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D06.02 In-depth report of organisational and cultural interoperability issues and practices in place within public administrations related to the four use cases

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Abstract

This report aims at identifying the main organisational and cultural interoperability challenges faced by local and regional public administrations when implementing local digital twins and data space projects. Following a literature review, the analysis of four use cases, and the collection of primary data, the report provides an overview of the EU legislative and policy framework supporting the emergence of data spaces and digital twin projects and the role of interoperability as a key enabler for the development of a data-driven society. The report then identifies a series of organisational and cultural interoperability challenges, including the insufficiency of common rules and processes, the need for a clearer governance framework, the lack of trust on data sharing and innovation culture, the deficit of awareness on the benefits of local digital twins and data spaces, and the scarcity of digital skills.

Executive summary

In the recent years, the number of **smart city initiatives** has increased significantly in Europe, with the main objective of enabling local, regional, and national public administrations to **leverage data and innovative technologies** to **improve decision-making** and **citizens' well-being**. As part of these initiatives, the establishment of **data spaces** and **local digital twins** appears to be particularly promising. While on one hand, developing these projects could bring many benefits; on the other hand, public administrations can also face various **challenges,** including the implementation **of interoperability principles**. To better ascertain these interoperability challenges, the report aims to identify and present the main **organisational and cultural interoperability challenges** arising when public administrations are establishing local and regional data spaces and local digital twins.

Local digital twin and data space projects usually involve **multiple stakeholders** (i.e., government, citizens, academia, non-profits, and businesses). Solid coordination and governance mechanisms are essential and, if not properly managed, can hinder the collaboration among stakeholders and the overall success of the project. Following a triangulated analysis of organisational aspects, **organisational interoperability challenges** were classified into three main clusters. The first challenge is the **lack of definition of leadership responsibilities and common processes**, which also encompasses the need to define a strong data management strategy. The second challenge relates to the **absence of common objectives** (e.g., insufficient problem definition, need to align with political strategies, need to ensure citizen-centricity and citizen participation). Lastly, the third challenge refers to the **impacts of organisational interoperability challenges on technical interoperability**.

With regard to **cultural interoperability**, this study revealed that local and regional authorities face four main challenges when implementing local digital twins and data spaces. The first challenge covers the **paradigm shift on data sharing and innovation** among participating organisations to avoid data silos. The second challenge is the **lack of trust among stakeholders** on data sharing and common objectives. The third challenge is linked to the **deficit of awareness on the benefits of smart city initiatives**, encompassing the difficulty to identify and measure these benefits. Finally, the last cultural interoperability challenge identified by this study refers to the lack of human resources and **digital skills and digital literacy,** creating a mismatch between skills needed to launch local digital twins and data spaces and the existing human resources within the public sector.

Introduction

The outbreak of the COVID-19 pandemic in early 2020 accelerated Europe's digital transformation process. The unprecedent health crisis required the enforcement all over Europe of stringent governmental measures on civil society such as lockdowns, curfews, and stay-at-home orders. This led to a strong reliance on digital tools, for instance to ensure the delivery of public services, as well as the continuation of business activities both within the private and the public sector, emphasising once more the need for interoperable IT infrastructures and digital solutions.

Through various policy and funding instruments such as, among others, the Digital Decade Policy Programme 2030 and the Digital Europe Programme, the EU is supporting the **digital transformation of cities and communities** to fully leverage the benefits digital tools can bring to our society and in turn tackle local challenges.[1] A so-called smart city aims at the well-being of its citizens through digitally enabled services that contribute to a better quality of life. To improve how the city works, such services anchor technology that collects data and use this data to take better informed decisions.[2]

This goes beyond an improved management of local resources, such as water or energy, and translates into several initiatives, for instance to improve road capacity, reduce the impact on the environment, as well as have a more responsive administration. In particular, the **developments of data spaces** can enable local authorities (cities, regions) to reap the benefits of the digital transformation and leverage the full potential of data. Data spaces are shared digital tools and infrastructures aiming at overcoming legal and technical barriers to data sharing and addressing issues of trust by way of common rules. Data space brings together relevant data infrastructures and governance frameworks to facilitate data pooling and sharing.[3] Other initiatives to embrace the potential of a data-driven society include the development of **local digital twins**, i.e., a virtual representation of a local authority physical assets, using data, data analytics and machine learning to help simulation models that can be updated and changed in real-time as their physical equivalents change.[4]

As part of the Digital Europe Programme[5], the European Commission's National Interoperability Framework Observatory[6] (NIFO) supports EU public administrations' interoperability activities and the development of digital public services. NIFO provides studies to understand how technologies and interoperability enhance the digital transformation of EU public administrations and share best practices. This report is part of an ongoing *study on organisational interoperability issues arising in local administrations when establishing local, regional, or national data spaces or local digital twins*. In a context in which accessing, managing, sharing, and using data is often still a challenge within many EU public administrations, the study focuses on the implementation of data spaces and local digital twins at local and regional level, which are key assets for the appropriate management and use of data in the context of smart city initiatives. Building upon an

[1] An overview of the EU policy and legislative framework supporting the development of smart cities is available in section 2.1.
[2] Ramaprasad, A., Sánchez-Ortiz, A., & Syn, T. (2017). A unified definition of a smart city. In Electronic Government: 16th IFIP WG 8.5 International Conference, EGOV 2017, St. Petersburg, Russia, September 4-7, 2017, Proceedings 16 (pp. 13-24). Springer International Publishing.
[3] European Commission, Commission staff working document on Common European Data Spaces, Publications Office, 2022, SWD(2022) 45 Final
[4] https://living-in.eu/
[5] European Commission, Directorate-General for Communications Networks, Content and Technology, ANNEX to the Commission Implementing Decision on the financing of the Digital Europe Programme and the adoption of the multiannual work programme for 2021 - 2022, Publications Office, 2021, C(2021) 7914 final.
[6] https://joinup.ec.europa.eu/collection/nifo-national-interoperability-framework-observatory

internal report[7] which identified four use cases, the present one investigates the **organisational and cultural interoperability challenges** posed to local and regional administrations in implementing data spaces and local digital twins, as well as governance practices and interoperability issues when relevant. For this reason, the scope of this report is to provide an analysis of these topics in relation to organisational and cultural interoperability. The analysis will serve as a basis for the development of a guidance document on the roles and responsibilities of each type of stakeholder (e.g., public administrations, academia, private companies) for the setup of data spaces and local digital twins.

Among the seven interoperability elements identified in the European Interoperability Framework for Smart Cities and Communities' (EIF4SCC) interoperability model[8], organisational and cultural interoperability appear as the most understudied ones, with an apparent lack of literature on these topics and the challenges they may pose to the establishment of data spaces and local digital twins. This can partially be explained because these two elements go beyond classic ICT matters, and include a human-centred and social dimension, which can echo deeper challenges faced by the public administrations in relation to new working methods and the digitalisation of public administrations.

Organisational interoperability refers to the way in which public administrations align their business processes, responsibilities and expectations to achieve commonly agreed and mutually beneficial goals, while keeping users in focus[9]. Organisational interoperability entails documenting, integrating or aligning processes and exchanging relevant information. It also aims to meet the needs of the users by making services available, easily identifiable, accessible and user focused. Furthermore, active involvement of the user community can also be part of the organisational interoperability element[10].

Cultural interoperability refers to the approach taken by individuals and organisations to take into consideration their social and cultural differences and, if applicable, any organisational cultural difference. Interoperability can be impacted by cultural differences, as individuals and organisations can respond differently to the same interoperability challenge. These cultural differences can, for example, be reflected in approaches and trust regarding data sharing, political challenges, and leadership styles. Different actors within a smart city can have varying views on how leadership, in the context of interoperability, is exercised. This requires a debate among the actors involved about how to exercise leadership in their interoperability context[11].

This report articulates as follows:

- Chapter 1 (Methodology) presents the methodology used to conduct the study, including selection criteria applied for the identification of the four uses cases analysed in the context of the study.
- Chapter 2 (Context and background) presents the context of the study with regard to data spaces, digital twins, and interoperability.
- Chapter 3 (Organisational interoperability challenges) provides the findings on organisational interoperability challenges faced by public administration upon implementing local digital twins and smart data spaces.

[7] The present report builds on the findings of the Report on the process of identification and selection of the two use cases on data spaces between cities or at local, regional or national level and two local digital twins use cases.
[8] Legal interoperability, semantic interoperability, organisational interoperability, technical interoperability, cultural interoperability, integrated service governance and interoperability governance.
[9] European Commission, New European Interoperability Framework – promoting seamless services and data flows for European public administrations, Publications Office of the European Union,2017, DOI: 10.2799/78681
[10] Proposal for a European Interoperability Framework for Smart Cities and Communities (EIF4SCC).
[11] Ibid.

- Chapter 4 (Cultural interoperability challenges) provides the findings on cultural interoperability challenges faced by public administration upon implementing local digital twins and smart data spaces.
- Chapter 5 (Conclusion) details the conclusions of the study.

1 Methodology

The main objective of this section is to describe the methodological approach adopted to elaborate this report, building upon the work conducted for the drafting of the *In-depth report of organisational and cultural interoperability issues and practices in place within public administrations related to the four use cases* (D06.02). The methodological steps to do so comprised three main steps:

- **Building upon previous findings**: the Project Team built upon the findings of the *Report on the process of identification and selection of the two use cases on data spaces between cities or at local, regional or national level and two local digital twins use cases* (D06.01) which identified four use cases to be analysed to gather insights on cultural and organisational interoperability challenges.
- **Data collection:** information was collected using qualitative research methods and leveraging primary data sources (i.e., interviews, focus group).
- **Data analysis and synthesis**: the data and information gathered was then analysed to identify the most relevant insights, and draw conclusions on existing knowledge gaps, topics that could offer valuable insights. On this basis, the Project Team was able to synthesise the most relevant insights and draw conclusions on the relevant organisational and cultural interoperability challenges regarding the implementation of local digital twins and data spaces by local authorities.

1.1 Analysis of four use cases

Based on eligibility and selection criteria, i.e. geographical coverage, digital maturity, political commitment of the local authority to become a smart city, stakeholder engagement, uptake of the Minimal Interoperability Mechanims (MIMs), a series of four use cases have been identified for the selection of use cases by the *Report on the process of identification and selection of the two use cases on data spaces between cities or at local, regional or national level and two local digital twins use cases* (D06.01). Eligibility and selection criteria ensured the representativeness of the use cases. The four uses cases selected include namely:

Data spaces:

- Flanders Smart Data Space[12] (Flanders Region, Belgium): Digital Flanders created the Flemish Smart Data Space in 2021 to ensure the sustainable publication and consultation of sensor data and their context information. The Flemish Smart Data Space is a project designed to connect data silos. Currently focused on smart mobility, Digital Flanders has the ambition to extend the data space to other domains such as water management and healthcare[13].
- Amsterdam Data Exchange[14] (City of Amsterdam, the Netherlands): the Amsterdam Data Exchange, or AMdEX, focuses on the co-design and co-development of a neutral and independent infrastructure for trusted data sharing, which will serve as a mechanism to facilitate local, European, and international cooperation in a transparent open data market.

[12] https://beslissingenvlaamseregering.vlaanderen.be/document-view/61653E6F364ED9000900045A
[13] More info on the Flanders Smart Data Space is available here (in Dutch).
[14] https://amsterdamsmartcity.com/updates/project/amsterdam-data-exchange-amdex

Local Digital Twins:

- Helsinki's Digital Twin[15] (City of Helsinki, Finland): created in 2015, 3D+ is one of the world's longest-running digital twin programmes. Helsinki executed its first urban digital twin pilot project in the Kalasatama district (2018-2019), with the aim to observe how changing weather conditions impacted the district and its environment over time and help the city meet its net-zero carbon goals by 2035. Lessons from Kalasatama will next be applied in the districts of Pasila, Malmi, and Kannelmäki.
- Valencia's Digital Twin[16] (City of Valencia, Spain): the GoAigua Digital Twin, developed by Idrica and Global Omnium in collaboration with the city of Valencia, supports operational and management decisions across Valencia's metropolitan water networks. The local digital twin constantly leverages data from smart meters, pressure/flow sensors, and other systems to virtually replicate the behaviour of the network in real-time, with high accuracy.

The selection of use cases allowed for the in-depth analysis of the implementation of smart city initiatives. Use cases enable the collection of precise and detailed data on the process of setting up a smart city initiative, the role of the EU and national legislative and policy frameworks, the relevance of the MIMs, and the organisational and cultural interoperability challenges that local or regional administrations might encounter. Due to the diversity of use cases in terms of scales (three cities, one region) and type of initiatives (e.g., mobility, water management, energy consumption), as well as their extensive experience in the topic (more than five years of smart city projects), this set of use cases can be considered as representative of data spaces and local digital twins initiatives in the EU.

1.2 Data collection

Building upon the desk research[17] conducted for the elaboration of the *Report on the process of identification and selection of the two use cases on data spaces between cities or at local, regional or national level and two local digital twins use cases* (D06.01), the literature review was complemented by the analysis of the documents shared by interviewees and the study's expert panel. The objective was to bridge potential gaps in the collection of information on current trends and factors impacting the implementation of local digital twins and data spaces by local authorities. To this end, a total number of 89 documents have been analysed to complete the findings on the current state-of-the art on the topic, including local authorities' documentation and academic documentation[18].

In parallel, the Project Team leveraged primary data. Consultations in the form of 14 in-depth interviews were conducted with relevant stakeholders within the use cases identified[19]. Interviewees represented various public and private sector organisations involved in the implementation of local digital twins and data spaces, namely Digital Flanders, the Flanders Environmental Agency, the Amsterdam Economic Board, Forum Virium Helsinki, the municipality of Helsinki, the municipality of Valencia, the Polytechnic University of Valencia, Arqueha, Ontola, and Marineterrein.

[15] https://www.hel.fi/helsinki/en/administration/information/general/3d/3d
[16] https://www.idrica.com/goaigua/
[17] Using key words such as "smart city", "data space", "local digital twins", "organisational interoperability", "cultural interoperability", "smart city model", "smart city processes", "smart city evaluation" and "digitalisation of municipalities".
[18] The complete list of resources used for the desk research can be found in **Error! Reference source not found.**.
[19] The list of interviewees can be found in **Error! Reference source not found.**.

An interview guide was developed to structure the interviews covering different domains such as the national legal and policy framework, the process of the implementation of smart city initiatives, the key benefits from setting up data spaces and developing interconnected local digital twins, the main organisational and cultural interoperability challenges, and the extent to which Minimal Interoperability Mechanisms (MIMs) could enhance the development of data spaces and local digital twins in Europe.

A focus group was organised to validate the findings collected through use case interviews, elaborate on the identified organisational and cultural interoperability challenges, and prioritise the challenges. The focus group was attended by 13 representatives of the use cases[20].

Drawing on the insights gathered through the previous report, the Project Team was not only able to tailor the consultation activities to better contextualise the topic of research but also to further investigate and expand the operational and cultural interoperability challenges encountered in the four use cases.

1.3 Data analysis and synthesis

At the end of the consultation process, the answers to the questions posed during the interviews were coded and clustered to identify recurrent challenges and topics, as well as to allow for further analysis. The conduction of the focus group allowed for the validation of the findings and their ranking per order of importance. The findings from the consultations were analysed in an aggregated manner and contextualised with the findings presented in the above-mentioned D06.01 report.

Once the specific data analysis was carried out, the Project Team analysed the interconnection of the answers throughout the corpus of texts and the use cases, analysing trends on the process to setup local digital twins and data space projects and findings on organisational and cultural interoperability challenges.

[20] The list of organisations that participated in the focus group can be found in **Error! Reference source not found.**.

2 Context and background

This section presents the context and background of the study, in particular the EU legislative and policy framework supporting the emergence of smart city initiatives, the uptake of data spaces and digital twin projects, and the role of interoperability as a key enabler for the development of a data-driven society.

2.1 EU legislative and policy framework supporting the emergence of a data-driven society

Europe aims at being a front-runner with regard to digital transformation and the uptake of a data-driven society. This is enabled by a policy and legislative framework at EU level that promotes the development of innovative and interoperable technologies, data-sharing, and the inclusion of local authorities in the digital transformation process.

2.1.1 Driving Europe's digital transformation

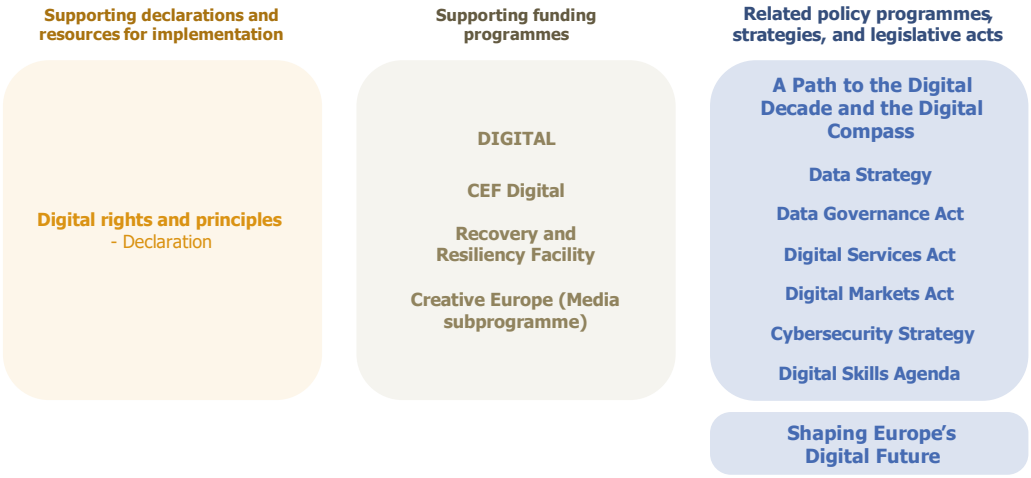
Digital transformation has been a priority for the European Union (EU) over the last decade, with the adoption in 2010 of a 10-year Digital Agenda for Europe[21], which identified for the first time the key enabling role of ICTs in reaching Europe's economic and social goals. In 2020, a second five-year digital strategy – Shaping Europe's digital future[22] – was adopted, recognising how profoundly digital technologies are changing our lives and setting three main objectives until 2025:

1. technology that works for people,
2. a fair and competitive economy,
3. an open, democratic and sustainable society.

The strategy acknowledges the need for Europe to invest more in the strategic digital capacities enabling the development of interoperable solutions, in particular regarding key infrastructures (e.g., 5G network). It was complemented by policy programmes and policy reforms, funding mechanisms and supporting declarations and resources ensuring the coherence of EU action in this field. **Error! Reference source not found.** below presents the interconnection between the Shaping Europe's Digital Future strategy and its supporting legislative initiatives, policy documents, funding programmes, and declarations.

[21] Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, A Digital Agenda for Europe, COM(2010)245 final.
[22] Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, Shaping Europe's Digital Future, COM(2020) 67 final.

Figure 1 Interconnections between policy and funding programmes



Source: Wavestone's own elaboration

The European Union multiannual financial framework (MFF) provides the Union with the financial means to fulfil its objectives. In particular, the Digital Europe Programme[23] is a funding programme dedicated to bringing digital technology to businesses, citizens and public administrations. With a total planned overall budget of EUR 7,5 billion (in current prices) for the period 2021 to 2027, the programme objectives are to support the digital transformation of the economy, industry, society, public administrations and businesses as well as to bring benefits to citizens in Europe. The programme supports projects in five key capacity areas: supercomputing, artificial intelligence, cybersecurity, advanced digital skills, and digital technologies across the economy and society. The objective 2 of the programme (artificial intelligence) includes the creation of common European data spaces that make accessible data across Europe, including information gathered from the re-use of public sector information, and become a data input source for AI solutions.

This set of policy objectives and funding programmes have been developed in accordance with EU values and ethical principles for human-centric algorithms, which are promoted in the proposal for a Declaration on Digital Rights and Principles for the Digital Decade[24]. Published by the European Commission in January 2022, the proposed Declaration stresses the importance of digital public services online, stating that everyone shall have access to them across the Union and that nobody shall be asked to provide data more often than necessary when accessing and using digital public services. In this context, EU institutions shall commit to ensuring that all Europeans are offered an accessible, secure and trusted digital identity that gives access to a broad range of online services guaranteeing wide accessibility and re-use of government information, facilitating and supporting seamless, secure and interoperable access across the Union to digital health and care services, including health records, designed to meet people's needs. Moreover, the proposed Declaration underlines how safety and security of the online environment represent pivotal cornerstones for digitalisation.

[23] https://digital-strategy.ec.europa.eu/en/activities/digital-programme
[24] Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions "Establishing a European Declaration on Digital rights and principles for the Digital Decade". COM(2022) 27 final.

2.1.2 Ensuring Europe's readiness for a data-driven society

The Union's Data Strategy[25] aims at creating a single market for data that will ensure Europe's global competitiveness and data sovereignty. In other words, common European data spaces will ensure that more data becomes available for use in the economy and society, while keeping the companies and individuals who generate the data in control. As part of its data strategy, the Commission has proposed a Regulation on European data governance (Data Governance Act[26]) which foresees a vital role in ensuring the EU's leadership in the global data economy by creating "data intermediaries", which will handle the sharing of data by individuals, public bodies and private companies. In addition, the Commission also proposed a Regulation on harmonised rules on fair access to and use of data (Data Act[27]) to ensure fairness in the digital environment, stimulate a competitive data market, open opportunities for data-driven innovation and make data more accessible for all.

As interoperability is detrimental to the emergence of a data-driven society in Europe, the reinforcement of interoperability between EU Member States and the coordination and common standards for secure and borderless public sector data flows and services are a priority for the Commission.

This is the objective pursued with the publication in November 2022 of the Interoperable Europe Act proposal[28]. The Act proposes to introduce a cooperation framework for EU public administrations with the following pillars:

- an Interoperable Europe Board - that is co-owned by the Member States and the EU and supported by public and private actors – for the development of a common strategic agenda for cross-border interoperability, the support in implementing interoperability solutions, and progress monitoring;
- mandatory interoperability assessments to evaluate the impact of changes in IT systems related to cross-border interoperability in the EU;
- an 'Interoperable Europe Portal' as a community platform and one-stop-shop for shared and reusable interoperability solutions;
- innovation and support measures, including regulatory sandboxes and GovTech cooperation, to promote policy experimentation, developing skills and the scaling up of interoperability solutions for reuse.

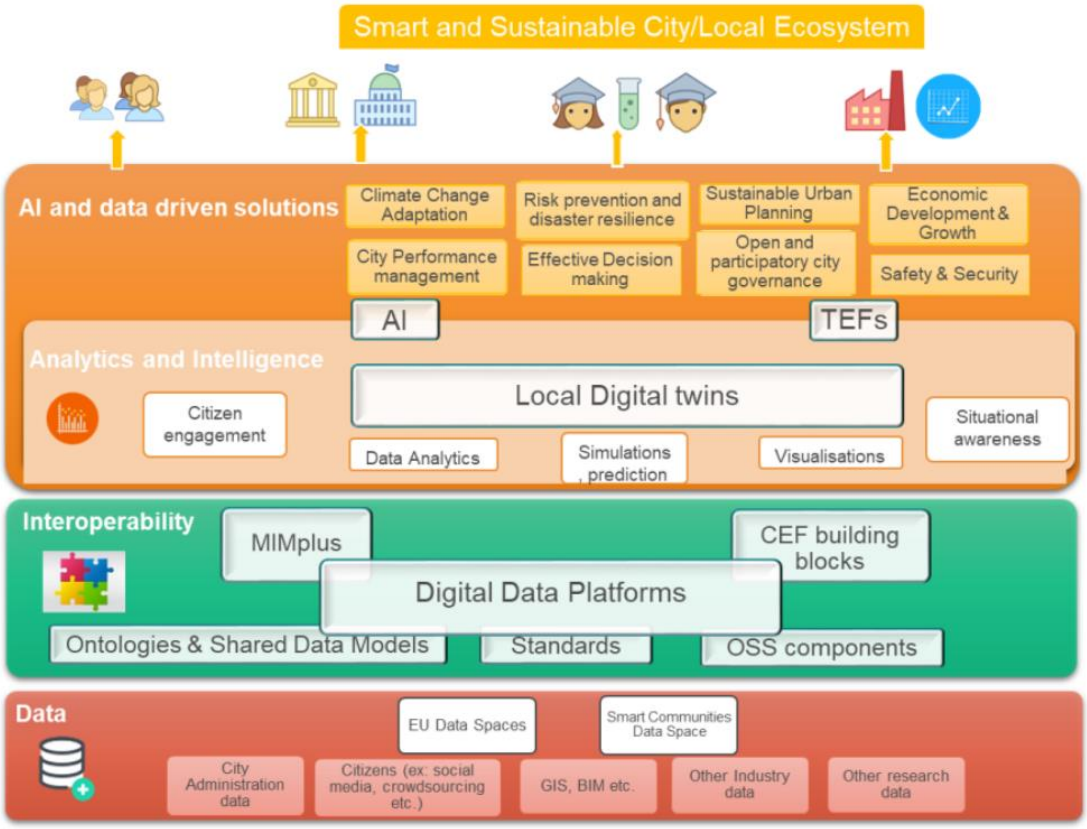
2.2 The development of smart city initiatives in the EU

In complementarity with the objectives of the abovementioned legislative and policy framework, the EU is supporting the digital transformation of cities and communities to fully leverage the benefits digital tools can bring to our society and in turn tackle local challenges. The financial support of the EU, including through the Digital Europe Programme, supported the development of smart city initiatives, including local data spaces and digital twins, considered as key components of smart and sustainable local ecosystem (cf. Figure 2). In parallel to the development of these initiatives, local authorities collaborated to exchange good

[25] Communication from the Commission to the European Parliament, the Council, the European Economic And Social Committee and the Committee of the Regions "A European Strategy for Data". COM (2022) 66 final.
[26] Proposal for a Regulation of the European Parliament and the Council on European data governance (Data Governance Act). COM (2020) 767 final, 2020/0340 (COD).
[27] Proposal for a Regulation of the European Parliament and of the Council on harmonised rules on fair access to and use of data (Data Act), COM/2022/68 final.
[28] European Commission, Proposal for a Regulation of the European Parliament and of the Council laying down measures for a high level of public sector interoperability across the Union (Interoperable Europe Act), 2022/0379 (COD).

practices and foster cross-border cooperation. One of the examples of such collaboration is the Living-in.eu movement, established in 2019 by a group of cities' networks and other city representation groups (such as Open and Agile Smart Cities (OASC), Eurocities and European Network of Living Labs (ENoLL). Living-in.eu is supporting cities and communities to accelerate their digital transformation, guided by the European Declaration on Digital Rights and Principles[29].

Figure 2 Smart and Sustainable local ecosystem



Source: Local Digital Twins, presentation of Andrea Halmos (European Commission, DG CNECT) during the CxC Festival (11/01/2022)

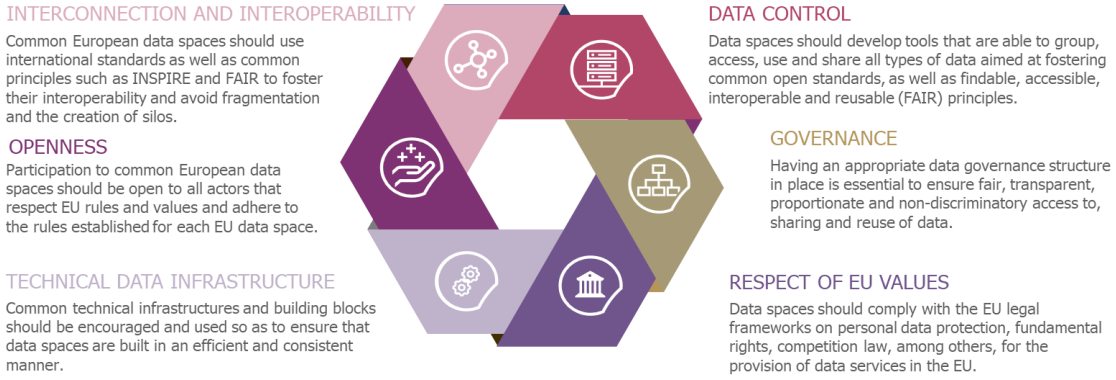
2.2.1 Data spaces

Data spaces aim to foster an ecosystem of companies, civil society and individuals creating new products and services based on more accessible data. These data spaces are meant to overcome legal and technical barriers to data sharing across organisations, by using the necessary tools and infrastructure (such as data sharing platforms), by creating data governance frameworks and improving the availability, quality and interoperability of data. Indeed, as mentioned in the Commission's Staff Working document on Data

[29] European Commission, Declaration for Digital Rights and Principles, Publication Office of the European Union, 2022.

Spaces[30], data spaces put in place by smart communities in Europe and Common European data spaces should be guided by the same design principles detailed in **Error! Reference source not found.**3 below.

Figure 3 Design principles of data spaces



Source: Wavestone's own elaboration on the basis of the Commission's Staff Working document on Data Spaces

These principles are aligned with the ones put forward by the EU-funded project Open DEI. As mentioned above, the design and implementation of data spaces requires a number of building blocks, which are common to all data spaces. Open DEI recommends distinguishing these building blocks into two distinct categories: the technical building blocks, which enable the implementation of the technical architecture of a data space, and the governance building blocks, which are necessary for the establishment of some guiding principles when creating data spaces. The three main technical building blocks necessary for the creation of data spaces are:

- data interoperability, which covers essential features such as data exchange APIs, as well as data origin and traceability;
- data sovereignty, which covers elements such as identity management, data access and usage control;
- data value creation, which covers aspects such as publication of data.

While the main governance building blocks for the creation of data spaces, are:

- business agreements, encompass service level agreements, data usage and access control policies, among others. These agreements determine the terms and conditions that regulate the sharing and exchange of data within data spaces;
- operational agreements are the regulatory policies that need to be enforced during data space operation (e.g., terms and conditions for the compliance with mandatory regulations such as the GDPR);
- organisational agreements are the terms and conditions on governance bodies and procedures for the establishment of the data spaces.

To support the development of data spaces across the EU, the Commission launched in October 2022 the Data SSpaces Support Centre (DSSC). The DSSC will facilitate the emergence of the European Common Data Spaces that collectively create an interoperable data sharing environment, to enable data reuse and

[30] Commission Staff Working Document on Common European Data Spaces, SWD(2022) 45 final.

secondary use within and across sectors, fully respecting EU values, and contributing to the European economy and society.

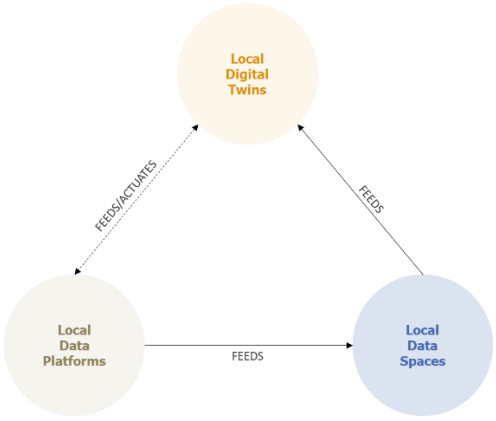
At local level, various data spaces have been developed to support the development of innovations. Most of the current applications of data spaces includes the creation of regional or local data spaces:

- focused on urban data, often linked to mobility or natural resources consumption;
- focused on personal data, with the creation of decentralised data stores based on the SOLID specification or other forms of human-centric use of personal data (MyData).

This non-exhaustive list of applications can be completed by the creation of data marketplaces, supporting data transactions between data providers and data users using transparent terms and/or contracts, and data platforms, supporting data sharing and exchange.

2.2.2 Local Digital Twins

Figure 4 Configuration of the emerging Smart City IT landscape



Source: Adapted from Gaia-X and European Smart Cities and Communities white paper[31]

In parallel to the development of data spaces, smart cities in Europe also started to create local digital twins as a mean to foster data sharing and make better use of their data to optimise the management of their city and the delivery of public services provided to citizens. Local Digital Twins (LDT) refer to virtual representations of a city's physical assets, using data, data analytics and machine learning to help simulation models that can be updated and changed (in real-time) as their physical equivalents change[32]. Based on the needs, challenges and specific characteristics of the cities implementing them, a wide variety of LDT can be found in Europe, focusing on different domains (from mobility, urban planning, air quality and energy or water consumption, to extreme weather prediction or crisis management) and established on different scales (local to regional).

When planning to create a local digital twin, cities should consider important aspects, such as its scope and scale, the main challenges to tackle, its governance model, functionalities, and technical specifications, as well as the integration of tools based on Internet-of-Things (IoT) technologies, cloud computing, big data, AI and other innovative technologies that can guide and improve data-driven decision-making. In addition to

[31] Gaia-X, Gaia-X and European Smart Cities and Communities white paper, Gaia-X website, 2021, available online: https://gaia-x.eu/wp-content/uploads/files/2021-10/Gaia-X%20SCC%20white%20paper.pdf
[32] European Commission, Local Digital Twins: Forging the Cities of Tomorrow, European Week of Regions and Cities, 2021.

this non-exhaustive list, cities should also take into account key aspects linked to data, which are common to both LDT and data spaces, such as data governance, data sharing, data quality and portability, interoperability and openness.

LDT can help its users (public servants, urban planners, services providers or citizens) to visualise processes and their interconnexions, as well as predict possible outcomes, find anomalies and their sources, and monitor the impact of decisions on a city ecosystem, using simulations. For this reason, there can be many benefits of implementing LDT for cities: decreasing operating costs, increasing efficiency, productivity and local/regional economic development, as well as improving citizens' participation (and participatory governance)[33]. From the environmental perspective, LDT can increase sustainability, reduce emissions and promote the creation of greener, liveable public spaces[34].

With the increasing number of smart city initiatives developed in recent years, there has also been a growing need of connecting these cities and regions' digital ecosystems. This called for the development and use of interconnected local digital twins. At European level, the European Commission supports the creation of local digital twins through its Digital Europe Programme[35], as well as the creation of an European Local Digital Twin toolbox, including reusable tools, reference architectures, open standards and technical specifications for the development and deployment of local digital twins. The EU LDT toolbox, which is still at an early stage of development, will aim to ensure that a large number of EU cities and communities have the ability to benefit from this technology and enable a minimal level of interoperability between LDT for the common challenges faced by cities in Europe.

2.3 Interoperability, key enabler of a data-driven society

The European Commission published in 2022 a Commission Staff Working Document for a European Interoperability Framework for Smart Cities and Communities (EIF4SCC)[36], adapting the European Interoperability Framework (EIF) to the local level to create an appropriate interoperability framework and guide city leaders and officials to complement initiatives funded through the Digital Europe Programme (DEP) to support smart communities.

According to the Proposal for a European Interoperability Framework for Smart Cities and Communities (EIF4SCC)[37], interoperability could be defined in the context of smart cities and communities as "the ability of organisations and individuals to interact towards the delivery of services in cities and communities, through the exchange of data, information and knowledge, enabled by aligned processes and digital technologies, taking into account security and privacy issues". To ensure this, smart cities should define and implement a holistic governance of interoperability, including decisions on interoperability frameworks, institutional arrangements, organisational structures, roles and responsibilities, policies, agreements, and other aspects

[33] White G., Zink A., Codecá L., Clarke S., A digital twin smart city for citizen feedback, Cities, Volume 110, 2021, 103064, ISSN 0264-2751, https://doi.org/10.1016/j.cities.2020.103064.
[34] European Commission, Directorate-General for Communications Networks, Content and Technology, ANNEX to the Commission Implementing Decision on the financing of the Digital Europe Programme and the adoption of the multiannual work programme for 2021 - 2022, Publications Office, 2021, C(2021) 7914 final
[35] Official Journal of the European Union, Regulation (EU) 2021/694 of the European Parliament and of the Council of 29 April 2021 establishing the Digital Europe Programme and repealing Decision (EU) 2015/2240, PE/13/2021/INIT, OJ L 166, 11.5.2021, p. 1–34
[36] European Commission, 2022, Commission Staff working document for a European Interoperability Framework for Smart Cities and Communities (EIF4SCC), Publications Office of the European Union, https://commission.europa.eu/system/files/2022-11/other_staff_working_paper_en_v2_p1_2249550.pdf.
[37] European Commission, Directorate-General for Communications Networks, Content and Technology, Directorate-General for Informatics, Proposal for a European Interoperability Framework for Smart Cities and Communities (EIF4SCC), Publications Office of the European Union, 2021, https://data.europa.eu/doi/10.2799/816559.

with an eye to fostering and monitoring interoperability at local, national and EU level. This holistic governance encompasses all interoperability elements: cultural, legal, organisational, semantic, and technical interoperability. However, adopting and implementing an interoperable approach often still results in a significant challenge for cities and regions. This is due to several factors, ranging from high integration costs to legacy issues and the existence of silos even within the same administrations. The resulting lack of interoperability poses several barriers to the creation of smart cities, and this translates into missing integration of systems and services provided at local level and beyond and insufficient communication among different (data) platforms and technologies.

To address this issue and help cities overcome these difficulties and embark on the digital transformation path, work has been done to identify a minimal interoperability level, which could be implemented to provide a common technical ground that enables choice, flexibility, value for money and independence avoiding vendor lock-in. At present, several interoperability enablers can support local and regional authorities to develop smart city initiatives.

- The Minimal Interoperability Mechanisms: Adopted by the Open & Agile Smart Cities Council of Cities (OASC), the MIMs have been recognised in the domain of smart cities as a reference guide. The MIMs are a set of practical capabilities based on open technical specifications that allow cities and communities to replicate and scale solutions globally. They provide the technical basis for the procurement and distribution of urban data platforms and end-to-end solutions for smart cities. At present, OASC is developing 10 MIMs, of which the earliest ones (MIM1 - Context Information Management, MIM2 - Shared Data Models and MIM3 - Ecosystem Transaction Management) have already been successfully used for several years by smart cities and communities – mostly in the context of setting requirements for municipal public procurements.
- The INSPIRE Directive: The implementation of this Directive, which established rules for the spatial data infrastructure, makes this type of data more visible, sharable and interoperable, which can support the policies affecting local or regional environments, such as mobility, utility transport and agriculture.
- Connecting Europe Facility (CEF) building blocks: The CEF buildings blocks support the security, interoperability and compliance with the complex legislation of smart city projects. Based on open European standards and technical specifications, they support secure environments, where data is safely handled and stored, and offer free supporting services, allowing cities to save time and money in the implementation of complex digital projects. Regarding the implementation of data spaces and local digital twins, the Context Broker Building Block is particularly useful, as it helps cities to collect, manage and share real-time data coming from multiple sources[38].
- FIWARE: FIWARE is a framework of open source software (OSS) platform components which can be assembled and, together with third-party components, used to build entire platforms that support a faster, easier and cheaper development of smart solutions for cities.

In the context of this specific study, two interoperability components are further explored, namely cultural and organisational interoperability, as well as the main challenges related to them arising when public administrations are implementing data spaces and local digital twins at local or regional level.

[38] European Commission, 2021, Local Digital Twins: forging the Cities of tomorrow, available online: https://smart-cities-marketplace.ec.europa.eu/news-and-events/news/2019/dare-rethink-your-city-cef-building-blocks

3 Organisational interoperability challenges

Organisational interoperability refers to the way in which public administrations align their business processes, responsibilities, and expectations to achieve commonly agreed and mutually beneficial goals, while keeping users in focus. Organisational interoperability entails documenting, integrating, or aligning processes and exchanging relevant information. It also aims to meet the needs of users by making services available, easily identifiable, accessible and user focused. Furthermore, active involvement of the user community can be part of the organisational interoperability element[39].

When implementing local digital twins and data spaces, local and regional authorities are faced with organisational interoperability challenges hindering various aspects of the smart city projects. The figureFigure 5 below presents an overview of such organisational interoperability challenges.

Figure 5 Organisational interoperability challenges

Source: authors' own elaboration

3.1 Definition of common objectives

The definition of common objective is the cornerstone of the planning of a local digital twin or data space project. Local and regional authorities can face challenges with the definition of the problem to solve, user participation, and the alignment with existing political strategies on smart cities.

Defining the problem to solve

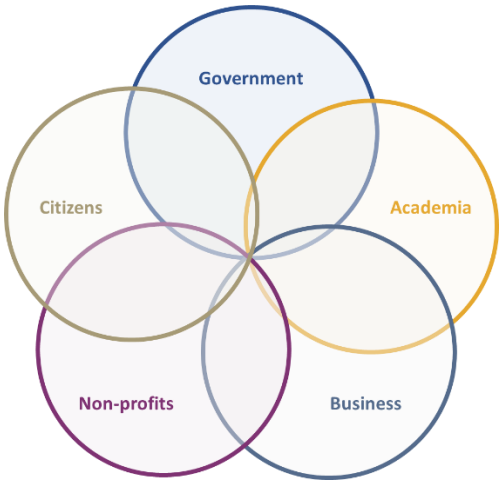
A key step of the initiation stage of the establishment of local digital twins and data spaces is the **identification of the problem(s) to be solved by the project**. Should the definition of problems to be

[39] European Commission, Directorate-General for Communications Networks, Content and Technology, Directorate-General for Informatics, Proposal for a European Interoperability Framework for Smart Cities and Communities (EIF4SCC), Publications Office of the European Union, 2021, https://data.europa.eu/doi/10.2799/816559

solved (e.g., through the identification of use cases) be insufficient, the positive outcomes stemming from the implementation of local digital twins and data spaces run the risk not to respond to citizens' needs, thus hampering their uptake and limiting their impact on the local/regional community. To ensure the representativeness and accuracy of the problem definition, the formulation of common objectives should result from a process of 'co-creation', defined in the smart city literature as "the active flow of information and ideas among five sectors of society: government, academia, business, non-profits and citizens - the Quintuple Helix - which allows for participation, engagement, and empowerment in, developing policy, creating programs, improving services, and tackling systemic change with each dimension of society represented from the beginning"[40]. As represented in Figure 6 below, each helix indicates a type of stakeholder group which contributes to the planning and implementation of local digital twins and data spaces. This is particularly well represented in the use case of Valencia's local digital twin:

- **Government** organisations are represented by the Municipality of Valencia and in particular its smart city office leading the initiative;
- **Academia** is represented through the participation of the University of Valencia and the Polytechnic University of Valencia which created a chair of Governance on data-issues;
- **Business** is closely involved in the Valencia's local digital twin with the participation of contractors to the implementation aspects of the project but also as data suppliers. For example, the architecture office Arqueha[41] is leading the implementation of a project while the telecommunication company Telefonica[42] is responsible for the maintenance of the city's data platform;
- **Non-profits** play a key role as the foundation Las Naves[43] is in charge of the coordination of social innovation stakeholders;
- **Citizens** are closely consulted via the AppValencia.

Figure 6 Smart city quintuple helix stakeholders



Source: Authors' own elaboration

The diversity of stakeholders and the interests they represent could steer the local digital twin or data space project away from the needs of the local community, e.g., technology companies advocating for the

[40] Agusti, C. et al., 2014, Co-Creating Cities: Defining co-´creation as a means of citizen engagement. 10.13140/RG.2.1.3684.5849.
[41] https://www.arqueha.com/
[42] https://www.telefonica.com/en/
[43] https://www.lasnaves.com/

procurement of expensive technological solutions[44]. To mitigate that risk, our research highlighted that political leadership plays an important role in steering and contributing to the problem definition of local digital twins and data spaces as the inception phase of such projects involves various stakeholders (e.g., several departments of the public administration launching the project, other public administrations, academia) which all have an important role in the problem definition.

On the one hand, the involvement of profit-driven companies in the smart city ecosystem is necessary to the success of data-driven projects such as local digital twins and data spaces. Their involvement should be framed by a strong definition of common objectives, anchored in the needs of the local community. On the other hand, the analysis of the use cases uncovered the link between the uptake of the local digital twins and data spaces projects and the **alignment with local businesses' needs and business flows**. The definition of common objectives should take into account all local stakeholders not to create negative spill-over effects (e.g., inadequacy with local business flows, vendor lock-in). The definition of common objectives needs to strike a balance between the different needs of the local community, both its residents and its businesses.

Ensuring user-centricity and user participation

The provision of better public services and the increase of public safety and quality of life was mentioned as some of the main benefits of implementing local digital twins and data spaces. As part of the challenge of defining common objectives, local digital twins and data spaces should avoid the pitfall of 'technological solutionism' by having a strong **user-centric focus**[45]. Smart city initiatives should not aim at showcasing the possibilities offered by new technologies but address current challenges faced by cities and regions.

User participation, defined as the "participation of citizens in the planning and administrative processes of governments"[46], is a key element of the scoping phase of smart city projects[47] and can take several forms:

- democratic participants: citizens can share their views on the policies and actions of the municipal or regional government;
- providers of experience: citizens chare share their experience to propose the implementation of new solutions or policies;
- data collectors: citizens collect and share data[48].

In order to be meaningful, the results of this consultation process need to be analysed by the municipal or regional government and feed into the definition of common objectives that should steer the local digital twin or data space project. Interviewees underlined that the engagement with citizens in discussions around data spaces and digital twins at the inception stages of initiatives may increase the chances of meeting their needs and increase support for the establishment of a data space or local digital twin. In line with the first recommendation of the EIF4SCC (Ensure that inhabitants and visitors play an active role by connecting, engaging and enabling them in policymaking, co-creation and testing of solutions for SCC), a large majority of European cities value and foster user participation. The United Nations' 2022 Global review of smart city

[44] Jared Mondschein et al., 2021, 'Smart cities as large technological systems: Overcoming organizational challenges in smart cities through collective action' in *Sustainable Cities and Society*, p.4, DOI: 10.1016/j.scs.2021.102730.
[45] Ezra Ho, 2016, 'Smart subjects for a Smart Nation? Governing (smart)mentalities in Singapore' in *Urban Studies*, p. 13, DOI: 10.1177/0042098016664305.
[46] Anthony Simonofski et al., 2017, 'Citizen Participation in Smart Cities' in *IEEE 19th Conference on Business Informatics*, p.228, DOI: 10.1109/CBI.2017.21.
[47] Luca Mora et al., 2023, 'Smart city governance from an innovation management perspective: theoretical framing, review of current practices, and future research agenda' in *Technovation*, p.16, DOI: 10.1016/j.technovation.2023.102717.
[48] Anthony Simonofski et al., ibid., p.229.

governance practices indicates that 77% of European residents have the possibility to share ideas on the smart city initiatives of their city while 71% of municipal governments act upon residents' input and feedback[49].

How to encourage citizen participation?

The City of Valencia offers to its citizens the possibility to download the mobile application AppValencia which offers direct access to public information on the municipality, an easy access to public services, as well as the possibility to provide feedback on digital public services and submit ideas to the municipal Council. In November 2022, the app counted 145,000 users.

Aligning with political strategies

The definition of common objectives for local digital twins and data spaces should be **aligned with existing smart city and digital strategies** implemented by local, regional, national, and European authorities to ensure the coherence of public action and the alignment with local needs and political priorities. The imbrication of multiple levels of strategies and political guidance raises the question of **coherence and subsidiarity**. The definition of the appropriate level of governance to set objectives and standards should enable decision-makers to formulate the "optimal policy mix" where the combined effects of multilevel governance pursue similar objectives and level of ambition[50]. Existing literature also suggests that smart cities policies and strategies should be citizen-centric and aim at responding to socioeconomic and environmental problems[51].

In its 2022 Global review of smart city governance practices, the United Nations note that 66% of European municipality governments have a vision statement that describes what the city wants to achieve in the long-term with smart city initiatives while 51% of European countries have a national policy to guide smart city initiatives[52]. The analysis of the four use cases highlighted the **importance of the EU legal framework** which provides key principles regarding the objectives of local digital twins and data spaces. The principles most mentioned by the interviewees were:

- interoperability principles and standards as defined in the EIF and the EIF4SCC;
- personal data protection rules (i.e., GDPR);
- use of public information in accordance with the Public Sector Information Directive[53].

How to use the EU legal framework?

When planning the Flemish Smart Data Space, the Flanders Region (Belgium) leveraged the key principles guiding the creation of European data spaces to create its own data space at regional level, on both governance and technical aspects. Good practices leveraged by the Flanders Region included the adoption of Open Standards for Linked Organisations (OSLO) and EU core vocabularies extensions.

[49] United Nations Human Settlements Programme, 2022, Global Review of smart city governance practices, HS/029/22E.
[50] Luca Mora et al., ibid., p.16.
[51] Ibid., p.10.
[52] United Nations Human Settlements Programme, ibid.
[53] Official Journal of the European Union, Directive (EU) 2019/1024 of the European Parliament and of the Council of 20 June 2019 on open data and the re-use of public sector information, PE/28/2019/REV/1, OJ L 172, 26.6.2019, p. 56–83

3.2 Definition of leadership responsibilities and common processes

The orchestration of various types of stakeholders involved in local digital twins and data spaces can be challenging for local administrations, even if experienced with smart city initiatives. In particular, the scoping of roles and responsibilities, the definition of leadership responsibilities and common processes, and the definition of data management leadership can be sensitive.

Scoping roles and responsibilities

The literature on smart cities distinguishes two types of innovation-oriented collaboration frameworks: cross- and intra-sector partnerships[54]. The former type of partnership involves stakeholders from different sectors (e.g., municipal governments, private companies, associations of public sector organisations or private organisations, local entrepreneurs, residents). **Cross-sector partnerships** have been adopted by all the use cases analysed in the framework of this report where the ecosystem around the local digital twin or data space project involved public and private stakeholders, as well as academia.

The nature of local digital twins and data spaces projects requires the involvement of various types of stakeholders with different work processes, interests and work cultures, the definition of roles and responsibilities can be challenging for local administrations with little existing experience in the field. European municipalities collaborate with external actors (e.g., private sector organisations, academia) at every stage of the project. 72% of them report collaborating with external actors at planning stage while 68% do so at implementation stage[55]. Organisational challenges that ensue potentially lead to additional administrative burden or even slow down the project.

Our research unveiled several good practices to mitigate this challenge:

- **The setup of a smart city unit**: smart city units play a detrimental role in the coordination of stakeholders involved in smart city projects including through the formation of partnerships, as well as the advocacy for smart city initiatives[56]. Dedicated horizontal mechanisms of coordination have been largely implemented in Europe with 64% of European cities having setup an entity tasked with overseeing the city's smart city initiatives while the world's average is 57%. 62% of European cities report that these dedicated entities are located in an existing public-sector department or agency, reinforcing their ability to mobilise public sector resources and actors[57].

[54] Luca Mora et al., 2023, 'Smart city governance from an innovation management perspective: theoretical framing, review of current practices, and future research agenda' in *Technovation*, p.12, DOI: 10.1016/j.technovation.2023.102717
[55] United Nations Human Settlements Programme, ibid.
[56] Claudio Coletta et al., 2017, 'From the accidental to articulated smart city: The creation and work of 'SmartDublin'', The Programmable City Working Paper 29, p.27, accessed at: https://osf.io/preprints/socarxiv/93ga5
[57] United Nations Human Settlements Programme, ibid.

What does a smart city office do?

The Smart City Office of Valencia was established in 2018 to:

1. advise, guide, and inform on the Smart City model and the different municipal strategies regarding Smart City and Connectivity;
2. coordinate and manage the analysis, design and management of Smart City projects;
3. coordinate action on IoT technologies, ICT in public services, and digital transformation;
4. design, control, and maintain Valencia's technological architecture;
5. manage the Integrated City Management Platform: VLCi Platform;
6. lead and coordinate the integration and functional compatibility between projects and computer systems and smart city technologies;
7. Cooperate in the management and coordination of smart-city R&D initiatives and programmes;
8. Develop methodologies and regulations regarding ICT in Valencia public services;
9. Coordinate technical staff regarding smart city projects;
10. Foster awareness on the use of new smart city products and technologies.

- **The definition of a clear governance model:** existing literature on smart cities and open data identify three governance models regarding the role of local authorities[58].
    - The cognitivistic approach where the city or region share its data without launching a public sector-led smart city initiative;
    - The connectionistic approach where the city or region coordinates the action of smart city stakeholders and creates communities around the data;
    - The autopoietic approach where the city or region ensures that the smart city / open data ecosystem organises itself without the active lead of the public sector.

  The connectionistic approach, more common in the context of smart city projects[59], was adopted by all the local authorities analysed in the frame of this report, which supports the hypothesis of its relevance to the implementation of local digital twins and data spaces. In the context of the analysed use cases, cities or regions were all at the origin of the project and had a leading role in their planning and implementation. 95% of European cities have a leading role in the planning of smart city initiative (the highest figure in the world) while 79% have a leading role in their implementation. Within a connectionistic approach, our interviewees identified several possible frameworks of cooperation that can be implemented by the city or region to coordinate stakeholders, i.e. centralised, decentralised, or network based. The cooperation framework needs to meet the needs of the local project to avoid the set up new of unnecessary structures leading to administrative burden. The recommendation 15 of the EIF4SCC encourages local and regional authorities to establish and maintain an integrated governance structure with relevant stakeholders to ensure interoperability in the delivery of the integrated services, in coordination with the holistic interoperability governance guidance.
- **The clear definition of roles and responsibilities**: the definition of a governance model needs to be paired with the definition of roles and responsibilities for each stakeholder (i.e. broker, data provider, data consumer, etc.). Clarity and transparency on the roles and responsibility of each stakeholder not only enable efficient collaboration but also contributes to trust-building. It is however one of the main challenges faced by local and regional administrations as only 55% of European municipal governments have a clear definition of roles and responsibilities regarding smart cities, below the world's average of 61%[60]. Good practices highlighted by use cases

[58] Jared Mondschein et al., ibid., p.5.
[59] Loc. cit.
[60] United Nations Human Settlements Programme, ibid., p.46.

stakeholders to mitigate this challenge include the implementation of specific rules regarding, the public-private collaboration, the setup of regular meetings, and the definition of accountability mechanisms (i.e., reporting obligations, publication of KPIs). The EIF4SCC recommendation 22 incentives local and regional authorities to put in place an organisational structure to establish and maintain clear roles and responsibilities of processes to deliver services at local level.

Implementing common rules and processes

The insufficient **definition of common rules and processes** hampers the coordination of stakeholders involved in local digital twins and data spaces, thus hindering data quality which, in turn, impacts negatively the quality of the outcomes of these smart city initiatives. The analysis of use cases also revealed that local and regional authorities leverage a wide array of **partnerships** with external stakeholders and establish clear rules and processes. These public-private partnerships can take several forms:

- grants and research projects for universities and innovative companies;
- public procurement with contractors for the implementation of technical aspects of the projects;
- creation of a network of partners.

Stakeholders involved in local digital twins and data spaces pointed to the importance of data sharing rules as the cornerstone of these partnerships. A data sharing strategy should be clearly defined and deployed with a transversal implementation plan to avoid any misuse of data and ensure compliance with data protection legislation and ethical standards. A good practice that local and regional administration can leverage is the signature of **Memorandum of Understanding** (MoU). Their usefulness appears to be particularly relevant when engaging with service providers using real-time or near real-time citizens' or businesses' data. MoUs aim to strike a balance between the agreement on common rules and the acknowledgement of private stakeholders' business processes.

Defining data management leadership

A particular focus on data management leadership was highlighted by the analysis of the use cases. In the context of the development of local digital twins and data spaces, insufficient clarity on data management leadership can hinder the interoperability of data and complexify data-related processes.

Oftentimes, cities and regions rely on a series of governance roles responsible for steering data management and guidance to all stakeholders to facilitate the design, development, deployment, utilisation, and maintenance of digital transformation and smart city technologies [61]:

- Chief Innovation Officers;
- Chief Information Officers (CIO);
- Chief Technology Officers (CTO);
- Chief Digital Officers (CDO).

The scope of their responsibilities can differ across cities and regions. However, our research confirmed the importance of these identifiable figures in steering the data management policy and processes of smart city initiatives. Their action is particularly important in the frame of local digital twins and data spaces projects as

[61] Jared Mondschein et al., ibid., p.4.

they are often public sector-led and require the coordination of multiples stakeholders. Chief Innovation Officers, CIOs, CTOs, and CDOs play a key role in encouraging collaboration with universities, foundations, and private companies.

Approaches to data maintenance should build upon existing legal and standard frameworks to avoid not only additional burden on local/regional administration staff but also overlaps, gaps, discrepancies, and contradictions with other EU initiatives as the heterogeneity of data maintenance standards may hamper the achievements of data spaces or digital twin initiatives. Legal and standard frameworks of high relevance to the establishment of local digital twins and data spaces include:

- **Interoperability and machine-readability principles** such as the FAIR principles[62]. The FAIR principles provide recommendations and guidelines to improve data Findability, Accessibility, Interoperability, and Reuse.
- **Sectorial data standards** such as, among others, the INSPIRE Directive[63] in the field of spatial information and the Open Geospatial Consortium (OGC) standards in the field of geospatial information.

How to use the FAIR principles in practice?

The AMdEX project of the City of Amsterdam is focusing on the application of the FAIR principles by using personal data pods, where centralised pieces of architecture are kept to a minimum. This decentralised technical architecture allows for greater findability, accessibility, interoperability, and reuse of the data while guaranteeing data control to the data supplier.

3.3 Organisation of technical aspects

Existing literature on smart cities differentiate horizontal and a vertical interoperability. Horizontal interoperability considers interoperability between data platforms, while vertical interoperability addresses the interoperability between platform and data user as well as data source[64]. In the context of local digital twins and data spaces, vertical interoperability is required to foster data exchanges between data suppliers, data maintainers and data-driven service providers. In this section, we will explore in particular how organisational aspects can contribute to alleviate technical interoperability challenges that local and regional authorities may face when implementing local digital twins and data spaces. Technical interoperability is defined as the inclusion of interface specifications, interconnection services, data integration services, data presentation and exchange, and secure communication protocols[65]. Local and regional authorities are faced with multiple technical interoperability challenges in the context of the establishment of local digital twins and data spaces in particular the maintenance of legacy systems, the interconnection of different systems, and the adoption of common standards.

Maintaining legacy systems

[62] GoFair, FAIR principles, available online: https://www.go-fair.org/fair-principles/
[63] Official Journal of the European Union, Directive 2007/2/EC of the European Parliament and of the Council of 14 March 2007 establishing an Infrastructure for Spatial Information in the European Community (INSPIRE), OJ L 108, 25.4.2007, p. 1–14
[64] Matthias Bunchinger et al., 2021, 'Towards Interoperability of Smart City Data Platforms' in *Hawaii International Conference on System Sciences*, p.6.
[65] European Commission, Directorate-General for Communications Networks, Content and Technology, Directorate-General for Informatics, 2021, *Proposal for a European Interoperability Framework for Smart Cities and Communities (EIF4SCC)*, p. 26, Publications Office of the European Union, https://data.europa.eu/doi/10.2799/816559.

One of the main technical interoperability issues resides in the **presence of legacy systems** and infrastructure and the associated requirements to maintain which result in high maintenance costs and cross-system integration costs[66]. The cumbersome maintenance of the legacy systems and the difficult integration process needs to be considered when developing new systems, not only in the infrastructure of these new systems but also when assessing their financial impact. To this end, local and regional authorities should take into account the Total Cost of Ownership (TCO) of a technological solution, defined as "all the costs of identifying and acquiring software, installing it and operating it, and finally the exit costs found in migrating away from the software"[67].

Our use case analysis did not allow to identify mitigating measure from an organisational perspective for this challenge which remains an issue that local and regional authorities can face when establishing local digital twins and data spaces. However, existing literature puts forward the hypothesis that **co-creation mechanisms**, i.e. user participation, could help alleviate the technical interoperability challenge of legacy systems. By leveraging the direct participation of end-users to collect information on their experiences, public service providers can tailor innovative solutions to respond to users' needs[68].

⇄ Interconnecting systems

The interoperability issue faced by most use cases representatives was the **difficult interconnection of local digital twins or data spaces systems** with other systems of the municipality/region, systems from other public administrations, including in the frame of European projects. Interconnection issues included the lack of common protocol for sharing and querying, requiring a high degree of specification.

As the interconnection between systems is one of the major challenges faced by public administration when establishing smart city initiatives, mitigating measures have been documented such as the use of building blocks, the reuse of solutions, and the use of open source software. The first good practice identified by our research is the setup of a **modular IT infrastructure** and the **use of building blocks** such as APIs, data filtering and querying tools, and data standards and schemas. The setup of a modular data infrastructure as a backbone to support the digital twin or data space initiative would allow other stakeholders or public administrations to connect easily. The use of building blocks could also help resolve the issue of 'data dumps', i.e. the sharing the large quantities of data which are little or not updated causing integration issues, by offering easier integration opportunities to external partners. Good practices from the use cases included the requirement in tender specifications for solution providers to use existing building blocks for standardisation. In its EIF4SCC, the European Commission recommends the use of the conceptual model for Integrated Smart City and Community Services to support the design of new services or update existing ones and reuse, where possible, existing data, service building blocks and digital solutions such as CEF Building Blocks, Digital Europe Programme and ISA2 solutions (recommendation 30). From an organisational perspective, the use of building blocks or the regular update of datasets need to be part of the commonly agreed rules between all participants of the local digital twin or data space project.

Our research also unveiled the key role of **reusable solutions**, including through the use of open source solutions. The standardisation of the use of open technology would enable local and regional authorities to

[66] Jared Mondschein et al., ibid., p.4.
[67] Maha Shaikh and Tony Cornford, 2011, Total cost of ownership of open source software: a report for the UK Cabinet Office supported by OpenForum Europe, UK Cabinet Office, p.4.
[68] Cesar Casiano Flores et al., 2021, 'Towards the Inclusion of Co-creation in the European Interoperability Framework' in *ICEGOV '21: Proceedings of the 14th International Conference on Theory and Practice of Electronic Governance*, p.3, DOI: 10.1145/3494193.3494320.

avoid vendor lock-in and foster cooperation between ICT, data, and model providers. The EIF4SCC includes a series of recommendations to foster interoperability:

- **Recommendation 14**: Reuse and share solutions, data, tools and services by cooperating with different stakeholders in the design, development, implementation and monitoring phase of service provision at local, regional, national and European levels.
- **Recommendation 21**: Communicate the right to access and reuse of solutions, data, tools and services. The legal permission for facilitating access and reuse, such as Creative Commons Licenses, should be standardised as much as possible.
- **Recommendation 28**: Ensure a local level playing field for open source software and demonstrate active and fair consideration to increase the quality and interoperability solution and become more cost-efficient.
- **Recommendation 29**: Develop apps/ digital services ensuring that these are open by default (even if not using open standards and open technical specifications, the apps/ digital services should allow integration with others through APIs, to boost the digital transformation at local level).

The promotion of the reuse of solutions by political leaders is necessary when establishing the strategy that will steer the development of smart city initiatives. The analysis of the four use cases also revealed that the promotion of the MIMs is particularly useful for smart cities without prior experience with local digital twin or data space projects. The MIMs can guide public administrations to increase interoperability within their project, close gaps between individual standards and allow organisations to become more independent and avoid vendor lock-in. However, during the interviews conducted in the scope of this study, seven out of the 13 interviewees revealed that they were not familiar with the MIMs and three among the remaining six highlighted the fact that the MIMs are still in development and are not fully operational yet. These findings demonstrate a lock of visibility for the MIMs which could benefit from greater awareness among cities and regions wishing to establish smart city initiatives.

How can open source contribute to smart city initiatives?

The Helsinki Digital Twin was built on open source components to avoid vendor lock-in by which a single supplier with competitive advantage can drive up prices due to its expertise with a specific proprietary software already used by the municipality. In addition, the use of open source allows the City of Helsinki to foster the reuse of solutions and interoperability.

Implementing common standards

Two main challenges regarding standards have been identified regarding the establishment of local digital twins and data spaces. On the one hand, the lack of standards hinders interoperability and prevent economy of scales. On the other hand, the existence of multiple sets of standards can create confusion if they are not aligned[69]. The lack of guidance or official decisions from national governments was pointed out by some local authorities as one of the causes of the technical interoperability challenge. Throughout the interviews conducted by the research team, the use of standards was the most mentioned success factor to develop local digital twins and data spaces.

[69] Loc. cit.

The European Union set up several initiatives to support local authorities to foster the technical interoperability of their solutions by local and regional authorities. The European Commission Data Space Support Centre aims at developing formal standard specifications, de-facto standards specification, and open source software projects and repositories[70]. Furthermore, the European Commission included several recommendations regarding the use of open standards and specifications in its Proposal for a European Interoperability Framework for Smart Cities and Communities (see section **Error! Reference source not found.**):

- **Recommendation 10**: Use open standards and open technical specifications when developing local data platform/space and services, include multiple access and assistance channels to ensure that users can choose the option that best addresses their needs and/or preferences.
- **Recommendation 12**: Set-up or consolidate interoperable local data platform(s)/space(s) that integrate and reuse data in cities and communities by stakeholders, and promotes open standards and open technical specifications, APIs and data models to provide a holistic view of the information. This aims to support the decision-making process and to foster innovation and citizen engagement.
- **Recommendation 26**: Use commonly agreed open standards and open technical specifications for achieving interoperability of data, systems, and services, to support cities/ communities and suppliers during the design, development and implementation phase of new services or reengineer existing ones (to avoid 'reinventing the wheel').
- **Recommendation 27**: Use and raise awareness of the benefits of open standards and open technical specifications amongst SCC service providers, during the design, development and implementation phase.

Interviewees underlined the importance of having clear **guidance on the standards** to be adopted at national or European level, in particular regarding metadata, APIs, and data models as well as monitoring mechanisms to assess the implementation of the standards. If EU initiatives such as the INSPIRE Directive and the new Interoperable Europe Act provides a common ground and a basic model that all EU Member States need to align with, use cases representatives expressed the need for stronger national and/EU action to define and promote standards, guidance material, and good practices.

As the implementation of smart city projects are on the rise, the UN noted that 57% of European cities have an open data policy. An open data process is defined as the process by which public organisations open their data which can be used by citizens, businesses, researchers, civil servants, and other types of users[71]. The **lack of harmonisation** on the open standards and specifications to be adopted can result in the development of conflicting, sector-specific standards hindering data interoperability given the transversal nature of smart cities initiatives such as local digital twins and data spaces. In addition, open standards and specifications as well as monitoring mechanisms should be taken into account while procuring smart city solutions and services to ensure a certain degree of interoperability.

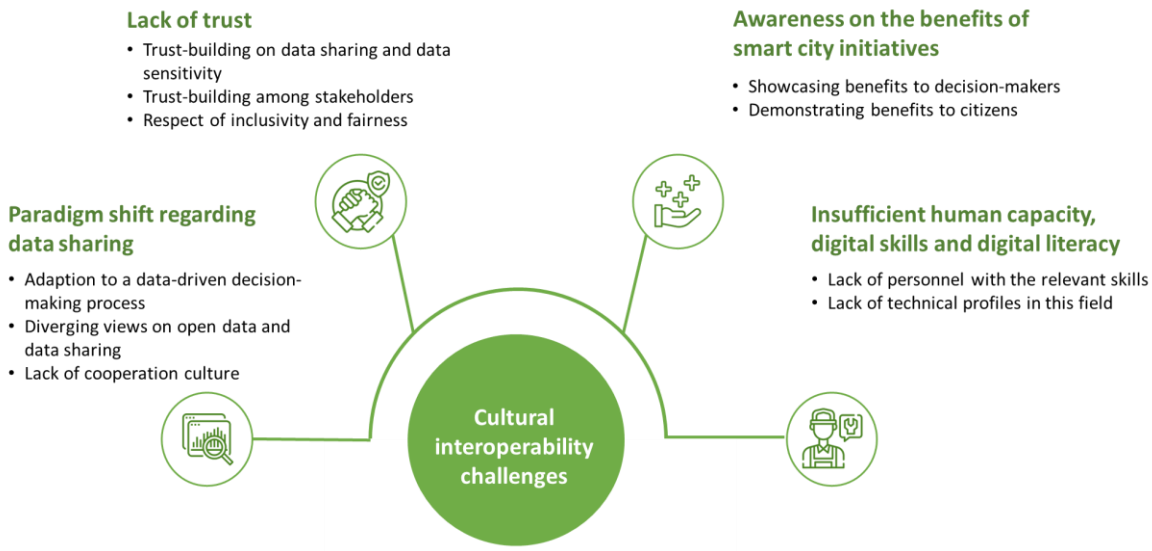
[70] Data Spaces Support Centre, 2022, *Starter Kit for Data Space Designers*, p. 13.
[71] Anneke Zuiderwijk et al., 2012, 'Socio-technical Impediments of Open Data' in *Electronic Journal of e-Government*, 10(2), p156.

4 Cultural interoperability challenges

Cultural interoperability refers to the approach taken by individuals and organisations to take into consideration their social and cultural differences and, if applicable, any organisational cultural differences. Interoperability can be impacted by cultural differences, as individuals and organisations can respond differently to similar interoperability challenges. For example, these cultural differences can be reflected in political challenges and leadership styles. Different actors within a smart city can have varying views on how leadership, in the context of interoperability, is exercised. This requires a debate among the actors involved about how to exercise leadership in their interoperability context[72].

When implementing local digital twins and data spaces, local and regional authorities are faced with cultural interoperability challenges which can obstruct the implementation of smart city projects. Figure 7 below presents an overview of the main cultural interoperability challenges.

Figure 7 Overview of the main cultural interoperability challenges



Source: Wavestone's own elaboration

4.1 Paradigm shift regarding data sharing

Smart initiatives such as data spaces or local digital twins require data sharing and rely on data accessibility. However, the increasing need to open, share, and make use of this data forces public administrations to re-evaluate their way of sharing data, both within public administrations and with external actors.

Adapting to a data-driven decision-making process

Adapting to a data-driven decision-making process can be difficult for some public administrations, as it requests them to change their internal processes and habits and to develop the ability to draw meaningful

[72] European Commission, Directorate-General for Communications Networks, Content and Technology, Directorate-General for Informatics, Proposal for a European Interoperability Framework for Smart Cities and Communities (EIF4SCC), Publications Office of the European Union, 2021, https://data.europa.eu/doi/10.2799/816559

and actionable insights from a large quantity of data collected internal or externally[73]. This resistance to change can be reinforced by other factors such as the lack of knowledge or prior experience on data analysis and data-driven decision-making, the lack of awareness on the benefits of data-driven decision-making, or the under-development of a culture of innovation. Indeed, the survey supporting the United Nations' 2022 Global review of smart city governance practices indicates that 71% of European residents considered that their city nurtures a culture of innovation and 34% reported resistance to change in public organisations as a barrier to smart city initiatives in their cities[74].

To further facilitate the adoption of data-driven decision-making, public administrations should establish **change management programmes** to foster innovation culture and support the use of new tools and technologies based on data analysis. According to Kotter's 8-Step Change Model, public administrations should plan carefully and take the time to build a proper foundation to implementing change and improve the chances of success. The eight septs include: creating a sense of urgency around the need for change, recruiting powerful change leaders to form a guiding coalition driving the initiative, building a vision and effectively communicating it, identifying and removing obstacles, creating quick or short-term wins, and building on the momentum[75]. In addition, the establishment of **regulatory sandboxes** could also encourage innovation and data-driven decision-making at local, regional or national level. In this context, the sandboxes approach could provide a controlled environment that facilitates the development, testing and assessment of the impact of the adoption of regional and local data ecosystems and digital twins, by exploring several governance and business models, for a limited time[76]. Finally, the change management programmes should also be complemented by **IT trainings** for public servants in order to familiarise them with these new tools and to increase their digital literacy (cf. section **Error! Reference source not found.**).

Diverging views on open data and data sharing

Stakeholders involved in the creation of smart initiatives such as data spaces or local digital twins can have diverging views on open data and data sharing, ranging from "closed" to "open if" to "open unless"[77]. This can be explained by multiple factors, revealed by the analysis of the four use cases:

- **Financial constraints**: Several interviewees underlined that there is a perception that using open data could be more costly for public administrations than keeping closed data. The benefits of openness and the reuse of information, as well as the reuse of solutions and open source solutions, are often undervalued while they could lead to significant financial savings[78].
- **Impact of external factors**: Despite having an open data culture in place, external political factors can lead to reopening discussions on the risks of opening data. Keeping the paradigm shift in the same direction in the long term perspective can be a challenge.
- **Fear of losing data control**: Data owners may be reluctant to share their data as they might see it as loosing data control over to data or technical experts with little accountability and liability.

[73] Bibri S. E., Data-driven smart sustainable cities of the future: An evidence synthesis approach to a comprehensive state-of-the-art literature review, Sustainable Futures, Volume 3, 2021, 100047, ISSN 2666-1888, https://doi.org/10.1016/j.sftr.2021.100047.
[74] United Nations Human Settlements Programme, 2022, Global Review of smart city governance practices, HS/029/22E.
[75] https://www.mindtools.com/a8nu5v5/kotters-8-step-change-model
[76] European Location Interoperability Solutions for e-Government (ELISE). 2022, Regional and local data-driven innovation through collective intelligence and sandboxing, Joinup. Available online, URL: https://joinup.ec.europa.eu/collection/elise-european-location-interoperability-solutions-e-government/regional-and-local-data-driven-innovation-through-collective-intelligence-and-sandboxing
[77] Berardi, R. & Belizario, M. (2019). Use of Smart and Open Data in Smart Cities Use of Smart and Open Data in Smart Cities. Americas Conference on Information Systems 2019. Available online, URL: https://www.researchgate.net/publication/335572202_Use_of_Smart_and_Open_Data_in_Smart_Cities_Use_of_Smart_and_Open_Data_in_Smart_Cities
[78] European Commission, Creating Value through Open Data: Study on the Impact of Re-use of Public Data Resources. European Open Data Portal, 2015. Available online,: https://data.europa.eu/sites/default/files/edp_creating_value_through_open_data_0.pdf

- **Public vs Private sector:** Differences regarding open data maintenance or sharing can appear between the private and public sectors. When developing a data space, developing a common way of dealing with both open and commercial data is critical. Our research also revealed that private parties tend to prefer commercialising data, which can lead to a lack of incentive to share open data.

The use cases analysis indicated that public administrations should further raise **awareness** on the benefits of openness and the reuse of information to counter these challenges, not only among public servants but also among all stakeholders involved in smart projects. In addition, adopting a **long-term smart city strategy** which highlights openness as a key priority can reduce the impact of external factors and strengthen the city or region's willingness to maintain data open. When it comes to the differences between public and private sectors and the municipalities' fear of losing data control, **clear and transparent rules** on (open) data maintenance and sharing should be defined and agreed upon at an early stage of the smart initiative creation.

How can open source contribute to smart city initiatives?

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Lack of cooperation culture

Public sector collaboration is mainly observed from two perspectives: horizontally, among different entities of the municipal government, and vertically, between the sub-national and national level. While better collaboration practices have been reported in horizontal collaboration, progress could be made by local authorities to increase the vertical cooperation culture, i.e. with local authorities and regional and national governments[79].

The lack of cooperation culture between departments is materialised by a paradigm shift regarding collaboration and working methods. Within public administrations, departments and ministries often work and manage data in sectorial silos, which conflicts with the cross-sector cooperation culture that is the brick and mortar of local digital twin and data space projects. In addition, working methods can vary from one department to the other, creating misalignments of processes and expectations in transversal and interdisciplinary projects. According to the survey supporting the United Nations' 2022 Global review of smart city governance practices, only 60% of European respondents considered that there is effective coordination between municipal agencies and departments in their city's smart projects, illustrating this challenge[80].

To promote the cooperation culture between departments, the involvement of **staff from different departments** in the establishment of smart city projects should be encouraged to stimulate interdepartmental cooperation, beyond the classic competence-oriented collaboration[81]. In addition, promoting **regional, national, or international cooperation** through the participation in European projects

[79] United Nations Human Settlements Programme, 2022, Global Review of smart city governance practices, HS/029/22E.
[80] Ibid.
[81] Mora L. et al., 2023, 'Smart city governance from an innovation management perspective: theoretical framing, review of current practices, and future research agenda' in Technovation, DOI: 10.1016/j.technovation.2023.102717

could provide greater visibility to local or regional initiatives. In turn this visibility will increase motivation locally to engage in smart city projects and positively impact the cooperation culture. As highlighted by the analysis of the four use cases, another way of fostering an interdepartmental cooperation culture is the organisation of **regular meetups** between stakeholders, via events, working meetings, site visits and/or the co-creation of proposals for new smart city initiatives. Creating an environment allowing an active and transparent dialogue among smart city stakeholders will not only facilitate and normalise cooperation but also contribute to foster trust between them.

4.2 Lack of trust

As already mentioned in the above section, trust appears as a key factor in the implementation of data spaces and local digital twins, and more specifically as a fundamental element to manage tensions and power dynamics among different stakeholders. This challenge is three-fold: the lack of trust towards data sharing and data sensitivity, the lack of trust among involved stakeholders, and the need to develop a trustworthy and secure smart city environment based on inclusivity and fairness.

Trust-building on data sharing and data sensitivity

When implementing data spaces or local digital twins, data to be shared can be commercially and financially sensitive or even include personal information. As smart city projects often rely on data as a way to track activities, measure consumption, learn about usage patterns, and optimise solutions, maintaining the trust of public and private entities with regard to data sharing, and especially for sensitive data, is of paramount importance and can be very challenging for public administrations[82].

All use cases considered that a smart project should be **transparent** about its data collection, maintenance and use policy. As recommended by the EIF4SCC (Recommendation 9), public administrations should ensure transparency on data sharing collaborations between and within government, citizens, businesses, and organisations[83]. The Smart City Guidance Package published by the European Commission in 2019 recommends that every dataset used in the context of smart city projects should include **privacy considerations** in its design and implementation[84]. Following the same rationale, open data should always be shared as aggregated data and never contain private information. A **standardised approach** to data sharing and privacy could help resolve some of the apprehension and resistance to share information and promote trust among stakeholders[85]. Following Recommendation 20 of the EIF4SCC, this standardised approach should be framed in the context of a solid and trusted legal framework enabling and facilitating data sharing across stakeholders and across domains at local, regional, national, and European level[86]. During the consultation's activities conducted under this study, several interviewees highlighted the importance of the GDPR, considered as an enabling factor for smart city projects.

[82] Borsboom, J., Gindroz, B., Costa, S. & Georgiev, G.. Smart City Guidance Package - A Roadmap for Integrated Planning and Implementation of Smart City projects. 2019, available online: https://www.researchgate.net/publication/343615678_Smart_City_Guidance_Package
[83] European Commission, Directorate-General for Communications Networks, Content and Technology, Directorate-General for Informatics, Proposal for a European Interoperability Framework for Smart Cities and Communities (EIF4SCC), Publications Office of the European Union, 2021, https://data.europa.eu/doi/10.2799/816559
[84] Borsboom, J., Gindroz, B., Costa, S. & Georgiev, G.. Smart City Guidance Package - A Roadmap for Integrated Planning and Implementation of Smart City projects. 2019, available online: https://www.researchgate.net/publication/343615678_Smart_City_Guidance_Package
[85] Ibid.
[86] European Commission, Directorate-General for Communications Networks, Content and Technology, Directorate-General for Informatics, Proposal for a European Interoperability Framework for Smart Cities and Communities (EIF4SCC), Publications Office of the European Union, 2021, https://data.europa.eu/doi/10.2799/816559

As revealed by the analysis of the four use cases, another way of mitigating this challenge is to use **formalised data exchange** between data providers and data users, using clear and transparent rules or contracts[87]. This would allow data sharers to have a greater degree of control over what can and cannot be done with their data. Finally, the use cases analysis also revealed that publishing and sharing **real-time data** should also be prioritised by the cities or regions working on data spaces and local digital twins in order to avoid data dumps, i.e. the sharing of large amount of little or no updated data, and to foster trust on data-driven decision-making.

Trust-building among stakeholders

When developing a data space or a local digital twin, the **lack of trust** between different stakeholders (e.g., governments, citizens, and businesses) can hamper the willingness to collaborate and share data. Far from being a challenge specific to smart city initiatives, trust is critical for the implementation of such initiatives, which usually involve a high number of actors. Stakeholders can doubt the intentions of others and their keenness to pursue the same objectives. In the smart city context, this lack of trust can also be observed between stakeholders towards the players holding or deciding on the choice of technologies or solutions to be used for the creation of data spaces or local digital twins. This specific trust issue can be motivated by the lack of insights and transparency on the use of the data or technology.

Consequently, strong efforts should be made to promote trust and **knowledge sharing**, thus fostering mutual understanding among partners, which are the most important prerequisites for a well-functioning and transparent working environment[88]. In alignment with Recommendation 7 of the EIF4SCC, public administrations should make sources of information (e.g., base registries and open data portals) open to inhabitants, business, visitors, organisations, and community administrators to provide them with an ethical and socially responsible access, use, sharing and management of this data and promote trust[89].

To generate consensus within their partnerships and build trust relationships with other involved parties, municipalities and regions should replace bureaucratic control with a **shared management approach** and mechanisms of **horizontal coordination**, like smart city units[90]. This approach effectively generates trust and stronger collaboration linkages between the municipal or regional government and its partners[91]. In addition, the analysis of the use cases demonstrated that trust between stakeholders can be reinforced by multiplying the occasions for them to interact. **Regular events**, and not only working meetings, should be organised by public administrations (e.g., knowledge sharing sessions, social events, and hackathons). Finally, the use cases analysis also highlighted that developers should foster the trustworthiness of the solutions, i.e., having a trust-centric vision of solution development by taking this element into account in each step of the production of the smart city solutions.

[87] Cf section on “Diverging views on open data and data sharing” in 4.1.
[88] Borsboom, J., Gindroz, B., Costa, S. & Georgiev, G.. Smart City Guidance Package - A Roadmap for Integrated Planning and Implementation of Smart City projects. 2019, available online: https://www.researchgate.net/publication/343615678_Smart_City_Guidance_Package
[89] European Commission, Directorate-General for Communications Networks, Content and Technology, Directorate-General for Informatics, Proposal for a European Interoperability Framework for Smart Cities and Communities (EIF4SCC), Publications Office of the European Union, 2021, https://data.europa.eu/doi/10.2799/816559
[90] Mora L. et al., 2023, ‘Smart city governance from an innovation management perspective: theoretical framing, review of current practices, and future research agenda’ in Technovation, DOI: 10.1016/j.technovation.2023.102717
[91] Sandulli, F.D., Ferraris, A., Bresciani, S., 2017. How to select the right public partner in smart city projects. RD Manag. 47 (4), 607–619. https://doi.org/10.1111/ radm.12250.

How to promote trust among stakeholders?

Digital Flanders put in place a steering committee to coordinate the establishment of the Flanders Smart Data Space with multiple departments of the Flemish Region and steer its development. The steering committee is also responsible of coordinating the collaboration with private actors and is open to all compagnies willing to contribute to the establishment of the data space.

Respect of inclusivity and fairness

In the design of inclusive smart cities solutions, it is crucial for public administrations to "use the appropriate means to engage and empower population groups difficult to reach such as people experiencing poverty and/or social exclusion, younger and older people, migrants, people with disabilities, and aim at gender balance in participation and engagement"[92]. Indeed, inclusivity appears as a key element to provide greater transparency and more sustainable and responsible urban innovations. The analysis of the use case revealed that inclusivity and the social dimension are often insufficiently measured and weighed in when planning the establishment of a local digital twin or a data space. Additionally, smart initiatives, which rely on data analytics and the use of disruptive technologies like artificial intelligence, can carry data bias resulting from existing inequalities in cities or regions. Consequently, decisions based on machine learning models or AI algorithms could result in discriminatory and unfair outcomes reinforcing socioeconomic disparities[93].

To foster inclusivity, neutrality, and fairness, public administrations should intensify their communication efforts to raise residents' awareness on smart city initiatives and their benefits. Different communication channels should be exploited to target multiple audiences and deliver regular progress updates. Local and regional authorities should also strengthen their capacity to collect, manage, and act upon the residents' **feedback** to ensure that smart city initiatives respond to their needs[94]. The EIF4SCC recommends that public administrations ensure that diverse stakeholders, including diverse inhabitants, are involved in a multidisciplinary process of definition and/or design of interoperable services so that societal and cultural differences (organisational, economic, ethnic, religious beliefs, gender, language) are accounted for[95].

Inclusivity can be further incentivised by formulating **inclusive engagement strategies** tackling existing barriers to public participation, such as a lack of experience in participatory processes, limited digital literacy, and time pressures, among others. For this reason, municipalities and regions should design inclusive participatory processes and entrust their management to topic experts[96]. In addition, smart cities should implement inclusive **procurement mechanisms** that promote citizens' involvement both at the ideation and implementation phases, while assuring that the final responsibility to provide basic services remains with public authorities. Citizen engagement is critical to the continuity of a project regardless of political changes

[92] European Commission, Directorate-General for Communications Networks, Content and Technology, Directorate-General for Informatics, Proposal for a European Interoperability Framework for Smart Cities and Communities (EIF4SCC), Publications Office of the European Union, 2021, https://data.europa.eu/doi/10.2799/816559
[93] Constantine E. Kontokosta, Boyeong Hong, 2021, Bias in smart city governance: How socio-spatial disparities in 311 complaint behavior impact the fairness of data-driven decisions, Sustainable Cities and Society, Volume 64,102503, ISSN 2210-6707, https://doi.org/10.1016/j.scs.2020.102503.
[94] United Nations Human Settlements Programme, 2022, Global Review of smart city governance practices, HS/029/22E.
[95] European Commission, Directorate-General for Communications Networks, Content and Technology, Directorate-General for Informatics, Proposal for a European Interoperability Framework for Smart Cities and Communities (EIF4SCC), Publications Office of the European Union, 2021, https://data.europa.eu/doi/10.2799/816559
[96] United Nations Human Settlements Programme, 2022, Global Review of smart city governance practices, HS/029/22E.

and a framework for continuous assessment and iteration based on citizen feedback should be developed [97,98].

4.3 Awareness on the benefits of smart cities

As previously mentioned in previous sections, the ability to raise awareness on the benefits of smart initiatives is critical for public administrations at various stages of project creation and implementation. Indeed, this ability is not only indispensable for cities or regions to become "smart", but also to foster cooperation and trust among stakeholders and increase data sharing. All four use cases analysed in the context of this study highlighted the difficulty to demonstrate and raise awareness on the benefits of establishing a data space or local digital twin, mainly due to the lack of established evaluation system and indicators of reference.

Showcasing benefits to decision-makers

Not only the benefits of smart city initiatives are hard to measure but public administrations can also face difficulties to define the period needed to showcase the benefits. The analysis of the four use cases revealed that there is a general lack of recognised monitoring and evaluation frameworks for data spaces and local digital twins which would allow cities and regions to assess the strengths and areas of improvement of smart projects. This issue does not only impact the smart cities and regions' ability to assess and monitor the progress of their projects, the rationalisation of resources, the prioritisation of actions and the reinforcement of communication and transparency, but also the public administrations' ability to legitimise their projects and explain how they create value.[99] This last point is particularly crucial when it comes to establishing a smart city plan, convincing decision-makers, making a business case, or finding investors[100].

To counter this challenge, knowledge sharing is essential. Showing **good examples of successful initiatives or use cases** from different points of views (e.g., as a user, as a planner or as an advisor for permits) could help to convince decision-makers or investors at early stages of the project. Benchmarks of success stories and best practices based on relevant and standardised KPIs, should not only be helpful in demonstrating potential benefits and assets for cities and regions, but also in indicating the volume of accompanying investments. Identifying similar challenges and potential solutions among a long list of success stories will reassure decision-makers and investors[101]. The analysis of the four use cases revealed that a publicly accessible list or catalogue of successful initiatives created at European level would be useful for public administrations to collect information on the different applications of smart city projects.

Additionally, our research demonstrated that public administrations should not hesitate to **collect stakeholders' feedback**. Indeed, collecting feedback at the design phase of the project (e.g., on a mock-

[97] Cf. section "Definition of common objectives" on user-centricity and user participation.
[98] European Innovation Partnership on Smart Cities and Communities (EIP-SCC), Inclusive Smart Cities: a European Manifesto on Citizen Engagement. Available online: https://smart-cities-marketplace.ec.europa.eu/sites/default/files/EIP-SCC%20Manifesto%20on%20Citizen%20Engagement%20%26%20Inclusive%20Smart%20Cities.pdf
[99] Lebas A. and Crutzen N., 2019, Methodology: How to evaluate your Smart City projects? Performance Measurement in Smart Cities. Smart City Institute, HEC Liege, University of Liege, Belgium. Available online, URL: https://www.smart-city.uliege.be/cms/c_5666400/en/methodology-how-to-evaluate-your-smart-city-projects
[100] Borsboom, J., Gindroz, B., Costa, S. & Georgiev, G. Smart City Guidance Package - A Roadmap for Integrated Planning and Implementation of Smart City projects. 2019, available online: https://www.researchgate.net/publication/343615678_Smart_City_Guidance_Package
[101] Ibid.

up) could result in a lot of suggestions on possible improvements. This preliminary feedback should not be considered negatively not to hamper the political support for the smart city initiative.

Finally, despite the lack of established evaluation systems and specific KPIs for data spaces and local digital twins, public administrations should rely on the numerous **existing smart city evaluation frameworks and indicators** described in the literature to develop their smart city plan and assess their progress as smart cities or communities, such as the Holistic KPI (H-KPI) Framework[102], the OECD Smart City Measurement Framework[103], the United for Smart Sustainable Cities (U4SSC) Key Performance Indicators (KPIs)[104] or the Smart city performance measurement framework CITYkeys[105], while adapting them to their local or regional reality. Another resource recommended by the use cases is the Sustainable Development in Communities – Indicators for Smart Cities framework, developed by the International Organisation for Standardisation (ISO). Including more than 85 indicators, the ISO 37120 standards[106] aim to steer and help public administrations to measure the performance of smart city services and residents' quality of life. While these evaluation systems and KPIs are not tailored for data spaces and local digital twins, it could be useful to assess the benefits of the elaboration of specific evaluation frameworks. In addition to evaluation frameworks, a new digital maturity assessment tool named LORDIMAS (Local and Regional digital Maturity Assessment Tool) is currently being developed at EU level to help public administrations assess digital maturity of municipalities and regions, based on local and regional digital indicators identified under the Living in EU initiative[107].

Figure 8 ISO 37120 - Set of indicators for smart cities

Source: ISO 37120 - Set of Indicators for Smart Cities[108]

[102] Wollman and all., 2022, Smart Cities and Communities: A Key Performance Indicators Framework. National Institute of Standards and Technologies (NISP), U.S. Department of Commerce, NIST SP 1900-206. Available online, URL: https://nvlpubs.nist.gov/nistpubs/SpecialPublications/NIST.SP.1900-206.pdf
[103] OECD, 2020, Measuring Smart Cities' performance: Do smart cities benefit everyone?, Scoping note 2nd OECD Roundtable on Smart Cities and Inclusive Growth, available online: https://www.oecd.org/cfe/cities/Smart-cities-measurement-framework-scoping.pdf
[104] https://u4ssc.itu.int/u4ssc-kpi/
[105] Airaksinen M., et al., 2017, Smart city performance measurement framework CITYkeys, International Conference on Engineering, Technology and Innovation (ICE/ITMC), Madeira, Portugal, pp. 718-723, DOI: 10.1109/ICE.2017.8279956.
[106] ISO 37101, ISO 37120, ISO 37122 and ISO 37123. More information on ISO certifications: https://www.iso.org/standard/69050.html More information on ISO certifications: https://www.iso.org/standard/69050.html
[107] European Commission. 2022. Digital Transformation, Digital Resilience and Innovation: connecting regional and national programmes with EU initiatives. Background paper for the Broadband Platform Meeting. URL: https://cor.europa.eu/en/events/Documents/Digital%20Transformation/BBP%2019%20October%20background%20paper_fin.pdf
[108] International Organisation for Standardisation, ISO 37120, Sustainable development of communities – Indicators for city services and quality of life. Available online, URL: https://www.iso.org/obp/ui/#iso:std:iso:37122:dis:ed-1:v1:en Available online, URL: https://www.iso.org/obp/ui/#iso:std:iso:37122:dis:ed-1:v1:en

How to use ISO 37120 indicators?

The city of Valencia obtained from the World Council on City Data (WCCD) the Platinum Certification ISO 37120 "Sustainable development in cities - Indicators for urban services and quality of life" in 2015. The certificate evaluates more than 100 homogeneous indicators measuring the efficiency of public services and the quality of life for citizens. Different indicators related to key areas of smart cities (Economy, Governance, Environment, Mobility and Citizen Welfare) are reflected in this standard, which allows Valencia to measure their progress over time and draw comparative lessons from other cities both globally and at local level.

Demonstrating benefits to citizens

As for the concept of "smart city", the terms "data spaces" and "digital twins" can be difficult to grasp for stakeholders with no prior experience in the field and seen as "buzzwords", especially without clear definitions provided by their local or regional public administrations. Sub-national governments can attribute different meanings to urban innovation and formulate place-based strategies of smart city development in relation to their socio-economic contexts, seeking to advance technological solutions to what they perceive as the most pressing problems of their territories and populaces[109]. In addition, the concept of "data space", for which different definitions coexist in the literature, can also be difficult to understand or unclear for non-technical profiles.

The lack of clear definitions and transparency on the smart city projects negatively impact the residents' support and can even provoke the emergence of significant backlash from the public regarding equity, privacy, and digital ethics. Citizens can express serious concerns regarding the misuse of data collecting tools and applications seen as surveillance devices by the government and private companies. Residents can also question the benefits of smart initiatives, the use of public funds on new technologies and the required supporting infrastructure and expertise, when potentially more pressing local needs are seemingly de-prioritised[110]. The lack of evaluation frameworks and indicators, as explained in the previous section, can worsen this challenge.

To mitigate these risks and potentially gain public support for smart city projects, public administrations should engage in **strategic communication efforts** focused on public outreach from an **early stage** of project development to disseminate information, receive feedback, and address any concerns linked to privacy and data governance. These efforts can include organising focus groups and workshops at local libraries or centres, starting discussions with local clubs, communities, and non-profit organisations, participating in neighbourhood's meetings, and interacting with residents on social media. The existing literature on smart cities describes that cities implementing a public engagement strategy early in their projects describe a high level of public acceptance and the implementation of citizens' feedback in the strategy development process, while those that waited until later in the pilot project phase usually face significant public push-back and typically regret not initiating earlier[111]. Another recommendation, which emerged from the analysis of the four use cases, is that teams behind smart city projects should promote residents' **interactions with the incoming or newly deployed technologies**, especially in the case of local

[109] Esposito, G., Clement, J., Mora, L. & Crutzen, N. One size does not fit all: Framing smart city policy narratives within regional socio-economic contexts in Brussels and Wallonia, Cities, Volume 118, 2021, 103329, ISSN 0264-2751, https://doi.org/10.1016/j.cities.2021.103329.
[110] Mondschein J., Clark-Ginsberg A., Kuehn A., Smart cities as large technological systems: Overcoming organizational challenges in smart cities through collective action, Sustainable Cities and Society, Volume 67, 2021, 102730, ISSN 2210-6707, https://doi.org/10.1016/j.scs.2021.102730.
[111] Ibid.

digital twins which usually rely on 3D models. This first-hand experience will allow citizens and other stakeholders to better visualise the benefits that could result from the implementation of these technologies, without the need of technical expertise or advanced digital skills. Smart cities could also create **'experience centres'** or **Living Labs** to facilitate and oversee these interactions[112].

How to foster stakeholders' interactions with the technology?

The local digital twin developed by the city of Helsinki is supported by two next generation 3D city models: a semantic city information model (City GML model) and a visually high-quality reality mesh model. The City GML model is more scientific, allowing users to perform a variety of analyses, while the reality model, which is physically more accurate, can be used in various online services or for design projects. The reality mesh centralises data for rendering the city via various game engines, including Minecraft. The Minecraft-Helsinki3D+ urban model is user-friendly and well-suited for teaching purposes, allowing a younger audience to learn more about urban planning, architecture and the history of Helsinki.

4.4 Insufficient human capacity, digital skills and digital literacy

The establishment of data spaces and local digital twins suffers from ongoing challenges faced by public administrations regarding digital skills and recruitment policies, as not all cities and regions have the human and technological capacity to respond to the increasing digitalisation of processes and use of innovative technologies. In addition, the establishment of data spaces and local digital twins require specific expertise in new fields that can be difficult to find. In many cases, municipal and regional governments lack the necessary human capacity to develop and adopt comprehensive smart city initiatives[113].

Lack of personnel with the relevant skills

Due to the constant evolution of society and technologies, new capacities are required to underpin technologically enhanced urban management and growth. The multiplication of smart city projects disrupted the skills that civil servants need to possess to remain productive and claim sustainable careers[114]. According to the survey supporting the United Nations' 2022 Global review of smart city governance practices, 27% of European respondents considered that the lack of skills within the public sector is a barrier to smart city initiatives.

To face this challenge and close the gap, training public servants under the framework of the smart city concept would provide cities' staff with a multidisciplinary approach, encompassing emerging technological tools in urban contexts. The identification of needed digital skills for smart city professionals is crucial as it will allow enactment of policies and measures by preparing a workforce capable of efficiently planning, developing, deploying, and managing smart city solutions. In addition to these skills, the analysis of the use cases highlighted that the ability to **anticipate technology trends and innovate** is particularly important for smart city professional to develop a vision merging the current emerging technologies with upcoming trends. As previously discussed in previous sections, revisiting city governance implies the development of a culture

[112] Ibid.
[113] OECD, 2019, Enhancing the Contribution of Digitalisation to the Smart Cities of the Future, Available online, URL: https://www.oecd.org/regional/regionaldevelopment/Smart-Cities-FINAL.pdf
[114] Panagiotakopoulos, T., Iatrellis, O & Kameas, 2022. A. Emerging Smart City Job Roles and Skills for Smart Urban Governance. Building on Smart Cities Skills and Competences (pp.3-19), doi:10.1007/978-3-030-97818-1_1.

of innovation that incentivises experimentation and risk-taking but also define dedicated goals, rules and strategies, a common base line, staff, trainings, and budget[115].

Smart investment in human resources, such as in life-long learning and digital skills and literacy, will need to be available in all cities and regions, and should be viewed as an investment and not a cost[116]. The analysis of the four use cases also demonstrated that a **minimum technical proficiency** should be defined for civil servants at local, regional, or national level. In addition to technical aspects, civil servants should be **trained on the biases and sensitiveness aspects** linked to smart city initiatives from a policy perspective. To do so, municipalities or regions could **collaborate with private actors**, which are also involved in the development of smart initiatives, to create trainings for their workforce. More courses designed by technology compagnies could also be made available through existing educational infrastructures in order to fill specific skills gaps in cities in the future[117]. In addition, several initiatives, such as the Skills4Cities project[118] and the Smart DevOPS MOOC[119], have been put in place by the European Commission to offer guidance and trainings dedicated to skills for smart cities to help cities and regions to overcome this challenge. To complement these trainings, interacting regularly with knowledge sharing initiatives such as city networks can also develop the expertise of civil servants.

Lack of technical profiles in this field

Public administrations wishing to develop smart initiatives such as data spaces and local digital twins need to rely on technical experts with advanced skills regarding the establishment of complex IT infrastructures, innovative technologies, and data. However, the use cases analysed in the scope of this study outlined the difficulty to find, hire, and retain technical experts. The number of technical experts and skilled workers is lagging behind demand, and therefore addressing the skill shortage of the smart cities' workforce has become vitally important[120]. Another factor contributing to this challenge is the lack of modernisation of working methods and habits within public administrations. As described in the literature, "the traditional approach in project management applied in public sector often causes difficult team communication due to high hierarchy and excessive bureaucratisation of project processes in the pursuit of enhancing control and accountability"[121].

To enhance the attractivity and retention of technical profiles, the public sector should evolve towards more **flexible contracts and work schedules**. Regarding working habits, public administrations should involve technical experts from the start of the ideation process instead of consulting them at the implementation phase and follow an **agile** organisation and methodology when relevant. Agile project management is characterised by rapid iterative cycles of planning and development that allow a project team to constantly evaluate its work and receive immediate feedback from other team members and, if possible, from

[115] OECD, 2019, Enhancing the Contribution of Digitalisation to the Smart Cities of the Future, Available online, URL: https://www.oecd.org/regional/regionaldevelopment/Smart-Cities-FINAL.pdf
[116] Ibid.
[117] United Nations - ECOSOC. 2016. Smart cities and infrastructure. Available online, URL: www.unctad.org/meetings/en/SessionalDocuments/ecn162016d2_en.pdf.
[118] Co-funded by the Erasmus+ Programme of the European Union, this project supports the elaboration of a competence map, referent competence framework, recognition and validation of new curricula and training materials for staff, managers, and experts of smart cities at European level, who are currently recruited or will be engaged to work for the cities after the respective training. Overall, this project supports the learning paths for the newly emerging roles/professions of smart city experts, personnel and managers. More information on the Skills4Cities project.
[119] The Smart DevOps MOOC dives deep into the subject of smart cities, and their evolution in Europe. Organised by experts of the Erasmus+ Sector Skills project (DevOps Competences for Smart Cities), the aim of the course is to chart a path to professional development in smart cities. More information here.
[120] Panagiotakopoulos, T., Iatrellis, O & Kameas, A. Emerging Smart City Job Roles and Skills for Smart Urban Governance. Building on Smart Cities Skills and Competences (pp.3-19), 2022, doi:10.1007/978-3-030-97818-1_1.
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stakeholders[122]. Therefore, this method is more indicated for the development of smart initiatives such as the establishment of data spaces and local digital twins and allows for the empowerment and cohesion of all team members, including technical experts.

Another way to mitigate this challenge is to complement public administrations' internal expertise by **reinforcing partnerships with external stakeholders** such as universities, research centres, and companies. To do so, a close cooperation with local regulatory and procurement experts should be organised. Rather than asking for specific functions or expertise, **open calls** can inspire innovation on the part of providers. This way, private actors are challenged to develop solutions taking into account the requested services while also contributing ideas of their own[123].

[122] Ibid.
[123] Borsboom, J., Gindroz, B., Costa, S. & Georgiev, G.. Smart City Guidance Package - A Roadmap for Integrated Planning and Implementation of Smart City projects. 2019, available online: https://www.researchgate.net/publication/343615678_Smart_City_Guidance_Package

5 Conclusion

Local and regional public authorities can face a series of organisational and cultural interoperability challenges when establishing local digital twins and data spaces. Both types of challenges appear to be applicable to local digital twin and data space projects in a similar fashion.

Organisational interoperability challenges hinder the collaboration among stakeholders involved as well as the outreach of smart city initiatives. The definition of common objectives is the steppingstone of the establishment of local digital twins and data spaces. The successful adoption of the smart city initiative depends on its ability to respond to well-defined citizen needs. Once the objectives are defined, the definition of leadership responsibilities and common processes appears as a key enabler for the successful implementation of the project as smart city initiatives involve numerous stakeholders in line with the quintuple helix model (i.e., government, citizens, academia, non-profits, and businesses). The coordination and involvement of multiple stakeholders allow the implementation of strong data management processes, guaranteeing high data quality. Moreover, organisational aspects can help alleviate technical interoperability issues. The elaboration of clear and harmonised guidance regarding common standards and the use of building blocks and reusable solutions can contribute to ensuring interconnection between systems.

In addition to organisational challenges, local and regional authorities can face cultural interoperability challenges stifling data-sharing, thus impeding the development of data-driven opportunities. Data sharing-based projects can represent a paradigm shift for public and private organisations managing their data in silos. Data openness being the cornerstone of local digital twins and data spaces, their success heavily depends on cultural change fostering collaboration, trust, and data exchanges which can be accompanied by a change management programme. The question of trust appears to be one of the main challenges preventing data sharing as organisations can be reluctant to share sensitive and/or commercial information or doubt the alignment of participating parties' interests. Identifying and raising awareness on the benefits of smart city initiatives can help public administrations overcome these cultural challenges. However, the lack of monitoring and evaluation frameworks specific to data spaces and local digital twins makes this mitigation action difficult to implement. These efforts need to be accompanied by a change of human resource policies, as local and regional authorities can face a shortage of personnel with the adequate digital skills and expertise required to establish smart city projects.

The next deliverable to be conducted under this study will detail the roles and responsibilities of each type of stakeholders to tackle the abovementioned challenges. In addition, the workflows and processes that can mitigate these organisational and cultural interoperability challenges will be analysed. Ultimately, the final report will include recommendation for the update of the recommendations of the EIF4SCC, as well as recommendations for the establishment of European common data spaces and the interconnection of local digital twins.

Annex 1 – List of stakeholders consulted

This annex provides the list of interviewees consulted for the scoping interviews, the complete list of smart cities and their related smart projects mentioned during the consultation activities, as well as additional smart city initiatives identified at the Flanders Region in Belgium and Amsterdam in the Netherlands.

1. Stakeholders consulted for the scoping interviews

The Project Team conducted eight interviews for the consultation activities:

- Tanguy Coenen, Digital Transformation Strategist at imec
- Karl-Filip Coenergrachts, Head of Urban Platform at OASC
- Lea Hemetsberger, Bid and Relationship Manager at the German Data Competence Centre for Cities and Regions
- Lodewijk Noordzij, Policy Advisor Digital Transformation at Eurocities
- Marek Bobis and Anke Schuster, Policy Officers at the Secretariat-General of the European Committee of the Regions - Directorate for Legislative work 2 - ECON — Commission for Economic Policy and Policy Officer of Digital Europe at eh European Committee of the Regions.
- Margarida Coquim Campolargo, Community and Project Manager at OASC
- Michael Mulquin, MIMs Ambassador at OASC
- Sven Schade, Team Leader at the Joint Research Centre (JRC)

2. Stakeholders consulted for the in-depth interviews

The Project Team conducted 14 interviews for the consultation activities[124]:

- Tom van Arman, CEO at Tapp
- Paula Autio, Digital Twin Specialist at municipality of Helsinki
- Javier Bono, Architect at Arquea
- Raf Buyle, Digital Flanders
- Simon Claus, Expert Smart Data at Digital Flanders
- Ernesto Faubel, Head of Valencia's Smart City Office
- Ignoacio Guillen, Professor at the Polytechnic University of Valencia
- Griet Heuvelmans, Project Leader at Digital Flanders
- Willem Koeman, Manager at the Amsterdam Economic Board
- Joep Meindertsma, CEO at Ontola
- Géraldine Nolf, Product owner at Digital Flanders
- Javier Orozco-Messana, Policy officer at European Commission
- Lieven Raes, Smart City Advisor at Digital Flanders
- Timo Ruohomaki, Programme director at Forum Virium Helsinki
- Ziggy Vanlishout, Programme Manager Smart Data Services at Digital Flanders

3. Stakeholders consulted for a focus group

[124] Some of the interviewees listed participated in a joint interview.

The Project Team organised a focus group to validate the findings of the previous data collection activities. Attendance to the focus group included:

- Tom van Arman, CEO at Tapp
- Paula Autio, Digital Twin Specialist at municipality of Helsinki
- Simon Claus, Expert Smart Data at Digital Flanders
- Martine Delannoy, Project leader at Digital Flanders
- Cornelia Dinca, International liaison offer at Amsterdam Smart City
- Ernesto Faubel, Head of Valencia's Smart City Office
- José Luis Alapont Ramón, Professor at the Polytechnic University of Valencia
- Kris Cauwenberghs, Expert Climate Services & Market Oriented Development at Flemish Environmental Agency
- Joep Meindertsma, CEO at Ontola
- Géraldine Nolf, Product owner at Digital Flanders
- Javier Orozco-Messana, Policy officer at European Commission
- Lieven Raes, Smart City Advisor at Digital Flanders
- Anthony Simonofski, Professor of Digital transformation at University of Namur.

6 Annex 2 – Data collection tools

This annex provides the questionnaires used by the Project Team to conduct the interviews with the stakeholders.

6.1 Scoping interview questionnaire

General introduction

1. Provide a short overview of your organisation and any background information regarding your expertise on [smart cities, data spaces, local digital twins or interoperability].

The role of the EU

2. To what extent the key principles guiding the creation of European common data spaces, (such as the respect of EU rules and values, openness, interoperability, accessibility) could be applicable to the establishment of local or regional data spaces?
3. How does the EU legal framework enable the adoption of data spaces and/or local digital twins in Europe?

Smart cities and communities

4. What would, in your opinion, be the pre-conditions needed for a city to embark on the path to become a smart city?
5. What are, in your opinion, the greatest benefits for cities in developing smart initiatives allowing evidence-based decision-making processes?

Local Digital Twins and Data spaces

6. What are, in your opinion, the main benefits for regions and cities in implementing data spaces and/or local digital twins within their public administrations?
7. What are, in your opinion, the preconditions/foundations needed within regional and local public administrations to invest in setting up data spaces and/or developing interconnected local digital twins?
8. What would be your top three guiding tips for any regional and local public administration who would want to set up a data space and/or develop a local digital twin?
9. Do you have any specific success story of a regional or local government who implemented data spaces and/or developed a local digital twin that you would be willing to share with us? What major factors made it, in your opinion, particularly successful?
10. What advice would you give to regional and local authorities wishing to adopt a holistic and multidisciplinary approach to its project development, so as to potentially up-scale its smart initiative in the future?
11. In your opinion, what would be the preconditions to build an interconnection between different data spaces at local/regional level? Could this interconnection be also envisaged at cross-border level? If so, how?

Interoperability

12. What are, in your opinion, the main interoperability barriers that hinder the deployment of local digital twins and/or data spaces within European public administrations?
13. Would cultural differences pose a threat to the creation and subsequent deployment of local digital twins and/or data spaces? If so, how?

14. Recommendation #5 of the EIF4SCC, which is focused on interoperability governance, encourages cities to promote a collaborative and open approach in the development of a smart city. Therefore, what kind of initiatives should cities invest in or focus on so as to ensure their compliance with the above-mentioned recommendation?
15. [Optional] In your opinion, to what extent the Minimal Interoperability Mechanisms (MIMs) could further enhance the development of data spaces and/or local digital twins in Europe?
16. [Optional] How are the MIMs complementing other principles and standards enhancing interoperability such as FAIR or INSPIRE?
17. [Optional] How would you define the concept of 'minimum common ground'? In more practical terms, do you believe that this concept is contributing to the promotion of organisational and cultural interoperability? If yes, could you give us an example?

Final remarks

18. Is there anything else that you would like to share with us?

6.2 In-depth interview questionnaire

Context and background

1. Could you please briefly describe the context in which the smart city strategy/programme was first developed by your administration?
2. In your opinion, what were the factors that encouraged/enabled your administration to embark on the development of smart initiatives such as data spaces and interconnected digital twins?
3. To what extent has the EU legal framework and the key principles guiding the creation of European common data spaces, (such as the respect of EU rules and values, openness, interoperability, accessibility) enabled the uptake of smart initiatives and the implementation of data spaces and/or digital twins by your administration?

Setting up data spaces / digital twins

4. Which were the strategic actions taken for creating a specific programme to implement data spaces / digital twins by your administration?
5. Who were the key internal stakeholders, and which were their responsibilities when setting up data spaces / digital twins at your administration?
6. Once the project was launched, which were the key external stakeholders engaged or consulted and which was their role when setting up data spaces / digital twins at your administration?
7. What type of partnerships (private sector, academia, etc.), if any, were needed to ensure the deployment of data spaces / digital twins at your administration?
8. How was interoperability taken into account when setting up data spaces / digital twins within your administration?

Organisational interoperability challenges

9. What were the main organisational interoperability challenges faced by your administration when setting up data spaces and/or digital twins?
10. With reference to your answer above, how were these organisational interoperability challenges addressed within your administration?

Cultural interoperability challenges

11. What were the main cultural interoperability challenges faced by your administration when setting up data spaces and/or digital twins?
12. With reference to your answer above, how were these cultural interoperability challenges addressed within your administration?

Benefits of implementing data spaces and digital twins

13. What are, in your opinion, the main benefits for your city / region in implementing data spaces and/or digital twins within your public administration?
14. When considering the cross-border dimension, what would be, in your opinion, the benefits of promoting the interconnection of different data spaces at local/regional level?

Minimal Interoperability Mechanisms (MIMs)

15. Are you familiar with the Minimal Interoperability Mechanisms (MIMs)?
16. If yes, in your opinion, to what extent the MIMs supported your public administration to overcome organisational and/or cultural interoperability challenges? Could you give us illustrative examples?

Final remarks

17. Based on your experience implementing data spaces and/or digital twins, what would be your recommendations for the roll-out of a European-wide smart communities data space and interconnected local digital twins?

7 Annex 3 – Glossary

Term	Definition	Reference
Cultural interoperability	It refers to the approach taken by individual and organisations to take into consideration their social and cultural differences and, if applicable, organisational cultural differences. Interoperability can be impacted by cultural differences, as individuals and organisations can respond differently to the same interoperability challenges. These cultural differences can, for example, be reflected in political challenges and leadership styles. Different actors within a smart city can have varying views on how leadership, in the context of interoperability, is exercised.	Proposal for a European Interoperability Framework for Smart Cities and Communities (EIF4SCC)
Data spaces	Seamless digital area where data providers, users and intermediaries apply the same standards to the storage and sharing of data so as to make a large pool of data available, combined with the technical tools and infrastructure necessary to use and exchange data, as well as appropriate governance mechanisms.	Annex to the Commission Implementing Decision on the financing of the Digital Europe Programme and the adoption of the multiannual work programme for 2021 - 2022
Interoperability	Ability of organisations and individuals to interact towards the delivery of services in cities and communities, through the exchange of data, information and knowledge, enabled by aligned processes and digital technologies, taking into account security and privacy issues	Proposal for a European Interoperability Framework for Smart Cities and Communities (EIF4SCC)
Local digital twins	Virtual representation of a city's physical assets, using data, data analytics and machine learning to help stimulation models that can be updated and changed (real-time) as their physical equivalents change.	EU DG CNCT - 'Digital twins for cities' (2021), European Week of Regions and Cities
Organisational interoperability	It refers to the way in which organisations align their processes, responsibilities and expectations to achieve commonly agreed goals. It means documenting, integrating or aligning processes and exchanging relevant information. It also aims to meet the requirements of users by making services available, easily identifiable, accessible, and user focused. Furthermore, active involvement of the user community can be part of the organisational interoperability component.	Proposal for a European Interoperability Framework for Smart Cities and Communities (EIF4SCC)
Smart city	A smart city or community aims at the well-being of its inhabitants, businesses, visitors, organisations and administrators by offering digitally enabled services that contribute to a better quality of life.	Proposal for a European Interoperability Framework for Smart Cities and Communities (EIF4SCC)

8 Annex 4 – Bibliography

This annex provides the list of documents that were consulted by the Project Tteam as part of the secondary data collection.

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9 Annex 5 – Use cases

This annex presents the use cases analysed by the Project Team.

9.1 Use case #1: Flanders Smart Data Space

Through its Digital Flanders initiative launched in 2021, the Flanders region in Belgium developed multiple initiatives on data spaces, as well as a local digital twin[125]. The smart initiatives linked to data include: the creation of personal data spaces (Solid project), the Flemish Data Utility Company and the Flanders Smart Data Space (VSDS), whose developments are ongoing under the Flemish Resilience and Recovery Plan adopted in 2020. This use case will be focused on the last initiate, the Flanders Smart Data Space for which an overview is provided in Error! Reference source not found. below.

The Digital Flanders initiative is built on the progress made under another programme of the Region, named Smart Flanders. This programme was put in place in 2017 and relaunched in 2021 by the Flemish Government to accelerate innovation in cities on the basis of linked open data. 13 Flemish cities[126], including large municipalities (such as Antwerp) and smaller municipalities, are part of Smart Flanders, together with the Flemish Community Commission (VGC) in Brussels. Under this programme, the Flemish government and two research centres, imec and VITO, worked together in a co-creative process with the business community and local authorities to draw up the Flemish Open City Architecture (VLOCA), designed as a support frame of reference for developing projects in Flemish municipalities or regions. It contains agreements and guidelines on interoperability between different IT systems and the exchange of data.

Table 1 Overview of the Flanders Smart Data Space

<table>
<tr><th colspan="4">Flanders Smart Data Space</th></tr>
<tr><td colspan="2">Lead organisation(s) name(s)

imec and VITO (research centres), Digital Flanders (agency of the Flemish Government)</td><td colspan="2">Type of smart city initiative

Data space</td></tr>
<tr><td>Administrative level

Sub-national, Regional</td><td>Geographic coverage

Flanders, Belgium</td><td>Start-End date

2021</td><td>Still active

Yes</td></tr>
<tr><td colspan="4">General description

Digital Flanders created the Flemish Smart Data Space in 2021, to ensure the sustainable publication and consultation of sensor data and their context information. The Flemish Smart Data Space is a project designed to contribute to connecting data silos. Currently focused on smart mobility, Digital Flanders has the ambition to extend the smart data space to other domains, such as water management and healthcare[127].</td></tr>
</table>

[125] More information on other smart initiatives of the Flanders Region can be found in **Error! Reference source not found.**.
[126] Aalst, Aalter, Antwerpen, Brugge, Genk, Gent, Halle, Harelbeke, Hasselt, Kortrijk, Leuven, Mechelen, Oostende, Roeselare, Sint-Niklaas, Turhout and Zoersel.
[127] More info on the Flanders Smart Data Space is available here (in Dutch).

Flanders Smart Data Space
Technical description As a decentralised solution, the Flemish Smart Data Space uses a joint ecosystem with clear rules to ensure the interoperability of the systems, allowing users to smartly share, publish and reuse data. The initiative has a strong focus on data accessibility, data integration and interoperability standards, agreements and software components, including the Open Standard for linked Organisations (OSLO) and the publication of FAIR data (Findable, Accessible, Interoperable and Reusable).

Source: Author's own elaboration

9.2 Use case #2: Amsterdam Data Exchange (City of Amsterdam, the Netherlands)

For more than 12 years, the city of Amsterdam in the Netherlands developed numerous smart city initiatives, such as the Amsterdam Data Portal and Smart Health Amsterdam, and is considered as a pioneer city in exploring the possibilities of improving urban life with data analytics.

Since its conception in 2009, the Amsterdam Smart City initiative, initiated by the Amsterdam Economic Board and supported by the municipality and a wide network of stakeholders, has facilitated over 80 pilot projects aimed at making the city smarter. Designed as a project incubator, this initiative has been materialised by an open innovation platform named Amsterdam City Platform, which allowed the city to test a wide variety of initiatives, share the results and communicate with citizens. The city is thus conceived as a laboratory of innovations where new modes of financing, technologies and cooperation help to implement a more efficient urban territory and to change mentalities on a large scale. Another key characteristic of Amsterdam to consider is that the city developed its first open data policy in 2011 and has extensive experience with the management of open data, mainly acquired through its work on the local open data portal.

This use case will be focused on Amsterdam Data Exchange, for which a brief overview is provided in Error! Reference source not found. below.

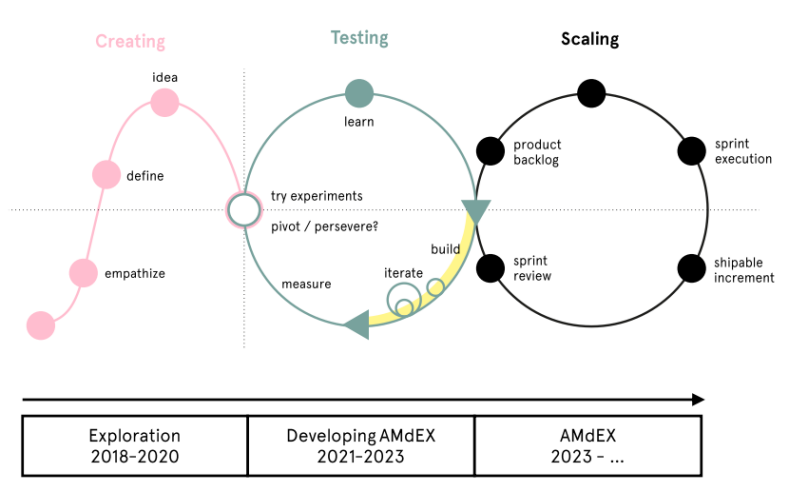
Table 2 Overview of the Amsterdam Data Exchange

Amsterdam Data Exchange			
Lead organisation(s) name(s) Amsterdam Economic Board, Science Park Amsterdam (European hub for digital innovation and sustainability)		*Type of smart city initiative* Data space	
Administrative level Sub-national, city	*Geographic coverage* Amsterdam Metropolitan area, the Netherlands	*Start-End date* 2018	*Still active* Yes

Amsterdam Data Exchange

General description

Amsterdam Data Exchange, or AMdEX, focuses on the co-design and co-development of a neutral and independent infrastructure for trusted data sharing, which will serve as a mechanism to facilitate local, European and international cooperation in a transparent open data market. Neutral because all data is treated equally, with no discrimination based on user, content or application, and independent as the infrastructure is not in the hands of one party but operates as a public facility, in order to accelerate the creation of trusted data spaces. AMdEX's ambition is to provide a neutral infrastructure that provides and executes reliable data sharing archetypes, that could be integrated by technology provider into their products and services.



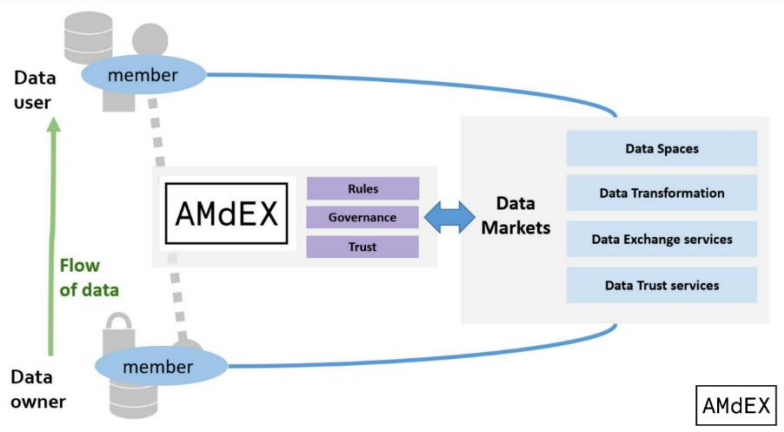
Source: AMdEX's presentation[128]

In development since 2018, AMdEX is a collaboration between the city of Amsterdam, AMS-IX, the University of Amsterdam, SURF and the Amsterdam Economic Board, and is co-funded by the European Regional Development Fund[129].

[128] Koeman W. (2021) AMdEX Meet-up 2 Presentation. AMdEX, Available online, URL: https://amdex.eu/wp-content/uploads/2021/12/20211202-AMdEX-Willem-Koeman-Amsterdam-Economic-Board.pdf
[129] More information on Amsterdam Data Exchange is available here.

Amsterdam Data Exchange

Technical description



Source: AMdEX presentation[130]

AmdEX ensures that data can be shared in a controlled, reliable and secure manner under the owner's conditions without the intervention of a third party. Data owners determine and control who is allowed to use which data, with which algorithms and for what purpose. As a trust provider, AMdEX aims to achieve two objectives: assist with finding the right conditions of data sharing by providing digital templates and experience and monitor the enforcement of these conditions by digital means, without being a platform or a data common[131].

Source: Author's own elaboration

9.3 Use case #3: Helsinki Digital Twin (City of Helsinki, Finland)

Over the last three decades, the Finnish city of Helsinki has pushed for an early adoption of computer-aided design, 3D city mapping, and, later, full-scale digital twins. As stated in the Helsinki City Strategy (2021-2025), the city seeks to be the most functional city in the world and to become carbon neutral by 2035. These goals are pursued through the digitalisation of local services and by the development of smart urban solutions.

As Amsterdam, Helsinki started to work on smart initiatives in 2011 by opening its data and developed more than 25 smart projects[132] since then, including the creation of an open data portal, Helsinki Region Infoshare, which is used today for decision-making processes, as well as for the evaluation of municipal activities. Most of Helsinki's smart initiatives have been led by the Forum Virium Helsinki, the city-owned innovation company founded in 2005 to develop local digital services, in collaboration the city's executive office and units, local businesses, universities and Helsinki residents. Building on its experience with open data, the city of Helsinki developed its first local digital twin in 2015, named 3D+ Digital Twin. The idea was to produce

[130] Koeman W. (2021) AMdEX Meet-up 2 Presentation. AMdEX, Available online, URL: https://amdex.eu/wp-content/uploads/2021/12/20211202-AMdEX-Willem-Koeman-Amsterdam-Economic-Board.pdf
[131] Goené R. AMdEX and data commons. Waag, 2022. Available online: https://amdex.eu/wp-content/uploads/2022/11/20221101-AMdEX-data-commons-Waag-Robert-Goene.pdf
[132] Helsinki's smart city development can be seen in many districts including Kalasatama (considered as the 'showroom' of Helsinki smart development), Jätkäsaari, the Maria 01 start-up campus and Otaniemi.

a 3D representation of the city to improve internal services and processes, promote smart city development and share city models as open data to citizens and companies for research and development. Since its creation, the 3D+ Digital Twin have been expanded to different pilot projects.

The use case will be focused on Helsinki's 3D+ Digital Twin, described in Error! Reference source not found. below.

Table 3 Overview of the 3D+ project in Helsinki

The 3D+ project in Helsinki			
Lead organisation(s) name(s) City of Helsinki (3D+ unit), Forum Virium Helsinki	*Type of smart city initiative* Local digital twin		
Administrative level Sub-national, city	*Geographic coverage* Helsinki, Finland	*Start-End date* 2015	*Still active* Yes
General description Created in 2015, 3D+ is one of the world's longest-running digital twin programmes. Helsinki executed its first urban digital twin pilot project in the Kalasatama district (2018-2019), with the aim to observe how changing weather conditions impacted the district and its environment over time and help the city meet its net-zero carbon goals by 2035. Lessons from Kalasatama will next be applied in the districts of Pasila, Malmi and Kannelmäki. Other applications of the 3D+ project address areas related to renovation history and energy data, heat savings, geo-energy and other alternative energy potential (Helsinki Energy and Climate Atlas). Helsinki's Energy and Climate Atlas is a free online application, which contains information on renewable energy and energy renovations throughout the entire Helsinki area. The atlas is meant for anyone to use, e.g., city planners, housing associations, citizens and also companies offering energy solutions.			
Technical description The local digital twin is supported by two next generation 3D city models of Helsinki; a semantic city information model (City GML model) and a visually high-quality reality mesh model. The City GML model is more scientific, allowing users to perform a variety of analyses, while the reality model, which is physically more accurate, can be utilised in various online services or for design projects. The reality mesh centralises data for rendering the city via various game engines, including Unreal Engine, Unity Engine, and Minecraft. The models are both available as open data.			

Source: Author's own elaboration

9.4 Use case #4: Valencia Digital Twin (City of Valencia, Spain)

The city of Valencia in Spain started its path to become a smart city in 2014. It was the first European city to successfully implement a smart city platform, the VLCi Smart City platform, based on open and interoperable standards. The same year, Valencia launched its open data portal. Since then, the city worked on various

smart initiatives linked to mobility, lightning and waste management, and tourism, among others[133]. Given the evolution of these projects and the importance of centralising the management of ICT, a specific Smart City Office was created in 2018, as a separate municipal service.

In parallel to these projects, a local digital twin focusing on water management, named GoAigua Digital Twin, have been developed for the past 13 years as the result of a public-private partnership between two compagnies, Idrica and Global Omnium, and the local public administration. In operation since 2009, it is considered as a best-in-class example of a local digital twin focused on water management.

This use case will be focused on Valencia's Digital Twin, for which a brief overview is provided in Error! Reference source not found. below.

Table 4 Overview of Valencia's Digital Twin

Valencia's Digital Twin			
Lead organisation(s) name(s) Idrica, Global Omnium, Municipality of Valencia		*Type of smart city initiative* Local digital twin	
Administrative level Sub-national, city	*Geographic coverage* Valencia, Spain	*Start-End date* 2009	*Still active* Yes
General description The GoAigua Digital Twin, developed by Idrica and Global Omnium in collaboration with the city of Valencia, supports operational and management decisions across Valencia's metropolitan water networks.			
Technical description The local digital twin constantly leverages data from smart meters, pressure/flow sensors, and other systems to virtually replicate the behaviour of the network in real-time, with high accuracy. Regarding the IT infrastructure, the local digital twin relies on a data-centric platform, supported by big data capabilities, that allows them to collect more than 6 billion data points per year from the entire utility system and translate that data into valuable insights for the operation. This platform has been complemented by an IT platform in 2010, along with a scientific data unit, incorporating disruptive technologies such as machine learning and artificial intelligence. Today, the GoAigua platform integrates information coming from different vendors and equipment including on-field components, IoT devices, proprietary and third-party data.			

Source: Author's own elaboration

[133] More information on the smart initiatives of Valencia can be found here.

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innovation ∞ govtech ∞ community