DIGITAL TER-X 2050 a Construction Data Space Ecosystem

# POSITION PAPER

**About this document:**

Digital TER-X 2050 is a Gaia-X Qualified project aiming to establish a European framework for the Construction Data Space.

This document results from the collaboration between Building Smart Chapters from Portugal, France, Finland, Gaia-X Hubs from Portugal, France, Finland and Slovakia, DST Group, CCG, University of Aveiro and OASC.

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# Executive summary

This Position Paper (PP) advocates for the creation of a European Construction Data Space (DS) to address challenges and opportunities in the sector. The paper outlines the current state of the construction industry, identifies key operational and market issues, and proposes solutions centred around data sharing and interoperability. The authors consider relevant throughout this position paper the following aspects:

- **Construction: A European key industrial sector** - up to now the construction sector is not included in the scope of the Common European, Data Spaces and this document reminds the reader of the specific and key role of this sector in the European economy; 7% (Employment in the construction sector as a share of total employment in selected European countries in the first quarter 2024, n.d.) of the EU's total employment, fully localized in Europe. It also underlines the large contribution the sector makes to the carbon impact. Due to the potential of digital technologies already in place, such as the collaborative processes involved in Building Information Modelling (BIM) and Geographic Information Systems (GIS), the construction sector is very much focused on a more efficient and sustainable future.

- **Mature digitalization process** - all the above reasons justify the need to support the effort of the construction sector for progressing on solutions for a European framework of data spaces for construction and territories with a dedicated governance. As so, it highlights the importance of aligning with:
    - European data regulations such as the GDPR, Data Act (DA), Data Governance Act (DGA) and AI Act (AIA).
    - European directives on the use of open source and open data integration with trustworthiness, service orientation accessibility and transparency.
    - European initiatives as Gaia-X, IDSA, Fiware, the MIMs and SIMPL.

  This PP prompts the importance of the work being done on ISO and CEN standards, already in place, developed by the construction sector to support the interoperability of data and processes including open standards such as the MIM related to the BIM and GIS tools.

- **A market very much diverse and horizontal** – the specificities of this sector have significant differences with other industrial sectors:
    - The data and information to be shared by the different parties are managed by contracts under national or international regulation, such NEC in UK or FIDIC.
    - The market is not structured by a single key and head leader. Clients are multiple, with short term contracts (3 to 5 years), even though the building's life cycle is 50 or even 100 years.

  - For each contract, the parties are different. It is important to remember that at least 80% of the turnover come from SMEs.

- **Not a simple B2B market** - regarding the economy of the data sharing, this position paper details the relationships between parties, underlining that in most cases, data sharing economy cannot be considered as a simple B2B market due to the intermediation of authoring tools, given that there are no contractual relationships between the stakeholders and the Cloud hyper scalers.

- **Business cases versus System cases** - due to the role of a DS the authors consider crucial two features:
  - low carbon solution approach - the data processing can be done by authoring tools dedicated for this in a long-term perspective (~100 years, meaning longer than the software vendors life cycle) and
  - the DS should offer a panel of services, based on system cases, delivered and used by the authoring tools and collaborative platform for managing under standardized tools, the DA and DGA obligation and the interoperability around data and metadata.

  The business plan for the DS can be based on a progressive approach by a catalogue of system cases, available for any business case, creating a portfolio asset of data provider or consumers, increasing step by step.

Throughout System and Business Use Cases, the authors believe that a Construction DS, facilitated by a strategic intermediary like Digital TER-X 2050 – a Gaia-X endorsed project - can unlock the potential of data in construction by promoting collaboration, innovation, and a more data-driven approach to the sector's digital and green transformation. (htt)

# Introduction

In March 2023 the European Union (EU) updated the EU industrial strategy, which states the need to accelerate the green and digital transition of EU industry (htt) and its ecosystems, and which has resulted in the publication of 14 transition pathways, one for each industrial ecosystem. (htt)
Knowing that the construction sector is the second largest industrial ecosystem in the European Union economy, and that it employs around 25 million people, it is not surprising that construction is one of the 14 selected industrial transition pathways.
The construction transition pathway co-creation process was worked out with about 220 representatives from industry, public authorities, social partners and other stakeholders from different EU countries, together with European Commission, resulting in the development of the "Transition Pathway for Construction" report. This report points out concrete actions the authors believe will ensure the evolution of this ecosystem towards a tangible greener, more digital, competitive and resilient European economy, including new business models and the digitalization of the whole supply chain ensuring its deep transformation. (htt)
To that end, this document defines the position of a group of stakeholders willing to contribute to this work, enabling R&I&D from the requirements to the deployment of the construction ecosystem to achieve the twin transition (digital and green) enabling a new approach to the Construction Ecosystem. The main recommendations covered include: (htt)

1. Implement a European framework for a Data Space (DS) of territories and urban areas founded on standards and enabling a set of innovative services not only for the stakeholders, but also for the citizens.
2. Contribute to the creation of a secure, trustful and transparent Common Construction European DS, able to integrate and federate, among others, technologies such as Geographic Information Systems (GIS) and Building Information Modelling (BIM) for the common representation of the built and non-built environment in a holistic way.
3. Promote sharing of data along the entire Construction chain, facilitating a full digitalization of the sector, keeping control, security and sovereignty for the owners of all data.
4. Bring together planning and managing tools targeting the overall construction sector, including the orchestration with overlapping sectors, such us energy, waste, safety, mobility or infrastructures.
5. Improve the competitiveness of the European construction sector by improving resources efficiency, easing circularity and increasing supply chain digitalization.
6. Make available data allowing Life Cycle Assessment (LCA) during the entire life cycle of built assets, increasing the visibility on the materials used while fostering the use of increasingly sustainable materials and managing the carbon trajectory from a long-term perspective.

7. Create an association of stakeholders with the common goal of implementing a strong European construction ecosystem able to align efforts and detect and close critical gaps.
8. Learn from Common European Data Spaces in the process of being implemented to accelerate the development of such a Common Construction European DS.
9. Initiate a comprehensive approach for a business model for a DS, at the European and national level.

# Current Construction Industry Overview

The European construction sector is a weighty component of the European economy, contributing to employment, economic activity, and social development, being the 2nd most important sector in EU-27. In 2018, the EU-27 construction sector employed 9,54 million persons, from 3,3 million enterprises generating an added value of EUR 2,1 trillion. (Annual turnover of the construction industry in the European Union (EU-27) from 2011 to 2022) The latest data points to the employment of around 10,43 million people in 2021, accounting for approximately 7% of the EU's total employment. (htt1)
The workforce is diverse, ranging from highly skilled professionals such as architects and engineers to manual labourers, and there is a significant presence of SMEs, with many workers employed in small companies or as independent contractors.
Data from Eurostat from 2018 reflects, that across EU-27, the division 'specialized construction activities' is the largest construction division, accounting for 59.0% of construction value added and for an even higher share of construction employment (62.9%).
Most of the employees in the specialized construction activities, work on demolition, site preparation, and areas such as electrical installation, HVAC installation, plumbing, roofing, painting, scaffolding, etc. For the construction of buildings division, the value added was 26,7% and for the civil engineering division was 14,3%. (htt1)
The underestimation of the potential of digitalization in the construction sector is often highlighted through real-world project examples where advanced technologies like GIS (Geographic Information Systems) and BIM (Building Information Modelling) play critical, but overlooked, roles. For instance, in a large urban infrastructure project, the initial focus might have been on the use of BIM for optimizing the construction phase. However, urban organizations and territorial operators increasingly rely on GIS for broader spatial planning, environmental impact assessments, and resource management. In one such project, the failure to fully integrate GIS from the outset resulted in a lack of coordination between urban planners, engineers, and utility operators. This oversight led to delays in mapping underground utilities and integrating environmental data, which are critical for long-term sustainability and infrastructure maintenance. Had the power of GIS been more fully recognized and integrated with BIM from the beginning, the project could have experienced smoother coordination across all phases, leading to enhanced productivity, improved data management, and reduced costs. This example shows how the sector often underestimates the transformative impact of digital tools beyond BIM, ignoring the potential of GIS in creating smart, resilient cities.
In most cases, construction is viewed primarily as civil works. However, for a long time, due to environmental requirements, the construction approach has been integrated into the broader concept of the built environment, which extends beyond construction alone to include.

- The impact of evolution of digitalization and cloud computing.
- The influence of environmental issues and regulations, alongside digitalization through GIS.

- How productivity gains from digitalization are widely captured by dominant tech players—not only well-known hyperscalers like Google, Apple, Meta, Amazon, Microsoft, and (GAMAM), but also software vendors of authoring tools such as Autodesk, ESRI, Bentley, and Trimble.

The European INSPIRE Directive promotes a standardized framework for data platforms dedicated to territorial infrastructure, placing a strong emphasis on data harmonization and accessibility rather than solely on physical infrastructure. A construction DS that aligns with INSPIRE could facilitate standardized, interoperable, and accessible data sharing within the construction industry, complementing INSPIRE's existing framework for spatial data and advancing goals related to environmental sustainability, digital transformation, and cross-border cooperation in the EU.

# Problem Statement

## Operational issues

The European Commission (EC) is actively promoting the adoption of digital technologies among its member states, advocating for the implementation of solutions such as BIM, GIS, Open Data, the Internet of Things (IoT), and Artificial Intelligence (AI). Alongside this digital transition, the EC is equally focused on driving a green transition, emphasizing sustainable construction practices, green building standards, carbon footprint reduction, sustainable material usage, and energy-efficient technologies. These digital innovations are essential not only for the digital shift but also for addressing the challenges of the green transition.

The challenges to implement the above recommendations are the same as in other sectors and can be summarized as the high initial costs of digital tools and technologies, the lack of digital skills among the workforce, and resistance to change.

In addition to these the construction sector is transversal, diverse and one that presents many discontinuities.

- **Transversal**: It intersects with many other industries, such as mobility (infrastructure usage), railway construction, nuclear projects, mining, and smart cities, to mention a few.
- **Diverse**: It includes a wide range of players, from small and medium-sized enterprises (SMEs), architects, and consultants to contractors, operators, and manufacturers. Not having a single key actor driving all the process creates an extra difficulty.
- **Discontinuity**: At each stage of a construction project, new stakeholders come in with their own processes and digital tools. In some cases, the digital workflow breaks down completely. For example, if there's no digital process for obtaining building permits, productivity drops when the digital output must be converted back into the old manual processes.

The adoption of advanced technologies and green strategies must consider the complexity of the construction sector. Another challenge is that SMEs, which represent over 80% of stakeholders in the construction industry, have a relatively low rate of digital technology adoption. This is partly due to the challenging conditions they face, including the strong influence of dominant technology suppliers, such as those providing authoring tools and cloud services. Despite the clear benefits - such as better project management, improved design accuracy, and more efficient resource use - most SMEs struggle to embrace these changes. With limited resources and often operating on tight, day-to-day margins, many are reluctant to alter their traditional ways of working.

## Market issues

When examining the key data transaction relationships in the construction ecosystem, a double decomposition must be done. These can be summarized as follows:

In most the cases, the data transactions are operated under contractual frameworks described by ISO 19650 by this schema shown Figure 1.

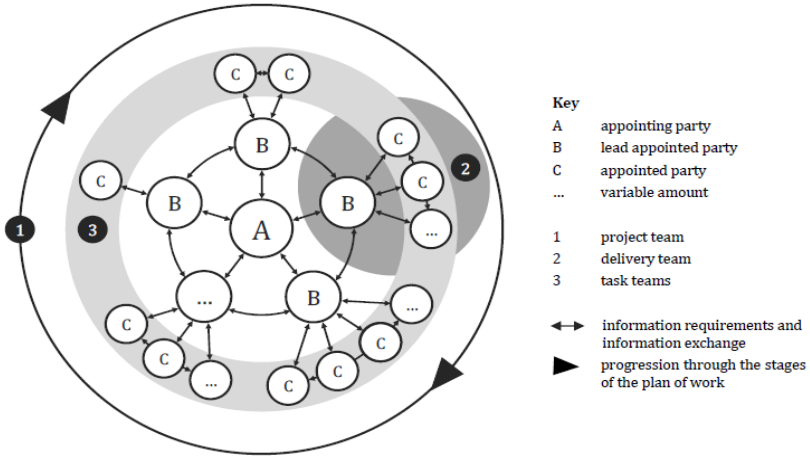



*Figure 1: ISO 19650 data transactions contractual framework*

Coming from ISO 19650 this figure shows the processes of sharing with different parties. In the context of ISO 19650:

- Information: data and metadata needed for using the data properly.
- A: the local authority contracting or appointing separately B entities such as designer, contractors, operators that may have roles of Data Producer, or Data User.
- B: a data or information producer appointed by A with the target to have the approval by A. The information will be published by A, to be shared with B, separately or on a collaborative platform with the Bs involved in the project, but also with C, as subcontractor of B.

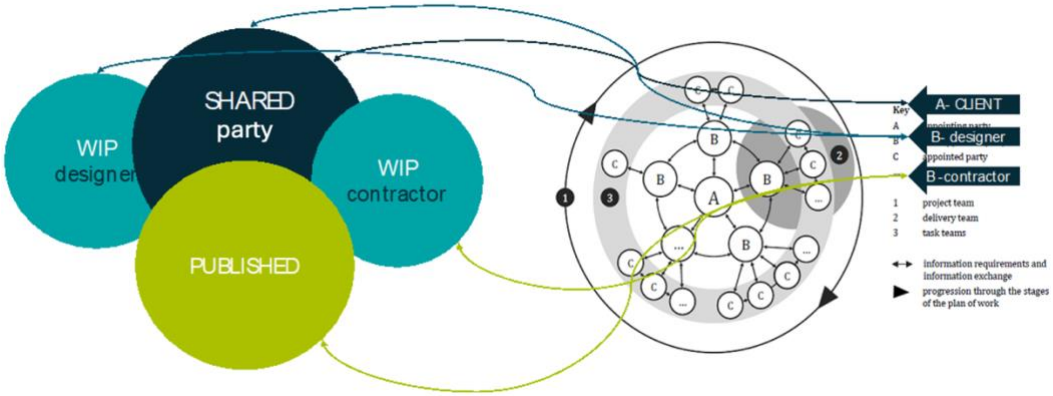



*Figure 2: ISO 19650: CDE, a collaborative approach and issues*

Figure 2 shows the workflow during the construction process, and what "shared party" means in a contractual process. The state of the information moves from "work in progress" to "shared" and to "published", where the Information means data and metadata. This state of the information are basic metadata needed for sharing information.

This schema proposed by ISO 19650 describes the workflow for parties involved in the contract (or business case).
And then there must be a description of how this workflow works. It is not simply a B2B: the ISO 19650 approach does say something about metadata to be shared but says nothing about the relation between the various parties and the cloud providers for the data and meta data.
In terms of data sharing economy (B2B)

- **B2B (Business to Business)**: the B2B approach can describe two options: the contract between the local authority and the contractor (A2B), or the contract between one of the parties and the cloud provider, or the contract between one of the parties and the software vendors (authoring tools and/or collaborative platform). The role of the data space is to propose services for solving all the issues not simply a B2B process and not described either in ISO19650 or by Data Act.

Next figures illustrate some schemas to detail the scope for sharing data:

- **B2B'2B": where B is the Appointing Party, B' is the Main Contractor and B" is one of the Subcontractor of B')**: This is a typical structure in the construction industry except that there is no perennity of this structure. B, B' and B'' are changing for each contract, operating only for few years, compared to the management of the construction once built, which may last 50 or 100 years. (Figure 3)


*Figure 3: B, B' and B"*

- **B2C (Business to Client)**: This relationship is less common in the construction industry except between the local authorities sharing information with the public through Open Data initiatives. It is an obligation to apply DA and DGA, but with no explicit business between B and C and no business at all between B', B'' and C. (Figure 4)


*Figure 4: C, B and B'*

- **B2B'2D:** In this case, B is the main appointed party (or possibly the appointing party), B' is the collaborative platform provider, and D is the hyperscaler (the cloud

provider). This is the most common scenario in construction, where B is contracted by the appointing party (local authority) to manage transactions via a collaborative platform (Common Data Environment). (Figure 5)

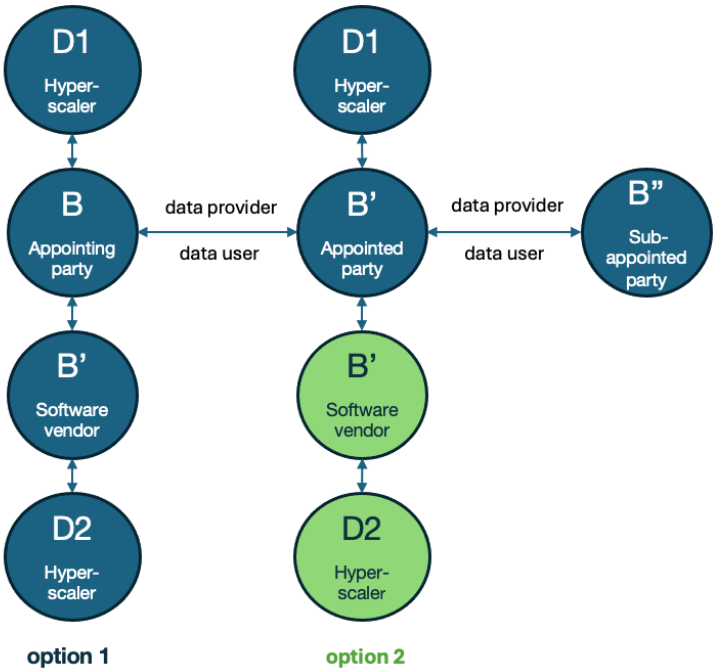



*Figure 5: B, B', D*

**Option 1**: the collaborative platform of Common Data Environment (CDE) such as defined by ISO 19650 is managed by the appointing party
**Option 2**: the collaborative platform is managed by the main appointed party.

A significant and massive challenge arises in the B2B'2D model, when B is a data producer that often has no direct contract with D (the hyperscaler) and may be unaware of the contractual terms between B' and D. This problem also exists in the B2B'2B'' setup, where managing relationships between multiple parties becomes even more complex.
The above breakdown helps clarifying regarding the requirements coming from DA and DGA and the capability to be compliant:

1) Large companies can manage B2B and even B'2B2C, however, in most of the cases, the challenges posed by B2B'2D and the adverse impact on productivity coming with the implementation of DA and DGA are not identified.
2) Local authorities, responsible for defining public works requirements (as per ISO 19650), will need to integrate DA and DGA compliance into the appointing party requirements. SME are clearly not able to move faster enough to accomplish in time DA and DGA requirements, that will be mandatory by 2025. As SME represent more than 80% of the stakeholders, this will impact negatively on the sector and will be the weakest link in the supply chain.

## Standardization issues

According to the European Edition of ISO standards 23386 and 23387, it is not expected that every country or region will adopt a single 'European' approach, as local realities often vary significantly. These variations lead to differences in terminology and how information is structured. The standards acknowledge that each country can have its own operating methods, terminology, and construction practices. What is essential is the development of Product Data Templates (PDTs), and governments should support their creation. PDTs are standardized formats used to define and organize detailed information about products, such as technical specifications, performance attributes, and compliance data, ensuring that this information is consistent, easily accessible, and compatible across different software systems and platforms. These PDTs will be connected globally through the Building Smart Data Dictionary, enabling a common understanding of construction data within a federated Data Space, fully in line with what is proposed with Digital TER-X 2050.

## Position and Argumentation

Digital TER-X 2050 is a Gaia-X Qualified project aiming to establish a European framework for the Construction Data Space, which is essential for promoting a data-driven approach to CO2 reduction. This framework will enable construction sector stakeholders to share data and information, creating mutual benefits while contributing to the overall goal of reducing carbon emissions. (htt2)

To turn this into a reality, we propose Digital TER-X 2050 as the Construction ecosystem **Data Space Strategic Intermediary** providing quality, transparency and confidence between the parts, being a SME intermediary and the direct interlocutor with contract management systems regarding the public market, whenever required. Creating such a Strategic Intermediary enables bringing onboard Construction participants, resulting in innovative Construction businesses at a global scale.

Digital TER-X 2050 as a strategic intermediary, operates on two distinct levels: strategic and technical. The strategic function creates value through the use of services, which must be managed under a unified governance framework. Regarding its technical role, Digital TER-X 2050 should be examined from the perspective of Use Cases (UC), including both business and system approaches (Business Use Cases and System Use Cases).

National and European levels must be analysed separately. At the national level, Digital TER-X 2050 plays both strategic and technical roles for two main reasons: the market structure and the need to comply with DA and DGA. By leveraging ISO 19650, including project delivery, the Construction Data Space can ensure strategic alignment globally by offering a standardized approach accessible to all stakeholders, including SMEs, starting with local authorities as clients. Since Digital TER-X 2050 is appointed by the entire ecosystem—including public authorities—it acts as a strategic vehicle in the market, safeguarding the interests of all stakeholders, promoting compliance with DA and DGA and ensuring neutrality in transactions. This also enables Digital TER-X 2050 to establish a solid technical framework that will support a variety of business cases while makes available the sharing of a catalogue of Digital TER-X 2050 services.

At a European level, and by following Gaia-X concepts of trust and interoperability, Digital TER-X 2050 will bring all the partners involved in its Data Space to follow the Gaia-X policy rules, use Gaia-X standards and any of the Gaia-X Digital Clearing Houses. Digital TER-X 2050 will interface with Gaia-X and will verify construction regulation compliance independently of the country in the world involved, enabling each country to manage its local catalogue. All the players are in concertation with EC enacted directives using the available tools, such as the MIMs, SIMPL and DSSC, that support data access and interoperability among European data spaces and will enable the creation of data-sharing standards aligned with European values

Figure 6 depicts the vision of Digital TER-X 2050 framework at a national level as well as at a European level

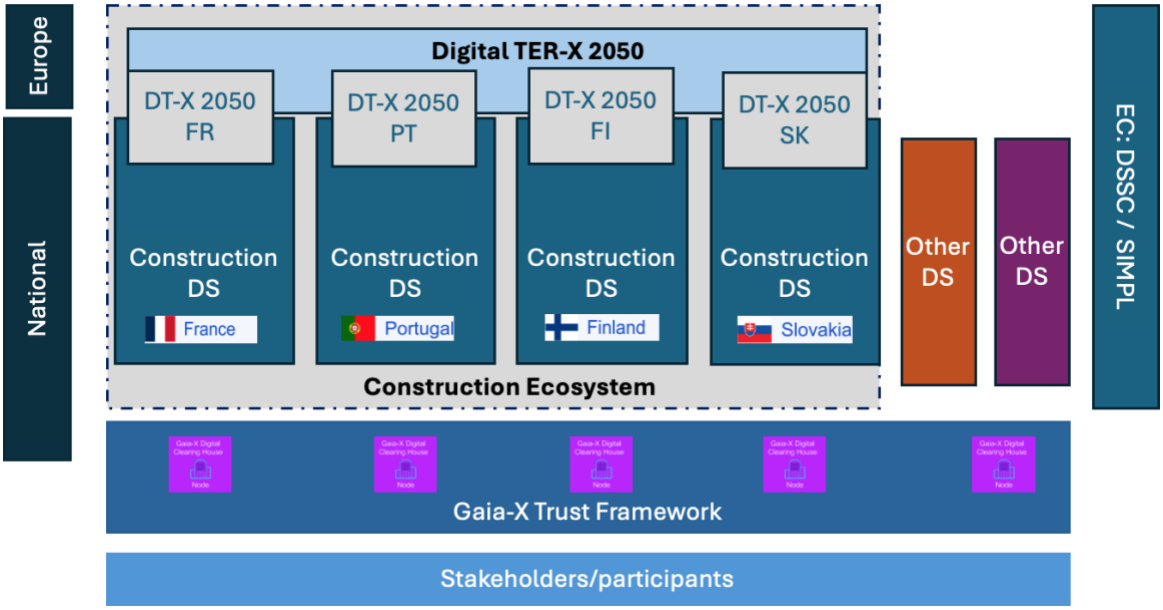



*Figure 6: Digital TER-X 2050 as a national and European Strategic Intermediary for the Construction DS*

The Digital TER-X 2050 consortium believes that all countries, even if they have their own internal data specifications and their own way of managing data, can have, through federated Data Spaces, a space where they can interoperate with information, where they can send and retrieve data in the correct formats, even though each one retains its own way of working.

# Impact Analysis

Considering the work made on (Eric brousseau), and looking at Figure 7, Digital TER-X 2050, positions itself as a **Strategic Intermediary**, requiring a public-private relationship and cross-subsidies, since data sharing will be a long-term process in the Construction sector as will be the return of investment.

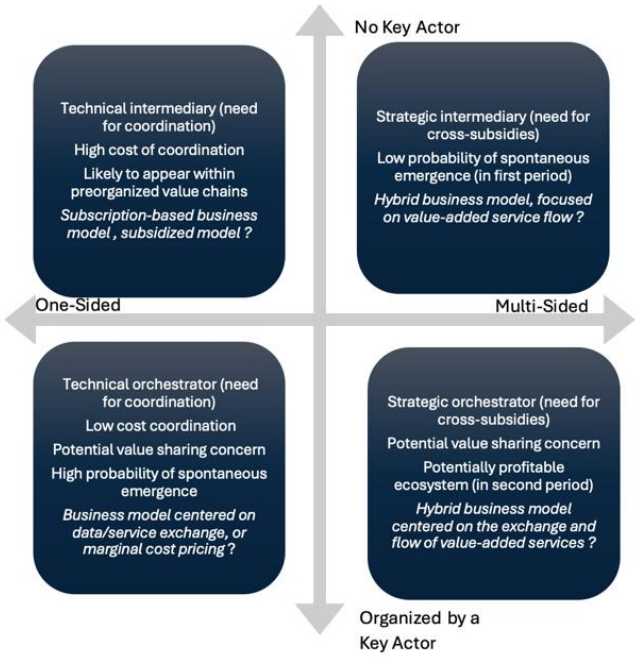



*Figure 7: Characteristics of value chains and their participants matrix (Eric brousseau)*

Due to the central role of public authorities, the need for a common approach for hybrid funding is central: the public sector does not want to pay private companies, but the reverse is even worse. Large companies could only accept delivering "common" services for SME, if the burden can be shared with the public sector. In addition, the question of funding is also a question of trust and confidence: a co-funding from public and private sectors, is the way for a data space to be considered as neutral, also from the sustainability perspective.

Figure 8 illustrates the benefits and costs of the ecosystem participants, as identified in (Eric brousseau).

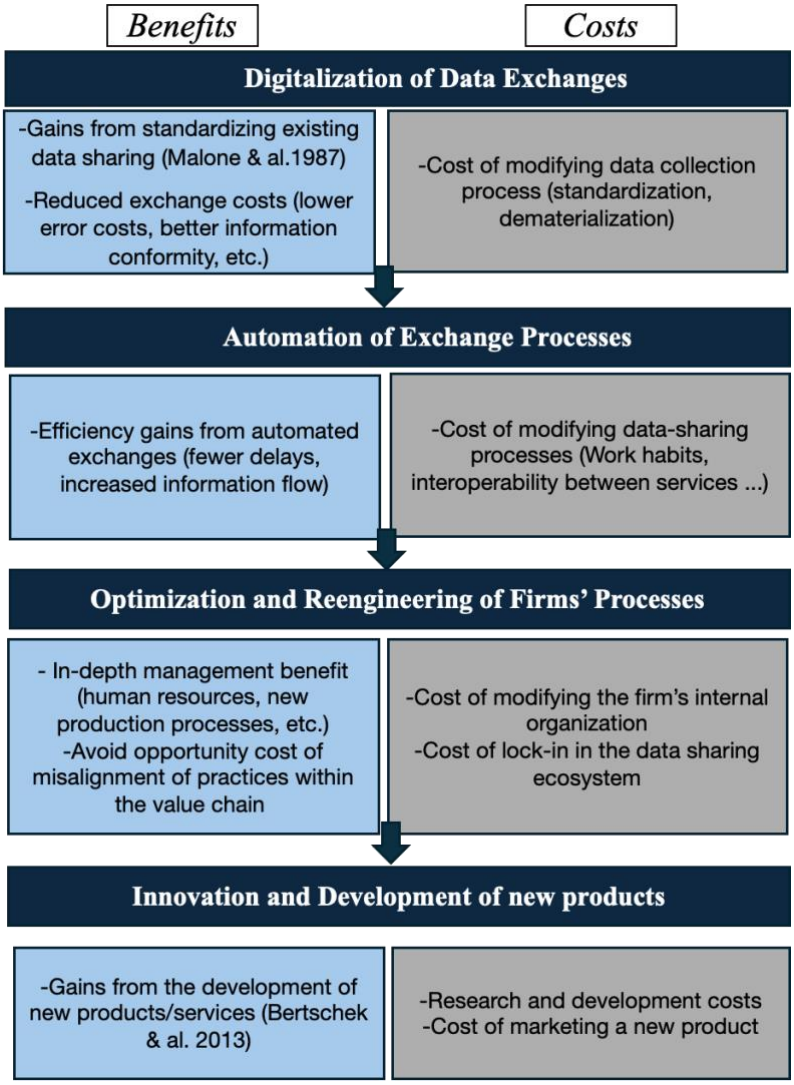



*Figure 8: Representation of ecosystem participants' benefits (Eric brousseau)*

It is worthwhile to mention that with DA and DGA entering into force, the costs mentioned in column two will come anyway, and Digital TER-X 2050 will not be an additional cost, but rather provide an opportunity for overall cost reduction. It presents itself as an opportunity, if we consider that there is already an obligation for the ecosystem to share information. Examples of contractual frameworks to share information are NEC contract in UK, FIDIC contract at the international worldwide and "CCAG" in France.

By opening up the opportunity of seamless data exchange between different software systems and platforms used by architects, engineers, contractors, and other stakeholders a Construction DS will enable data integration from various sources such as BIM (Building Information Modelling), CAD (Computer-Aided Design), GIS (Geospatial information system), ERP (Enterprise Resource Planning), IoT, and project/resources management tools enabling better tracking of project progress, schedules, and budgets, leading to improved overall management and on-time delivery.

As a matter of fact, having the supply chain fully digitalized and operating with standardized processes, will improve quality and will increase efficiency and productivity by streamlining the processes through automation, minimizing the errors, optimizing

resources and labour and contributing to regulatory compliance transparency and effective risk mitigation across the entire asset lifetime. Also, it will enable the creation of omni-channels between all the involved actors, easing communications and solving problems with unparalleled speed, even among SMEs, with benefits for all (Figure 9).
A DS is an extraordinary tool in assisting the management of the entire lifecycle of construction assets from design and construction to maintenance and decommissioning. Throughout the creation of digital twins, it will be possible to interconnect buildings, urbanizations, infrastructures towards intelligent territories offering citizens a better quality of life.

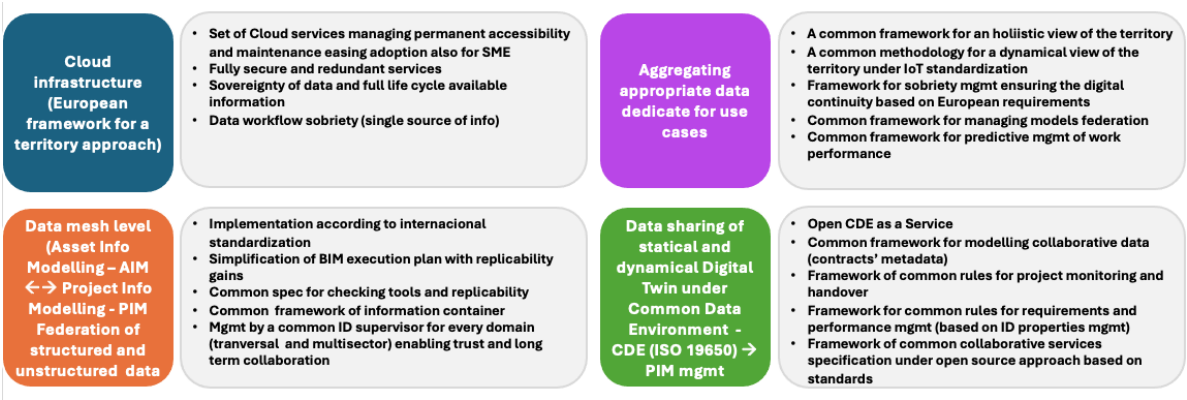



*Figure 9: Benefits for all stakeholders*

A survey is currently underway to quantify the potential improvements for each KPI achievable through the implementation of Digital TER-X 2050.

# Policy, Regulation and Standardization on the Construction industry

The future of the European economy is driven by the digital economy, a new way to build value on top of the existing physical ecosystems, products, and services, using data. Stakeholders of this new economy will require legislation and regulation to enable a trustful, effective and fair environment.

The implementation of a Construction DS involves understanding how EU regulations interact and apply to the governance, management, sharing and protection of data. Currently work on this domain includes the General Data Protection Regulation (GDPR), Digital Services Act, Digital Markets Act, Data Act, Data Governance Act and Artificial Intelligence Act. (Regulatory Compliance, n.d.), (Building a Robust Data Compliance Framework: A Comprehensive Guide for Organizations, n.d.)

Figure 10 presents a set of steps required to have an EU compliant DS, integrating data regulatory frameworks, generating trust among the stakeholders who, in turn, will adhere more strongly to the DS and to the opportunity to have a new source of income.

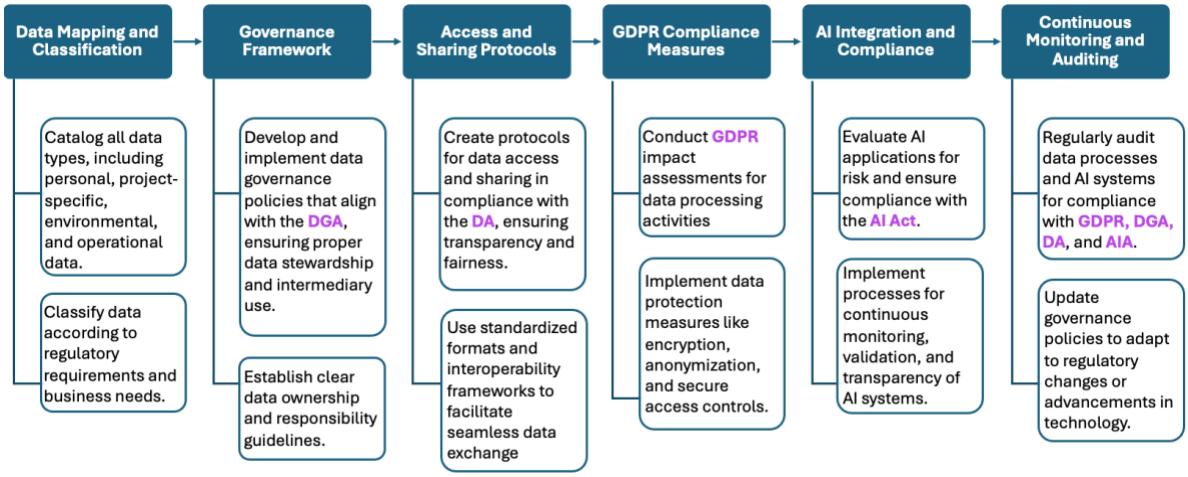



*Figure 10: Practical Steps for Data Space Compliance*

There also exist regulations for sustainability, environment (green buildings: compliance with various regulations often requires additional expenditures for materials, permits, consultants, and legal services), among others. (htt2) bring the attention to the Net-Zero Industry Act (NZIA) as a tool enabling the acceleration towards the transition to climate neutrality

To be compliant with the above regulations there are several challenges to overcome in the Construction sector, the most important being the following:

- Compliance with various regulations often requires additional expenditures for materials, permits, consultants, and legal services that are many times a barrier for SMEs
- sharing costs between public and private

- Compliance with Complex Building Codes - Building codes and standards can be highly specific and vary from region to region - the solution could be to develop Product Data Templates (PDT)
- For multinational construction companies, compliance with international regulations and standards can be complex, as different countries have unique sets of requirements - require coordination between various regulatory frameworks, which increases complexity and cost
- Increasingly, governments are mandating the use of Building Information Modelling (BIM) to enhance project planning and execution. This digital technology ensures compliance with building regulations and helps with environmental sustainability - While BIM can improve efficiency, adopting the technology requires significant upfront investment in software and training. SMEs may struggle to keep up with this shift.
- Green building certifications such as LEED (Leadership in Energy and Environmental Design) require developers to meet specific environmental and sustainability criteria. Governments are also imposing stricter regulations for sustainable and green construction - achieving these certifications can drive up costs due to the need for specialized materials and designs. It also requires extensive documentation and audits to ensure compliance.
- Low digital and data literacy, resistance to change, vendor lock-in
- Data integration, orchestration and governance.
- Data silos

Standards play a critical role in the development and management of a Construction Data Space**,** ensuring interoperability, efficiency, and security in data exchange across the industry. This is becoming even more essential with the push towards digital transformation of the value chain and the use of BIM, AI, Digital Twins**,** and other advanced technologies in construction enabling the integrated and holistic development of the construction sector. Integration of standards such as the ISO standards (ISO 19650, ISO 23386, and ISO 23387), Minimal Interoperability Mechanisms (MIMs) standards and the directives coming from European Commission, as well as those from several entities as Gaia-X, IDSA, and Eclipse is of vital importance, allowing for instance, the creation of interoperable data dictionaries in construction enabling the exchange of information with entities such as Environmental Product Declarations, and Construction Product Regulations. It is worth mentioning that through ISO standards, Product Data Templates (PDTs) for each country can be created and then data dictionaries will allow the mapping between all, making it easier to work on construction across borders.

# Use cases

A construction ecosystem, where data flows securely, transparently, and trustfully between construction providers and consumers will enable the demonstration of several use cases (UC) to the construction community, being a showcase for community adoption.

Our approach (see Figure 11) will be the breakdown of a panel of Business case in a panel of System case that will describe the overall strategy of the Construction DS business, including how it creates and captures value. That's why the implementation of System Use Case (SUC) common to a set of Business Use Case (BUC) is important[1].

The data space, as a data intermediary, should not be responsible for data processing. Instead, its role is to provide an infrastructure to an open-source catalog of standardized services for the software market and service providers, creating a marketplace of solutions that comply with the DA and DGA directives.

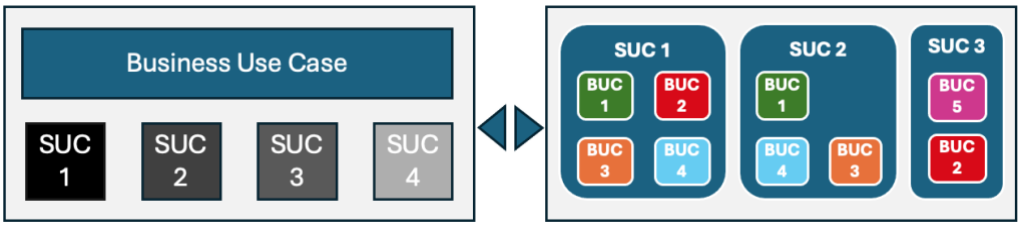



*Figure 11: Business model materialization*

Digital TER-X 2050 proposal is to build the set of elementary SUC that can be used and re-used by all BUC in the construction ecosystem and that is exactly the added value of this project, meaning that within the same technical environment, a **multitude of BUC** can be implemented. **Other BUC will be considered throughout the project reflecting for instance the digitalization of Construction Supply Chains and intelligent logistics**.

Digital TER-X proposes a first set of SUC as indicated in Table 1.

*Table 1: List of some Digital TER-X SUC*

| Digital TER-X SUC | Description |
|---|---|
| TRUST - authentication | Portfolio manager, digital contract edition, profile manager, certified transaction manager, clearing house protocol manager |
| CONTAINER - builder | Container ID, Ontologies editor, data template editor, ID management delivery, container checker |
| CONTAINER – data reconciliation | Container monitoring, deconstruction, semantic manager, data dictionaries synchronizer |
| CATALOG | Container index, lifecycle manager, cartography, portfolio |

[1] IEC 62559-2 standard template

| | |
|---|---|
| LIFECYCLE | Meta data identification, indexation, lifecycle checker |
| CHECKER factory | IDS, MVD, monitoring, certification, synchronisation dictionaries and catalogue |
| UPDATE | container update, data dictionaries<br>container checker |
| VIEWER | API catalogue (htt) (htt) (htt)(automatic publication)<br>helpdesk for protocols with hyperscalers data storage strategy (backing-up)<br>Data pre-viewers, Collaborative platforms assistance and monitoring |

Digital TER-X is a holistic framework and will be key from the business cases' pre-processing to post processing as illustrated in Figure 12.

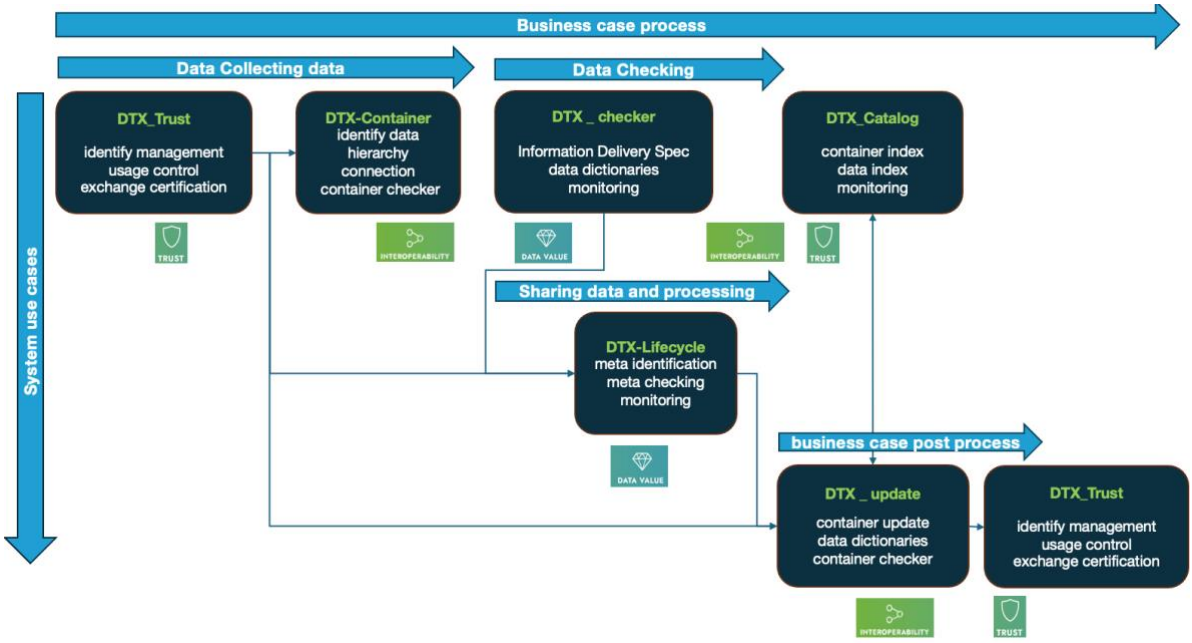



*Figure 12: Digital TER-X 2050 BUC and SUC relationship*

With the list of SUC mentioned in Table 1, DA and DGA, from Figure 9, can be implemented as shown in Figure 13.

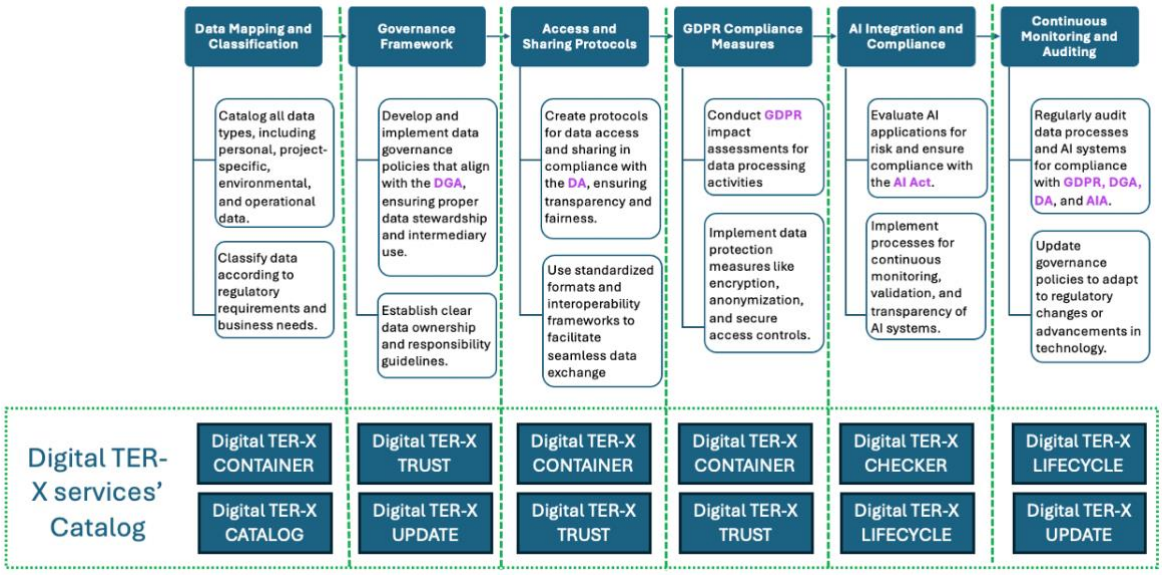



*Figure 13: Construction DS implementing GPDR, DA, DGA and AIA regulation through using Digital TER-X SUC*

## BUC 1: Urban Cavities Management

| *ID* | *Area / Domain(s)* | *Name of Use Case* |
|---|---|---|
| 1 | Construction | Cavities monitoring |

Urban cavities management is a typical business for a local authority. Figure 14 shows an example of the relationships between stakeholders from a business case perspective.

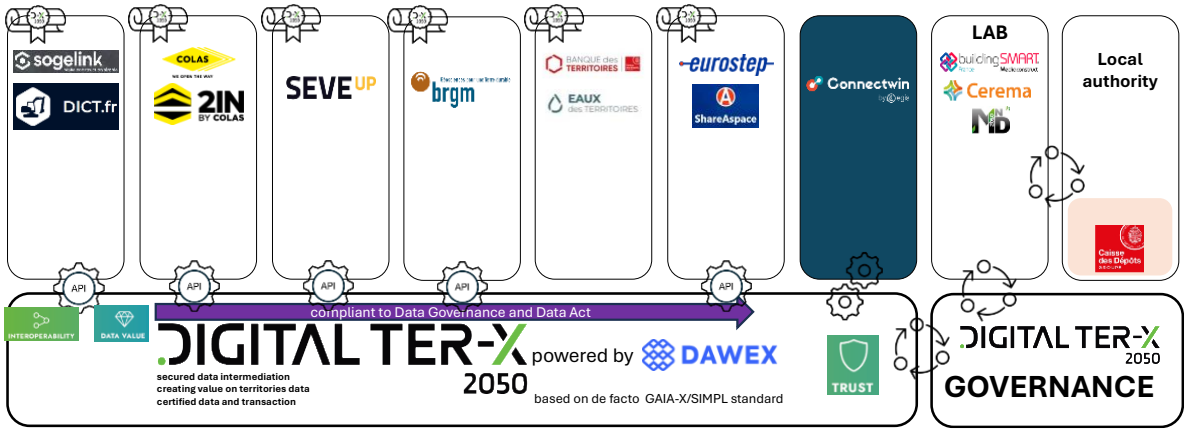
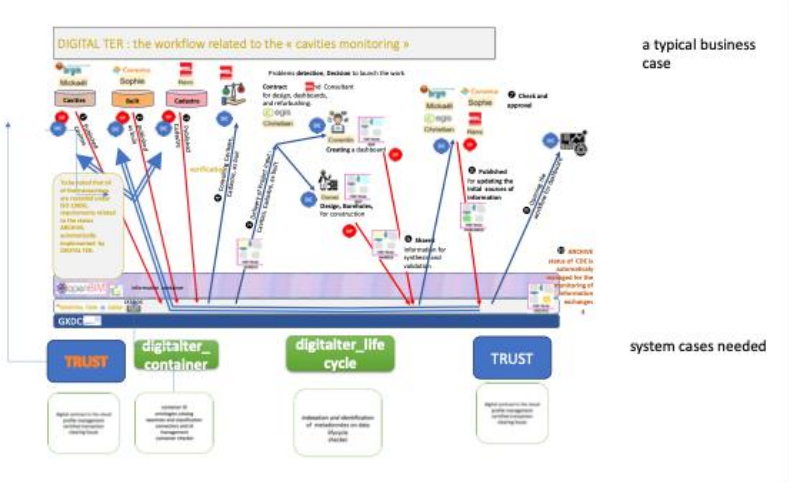



*Figure 14: Digital TER-X 2050 stakeholders relationships on the Business Case used in the French PoC.*

| *Business Use Case* | |
|---|---|
| *Scope* | This BUC will be implemented under operating phase and impacting the design, construction and operating phases.<br>The urban authority needs to display the cavities evolution, the forecast in 50 years and the impacts on buildings foundations of all the facilities (buildings, infrastructure). |
| *Objective(s)* | To mitigate the climate impacts on a construction it is required to monitor the geotechnical issues of the construction. The construction DS is needed for the data transaction management and the monitoring of the data. |

| | |
|---|---|
| *Short description* | This business requires very specific kinds of information, and a very large panel of information to be collected from very different specific data providers.<br>The Construction Data Space is needed for the collection of all the related information, for updating the information and for creating the dashboard for stakeholders and public monitoring.<br>The challenge is to provide a permanent and long-term hypervisor to advise the urban authorities on the risks, to provide data and information for the experts (consultants and contractors), to develop recommendation, new designs, construction releases and to update all the data. To achieve this, a Construction Data Space can be implemented, leveraging digital technologies like BIM, IoT, and geospatial data, while ensuring interoperability and data sharing across stakeholders. |
| *Actors (see Figure 14)* | **Client** – the local authority in charge of the monitoring who sets goals and works to be done: "MEL"<br>**Architects and designers** – responsible for developing dashboard, hypervision and design modifications: "EGIS"<br>**Intermediary –** Generic **e**ntity that may cover one or several roles as Data Space provider, Data Governance Authority, Data Intermediary: "BRGM"<br>**Expertise on geo-tech** – delivers modellsation and reports on the geotechnical issues, verify the feasibility of the new design to reach client's goals<br>**Urban planners** - ensure that the project aligns with local planning regulations and sustainability goals: "CEREMA"<br>**Data Analysts on Climate** - responsible for quantifying the carbon footprint of different design and planning scenarios using various tools and models, such as BIM.<br>**Regulatory Bodies/Local Authorities** - ensure that the project complies with relevant environmental regulations and standards, which often include carbon reduction requirements. "MEL" for the inventory.<br>**Material Suppliers** (Consultive Role) - although not always directly involved in the planning phase, material suppliers need to be consulted to provide information on the carbon footprint of materials being considered for the project. |
| *Flow* | The flow is according to Figure 15 below.<br>  <br>*Figure 15: Flow related to the cavities monitoring employing System cases* |

In the appendix the reader can find examples of the detailed description of the panel of System Use Cases, which can be used for the implementation of the Urban Cavities Management BUC. (See 40)

The second BUC presented deals with a 360º holistic vision of the inside and the outside of the building.

## BUC 2: DT 360º - Building Life Cycle Management

| *ID* | *Area / Domain(s)* | *Name of Use Case* |
|---|---|---|
| 2 | Construction | DT 360º - Energy and Low Carbon Footprint |

| *Business Use Case* | |
|---|---|
| *Scope* | This BUC will be implemented through a Proof of Concept (PoC) consisting of a small-scale deployment |
| *Objective(s)* | Validate the use case by considering Gaia-X specifications in the scope of building LCM and energy efficiency. |
| *Short description* | Focused on the building, this Use Case will focus on the physical dimension in terms of its infrastructure, its different specialties and construction materials, lifespan of the building (LCM) and Life Cycle Assessment (LCA), through monitoring and management of utilities and maintenance.<br>This BUC focus also on energy efficiency in terms of the building's thermal comfort, overall energy management of the building asset and existing loads, i.e: EV charging, storage, etc. Furthermore, we introduce a vital element in the LCM of the building, its tenants. We intend to engage tenants promoting internal energy efficiency and energy literacy as well as promoting active maintenance of the building with small chorus and best practices to handle the building materials (painting, flooring, sewers, cleaning, etc)<br>To achieve these goals, it must be created a multi-stakeholder view of the building, that preserves the privacy of its tenants at the same time it provides valuable information to the various stakeholders involved in the building lifecycle. This shared view can only be achieved through a digital data model of all the building and its dynamic aspects (tenants and utilities).<br>This proposal shall focus on the energy dimension, and the most important aspect to consider according to the guidelines for decarbonization of the sector. (htt2)<br>Developing a data model, where the building asset functions as a Digital Twin—a shareable and interactive data model—will facilitate not only the decarbonization of the sector and the building asset itself but also the entire surrounding environment. This model, driven by infrastructure and energy as catalysts for innovation, will contribute to existing frameworks in terms of regulation and standards for the construction and buildings sector.<br>Our vision is based on a digital model of the building and/or set of buildings (i.e: districts), using a matrix where the 'physical layer meets the energy layer' to enhance energy efficiency and asset management through Digital Twin simulation. This approach assesses the building's lifecycle (LCA) to evaluate the environmental impact of materials, guiding sustainable choices that align with decarbonization goals and improve energy comfort and efficiency (considering for instance the renewable energy community). In this BUC, we leverage ICT technologies to advance the project's goal of creating Nearly Zero - Positive Energy Districts (NZ-PED) from a Smart Building perspective. (htt2)<br>Through the development of an holistic platform and data model that monitors the decentralized production of renewable energy in the PED as well as the dynamics of the buildings and households (thermal comfort, energy efficiency and security) we intend to create a digital twin platform (DT) of the PED that can be used to optimize algorithms that balance energy storage, optimize tariffs, guarantee thermal comfort) and to balance building operation and maintenance into a predictive view and process as well as circular economy principles for building design. |
| *UC conditions* | • To be aligned with all relevant Construction standards.<br>• To comply with the IDSA/Eclipse Data Space Protocol. |

| | |
|---|---|
| | • To be aligned with Gaia-X specifications to enable a federated and interoperable data infrastructure.<br>• Must have the support from a local player managing a building in which the PoC will be developed.<br>• Must have the approval of tenants. |
| *Actors* | **Client** – who sets their sustainability goals<br>**Architects and designers** – responsible for integrating the specifications (material selection, building orientation)<br>**Intermediary –** Generic **e**ntity that may cover one or several roles as Data Space provider, Data Governance Authority, Data Intermediary<br>**Engineers** – verify the feasibility of the design to reach client's goals<br>**Urban planners** - ensure that the project aligns with local planning regulations and sustainability goals<br>**Real Estate Developers:** companies that are responsible for driving new specifications, innovation and best practices into new construction and existing buildings renovation markets<br>**Data Analysts** - responsible for quantifying the carbon footprint of different design and planning scenarios using various tools and models, such as BIM and IoT.<br>**Regulatory Bodies/Local Authorities** - ensure that the project complies with relevant environmental regulations and standards, which often include carbon reduction requirements.<br>**Material Suppliers** (Consultative Role) - although not always directly involved in the planning phase, material suppliers need to be consulted to provide information on the carbon footprint of materials being considered for the project.<br>**Construction Companies**: responsible for new building construction or buildings rehabilitation/renovation<br>**Technological Companies:** responsible for adding intelligent systems do buildings form automation to IoT<br>**Energy auditors:** entities that carry out audits for the energy certification of buildings<br>**Utility Providers**: entities that carry out support services to the building throughout its lifecycle such as installing telecommunications, renewable energy units, hygiene services, etc<br>**Building Management:** specialized entities responsible for the LCM of the building<br>**Tenants**: entities that will inhabit the building, requiring comfort and efficient Maintenance.<br>**Smart City ecosystem:** stakeholders that provide different services for a Smart city roadmap (i.e: platforms, IoT, Fiware, Open Data providers, consultancy) and best practices<br>**Universities and other relevant scientific organizations**: Key stakeholders that develop common frameworks for regulatory work and standardization and data-driven technologies and systems. |

| | |
|---|---|
| ***Flow*** | Client sets up project defining a set of efficiency goals, uploading this information to the Construction DS, according to the set of Digital TER-X 2050 SUCs available.<br>Architects and Designers create the project based on the requirements of the client using BIM and IFC and upload to the DS using the Digital TER-X 2050 catalogue of services<br>Plans are validated by various stakeholders (from Engineers to Real Estate Developers) according to permissions defined by the Client, preserving business secrets.<br>Regulatory Bodies/Local Authorities have special permissions that enable broader view of the project data to assess compliant with regulation and local ordinance.<br>Material Suppliers and Construction Companies get selective access to the project to bid on the construction phase. This access is limited by the client in accordance with business requirements.<br>During construction phase various auditors have access to plan in a timely and private away as defined by the client and contractors.<br>Upon completion of the building construction phase, the utility providers are provided access for commissioning of the build before the first tenant can arrive.<br>To be tenants are provided with information on the provenance and sustainability of the materials used in the construction of the building as documented in the DS during the construction phase.<br>Energy Auditors can easily carry out audit and certification of the building based on the information in the DS.<br>Real Estate construction companies - a public administration - can find a common ground for bringing innovation (i.e: Tech, RECs, mobility, etc) in new construction envelopes in cities on a new district level integration of assets.<br>Smart City stakeholders can now integrate the building and its sensors into a Digital Twin that is part of the smart city.<br>All stakeholders can monitor the building for its lifetime, providing maintenance services and upgrades.<br>All the mentioned services will exist as System UC as defined on the top of this section, particularly in Table 1. |

BUC2 will use the SUCs described in (See 40).

# Recommendations

In summary, the most important recommendation is the creation of a **Construction Data Space,** as this is crucial for several transformative reasons, which address key challenges in the construction industry while driving innovation, efficiency, and sustainability.
Construction projects involve multiple stakeholders (architects, contractors, suppliers, regulators, etc.) who need to collaborate efficiently, and a Construction DS will allow the data to be federated, making it easier for different actors to share critical information.
The construction industry generates vast amounts of data, but much of it remains underutilized and a DS leveraging on that will enable advanced analytics, AI, and machine learning to derive actionable insights from this data, throughout a series of services that can be fully available in a catalogue.

A second recommendation is to capture public investment for the infrastructure implementation. Our conviction is that a 50/50 public and private funding will enable the liftoff of such a DS.
The third one is to prepare BIM-based solutions in the development of the DS able to guarantee the return of investment also for the big players in private sector and not only for SMEs.
The fourth concerns the increasing pressure to meet sustainability targets and reduce carbon footprints. A Construction DS can monitor and optimize energy usage, carbon emissions, and material sustainability throughout all the construction lifecycle assessment. This will accelerate the adoption of Digital Product Passport by the stakeholders as a fundamental piece in the sustainability path. (htt2)
Construction supply chains are often complex and fragmented, leading to delays, cost overruns, and inefficiencies. A Construction DS improves transparency across the supply chain, from procurement, logistics to delivery. Providing real-time visibility into material availability, delivery schedules, and inventory levels, enables better planning and coordination, reducing material shortages, delays, and transportation inefficiencies.
The construction industry must comply with strict regulations related to safety, environmental standards, and quality. A Construction DS is a single point to obtain the same and updated information shared with all stakeholders, ensuring that all relevant data is available for audits, inspections, and compliance monitoring. By maintaining accurate, up-to-date records of project data, it helps reduce the risk of non-compliance, costly fines, and legal issues, while improving overall safety and quality control on construction sites.

# Conclusions

Distinguishing between the business case and the system case is essential for achieving a critical mass more effectively.

Three elements are important for Digital TER X

- The reference to ISO 19650, in modelling the information exchange transaction creates a strong framework of requirements, coming from the ecosystem.
- Using ISO standards for structured data, mitigates the risk due to a wide diversification and provides an opportunity for partnership with BuildingSmart and OGC, for resources to manage the checking of information exchange and to coordinate the ecosystems.
- The level of maturity is globally underestimated for at least two reasons:
  - Some key communities are living very well with no governance
  - At the same time, there is a real gap between teams involved in GIS or BIM process around the digital twin and the top management

On the other hand, the needs to be able to manage rapidly a large panel of information due to the climate impact, could grow rapidly, in the short term.

**Conclusion 1**: Digital TER-X is Strategic Intermediary for a European Construction DS supporting EU legislation and regulation. Digital TER-X aligns private and public European initiatives, and also global ones and will pave the way to a resilient economic sector guided by EU values while promoting digital and green transition among construction stakeholders.

**Conclusion 2:** The implementation of a Construction DS is urgent regarding the implementation of the European policies on data economy (DA and DGA). As one of Europe's strongest economic sectors and one that employs the most people, it is urgent to make it increasingly competitive in the data sharing economy, in order to speed up the digital and green transformation of its value chain. This will at the same time energize a whole range of emerging companies that will look at construction data in multiple ways, enabling the co-creation of a creative and innovative ecosystem.

**Conclusion 3:** A Construction Data Space, such as recommended by the European regulation, is crucial for creating a cohesive and efficient ecosystem where data can be securely shared, managed, and utilized. It promotes innovation based on the data sharing economy, enhances decision-making, ensures compliance and security, and supports economic and societal advancements. At the European level, Digital TER-X can be considered as a strategic and governance body for the implementation of the European regulation, driving the technical requirements of the ecosystems, including private and public organisations. At national level Digital TER-X could be considered as a strategic and technical body in offering a framework and a technical platform for the implementation for the national ecosystems, in line with European recommendations.

**Conclusion 4:** Business and system use cases examples discussed on this document are crucial because they address the construction industry most pressing challenges while unlocking significant opportunities for improvement. The role of being a Gaia-X Qualified project will enable the consideration of a large panel of business cases required for the progress of the green transformation, regarding the need of system use cases to be developed for delivering the business. In this way, Digital TER-X 2050 is in position to propose a strategic governance on the digital and technical requirements and to optimise the cost for the ecosystems in the achievement of robust business cases.

- Operational Efficiency: The use cases highlight how real-time data analysis and optimization of logistics, energy consumption, and machinery usage can significantly improve productivity, reduce waste, and lower costs, driving operational efficiency in the construction process.
- Energy Reduction and Sustainability: The system use cases, particularly around energy optimization and sustainable material usage, underscore the importance of using data to meet sustainability goals and reduce the environmental impact of construction projects, a key priority in Europe today.

**Conclusion 5**: A strong and united consortium, covering 4 different European countries, private companies and public authorities, working together is crucial to implement the European regulation under at least one of the proposed business cases. The only one chance of success for the European regulation, expected by the ecosystems will come by a **data-driven construction process** accelerating digital transformation in the perspective of green transformation. Portuguese public authorities, including the municipality of Gaia (GaiUrb) and various municipalities under the Portuguese Directorate-General for Territory have expressed their interest in this project and in joining its efforts.

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# Appendices

## European Construction Data Space

The term Data Space (DS) refers to "relevant data infrastructures and governance frameworks brought together in order to facilitate data pooling and sharing[2]". Its design should include a common technical infrastructure and building blocks, as well as interconnection and interoperability, allowing different European data spaces and different individual or organizational data providers, to interconnect with each other sharing data and giving rise to a single European data market complying with EU values and regulations. In other words, a DS is a distributed system, defined by a governance framework enabling data transactions between participants in a trustful way and supporting data sovereignty. It can be implemented over several ICT federated infrastructures provided by Data Infrastructure Service Providers.

The Commission Staff Working Document on Common European Data Spaces defines the following key features of a common European data space[3]:

- A secure and privacy-preserving infrastructure to pool, access, share, process and use data.
- A clear and practical structure for access to and use of data in a fair, transparent, proportionate and/non-discriminatory manner and clear and trustworthy data governance mechanisms.
- European rules and values, in particular personal data protection, consumer protection legislation and competition law, are fully respected
- Data holders will have the possibility, in the data space, to grant access to or to share certain personal or non-personal data under their control.
- Data that is made available can be reused against compensation, including remuneration, or for free.

Participation of an open number of organizations/individuals.

## Data regulation

### General Data Protection Regulation - GDPR

When building a DS, compliance with GDPR is mandatory as it sets the standard for data protection and privacy. This includes ensuring that personal data collected (e.g., from workers, providers, partners or clients) is processed lawfully, transparently, and for a specific purpose. Data subjects' rights, such as the right to access, modify, and delete their data, must be respected. To protect personal data from breaches robust security measures should be in place, given the mobile nature of construction projects.

[2] https://joinup.ec.europa.eu/collection/semic-support-centre/data-spaces
[3] https://joinup.ec.europa.eu/collection/semic-support-centre/data-spaces

### Data Governance Act - DGA

DGA aims to promote data sharing across the EU and improve the availability of data for use by businesses and public authorities. The construction sector generates vast amounts of data, including project designs, environmental data, and supply chain information. The DGA, that will become mandatory by 2025, provides a framework for data intermediaries and other entities to facilitate secure and trusted data sharing among different stakeholders (e.g., contractors, suppliers, regulators). It engages in data altruism initiatives, allowing for voluntary data sharing to support public projects or research that can benefit the sector (e.g., sustainability research, urban planning).

### Data Act - DA

DA, to be put in stage also by 2025, is relevant to ensure fairness in the digital environment, stimulate a competitive data market, and open opportunities for data-driven innovation. This regulation impacts on data access and sharing by setting rules on who can access and use data generated by connected devices and related services. It emphasizes making data available to a wider range of stakeholders, including public authorities, under fair, transparent, and non-discriminatory conditions. DA application will ensure that data formats and standards are interoperable across several platforms and systems used in the construction process.

### Artificial Intelligence Act - AIA

AIA is designed to ensure the safe and ethical use of AI within the EU, establishing requirements for AI systems depending on their risk level. When integrating AI into a data space, compliance with the AI Act is crucial. This includes adhering to transparency requirements, ensuring the robustness and accuracy of AI systems, and mitigating risks, especially for high-risk AI applications. The data used to train and operate AI systems must be managed in accordance with the AI Act's provisions.
AI is increasingly used in the construction sector for predictive maintenance, project management, safety monitoring, and design optimization.

## European DS Initiatives

EU directives are accompanied by the development of a few private initiatives to promote and accelerate the adoption of the EU strategy for a single European data market, through the development of specifications and standards.

### Gaia-X

Created in 2021 as a private non-profit association, Gaia-X brings together a community of organizations around the common goal of boosting the European data economy, enabling the creation of common data spaces, in full alignment with the objectives of the EU data strategy, and building a common open standard for transparent, controllable and interoperable data infrastructures for the exchange of reliable data.

It provides a federated and secure data infrastructure through which data is shared, while users retain control over the access and use of their data. To this end it develops policies and rules, technical and regulatory frameworks following three main objectives:

- Develop specifications for the reference architecture and federation services
- Implement Open-Source Software required to operationalize the specifications
- Implement automatic certification of compliance

The software implemented for the Gaia-X Digital Clearing House is freely available from Gaia-X AISBL and the software for the Cross Federation Services Components (XFSC) is available from an Eclipse project under Apache License 2.0

## Eclipse Dataspace Components (EDC)

The Eclipse Dataspace Components (EDC) is a framework providing a basic set of features that dataspace implementations can re-use and customize by leveraging the framework's defined APIs and ensure interoperability by design. The framework implements the IDSA/Eclipse Dataspace Protocol and is aligned with the Gaia-X AISBL Trust Framework. The framework is freely available u an Eclipse project under Apache License 2.0. The project is governed by the Eclipse Foundation. Also, the framework is being used by two Gaia-X Lighthouse projects: EONA-X and Catena-X.

## International Data Spaces Association - IDSA

The International Data Spaces Association (IDSA) is a global alliance that develops and promotes standards for secure and sovereign data exchange across industries. It was established to create a framework that enables organizations to share data securely and confidently, ensuring that data owners retain control over their data. Key activities are:

- Data Sovereignty: IDSA focuses on ensuring data sovereignty, meaning that data providers maintain control over who can access their data, under what conditions, and for what purposes.
- Standardization: The alliance develops and promotes the International Data Spaces (IDS) standard, a reference architecture and a set of protocols for secure data exchange. The IDS RAM[4] - the heart of the IDS includes the standards for secure and sovereign data exchange, certification, and governance.
- Certification: IDSA provides a certification scheme to ensure that participants and components in the data space comply with the IDS standards ensuring interoperability.
- Ecosystem Development: IDSA fosters the creation of a global ecosystem of data spaces, enabling interoperability across different platforms and industries.

The IDSA Rulebook serves multiple purposes and at its core it aims to provide a clear delineation between mandatory rules and optional guidelines, encompassing functional, technical, operational, and legal dimensions.

[4] https://github.com/International-Data-Spaces-Association/IDS-RAM_4_0

## Data Spaces Business Alliance (DSBA)

Founded in 2021 by Gaia-X European Association for Data and Cloud AISBL, the Big Data Value Association (BDVA), FIWARE Foundation, and the International Data Spaces Association (IDSA) DSBA join forces to drive the adoption of data spaces across Europe and beyond.

To materialize the required technical convergence, an implementation-driven plan was proposed through a Minimum Viable Framework (MVF) enabling creation of data spaces and its subsequent evolution.

A first version of the MVF was the result of a first workstream targeted to provide a minimum set of building blocks required to cover the three major technology pillars for creation of data spaces: data interoperability, data sovereignty and trust and data value creation. A second workstream is about incorporation of IDS Connector functions and support to ODRL for the definition of access/usage control policies; a third workstream is on shared catalogue and federated marketplace services based on TM Forum standards and aligned with Gaia-X and IDS RAM specifications and finally a fourth workstream tackles the incorporation of additional IDS architectural elements for usage control.

## SIMPL - Secure Interoperable Middleware for Public and Private Services

SIMPL is a European Commission initiative that aims to develop an open-source middleware platform designed to support secure data sharing and interoperability across different data spaces. The platform facilitates seamless data exchange between various stakeholders in sectors like public procurement, healthcare, and smart communities. It focuses on ensuring compliance with European values, including data sovereignty, privacy, and transparency. The SIMPL program is divided into three main components:

1. **SIMPL-Open**: The core open-source middleware that enables secure and controlled access to data, supporting both cloud and edge deployments.
2. **SIMPL-Labs**: A testing environment where data spaces can experiment with SIMPL's components to ensure compatibility before full-scale implementation.
3. **SIMPL-Live**: Sector-specific implementations of the platform, including data spaces dedicated to healthcare, public procurement, and other domains.

This initiative is part of the EU's broader effort to create standardized and interoperable data infrastructures that can be used across sectors, providing transparency, trust, and security in data transactions.

## Data Spaces Support Centre (DSSC)

The mission of the Data Spaces Support Centre is to help establish Common European Data Spaces that together foster a secure, interoperable, and reliable environment for sharing data. This initiative aims to facilitate data reuse across different sectors while adhering to EU principles, ultimately benefiting the European economy and society. Funded by the European Commission under the Digital Europe Program, the Centre primarily targets the public sector and businesses interested in creating sovereign data spaces.

The DSSC will assess the needs of various data space initiatives, identify shared requirements, and set best practices to speed up the creation of sovereign data spaces, which are vital for digital transformation across all sectors. Leveraging the combined expertise of its 12 consortium partners, the Centre aims to offer the best possible support to these initiatives, particularly in ensuring the interoperability of data spaces.

## Minimum Interoperability Mechanism

The Minimal Interoperability Mechanisms (MIMs) enable minimal but sufficient capabilities needed to share, use and re-use data across systems, and they address the key challenges of setting up a local data ecosystem and the cross-cutting data models and architectural framework.
Each MIM identifies an area where interoperable mechanisms make sense and 10 different MIMs were defined. The Foundational 5 MIMs address issues of data access, data representation, data interlinking, data sharing and collaboration and data security. The Application MIMs are also relevant, addressing issues such as Personal Data Management, Interoperable AI and Digital Twins. MIM7, key to the Construction sector, aims to provide Minimal Interoperability Mechanisms related to geospatial data, so that cities and communities can integrate and transfer data between internal and external IT systems. With this mechanism in place, cities and communities can easily integrate data about spatial assets (buildings, streets or other infrastructures) with temporal data from sensors, together with other data sources that can provide helpful insights. MIM7 therefore addresses how to integrate data that use OGC standards with data that use BIM data such as IFC and how to integrate both with linked data that provide added insights, for instance data conforming to NGSI-LD.

## Fiware

Fiware is an open-source initiative launched to accelerate the development of smart applications for various sectors, including smart cities, industry, and energy. Created by the Fiware Foundation, the platform provides a suite of software tools that allow developers to manage, process, and analyze large-scale IoT data in real-time. At its core, Fiware uses the "Context Broker" component, which centralizes real-time data from diverse sources and makes it available to other applications through standard APIs. This enables seamless integration and interoperability, fostering collaboration across different IoT systems and ensuring that data can be accessed, shared, and acted upon in real-time. Fiware's standards and open-source approach offer a robust foundation for public and private organizations, helping them build applications that are sustainable, scalable, and tailored to evolving smart infrastructure needs.

Beyond its technical aspects, Fiware is known for its strong community and ecosystem, which includes global developers, startups, enterprises, and cities working together to build smart solutions. Supported by the European Union, the platform has been widely adopted across Europe and beyond. Fiware’s modular architecture allows organizations to customize their solutions by adding only the necessary components, which lowers costs

and development time. Its commitment to data sovereignty and privacy further aligns with global regulatory frameworks, making it a trustworthy choice for cities and industries aiming to become smarter and more efficient while retaining control over their data.

### Solid

The Solid project, initiated by Sir Tim Berners-Lee, is an open-source initiative aimed at decentralizing the web by giving individuals more control over their personal data. "Solid" stands for *Social Linked Data*, and the project envisions a web where users manage their data in decentralized "pods" (personal online data stores) instead of it being held and controlled by large corporations. These pods allow users to store their data securely and decide who can access or use it, effectively separating data from the applications that utilize it. By enabling this data sovereignty, Solid seeks to restore privacy and autonomy to web users, fostering a more open and user-centric Internet where data interoperability is seamless, and users' privacy rights are upheld. This paradigm shift is intended to empower individuals and create a more equitable digital ecosystem, where innovation can thrive without compromising personal privacy.

## Panel of System Use Cases description

The tables below show the detailed description of the list SUC for the implementation of BUC 1: Urban Cavities Management and the BUC 2: DT 360º - Energy and Low Carbon Footprint will reuse them among others to be further developed.

| *System Use Case 1 - trust* | |
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| *Brief description* | For collecting data, the DS is offering a set of services for the automatization of notary process and digital contract processing |
| *Actors* | **Client** – who sets their sustainability goals<br>**Architects and designers** – responsible for integrating the specifications (material selection, building orientation)<br>**Intermediary –** Generic **e**ntity that may cover one or several roles as Data Space provider, Data Governance Authority, Data Intermediary<br>**Engineers** – verify the feasibility of the design to reach client's goals<br>**Urban planners** - ensure that the project aligns with local planning regulations and sustainability goals<br>**Data Analysts** - responsible for quantifying the carbon footprint of different designs and planning scenarios using various tools and models, such as BIM.<br>**Regulatory Bodies/Local Authorities** - ensure that the project complies with relevant environmental regulations and standards, which often include carbon reduction requirements.<br>**Material Suppliers** (Consultative Role) - although not always directly involved in the planning phase, material suppliers need to be consulted to provide information on the carbon footprint of materials being considered for the project. |
| *Trigger* | At any phase, when collecting or delivering data is required |
| *Pre-conditions* | The infrastructure is set-up. |

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| | Intermediary and Gaia-X Digital Clearing House (GXDCH)[5] are defined, up and running.<br>The actors' roles are well defined.<br>Actors must be recognized by the infrastructure<br>A wallet is attributed for each one |
| *Pos-conditions* | After analyzing the areas for improvement all data related to the business case is delivered under a handover process.<br>Insights are shared across the data space, allowing stakeholders to refine future projects and contribute to industry-wide best practices for reducing carbon emissions.<br>The federated Construction Services Catalogue may be updated with a set of updated data |
| *Basic flow* | All actors generate their own credentials that are required for onboarding.<br>All actors connect to the intermediary and GXDCH providing their credentials.<br>GXDCH verifies if credentials are Gaia-X compliant (selection of federation(s) and policies verification)<br>All should access the Service Catalogue and choose among the available data services to perform the intended tasks.<br>The construction process is monitored in real-time, for managing the modification of the role Data provider vs Data user |

| *System Use Case 2 – Container and data mesh* | |
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| *Brief description* | For collecting data, the DS is offering a set of services for the automatization of the dataset delivery, based on data templates for the information container.<br>An information container is a dataset, based on ontologies, with hierarchy and relationships. For geotechnical, an information container includes at least: boreholes, geotechnical expert report, and modelling. |
| *Actors* | **Client** – who sets the data needs and requirements<br>**Data providers:** actors in charge to provide data set in line with the Client requirements<br>**Data Consumers**: actors in charge of using or processing data.<br>**Intermediary:** Generic **e**ntity that:<br>• provides an information container template (data template) from the catalog if existing<br>• or specifies a new template<br>• or certifies the template. |
| *Trigger* | At any phase, for collecting or delivering data (included in the BIM execution plan if relevant) |
| *Pre-conditions* | The infrastructure is settled and includes:<br>• the catalog of Data Template for information container<br>• actors' roles are well defined.<br>• a list of data standard format<br>• a list of certified linked data<br>• a list of metadata to be assigned to data and container in line with ISO 23386<br>• pre-conditions specifications are available under human and machine-readable format |
| *Pos-conditions* | After project completion and after analyzing the areas of improvement, all data related to the business case is delivered under a handover process.<br>Information container checker is used for certifying and updating the catalog of container<br>Insights are shared across the data space, allowing stakeholders to refine future projects and contribute to industry-wide best practices for automatizing the information container issuance. |

[5]: https://gaia-x.eu/gxdch/

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| | The federated Construction Services Catalogue is updated with a set of updated templates and containers. |
| *Basic flow* | To be defined under 23386 methodology. |

| *System Use Case 3 – Container catalog* | |
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| *Brief description* | The DS is offering a set of services for extracting metadata attached to any information related to the process embedded in the CDE, under ISO 19650 approach:<br>• set of metadata identification<br>• metadata set checking<br>• monitoring the metadata set |
| *Actors* | **Client:** who specifies the information container to be used.<br>**Data providers:** actors in charge to certify the metadata attached to the container in line with the Client requirements<br>**Data Consumers**: actors in charge of using or processing the information container under Client requirements.<br>**Intermediary –** Generic **e**ntity provides a set of tools:<br>• to assign metadata on the information container<br>• to automatize the indexation<br>• to deliver the catalog viewer |
| *Trigger* | At any phase, for collecting or delivering data |
| *Pre-conditions* | The infrastructure is settled and includes:<br>• a catalog of Data template for information container<br>• actors' roles are well defined.<br>• a list of data standard format<br>• a list of metadata to be assigned to |
| *Pos-conditions* | After project completion and after analyzing the areas for improvement, all data related to the business case is delivered under a handover process.<br>Information container checker is used for certifying and updating the catalog of container<br>Insights are shared across the data space, allowing stakeholders to refine future projects and contribute to industry-wide best practices for automatizing the information container issuance.<br>The federated Construction Services Catalogue may be updated with a set of updated templates and containers. |

| *System Use Case 4 – Lifecycle monitoring* | |
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| *Brief description* | The DS is offering a set of services for the monitoring of the list of information container and the lifecycle monitoring, including:<br>• set of metadata related to the ISO 19650 approach and data under the process<br>• API for extracting metadata from CDE and to attach to the data inside information container.<br>• a viewer of the list of containers and the monitoring of the lifecycle. |
| *Actors* | **Client:** who specifies the workflow<br>**Data providers:** any data providers, to be in the portfolio<br>**Data consumers**: the main appointed party actors in charge of the workflow management<br>**Intermediary –** Generic **e**ntity provides a set of tools:<br>• To assign metadata to the CDE<br>• For maintaining API for extracting metadata |
| *Trigger* | At phase 6 and 7 of ISO 19650 process |

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| *Pre-conditions* | The infrastructure is settled and includes:<br>• A catalog of workflow templates especially related with the shared and published, according to the various contracts and that could be defined in the scope of the archive to be embedded.<br>• actors' roles are well defined.<br>• a portfolio of collaborative platform providers as accepted actors |
| *Pos-conditions* | Further to the project completion and after analyzing the areas of data improvement, all data related to the business case is delivered under a handover process.<br>Information container checker is used for certifying and updating the catalog of container.<br>Insights are shared across the data space, allowing stakeholders to refine future projects and contribute to industry-wide best practices for automatizing the information container issuance.<br>The federated Construction Services Catalogue may be updated with a set of updated templates and containers. |

| *System Use Case 5 – Data checker* | |
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| *Brief description* | The DS is offering a set of services for verifying and certifying the quality of data that is federated in the data mesh associated to the business case. The services are as below:<br>• Data Product (a set of data, metadata, semantics, and templates)<br>• human readable specification (Information Delivery Specification - IDS)<br>• machine-readable Model View Definition (MVD) for extraction the right subset of the model<br>• Machine-readable IDS for verifying the relevance of the information delivered by the MVD<br>• metadata associated to the checking<br>• metadata associated to the checker monitoring |
| *Actors* | **Data Product Provider -** the actor in charge of the BIM Execution Plan (DPUA): who specifies the content of Data Product<br>**Data providers:** actors in charge of the dataset delivery and compliant with the requirements related to the Data Product<br>**Data consumers:** actors in charge of using or processing the information container under Client requirements.<br>**Intermediary –** Generic entity that provides a set of tools as part of the federated catalog:<br>• Data product Usage agreement<br>• Data product description<br>• To deliver the catalog viewer |
| *Trigger* | At any phase, for collecting or delivering data |
| *Pre-conditions* | The infrastructure (the federated catalog) is settled and includes:<br>• a catalog of Data Product description<br>• a list of data standard format<br>• a set of certified MVD, IDM and IDS or equivalent |
| *Pos-conditions* | After project completion and after analyzing the areas for improvement, all data related to the business case is delivered under a handover process.<br>The data checker is used for certifying and qualifying the data used within the business case under the data processing. The data processing is clearly not part of the scope of Digital TER X.<br>The federated Construction Services Catalogue may be updated with a set of updated templates. |