). A user interface, which is being developed, will provide structured data to allow for a twofold analysis of the ISS's contribution to different sectors of economic activity: quickly comparing the data using an interactive interface diagram; or conducting a detailed and cross-sectional analysis using a data summary.	Structure Classify	The solution helps with mapping differently structured datasets and automatically classifies certain kinds of knowledge usage across the Lithuania business cooperation ecosystem
5	Procurement data quality and CPV improvement for TED data	Belgium	European Publication Office	ML NLP	This AI-based solution aims at improving Tenders Electronic Daily (TED) data quality and to have better expenditure data and statistics. The Common Procurement Vocabulary (CPV) codes establish a single classification system for public procurement aimed at standardising the references used by contracting authorities and entities to describe procurement contracts. These codes are introduced by a human who is trained through his or her own experience, knowledge and environment, introducing involuntarily bias into the into the data. This project is in a proof-of-concept phase and has the objectives of suggesting to the user CPV codes from notice/procurement documents, elaborating statistics (e.g., which contractor has been awarded the most contracts from the EU Parliament?), and foreseeing which companies would be awarded with a contract in the future if a tender has certain characteristics (e.g., if OP launches a CFT for IT services in 2025 with 500k EUR<value<EUR 1 million, which companies are more likely to be awarded with that contract?).	Decision support	The system identifies the budgetary value in the procurement documentation and validates it. Moreover, it classifies the codes, and the result can be, for example, suggesting a ranking of CPV to the user with the objective of improving procurement data quality.
6	Automated transcripts to speed up judicial proceedings	Spain	The Basque Government IT company	ML NLP AP	Legal proceedings have a peculiarity when it comes to the drafting of judgments. Sometimes transcriptions of the proceedings are needed, especially when the judgment is appealed to higher instances. Given the recording of the proceedings, the video clip is examined to determine, for example, where exactly something was said or who was named. In the Basque Country, administration transcripts are made by manually reviewing the videos of all the sessions. Thus, it is not possible to easily search for words, phrases and generic entities across the video clip and there is not any correlation between the speech and the person who uttered it. Converting voice data into searchable text using automated transcription services may save significant time and create actionable value. With this solution, 100% manual transcription is no longer necessary, and efforts can be focused on correction and completion. In addition, if a court case is appealed to a higher instance, time is also saved by making it easier to find the exact points in the video in which specific information has been given.	Digitise Structure	The solution provides speech-to-text functionality, digitising the audio signal and keeping track of the audio and its transcription, as the legal value is still in the audio. The text is extracted in subtitle format and a web application is used to link the text with the concrete minute of the video/audio. Texts are saved and made available in a structured form.

7	Anomaly detection in e-government administration	Hungary	Idomsoft ZRT (indirect state owned IT company)	ML PS	In digital government administration, various critical services are widely used. To maximise the reliability and availability of these services, this AI-based solution introduces various ML techniques. More concretely, this solution focuses on the smooth operation of huge number of services, minimising the risk of service corruption. Moreover, it predicts the future load or tries to identify the miss usage of certain services. Furthermore, it uses different algorithms to create models for anomaly detection to analyse huge amounts of data produced by various public services used by many people.	Detect	The system detects artefacts/events/mistakes combining several input data sources (system logs), most of them non-structured. In addition, it structures the data before analysis. Moreover, it uses deep learning to create a model which can be used for predicting future events. Furthermore, the system includes a visualisation dashboard and alarms. The model is trained using historical data in order to facilitate prediction.

Source: JRC's own elaboration

(AI legenda: AP=Audio Processing, AR=Automated Reasoning, CV=Computer Vision, KR=Knowledge Representation, ML=Machine Learning, NLP=Natural Language Processing, OP=Optimisation, PS=Planning and Scheduling)

4.1.2 Case analysis

The analysis of the collected data followed an inductive, bottom-up approach. The coding protocol followed precise steps to ensure the accuracy of the data. First, at the conclusion of each interview, the research team shared its initial idea, to disentangle the open points and discuss the understanding of the data. Second, each team member manually coded the interviews by highlighting the main concepts. Moreover, the extracted concepts were reported in a spreadsheet and each observation was discussed and reviewed by the entire research team. This phase was crucial in identifying the relevant themes, matching the empirical evidence with the theoretical domain. This iterative corroboration process was repeated until the entire research team was satisfied and the coding was consistent.

Due to this process the research team identified factors that facilitate or limit the adoption of AI-based solutions to support interoperability, identifying **benefits and challenges**, **Table 8**:

- **Benefits** refer to the positive outcomes, advantages or gains that motivate or influence a particular action or decision. They can be internal or external and vary depending on the situation. In the context of this study, the drivers are useful for a better understanding of the **benefits and advantages** of using an AI-based solution to solve issues related, even partially, to data interoperability. Evaluating and understanding the benefits is important in assessing the effectiveness and value of a particular endeavour or undertaking
- **Challenges** refer to a complex issue, obstacle or problem that hinders the effective functioning, performance or achievement of the objective. Challenges can arise from various factors such as limited resources, complex environments, technological limitations, organisational constraints, social or cultural barriers, competing priorities, changing circumstances, or external influences. In the context of this study, the analysis of the challenges is useful for a better understanding of the **limitations and common problems** that must be faced to implement an AI-based solution to support interoperability.

Table 8. Breakdown of the benefits and challenges identified

Benefits	Improve users' interactions
	Workload reduction
	Service replicability
	Cost optimisation
	Improve transparency
	System reusability
Challenges	Skills availability
	Cross-border interoperability issues
	Complexity
	System integration issues
	Law compliance
	Financing, budget issues
	Data quality issues

Source: JRC's own elaboration

Moreover, to better understand how each case supports interoperability, the research team has focused more specifically on the analysis of the support of each use case in relation to the EIF interoperability layers.

The awareness of the benefits, challenges and the support of each case to the different interoperability layers is of utmost importance to understand how and why these AI-based solutions successfully support data interoperability in the public sector. Whilst the analysis of the selected use cases in the public sector varies greatly between their applications, purpose, policy domain and even the status of their implementation, it reveals a variety of insights, consistently with the particular view on how AI could support interoperability.

4.2 Results

4.2.1 Benefits

In order to identify common dynamics that motivate public administration to implement an AI-based solution that supports interoperability, the research team has identified specific potential benefits among the selected case studies. This section describes each driver in detail, highlighting the specific peculiarities identified in the case studies.

Table 9. List of benefits and their relevance in the analysed cases

	1	2	3	4	5	6	7
Improvement of users' interactions	●	●	●	●	●	●	●
Workload reduction	●	●	●	●	●	●	●
Service replicability	●	●	●	●	●	●	●
Cost optimisation	●	●	●	●	●	●	●
Improve transparency	○	○	○	●	●	○	●
System reusability	●	●	●	○	●	●	●

Source: JRC's own elaboration

Note: ● Relevant benefit(s) of the project ● Benefit(s) partially or indirectly present in the project ○ Benefits(s) not present

4.2.1.1 Improvement of users' interactions

The first of the identified benefits responds to the need of improving the system's interaction with different types of users who, in one way or another, participate in the public service processes (e.g., end users, public employees or external providers) by making services available, easily identifiable, accessible and user focused. This need can be linked to the need of increasing **organisational interoperability**. In this respect, AI-based solutions can streamline interaction between the system and the different types of users **by offering simpler, user-friendly interfaces**. This is accomplished by automating data processing tasks, often performed in the backend of the public service.

For instance, in the SAFERS project (**case 2**) the AI-based solution provides an improved user interface based on maps that displays information collected automatically from specific public sources such as Twitter and public forums. Users can draw a specific area of interest on a digital map and trigger a digital request to a backend digital service already in operational use.

Moreover, public agencies can provide services to citizens through a single conversational channel, as seen in the case of BÜROKRATT (**case 1**), facilitating the interaction with the end users (Estonian citizens) who can access any needed service from different public agencies in one communication session.

Finally, the concept of 'Machine Learning as a Service' (MLaaS) used in the anomaly detection in e-government administration project (**case 7**) should be pointed out. This concept involves providing an interface that allows users to perform data analysis and transfer the data into an AI model for further use.

4.2.1.2 Workload reduction

Workload reduction is another expected benefit highlighted in all the cases analysed. Interviewees highlight how AI4IOP solutions can **automate repetitive administrative tasks** that are repetitive in nature.

All of the use cases reduce the administrative burden for civil servants, or any end user, by increasing efficiency and **supporting the information exchange between areas**. For example, the AI-based solution used in the Energy Vulnerability project (case 3) has the capability of processing a large volume of data, integrating **diverse and heterogeneous information systems**. Hence, it significantly reduces the workload for public employees, and increases the efficiency in information exchange among the different participating organisations.

Moreover, in the case of automated transcripts in judicial proceedings (**case 6**), the solution adopted has been described as a productivity tool to modernise justice administrative tasks, by enabling the storage of the transcripts and constantly keeping track of audio and its transcription.

Furthermore, anomaly detection in the e-government administration project (**case 7**) proposes AI techniques that can significantly reduce the workload of system administrators. By automating system administration tasks and monitoring with greater accuracy, AI can help save time and resources, allowing organisations to focus on core tasks and deliver better services to end users.

4.2.1.3 Service replicability

Service replicability is another highly pertinent identified benefit in all of the use cases analysed. For example, the Energy Vulnerability solution (**case 3**) enables the automatic draft of the energy vulnerability report, which responds to the needs of Catalonia region to more than 2000 public bodies (municipalities, etc.). However, in addition to the technological capability of the system to be easily replicated, an organisational factor to consider is the presence of a **common understanding** (which is not always obvious) of the problem in a standardised, non-partitioned view of the administration.

Moreover, in the case of BÜROKRATT (**case 1**), the solution is built on a shared communication model by the Estonian government and placed on top of open-source components in a standardised way making it easily replicated among other various Estonian public agencies with very limited NLP AI-model contextualisation changes.

Finally, in the case of automated transcripts in judicial proceedings (**case 6**), an application programming interface (API) is used to integrate the service in other platforms, easily replicating it in other organisations.

4.2.1.4 Cost optimisation

Cost optimisation also emerged as a key motivating benefit across all of the cases analysed. This can be effective through direct savings due to workload reduction. In most of the cases the AI-based solution substitutes a costly process previously done manually.

For example, in the Energy Vulnerability project (**case 3**), a pilot test was done with a very low investment compared to the huge potential for savings after adopting the solution. The new system **automates a very costly, burdensome and bureaucratic process** that is presently done manually and requires many dedicated public employees. Moreover, the initial investments can be reduced with the reuse of system components, which often eliminates the need to develop new components from scratch. Instead, existing components that have already been created and tested can be leveraged, saving both time and money. By reusing these components, organisations can avoid the costs associated with designing, developing and implementing new systems, thereby reducing the initial investment required for IT projects. Unique to some AI solutions is that the cost reduction or the speeding up of adoption can also be made by adopting and adapting an available solution (e.g., a commercial solution, which requires less resources and development time). This has many advantages such as a quicker 'Time to Market', good flexibility and scalability.

Furthermore, the need to reduce costs is one of the main benefits in the case of BÜROKRATT, a virtual assistant for public administration (**case 1**) in Estonia. This use case responds to the need of alleviating the workload of customer support specialists through automating many of their processes, thereby reducing costs. This is especially beneficial in a country like Estonia,

where many citizens live in sparsely inhabited areas and are therefore difficult to reach.

Similarly, in the anomaly detection in e-government administration project (**case 7**), the main benefit is to reduce the cost of the operations of the IT systems to make all IT services more reliable and maintainable, with better performance, and to provide more stable online public services to Hungarian citizens.

4.2.1.5 Improve transparency

Another significant benefit appears in the desire to enhance transparency, although it was identified in only a subset of the cases.

In this respect, the main positive outcome for the European Publication Office (**case 5**) regarding procurement data was to improve transparency in the data collected from the national public procurement authorities. Though higher quality data available for the users, the Publication Office aims at supporting companies in conducting their business in several ways. First, it provides a TED data entry system that can suggest which CPV to apply to certain procurements to then be published. Second, it enables a smart search for the identification of the calls for tender. Similarly, public administrations that want to launch a new tender could automatically generate a tender notice, a summary and a classification in an assisted and simplified way.

A valuable benefit for the Lithuanian Innovation Agency (**case 4**) is to empower it in monitoring and measuring more transparently which knowledge transfer activities are effective. Knowledge transfer come about through science and business cooperation, one of the biggest systematic issues of every national innovation ecosystem.

4.2.1.6 System reusability

One of the most interesting actions to foster interoperability and cooperation among public administrations is the possibility of reuse, as much as possible, of IT system solutions or components. This action is part of the overall interoperability strategy and has many benefits as it promotes standardisation and simplified, faster and more efficient administrative procedures while reducing public expenditures and saving time and effort.[65]

In this respect, in the qualitative analysis carried out by the research team, we have identified two different approaches:

- A **decentralised approach** based on creating products on top of open-source components and/or developing open-source components that are **published for reuse**.
- A more **centralised approach** is where the AI system is developed by one organisation that has the know-how concerning the technical, semantical, legal and organisational constraints. It then offers the same service or 'pack' of services to other agencies, which are then **replicated** among other public organisations. Hence, the AI system exchanges data between many other public organisations with the same format and rules, thus improving the interoperability between them. Moreover, when a critical mass is reached it can also 'impose' concrete standards of use. Moreover, AI4IOP AI systems promote reusability through the concept of AI model reuse.

One of the main differences between both approaches lies in the concepts of reusability and replicability. While the decentralised approach is based on the reusability of system components and requires some kind of adaptation to be reused in another similar AI-based solution, the centralised approach replicates the same service among other organisations, copying the exact same service delivered in different organisations. Moreover, in the centralised approach, the organisation that offers the services to other public agencies acts as a service provider, being responsible for the set-up, delivery, maintenance and other related aspects of the service (e.g., legal support), while in the decentralised approach, the organisation who publishes the open-source components has no responsibility over its future use in other projects or services implemented in other organisations, as the

65. https://ec.europa.eu/isa2/actions/promoting-sharing-and-reuse-interoperability-solutions_en/

publication is made for the benefit of the community of software developers and other organisations that are building similar solutions.

While both approaches support interoperability in one way or another, the difference is that in the decentralised approach there is a margin to modify or adapt data structures or formats, depending on the needs, but in the centralised approach, the service provider 'imposes' concrete standards of use. **Table 11** shows the relevance of each of these two approaches for each of the use cases analysed.

Table 10. Relevance of each of these two approaches for each of the use cases analysed

	1	2	3	4	5	6	7
Decentralised approach	○	●	○	○	●	●	○
Centralised approach	●	○	●	●	○	○	●

Source: JRC's own elaboration

Note: ● Relevant feature(s) of the project ○ Feature(s) not relevant

4.2.2 Challenges

Implementing AI in the public sector also poses various challenges. These challenges range from ethical and legal issues to technical and cultural barriers (Tangi et al., 2023; Wirtz et al., 2019). As such, it is important to carefully consider the potential challenges of AI adoption in the public sector. In this section, we will explore some the challenges that our respondents have faced or are expecting to face when adopting AI in support of interoperability. We will describe each challenge in detail, highlighting the specific peculiarities identified in the case studies.

Table 11. List of challenges and their relevance in the analysed cases

	1	2	3	4	5	6	7
Skills availability	●	●	●	●	●	●	●
Cross-border interoperability	○	●	○	○	●	●	○
Complexity	●	●	●	●	○	○	○
System integration issues	●	●	●	●	○	○	●
Law compliance	○	●	●	●	○	●	●
Budget Constraint, financing	○	○	●	●	●	○	○
Data Quality issues	●	●	●	○	●	●	○

Source: JRC's own elaboration

Note: ● Relevant feature(s) of the project ● Feature(s) partially or indirectly affecting the project ○ Feature(s) not relevant

4.2.2.1 Skills availability

One of the biggest challenges in adopting AI in the public sector is the need to acquire the necessary skills and competencies to develop, implement and maintain AI-based solutions. Our research has identified this challenge in all cases analysed to a greater or lesser degree. Some responsible organisations, such as Estonia's Digital Government (**case 1**), struggle to find partners with the required expertise to develop and implement AI solutions. Regione Piemonte (**case 2**) has installed the entire system in its own cloud, managed by its in-house IT company, being complex to maintain the technological stack created. To manage this complexity, will be necessary the help of external consultants to use their expertise to develop and maintain the licensed software.

Furthermore, an important skills gap to point out involves **the legal framework to apply to data interoperability** for exchanging data between organisations or to understand which data are available and what can be done with them. For example, this is the case of the Lithuanian Innovation Agency (case 4) who is also considering outsourcing the need for these skills to companies who have this specific expertise.

Finally, there is need to develop an internal/external workforce with a diverse set of skills, including data analysis, programming and ethical decision-making. The experience of the European Publication Office (case 5) is that it is possible to reuse the organisational capabilities despite, in some cases, the availability of the needed profiles being very difficult to find. In those cases, the support of external consultants with the relevant expertise was needed. These challenges highlight the need for ongoing training and development programs to build the capacity of public sector organisations to effectively adopt and apply AI solutions.

4.2.2.2 Cross border interoperability issues

Cross-border interoperability issues are not widespread in the analysed cases, and are

only present in the cases with an international scope. Moreover, the use of AI technology can introduce additional complexities. One of the main challenges is the **lack of standardisation across different national and international systems**, making it difficult to develop common protocols for data exchange. Additionally, there may be legal and regulatory barriers to sharing data across borders, particularly with regard to sensitive information such as health records. The use of AI to support cross-border interoperability requires the development of robust and reliable AI algorithms that can handle complex data from multiple countries, requiring coordination and collaboration across different agencies and jurisdictions to ensure that interoperability standards are implemented consistently and effectively. For example, the SAFERS project (**case 2**) worked around a cross-border data exchange to implement an alerting monitoring system that has been experimented with in different EU countries (France, Italy, Greece). Moreover, European Publication Office (**case 5**) collects structured procurement data from all the EU Member States.

4.2.2.3 Complexity

Some of the projects analysed are affected by complexity management. The public sector manages vast amounts of data, which can be complex, diverse and often stored in various formats across different systems. Managing **data complexity, availability and formatting can be a significant challenge**, particularly when attempting to use AI to support data analysis and decision-making. Ensuring data quality and accessibility is crucial, as AI systems rely on high-quality and relevant data to function effectively. Additionally, data privacy and security concerns must be addressed to prevent unauthorised access or misuse of sensitive information. Furthermore, the development of AI algorithms must consider the potential complexity and variability of data in the public sector to ensure that solutions are relevant and effective in practice.

For example, the Energy Vulnerability project (**case 3**) deals with a complex data verification process to solve an interoperability-related problem that is repeated, involving different companies that send files monthly in different formats to 947 municipalities, thus increasing its complexity. In addition, the automation of the authorisation processes to access external information systems is also complex and rigorous.

The Lithuanian Innovation Agency (**case 4**) manages three types of information in different formats, scientific publications, university graduates, and joint science and business projects, besides the general issue of a lack of accuracy of the input data. This has led to the implementation of a complex data verification system process using ML.

4.2.2.4 System integration issues

System integration, in support of interoperability, is a critical challenge, as it involves integrating complex and diverse systems across different departments and agencies. Our research has identified this challenge in the specific use cases that **require continuous data exchange with external systems**. Achieving seamless system integration requires addressing several other challenges, such as incompatible data formats, inadequate legacy systems and complex regulatory frameworks. AI-based solutions play a key role in addressing these challenges, by providing tools and techniques for data mapping, data cleaning and data transformation, and by enabling automated system integration testing and monitoring. Additionally, AI-based solutions can support system integration by providing intelligent decision support systems that can automatically analyse and interpret data from multiple sources, identify patterns and provide insights into support decision-making. However, the successful implementation of AI for system integration requires a strategic and collaborative approach that involves a **close partnership between public sector organisations**, technology vendors and other stakeholders.

For example, this is one of the main challenges of the Energy Vulnerability project (**case 3**) as the municipalities that adopt the AI-based solution offered by the responsible organisation, Administració Oberta de Catalunya (AOC), face

an integration process consisting in some tasks to enable this technology to access their information systems and to enable them to share digital certificates that permit the entire automated process.

4.2.2.5 Law compliance

The challenge of ensuring legal compliance is not widespread in the use cases analysed. It is a critical challenge in the use cases where there is **an exchange of sensitive data between different administrations**, requiring compliance with data protection laws or the GDPR. Moreover, there is also a relevant challenge **in cross-border cases**, as these involve adhering to complex and constantly evolving regulatory frameworks across multiple jurisdictions. Achieving legal compliance requires several actions, such as identifying and interpreting relevant laws and regulations, monitoring compliance, and identifying and mitigating potential risks. However, the successful implementation of AI-based solutions with respect to legal compliance requires a strategic and collaborative approach that involves a close partnership between public sector organisations, technology vendors, legal experts and other stakeholders.

Moreover, the interoperability between administrations with respect to sensitive data often requires managing complex **authorisation systems** to automate the processes and seeking permissions from each of the administrations involved, specifying the purpose for the consultations. In addition, sometimes the responsible organisation needs the **prior consent of the citizen** to access specific sensitive information. For example, one of the challenges of the Energy Vulnerability project (**case 3**) is to check if a citizen has a social file in order to have access to it. This requires prior consent of the citizen to the administration to access it, otherwise the administration has to ask for this consent to the citizen, who has to go physically to the city council to give it.

4.2.2.6 Financing, budget issues

Our research has identified budget constraints in some of the use cases analysed. Moreover, dedicated funds were always allocated and relied on ad-hoc funds for innovative projects. These funds often came either from national, regional or European Union administrations. Budgetary issues are a risk for the continuation of the project. Some of the constraints faced by the European Publication Office (**case 5**) in the development of the use case concerned the management of the budget infrastructure and the forecasting of the correct amount needed. Furthermore, for the Lithuanian Innovation Agency (**case 4**), the most important issue was likely the financing, as the budget was insufficient to further develop this use case.

4.2.2.7 Data quality issues

The need for enough quality data upon which to base the AI is an important technological requirement, which in all cases analysed is an important factor, to different degrees depending on the use case, during the AI-based solution implementation. Moreover, data quality issues can reduce the possibility of using external data sources or may require the need to generate new data with the desired quality. In this respect, the Basque Government Information Society (**case 6**) needed a data generation contract with an external supplier to generate data of sufficient quality, involving users, for the automated transcripts of judicial proceedings.

Furthermore, one of the purposes of the AI4I-OP cases themselves is to improve data quality. This can be achieved in different ways, depending on the type of application or main focus of the use case. One of the common goals is to produce interoperable data by structuring it in standard formats that can be shared with other systems, allowing reuse. Another action to improve the quality of the data content by cleaning it up, improving its accuracy and overall quality, is seen in the case of the European Publication Office (**case 5**) involving procurement data. In this case, procurement data was not accurate, more concretely the CPV code. The CPV code is introduced by humans and is influenced by their own experience, knowledge and environment, potentially introducing involuntarily bias into the

data. The purpose of this AI-based solution is to prevent biased codes by suggesting a range of CPV codes to the user that could fit. Finally, there are other cases where there may be problems with the quality of the data, but this has not been the biggest issue for them. This is the case of BÜROKRATT (**case 1**) and the Energy Vulnerability project (**case 3**). In these cases, that the sources of information may not be correct involves small and circumstantial risks.

4.2.3 Interoperability layers

This section aims at better understanding of how AI systems support interoperability in the public sector through an analysis of the support of each of the selected use case in relation to the EIF interoperability layers. In this respect, depending on the specific application, purpose or policy domain, the type of support of each use case in relation to the different EIF interoperability layers varies. The in-depth analysis of these relationships allows to identify more accurately where the real added value of AI-based solutions to support interoperability is. **Table 12** summarises the relevance of each of the layers with respect to the use cases analysed. In the following sections, further detail is provided to better understand how each layer is being supported to improve interoperability.

Table 12. List of interoperability layers and their relevance in the analysed cases

	1	2	3	4	5	6	7
Technical layer support	●	●	●	●	○	●	●
Semantic layer support	●	●	●	●	●	●	●
Legal layer support	●	●	●	●	●	●	●
Organisational layer support	●	●	●	●	●	●	●

Source: JRC's own elaboration

Note: ● Relevant Interoperability layer(s) of the project ● Partially or indirectly supporting the layer ○ Not relevant Interoperability layer(s)

4.2.3.1 Technical layer support

Support for the technological layer is important per se in any AI-based use case. The development of an AI system is always complex from the technical point of view. However, from the AI4IOP perspective, the support **for the technical layer interoperability is no different from generic AI use cases, except when the use case performs actions related to structuring or digitising information**. For example, in the case of automated transcripts of judicial proceedings (**case 6**), audio recordings are digitised, generating data structured in subtitle format, allowing in this way to keep track of the transcribed audio. Furthermore, many of the technical issues arise from the **requirement of having enough input data available in terms of quantity and quality**. This is a key aspect for the development of any AI solution. How to acquire data and which actions are required to improve standardisation or structure differs among the analysed use cases.

From the perspective of AI systems that support the interoperability of data, it is not enough to merely be able to support different data formats. It is remarkable that in some cases the ontologies used in the input data are incomplete or need restructuring, such as in the SAFERS project (**case 2**). Moreover, there are cases where different datasets are part of the input data, with different or incomplete ontologies or structures, requiring that the AI system consolidates and/or complements the ontologies or the data structures, to make them more interoperable and to be better adapted to the needs of the AI system. In addition, it is possible that the input data is completely non-structured. In this respect, a structuring process is a prior step to a further analysis in order to perform another action. For example, the anomaly detection in the e-government administration project (**case 7**) uses transformer models to transform the non-structured data into structured data formats.

Finally, the support of the technical layer also consists in creating output data in interoperable standard formats that can subsequently be reused, published or shared. This way, other components of the same system that use the same type of data or other projects at the European or global levels can reuse this data easily. For example, in the SAFERS project (**case 2**), weather

forecast data is published in a data catalogue. In this way, another component of the system that uses this type of data detects new data and reuses it.

4.2.3.2 Semantic layer support

The support of the semantic layer is crucial in most of the cases analysed. From the AI4IOP perspective, in many cases AI systems have to **analyse and process the input data semantically** in order to consolidate and establich a **uniform and standardised data ontology or structure before the data are analysed**. For example, the anomaly detection in the e-government administration project (**case 7**) has text strings as input data (system logs), which most of the time do not follow any specific format being necessary to use self-supervised learning to structure the data before they are analysed for anomaly detection, root cause analysis or forecasting. Another illustrative case is the use case carried out by the European Publication Office (**case 5**), which has developed a specific ontology for public procurement.

Moreover, the support of the semantic layer is also crucial in the cases where the main focus is automated language analysis, for example, a transcription or translation application. In these cases, it is sometimes necessary to generate more input data in order to increase the quality of data and to better train the models. This is the case of the automated transcripts of judicial proceedings (**case 6**) where it was necessary to improve the input data quality by including more audio sentences than were read in Spanish and Basque and that were selected to try to find specific noises or to better identify questions or exclamations.

The BÜROKRATT chatbot platform (**case 1**) is an example of a sustainable AI-based solution that is scalable and ensures privacy when processing human data through the entire Estonian public administration. The aim is to train the solution and develop its basic functionality to the point that most public services that use voice-based communication are available through it and by other channels, such as instant messengers, with a standardised communication between the state and the consumer.

Finally, there are other types of support of the semantic layer detected in this qualitative analysis, for example, part of the SAFERS project (**case 2**) consists in a fire detection service based on automated text analysis of social networks to detect fire reports made by citizens who report the matter by mobile phones (more specifically on Twitter, now X). In addition, as part of the same project, an ML algorithm (Computer Vision), carries out a semantic segmentation of images coming from ground-based cameras.

Overall, one of the main aspect regarding the support of AI-based solutions for interoperability is the **capability of supporting the semantic layer**.

4.2.3.3 Legal layer support

The support of the legal interoperability layer is also very relevant in the use cases analysed. Firstly, many cases are created with the specific goal of complying with the current law in a more efficient way or to ensure that the rights of the citizens are respected, **with a reduced workload for the administration and providing a better service to the citizen**. Secondly, as with any other AI-based solution, legal compliance (e.g., data protection or the GDPR) can also affect its implementation. For example, Spain has a law that prevents citizens who are in a complex social or economic situation from being cut off from basic supply services. In this case, the automation of the generation of the Energy Vulnerability report (**case 3**) improves data interoperability to verify all of the required data, thereby reducing the workload and costs for the administration while ensuring that the rights of the citizens are respected. At the same time, to access and verify these data, that can sometimes be sensitive, the system legally requires obtaining authorisations from other administrations where the data are stored, which can be other departments or other public administrations.

Moreover, it is remarkable that the lack of coherence between legislation, in view of ensuring interoperability, can create differences, for example, on how data are tagged. This is the case of the SAFERS project (**case 2**) where the

algorithm is not uniform but varies according to country-specific or territorial rules. In this case, the AI system's forecasts have a combination of factors that are high-risk, according to locally defined rules (in each territory, Greece, Spain or Italy, but also at the regional level, there are different rules). Hence, the way the AI-based solution supports the legal layer **should be assessed in the pilot phase and through evaluating its performance regularly once it is in production**.

4.2.3.4 Organisational layer support

From the perspective of interoperability, the organisational layer is very relevant in all the cases analysed in order to obtain a successful service based on AI by documenting and integrating or aligning business processes and relevant information exchanged between public administrations. In this respect, the different solutions answer in different ways to the lack of interoperability considering the organisational challenges. Its design is centred in satisfying the needs of the participants and end-users of the system by improving data interoperability, **requiring a common understanding of the initial problem by all partie**s.

Furthermore, those responsible for the AI system must facilitate the involvement of users/participants, providing end-to-end solutions that in some cases will require some level of integration and initial setup efforts with other organisations. In this respect, there are some cases where the responsible organisation has the know-how concerning the implementation and its constraints, and is offering the AI-based service to other agencies, replicating it among other public organisations. This is the case of BÜROKRATT, a virtual assistant for Public Administration (**case 1**) where the responsible organisation attracts other public agencies in Estonia to use their service and shows them the benefits, for example, reducing customer support specialists' workload. In the same way, the Energy Vulnerability project (**case 3**) offers an end-to-end AI-based service to municipalities that do not have the resources to implement major digital transformation projects or that have a structure that does not allow the required change. In addition, the responsible organisation takes care of all legal and data protection issues, and other related issues (e.g., setting up a dedicated call centre for the service). These are clear examples where different public administrations **align their processes, responsibilities and expectations** to achieve commonly agreed and mutually beneficial goals.

In addition, sometimes data collection is one of the most difficult tasks requiring external help from other organisations, for example, in order to train the models. This is the case of automated transcripts of judicial proceedings (**case 6**), where the data coming from real recordings of court proceedings has to be complemented with other recordings from public television. In addition, it was necessary to contract a private company to generate the needed quality data.

Likewise, the relationship of the responsible organisations with different technology providers and universities varies significantly among the cases analysed. Some cases developed the project entirely internally or with a minor contribution from external suppliers (e.g., **case 1**). However, most of the cases rely on external organisations. Some rely mostly on completely externalising the technical development, for example EJIE, the Basque Government Informatics in house company, relies on VICOMTECH[66] (**case 6**) as the external supplier of the adopted AI technology. In addition to private organisations, collaboration with universities was a key factor in several projects. Several cases found in university departments the right attitude towards innovation as well as the missing competences (e.g., **case 5** from the European Publication Office).

66. https://www.vicomtech.org/en/

4.3 Result analysis

The cases analysed provide a concrete example of the importance of considering and implementing AI to promote interoperability in the public sector. The **benefits are significant** and diverse, ranging from the elimination and automation of repetitive tasks to easier replicability and reusability of the service. This has a direct impact on the cost and quality of public services.

In other words, the cases demonstrate the need to invest in the use of AI solutions to improve interoperability: these AI tools have the potential to help the public sector take an important step forward in the long-standing and complex issue of creating a single, interoperable European public sector.

Of course, this is not to say that the characteristics of AI and the structure of the public sector do not pose challenges. The cases analysed have **identified a number of challenges**: (i) lack of skills and expertise, (ii) cross-border interoperability, (iii) complexity, (iv) system integration issues (v) compliance with laws and regulations, (vi) budget constraints, and (vii) quality of data.

On the basis of this finding, it is interesting to reflect on the way forward.

First, even though all the cases analysed clearly promote interoperability, the link to interoperability was not immediately clear to the interviewee. It was only after we explained why we considered the case to be an 'AI for Interoperability' solution that this link became clear to the interviewee. This is because **there is a significant distance to cover in terms of the approach to interoperability and awareness of the benefits that AI-based solutions can offer** in terms of data or system interoperability.

Secondly, **public organisations need to move from a sporadic use of AI for interoperability to a more structured use based on specific and defined strategies for a more interoperable European public sector**. We have observed that in most cases AI solutions are not part of an existing strategy. And this is of course related to the previous point, i.e., the lack of awareness of the importance and benefits of AI4IOP. The initiative has often been taken in occasionally, depending on the context and the awareness of each organisation on how to deal with interoperability aspects. In most cases, the AI solution responds to a specific need with a very limited scope. For example, the Basque Government (case 6) implemented a strategy for the use of the Basque language, including a plan for the modernisation of the judiciary, which allowed the development of the use case of automated transcripts of judicial proceedings. In this case, interoperability (as such) was not considered in the design and implementation phase of the project, despite the clear link to it.

Thirdly, **public organisations need to move towards a comprehensive, cross-organisational approach**. In some of the cases analysed, AI has been considered as a tool to improve interoperability between public organisations, sometimes including other private sector organisations with which they exchange information (e.g., the Energy Vulnerability project, case 3).

This logic must be systematically applied: AI allows for easy replication once everything is in place. To accomplish this, public organisations need to share a common good understanding of the problem with the other public organisations in a **unified, non-segmented view of the administration to avoid digital silos**. All this without forgetting that there is always an initial phase of system integration and training needed for all public organisations.

5

Policy implications and recommendations

Interoperability of public services has become a major concern for governments around the world. The increasing digitalisation of public services, the rise of big data, and the emergence of new technologies such as AI have created both challenges and opportunities for achieving interoperability.

In this section, we will discuss policy recommendations for the public sector to use AI to improve interoperability for public services. Drawing on a literature review and quantitative and qualitative research and analysis, these recommendations address areas such as governance, service delivery, resource allocation and stakeholder engagement. By implementing these recommendations, governments can foster innovation, promote transparency and optimise public services to meet the evolving needs of citizens. This chapter serves as a practical guide for policymakers seeking to drive positive change and achieve sustainable development in the public sector.

Moreover, the recommendations reported here follow and elaborate on those published in the previous report 'AI Watch, road to the adoption of Artificial Intelligence by the public sector' (Manzoni et al. 2022). The report outlined the path towards a fair and trustworthy adoption of AI and provided several recommendations for public administrations. This section proposes more specific and detailed recommendations to help public administrations identify concrete actions to be taken to start using AI as a tool to improve interoperability.

The data collected allows us to draw recommendations at two different policy levels:

- Recommendations **for public administrations** and public managers that aim at using AI to enhance interoperability.
- Recommendations **at the European level** on how to include AI for Interoperability in the European policy agenda.

5.1 Recommendations for public administrations

The evidence collected is mainly based on concrete examples and cases, hence the recommendations drafted here mainly focus on the elements public organisations should consider when approaching the **implementation and use of AI-based solutions to support interoperability**.

5.1.1 AI4IOP, an opportunity to explore

The 189 cases on the type of applications and public administration sectors **are very diverse**. For example, AI applications based on smart recognition or to support inspection processes are already in use in many sectors like general public services, environmental protection or health. These results show that there is widespread interest **in embracing AI's benefits** to foster interoperability of systems, processes, services and organisations.

However, in most of the case studies, the implementation of the solutions was extremely dependent on the context and the level of awareness of each organisation or even each public manager. The implementation of AI was often an initiative of an individual, or a small group of receptive public servants. Moreover, in many cases the link to interoperability was not immediately clear to the interviewee.

These data show **a significant distance to cover in terms of awareness** of the opportunities and benefits that AI-based solutions can provide for enhancing interoperability.

The first step is therefore ensuring that public managers are aware of the inherent characteristics of AI technology, being able to operate across **different layers** including all the different interoperability layers, technical, semantic, legal and organisational.

This general awareness can be achieved in various ways and through various instruments. One possible way forward can be the design of a specific strategy for the implementation of AI for interoperability. This strategy should include an adequate communication plan with dedicated campaigns, workshops and seminars for public servants, including, to some degree, the involvement of other actors, such as citizens and businesses. In none of the cases ana-

lysed was the project part of a larger strategy. However, a more strategic view will foster and nudge a general curiosity and therefore a general awareness, allowing a more systemic and diffuse approach that goes beyond individual initiatives.

Recommendation 1

Public administration should raise internal awareness regarding the possibilities of AI to improve interoperability, experimenting and discovering the benefits and potential to be exploited.

5.1.2 Adopting AI4IOP, complexity and other issues

Like any other emerging technology, the implementation of an AI-based solution that supports interoperability is **complex**. For this reason, it is important to carefully consider possible challenges in its adoption in the public sector. In synthesis the challenges that arise from our case studies analysis are: (i) lack of skills and expertise, (ii) cross-border interoperability, (iii) complexity, (iv) system integration issues (v) compliance with laws and regulations, (vi) budget constraints, and (vii) quality of data.

On the one hand, data issues related to quality, availability or formatting are one of the main factors that increase the complexity of AI solutions. On the other hand, however, AI solutions have the potential to increase data quality. The latter is less debated and recognised. Public managers should consider **using AI techniques** to enhance the quality of the data content by structuring or cleaning it up, improving in this way the accuracy and overall quality before a further data analysis.

Legal, regulatory and ethical compliance is another critical factor to consider. In this regard, successful implementation requires a **strategic and collaborative approach**, involving a close partnership between public sector organisations, legal experts, technology providers and other relevant stakeholders. These partnerships can help organisations understand and comply with relevant laws, regulations and ethical considerations to easily navigate the legal landscape associated with AI implementation. Another layer of complexity is the integration of different systems, which is hampered by various elements such as incompatible data formats, data quality, data ownership and privacy, and inadequate legacy systems, requiring similar measures to address them.

In summary, addressing the complexity of AI4IOP requires a comprehensive focus on organisational aspects, facilitating interdepartmental relationships, process improvements, partnerships, compliance and ethics, and not just on the technological capabilities offered by new AI technologies in the public sector.

Recommendation 2

Public administration should treat the adoption of a sustainable AI-based solution to support interoperability as a complex project with a special focus, both collaboratively and individually, on system and data integration, law, regulation and ethical compliance.

5.1.3 Support cross-organisation collaboration

AI has been considered as a tool to improve interoperability between public organisations, but also with private actors. In this respect, one of the takeaways of the case studies analysis is that public organisations need to move towards a comprehensive, **cross-organisational approach**. Its successful implementation always requires a **common understanding** of the initial problem by all parts. To accomplish that, documenting, integrating or aligning business processes and relevant information is crucial, highlighting the importance of the organisational layer.

This need can be seen, for example, in cases where there is a public authority acting as a service provider to other public organisations. In these cases, the public provider, which is responsible for the establishment, provision, maintenance and other related aspects of the service, needs to facilitate the involvement of

the other users/participants in providing end-to-end solutions. This will require integration and initial set-up efforts to be led by the responsible organisation.

Recommendation 3

Public administration should create the best environment for an effective collaboration between public agencies: this is based on a common understanding of the problems in order to facilitate data exchange and the integration of different systems and services.

5.1.4 Promotion of semantic interoperability

The results of this study show how AI4IOP developments seem driven by **semantic** data interoperability issues, being relevant in 91% of the cases selected. In addition, the data show how ontologies and taxonomies combined with AI technology can help in establishing semantic interoperability between different systems. More concretely, in many cases, the AI systems analyse and process input data semantically to consolidate and establish a uniform and standardised data ontology or structure before the data are further analysed.

The lack of data interoperability can be solved by combining AI and semantics, structuring the data according to a reference ontology. The problem comes when this reference ontology does not exist and worse, when there is an ontology fragmentation with a great deal of customisation or statistical extension. Hence, the public administration should accelerate the **creation, promotion and use of reference ontologies and taxonomies** to become widely adopted and recognised to facilitate and support semantic interoperability.

Furthermore, promoting the use of standardised ontologies and taxonomies within AI solutions requires collaboration with industry, international organisations and experts. It is crucial to establish appropriate governance in this context. The responsible authority should select specific semantic standard(s) to be adopted in AI solutions, avoiding complications that may arise when different governance regimes are in place.

Finally, the public administration should also ensure that AI systems are developed and used ethically and responsibly with a risk-based approach, as also imposed in the upcoming AI Act. This includes ensuring as much as possible that the AI solutions adopted are transparent, accountable and unbiased, also from the semantic point of view. The public administration should also establish governance frameworks to monitor and track the development and deployment of AI solutions inside IT systems. These frameworks should include mechanisms for monitoring and evaluating the impact of AI systems on the interoperability of public services.

Recommendation 4

Public administration should promote the use of uniform and standardised ontologies and taxonomies to create a common language and shared understanding of data that, combined with AI technology, can help in establishing semantic interoperability between different systems.

It is important to highlight the activities carried out by the European Commission, over the past years: Interoperable Delivery of European eGovernment Services to public Administrations, Businesses and Citizens (IDABC[67]), Interoperability Solutions for European Public Administrations (ISA[68] and then ISA[2]), Digital Europe Programme (DEP[69]), and also the participatory platform that supports the sharing of assets of interoperability to be used in public administration and eGovernment (Semantic Interoperability Centre Europe[70]). The fundamental objective of these actions was and still is to **foster semantic interoperability** in the context of pan-European data exchange among public administration by creating a repository for interoperability assets that can be used by e-government projects and their stakeholders. Moreover, SEMIC.EU has

67. https://eur-lex.europa.eu/EN/legal-content/summary/the-idabc-programme-2005-2009.html
68. https://ec.europa.eu/archives/isa/
69. https://digital-strategy.ec.europa.eu/en/activities/digital-programme
70. https://joinup.ec.europa.eu/collection/semic-support-centre

published a large number of reports, studies and guidelines on various topics[71] promoting the creation and use/reuse of a common language, supporting in this way semantic interoperability.

5.1.5 Support early legal assessments

Legal issues are one of the main aspects to be considered before implementing AI4IOP solutions. One of the main challenges is the **lack of legal consistency** among different national and international systems, making it difficult to develop common protocols for data exchange.

Moreover, the way an AI-based solution supports the legal layer should be **assessed in the pilot phase** and through evaluating its performance regularly once it is in production.

Furthermore, public administration should consider the possibility of collaborating with external parties when assessing the legal framework to apply for data interoperability, especially given the difficulties of hiring people with the necessary skills. In particular, legal issues often arise when public administrations need to exchange data among each other or to understand what can be done with the available data.

71. https://joinup.ec.europa.eu/collection/semic-support-centre/studies-and-guidelines.

Recommendation 5

Public administration should assess current legislations at the early stages of the experimentation phase and regularly after the implementation of an AI4IOP solution.

5.1.6 Support upskills acquisition in the public sector

As stated in the previous sections, one of the biggest challenges to adopt AI in the public sector is the need to acquire the necessary skills and competencies to develop, implement and maintain AI-based solutions. Our research has identified this challenge in all cases analysed, even if with different impacts in the implementation process. Upskilling civil servants is crucial for ensuring that government agencies operate efficiently and effectively. Training and development programs, coaching and mentoring, and job rotation opportunities can help civil servants gain exposure to new techniques and technologies, build their leadership skills, and stay current on evolving policies and regulations. Moreover, by investing in the development of civil servants, the public administration can build a strong workforce that is equipped to serve the public good.

In particular, regarding AI4IOP solutions, the suggestion is to incorporate within the public administration, AI and interoperability specialists who possess expertise in both at certain level. Their role can be crucial in developing reliable solutions for the public administration, both within government agencies and beyond. Additionally, in order to guarantee an appropriate understanding, supervision and adoption of AI4IOP solutions there is a need for comprehensive upskilling programs for civil servants, ensuring a responsible and effective use in the public sector.

Recommendation 6

Public administration should support the upskilling of AI and interoperability specialists within the public administration, internalising in this way critical supervision tasks of AI systems that support interoperability.

Despite this need, the public sector is going through an historic moment when finding people with the right skills is becoming more and more difficult. In the long term, the public sector must find a way to reverse the tide, as internal skills are needed to ensure a sustainable and trustworthy use of AI. In the short to medium term, public administration could also leverage on collaboration and partnerships among public agencies, departments and private sector organisations. Encouraging and supporting collaboration can help leverage the expertise and resources of different organisations to develop and deploy AI4IOP solutions, for example by:

1. Using existing collaborative structures such as the EDIH network working with AI

in the public sector (train the trainer, pilots, etc.);

2. Supporting TSI (Trans-European Services for Public Administration) actions and/or exchange of best practices to develop AI strategies for the public sector.
3. upporting the creation of an expert group focusing on how AI could support interoperability, setting up knowledge sharing platforms, developing a maturity model (with the help of the SEMIC.EU community).
4. Providing training and funding to support the development and implementation of AI strategies, in particular to improve interoperability, in public administrations.

5.2 Recommendations for upcoming EU policies updates and initiatives

This exploratory study could influence some upcoming EU policies updates and other EU initiatives. Policy documents and initiatives can play a role in stimulating the use of AI to improve public sector interoperability. Together with this study, we have demonstrated its potential, but we have also highlighted the need to make this type of use more systemic by raising awareness, designing strategies, etc.

Therefore, this chapter aims to open a dialogue to find the best way forward to promote the use of AI as a tool for a more interoperable Europe. We propose here a non-exhaustive list of possible suggestions.

1. **Interoperable Europe Act:** The actual policy draft does not explicitly refer to AI. However, the connection between AI adoption and **interoperability solutions** is clear throughout the regulation as it refers to innovation measures. First, AI can be a useful innovative tool **to enhance data and system interoperability solutions** across Europe. Second, the use of AI can also be considered for the mandatory IOP assessment requested by the Act. **Therefore**, this research study provides valuable guidance for the Interoperable Europe Board, especially on action 2 (new innovation measures for the development of existing or new interoperable solutions), on how to **include AI** into the debate, continuously **monitor its potential** to promote cross-border interoperability, and encourage Member States to **explore the use** of AI solutions according to their needs. **In addition**, there is the possibility to link AI with GovTech incubator/pilots and EDIH focusing on AI and public sector, to develop and test innovative AI4IOP solutions.
2. **European Interoperability Framework:** although the current version of the EIF does not mention AI explicitly, the findings of this research indicate that it may be appropriate to consider some additional AI elements in the next version of the EIF. The general recommendation is to add guidance for leveraging on AI to implement more advanced interoperability, particularly at the semantic level for the use of uniform, transparent, accountable, standardised and accepted data ontologies and structures. Some more specific suggestions are:
   - To promote interoperability and compatibility among different AI systems, including data and software licenses as it is essential to standardise AI frameworks. This can be achieved by sustaining common standards and open-source frameworks for AI development and deployment.
   - Enhance trust and confidence in using AI technologies providing links to basic AI ethical/transparency guidelines to ensure that AI systems developed in support of interoperability, respect fundamental rights, privacy, data protection and transparency.
   - Transparency, explainability and accountability are necessary distinctive features in AI solutions in support of interoperability, particularly when AI algorithms are involved in critical decisions. Thus, it is essential to frame the importance of these

features in any AI solution, enabling clear explanations of how AI models reach their conclusions or decisions, thereby reducing biases wherever AI is deployed.

- To incentivise the design and adoption of legal and regulatory guidelines through a continuous review and update of existing legal frameworks and regulations.

3. **Common European Data Spaces:** AI can also play an important role in improving the interoperability of data spaces, with a direct impact on the Common European Data Spaces. In particular:
   - Data mapping: AI can help automate the process of mapping data between different formats, protocols, ontologies and standards used by different data spaces. This can facilitate the exchange of data between different data spaces without manual intervention, reducing the risk of errors and improving the efficiency of data exchange.
   - Data integration: AI can help integrate data from different sources and formats, removing redundancies and inconsistencies and creating a single view of the data. This can enable the seamless exchange of data between different data spaces, making it easier for users to access and use the data.
   - Data cleaning: AI can help identify and clean low-quality data, ensuring that data exchanged between different data spaces is accurate, consistent and trustworthy. This can improve the reliability of data and increase the interoperability of data spaces.
   - Data analysis: AI can help analyse large volumes of data exchanged between different data spaces, extract insights and patterns, and make predictions. This can help improve decision making, identify opportunities for innovation and increase the value of data.
4. **Coordinated Plan on Artificial Intelligence:** the current version of the Coordinated Plan places emphasis on the public sector leading the way in AI adoption. Given (i) that 25% of AI solutions aim at fostering interoperability, that (ii) data play a key role in the public sector, and (iii) the need of more interoperability across Europe, **the public sector has the potential to become a trailblazer in using AI for interoperability**. By doing so, the public sector can set a positive example for other sectors to follow. This relevant subset of AI solutions could find their space in the next version of the Coordinated Plan.
5. **Funding mechanisms:** the increasing importance of interoperability, jointly with a reliable adoption of AI in the public sector should be reflected in future EU funding opportunities. On that direction, EU programmes such as Horizon Europe and cooperation programmes such as INTERREG should support cross-organisational real experimentation, using AI to support interoperability, establishing connections between the EU research agenda and these new AI applications.
6. **Monitoring:** by incorporating AI technologies, **several of the DESI** (Digital Economy and Society Index) **indicators could be improved**, such as digital public services, interoperability, and the use of new technologies, as well as AI can help enhance cross-border **public service delivery in smart cities**, by enabling seamless collaboration and information sharing across different sectors and domains.

6 Conclusions

This report aims to provide an analysis of how AI systems are improving interoperability in the public sector in Europe by gathering data from a **literature and policy review** on the synergies between AI and interoperability, a **selected inventory of 189 use cases** and an **in-depth analysis of seven case studies**. Moreover, the cases analysed are also made available in open data, and they represent one of the legacies for any researcher or policymaker who wishes to do a deep-dive, refine or integrate the analysis, aiming at being the starting point that can foster further analysis on the topic.

The results provide a clear link between AI and interoperability and illustrate, with a clear picture, how the capabilities of AI technology can improve interoperability by operating across **different layers**, i.e., technical, semantic, legal and organisational. Hence, AI could become an essential tool for better **structuring, curating, standardising and processing** public administration data and enhancing interoperability within and outside public sector organisations. However, implementing an AI4IOP solution is a complex project that often requires cross-organisational collaboration. Moreover, there is a significant distance to cover in terms of approach to interoperability and **awareness** of the benefits that AI-based solutions can offer in terms of data or system interoperability. In this direction, further research should gather and analyse additional practices that promote sharing experiences among public organisations.

The present research is only a **starting point to fill the gap** in the existing body of knowledge. Furthermore, greater emphasis must be placed on **ensuring a consistent and feasible implementation in everyday operations** by examining how technological innovation is transforming organisational practices, procedures, processes and approaches in the public sector.

Moreover, the report does not cover how interoperability could support AI implementation – this merits further investigation. Interoperability plays a crucial role in the success of AI since it enables diverse systems to work together seamlessly and utilise the data generated by AI-powered processes more effectively.

In addition, there are emerging traces, gathered during the research, that many public servants are already using online generative AI-powered tools with the potential to significantly disrupt conventional working methods. Some of the highly recognisable AI tools that currently exist online include ChatGPT, Dall-E, Midjourney, Bard AI/LaMDA, Aleph Alpha, Bloom, Llama v1-2 and Stable Diffusion. These generative AI models leverage computer programs to generate content that closely mirrors content produced by humans. Anyone can prompt these models via online chatbots to generate new text, summarise content, produce images, suggest data visualisations, and much more. These online AI tools are very flexible and quite easily also support interoperability tasks performing several types of **actions, such as digitising, structuring, detecting and extracting**, as well as writing better and more interoperable source code and data queries. This kind of AI is accessible online for free with the risk of missing a detailed monitoring on an appropriate (especially legal) usage. Hence, further research is needed to collect and analyse **quantitative and qualitative data on generative AI** use cases including a focus on their use to enhance interoperability. In doing researchers can focus on assessing real risks versus real advantages for the public sector to better understand its suitability to solve real problems.

Overall, the report offers a fresh view on how the public sector is innovating through the application of technology, **adding new dimensions of analysis and insights** in the existing body of knowledge on the topic, contributing to a transition away from a primarily theoretical and anecdotal perspective on AI and interoperability in the public sector to a more organised and methodical analysis between the two topics.

Finally, from the policy perspective, the introduction of the **Interoperable Europe Act** regulation jointly with the **Artificial Intelligence Act** is fundamental for fostering innovation and to develop, pilot and deploy AI-based solutions that support interoperability.

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List of abbreviations and definitions

AI	Artificial Intelligence
AI4IOP	Artificial Intelligence for Interoperability
AOC	Open Government of Catalonia
AR	Automated Reasoning
BRP	Personal Records Database
COFOG	Classification of the functions of government
CPV	Common Procurement Vocabulary
CV	Computer Vision
DMA	Digital Markets Act
DSA	Digital Services Act
DSS	Decision Support System
EDIH	European Digital Innovation Hubs
EC	European Commission
EFISC	European Framework for Interoperability Skills and Competences
EIF	European Interoperability Framework
EIF4SCC	European Interoperability Framework for Smart Cities and Communities
EIRA	European Interoperability Reference Architecture
EJIE	Technological management body of the Basque Government
EPISA	Entity and Property Inference for Semantic Archives
ESRB	Entertainment Software Rating Board
EU	European Union
EWI	Department of Economy, Science & Innovation of the Flemish Government
GDPR	General Data Protection Regulation
GovTech	Refers to the use of emerging technologies and digital products and services by government from start-ups and SMEs - instead of relying on large system integrators
HLEG	High-Level Expert Group. It is a European Commission appointed group of experts to provide advice on its artificial intelligence strategy
HTR	Handwritten Text Recognition
IDABC	Interoperable Delivery of Pan-European eGovernment Services to Public Administrations, Business and Citizens
ICT	Information and Communications Technology
IMAPS	Interoperability Maturity Assessment of a Public Service
IoT	Internet of Things
ISA, ISA²	Interoperability solutions for public administrations, businesses and citizens

IT	Information Technology
IOPEU Academy	Interoperable Europe Academy
KR	Knowledge Representation
LEOS	Legislation Editing Open Software
JRC	Joint Research Centre
ML	Machine Learning
MLaaS	Machine Learning as a Service
NER	Named-Entity Recognition
NIFs	National Interoperability Frameworks
NLP	Natural Language Processing
NUTS	Nomenclature of Territorial Units for Statistics
RRF	Recovery and Resilience Facility
OCR	Optical Character Recognition
OECD	Organisation for Economic Co-operation and Development
ONNX	Open Neural Network Exchange
OP	Optimisation
PS	Planning and Scheduling
Q&A	Question and Answer
SEMIC	Semantic Interoperability Centre Europe
SDGs	Sustainable Development Goals
TED	Tenders Electronic Daily

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Annex

Bürokratt - *Estonia - Information System Authority*	**Function of Government**	General public services	**Status**	Implemented
	Relevant interoperability layers	Semantical and organisational	**AI Action**	Converse and connect

The organisation

The Information System Authority (RIA) coordinates the development and administration of information systems ensuring the interoperability of the state's information system, organises activities related to information security, and handles security incidents in Estonian computer networks. Information System Authority is within the administrative area of the Ministry of Economic Affairs and Communications.

The solution

The idea of Bürokratt is to allow an end-user individuals, businesses) from any device and through a virtual assistant to have **access** to any service needed in one communication channel. Bürokratt is thus an interoperable network of public sector agencies attached to national information communication systems, which, from the user's point of view, acts as a single channel for obtaining seamlessly public information and to reach the most appropriate public services provided from the whole Estonian public administration.

Technical information

Bürokratt is being developed on the basis of open development. In short - no private repositories, no private planning, no private anything. The code committed by developers ends up straight at public GitHub repositories and the moment we see it, everyone else sees it as well. The backend components stack is called Bükstack, these include Ruuter, Resql, Datamapper and TIM. As Bürokratt is based on a machine learning, RASA NLP/Chatbot framework is currently used for creating rules, stories etc. More information can be found here.

> *The interoperability has been addressed using the same software platform in every public agency.*

Interoperability support

The solution supports the interoperability of information by being a single **conversational channel** for all the questions of the citizens or businesses regarding most of the digital services that Estonia provides and **giving access** to any service needed in one communication session.

The most relevant interoperability layers of this use case are **semantic and organisational**. This case is example of scalable AI-based solution that ensures privacy when processing users' data through all the Estonian public administration. It aims is to make available most public services using voice-based communication, relying most of its value in the semantic interoperability. From the organisational point of view, RIA attracts other public agencies in Estonia to use their service and show them the benefits of using this AI-based solution, for example reducing the customer support specialist's workload.

Benefits and challenges

Since Estonia is a very young republic with citizens living in very sparsely inhabited areas added to the high level of digitisation of the population, facilitating to provide digital public services for all its citizens, one of the main benefits of Bürokratt is that **automates** many processes and **alleviates** the customer support specialist workload. Furthermore, it provides services to citizens through a single conversational channel, **facilitating the interaction with the end user**s (Estonian citizens) that can have access to any needed service from different public agencies in one communication session.

Moreover, several challenges arise, like the difficulty to **find partners** with the required expertise to develop and implement AI solutions. In addition, the Estonian language is not widely spread, the reuse of language technology components can prove to be difficult.

Useful links

Burokratt: the next level of development of the digital state in e-Estonia

Bürokratt: government virtual assistant

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SAFERS – Structured Approaches for Forest fire Emergencies in Resilient Societies

Fondazione LINKS (Regione Piemonte)

Function of Government	Environment protection	**Status**	In development
Relevant interoperability layers	Semantic	**AI Action**	Detect

The organisation

LINKS is a powerhouse. For nearly two decades, we have led the way in the innovation process, with the clear objective of revolutionising industries and communities across the globe. With a keen eye toward the global landscape, we conceive and execute projects that have the power to impact both the public and productive sectors, driving change from the foundation. We hold ourselves to the highest ethical standards, driven by a steadfast commitment to the greater good, and strive to forge partnerships with public institutions, non-profit entities, and cultural organisations. Our unwavering pursuit of excellence has made us an indispensable contributor to the innovative ecosystem of our region.

The solution

SAFERS developed an innovative platform to improve the management of forest fires, whose impact has greatly increased due to climate change. With the objective increasing resilience to forest fires, SAFERS developed a new Big Data platform based on AI, coupled with other information systems and using **different data sources** like the Copernicus Sentinel satellites. In addition to satellite data, the system analyses, in real time, data from ad hoc monitoring cameras, social media as well as mobile phones of professional users, volunteers and citizens who, through a chatbot, may report the situation they are observing and get updated information from control centres.

Technical information

An open platform is the core of the implementation of some specific AI-based services. It uses EFFIS, Copernicus EMS and SENTINEL 2 data. The AI-based services include a fire detection system, a fire propagation model, a fire and burned area delineation model, and post-event monitoring models. The platform provides a web-based dashboard that displays interactively the data collected and structured in the backend.

Useful links

SAFERS Project; Fondazione LINKS; CSI Piemonte

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> *What is lacking in the emergency management landscape is the interoperability of data, which could be achieved using a standard and common ontology.*

Interoperability support

The solution improves interoperability with existing systems by providing a service-oriented architecture and web-based APIs for data exchange and service triggering. SAFERS includes a geodata repository extended from CKAN (open-source software), which supports INSPIRE compliant metadata and it is interoperable with other geodata repositories such as GEOSS and NextGEO. SAFERS also features an importer and mapper that selectively ingest the data included in the geodata repository and serves through OGC standards (e.g., WMS, WMTS). SAFERS automatically **detects** fire events by combining different types of input data (e.g., ground-based cameras, social networks, satellite data), which are automatically **validated, classified and corrected** using **ML models** to deliver **accurate and actionable information**.

The most relevant interoperability layer is the semantic Decision Support System that uses an ontology extended from previous works to analyse the data generated by the SAFERS services and trigger suggestions, e.g., which actions should citizens do or not depending on the forecasted risk index.

Benefits and challenges

One of the main benefits of this AI-based solution is the possibility of transforming data into **actionable information** and to **automate processes**. As a result, decision makers will be able to **act faster** and take **better informed decisions** at all phases of the emergency, thus reducing the impact of current and future forest fires. A usable web-based **user interface** allows to effectively visualise all the generated information and enables users to interact with the system, e.g., trigger map requests to a specific service simply drawing an area of interest and specifying the reference temporal interval.

Complexity is one of the main challenges. In this respect, the involvement of an ICT company is required to maintain, evolve and provide the SAFERS service to end-users, e.g., public administrations, developing specific interfaces with the existing system currently used. To this end, a collaboration and an adoption roadmap has been defined with Regione Piemonte and CSI Piemonte (IT inhouse company of Piedmont Region).

Moreover, the development of robust and reliable AI algorithms that can handle **complex data** from multiple countries require coordination and collaboration across different agencies and jurisdictions. More concretely, the algorithms related to the Decision Support System shall be adapted according to the end-user due to country-specific or regional rules, different operational procedures and policies.

Automating the energy poverty report

Administració Oberta de Catalunya (AOC)

Function of Government	Social protection	**Status**	Pilot
Relevant interoperability layers	Legal and organisational	**AI Action**	Detect

The organisation

The mission of the AOC is to accelerate the digital transformation of the Catalan administrations promoting agile and collaborative governments by fostering the interoperability of Catalan information systems with other administrations, creating and providing common e-government services, reusing e-government applications and services and guaranteeing the identity of the citizens and the staff of the public sector, as well as the confidentiality and the non-rejection in the electronic communications.

The solution

According to the law in Spain, the citizens who are facing complex economic or social situations cannot be cut off from basic supply services (gas, water or electricity). When the suppliers detect unpaid invoices, before cutting off the service, they must do a consultation to the municipality to know if the citizen or family is facing a situation of social vulnerability. The municipalities receive monthly lists from the companies in different formats and channels (email, online forms, etc.) and have to go through a costly bureaucratic manual process in order to validate if a citizen is in social or economic risk. The solution developed by AOC **automatises this complex process** of data verification by improving the interoperability between the companies and the municipalities and between the municipalities and other administrations to verify the data. It is currently being piloted in several municipalities.

Technical information

The solution is an AI-based complex process automation system, using Robot Process Automation (RPA) and Business Process Modelling (BPM) technologies. In addition, is based in a cloud service provided by a private company, doesn't require any installation but it needs to be integrated with many other information systems.

Useful links

Consorci AOC - Administració Oberta de Catalunya

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> *We build services that are common to the needs of Catalonia where there are more than 2000 public bodies.*

Interoperability support

The solution improves interoperability to **verify** the relevant data to automatically **detect** if a citizen or a family are facing complex economic or social situations. The most relevant interoperability layers of this use case are the **legal and organisational**. At organisational level, the solution offers an end-to-end AI-based service to municipalities that don't have the resources to put forward major digital transformation projects or that have a structure that doesn't allow the required change. This way, this use case aligns processes, responsibilities and expectations between organisations to archive common goals. In addition, AOC offers care about all about all legal and data protection issues, and other related issues (e.g., setting up a dedicated call centre for the service). The solution ensures that the rights of the citizens are respected, and the administration can apply the existing law with efficacy.

Benefits and challenges

One of the main benefits is that this solution has a strong capacity to **automate repetitive** administrative tasks with a large volume of data and to be integrated with **diverse and heterogeneous** information systems. On average, the system performs fifteen verifications using seven different sources of information from local, regional, and central government. In addition, the verification process is conducted for all members of legal age. Another value is the **replicability**, enabling to build services that are common to the needs of different Catalan public bodies. In addition, the use of an adapted commercial cloud solution, with a quick **time to market**, being flexible and scalable. Moreover, the cost entirely acceptable given the **huge potential for savings** that exists for the coming years.

The challenges to be faced are diverse, as this solution addresses a very **complex** process of verifying data, needing to be **integrated with many** information systems ensuring compliance with the legal framework. In addition, municipalities must do the integration process **with rigorous authorisation systems**, needing in some cases that the citizen submits **additional documentation or gives the consent** to access to the social file, having to go physically to the city council. Finally, the format of the data provided by the companies is not standardised.

Science business cooperation in knowledge usage efficiency

Lithuania - Lithuanian Innovation Centre

Function of Government	Economic Affairs	**Status**	Pilot
Relevant interoperability layers	Semantic	**AI Action**	Structure, Classify

The organisation

Lithuanian Innovation Centre's mission is providing innovation support services by implementing Lithuanian innovation policy. The main strategic goal of LIC is the increasing of Lithuanian international competitiveness by stimulating innovations in business. This goal is divided into the following objectives: to foster capabilities of the companies to develop and implement innovations, to accelerate commercialisation of achievements of advanced sciences, to decrease the risk of innovation implementation.

The solution

The solution is an AI-based tool that will allow the collection, processing and systematisation of relevant data on the knowledge generated by the Institutions of Science and Studies (ISS). A user interface, that is being developed, provides structured data, to allow for a twofold analysis of the ISS's contribution to different sectors of economic activity: quickly comparing the data using an interactive interface diagram; or conducting a detailed and cross-sectional analysis using a data summary.

Technical information

The AI solution is based on a trained neural network in a vector space representation. The process is replicated with specific data from the academia (e.g., publications) creating a general vector space with their keywords and summaries. It is using cosinus similarities to find the semantic closest equivalents to find the three best results that are assigned to each publication. Language detection is also automatic.

Interoperability support

The solution is supporting interoperability by mapping differently structured datasets and **classifies** automatically certain kind of knowledge usage across Lithuania business cooperation ecosystem.

Useful links

Lithuanian Innovation Centre - Lietuvos inovacijų centras (lic.lt)

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> *We think we have a skills and knowledge gap when it comes to data law, to understand what is available and what we can do with data, more open data could simplify this issue.*

For example, the solution analyses publications provided by universities, identifying for each one in which sector has the most potential to be to be used. AI helps in the decision-making.

The most relevant interoperability layer of this use case is the **semantic** as the AI-based solution analyses text data provided by some organisations from Lithuania (e.g., the name, keywords or the whole text of a publication) and creates links between these publications and economic sectors.

Benefits and challenges

A valuable benefit of this AI-based solution is its capability to empower the whole Lithuanian innovation ecosystem, LIC and other business support organizations (technology parks, clusters), scientific community (universities, Research Council), business representatives (associations), policy makers, in monitoring and measuring **more transparently** how knowledge transfer activities are effective. The tool contributes to improve the knowledge transfer between science and business cooperation, one of the biggest systematic issues of every national innovation ecosystem and to enhance evidence-based innovation policy making.

Lithuanian Innovation Centre **has understanding about knowledge transfer**, but **lacks internal skills** about programming, AI, machine learning. On the other hand, **product developers are experts in AI and coding but lacked competences about knowledge transfer**. One of the main challenges faced was **complexity** to manage 3 types of information in different formats: scientific publications, university graduates and joint science and business projects; besides the general issue of lack of accuracy of the input data. **This led to the implementation of a sophisticated data verification system process using machine learning (AI)**.

Moreover, the process of **engaging** other institutions to participate in the project and provide data presented many difficulties. In addition, one of the main issues is that the data provided could contain **sensitive and/or personal data**, being one of the most important issues. **Procurement documents were prepared by the internal team** and a market consultation has been made to better understand what available on the market, and therefore a **consultation with private companies and academia**.

Other challenges are related with **the project continuation** that are dependent not only **budgetary constraints**, but also **support from other institutions**.

Procurement data quality and CPV improvement for TED data *Publications Office of the European Union*	**Function of Government**	General Public Services	**Status** In development
	Relevant interoperability layers	Semantic and organisational	**AI Action** Decision Support

The organisation

The Publications Office of the European Union is the official provider of publishing services to all EU institutions, bodies and agencies. This makes it the central point of access to EU law, publications, open data, research results, procurement notices, and other official information. Its mission is to support EU policies and make a broad range of information publicly available as accessible and reusable data. The overall aim is to facilitate transparency, economic activity, and the dissemination of knowledge.

The solution

This AI-based solution aims at improving TED data quality and to have better expenditure data and statistics. The Common Procurement Vocabulary (CPV) codes stablish a single classification system for public procurement aimed at standardising the references used by contracting authorities and entities to describe procurement contracts. These codes are introduced by a human who is conditioned by its own experience, knowledge and environment introducing bias into the into the data. This project is a proof of concept that has the objectives of elaborating and **suggesting to the user** CPV codes from notice/procurement documents, elaborate statistics (e.g.: Which contractor got awarded the most contracts from a certain PS organisation) and predict which companies would be awarded a contract in the future if a tender has certain characteristics (e.g a possible call value, in a certain market sector, to predict which companies are more likely to be awarded with that contract).

Technical information

This AI-based solution uses used different approaches: 1) supervised learning algorithms with own training data. 2) Pretrained model of the shelf but specialising it with own training data. 3) Clustering techniques (unsupervised learning). These AI models together with the solution that deals with the procurement classification aimed in long term to be available for reuse from any public organisation to validate the incoming procurement data posted by anyone else.

> *We had a very strong support from our hierarchy because they strongly believe that this is important.*

Interoperability support

The system supports the interoperability of data by identifying the budgetary value in the **procurement documentation** and validating it. Moreover, it classifies the codes, and the result can be, for example, **suggesting** a ranking of CPV to the user with the objective of improving procurement data quality.

The most relevant interoperability layers of this use case are **semantic and organisational**. The project has created its own model adapted to this specific needs inspired to a specific eProcurement ontology developed for public procurement.

Benefits and challenges

One of the main benefits of this AI-based solution is the improvement of **transparency** in in the in public procurement data. Moreover, this classification can be **reused**, for example to validate the incoming data and immediately warn in case there is an error or bias in the data. In addition, when the CPV is well introduced, the companies **can search using this code** and the system can **suggest** which projects and which tender to apply to in in order to compete for more suitable projects. Similarly, public administrations that want to launch a new tender can **automatically generate** a tender notice, a summary and a classification in an assisted and simplified way.

The challenges faced are diverse, **lack of accuracy** of the input data is one of the main ones. Moreover, from the organisational point of view the solution is framed inside highly complex organisational context with multiple governmental levels. Other challenges are related to **budget constraints**, the risk of discontinuation of the project due to budgetary limitations and the difficulty to forecast the budget needed for future phases. Finally, regarding the **required skills**, in some cases, the availability of the needed profiles was very difficult to find. In those cases, to help the Publication Office to build its own AI expertise, some support of external consultants has been acquired.

interoperable europe

Useful links

Home - Publications Office of the EU (europa.eu)
eProcurement Ontology

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Automated transcripts to speed up judicial proceedings *Basque Government Informatic Society (EJIE)*	**Function of Government**	General Public Services (Law Courts)	**Status**	Implemented
	Relevant interoperability layers	Technical, semantic, legal and organisational	**AI Action**	Digitise and Structure

The organisation

The technological management body of the Basque Government that facilitates the digitisation of public services, and guarantees the quality, security and continuity of the information and communication technologies that support them. To deploy the ICT services required by the Basque Public Sector through a complete catalogue of services and advanced service levels, with a competent and healthy professional team.

The solution

Legal proceedings have a peculiarity when it comes to judgments drafting. Sometimes the transcriptions of the meetings are needed, especially when the judgment is escalated to higher instances. Given the recording of the meeting, the video clip is examined to find out, for example, where exactly something was said or who was named. In the Basque Country, administration transcripts are made by manually reviewing the videos of all the sessions. Thus, it's not possible to easily search for words, phrases, and generic entities across the video clip and there isn't any correlation between the speech and the person who pronounced it. Converting voice data into searchable text using **automated transcription services** may save significant time and create actionable value. With this solution, 100% manual transcription is no longer necessary, and efforts can be focused on correction and completion. In addition, if a court case is taken to a higher level, it will also save time by making it easier to find the exact points in the video in which some information has been said.

Technical information

The solution is using **neural networks**. Moreover, as GPU resources are not something that exist usually in classic datacenters, the solution uses V100s graphic units virtualised over on-premise k8s solution (OpenShift).

> *"There is group of people that want to do use this language and this is a citizen right in the Basque Country.*

Interoperability support

The solution supports data interoperability by providing **speech-to-text** functionality, **digitising** the audio signal. The text is extracted in subtitle format and a web application is used to link the text with the concrete minute of the video/audio. Texts are saved and made available in a **structured** form. All the interoperability layers, **technical, semantic, legal and organisational** are relevant in this AI-based solution. Technically, the system generates data in subtitles format, being able to keep track and link the transcribed words with the audio recording as the **legal value** is still in the audio. From the semantic point of view, **it transcribes**, spoken language to text. This solution is made available also through other organisations (using an API) being accessible and user-focused, supporting this way the organisational layer.

Benefits and challenges

One of the main benefits is the **workload reduction**, the solution has been described as a productivity tool to **modernise justice** administrative tasks, by automatically transcribing judicial proceedings and enabling the storage of the transcripts, always keeping track of the audio and its transcription. Moreover, it uses an API to integrate the service in other platforms, easily **replicating** the solution in other organisations.

One of the main challenges is the **data quality issues**, especially in the training phase, the Basque Government Information Society needed a data generation contract with an external supplier to generate data with quality enough, involving users, for the automated transcripts in judicial proceedings. Moreover, to meet the **required skills** for the AI system development and implementation was also necessary to work with a research company.

Useful links

Basque Government Informatic Society (euskadi.eus)

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Anomaly detection in e-government administration *IdomSoft Zrt.*	**Function of Government**	General Public Services	**Status**	In development
	Relevant interoperability layers	Semantic	**AI Action**	Detect

The organisation

The name of IdomSoft may sound less familiar than that of many other large IT companies, although we can say without immodesty: every Hungarian citizen has already encountered our developments. Anyone who has ever been abroad, has a customer portal, has a driver's license, has a car, has voted, has an identity card, lives somewhere or was born at all, has come into contact with us, perhaps without even knowing it.

The solution

In the digital government administration, various critical services are widely used. To maximise these services' reliability and availability, this AI-based solution introduces various Machine Learning techniques. More concretely, this solution focuses on the **smooth operation** of huge number of services, minimising the risk of service corruption. Moreover, it **predicts** the future load or tries to **identify the miss usage** of certain services. Furthermore, it uses different algorithms to create models for **anomaly detection** to analyse huge amounts of data produced by various public services used by many people.

Technical information

The solution is using **transformer models** to analyse non-structured data generated by the public services. Moreover, is using **deep learning on neural networks**, developing models to predict different events in e-gov data. MLOPS methods are used to manage the workflows: the data pipelines and the models. The platform is implementing the concept of "Machine Learning as a service" providing an interface where custom data analysis is possible.

> *We want to reduce the workload of the system administrators, automatise the system administration tasks.*

Interoperability support

The system supports interoperability by detecting artefacts/events/mistakes combining several input data sources (logs, metrics and traces) most of them non-structured. Hence, before analysing the data, in most of the cases it must structure it. Moreover, it uses deep learning to create a model which can be used for predicting future events. Furthermore, the system includes visualisation dashboard and alarms. The data is trained with the history to be able to predict.

The most relevant interoperability layer of this case is the semantic. The system is analysing various logs (system, application etc.) that are text strings/messages, in some cases this text is structured and has a format and sometimes not. In these cases is used self-supervised learning to structure it.

Benefits and challenges

One of the main benefits is to reduce the cost of the operations of the IT systems and to make all the services more reliable, maintainable, with better performance, and to provide more stable online public services to Hungarian citizens. Moreover, this solution proposes AI techniques that can significantly reduce the workload of system administrators. By automating system administration tasks and monitoring with more accuracy, AI can help save time and resources, allowing organisations to focus on core tasks and deliver better services to end-users. In addition, the concept of "Machine Learning as a Service" (MLaaS) involves providing an interface that allows users to perform data analysis and transfer data into an AI model for further use.

One of the main challenges is the accomplishment of GDPR to avoid managing personal data. However, there is a plan to anonymize the sensitive data to fulfil the law. Another challenge is the reorganisation required to adopt this solution, as this innovation reduced the manpower required for the system administration tasks.

Useful links

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