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The Culture Dataspace (*Datenraum Kultur*) – a Data-Sovereign Open-Source Digital Infrastructure based on the Eclipse Dataspace Components (EDC) Framework

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Abstract

The Datenraum Kultur (Culture Dataspace) project represents a strategic data infrastructure initiative within the EU Digital Strategy framework, designed to transform data sharing in the cultural, media, and creative industries, pioneering innovative approaches to create new digital services while respecting intellectual property rights. As a flagship project in Germany’s National Digital Strategy, it aims to develop foundational infrastructure for the future data economy. The project focuses on a B2B data exchange model that aims to accelerate value-added digital service development. It is characterized by three key architectural principles: (1) data sovereignty, ensuring content owners maintain control over their digital assets; (2) decentralized architecture, facilitating direct content transfer between stakeholders without centralized routing; and (3) collaborative ecosystem development, for negotiated content exchange within trusted networks. Beyond economic considerations, Datenraum Kultur addresses a societal need for culture in the digital age, highlighting trustworthy relationships among actors, ultimately strengthening the competitiveness and relevance of the cultural sector while maintaining participant autonomy in an increasingly data-driven landscape.

1. Introduction

In the digital age, society is undergoing a profound transformation characterized by instant access to information and constant connectivity, which in turn has fundamentally changed the way culture is documented, managed, and created. While this shift has democratized creative tools, blurred the boundaries between creators and consumers, and enabled the formation of geographically dispersed communities with shared interests, it has also brought with it significant infrastructural challenges. The unprecedented scale of digital cultural documentation, the replacement of traditional gatekeepers with algorithmic curation, and the dual existence of cultural artifacts as both physical objects and digital data require new digital infrastructures capable of addressing issues of preservation and stewardship and, more fundamentally, of accessibility and equitable participation in cultural and creative resources. As cultural production accelerates and becomes increasingly networked, robust digital frameworks are essential to support this transformation, balance opportunities for wider engagement with concerns about authenticity, manage the attention economy, and reduce the digital divide that creates unequal access to cultural participation and expression. These requirements are further complicated by the growing uncertainty on the reliability of global hyperscaler service providers.

1.1 The Relevance of Culture: a European Perspective

The cultural sector, which includes cultural heritage, media, and creative industries, plays a crucial role both in the economy and for the social fabric by driving innovation, employment, and socio-economic development. According to the Organisation for Economic Co-operation and Development (OECD), the cultural and creative industries have a significant economic footprint, especially in high-income economies, accounting for an average of 7% of all businesses and 2.2% of total gross value added (GVA) in 2018 (OECD, 2022). In Europe, the cultural and creative industries make a significant contribution to the economy: they generate around 4.4% of the EU’s GDP and employ around 7.6 million people (European Commission, 2023). Despite methodological uncertainties, a similarly high level of performance has been observed at the national level in Germany for years. With 1.2 million people employed in cultural occupations, this sector often exceeds the employment figures in the German automotive industry (German Ministry of Economy, 2019, German Ministry of Economy, 2024). Beyond such economic metrics, the cultural heritage sub-sector represents a collective effort that requires a governance framework that serves both public knowledge and institutional or even commercial goals. The increasing digitization of cultural artifacts and practices creates unprecedented opportunities for innovative analysis and deeper insights. New methods are being developed for collaborative documentation, participatory archiving and collaborative interpretation that view cultural heritage as a shared resource rather than institutional property. New digital tools facilitate access to cultural material and make it possible to develop different narratives about cultural heritage, contributing to a growing body of knowledge that considers cultural heritage as part of the digital commons. Such a commons orientation recognizes cultural heritage, its documentation, preservation, and management as an inherently democratic process that requires access modalities that enable participatory knowledge and value creation by different communities and actors, as expressed in a variety of treaties and conventions[1].

[1] For the conventions maintained by the Council of Europe see: https://www.coe.int/en/web/culture-and-heritage/standards. For the European Commission’s perspective on Culture see: https://culture.ec.europa.eu. The European Commission’s approach on Cultural Heritage see: https://culture.ec.europa.eu/cultural-heritage

1.2 Data Sovereignty as the EU’s Strategic Goal

To support this overall digital transition, the EU Digital Agenda emerged over the last two decades as a comprehensive strategic framework designed to leverage digital technologies for economic growth, societal advancement, and enhanced European competitiveness in the global digital landscape (European Parliament, 2025). Originally conceived within the broader Europe 2020 strategic vision, this initiative has subsequently developed into a foundational component of the European Union’s policy architecture governing digital transformation across both social and economic domains. The initiative’s core architectural approach involves developing domain-specific dataspaces for different areas of society, including culture.

1.2.1 Key Strategic Objectives and Ethical Governance Such dataspaces are carefully built around several key strategic aspects. Collaborative Ecosystem: Enabling equitable access to data, particularly for small and medium-sized enterprises (SMEs) to catalyze innovative economic potential and reduce structural data access asymmetries. Digital Sovereignty: Reinforcing Europe’s technological autonomy by creating robust domestic data infrastructure frameworks that minimize dependency on external technological ecosystems. Interoperability and Standardization: Developing comprehensive, cross-domain technical standards and workflows that enable seamless data exchange, semantic compatibility, and integrated technological interactions. Ethical Data Governance: Implementing rigorous governance mechanisms that ensure responsible data usage, transparent data handling, and alignment with fundamental European ethical principles.

1.2.2 The Funding Instruments Key EU funding programs to achieve the Agenda’s objectives include the Digital Europe Program (DIGITAL) and Horizon Europe (HORIZON). The Digital Europe Program[2] funds projects such as the *Common European Data Space for Cultural Heritage*, which aims to accelerate the digital transformation of the sector, support 3D digitisation, and promote cross-border cooperation and the reuse of digitised cultural resources (Europeana Pro, 2025), whereas within Horizon Europe, the EU’s primary research and innovation program, a dedicated cluster *(Cluster 2: Culture, Creativity and Inclusive Society)* is focusing on the protection, enhancement, and digital innovation of cultural heritage[3] (European Commission, 2021).

1.3 Digital Infrastructure – a Characterization

A digital infrastructure is defined as “the basic information technologies and organizational structures, along with the related services and facilities necessary for an enterprise or industry to function” (Tilson et al., 2010). Based on Susan L. Star’s influential framework, we understand digital infrastructures to be founded on several interconnected dimensions that reveal their deeply social and technical nature. Similar to classical infrastructures like road or electricity networks, they are *embedded* within existing social structures and technologies, operating with *transparency* as they fade into the background to support other activities seamlessly. Their *scope* extends both spatially and temporally, creating persistent networks that transcend individual events or locations. Digital infrastructures are *learned as part of membership* in communities of practice and become linked to conventions of practice, which means that they are acquired through participation and naturally fit into established work patterns and usage habits. They *embody standards* by materializing societal norms, classification systems, and naming conventions into their technical design. Critically, they are *built on an installed base*, inheriting both the capabilities and constraints of preexisting systems, which creates path dependencies that shape future development. Their evolution is *modular and incremental*, changing through layered, step-by-step processes that require time and negotiation rather than sudden transformation. Perhaps most tellingly, digital infrastructures *become visible on breakdown* - they typically remain invisible during normal operation but suddenly become apparent when they fail or “go down”, revealing the extent of our dependence on these foundational systems (Star, 1999).

1.4 The National Background

The *Culture Dataspace (Datenraum Kultur)* project was created in response to the challenges of the municipal cultural sector in the wake of the COVID-19 pandemic. The Association of German Cities has requested support from the federal government for overcoming the challenges of digital transformation in municipal cultural policy with smaller organizations still struggling with limited IT infrastructure and digital access for their audiences. Building on first regional experiences with e-culture administration frameworks in the public sector (e-government), the Federal Government Commissioner for Culture and the Media is funding a comprehensive trial of the dataspace concept. The objective is to explore the potential of decentralized digital infrastructures as a key element in the transformation of the cultural sector and to create new value-added services that facilitate the effective and forward-looking reuse of cultural data while preserving data sovereignty. The initiative is consistent with the national data strategy, devised to facilitate a greater quantity of data reuse.[4] To achieve rapid results, the project follows the blueprint and analysis of existing data space initiatives in the mobility and industrial sectors[5] to evaluate the experiences and applicability of the concept in the cultural domain.

1.5 Digital Age Challenges to CH Management

Among the many reasons that can be discussed, the change in perception and action in the digital age by younger cultural audiences (who have never experienced a world without the internet or networked technology) can serve as an example. For them, the digital experience is not a separate one, but an integral part of daily life experience and thus central to identity building (Hällgren and Björk, 2022). Especially, the social component of the digital interconnectness has become dominant, with fast interactions across different platforms, retrieving pieces of information here and there, embedded in daily activities. This seamless integration into life shapes their expectations and perceptions of the world around them, and institutions and organizations that reach out to them need to take this into account. This is especially true for cultural heritage institutions, which are now competing with entertainment platforms and other digital content providers for audience attention in an increasingly crowded attention economy. Therefore, they need to provide audiences with broad access to cultural content to explore memorable experiences for education, enjoyment, reflection, and knowledge sharing (Bellio et al., 2024). Unlike

[2] See also: https://pro.europeana.eu/page/digital

[3] See also: https://rea.ec.europa.eu/funding-and-grants/horizon-europe-cluster-2-culture-creativity-and-inclusive-society_en

[4] See also: https://www.bmi.bund.de/SharedDocs/pressemitteilungen/DE/2023/08/nationale-datenstrategie.html

[5] See also: https://catena-x.net/ and https://mobility-dataspace.eu/

older generations, who see the internet as a tool for disseminating and sharing authentic information of interest, younger audiences see it as a space for entertainment, networking, and self-expression, where the "authentic experience" understood as perceived credibility of the source outperforms accurate information retrieval.[6] On the other, research also shows that access to digital culture can be seen as a driver of social and cultural openness, if it takes into account that it tends to reproduce bias and also may intensify real-world inequalities (Mihelj et al., 2019, Lamberti et al., 2025). At the same time, the heritage preservation landscape is changing as digital formats themselves become cultural artifacts that need to be preserved, while traditional preservation methods increasingly benefit from digital enhancements, allowing experts and amateurs to engage as *communities-of-practise* in topics of shared interest (Wenger et al., 2002, Van Balen, 2017). For the heritage management community, this presents opportunities for collaborative documentation approaches that engage communities as co-creators rather than passive consumers, promoting participatory knowledge creation that strengthens democratic engagement with cultural heritage (Adell et al., 2015). The digital transformation thus offers significant opportunities to make cultural heritage more accessible to different audiences, including people with disabilities, geographically restricted access, and communities that have historically been excluded from cultural heritage narratives. Efficient digital strategies are therefore crucial for sustainability and reaching a larger audience with limited resources. This aspect is particularly important as many cultural heritage institutions that depend on public funding are coming under increasing pressure as their relevance is called into question. The institutions that will succeed in this changing environment are those that strategically integrate digital approaches while maintaining their core mission of preserving and communicating cultural heritage (Pöllmann, 2021).

2. What are Dataspaces?

Dataspaces are decentralized digital infrastructures designed to facilitate the secure and efficient exchange of data between stakeholders or participants within a dataspace entity. Dataspaces represent a paradigm shift in data management architecture, fundamentally diverging from conventional centralized systems by establishing a federated ecosystem that prioritizes data sovereignty while enabling controlled data sharing. Unlike traditional data lakes or data warehouses that consolidate information in central repositories, dataspaces implement a decentralized framework where data remains under the management control within the system of its original creators or owners, yet becomes accessible to authorized parties through well-defined protocols and governance mechanisms (Jarke, 2023). Despite increasing academic engagement and the establishment of the topic (Curry 2020; Curry, Scerri, and Tuikka 2022; Otto, Ten Hompel, and Wrobel 2022; Otto and Burmann 2021), the term "data space" remains poorly defined outside of the core disciplines of computer science, particularly in the fields of databases and information systems (Reiberg, Niebel, and Kraemer 2022). It exists alongside the much better-known term of platform economies in the context of "*Smart Service Worlds*" (Engels, Plass, and Rammig 2017), which are primarily characterized by their business-to-consumer (B2C) orientation. The dataspace concept is particularly characterized by its focus on business-to-business (B2B) data exchange among the involved actors. The goal of the dataspace is to accelerate the development of digital value-added services for cultural creators through simplified data reuse. This dataspace approach adheres to the regulatory frameworks established within the European data strategies and the legislative initiatives built upon them, including the EU's *Data Governance Act*, the *Data Act*, and the *AI Act*, as well as in the technological vision of *Gaia-X*. Furthermore, this approach is supported by the *International Data Spaces Association (IDSA*) and follows the blueprint recommendations of the *European Data Space Support Centre (DSSC)* for the creation of sector-specific dataspaces. It is important to note that the term "dataspaces" is currently employed inconsistently across the many projects emerging in Europe, which hinders the establishment of standardized procedures and technological approaches.[7]

Objective	Description
Standardized Connectors	These act as wrapper gateways for the transfer of data between the endpoints of the information systems of the involved organizations. Connectors can assume the technical roles of a data supplier, a data recipient, or both. The exchanged data elements represent an object of relevance or value for both role holders.
Broker Functionality	This includes one or more metadata catalogs with associated vocabulary to support the search and matching between information offers and demands.
Contract Management	This includes contract templates, contract workflows, and monitoring of contract fulfillment to ensure sovereign data exchange processes. This also involves defining and partially automating the monitoring of access and usage restrictions.
Authentication Services	These are intended for the identification of participants and the certification of all the mentioned system components according to IDSA rules. The goal is protection against the misuse of the dataspace by outsiders.

Table 1. Core elements of a minimal viable dataspace

2.1 Dataspaces for Digital Sovereignty

Here, data sovereignty means that data owners retain full control and decision-making authority over their data, including determining who can use it and under what conditions, how it can be processed, and what legal requirements need to be met. Dataspace concepts emerged in the early 2000's in the context of Google Research as a proposal for handling the ever-growing amount of data in various formats (Franklin et al., 2005). Dataspaces aim to enable the accessibility of different data sources without the need for complete integration into a single system beforehand. The omission of the integration aspect in data exchange transactions reduces the workload and focuses on a situational, demand-oriented strategy for data integration. This significantly simplifies data management (Halevy et al., 2006a, Halevy et al., 2006b). By introducing standardized protocols, dataspaces enable the seamless sharing of data

[6] This effect is currently focus of discussion in the context of Social Media and the transformation of the News Sector, i.e. see also: https://digitalcontentnext.org/blog/2024/08/08/engaging-young-audiences-top-trends-and-tactics/

[7] For an overview on various dataspace projects across Europe see also: https://www.dataspaces-radar.org/

Objective	Description
Efficiency Gains through Digital Networking	The EDC connectors enable sovereign data exchange, strengthen interoperability, and facilitate automated data usage contracts among cultural actors.
Support for Smaller Cultural Institutions	Providing guidance in a rapidly changing technical and regulatory environment, technical support for scalable decentralised storage solutions, and professional data management in applying sector-specific metadata standards.
Data-Driven Value Creation	The framework enables innovative value-added services and business models, supporting new value creation chains in the cultural and creative industries that overcome existing silo solutions.

Table 2. Value Proposition of the Culture Dataspace project

Use Case	Description
Content Data	Digital representations of creative works, e.g., digitization of physical art or written records stored in analog format; relevant for value creation.
System-generated Data	Essential for audience development statistics combined with personal data for effective analysis.
Personal Data	The basis for evaluations and future personalization strategies; records subject to enhanced regulations and GDPR.
Metadata	Relevant for realizing the value proposition for all data types; necessary for interoperability and semantic richness.

Table 3. Types of Data in the Culture Dataspace.

across different systems and thus promote the development of new value-added services and business models. Once the exchange transcends the boundaries of individual organizations, so-called data ecosystems emerge. The dynamics of such ecosystems further drive data exchange both within and between various organizations. Dataspaces are therefore well-suited for the exchange of data that, due to their nature, are suitable for direct value creation (Jarke et al., 2019). They offer a sovereign alternative to platform-based service offerings and support new business models in an ecosystem of data and service providers. Dataspaces are in line with legal frameworks such as the EU Data Governance Act and ensure responsible data use and compliance with data protection laws.

2.2 The Conceptual Framework of Dataspaces

The architectural foundation of dataspaces comprises several components that collectively enable sovereign data exchange. The technical core elements for a minimal viable dataspaces are summarized in Table 1. At its core, this infrastructure maintains decentralized data storage, allowing organizations to retain physical control over their digital assets. Interoperability across heterogeneous systems is achieved through so-called *connectors*, i.e., standardized interfaces—including common protocols and application programming interfaces API's—that facilitate seamless connectivity while preserving organizational autonomy. A sophisticated metadata layer provides rich descriptions of available data assets without exposing the underlying data itself, functioning as a *broker* discovery mechanism within the ecosystem. Perhaps most critically, dataspaces incorporate a robust policy element that translates governance requirements into technical implementations. The special ability of dataspaces to enforce data sovereignty manifests itself in several technical mechanisms. Granular access control enables data providers to define precise parameters as to who may access certain data elements, under what circumstances, and for what purposes. Usage control extends this sovereignty beyond initial access by imposing conditions on subsequent data use, e.g., permission to analyze but prohibiting redistribution. Digital *contract management*, encoded as machine-readable and, perhaps more importantly, machine-processable agreements, automates policy enforcement without the need for human intervention for routine administrative tasks. Comprehensive audit trails document all data transactions, ensuring accountability across the ecosystem. In practical implementation, these sovereignty principles materialize through several technological components. Connector technology serves as a secure gateway that verifies credentials and enforces access policies at network boundaries. Contract automation translates legal and business agreements into programmatic implementations that govern data usage agreements. *Identity and authentication services* rigorously verify all participants within the trusted network, ensuring that only authorized entities engage in data exchange. Monitoring systems continuously validate policy compliance, detect and mitigate potential violations.

2.3 Data Management and Policy Enforcement

This architecture delivers significant advantages for data governance across organizational boundaries. Dataspaces achieve a critical balance between accessibility and protection, enabling valuable data sharing and preventing misuse through technical safeguards. This balance builds institutional trust, allowing organizations to share potentially sensitive data with confidence that sovereignty constraints will be technologically enforced. The infrastructure facilitates regulatory compliance by automating adherence to complex legal frameworks such as the *General Data Protection Regulation (GDPR)*. Perhaps most importantly, this sovereignty-preserving environment fosters ecosystem development by enabling secure collaboration that might otherwise be inhibited by data control concerns. For the cultural domain, the infrastructure shall enable transformative applications while respecting the unique requirements of cultural institutions. Creative content can circulate among authorized users while preserving intellectual property rights through technically enforceable policy mechanisms. Cultural assets become available for research, educational, or commercial applications under carefully specified conditions that respect both donor agreements and creator rights. The dataspace enables diverse stakeholders—including museums, archives, publishers, and even individual artists—to collaborate without relinquishing control over their contributions. This technological foundation supports the emergence of novel business models without compromising creators' rights or institutional governance requirements.

3. The *Datenraum Kultur* (Culture Dataspace)

By creating dedicated digital infrastructure environments for data sharing, the EU aspires to position itself as a leader in the data economy while maintaining control over its digital future. *Datenraum Kultur* is one of the lighthouse projects of the German government's National Digital Strategy (Acatech, 2025), which aims to contribute to sovereign data exchange across the cultural and creative sectors. A key objective of the Culture Dataspace is to develop a highly accessible, user-friendly and value creating digital infrastructure. At its core, the project prioritizes the data sovereignty of content owners, creators, and service providers. This system will enable different stakeholders to negotiate sharing machine-readable agreements and exchange content securely within a trusted network. This commitment is reflected in the system's decentralized architecture, which facilitates the direct transfer of content between parties rather than routing it through a central hub. As an integral part of the German government's Digital Strategy (Digitalstrategie Deutschland) [8], the project empowers cultural organizations to cultivate data-driven business models, thereby increasing their economic resilience and digital autonomy.[9] The project pursues three strategic goals (see Table 2): demonstrating efficiency gains through digital networking, supporting smaller cultural institutions, and making data-driven value creation visible.

3.1 The Culture Dataspace Implementation Approach

Culture Dataspace aims to strengthen the competitiveness and visibility of the cultural sector by creating a shared digital infrastructure that functions as a balanced data ecosystem. In this ecosystem, participants from different cultural domains collaborate and benefit from each other while maintaining sovereign control over their data assets. What distinguishes this cultural dataspace concept from other platforms is its transactional focus on business-to-business (B2B) data exchange between dataspace participants. The primary goal of the dataspace is to accelerate the development of value-added digital services by cultural creators and their service providers, facilitating the reuse of data. A major challenge here is the fragmented and heterogeneous composition of the various service players in the cultural sector. Here, the digital transformation blurs the boundaries between value chains throughout the creative process, where various subsectors interact and innovate with each other. Different convergence processes can be observed; some areas, such as broadcasting and the gaming industry, are more open to cross-sectoral innovations, meaning they readily collaborate with other industries to develop new ideas and easily embrace digital technologies. In contrast, other sectors, such as artistic crafts or visual arts, show less willingness to engage with non-cultural sectors, as illustrated in several case studies analysed in an EU study (De Voldere et al., 2017).

3.2 Understanding Requirements through Use Cases

The viability of the technical framework is tested via use cases selected from different cultural domains (Datenraum Kultur, 2025). The framework showcases its adaptability in addressing a variety of use cases (see Table 4) with differing technical requirements while prioritizing data sovereignty. Four use cases from distinct cultural domains are analyzed to explore specific opportunities and challenges, thereby identifying the technical and organizational prerequisites for a cultural data space. The use case studies were selected for their relevance to the topic and their ability to highlight specific challenges and perspectives of digital transformation in culture and the arts. These case studies provided valuable empirical evidence and practical insights into the challenges and perspectives of digitalization in this field. These use cases, derived from open stakeholder dialogues facilitated by the National Academy for Technical Sciences (acatech)[10], illustrate how multiple actors can collaboratively enrich and integrate their data resources while preserving their autonomy. They were selected to gain insights into the technical and organizational demands of a cultural data space ecosystem where no single entity exerts dominance, validating these concepts through real-world applications. The project encompasses various types of cultural data, represented by heterogeneous sets of diverse data types (Table 3), including both works and their digital representations (i.e., Cultural Heritage assets), system-generated personal data, and metadata essential for value creation and interoperability. To manage the significant data heterogeneity of the data assets provided and facilitate the search for appropriate data in the catalog, the project employs a comprehensive information model utilizing Linked Data and Knowledge-Graph technologies to augment catalog functionalities.

Use Case	Description
Connected Cultural Platforms	Improving interoperability between urban or regional cultural platforms to enable cross-regional event inquiries and integration with repositories like the German Digital Library.
Smart Museum Services	Developing federated thematic web portals that collect and present information from distributed sources, examining tensions in handling open and non-open data and various rights constellations.
Smart Theater Services	Creating machine-readable standards for theater schedules to simplify the distribution and reuse of updated information through semantic data standards and software tools.
Smart Music School Services	Building a quality-assured platform for online music-making, providing of music sheets and multimedia files, designed as a matching tool for musicians and teachers.

Table 4. Use Cases in the Culture Dataspace project.

3.3 Preliminary Findings and Participant's Evaluations

The project addresses various types of cultural data exemplified in heterogeneous sets of different data types (Table 3): works and their digital representations (i.e. Cultural Heritage assets), system-generated transaction data, personal data, and metadata crucial for value creation and interoperability. The project implements a broad information model with Linked-Data technologies (Fraunhofer FIT, 2025) collaboratively developed with the Use Case communities to handle the significant data heterogeneity of data assets provided. The model also facilitates searching for suitable data assets in the catalog. Despite the considerable strengths in trusted data transfer, the framework

[8] See also: https://www.bundesregierung.de/breg-de/service/archiv-bundesregierung/datenstrategie-2023-2216620

[9] See also: https://datenraum-kultur.fit.fraunhofer.de

[10] See also: https://en.acatech.de/project/the-culture-data-space

exhibits notable limitations in data processing, lacking critical tools for format mapping and integration, both at the data provider and data consumer side. This gap impedes comprehensive data quality enhancement and represents a significant area for improvement. Moreover, the software design and code require considerable computational skills of experienced developers with knowledge in distributed information systems, exceeding what cultural actors typically can realize themselves. It turns out that interacting with the frameworks requires graphical user interfaces tailored to specific needs, capturing the modeling and discourse practices of the different participant communities, especially when it comes to handling metadata. On the other, the EDC framework's ability to function as a socio-technical system, where governance, user interaction and trust building among its participants are as important as technical implementations, emerges as a key strength.

4. The Eclipse Dataspace Components (EDC) Framework

The *Eclipse Dataspace Components (EDC)* framework is used to provide core functionalities of a minimal dataspace system with its basic components, actively developed by a large international developer community and maintained by the Eclipse Foundation (Eclipse Project, 2025, Github, 2023). The software is Open-Source, written in the *Java* programming language and used by dataspace projects across various domains. It provides domain-agnostic components for setting up dataspaces based on the specific needs of different communities. Essential to the framework are *secure connectors*, robust mechanisms for contract templates, workflows, and monitoring of contract fulfillment, enabling the definition and partial automation of access and usage restrictions, thus fundamental building blocks for sovereign data exchange. The Culture Dataspace EDC-implementation[11] by design deviates from the prevailing platform models that aim to collect and centrally store user data. Instead, the system architecture of the Culture Dataspace system facilitates decentralized data storage and exchange among participating entities, thereby ensuring full data sovereignty for its members (Figure 1). Additional components provided through the Culture Dataspace project ensure trust through adapted policy extensions and persistent data usage agreements. Expressed in the *Open Digital Rights Language (ODRL)*[12]– a policy expression language that provides a flexible and interoperable information model, vocabulary, and encoding mechanisms for representing statements about the usage of content and services–these extensions are customizable for different scenarios. The *Eclipse XFSC (Cross Federation Services Components)*[13] is included, functioning as a decentralized catalog, allowing for extended vocabulary handling based on a knowledge-graph approach, integrating Linked Data principles and existing semantic standards compatible with the federated services architecture of Gaia-X. The *Connector-as-a-Service* implementation proves especially valuable for institutions with varying levels of digital maturity since no on-site deployment of the connector software is required, offering dataspaces accessibility, low-threshold cloud storage access, and a basic collaboration environment for participants linked to the dataspace. To our knowledge, the Dataspace Culture project so far is the first of its kind in the culture domain to adhere to the blueprint provided by the *EU Data Space Support Center (DSSC)*[14].

[11] See also: https://github.com/Fraunhofer-FIT-DSAI/drkultur-edc
[12] See also: https://www.w3.org/TR/odrl-model/
[13] See also: https://projects.eclipse.org/projects/technology.xfsc
[14] See also: https://dssc.eu/

5. Adoption Requirements from the Heritage Community

Dataspaces for the cultural domain are relatively new. Our architecture is aimed at implementing trusted transfers of data assets that are only available to authorized users after prior acceptance of usage policy rules to trigger value chains in the data economy. In this regard it differs from other major dataspace initiatives primarily aimed to the scientific and educational sphere, such as the Italian *DataSpace of the Institute of Heritage Science-ISPC* (Bucciero et al., 2023) initiative or the scope of the EU funded *European Cloud for Heritage Open Science (ECHOES)*[15] project consortium overseeing the creation of the European Collaborative Cloud for Cultural Heritage. In any case, we also consider the *FAIR principles* (Wilkinson, 2016) to be fundamental in achieving the desired community orientation within the project and actively examines the EDC's viability with integration of FAIR-compatible research data infrastructures. Future development, therefore, shall focus on implementing more standardized ontologies, semantic querying capabilities, schema mapping support, format conversion utilities and configurable data transformation pipelines specific to different cultural domains. For the heritage documentation field, transformative dimensions can be identified as follows: **Federated access to Heritage documentation**: The documentation of cultural heritage generates diverse technical data sets—from point clouds and photogrammetric models to GIS layers and parametric BIM components, which have competing requirements in terms of accessibility and protection. The dataspace architecture enables comprehensive access to documentation resources while respecting institutional autonomy and cultural sensitivities. Rather than centralizing collections, this approach creates federated pathways to distributed resources governed by nuanced access policies, and without the need to transform data to a specific format or schema before transaction. **Cultural sovereignty on sensitive spatial data**: Spatial data infrastructures already employ similar distributed approaches, and the dataspace model extends these principles by introducing sophisticated usage controls, particularly valuable for culturally sensitive locations, including heritage sites where geographic information requires specialized governance. Also, many collections embody complex stewardship arrangements exemplified with the *CARE-principles*[16] involving multiple jurisdictions, communities, and international conventions (Carroll et al., 2021). Dataspaces can translate these nuanced requirements into technically enforceable policies rather than relying solely on legal agreements. **Transforming dissemination and interpretation**: Dataspaces have the potential to revolutionize the way heritage content is shared and interpreted in virtual environments and public engagement. Within these digital frameworks, interactive experiences can be seamlessly drawn from multiple data sources, tailoring content to users based on their credentials and context. For example, educational users may be granted different access rights than commercial users, with these distinctions managed automatically by the system. This approach enables layered interpretive experiences, where scholarly research, community narratives, and original documentation coexist—each clearly attributed to its source.

[15] See also: https://www.echoes-eccch.eu/
[16] A set of guidelines aimed at supporting the ethical management of cultural memory institutions, promoting equitable access, representation, and collaboration. These guidelines emphasize the importance of community ownership and authority, as well as the responsibility of institutions to adhere to ethical standards in the management of cultural heritage

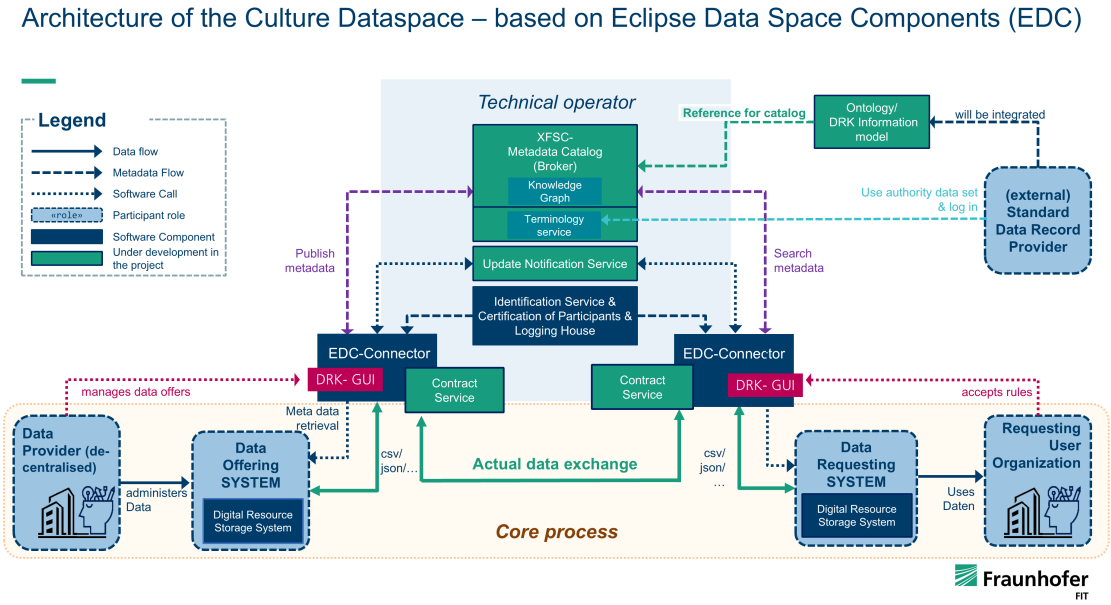

Figure 1. EDC Infrastructure for decentralized data exchange in the Culture Dataspace

6. Societal Value of Cultural Heritage and the Role of Digital Infrastructures for Culture

Cultural heritage operates as a foundational identity infrastructure that serves society by embodying shared narratives, collective memory, and a sense of belonging that transcends individual experience. These inherent values function as invisible scaffolding for social cohesion, enabling intergenerational understanding while preserving the diverse cultural expressions that define communities across time and space. We are convinced that digital infrastructures for culture should be guided by frameworks that elevate societal values—identity, collective memory, and wellbeing—alongside institutional and economic considerations, enabling the cultural sector to fulfill its essential role in fostering informed, connected, and resilient societies. Dataspace frameworks as presented above, therefore, must be further developed to promote broad knowledge sharing across the entire data spectrum range—from closed to shared to open data, e.g, through easily connecting also to open access platform technologies that are already aimed at democratizing engagement with heritage materials. The current transactional focus of dataspaces on data exchange needs to be broadend to allow for easy integration with other existing digital frameworks and infrastructures that serve educational, inclusive, and culturally continuous purposes rather than merely operational efficiency, without compromising or abandoning the trust and policy mechanisms essential to the dataspaces and the EDC framework in particular.

6.1 Technical and Organizational Implications

However, the direction of development is determined by both internal and external factors, which must go beyond more technical considerations and take into account the diversity of systems and technologies faced by decision-makers at the operational and administrative levels. For the infrastructure to grow it requires broad acceptance and adoption of the technology, a step that has to address real-world benefits for its participants and also be a driver for motivation. Research in the field of digital infrastructures confirms that the dynamics of configurations require a loosely coupled architecture and decentralized governance to create the space of possibilities necessary to mobilize the innovation mechanisms within the system (Henfridsson and Bygstad, 2013). Digital infrastructures for culture should be guided by frameworks that elevate societal values—identity, collective memory, and wellbeing—along with economic considerations, enabling the cultural sector to fulfill its essential role in fostering informed, connected, and resilient societies. When properly designed and managed, these infrastructures become transparent enablers of cultural continuity. However, to effectively serve emerging possibilities and changing purposes, a key question concerns how an infrastructure can be extended to cater for future services in its functional areas. This requires aligning new partners whose digital capabilities spur innovative services that attract more users. Research on digital infrastructures provides helpful typologies that cover various growth tactics, i.e., adding helpful services and tools, inventing purposeful processes, using common identifiers as a means of standardizing classifications with names for objects that identify salient things in a functional area, and providing interfaces to easily connect and integrate with third-party systems to enable the growth of a digital infrastructure. The key point is that adding services and connecting existing systems to a digital infrastructure can increase the willingness of stakeholders to actively participate in its development over time. Innovation processes can help scale activities that enable a digital infrastructure to reach the level of maturity necessary for its continued growth and development (Koutsikouri et al., 2018).

6.2 From Sovereignty to Commons: Cultural Heritage as Epistemic Infrastructure

Digital infrastructures in the cultural sector require management frameworks that consider societal benefits next to institutional or commercial interests. This transformation requires infrastructure that supports not only institutional stewardship but also community-based preservation practices and diverse epistemological approaches to heritage documentation. The data-

space architecture, while beginning with sovereignty principles, must evolve towards a more general-purpose open-ended infrastructure that also promotes participatory knowledge creation. Cultural heritage documentation represents collective memory, requiring access modalities that serve not only current institutional needs but unforeseen future uses by communities, researchers, and publics not yet imagined. This commons orientation demands governance frameworks that balance transactional protection with broad participation in cultural knowledge creation. Although data sovereignty provides the necessary technical foundations, the ultimate vision for cultural dataspaces may reach further and extend toward creating *epistemic commons*—shared knowledge infrastructures that serve collective understanding rather than predetermined institutional objectives. To what extent such digital infrastructures for the cultural sector should be assigned a designated role, such as *data intermediaries* as defined within the EU’s legislative framework of the *Digital Governance Act (DGA)* or concerning the re-use of certain categories of protected cultural data held by public sector bodies as per the *Open Data Directive* still needs more elaboration.[17]

7. Conclusion and Outlook

Dataspaces play a systemic relevant role in the realization of data sovereignty, establishing necessary levels of trust for actors through decentralized, orchestrated access to data resources based on negotiated usage contracts. By implementing governance policies through a technical infrastructure rather than merely documenting them in agreements, dataspaces create environments where organizations can confidently participate in collaborative data ecosystems while maintaining appropriate control over their digital assets. This characteristic proves particularly essential in domains where intellectual property considerations, sensitive information handling, and specific usage restrictions constitute critical operational requirements. However, beyond technology, increasing attention must be given to transparency, governance, and trustworthiness for broader acceptance of future data ecosystems.

7.1 Positioning Dataspaces next to Open Data Initiatives for Culture in the Context of EU’s Data Strategy

Initiatives like *Datenraum Kultur* represent significant progress toward collaborative value-creating ecosystems that respect the complex sovereignty considerations inherent in cultural heritage while maximizing the potential of digital technologies for conservation, research, and public engagement. Beyond investing in the economic and social value of culture, the project aims to maintain the relevance of publicly funded cultural initiatives in the digital age by fostering reliable and trustworthy data-sharing relationships. Within the European data strategy, Open Data and dataspaces are not mutually exclusive but rather complementary concepts. The *Open Data Directive* provides the foundation for making non-sensitive public data a common good, yet not all data—probably most of it—can be treated as such. Dataspaces offer a secure, regulated, and sovereignty-preserving infrastructure for vast amounts of data—both public and private—that are more sensitive and cannot be shared without strict controls and clear governance. The Culture Dataspace, for instance, must handle complex rights constellations and intellectual property, making the controlled environment of a dataspace more suitable than a plain Open Data approach.

[17] Recommendations for DGA implementation see: https://digital-strategy.ec.europa.eu/en/library/new-practical-guide-data-governance-act

7.2 Evolutionary Response to Web Infrastructure Growth

The development of dataspaces represents an evolutionary, top-down response to the outcomes of the Web’s success, contrasting sharply with the Web’s revolutionary, initial bottom-up origins. While the Web was built on a minimal set of simple, open protocols that enabled highly dynamic, almost chaotic, and permissionless innovation, dataspaces are intentionally designed to solve problems that emerged from this openness: loss of data control, the rise of global hyperscaler service providers, and the need for trustworthy B2B collaboration. Such a dataspace infrastructure development is deliberate, using blueprints, standardized components, and policy enforcement to create secure, sovereign, and economically focused environments. The emphasis shifts from open access for all to controlled access for trusted partners, ultimately aiming at a decoupling from the market power of global hyperscaler service providers.

7.3 Implementation Challenges, Dependencies, Critical Success Factors and Risks

The Datenraum Kultur project leverages existing governance structures and software components from the mobility data field to shorten entry to market and facilitate early adoption of the concept. While this orientation reduces barriers to entry, it creates dependencies on fundamental system design decisions in the selection and realization of individual software components. The main goal remains encouraging innovation processes that enable stakeholders to develop new and appealing digital services for end users, though this involves considerable technical and regulatory challenges in creating necessary B2B2C (Business-to-Business-to-Consumer) platforms or services. The successful establishment of dataspaces in the cultural sector will heavily depend on low-threshold access, user-friendliness, the number of participants and their active engagement to act as a community, and volume and quality of available data provided by the dataspace. The deliberate, centralized development approach presents several challenges: *risk of inflexibility and slow pace of innovation* as centralized planning may inhibit the rapid experimentation that characterized early Web development, *high barriers to entry and limited adoption risk* where complex governance structures may deter smaller institutions with limited technical capacity, *path dependency and technological mismatch* because early architectural decisions may create long-term constraints incompatible with evolving cultural heritage needs, *disconnect between central planning and user needs* since top-down design may not adequately address diverse institutional requirements across the cultural sector, and *contradiction in fostering a “Commons”*, here the controlled nature of dataspaces may conflict with epistemic cultural values of unrestricted open access and knowledge sharing.
Overcoming these challenges requires continued research focus on balancing sovereignty with accessibility, developing flexible governance models that can adapt to diverse institutional needs, and creating technical solutions that maintain security while enabling innovation. Future studies should examine how cultural dataspaces can maintain their collaborative potential while addressing the inherent tensions between control and openness that define the cultural heritage sector.

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