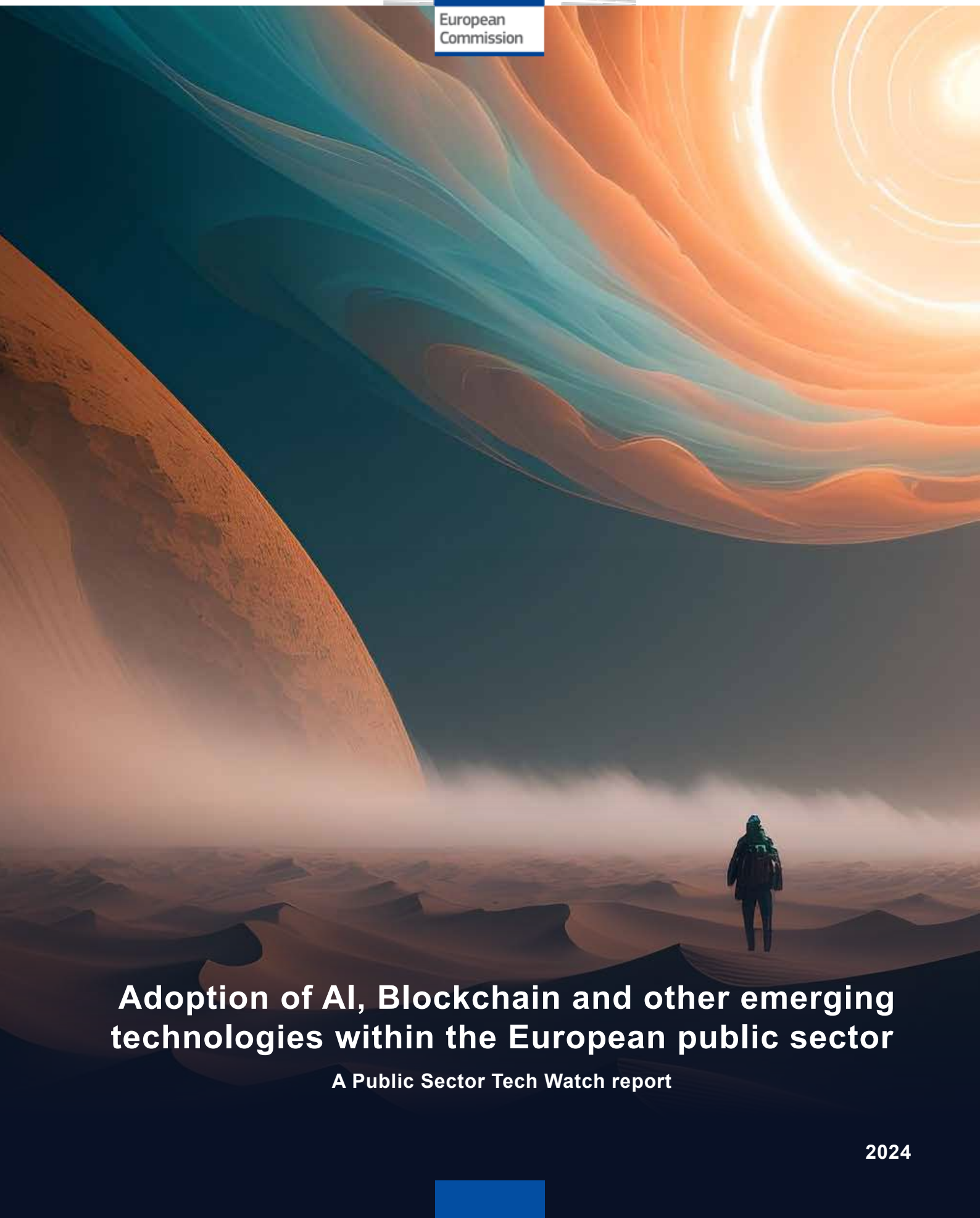

Adoption of AI, Blockchain and other emerging technologies within the European public sector

A Public Sector Tech Watch report

2024

Disclaimer

European Commission

Directorate-General for Digital Services
Directorate B — Digital Enablers & Innovation
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Table of contents

Table of figures

All the figures have the same source: Authors' own elaboration

Abstract

This report provides an overview and analysis of the adoption status of Artificial Intelligence, Blockchain, and other emerging technologies such as Augmented and Virtual reality, Virtual Worlds and Quantum computing, within the European public sector. Conducted under the Public Sector Tech Watch (PSTW) observatory, managed by the Directorate-General for Digital Services (DG DIGIT) and the Joint Research Centre (JRC) of the European Commission, the study aims to support European policymakers and researchers in steering and studying digital transformation in the European public sector.

The analysis is based on a database comprising a total of 1,617 cases (at the time of writing this report) of innovative solutions piloted and implemented across European public administrations. Research findings indicate that emerging technologies are being adopted across both public service delivery and administrative efficiency in various government functions, mainly those regarding general public services, economic affairs, public order and health departments. Moreover, the national and local administrations pilot or implement most cases (80%), and services personalisation, information analysis processes and prediction and planning are the most common applications.

Based on these findings, the report provides recommendations to boost the technologies' potential to foster the effective adoption of these technologies by moving a more theoretical view to a more systematic analysis based on empirical evidence.

Executive Summary

Scope of the study

This report presents the findings of a study on the adoption of emerging technologies within the European public sector, conducted under the Public Sector Tech Watch (PSTW) observatory, which is dedicated to monitoring, analysing, and disseminating evidence on the public sector's application of technology-based innovations across Europe. The PSTW observatory is managed by the Directorate-General for Digital Services (DG DIGIT) and the Joint Research Centre (JRC) of the European Commission.

This is the second publication expanding on the preliminary results presented in the previous report "Mapping innovation in the EU public services: a collective effort in exploring the applications of Artificial Intelligence and Blockchain in the public sector" (DG DIGIT et al., 2024). The report aims at civil servants, private sector actors, academia and citizens interested in learning from the experiences of other public bodies, businesses and startups that have piloted and implemented these technologies to innovate in the European public sector.

Objectives

The primary objective of this report is to provide an overview and analysis of the adoption of emerging technologies in the European public sector, building upon the PSTW database, which at the time of analysis includes 1,295 AI cases, 270 Blockchain cases, and 52 cases of other emerging technologies accessible via the PSTW online dashboard.[1] The findings allow to draw meaningful conclusions to suggest recommendations for policymakers, administrations and researchers.

Analytical insights

Key analytical insights indicate that, while almost half of the cases (47%) are set at the national administrative level, local administrations follow closely (33%) and regional or cross border solutions concern 10% each. In terms of the type of public value created, 47% of the cases (748 in total) are implemented to improve administrative efficiency, enhancing government-to-government (G2G) services. 53% (859 cases) aim at enhancing public services, both addressed to citizens (government-to-citizens – G2C – interactions) and to businesses (government-to-businesses – G2B – interactions). More in detail, key factors contributing to administrative efficiency are:

- Better quality of processes and systems, which is achieved in 79% of government-to-government (G2G) cases.
- Improved management of public resources, which accounts for 41% of administrative efficiency.
- Quicker responsiveness of government operations, observed in 40% of cases.

In addition, public services show significant improvements in:

- Responsiveness, efficiency, and cost-effectiveness, as observed in 72% of government-to-citizen (G2C) and government-to-business (G2B) cases.
- Public-centredness, which represents 59% of public services.
- The quality of public sector information, which is improved in 54% of cases.

A further analysis of the AI cases reveals that the solutions applied to services with a G2C interaction are implemented or piloted relatively more at the local level (41% of G2C solutions), while solutions improving G2G processes are relatively implemented more at the national level (54% of G2G solutions). These findings highlight the different needs of each administration level: local administrations use of AI to enhance citizen services, since most of public services are delegated at the local level leading them to innovate relatively more in the citizen-facing services, while national administrations are relatively more focused on improving internal processes, such as internal management and administrative support, among others. Other most common AI applications identified are service personalisation, information analysis processes, and prediction and planning, particularly within general public services, economic affairs, and health.

1 The online dashboard is available at the following link https://joinup.ec.europa.eu/collection/public-sector-tech-watch/cases-viewer-statistics

The analysis of Blockchain cases shows that the majority (64%) are pilot phases, indicating that public administrations are still in the early stages of experimentation with this technology. National administrations are the most prominent users (46% of cases), followed by local administrations (25%). Blockchain technology is predominantly used to improve services for citizens (G2C), especially within general public services, economic affairs, and education. The most common Blockchain applications identified are certification and validation processes (e.g., university degrees), payments and international transactions, and data-sharing management, where this technology can enhance security. Additionally, findings show that cross-border and cross-sector cases concern the 26% and 18% of the total number of the Blockchain cases (the double with respect to AI cases), and that cases with "across countries" application extent account for the 20% (compared to AI's 8%), underlining the role of Blockchain to improve interoperability at the EU level, remarkably, through the European Blockchain Services Infrastructure (EBSI).

In addition to AI and Blockchain, the data reveals the presence of **few cases (3% of the database) in which public administrations are exploring the use of other emerging technologies such as Augmented or Virtual Reality (AR/VR), Virtual Worlds, and Quantum Computing.** The cases collected (52 in total) are still not statistically representative, as the PSTW data collection, regarding this type of cases, is incipient and, in parallel, their adoption is still at the earliest stages. However, few insights can be drawn. While quantum computing is being implemented by national governments primarily for research and development purposes, the rest of these technologies are primarily used to enhance government-to-citizen services at the local level, especially AR/VR, with applications ranging from improving the user experience in training courses to enhancing hospital services.

An overview of the main findings presented by technology is shown in Table 1.

Technology	Top areas of implementation	Levels of government	Top processes improvement
Artificial Intelligence	1. General public services (27%) 2. Economic affairs (18%) 3. Public order and safety (17%) 4. Health (13%) 5. Other (25%)	1. National (49%) 2. Local (33%) 3. Regional (10%) 4. Across countries (8%)	1. Public services and engagement (32%) 2. Analysis, monitoring, and regulatory research (28%) 3. Enforcement (21%) 4. Internal management (16%) 5. Adjudication (3%)
Blockchain	1. General public services (37%) 2. Economic affairs (25%) 3. Education (11%) 4. Health (7%) 5. Other (20%)	1. National (46%) 2. Local (25%) 3. Across countries (20%) 4. Regional (8%)	1. Public services and engagement (46%) 2. Enforcement (30%) 3. Internal management (14%) 4. Analysis, monitoring, and regulatory research (9%) 5. Adjudication (1%)
Other emerging technologies (VW, AR/VR, QC)	1. Recreation, culture, religion (25%) 2. Education (23%) 3. Health (19%) 4. Housing and comm. amenities (12%) 5. Other (21%)	1. Local (65%) 2. National (19%) 3. Across countries (13%) 4. Regional (2%)	1. Public services and engagement (77%) 2. Analysis, monitoring, and regulatory research (19%) 3. Other (4%)

Table 1. Overview of landscape analysis by technology and main fields of analysis. Source: Authors' own elaboration

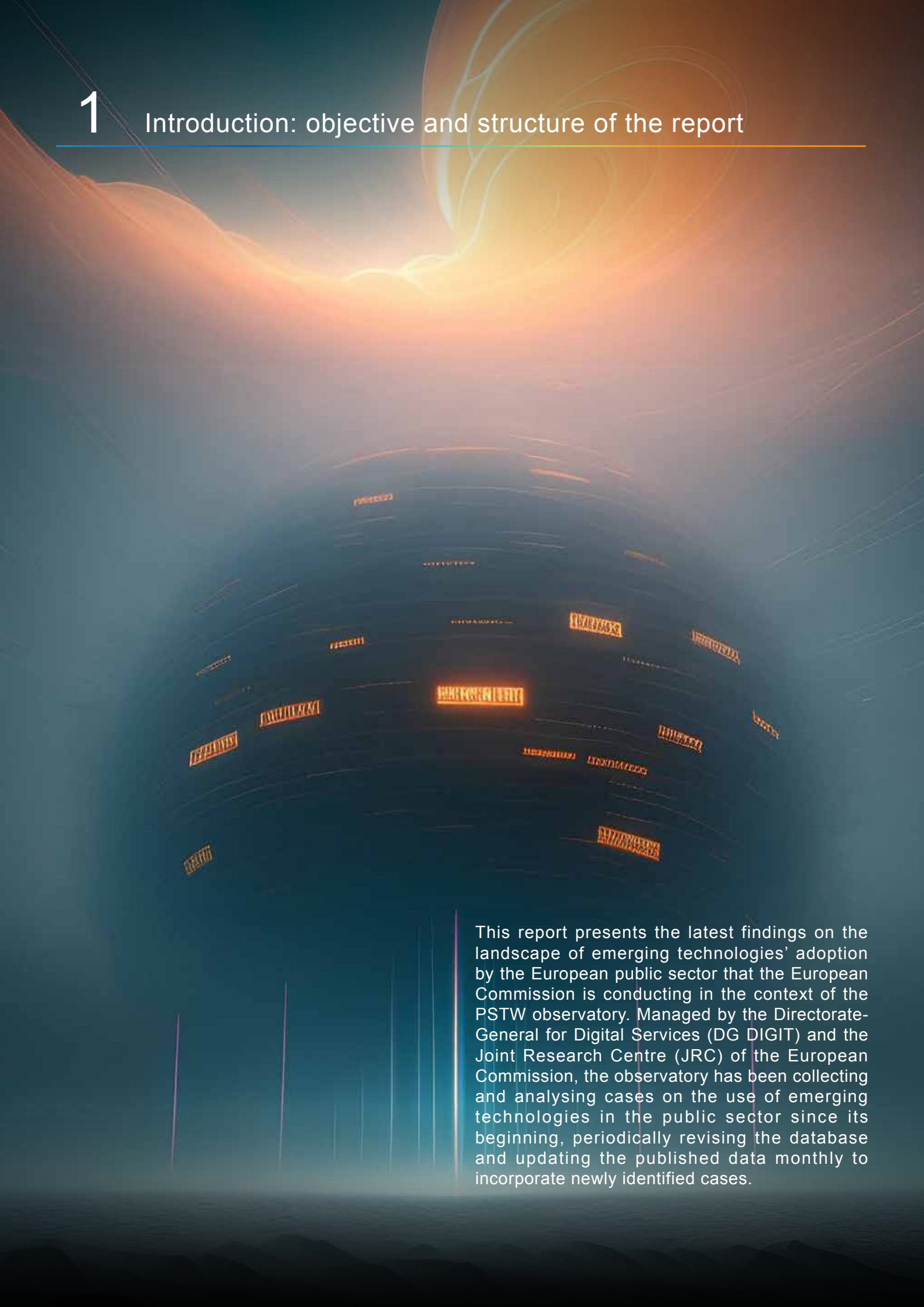
Recommendations and conclusions

The analytical insights presented highlight the increasing adoption of emerging technologies in the European public sector and their transformative potential for public service delivery and administrative processes. With this base of evidence, the report outlines a set of policy and research recommendations to foster the inclusive and effective adoption of emerging technologies within the European public sector. The main proposed recommendations are:

- Public administrations should actively develop mechanisms for ongoing knowledge sharing, adopt open-source solutions, establish shared repositories, and leverage EU-supported infrastructures. These actions should aim to boost interoperability, replicability, and reusability across various platforms and services
- Public administrations should assess the 'implementability' of the projects at the early stages of the experimentation process, to decrease the likelihood of discontinuing pilot initiatives.
- Public administrations should actively engage in experimenting with AR/VR, and Virtual Worlds technologies to gain insights into their advantages. This exploration could lead to enhancements in public service delivery and citizen engagement, particularly within sectors such as education, culture, healthcare, and tourism
- Public administrations should actively promote ongoing research, knowledge acquisition, and increased awareness regarding the adoption of novel AI technologies, such as Generative AI and General Purpose AI, within the public sector.
- Public administrations should have the necessary knowledge and tools to evaluate the risks and impacts of their AI solutions, and should transparently share these evaluations with the public.
- Public administrations should actively seek out and integrate innovations by collaborating with SMEs and startups. To achieve this, they should invest in mapping and comprehending the GovTech ecosystem, pinpointing good practices and successful cases to guide their approach.

Overall, the report is recommending expanding research, ongoing monitoring, and knowledge building on the adoption of new technologies in the public sector. This effort should focus not only on understanding the current landscape but also on identifying best practices, challenges, and opportunities for scaling. Particular attention should be given to the emerging area of generative AI, exploring its potential applications, impacts, and the conditions necessary for successful integration into public services.

1 Introduction: objective and structure of the report



This report presents the latest findings on the landscape of emerging technologies' adoption by the European public sector that the European Commission is conducting in the context of the PSTW observatory. Managed by the Directorate-General for Digital Services (DG DIGIT) and the Joint Research Centre (JRC) of the European Commission, the observatory has been collecting and analysing cases on the use of emerging technologies in the public sector since its beginning, periodically revising the database and updating the published data monthly to incorporate newly identified cases.

1.1 Objectives of the report

The analysis of cases allows to gain a **hands-on understanding of how public administrations across Europe are piloting and implementing emerging technologies,** identifying the **main trends** and impacts of these technologies for public service delivery and public administration efficiency. Building on this **database**, the report also provides a series of **recommendations** to catalyse further change and innovation within Member States' national, regional, and local administrations. The report primarily aims at civil servants, policy makers, private sector actors, academicians, members of the European GovTech ecosystem, practitioners and citizens interested in following the footsteps of other public bodies and startups that have successfully innovated public and administrative services. This report ultimately supports the PSTW's mission of fostering public sector innovation through the construction and exchange of knowledge and best practices.

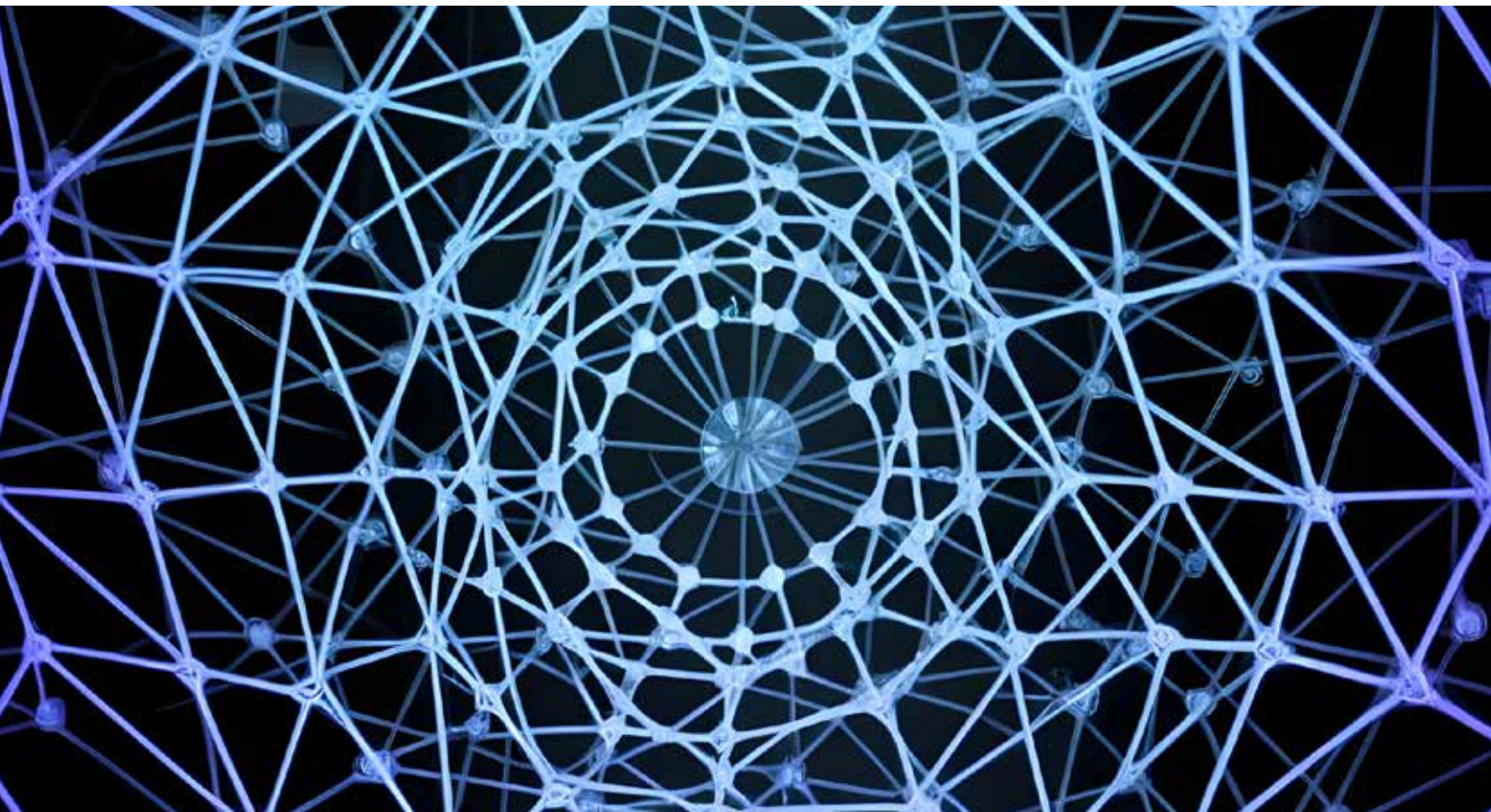
This publication provides a snapshot of the data collected and classified according to the PSTW methodology (Tangi et al., 2024) up until June 2024, and it provides an in-depth analysis of the available data. More in detail, the current report presents an analysis of **1295 AI cases, 270 Blockchain cases and 52 emerging technologies cases, which include Augmented and Virtual Reality, Virtual Worlds and Quantum Computing.**

A similar exercise has been done in the previous publication "Mapping innovation in the EU public services: a collective effort in exploring the applications of artificial intelligence and Blockchain in the public sector" (DG DIGIT et al., 2024). Although the previous report had the broader scope of introducing PSTW, it also included an analysis of available to the date dataset of cases, on which this report builds with an expanded dataset studied.

1.2 Structure of the report

The structure of the report is as follows:

- **Section 2. Background context:** This section provides the necessary definitions used for each technology in the context of the PSTW, as well as an overview of the latest developments in the policy landscape related to those technologies.
- **Section 3. PSTW Context:** Review of the observatory and the activities carried out to uphold its mission, including reports writing, data collection and stakeholder engagement activities such as events and workshops.
- **Sections 4, 5, 6, and 7. Innovation in the EU public sector and the use of AI, Blockchain, and other emerging technologies in the European public sector:** Section 4 provides a high-level analysis of the findings related to all emerging technologies. The other three sections focus on AI, Blockchain and the remaining technologies singularly, offering in-depth analysis and key insights on their adoption across the European public sector and on their peculiarities.
- **Section 8. Recommendations:** This section summarises the main insights and lessons learned from the analysis of the cases and provides a set of policy and research recommendations to foster and support the adoption and diffusion of emerging technologies in the public sector.
- **Section 9. Conclusions:** The concluding section summarises the findings of the overall landscape analysis.



2 Background

The present section introduces the emerging technologies included in the scope of the PSTW observatory until today and that are analysed within this report. Moreover, it presents the adopted definitions of these technologies, including high-level descriptions that draw upon established understandings within the European Union (EU). Subsequently, a concise overview of the most relevant EU policy instruments supporting the adoption of the analysed technologies is presented to provide context for the analysis that follows. While this overview is not intended to be exhaustive, it serves as a foundation for understanding the technological and regulatory landscape in which these innovations are being applied.

2.1 Emerging technologies monitored in the PSTW obervatory

The emerging technologies currently analysed in the PSTW observatory include AI (such as General Purpose AI (GPAI) and Generative AI), Blockchain, Virtual Worlds, Virtual Reality and Augmented Reality and Quantum Computing. As discussed, this selection is subject to change and be expanded, as the PSTW observatory keeps reviewing the data collection methodology to monitor the rapidly changing public sector technology-based innovation scenarios and encompass additional technological domains deemed relevant for the European public sector.

2.1.1 Artificial Intelligence

Artificial intelligence (AI) is the technology by which machines mimic the patterns seen in the training data. While academic debate is still weighing different definitions of AI, the European Union's AI Act describes an AI system as "a machine-based system that is designed to operate with varying levels of autonomy and that may exhibit adaptiveness after deployment, and that, for explicit or implicit objectives, infers, from the input it receives, how to generate outputs such as predictions, content, recommendations, or decisions that can influence physical or virtual environments" (Regulation - EU - 2024/1689, 2024, art. 3).

AI systems are categorised into intended or general purpose by the EU AI Act, in line with the scientific literature. Intended purpose systems, also called Narrow AI, are thought to operate within a limited domain, such as facial recognition or natural language processing, and cannot extend their functionality beyond their predefined scope or the use intended by the provider of the system (Regulation - EU - 2024/1689, 2024). Conversely, General Purpose AI systems represent advanced models capable of performing human-equivalent

intelligence tasks unfamiliar situations without being restricted to specific domains. In particular, the EU AI Act defines general-purpose AI (GPAI) as an “AI model [supporting a system] (…) that displays significant generality and is capable of competently performing a wide range of distinct tasks regardless of the way the model is placed on the market and that can be integrated into a variety of downstream systems or applications, except AI models that are used for research, development or prototyping activities before they are placed on the market.” (Regulation - EU - 2024/1689, 2024, art. 3).

AI comprises various categories, with Machine Learning (ML) as a subset of AI models that encompasses Deep Learning and Generative AI. ML refers to the system’s ability to automatically learn, decide, predict, adapt, and react to changes, improving from experience, without being explicitly programmed. ML is widely included in most efforts to identify AI categories, as the basic algorithmic approach to achieve AI regardless the type of learning, namely reinforcement, supervised, semi-supervised, unsupervised (Samoili et al., 2021). Deep Learning, a specialised branch of ML, utilises deep neural network architectures inspired by the function of neurons in the human brain to learn from vast amounts of data. These networks, with their numerous interconnected layers and in different architectures (such as neural networks and convolutional neural networks), can perform tasks like speech recognition, computer vision, and natural language processing, achieving significant levels of accuracy (LeCun et al., 2015). Generative AI is another significant category within AI, that can be conceptualised as a branch of deep learning models. It consists of al-gorithms designed to create new data instances that resemble the training data: by learning the underlying patterns and distributions of the input data, generative models can produce new content in form of text, images, music, among others. The most frequent techniques in this field include Generative Adversarial Networks (GANs), Variational Autoencoders(VAEs), Recurrent Neural Networks(RNNs),and Transformers(Goodfellow et al.,2020; Fernández-Llorca et al., 2024).

2.1.2 Blockchain

Blockchain technology is a specific type of Distributed Ledger that organises data into a series of blocks forming a single chain. In addition, a peer-to-peer network (P2P) shares and manages the ledger across multiple nodes of a computer network, where participants have decentralised control over the data, and numerous nodes participate in the distribution, administration, and exchange of data (Allessie et al., 2019). The differentiating factor between Blockchain and other Distributed Ledger Technologies (DLTs) is its method of organising data into a series of blocks, where each block contains a set of transactions verified by network nodes through a consensus mechanism, and where each block is cryptographically linked to the previous block. This creates an immutable and transparent chain of records. While both Blockchain and DLTs are typically decentralised, DLTs can have a central authority with some degree of control over the network, while Blockchains are designed to be fully decentralised (Martin-Bosch et al., 2022). The decentralised nature of the technology

eliminates the need for intermediaries, presenting the potential to ensure security and efficiency in transactions across a wide variety of sectors (Martin-Bosch et al., 2022).

Blockchain technology is being adopted across several fields and industries. The decentralised and immutable features have proven instrumental for its application in the financial sector, especially for cryptocurrencies, smart contracts, and decentralised finance platforms (DeFi). As well, in supply chain management, Blockchain has been adopted to improve processes transparency and traceability of products. In turn, the healthcare sector is implementing this kind of technologies to store medical records and track pharmaceuticals, as well as real estate utilise them for property records and smart contracts, among many other applications (Martin-Bosch et al., 2022).

2.1.3 Other emerging technologies

In the current report, the PSTW observatory has expanded its research beyond AI and Blockchain to include other emerging technologies that are considered relevant to be monitored and analysed, increasing the scope of its work. While study and evidence consolidation on these technologies are still in its early stages, there is keen interest from public administrations and researchers across Europe. This report aims to present, for the first time within the PSTW observatory, the cases and evidence collected to support build and disseminate knowledge on new areas, like Virtual Worlds, Augmented and Virtual Reality, and quantum computing.

2.1.3.1 Virtual Worlds

Virtual Worlds are immersive digital environments that blend physical and digital spaces. According to the European Commission, Virtual Worlds are "persistent, immersive environments, based on technologies including 3D and Extended Reality (XR), which make it possible to blend physical and digital worlds in real time, for a variety of purposes such as designing, making simulations, collaborating, learning, socialising, carrying out transactions or providing entertainment" (European Commission, 2024b). Virtual Worlds are highly immersive digital environments where individuals can socialise, play, and work, and where social and economic elements mirror reality. They are used for various purposes, including design, simulation, collaboration, learning, socialising, conducting transactions, and entertainment. Virtual Worlds are persistent, meaning they continue to exist even when users are not actively participating, and they are often based on 3D and XR technologies. Key socio-economic features and enabling technologies of Virtual Worlds include: (1) immersive environments that use 3D graphics, spatial audio, and other technologies that simulate the real world; (2) real-time interactions among users; (3) social interactions and economic activities, which can be facilitated through the use of virtual currencies and Blockchain technology; and (4) customisation and personalisation of users' experiences (Hupont et al., 2023).

Virtual Worlds are part of a spectrum with the real environment and a fully immersive digital environment at its extremes, and different levels of digital content and physical realms in between. Considering the ongoing debate on the specific definition of virtual Worlds in relation to other terms such as Metaverse and Extended Reality, the current academic and policy literature closely relates the concept of Virtual Worlds to the concepts of Virtual Reality (VR), Augmented Reality (AR), immersive 3D environments, worlds or spaces and related user interfaces (Hupont et al., 2023).The existing literature discussions acknowledge that the webs 3.0 and 4.0, in fact, is characterised by a continuum between fully virtual and fully real worlds that are enabled by a range of technologies, in which users access with varying levels of immersiveness and interaction (European Commission, 2023; Hupont et al., 2023).

It must be considered that **Augmented Reality (AR) and Virtual Reality (VR) are bridging the gap between the real and digital worlds** (Figure 1). AR overlays virtual elements onto our physical environment, enhancing real-world interactions with digital data. VR immerses users into completely virtual landscapes, offering a deep sense of presence in a computer-generated realm. These technologies enable a seamless transition from physical to virtual experiences, with broad applications across education, entertainment, healthcare, and industry, transforming how we interact with our world, creating a continuum between the two side (Skarbez et al., 2021).

Figure 1 Virtual Worlds' continuum

2.1.3.2 Virtual Reality (VR) and Augmented Reality (AR)

On one end of the Virtual Worlds' continuum (Figure 1), **Virtual reality (VR) is an "immersive technology that creates an interactive and fully digital environment accessible through different devices"**, as defined by the European Commission (European Commission et al., 2022, p.10). It includes different senses, such as sight and hearing, through the use of devices like headsets, lenses, haptic gloves, or virtual rooms. VR is usually applied for trainings and gamification, where users interact with a digital environment and simulations.

Differently from VR, Augmented Reality (AR) is a "technology that overlays digital information to the real world through a screen of surface onto which the digital information is projected or shown", integrating digital sensory inputs with the users' physical surroundings in real-time (European Commission et al., 2022, p. 10; European Commission, 2023). Also in this case, gamification is among the most frequents applications of AR, as well as trainings and other tools supporting workers on their worksites, with the support of smartphone cameras, headsets, and smart glasses, among other devices.
In conclusion, all applications belonging to Virtual Worlds, ranging from web 4.0 to Augmented Reality, and often also the other technologies like AI, appear as an opportunity for the public sector to shape a future that blends digital and physical experiences, allowing users (citizens) to either enter into fully digital spaces, offering new ways to learn, work, and play or to bring digital elements into their real-world view, enhancing their interaction with surroundings. The emergence of this network of 3D spaces where people can connect and collaborate created at the same time the need for a policy framework that protects users and encourages positive societal impacts (Next Generation Virtual Worlds, 2024).

2.1.3.3 Quantum computing

Quantum computing is considered as a transformative technology that holds tremendous potential for the public sector. Quantum computing leverages quantum mechanics phenomena to process information using quantum bits, or qubits, which can simultaneously exist in multiple states due to superposition and entanglement properties. These properties enable quantum computers to perform complex computations at speeds that would require enormous resources if conducted by classical computers. This technology presents the possibility to handle and operate on a vast amount of data simultaneously, made possible by the principle of quantum entanglement (World Economic Forum, 2022).

This leap in the computational capability has remarkable potential applications in various fields, including cryptography and cybersecurity enabling the public sector to develop highly secure communication networks for national security. It could also be used in processes' optimisation in logistics and transportation, leading to more efficient public services. It can also be used in a wide variety of fields in research. For example, in healthcare, it could offer the possibility of accelerating drug discovery and personalised medicine through its ability to analyse vast datasets. Additionally, the emerging cross-technology application of Quantum AI aims to develop quantum algorithms for AI and ML tasks, leveraging the superior processing power of quantum technology. Quantum ML algorithms can potentially offer exponential speedup over their classical counterparts (World Economic Forum, 2022), for example in simulating environmental changes at a quantum level, enhancing climate models and disaster response strategies.

2.2 EU Policy landscape

Policymakers have recognised the need for the **public sector to actively steer its digital transformation process** for enhancing the development and adoption of emerging technologies, and the development and (re) use of measures and guidelines. At the same time, **cross-technology policies** have come into play with the objective of being inclusive and technologically impartial and for building a European policy framework ecosystem for digital innovation, within both the private and public sector.

The European Commission has historically supported broad policies for digital transformation in public administrations and society. The Commission approved in 2022 the overarching **Digital Decade Policy Programme 2030**[2], setting up a cooperation and monitoring body to achieve a list of common objectives guiding Europe's digital transformation (Decision EU - 2022/2481, 2022). The Policy Programme is supported by the Digital Europe Programme[3], which is part of the long-term EU budget covering 2021-2027 period, with a financial endowment of EUR 7.6 billion, to cover the industry needs to reach those goals[4]. On the single market and private sector side, the **Commission concurrently approved in 2024 the Digital Services Act and Digital Markets Act**[5] to "create a safer digital space where the fundamental rights of users are protected and to establish a level playing field for businesses" and to regulate the digital market in the Union and guarantee the safety and protection of citizens (European Commission, 2024d). At the same time, **the European Commission addressed the theme of digitalisation within public services approving the Interoperable**

2 Digital Decade Policy Programme 2030: https://digital-strategy.ec.europa.eu/en/library/digital-decade-policy-programme-2030
3 The Digital Europe Programme: https://digital-strategy.ec.europa.eu/en/activities/digital-programme
4 EUR 2.1 billion were earmarked to AI investments, both targeted at businesses and public administrations.
5 The Digital Services Act package: https://digital-strategy.ec.europa.eu/en/policies/digital-services-act-package

Europe Act[6] to "facilitate and enhance cross-border data exchange and accelerate the digital transformation of the European public sector" (European Commission, 2024c). This is also in line with the Digital Decade policy objectives of achieving 100% of key public services available online by 2030, and interoperability as a platform for functioning digital single market.

It is important also to remark that **the European Commission reiterated the same objectives in the Political guidelines for the next European commission 2024–2029**[7]. Among several goals, "boosting productivity with digital tech diffusion" is recognised as one of the pillars for the next 5 years mandate, committing to intensify the enforcement of already approved Acts, enhance European international position on AI systems development and the design of a new European Data Union strategy (von der Leyen, 2024). These initiatives spill over in the public sector.
In addition to the broader policies mentioned above, the European policy framework for digital innovation is also complemented by more technology-specific elements. The following paragraphs briefly outline the specific policies directly related to each of the emerging technologies that are the focus of the PSTW observatory.

2.2.1 Artificial Intelligence

The European AI Act[8], which formally entered into force on August 1st 2024, is the first legal framework on AI worldwide, aimed at fostering trustworthy AI in Europe by ensuring that AI systems respect fundamental rights, safety, and ethical principles, while addressing the risks AI models. The Act is a culmination of a longstanding series of EU policy efforts aimed at fostering a balanced approach to AI regulation and it will be smoothly enforced across both the public and private sector through a multi-step timeline after entering into force[9].

The AI Act is designed to create a comprehensive legal framework for the development, marketing, and use of AI in the EU, aligning with EU values. Its main objectives include:

1. promoting the uptake of human-centric and trustworthy AI
2. ensuring a high level of protection for health, safety, and fundamental rights, including democracy, the rule of law, and environmental protections, and,
3. supporting innovation while mitigating the potential harmful effects of AI systems.

This legislation introduces a risk-based approach. It classifies AI systems into three categories: unacceptable risk, high risk, and low or minimal risk. According to Article 5 of the Act, in February 2025, prohibitions will start to apply to unacceptable risk systems with "subliminal techniques beyond a person's consciousness or purposefully manipulative or deceptive techniques", AI systems that allow social scoring, algorithms for predictive policing, AI-enabled facial recognition and remote biometric identification systems, among others. High-risk AI systems, on the other hand, including those used in critical infrastructure, healthcare, and law enforcement, are subject to strict requirements for transparency, accountability, and human oversight. Low or minimal risk AI systems, finally, like spam filters or video games, have fewer obligations but must still adhere to basic transparency principles. The Act also addresses specifically General-Purpose AI models, AI systems with potential for broad applications. The AI Act regulates various aspects of AI development and deployment, including risk management, data governance, transparency and explainability, human oversight, and technical robustness and cybersecurity. It sets provisions for various stakeholders, including AI providers, AI users. As the other actors, public administrations are, therefore, expected to comply with these rules in the future, impacting the type of applications AI shall be used to. To ensure the Act's enforcement, mandates on competences and obligations are

6 Interoperable Europe Act: https://commission.europa.eu/publications/interoperable-europe-act-proposal_en
7 Political guidelines 2024-2029: https://commission.europa.eu/document/download/e6cd4328-673c-4e7a-8683-f63ffb2cf648_en?filename=Political%20Guidelines%202024-2029_EN.pdf
8 AI Act: https://digital-strategy.ec.europa.eu/en/policies/regulatory-framework-ai
9 AI act implementation timeline: https://artificialintelligenceact.eu/implementation-timeline/

provided for national competent authorities and new regulatory and governance bodies, the European AI Office, and the AI Board.

The AI Act is a cross-sectoral horizontal regulation, applying uniformly to all sectors. It does not explicitly differentiate between the private and public sectors in terms of conformity criteria, but the impact on the public sector cannot be underestimated (Alon-Barkat & Busuioc, 2023; Manzoni et al., 2022; Tangi et al., 2022). As described in this report, AI is now extensively used across various public services, with over 1000 use cases identified. Some of these cases fall under the critical categories outlined in Articles 5, 6 and 52, as well as Annexes II and III of the AI Act, signifying the public sector's role as a major deployer and provider of AI systems, often involving high-risk scenarios. It must be pointed out that **public authorities also act as regulators, enforcers and are responsible for appointing notified authorities.**

The AI Office, established within the European Commission in February 2024[10], exemplifies this by overseeing the enforcement and implementation of the AI Act across Member States. Additionally, **public bodies are tasked with implementing AI regulatory sandboxes,** crucial for the AI Act's rollout, and hold a significant responsibility in **shaping the market dynamics for AI technologies through public procurement.** Procurements' clauses will need to strictly adhere to the AI Act's obligations and standards, ensuring that any AI system acquired through public funds not only meets regulatory compliance but also upholds the ethical, safety and transparency standards set forth by the legislation. In addition, the AI package allocated EUR 500 million euro, up to EUR 4 billion euro considering private investments, to the **GenAI4EU initiative**[11] which supports the development of novel use cases and emerging applications in areas such as robotics, health, biotech, manufacturing, mobility, climate and Virtual Worlds, involving the public sector as well (European Commission, 2024a). To help public administrations, the AI Office is expected to "develop a template for a questionnaire in order to facilitate compliance and reduce administrative burden for deployers" (Regulation - EU - 2024/1689, 2024, para. 96) and that administrations should involve independent experts, civil society organisations and any group likely to be affected by the AI system when designing and piloting solutions and when carrying out ad hoc impact assessments with a focus on risks (Regulation - EU - 2024/1689, 2024). Another critical role of public administration is its authority to enable the deployment of high-stakes AI systems, especially through the application of exceptions to prohibited uses under Article 5. It must be also noted that the AI Act provides specific exemptions for some public sector activities related to national security or other essential state functions.

The AI Act represents a significant step towards regulating AI technologies in a manner that balances innovation with the protection of fundamental rights. By classifying AI systems based on risk, and enforcing transparency and accountability measures, the EU aims to ensure that AI development and deployment in the EU are safe, ethical, and aligned with European values. This regulation represents a historic step not only for the EU but globally, as it sets a precedent for AI governance worldwide towards a trustworthy and human-centric AI approach. It is also important to understand how the AI Act is part of a broader scenario of EU digital strategies, briefly described above, and it is aligned to the Digital Decade Policy Programme 2030, namely for the targets of digitisation of public services and the use of AI in healthcare. As well, it complements other EU regulations like the General Data Protection Regulation (GDPR), the Digital Markets Act (DMA), and the Digital Services Act (DSA), building upon a broad existing regulatory framework for the digital sphere.

10 AI Office establishment: https://digital-strategy.ec.europa.eu/en/policies/ai-office
11 https://ec.europa.eu/commission/presscorner/detail/en/ip_24_383

2.2.2 Blockchain

The EU's approach to Blockchain seeks to foster innovation and growth in Blockchain and Distributed Ledger Technology (DLT) while ensuring consumer protection and regulatory compliance. Moreover, it is characterised by a balance between promoting technological advancement and addressing potential risks associated with these emerging technologies. The EU's Blockchain strategy includes regulatory frameworks, infrastructure development, research funding, and stakeholder engagement.

Various legislative instruments are designed to promote the secure and efficient adoption of Blockchain technology while addressing associated risks and challenges. The most significant legislative measures include the Markets in Crypto-assets Regulation (MiCA)[12], and provisions in the eIDAS Regulation[13], the Data Act[14] and the Interoperable Europe Act. The MiCA regulation, adopted in June 2023 and entering into force in December 2024, provides a regulatory framework for crypto assets across the EU. It pursues three paired objectives of protecting consumers, ensuring market integrity, and fostering innovation and adoption. The MiCA regulation covers different types of crypto-assets, including asset-referenced tokens and e-money tokens, and sets out requirements for their issuance, trading, and custody. As well, the proposed amendment to the eIDAS Regulation introduces the European Digital Identity Wallet[15], which enhances digital identification processes within the EU and supports the use of Blockchain for secure, decentralised identity management, allowing citizens and businesses to control their digital identities without relying on central authorities. The European Digital Identity Wallet aims to provide a trusted, interoperable framework for digital identity verification across member states. Furthermore, the Data Act, published on December 22nd 2023, and becoming applicable on September 12th 2025, aims to promote a fair and competitive data economy by facilitating data sharing and ensuring data portability. With regards to Blockchain, the legislation includes provisions for smart contracts, which are crucial for automating data transactions on Blockchain platforms, establishing essential requirements for the deployment of this type of contracts to ensure their interoperability and security across different applications and industries. Finally, the Interoperable Europe Act, which entered into force on April 11th 2024, seeks to enhance the interoperability of digital public services across the EU, supports the integration of Blockchain. In fact, the legislation provides a framework for cross-border and cross-sector collaboration and seeks Blockchain-based solutions to seamlessly interact with existing digital systems.

The EU is also investing in research and development to explore and boost the potential of Blockchain technology adoption in various sectors, including public services, sustainability, and climate action. The European Blockchain Services Infrastructure (EBSI) is a key pillar of these efforts, through which the EU aims develop cross-border Blockchain-based services for public administrations with the purpose of enhancing the efficiency, security, and trust in public services across the region. In addition to EBSI, the Commission has allocated additional funding to support Blockchain-related research and innovation projects through various EU programmes, particularly through the Horizon Europe, the Digital Europe Programme, and InvestEU, **to engage with the private sector, academia, and the Blockchain community is an important feature of existing initiatives,** implemented through organisations like the International Association of Trusted Blockchain Applications (INATBA)[16] and the European Blockchain Observatory and Forum[17], which trigger platforms and networks to deploy collaboration and knowledge exchange in the Blockchain ecosystem.

12 https://finance.ec.europa.eu/digital-finance/crypto-assets_en
13 eIDAS Regulation: https://digital-strategy.ec.europa.eu/en/policies/eidas-regulation
14 European Data act: https://digital-strategy.ec.europa.eu/en/policies/data-act
15 The EU Digital Identity Wallet: https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/europe-fit-digital-age/european-digital-identity_en
16 INATBA website: https://inatba.org/
17 European Blockchain Observatory and Forum: https://blockchain-observatory.ec.europa.eu/index_en

Recently, the European Commission (EC) established EUROPEUM-EDIC[18], a legal entity formed by a consortium of nine Member States. The primary objective of this entity is to enhance the European Blockchain Services Infrastructure (EBSI) and advance cross-border public services, cyber resilience, and compliance with EU regulations, including the recently enforced European Digital Identity (EUDI) regulation[19]. Moreover, EUROPEUM-EDIC supports cooperation on Web3 and decentralised technologies within the framework of the Digital Decade Policy Programme 2030. Another significant initiative is the European Blockchain Regulatory Sandbox[20], operational from 2023 to 2026. This sandbox seeks to facilitate dialogue between regulators and innovators, addressing legal uncertainties and promoting the development of compliant Blockchain-based solutions. It is anticipated to support 20 projects annually, including public sector use cases linked to EBSI.

2.2.3 Other emerging technologies

A vivid scenario of policy initiatives and EU-led projects specifically for other emerging technologies beyond AI and Blockchain emerges as the development and diffusion of novel technologies expands. As such, they should be acknowledged within the broader policy ecosystem and as a comprehensive government approach, although in this report they are addressed individually to favour clarity.

2.2.3.1 Virtual Worlds

The EU acknowledges Virtual Worlds as an important part of the technological transition to Web 4.0 (European Commission, 2023). According to the European Commission's Communication for the EU initiative on Web 4.0 and Virtual Worlds, the web 4.0 is the fourth generation of the World Wide Web, in which "digital and real objects and environments are fully integrated and communicate with each other" (European Commission, 2023, p. 1). The web 4.0 builds on and goes beyond the web 3.0, characterised by openness, decentralisation, user empowerment and semantic web capabilities. As a result of the utilisation of "advanced artificial and ambient intelligence, the internet of things, trusted Blockchain transactions, Virtual Worlds and XR capabilities" (2023, p. 1), the web 4.0 can enable intuitive and immersive experiences that merge the physical to the digital world. **EU recognises the opportunities and challenges that the adoption of Virtual Worlds enabling technologies play both at the social, economic, and public services levels.** On the one hand, Virtual Worlds present potential impacts on "the way people live, work, create and share content, as well as the way businesses operate, innovate, produce and interact with customers" (European Commission, 2023, p. 1). On the other hand, they can also play a role in how governments provide public services in the transition to the Web 4.0. Some potential opportunities identified by the EU are the improvement of the "design and delivery of public services and services of general interest in urban and rural environments through digitalisation" (European Commission, 2023, p. 12). Some of the more diffused applications of virtual worlds for the public sector include the creation of digital twins (which are increasingly being applied to urban planning and local public services), healthcare applications (med-tech field), education, social services and training for public order bodies (e.g., law enforcement agencies, fire departments and emergency medical services) (Directorate-General for Research and Innovation(European Commission), 2024). The EU's policy instruments directed at promoting and steering the diffusion and application of virtual worlds are framed under the 2030 objectives of the Digital Decade programme (Decision EU - 2022/2481, 2022) structured on the pillars of skills, businesses, public services and enabling infrastructures.

18 EUROPEUM-EDIC: https://digital-strategy.ec.europa.eu/en/news/blockchain-creation-europeum-edic
19 EUDI Regulation: https://digital-strategy.ec.europa.eu/en/policies/eudi-regulation
20 EBSI: https://digital-finance-platform.ec.europa.eu/cross-border-services/ebsi

On July 2023, the EU has launched a strategy on Web 4.0 and virtual worlds is to shape technological transitions in Europe towards "an open, secure, trustworthy, fair and inclusive digital environment for EU citizens, businesses and public administrations" (European Commission, 2023, p. 1). The strategy was built on consultation with citizens and with the involvement of other stakeholders, such as private sector, civil society, and academic institutions. **The Strategy prioritises four key strategic components, aligned to the Digital Decade Programme, structured on skills, businesses, public services, and infrastructure.** First, it aims at empowering people and reinforcing skills. Secondly, it seeks to support a European Web 4.0 industrial ecosystem. As well, the Strategy pursues supporting societal progress and virtual public services and shaping global standards for open and interoperable Virtual Worlds and Web 4.0. First, the objectives pursued to **promote skills and businesses' industry-wide adoption of Virtual Worlds will be pursued through the implementation of projects funded by the Digital Europe Programme** (Decision EU - 2022/2481, 2022), the Creative Europe programme, and the Horizon Europe. As well, the European Digital Innovation Hubs, part of the Digital Europe programme, and the Enterprise Europe Network can act as support and catalysts for these efforts. Likewise, the European Commission has also launched MediaInvest, a financing tool that aims to advance Europe's audiovisual industry, which can further support projects and applications on Virtual Worlds. **Second, to support governments in promoting societal progress and adopting virtual public services, the EU is investing in initiatives** like the Destination Earth (DestinE), Local Digital Twins for smart communities, and the European Digital Twin of the Ocean. Additionally, the EU is supporting the development of domain-specific digital twins, such as the two new public flagships "CitiVerse", an immersive environment that will help to optimise spatial planning and management, where relevant common European data spaces will strengthen the flagship and pilot applications will be launched under the Horizon Europe programme. As well, In the field of public health, the European Commission is supporting the development of the European Virtual Human Twin, a digital replica of the human body, by bringing together advanced digital technologies, access to high-performance computing and access to research and healthcare data facilitated by the European Health Data Space.

Finally, the launch of the European Digital Infrastructure Consortia (EDIC) can support the consolidation of underlying digital infrastructures, such as high-performance computing and advanced networks, on which Virtual Worlds deployment strongly rely. EDICs are legal entities established with the aim of facilitating the joint development of secure, trustworthy, and accessible European digital infrastructures, such as high-performance computing, cloud infrastructure, data spaces, and 5G and 6G networks.

2.2.3.2 Virtual Reality (VR) and Augmented Reality (AR)

The above-described **EU's efforts** to support the diffusion of Virtual Worlds and immersive technologies **also support the development and adoption of VR/AR technologies.** In this regard, particularly relevant for the research, development and application of VR and AR technologies are the Creative Europe programme and the Horizon 2020 funded projects in a wide range of sectors. For instance, different projects promoting VR/AR technologies in urban planning and participatory city planning were implemented, such as the MindSpaces and the Augmented Urbans projects (European Commission, 2023).

In addition to the already described policy instruments supporting the development and use of VR and AR, **the European Commission has also supported the creation of the VR/AR Industrial Coalition.** The Coalition, launched in September 2022, seeks to "inform policy makers about the potential of VR/AR, encourage investment in the European VR/AR ecosystem, facilitate dialogue amongst its stakeholders, and

address the current challenges whilst leveraging opportunities for Europe" (European Commission et al., 2022, p. 1).

2.2.3.3 Quantum computing

The European Union (EU) has recognised the strategic importance of quantum technologies and has promoted its development and adoption through various regulatory and policy instruments. These instruments are designed to create a supportive environment for innovation, collaboration, and commercialisation of quantum technologies. Central to this framework are the Quantum Technologies Flagship, the EuroHPC Joint Undertaking, and various legislative acts under Horizon Europe and the Digital Europe Programme.

Launched in 2018, the Quantum Technologies Flagship is a long-term research and innovation initiative with a budget of €1 billion over ten years (Quantum Tech Flagship Ramp-up Phase Report | Shaping Europe's Digital Future, 2023). It aims to consolidate European leadership in quantum research, support the development of commercial applications, and foster a competitive quantum industry in Europe. The Flagship funds projects across four main domains: quantum computing, quantum simulation, quantum communication, and quantum sensing and metrology, Key achievements of its ramp-up phase (2018-2022) included the development of a 100-qubit quantum computer system, and a 50-qubit trapped ion system. The initiative also includes efforts to develop standards and promote interoperability within the quantum ecosystem, essential for transitioning research from the lab to industrial applications.

The Quantum Technologies Flagship has also set a long-term vision and research priorities for quantum technologies in Europe, the Strategic Research Agenda (SRA). It was developed with contributions from over 2,000 European quantum experts and contemplates four main areas: quantum computing, which focuses on developing quantum processors and algorithms; quantum simulation, aimed at using quantum systems to model complex problems; quantum communication, which seeks to develop secure communication methods; and quantum sensing and metrology, which involves creating highly sensitive measurement devices (Quantum Tech Flagship Ramp-up Phase Report | Shaping Europe's Digital Future, 2023).

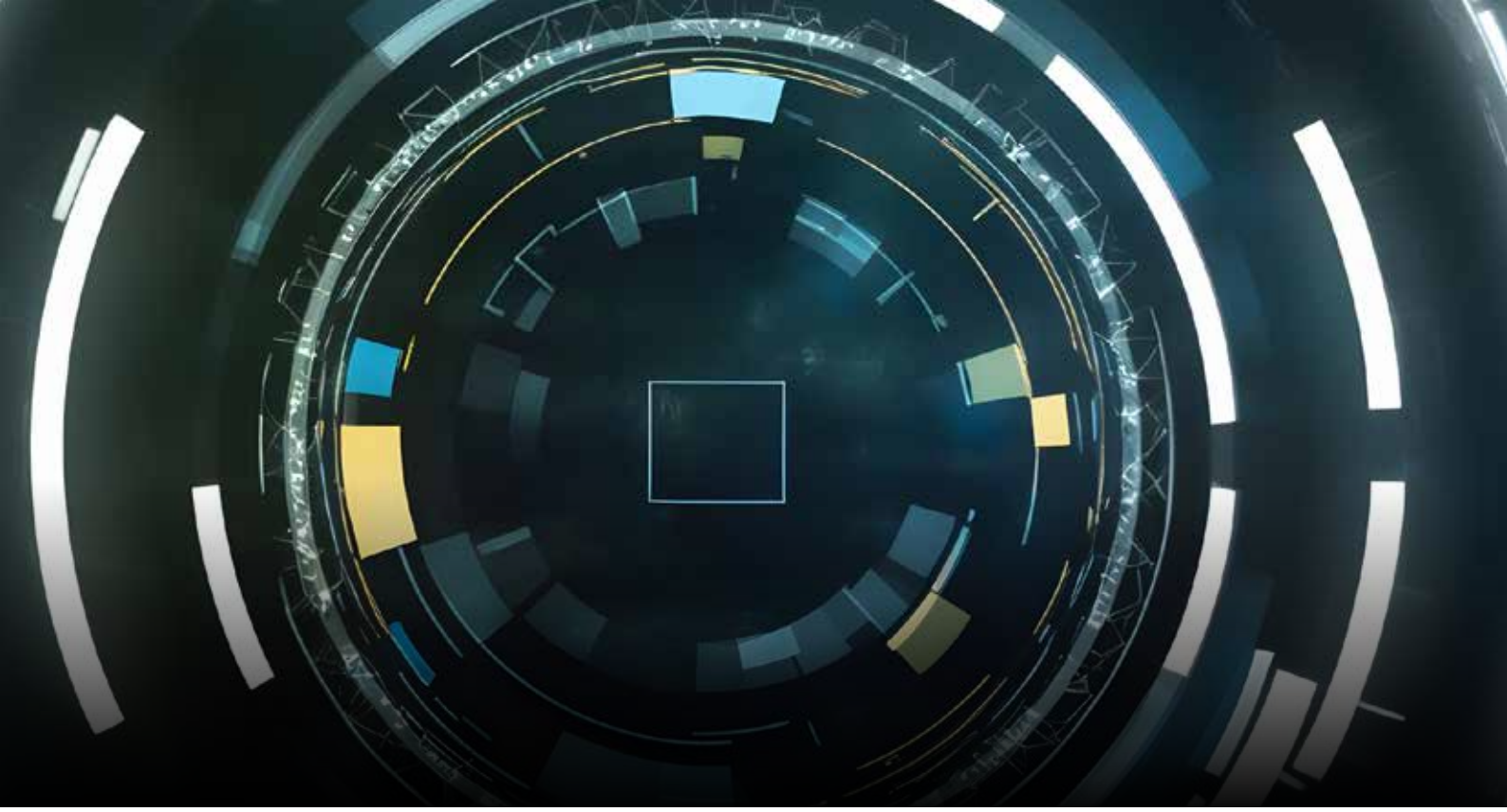
The EuroHPC Joint Undertaking, established in 2018, pools resources from the EU, European countries, and private partners to develop a world-class supercomputing ecosystem in Europe. EuroHPC supports the integration of quantum computers with high-performance computing (HPC) systems, aiming to create a federated computing infrastructure that combines classical and quantum computing resources (Regulation EU - 2021/1173, 2021). EuroHPC has acquired multiple petascale supercomputers and is working towards deploying exascale supercomputers capable of performing a billion operations per second. Additionally, it supports the integration of quantum simulators within its supercomputing infrastructure. Within the AI innovation package, there has been an amendment in 2024 to the EuroHPC Regulation for supercomputers, with the scope of facilitating the financing to support the development of AI factories that can train large General Purpose AI models, contributing to the widening of the use of AI to a large number of public and private users, including startups and SMEs (European Commission, 2024a).

Additionally, the European Quantum Communication Infrastructure (EuroQCI) initiative aims to deploy a secure quantum communication infrastructure across the EU. This infrastructure will integrate quantum and classical cybersecurity technologies to protect critical data and communications, using both ground- and space-based components (Castelein et al., 2023).

Horizon Europe and the Digital Europe Programme, furthermore, provide substantial funding for quantum computing research and innovation. Horizon Europe consists of the EU's research and innovation framework programme and supports projects that aim to advance quantum technologies and bring them closer to market readiness. Under the 2023-2024 digital, industrial, and space work programme of Horizon Europe, the European Commission has allocated EUR 40 million to boost research into cutting-edge quantum technologies. The Digital Europe Programme, on the other hand, focuses on building the digital capacities of the EU, including investments in quantum technologies to enhance digital infrastructure and support the development of advanced quantum applications (COM(2021) 118 Final - 2030 Digital Compass: The European Way for the Digital Decade, 2021).

Finally, standardisation is crucial for the interoperability and commercialisation of quantum technologies. The EU promotes coordinated standardisation and certification efforts through organisations such as CEN, CENELEC, and ETSI (COM(2022) 31 - An EU Strategy on Standardisation Setting Global Standards in Support of a Resilient, Green and Digital EU Single Market, 2022). These efforts aim to establish common standards for quantum devices, protocols, and applications, focusing on various aspects such as defining terminologies, quality benchmarks, and exchange protocols, with the aim of facilitating the development of a coherent and competitive quantum ecosystem in Europe (Castelein et al., 2023).

3 The Public Sector Tech Watch



The PSTW observatory has made notable progress in just over a year. A range of activities have contributed to the observatory's development, enhancing the knowledge hub with resources such as reports and individual success stories, as well as fostering community engagement through events like online webinars and the 2024 Semantic Interoperability Community (SEMIC)[22] conference in Brussels. These efforts underscore the observatory's growing relevance to both the European Commission and its stakeholders. For a more comprehensive understanding of the observatory's founding objectives, Box 1 offers further information.

In detail, the most important objective of the PSTW observatory is to **collect knowledge** across Europe. This is made by analysing selected use cases, and further developing more detailed success stories with information that can serve to raise awareness and provides inspiration for other administration to do the same. At the time of writing, the PSTW has collected and published 15 stories[23] showcasing public administrations using AI and Blockchain to improve their services. These success stories are published regularly to share insights and learnings with the members of the observatory. The stories regarded different sectors of government such as healthcare, fire protection services, public services, and urban planning. AI and Blockchain technologies have been piloted and fully used in these success stories for different applications such as information analysis, public service personalisation and internal management processes.

The database of cases, which forms the heart of the PSTW observatory, stands as one of its key components. This curated collection fosters

Box 1. The Public Sector Tech Watch's mission

The Public Sector Tech Watch is an observatory launched in 2023 by the European Commission dedicated to monitoring, analysing, and disseminating the use of AI, Blockchain and other emerging technologies[21] within the public sector in Europe.

It is managed by the **Directorate-General for Digital Services** (DG DIGIT) and the **Joint Research Centre** (JRC) of the European Commission and is hosted within the Joinup platform.

The observatory functions as a **'one stop shop' for all stakeholders – public sector officials, policy makers, private companies, and academia** – who look for resources on latest trends and developments on how emerging technologies improve public sector operations and service delivery.

21 Public Sector Tech Watch link https://joinup.ec.europa.eu/collection/public-sector-tech-watch
22 SEMIC website: https://semic2024.eu/
23 Stories are available at the link https://joinup.ec.europa.eu/collection/public-sector-tech-watch/stories

understanding and raises awareness about the potential offered by emerging technologies. The PSTW aims to push innovation across the administrations of Member States at national, regional, and local levels, by encouraging them to adopt the solutions documented within. Users can access the PSTW case viewer to easily explore the AI, Blockchain, and other technological cases gathered since 2019 in a user-friendly manner. The dashboard will continue to be feed and will constitute a valuable resource, featuring new cases as they will be added, keeping the PSTW database up-to-date and expansive. Navigating the PSTW case viewer, each case can also be consulted singularly with a brief description, accompanied by an external link or source that describes in more detail the solution.

Furthermore, the observatory has shared narratives that highlight the application of Generative AI across various domains. This includes examples such as the City of Helsinki's adoption of participatory tools for urban planning, as well as the European Commission's use of AI to enhance multilingual services, demonstrating how these technologies can be leveraged for innovative policymaking and increased administrative efficiency. All the stories provide information on the challenges that administrations face when carrying out technological changes, seeking to equip the observatory's members with learnings and tools for further analysis and potential replications in other settings and administrations.

In addition to the stories, the observatory has shared under its 'Knowledge Centre' to all the related JRC publications under other collections or observatories that were deemed important, also including EU-funded initiatives and projects to promote synergies. Scientific reports, including the first PSTW report on digital innovation within European public services (DG DIGIT et al., 2024), provided insights into digital innovation trends in the public sector, based on the data collected.

The **PSTW community** consists of public administrators, researchers, private sector actors, practitioners and citizens, **accounting for more than 300 members**, has been engaged in a series of workshops, webinars and events designed to disseminate the results, and engage relevant actors in discussions. In addition, JRC experts have also carried out multiple online webinars with hundreds of participants from across Europe covering the topics of *"Competencies and Governance Practices for AI in the Public Sector"* [24], *"GovTech in Europe: Critical Influencing Factors for Cross-Border GovTech Practices"*[25]and *"What Factors Influence Perceived AI Adoption by Public Managers? A Survey in Seven EU-countries"*[26], All these events and materials have also been shared and made available for all users through the online observatory, in order to disseminate results and promote collaboration among all stakeholders. Moreover, to engage stakeholders, the PSTW observatory has launched the **Best Cases Award** competition to award the best cases in Europe allowing the community members to submit cases and further enrich the database with new cases of AI, Blockchain and other emerging technologies. **Therefore, PSTW is an open community that relies on the participation and co-creation by the users,** where everyone is invited to become a member and contribute to the construction and dissemination of knowledge.

This study is the second report prepared under the PSTW observatory and builds on the previous work conducted and following the PSTW methodological approach described in the publication *"Methodology for the public sector Tech Watch use case collection – Taxonomy, data collection, and use case analysis procedures"* (Tangi et al., 2024). On the basis of a more extensive body of qualitative and quantitative information, this report analyses in more detail the adoption of emerging technologies within the European public sector, offering new findings, expanding the body of knowledge and practical recommendations for public administrators, academics, private sector, and citizens. The findings presented are provided on the analysis of the PSTW cases collection as per May 2024.

24 See the webinar at the following link https://joinup.ec.europa.eu/collection/public-sector-tech-watch/news/webinar-13-highlights
25 See the webinar at the following link https://joinup.ec.europa.eu/collection/public-sector-tech-watch/news/webinar-23-highlights
26 See the webinar at the following link https://joinup.ec.europa.eu/collection/public-sector-tech-watch/news/webinar-33-highlights

4 Landscape Analysis

As of May 2024, the PSTW database has been expanded to include a total of 1,617 cases from across EU27 and neighbouring countries, which represents an increase of 494 (44%) cases since the previous publication[27]. Within the EU27 cohort, Germany and Italy have the highest representation, with 192 identified cases each, followed by the Netherlands (187), the United Kingdom (115) and Spain (108). Despite the efforts conducted to ensure balance across all analysed countries, the dataset is not statistically representative due to the limitations of the data collection tools and the publicly available evidence. Therefore, the presented figures cannot be interpreted as a statistically robust representation of the adoption rate of emerging technologies across the countries and, as a consequence, no comparison or benchmark is proposed among countries. For more information regarding the PSTW methodological approach consult Box 2.

Box 2. PSTW methodology

The PSTW methodology encompasses the **taxonomy designed to categorise collected cases** of emerging technologies, alongside the **protocols established for data gathering and dataset maintenance.** Under development by the JRC since 2021, this methodology has been employed in various reports preceding this one, ensuring a robust and methodologically sound framework for the ongoing collection, analysis, and dissemination of cases. For this reason, the methodology is constantly reviewed and strengthened if needed.

Firstly, the taxonomy aims to describe all types of technological innovation cases in the public sector, **starting with AI and Blockchain** and **extending to any other emerging technological trend.** The objective is to establish a common standard for evaluating all the cases, considering factors such as the type of technology chosen, the functions of government involved, the type of application, and the level of government. To keep the taxonomy relevant in a rapidly evolving technological environment, it is regularly updated and reviewed. This taxonomy offers a structured conceptual framework of the landscape of public service innovation, enabling comprehensive analyses and cross-comparisons, as demonstrated in this report. Ultimately, it serves as a guiding framework for decision makers and policy makers in public innovation.

The second pillar is the data collection and maintenance process. The database relies on data derived mainly from secondary sources. Such sources encompass a diverse array of previously compiled information, including **academic papers, sector-specific analyses, official governmental documents, and press coverage.** All cases are then checked, filled according to the taxonomy, and published. The use case database is checked regularly to maintain its accuracy. **Every month, the PSTW observatory adds new use cases to it.** This process ensures the database remains up-to-date and useful for users who require the latest information.

Lastly, the limitations of the methodology should be considered and weighted when assessing the analysis results. The main limitations are:

- The database is only a **limited statistically representative sample,** which does not allow to conduct statistically robust comparison in the rate of update, across time and across technologies.
- Data categorisation might be susceptible to **misinterpretation and definitional inconsistencies.**
- The definition of what constitutes the public sector have its intricacies, because of the diversity of organisations, institutions, and entities.

For more information, please consult the *"Methodology for the public sector Tech Watch use case collection – Taxonomy, data collection, and use case analysis procedures"* (Tangi et al., 2024).

27 Previous publication link https://op.europa.eu/en/publication-detail/-/publication/805e08cc-0383-11ef-a251-01aa75ed71a1/language-en

In terms of types of technology, the database used for this report includes **1,295 cases of AI** (80% of total cases), **270 cases of Blockchain** (17%) and **52 cases of other emerging technologies** (3%, including 4 quantum computing cases, 6 Virtual Worlds cases and 42 AR/VR cases). Figure 2 and Figure 3 show the evolution of the PSTW database from the previous publication with respect to each technology type and the current composition.

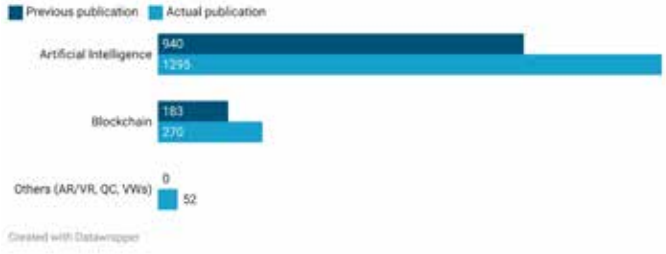


Figure 2 Evolution of the PSTW database from previous publication

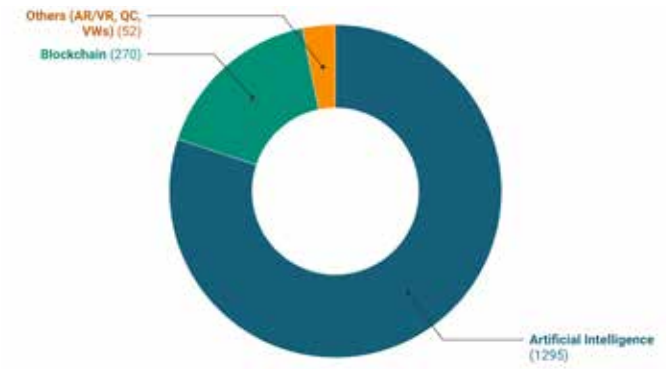


Figure 3 PSTW composition by technology type

The PSTW database includes cases from across the last decade, with 60% of the cases having started being implemented or piloted from 2020 onwards, with a steep rate of increase recorded from 2016 (Figure 4). The figure below shows the starting date of the cases collected by the PSTW observatory from the public administrations in Europe. These dates are based on available information and represent the actual starting date, or an informed approximation, based on the source's publication date. The decrease of cases collected that is recorded after 2022 is most likely due to the limitations and scope of the data collection processes limitations and to the availability of public information on the most recent cases, rather than an actual decrease in cases' implementations. For instance, compared to the previous report, more cases from 2023 and 2024 were gathered during the recent data collection across publicly available sources. Considering the fast-changing character of this type of innovations, the database is regularly reviewed and maintained, with a maintenance cycle conducted every six months for the identified cases.

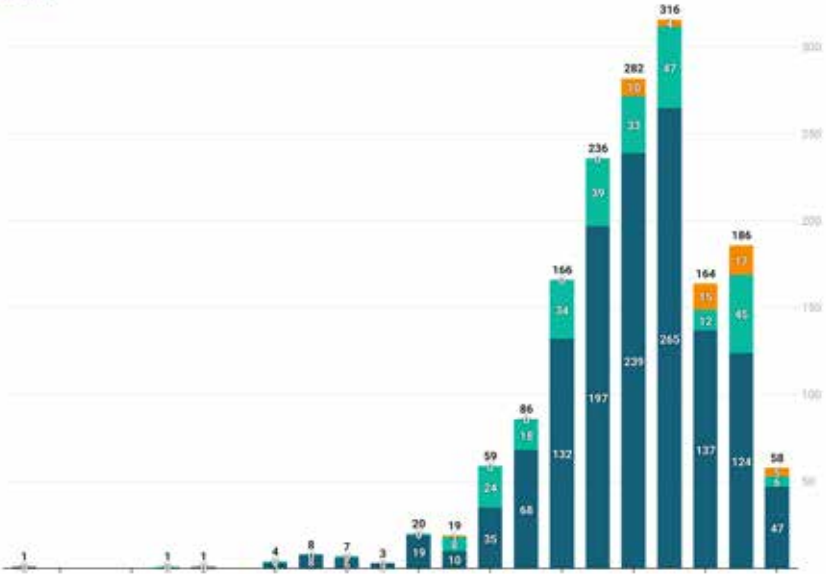


Figure 4 Distribution of cases according to their starting date.

Figure 5 shows that half of the cases (47%) are set at the national administrative level, while local administrations follow closely (33%). Cases implemented across countries (e.g., EU projects and consortia) and at the regional level represent 10% of the cases each. When considering the type of technology (Figure 6), the results show some insightful differences. AR/VR cases are mostly found within local administrations (71% of the cases). Blockchain-based cases, on the other hand, are more often used in projects involving multiple countries to implement interoperable solutions. In the case of Blockchain, cross-border projects are largely common mainly because their benefits include, among others, secure cross-border data sharing facilitation, supply chain management and international financial transactions. **AI**, compared to blockchain, **is adopted more frequently at the national level, and only slightly more at regional and local levels. However,**

Figure 5 Distribution of cases according to administrative level of application

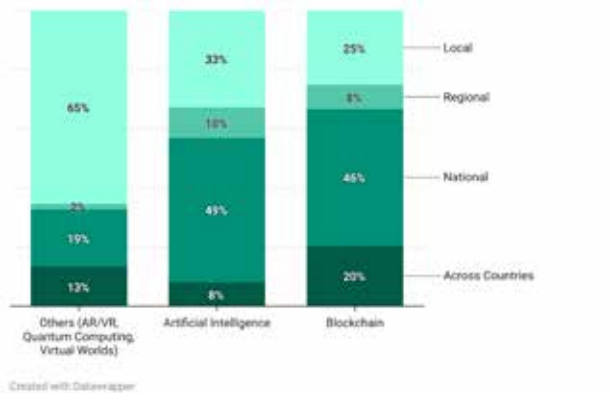


Figure 6 Cases across levels of administration, by technology

Blockchain is more adopted at the cross-country level (20% against 8%). About the AR/VR counts, it could be that local administrations are starting to experiment AR/VR to improve citizen engagement, also thanks to their proximity with citizens that enable **to link them better to the specific citizens needs** and involving them actively. By integrating AR/VR, these local administrations could provide more specialised and faster interactive experiences, **providing better public services.** In addition, it is also realistic to suggest that **local entities may have greater capacity to experiment with emerging technologies** such as AR/VR, considering that these technologies can be rapidly adopted without the need for large infrastructure deployments, which are typically the responsibility of central governments. Finally, local governments may have more flexible internal processes, enabling them to pilot and implement these innovative solutions.

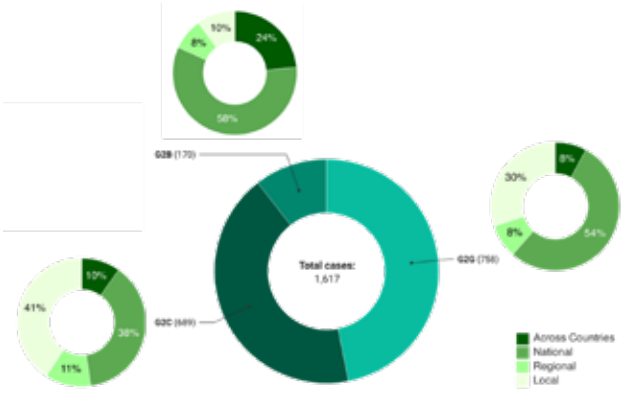


Figure 7 Distribution of cases according to administrative level and e-government interaction

When considering the type of e-government interactions and the level of administration (Figure 7), other interesting layers of analyses appear. The first variable refers to whether the solution affects government-to-government (G2G), government-to-citizens (G2C) or government-to-business (G2B) interactions. Figure 7 shows that relatively more G2C cases are found within local administrations, indicating their crucial role in driving the digital transformation of public services: 41% of G2C cases are in fact found within local administrations, while G2G cases are predominant within national

administrations (54% of the cases). This data may indicate that central-national organisations seem to be more focused in relative terms in streamlining administrative efficiency with emerging technologies such as AI or Blockchain. On the other end, local administrations prioritise innovating and improving public services for citizens. Lastly, cases to improve services for businesses are seen especially at the national and supranational level: 24% of the G2B cases are across countries, particularly because of Blockchain-based applications to improve cross-border interoperability and use cases participating in the European Blockchain Regulatory Sandbox.

An additional finding at this level of analysis regards the status of development, which is different across levels of administrations. Figure 8 shows that local administrations have relatively more implemented cases than national administrations. Despite fewer cases in absolute numbers, there are more fully operational solutions based on AI, Blockchain or other emerging technologies within local administrations. Even if local and regional administrations might have relatively lower technical, organisational, legal, or financial capabilities than national organisations, they seem to fully implement new solutions at higher rate. On the other hand, national administration might have more capacity to develop and test new solutions, explaining why there are more pilots or solutions at the development stage. Another possible explanation might be that central organisations have higher organisational, technical, legal, and probably political obstacles before fully implementing solutions or scaling pilots, which can delay cases' final implementation. The same reasoning could be applied to explain the data related to regional level cases. Lastly, the overwhelming majority of across country cases (79%) are pilots, indicating that cross-border solutions for public services in Europe are still at an initial stage of development.

These results might also depend on the type of administrative structure each European country has. For example, local administrations invest more in the full implementation of the solutions. In addition, among the total of 195 cases found in Italy, half of them are implemented or piloted within local or regional administrations. However, and given the limitations of the data collection and the construction of the data sample presented in the methodological report (Tangi et al., 2024), it is not possible however to identify whether the status of development of emerging technology is causally related to the type of national administration implementing or piloting it.

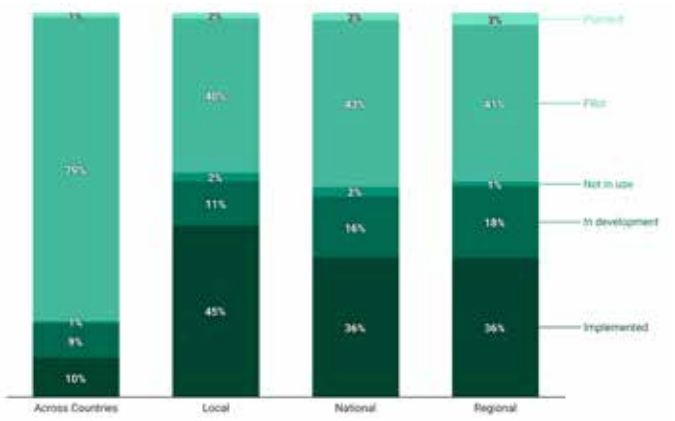


Figure 8 Distribution of cases according to level of administration and status of development

Furthermore, each case was evaluated according to the type of public value that the solution produced or is expected to produce, categorised in three areas:

- Improving public services,
- Administrative efficiency, and,
- Enhancing open government capabilities.

The first two are mutually exclusive—improved public service focuses on better services for citizens and businesses (G2C, G2B), while improved administrative efficiency targets internal processes within public agencies (G2G). Open government capabilities assess the impact on transparency and openness, recognising solutions that enhance visibility and engagement in both public services and administrative operations

(Tangi et al., 2024), see Box 3 for more details.

Moreover, according to the PSTW methodology (Tangi et al., 2024), the assessment process for evaluating the public value of the collected use cases incorporates both the tangible benefits outlined in the use cases and the potential value they could deliver to the public sector. Given that many of these cases are still in early stages and have not yet undergone formal impact assessments, the evaluation of public value is predominantly based on informed projections and expectations provided by the PSTW team.

Figure 9 shows that 47% of the cases (759 cases) have improved or are aiming to **improve administrative efficiency,** while 53% (858 cases) have improved or are aiming to **improve public services.**

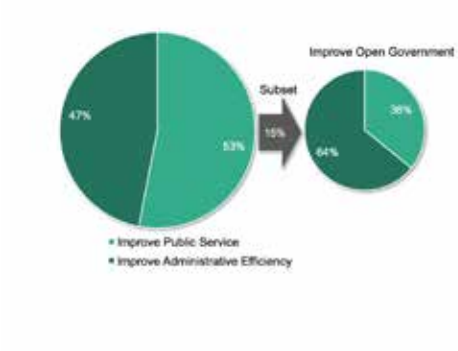


Figure 9 Public value assessment of the cases

From the total, 15% of the cases (240 cases) improved or are expected to **improve the open government capabilities** of administrations. From these 240 cases, 36% improve public services (G2C or G2B) and 64% improve administrative efficiency. Box 3 further develops this variable, diving into each category's component.

Different technologies seem to provide relatively different public values creation potential (Figure 10). AI-based cases improve administrative efficiency relatively more than the cross-technology average (53% against 47%) in the analysed dataset, while Blockchain-based solutions overwhelmingly improve public services (77% of cases). AR/VR applications also enhance mostly public services.

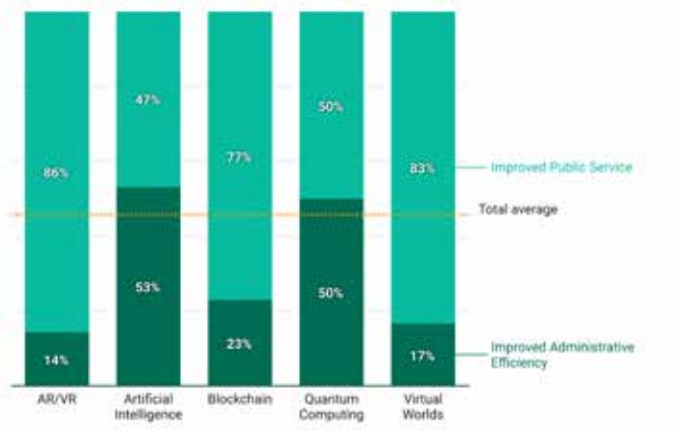


Figure 10 Public value assessment by type of technology

Box 3. Focus on the public value assessment.

Each public value category (i.e. improved public service, improved administrative efficiency, and open government capabilities) was also analysed in different features to better understand the value created by the cases. As explained in the methodology report, the categorisation was drawn and elaborated from Maragno et al., (2021a) and J. D. Twizeyimana & Andersson (2019).

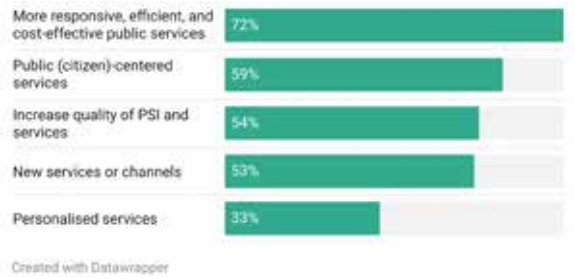


Figure 11 Public assessment subcategories for Improved Public Services

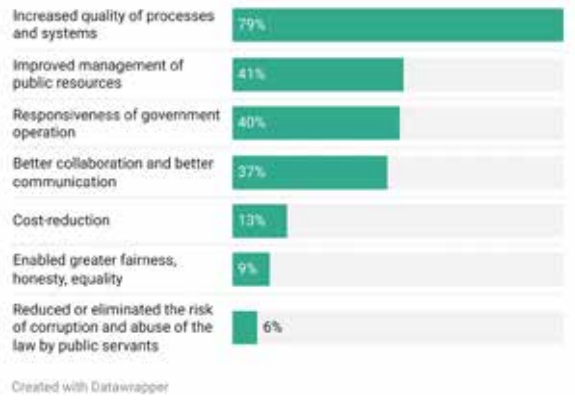


Figure 12 Public assessment subcategories for Improved administrative efficiency

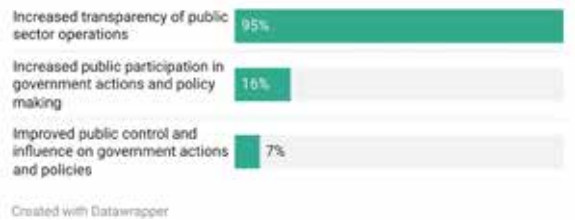


Figure 13 Public assessment value for Open government capabilities

Note: Each case could be evaluated with more than one subcategory, therefore the sum is not equal to 100%.

Solutions that improved **public services** have made them more responsive, efficient, and cost-effective (72% of the total), more citizen-centric (59%) and with a more quality of information (PSI – public service information) (54%). Following, 53% of the cases created new services and channels for citizens, while 33% made them more personalised and tailored to the single citizen.

Among cases that improved or are expected to improve the **administrative efficiency,** 79% of them increased the quality of internal processes and systems, 41% improved the management of public resources and 40% increased the responsiveness of government operations. In smaller number, 37% of cases improved the collaboration and communications within administrations, 13% of them abated financial costs, and a minority of cases enabled greater fairness, honesty, and equality (9%) and reduced or eliminated the risk of corruption and abuse among public servants (6%).

Lastly, it must be noticed that among those 15% overall cases (240 out of 1,617, Figure 13) enhance **open government capabilities**, 95% of them improved the transparency of public sector operations, while public participation and control on decision making processes was improved with emerging technologies only in the 16% and 7% of those cases, namely very few cases across the whole PSTW database. In fact, the main part of them (64%, Figure 13) are cases targeting administrative efficiency improvements.

5 The use of AI in the European Public Sector

5.1 Context and introduction

The updated version of the PSTW Database includes 1295 AI-based cases, gathered from a multiple range of sources and through the reporting tool available on the PSTW collection website, representing an increase of 29% from the previous report. The cases are distributed across the continent. The countries with more cases are Germany (167 cases), the Netherlands (154), Italy (138), and the United Kingdom (81), followed by Belgium, Spain, and Estonia with more than 70 cases each. It is worth noting that 11 cases are implemented by the European Union institutions as well. Since the previous report, new cases were spotted across all countries, without significant differences, indicating that the adoption of this technology is increasing throughout the continent. New cases from Iceland, Albania and North Macedonia were also identified and analysed for the first time in this report.

According to the status of development, 42% of AI cases are pilots, while 40% of cases are already implemented and functioning, followed by solutions in development (14%), see Figure 14. The finding is especially relevant because it highlights how most solutions are either pilots or still in development, indicating that administrations are at experimental stage of adoption of this technology. Scaling up innovative solutions such as AI is still a challenge in some organisations, but the pilot-to-in development ratio among cases indicate that many administrations are moving their projects from proof of concepts or tests to production. Similarly, the 40% of cases are already implemented, possibly indicating that the AI diffusion stage is shifting from early adopters to early majority. Future analysis might consider exploring this aspect and analyse the temporal evolution of the status of development of solutions collected in the PSTW, leveraging on the data maintenance operations conducted on the dataset.

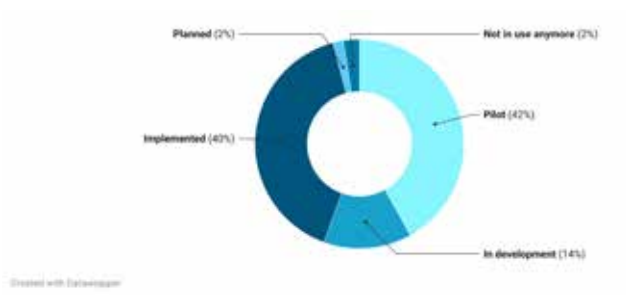


Figure 14 Distribution of AI cases by status of development

5.2 Analytical insights

AI cases that affect G2C interactions are implemented or piloted relatively **more at local level compared to the national one (41% compared to 31% of cases), while G2G solutions show the opposite (54% compared to 37%) as shown in Figure 15.** At the national level, AI solutions are relatively more focused on improving internal and cross-organizational administrative processes and streamlining bureaucratic tasks that can be supported with the adoption of AI. At the local level, however, AI solutions are more frequently used to enhance the implementation of public services (41% of G2C) than to increase the efficiency of administrative processes (31% of G2G). This underscores the importance of equipping local administrations not only with G2G-enabling services from higher-governmental levels (regional and national) but also with ready-to-use tools and reusable best practices to help bridge their budget and skills gaps, thereby fostering AI adoption in the provision of services to citizens.

Figure 15 Distribution of cases by type of e-government service and level of administration

Moreover, the **'process type'** categorisation allows to see at a high-level which AI-based applications are meant to improve the performance of public administrations from a governance and procedures processes perspective, as delineated in the PSTW methodology, based on Engstrom et al. (2020). As shown in Figure 16, there are relative **more cases at local level that affect public services and engagement processes (35%) than national administrations (24%).** Additionally, and in line with percentage of G2G solutions for improving administrative efficiency, internal management and enforcement processes are encountered more at national (45%) than regional and local levels (27% and 34% respectively). Furthermore, national administrations have less cases that improve public services and engagement procedures with citizens than local and regional governments (24% compared to 35% and 43% respectively).

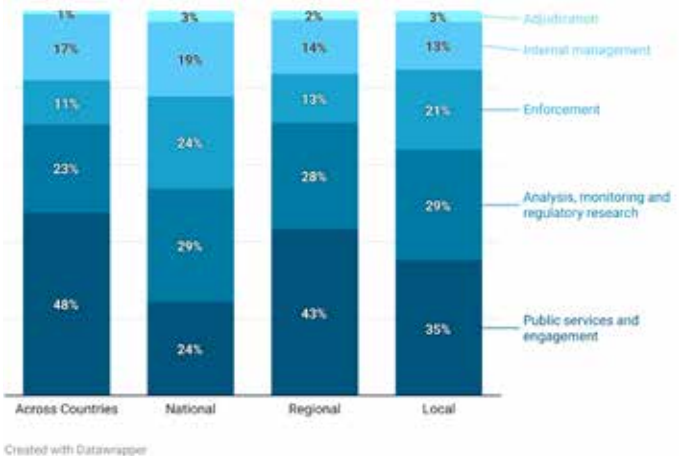


Figure 16 Distribution of AI cases by process type and level of administration

Another point to consider is the cross-sectional analysis between public administration functions and the types of implemented AI-based applications that presents specific patterns. As shown in Figure 17, **public order and safety applications are mostly G2G, while G2C solutions regard general public services, health, economic affairs, and social protection.** The heatmap presented below shows the different types of services, enhanced with AI, across the different functions of government, where some trends can be identified. A deeper analysis and understanding of the trend can be obtained when examining the correlation between the functions of government and the type of AI-based applications piloted or implemented within those sectors.

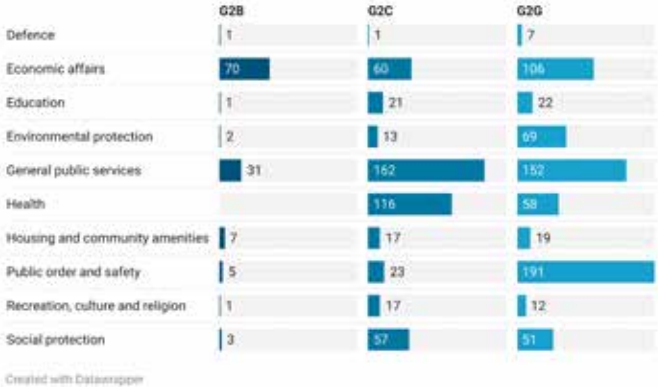


Figure 17 Distribution of cases across type of services and functions of government

Moreover, regarding the **functions of government** that use AI-based tools, the most prominent ones are **general public services, economic affairs, public order and safety, and health.** Within these functions, AI is mostly used for service personalisation, information analysis processes and prediction and planning. In addition, a more detailed heatmap is provided below (Figure 18) to present insights regarding the distribution of AI-based cases across application types and functions of government. AI is mostly used to support general public services, health and social protection and is applied in areas such as service personalisation, smart recognition, information analysis, and prediction and planning.

Furthermore, **the most used application types adopting AI** within the **general public services** function of government are **service personalisation, internal primary and support processes, engagement management and information analysis processes.** The types of solutions appearing in these areas include: chatbots, automative processes to streamline general services, automate clerical tasks, and knowledge representation dashboards for city management (i.e., control rooms for city info analysis regarding water consumption, traffic etc.). All these solutions are represented at national, regional, and local levels.

Besides that, within the second most common function of government, **the economics affairs, AI is implemented mostly for prediction and planning, information analysis processes and internal primary processes.** Some examples include applications in transportation, for example in the streamlining of transport nodes networks (e.g. harbours ship management, train etc.) but also in energy management, where AI is used to predict energy consumption to improve local networks and satisfy future demand. The agricultural domain also uses some of these solutions that are developed especially for improving production efficiency meeting the needs of the general demand. Similar solutions are used to analyse crop quality, and to predict possible shortages due to illnesses.

Also, within **public order and safety,** which is the third biggest function of government impacted by AI, AI is mostly used for smart recognition processes, **smart inspection processes and predictive enforcement processes.** The majority of cases involve AI use by police forces for recognising objects, vehicles, and individuals for security purposes. The number of real uses of AI in this sector could be even higher, given that some cases might not be disclosed for security reasons. Other cases include the automatic recognition of objects by public transportation vehicles for reducing the number of incidents.

It should also be noted that **AI applications**, particularly in healthcare, are increasingly being used for **service personalization** (e.g., computer vision tools to identify patterns and predict illnesses). Additionally, AI is adopted for environmental protection to **support information analysis, prediction, planning, and decision-making processes,** including supporting the **determination of social protection benefits,** with 21 cases documented in the PSTW database. Examples include the use of algorithms to disburse welfare bonuses based on specific variables, as well as chatbots or virtual assistants that guide citizens through administrative processes for welfare benefit applications and algorithms that automatically assess citizens' eligibility for specific welfare programs.

	Application types	General public services	Economic affairs	Public order and safety	Health	Social protection	Environmental protection	Education	Housing and community amenities	Recreation, culture and religion	Defence
1	Service personalisation (various)	91	23	5	70	35	3	7	4	10	1
2	Information analysis processes	30	35	18	16	11	31	13	2	7	2
3	Prediction and planning	7	55	19	19	7	16	5	9		1
4	Internal primary processes	38	30	13	15	2	7	6	6	2	1
5	Smart Recognition processes	6	17	60	3	1	7	4	3	1	1
6	Supporting inspection processes	22	8	31	5	11	5	1	2		1
7	Internal support processes	50	5	13	10	1	1		2	4	
8	Service integration (various)	26	16	2	12	4	1	3	5		
9	Predictive enforcement processes	9	5	37	2	6		1	1		2
10	Engagement management	34	8	2	3	4	2	2	4	4	
11	Innovating Public Policy	3	14	4		3	5	1	1	2	
12	Taking decisions on benefits	5	2	3	1	21		1			
13	Monitoring policy implementation	5	7	8	2	2	4		4		
14	Data Sharing Management	10	3	1	3		1				
15	Management of auditing and logging	3	1	1	3						
16	Internal management processes	2				3	1				
17	Improving Cybersecurity	1	1	1	1						
18	Certification and validation processes	1	1	1							
19	Tracking of goods and assets along the supply chain		2								
20	Supporting disintermediation		1								
21	Procurement management		1								
22	Registration and data notarisation processes	1									
23	Managing Copyright and IPR	1									

Figure 18 Distribution of AI according to application type and function of government.

As shown in Figure 19, when it comes to analysing the types of AI utilised in the cases collection (technology subdomains), half of the AI-based case use Machine Learning (ML), followed by Natural language processing (24%), computer vision (22%), automated reasoning and planning and scheduling (22% and 20% respectively). Compared to the previous report, Deep Learning and Generative AI techniques were added to the taxonomy of the PSTW. As of May 2024, the PSTW included 23 cases of Generative AI and Deep Learning, representing 2% of the total cases each.

ML is employed because of its ability to process large volumes of data, identify trends, and leverage them to support decision-making processes. This is the most used AI technique within public administrations, having the potential to automate repetitive tasks, improve efficiency, and free up human resources to focus on more complex and strategic activities. Additionally, ML algorithms can continuously learn from new data, making them a powerful tool for addressing evolving challenges faced by public administrations.

The PSTW observatory started recently to collect AI cases adopting two different AI categories, **Deep Learning and Generative AI, as different categories,** and both as subsets of ML. In particular, **Large Language Models (LLMs),** that are increasingly important within the public sector, are categorized as Generative AI systems. This categorisation criteria have been applied also to all collected AI cases in the database. It should also be noted that **most of the generative AI cases collected involve LLMs,** which are used to enhance chatbots' fluency and enable human-like, effective interactions, thanks to the latest developments in AI techniques.

Automated reasoning techniques and ML share similarities in their approach to interpreting data for decision-making support systems. Both methodologies involve the use of algorithms to process and analyse data, enabling the systems to make informed decisions or recommendations based on the information available. ML focuses on pattern recognition and predictive modelling, while automated reasoning techniques emphasise logical inference and rule-based reasoning, providing complementary approaches to leveraging data for decision support.

Computer vision and Natural Language Processing (NLP) produce significant impacts on public sector services. Computer vision encompasses applications that utilise video and image scans to monitor social phenomena (e.g., public security management and monitoring, car traffic etc.), with extensions into the healthcare sector (e.g., cancer recognition and monitoring through scanning and disease-detecting algorithms). NLP finds its niche in chatbots and virtual assistants for citizens, where understanding and interpreting human language is necessary to produce human-like outputs and interactions. Lately, with the rise of Generative AI models, this technology is further improving and shifting the paradigm from rule-based human-chatbot interaction to GPT models who can generate and produce content by themselves elaborating from the training data.

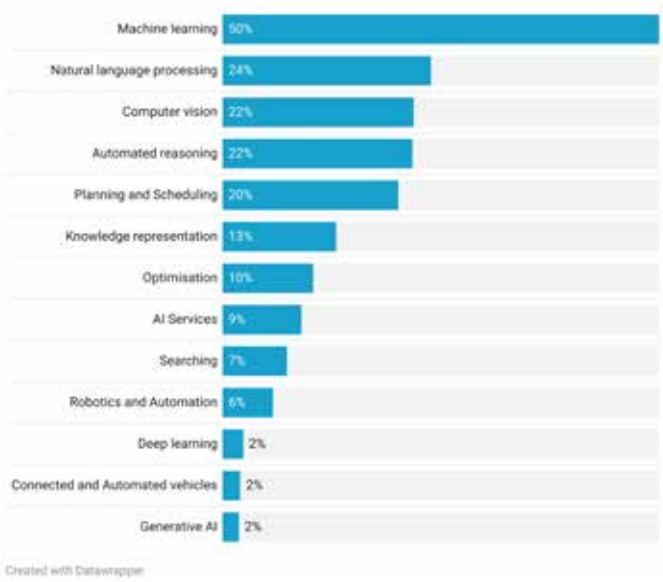


Figure 19 Distribution of AI cases according to technology subdomain

Box 4. Focus on Generative AI.

During 2024, **23 cases of Generative AI** were collected and included in the database, with this number expected to grow with data collection in the near future. Despite the lower number of cases compared to other AI domains, some possible trends seem to emerge.

Generative AI is being equally used to improve public services and enhance administrative efficiency. Regarding the applications of Generative AI, the most common type of application is internal support processes and internal primary processes. These cases include solutions that streamline administrative procedures, such as the "eBriefing" and "eSummary" use cases in the European Commission, that fasten the way public servants get summarised information and briefs on EU legislation and reports. Service personalisation (e.g., chatbots with GPT technology) and engagement management (e.g., generative AI tools to involve citizens in decision making and urban planning), which adapt services or interactions to citizens' needs and preferences, are both third in application types, with four cases each.

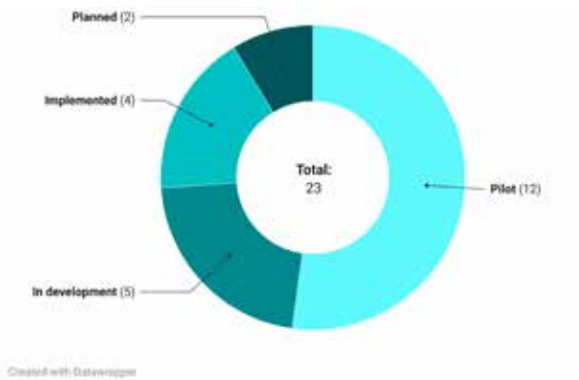


Figure 20 Distribution of Generative AI cases by status of development

Public policy innovation and information analysis (e.g., sentiment analysis) come next with one case each. For example, the Albanian government is planning to test ChatGPT to assess the national legislation in the analysis of the EU requirements for EU accession. Figure 22 below shows the adoption of these cases across the continent. In terms of functions of government, Generative AI cases are generally used within General Public services (11 cases).

Among the 23 cases (Figure 21), 19 of which started in 2023 or 2024, only four are already implemented, indicating the extreme novelty of the technology and the experimental stage in which public administrations are at the moment.

Figure 21 Geographic distribution of the Generative AI cases and their responsible organisations

6 The use of Blockchain in the Public Sector

6.1 Context and introduction

This chapter presents the main findings from the analysis of 270 Blockchain-based cases in the public sector across the EU and beyond. This represents an increase of 87 cases since the previous report in May 2024, indicating growing interest and experimentation with this technology among public administrations. Moreover, five new countries have been added to the database, namely Norway, Slovenia, Ireland, Georgia, and Croatia, expanding the geographical scope and diversity of the cases. The country with the most identified Blockchain-based cases is Italy (48), followed by the Netherlands (33), Spain (28), the United Kingdom (23) and Germany (18). Notably, EU institutions emerge as important promotors and implementors of Blockchain solutions, with 24 cases identified, indicating the significant cross-border potential posed by this technology to improve services and administrations, as illustrated in the following sections.

6.2 Analytical insights

The largest portion of cases collected consists of pilots, which suggests that public administrations are currently experimenting and learning from the application of Blockchain technology. As shown in Figure 22, 64% of the Blockchain-based cases are pilots, while only 17% have reached full implementation. This suggests that there is still a gap between the exploration and the exploitation of Blockchain solutions in the public sector. Moreover, this can also indicate that although there is widespread interest in better understanding this technology, Blockchain is still in its early stages in technology and adoption.

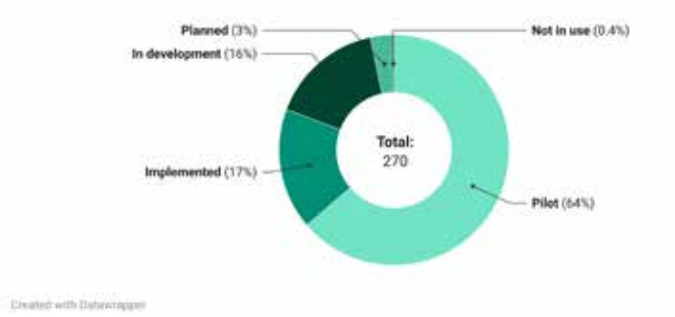


Figure 22 Distribution of Blockchain-based cases by status of development

In terms of level of administration, as shown in Figure 23, **national organisations continue to be the most prominent players, with 46% of the cases being developed at the national level.** However, it should be noted that this data decreased since the previous publication, due to the gathering of more cross-border Blockchain-based pilots. Local administrations follow closely behind (25%), while cases at the European level or across countries account for 20% of the total (11 percentage points more than the in previous report). This result exceeds that of AI-based cases, highlighting the employment of Blockchain solutions for interoperability and cross-border processes. Regional administrations remain relatively minor, with 8% of the cases. National administrations appear to possess more substantial resources for funding or implementing Blockchain-based solutions or projects, considering that 66% of the total cases are piloted or implemented by national administrations or in across-countries applications, where national administrations are either way involved directly.

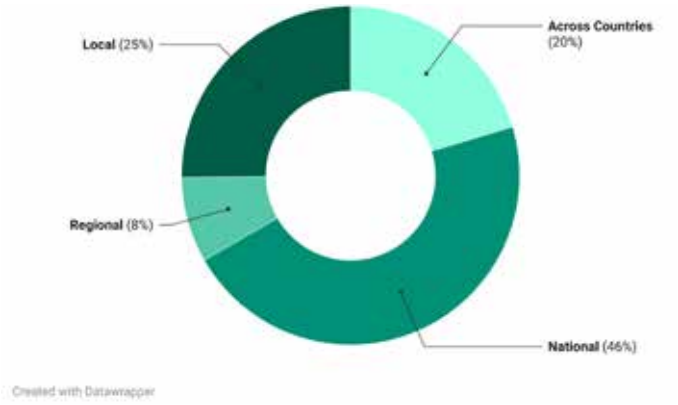


Figure 23 Distribution of Blockchain-based cases by level of administration

When considering the type of interactions, as shown in Figure 24, Blockchain-based solutions are predominantly used to support services targeting citizens (G2C). Moreover, crossing the e-government types of interactions with the different levels of administration, there are some interesting trends on local administrations. Local administrations adopt Blockchain technologies increasingly in support of services targeting citizens (G2C). Similarly to the findings on AI, 32% of G2C cases are set at the local level, while only 19% of Blockchain-based cases focus on G2G interactions within local administrations. Given their proximity and direct contact with citizens, it is commendable that local administrations are exploring how Blockchain technology can serve their needs as well.

Figure 24 Blockchain-based cases by e-government type of interaction and level of administration

Moreover, crossing the type of interaction with function of government fields, Blockchain-based services are especially prevalent in general public services, economic affairs and education sectors. As shown in Figure 25, there is a notable role of Blockchain within the education sector, especially with respect to academic credentials. Furthermore, the role of the technology is significant within the health sector and social protection functions: eHealth certificates data-exchange applications can be enhanced with Blockchain technology, which can also be leveraged for safer payments of welfare benefits, for instance. Blockchain is also used consistently for G2B solutions within the economic affairs departments of administrations to increase the safety of digital and economic transactions between actors, or to improve supply chain management for economic operators. Lastly, Blockchain technology is used predominantly in general public services when considering G2G interactions: examples include Blockchain-based procurement procedures and data sharing processes within administrations.

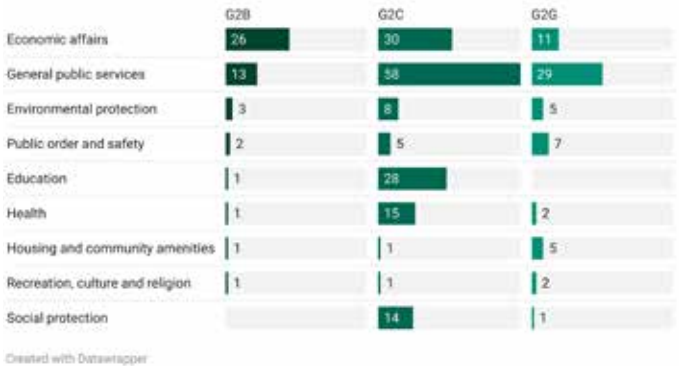


Figure 25 Blockchain-based cases across type of interaction and function of government

Another point to consider is how Blockchain-based cases are distributed according to **the type of application and the function of government classification,** as shown in Figure 26 below. Public administrations explore and use Blockchain in general public services, education, and economic affairs, particularly in applications that concern certifications, authentications, data sharing and tracking of goods and assets. These findings are in line with previous discussion on the role of Blockchain technology to improve either public services for citizens and businesses or administrative processes.

Certification and validation processes represent the most prevalent application type for Blockchain technology, especially within the education sector, which gathers the highest concentration of implemented cases. This emphasis centres on the certification of academic credentials and the validation of academic degrees across international borders. Additionally, Blockchain technology enhances certification and validation processes within general public services, as exemplified by legally binding e-signatures and COVID-19 certificates employed in the healthcare sector during the pandemic.

Additionally, the second most prominent application type is **payments and international transactions.** Not surprisingly, the **economic affairs sector,** is the sector with more cases that use this blockchain-based application. In these cases, blockchain technology facilitates secure transactions between individuals, as demonstrated in trials for incentive programs rewarding citizens for adopting eco-friendly practices such as reducing CO2 emissions. **Environmental protection** is the second sector with most cases, where blockchain technology is employed for payments. Moreover, the payments and international transactions is complementary of financial management and support application type, ranked in the 9th position of Figure 26, where social protection is the predominant sector utilising such Blockchain-based applications.

The following application type is **data sharing management.** In this case, general public services and healthcare are the sectors that mostly make use of this application type. The secure exchange of sensitive information, such as medical records, is a critical area where Blockchains' inherent immutability and transparency offer unparalleled advantages. Blockchain and DLT can safeguard sensitive data and ensure compliance with data privacy regulations. In general, they can help in securing and guaranteeing safety and privacy-related abidance. Estonia, for instance, has built a common e-Health record for every patient that can be accessed online, based on Blockchain.

Other interesting application types are related to **registration and data notarisation processes and self-sovereign identity authentication, both primarily implemented in general public services.** In relation to registration and data notarisation processes, there are examples of use cases in the digitisation of land registration as well as vehicle and property transactions. Furthermore, regarding self-sovereign identity authentication, national blockchain-based IDs are emerging, being implemented, and piloted in numerous European nations, such as Netherlands, Switzerland, and Germany. It is worth mentioning the European self-sovereign identity framework (ESSIF), a component of the European Blockchain service infrastructure (EBSI). The EU is clearly pursuing this path, including both Member States levels and the community level.

Finally, another significant application type is **tracking of goods and assets along the supply chain, primarily utilised in the economic affairs sector.** Blockchain provides solutions to trace the origin of each good and monitor its movement in a secure and reliable manner. Pilot projects are experimenting with Blockchain's' potential to verify the origins of goods entering the EU's' single market and enhances supply chain transparency, traceability, and reduces administrative costs. Italy has several cases of Blockchain applications in the agri-food industry, involving products such as meat, milk, and wine.

	Application types	General public services	Economic affairs	Education	Health	Environmental protection	Social protection	Public order and safety	Housing and community amenities	Recreation, culture and religion
1	Certification and validation processes	14	1	23	4	3	2		1	2
2	Payments and international transactions	5	14	1	1	6	3	2		
3	Data Sharing Management	12	2		9	1		1		
4	Authentication of self-sovereign Digital ID services	15	1	2	1	1		3		
5	Registration and data notarisation processes	14	4		1			2	1	
6	Tracking of goods and assets along the supply chain		14		1	2		1		
7	Innovating Public Policy	6	9			1			1	
8	Internal management processes	7	2			2	2		1	1
9	Financial management and support		4				7			
10	Governance and voting	10								
11	Supporting disintermediation		8							
12	Service integration (various)	4	1	1			1			
13	Procurement management	6								
14	Prediction and planning		2						2	
15	Improving Cybersecurity	1	1		1			1		
16	Supporting inspection processes	1	1					1		
17	Internal support processes	1	1					1		
18	Internal primary processes		1	2						
19	Managing Copyright and IPR	1	1							1
20	Service personalisation (various)	1						1		

Additional 3 rows not shown.

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Figure 26 Blockchain-based cases by type of application and function of government.

Box 5. Focus on and cross-border features of Blockchain cases.

A key characteristic of the identified Blockchain-based cases is their potential for cross-sectoral and cross-border application (Figure 27 and 28). In fact, some cases identified by the PSTW observatory reflect the level of applicability of Blockchain services across industries and nations and its potential to sustain systems interoperability or services across different government levels. In these cases, interoperability pertains to the ability for a network to share and access information across countries without the involvement of an intermediary.

Compared to the 2022 publication (Martin-Bosch et al., 2022), a greater number of cross-border cases were identified (increase from 13% to 26%), primarily attributed to increased initiatives and pilot projects at the EU level and a surge in pilots involving the exchange of university credentials using Blockchain. Similarly, only 18% of the cases are cross-sector applications, primarily due to use cases involving data sharing across institutions and industries, where multiple entities can securely access data.

Similarly, **18% of the cases are cross-sector applications,** primarily due to use cases involving data sharing across institutions and industries, where multiple entities can securely access data.

While the illustrated data analysis shows that these applications are still at early stages, these findings suggest that Blockchain technology has the potential to facilitate cross-border and cross-sectoral collaboration.

Figure 27 Distribution of AI and Blockchain cases by cross border sector feature

Figure 28 Distribution of AI and Blockchain cases by cross sector border feature

7 Other emerging technologies' adoption in the European Public Sector

7.1 Context and introduction

Besides AI and Blockchain, other emerging technologies have the potential to transform the public sector in delivering better services for citizens or streamlining administrative processes. These include Augmented Reality (AR), Virtual Reality (VR), Virtual Worlds, and quantum computing, as discussed in the background chapter. In this section, we present an overview of these technologies and their applications in the public sector, based on a sample of **52 cases** collected from across the European public sector. As of today, this analysis should be considered as explorative rather than comprehensive or statistically significant regarding the rate of adoption of such technologies in the European public sector. Consult the methodology report for further details on the limitations (Tangi et al., 2024).

The country with most cases gathered from public information is the United Kingdom (11 cases), followed by Germany (7), Italy (6), Sweden and Ireland (5 each) and Finland (4), for a total of 16 Member States represented. This finding should be considered in the context of the PSTW observatory. It does not fully represent the rate of adoption of these new and emerging technologies across the continent. Despite the small sample size that impedes describing general trends, some relevant insights can be identified.

Virtual Worlds and quantum computing projects and cases **are mostly pilots or in development,** given the novelty of the technology and the exploration of their potential applications within the public sector. AR/VR-based solutions, on the other hand, seem to be fully implemented at a higher rate.

While AI-based innovations represent the current scenario of public sector innovation, this new set of emerging technologies may represent future directions. Therefore, the observatory seeks to start monitoring and analysing the front runners, the first movers of these technologies, in order to better understand their potential. This report aims at presenting a first attempt in this direction, with a fresh view over a small set of identified cases in Europe.

7.2 Analytical insights

Most of the AR/VR application (23 cases in total) are within **education and recreation, culture, and religion functions of government** (Figure 29). In the case of education and recreation, VR/AR technologies are used and piloted to improve the user experience in formation courses or to enhance visitors' experience in public museums. The application of AR/VR within the healthcare sector is also relevant, with piloting of solutions that enhance the efficiency and effectiveness of health services for patients through those technologies like for example in Denmark, in Viborg Municipality,[28] VR glasses have been tested in connection with the treatment of wounds in home care and rehabilitation caring.

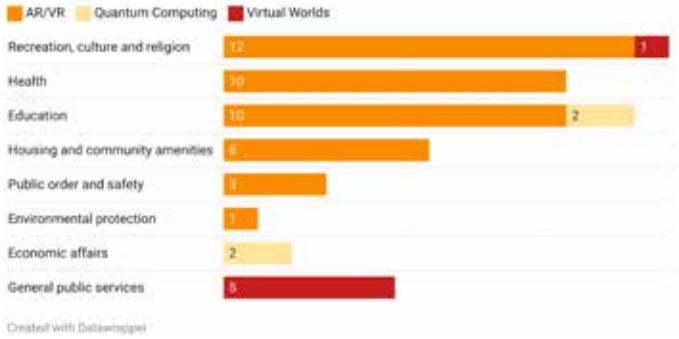

Figure 29 Distribution of cases of other emerging technologies across functions of government

Service personalisation, engagement management and service integration are the most numerous application types among these new emerging technologies and concern the majority of G2C services.

As shown in Figure 30 below, the distribution of cases of other emerging technologies by type of service and level of administration **is strongly skewed towards local administrations and G2C services**. There are nonetheless some variations depending on the type of technology. Moreover, VR/AR-based cases are more prevalent at the local level, as they are often used to enhance the user experience and accessibility of existing services, such as tourism, education, cultural services, or health. Similarly, Virtual Worlds are more common at the local level, as they can create immersive and interactive environments for citizens and businesses, such as virtual town halls, museums, or markets.

Quantum computing is mostly concentrated at the national level, as it requires large-scale investments and infrastructures, as well as advanced research and development capabilities. Quantum computing is mainly used for R&D and scientific purposes, such as cryptography, simulation, or optimisation.

These findings suggest that the analysed emerging technologies **have different potential applications according to the opportunities and challenges they pose for public sector innovation,** depending on the level of administration and the type of service they aim to improve. Their development is still novel and requires continue future monitoring and study of their diffusion across European public administrations. The Public Sector Tech Watch therefore aims at keeping constantly updated the taxonomy and to identify new emerging technologies that might be relevant for public administrations.

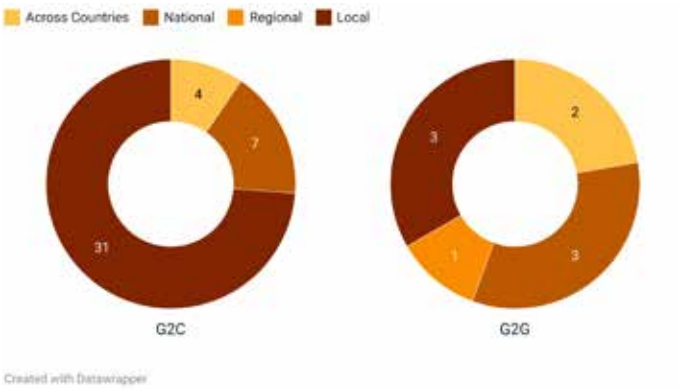

Figure 30 Cases of emerging technologies by type of service and level of administration

28 https://viborg.dk/demokrati-og-indflydelse/udvikling-og-planer/udvikling/vi-udvikler-velfaerden/velfaerdsteknologi-og-digitalisering/projekter/vr-briller-i-saarsygeplejen/

8 Recommendations

Based on the afore-presented analysis and the main findings of this study, a series of recommendations are presented. The recommendations are conceived as actionable steps to inform both policy and research efforts, aiming at promoting the inclusive, sustainable, responsible, and trustworthy adoption of emerging technologies within the European public sector.

1

Public administrations should actively develop mechanisms for ongoing knowledge sharing, adopt open-source solutions, establish shared repositories, and leverage EU-supported infrastructures. These actions should aim to boost interoperability, replicability, and reusability across various platforms and services. Cross border cases in the database are still very limited. Moreover, the prevalence of cross-border cases in their pilot phase, at 79%, suggests that the current level of interoperable services is modest. In this scenario, emphasising reusable solutions can expedite the progress towards interoperability and enhance the scalability of successful projects. The diversity in governmental functions, administrative levels, and applications across Europe underscores the need to craft solutions that are readily adaptable and reusable in various settings. For instance, at the national level, central administrations have the opportunity to drive innovation at local and regional tiers by offering reusable solutions, disseminating best practices and tools that have already been implemented, and aiding in their integration at subordinate levels of government. Additionally, public administrations are prompted to make full use of EU-backed infrastructures, such as the European Blockchain Services Infrastructure (EBSI), as well as available funding opportunities and cooperative platforms. This active engagement can help to surmount technical and financial hurdles, facilitating the development and adoption of interoperable and reusable solutions across Europe. The PSTW initiative will further bolster this exchange of knowledge by continuing fostering an active community of practice. This community will engage in webinars, discussions, and collaborative experimentation to share insights and experiences.

2

Public administrations should assess the 'implementability' of the projects at the early stages of the experimentation process, to decrease the likelihood of discontinuing pilot initiatives. The analysis indicates that solutions involving emerging technologies are frequently in the pilot stage across different government levels - 40% at the local, 41% at the regional, and 43% at the national levels. To improve project outcomes, public administrations should enhance their capabilities to ensure the effective implementation of projects, extending beyond the preliminary pilot stages and towards full-scale deployment. This enhancement involves capturing and sharing knowledge from past projects and quickly identifying both the drivers and barriers to scaling up. Assessing 'implementability' should cover several key areas, including scalability potential, alignment with the current legal framework, economic viability, and resource availability for future deployment. Furthermore, creating a clear roadmap that encompasses risk and impact evaluations is crucial for guiding projects through to successful implementation.

3

Public administrations should actively engage in experimenting with AR/VR, and Virtual Worlds technologies to gain insights into their advantages. This exploration could lead to enhancements in public service delivery and citizen engagement, particularly within sectors such as education, culture, healthcare, and tourism. The research reveals that the majority of AR/VR and Virtual Worlds applications are designed to enhance Government-to-Citizen (G2C) interactions, predominantly at the local level. These technologies are often employed to improve the accessibility and user experience of existing services. Applications tend to focus on personalising services, managing engagement, and integrating services, demonstrating their capacity to enrich citizen experiences and streamline service delivery. Furthermore, the data suggests that AR/VR technologies are reaching full implementation at a higher frequency than Virtual Worlds, which could indicate that AR/VR is on a faster track to becoming a standard tool within the public sector. To capitalize on the potential of these technologies, it is crucial for public administrations to continue their exploration and experimentation. This should be supported by forming partnerships, securing funding, and investing in capacity-building initiatives. Such efforts are likely to lead to innovative applications that not only enhance the quality of citizen interactions and participation but also improve overall service delivery in the public sector.

4

Public administrations should actively promote ongoing research, knowledge acquisition, and increased awareness regarding the adoption of novel AI technologies, such as Generative AI and General Purpose AI, within the public sector. The predominance of AI initiatives, particularly those involving Generative AI, in the pilot phase signals a clear need for more research and a better grasp of the ethical implications these technologies carry. There is a critical requirement to accumulate further knowledge on emerging practices, as well as the testing and deployment processes. Data analysis from the PSTW has identified a swift rise in Generative AI applications, with 23 new cases documented. Public administrations are not only piloting this kind of technical solutions, but public servants are also increasingly using third parties' online services. This trend suggests a growing movement towards the adoption of Generative AI within European public administrations. With this incremental use comes the necessity for proactive research to deepen the understanding of Generative AI's capabilities and to confront the ethical issues it presents. Such research will play a pivotal role in guiding responsible implementation and ensuring that the deployment of these technologies aligns with the core values and regulations of the public sector.

5

Public administrations should have the necessary knowledge and tools to evaluate the risks and impacts of their AI solutions, and should transparently share these evaluations with the public. As the reliance on AI systems grows, public administrations are increasingly expected to perform thorough risk assessments, particularly for high-risk systems, to identify and understand the potential dangers these technologies may pose. Furthermore, there is an anticipated need for clear and transparent communication with citizens and civil society about the outcomes of these evaluations. The AI Act mandates such measures, underscoring that the necessity for these actions will intensify shortly. Consequently, accumulating knowledge on best practices, tools, and insights on AI Act compliance will become crucial. This knowledge base will aid public administrations in grasping, disseminating, and enacting AI solutions that are both compliant with regulations and worthy of public trust.

6

Public administrations should actively seek out and integrate innovations by collaborating with SMEs and startups. To achieve this, they should invest in mapping and comprehending the GovTech ecosystem, pinpointing good practices and successful cases to guide their approach. The current lack of comprehensive quantitative data hampers a full evaluation of the contribution that European SMEs and startups make to the adoption of emerging technologies in Europe. Consequently, there is a pressing need for detailed measurement and analysis of the GovTech ecosystem's role and impact on the public sector. Additionally, the dissemination of best practices, success stories, and effective collaboration models is essential to facilitate a learning environment among public administrations. The absence of structured and extensive datasets further complicates efforts to examine this dynamic at a European scale. To address these challenges, the establishment of systematic data collection is crucial. This will enhance our understanding of prevalent collaboration patterns between public administrations, the GovTech community, and the public procurement processes involved.

9 Conclusion

This report has provided an overview of the **adoption of emerging technologies within the European public sector.** In total, 1,617 cases have been analysed to understand how AI, Blockchain, and other technologies such as VR/AR, Virtual Worlds, and quantum computing, are being adopted by European public administrations to enhance public services and streamline administrative processes. The analysis of these cases has provided valuable insights into the current state and the predominant trends of technological adoption in the European public sector. It also **highlighted the diversity of applications and sectors of government in which emerging technologies are increasingly being piloted, implemented, and scaled in the public sector.** Key insights include the differentiated application across administrative levels. In effect, local administrations are more experienced in utilising emerging technologies for enhancing user experiences in services like tourism, education, and health, while national administrations are better positioned to handle large-scale investments required for technologies like quantum computing.

Other findings describe the way in which the different types of technologies are applied. While AI and Blockchain technologies continue to be the most diffused technologies within the European public sector, demonstrating their potential for wide-ranging applications, other emerging technologies like VR/AR, Virtual Worlds, and quantum computing are increasingly being tested, particularly identifying specific sectors and use cases. On the one hand, **AI is being used to improve a wide range of public services, from healthcare and education to transportation and environmental protection.** Notably, the emergence of Generative AI is highlighted, with cases that show its potential to automate administrative procedures and content creation and public services' personalisation. On the other hand, **Blockchain technology is predominantly utilised in the areas of education, economic affairs, and general public services.** Its applications predominantly focus on certification and validation processes, payments and transactions, data sharing, and the tracking of goods and assets. The report emphasises also the cross-border and cross-sectoral nature of many studied Blockchain solutions, highlighting their potential to foster interoperability and collaboration across different levels of government and sectors.

Additionally, **the analysis made begin to illustrate some early adoption of other emerging technologies in specific sectors,** such as education, recreation, culture, and healthcare. VR/AR applications are primarily concentrated at the local level, enhancing user experiences and accessibility of services. Virtual Worlds are also being tested in local administrations, while quantum computing is mainly explored at the national level for research and development purposes.

This report aims **to serve as a tool to build collective knowledge on the status, challenges, and opportunities associated with the adoption of emerging technologies across the European public sector,** as well as seeking to provide high-quality evidence to inform policymaking at the EU, national and local levels. From this perspective, the analysis emphasises the critical role of EU-level policies in standardising and promoting the adoption of emerging technologies across different levels of administration, which is expected to continue at the same – if not higher – rate of adoption. In addition, several actionable policy recommendations for fostering the inclusive, sustainable, and trustworthy adoption of emerging technologies were presented to contribute to facilitate the widespread and effective use of these technologies by promoting reusable solutions, ensuring the scalability of pilot projects, supporting cross-border collaboration, leveraging EU policy instruments and infrastructure, and emphasising continuous research and knowledge building, identifying potential areas for further research.

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