Chapter 9
Digital Transition Strategies for Architectural Heritage

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Abstract The implementation of digital technologies has been a feature of many of the most important socio-economic changes of the last two decades and has introduced significant transformations also in the field of cultural heritage.

The digital transition had already been underway for some time with objectives focused on the preservation and protection of heritage sites increasingly exposed to risks from natural, climatic, and anthropogenic factors. In the last few years (partly because of the pandemic crisis), new ways of perceiving, communicating, and enjoying cultural heritage have also become objectives to be achieved through digitization. The process of digitization is one of the strategic objectives of the cultural heritage preservation and enhancement policies pursued by the European Commission and, on a national scale, by several member states.

Recent recommendations published by the European Commission set out the objectives of the digital transition in the sector and strategies for the realization of a common European data space to ensure the accessibility and interoperability of digitized cultural resources. Contributing to the achievement of these goals are ongoing initiatives in different countries to strengthen cooperation and create transnational networks for the sharing and dissemination of technologies, services and products for the preservation of cultural heritage.

Keywords Cultural heritage · Digital transition · Digital infrastructures · CH Competence Centre

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9.1 Digital Technologies for the Architectural Heritage

The rapid development of digital technologies, often a determining factor in socio-economic changes over the past two decades, has introduced significant transformations in the field of preservation, knowledge, and enjoyment of cultural and architectural heritage.

The judgements on these transformations and the ways in which they have been implemented are controversial. Nevertheless, the contribution that these technologies have offered in implementing actions aimed at preserving the social and identity values, both tangible and intangible, of cultural heritage, especially in times of crisis, is undeniable.

During the recent pandemic, in particular, this contribution very often took the form of actions that were able to give substance to that relationship, so often referred to in those years, between crisis and opportunity.

Information and communications technologies (ICTs) played a fundamental role during a time when all activities related to the cultural heritage sector were severely affected by restrictions that, in many cases, limited or completely closed access to monuments and sites.

These events have provided a tremendous boost to the innovation process of ICT applications and tools, resulting in radical transformations not only in the modes of access and consumption but also in the ways of visiting and understanding places and artworks, expanding the scope of contributions offered by digitization.

A proper use of digital tools has demonstrated the ability to transform and enhance the quality of programming and managing access to sites of historical and artistic heritage. Rather than replacing the physical and sensory experience, digital technologies enrich that experience with supportive tools and access to information. They can contribute to a better understanding of monuments and artworks, refocusing attention on dispersed heritage sites and locations, stimulating participation in innovative cultural initiatives and programs, and ultimately fostering active community involvement in the preservation of historical and artistic heritage.

All of this has broadened horizons and multiplied the objectives of a digitization process in the cultural heritage sector, which, although already initiated some time ago, had primarily focused on applications aimed at prevention, documentation, and preservation of the parts of heritage most exposed to risks from natural, climatic, and anthropic factors.

The new objectives and challenges they pose require a strengthening of cooperation between digital and physical infrastructures in the field of cultural heritage preservation. It is crucial to create transnational networks that facilitate the sharing and dissemination of technologies, services, and products aimed at conserving the historical and artistic heritage.

A proper approach to the application of Information and Communication Technologies in the conservation, safeguarding, and enhancement of architectural heritage is essential to ensure that these actions significantly contribute to positively guiding ongoing transformation processes.

In summary, to address the current challenges and achieve the new objectives in the field of cultural heritage preservation, it is crucial to promote cooperation between digital and physical infrastructures, create transnational networks, and adopt a proper approach to the application of ICTs. Only through conscious and strategic use of digital technologies will it be possible to positively shape transformation processes and preserve cultural heritage for future generations.

The European Commission has played a significant role in encouraging and guiding the development of this process. Over the past two decades, numerous studies, reports, and recommendations have been issued by the European Commission, indicating to member states the objectives to be attained and the areas in which they should politically and financially support institutions that promote technological innovation in the cultural heritage sector.

Recommendations published in the last years have consistently emphasized the importance of enhancing collaboration between digital and physical infrastructures and establishing transnational networks for the exchange and dissemination of technologies, services, and products related to cultural heritage preservation.

It is crucial to recognize the European Commission's efforts in fostering this process, as they have provided valuable guidance and strategic direction to member states. By aligning their policies and investments with these recommendations, countries can effectively leverage the potential of digital technologies in preserving and promoting their cultural heritage.

Moreover, the European Commission's involvement in supporting technological innovation in the cultural heritage sector has paved the way for cross-border collaborations and knowledge-sharing initiatives. Through transnational networks, institutions and professionals can exchange best practices, share research findings, and collectively address common challenges. This collaboration not only enhances the preservation and safeguarding of cultural heritage but also fosters a sense of shared identity and cultural understanding among European countries.

9.2 Principles, Aims, and Expectations

The process of digitizing architectural heritage is one of the strategic objectives of the conservation and enhancement policies pursued by the European Commission and, at the national level, by several member states.

The *Commission Recommendation of 27 October 2011 on the digitization and online accessibility of cultural material and digital preservation (2011/711/EU)* represents an initial assessment of the actions undertaken in the first decade of the 2000s and is considered a milestone in the European digital cultural policy.

In this document, the European Commission provides a detailed overview of the principles on which it intends to bring concreteness and consistency to a European strategy for the digitization and preservation of cultural heritage.

This strategy, as stated in the 18 points introducing the recommendations, is based on the work carried out in previous years, which until that moment had been

hindered by inconsistencies and lack of uniformity in the results achieved and the actions taken by member states.

In 2006, the Commission issued a recommendation to member states to optimize the economic and cultural potential of European cultural heritage using the Internet.

In the following years, initiatives aimed at further development of digitization and collaboration at the European level intensified. Among the most significant ones were the launch of Europeana in November 2008; the publication of the report "The New Renaissance" by the "Comité des Sages on bringing Europe's Cultural Heritage online" on January 10, 2011; and the Commission's proposal for a directive on so-called Orphan Works on May 24, 2011 (works protected by copyright or related rights whose rights holders have not been identified or, if identified, cannot be located).

The fundamental principles guiding the European strategy for the digitization of cultural heritage during those years already contained some of the key concepts that would be found in the *The FAIR Guiding Principles for scientific data management and stewardship* in 2016, namely, findability, accessibility, interoperability, and reuse of digital assets (Wilkinson et al. 2016).

Member states were recommended a series of measures for the digitization and online availability of cultural heritage and for the preservation of digitized material from libraries, archives, and museums, with the aim of ensuring that Europe maintains its position as an international leader in the field of culture and creative content and maximizes the use of its wealth of cultural material.

The need for digitized material to be accessible and reusable, both for commercial and non-commercial purposes such as educational content development, tourism applications, games, and animations, is emphasized, provided that this is done in full compliance with copyright and related rights. This is aimed at contributing to the development of creative industries, transforming value chains, and developing new business models.

The need for technical solutions for the preservation and management of digital material that considers the risks of hardware and software obsolescence and dedicated data storage infrastructure is highlighted.

Despite progress in digital material preservation, several member states still lack clear and comprehensive policies on digital content preservation. The absence of such policies poses a threat to the survival of digitized material and the risk of losing born-digital material. The development of effective digital preservation methods and the establishment of common standards emerge as significant concerns for any public or private organization that is obligated or wishes to preserve digital material.

The process of digitization has gained significant momentum in recent years. This is due to the emergence of new expectations driven by innovations in the field of ICT, as well as the need to safeguard an increasingly fragile heritage threatened by environmental risks (climate variations, floods, earthquakes, etc.) and "anthropic" risks (resulting from human behaviours: negligence, excessive number of visitors, vandalism, etc.).

In his statement released on Nov. 20, 2021, *How digital will help us preserve our Cultural Heritage Statement*, following the Notre Dame fire, Thierry Breton stated:

> Our Cultural Heritage is an intrinsic part of our shared European values and cultural diversity, which are the foundation of our European identity. This is why we need to preserve it. And in order to preserve it, we need to help ensure that our European heritage is fully embedded in the Digital Decade.

Emphasizing the importance of a digitization strategy focused on 3D digitization, he also said:

> Less than 20% of the collections at our museums, galleries, or libraries are digitized. The situation is even more dramatic for sites and monuments. At the same time, these treasures are increasingly exposed to natural and man-made risks: from the fire of the cathedral of Notre-Dame in Paris, to the regular flooding of Venice, or vandalism in the Modern Theatre in Sofia.

His conclusions, "By 2030, we want all monuments and sites at risk, and at least 50% of the most visited ones, to be digitized in 3D," and "I want a digital twin of Notre Dame, for preserving it, for re-using it. In video games, in education, in research, in tourism," are echoed on the same day in the Commission Recommendation on the common European Data Space (Commission Recommendation (EU) 2021/1970 of 10 November 2021), which launches some very big challenges.

The objectives and challenges outlined in the recommendations place 3D modelling for the creation of digital twins, the establishment of a common European data space, and adherence to FAIR principles at the core of the digital transition process.

In the text, the European Commission provides detailed content and objectives for the strategies in realizing a common European data space for cultural heritage, aiming to ensure the accessibility and interoperability of digitized cultural resources. The document indicates to member states the objectives to be achieved and the areas in which they should politically and financially support institutions operating in the cultural heritage sector.

All monuments and sites at risk, as well as 50% of the most physically visited monuments, buildings, and sites, must be digitized in 3D by 2030. This represents a significant number of assets, with a target of 2,400,000 by 2025 and 16,000,000 by 2030.

The Recommendation also calls for the creation of a common European data space that can host and make 3D digital assets findable, accessible, interoperable, and reusable, following the FAIR principle. It also emphasizes the need for semantic interoperability of formats and standards for 3D digital assets and metadata.

To achieve the goals outlined in the Recommendation, it is essential to strengthen cooperation between digital and physical infrastructures and create transnational networks for the sharing and dissemination of technologies, services, and products for the preservation of cultural heritage.

Defining a strategy to address this challenge raises several questions:

– Are those targets achievable? Considerations should be given to the time and cost involved in 3D digitization.

– Are the targets appropriately tailored to each member state? Various factors such as size, characteristics, and risk exposure necessitate the development of suitable strategies for each country.
– Should a level of quality be established? How can the level of quality be determined? Which parameters should be considered? FAIR principles?
– How should the satisfaction of FAIR principles be assessed? For whom, for what purposes, and in what ways should the 3D digitized assets be FAIR (i.e. findable, accessible, interoperable, and reusable)?

With the National Plan for the Digitization of Cultural Heritage (PND), developed by the Central Institute for the Digitization of Cultural Heritage (Digital Library of the Ministry of Culture), Italy has defined the strategic vision with which it intends to address these challenges and tackle the digital transformation process in the period 2022–2026.

In accordance with the FAIR principles outlined in the recommendations of the European Community, the Plan aims to expand access to digital resources, promote cooperation in data management and interoperability, and foster exchange with international digital research infrastructures.

The tools provided by the Plan for planning and implementing activities related to the digitization of cultural heritage and related services are structured in the form of guidelines that "…define approaches and procedures and provide informative and non-prescriptive references, illustrating the main methodological and technical frameworks…" (Piano nazionale di digitalizzazione del patrimonio culturale 2022–2023, Documento di Sintesi, Versione 1.1). The guidelines specifically address the following:

1. Procedures for the creation, metadata assignment, and archiving of digital objects.
2. Data management plans.
3. Acquisition, circulation, and reuse of reproductions of cultural assets in a digital environment.
4. Classification of digital products and services, processes, and management models.
5. Tools for evaluating the digital maturity assessment of cultural institutes.

The initial phase of work by the Digital Library task force focuses on museums, archives, and libraries, as well as central institutions and state cultural sites that possess, protect, manage, and enhance cultural assets. Subsequently, after careful definition of standards and classification criteria for existing digital assets and identification of acquisition procedures and infrastructure for data storage and access management, the activities will shift to the more complex topic of 3D digital assets, which, as we will see in the following paragraphs, raise particularly intricate issues.

9.3 European Strategies

To outline the possible scenarios faced by a digital transition policy for cultural heritage, particularly regarding its immovable part consisting of architectural heritage, we need to go back to the major challenges and ambitious objectives set by the Commission Recommendation of 10 November 2021 (Commission Recommendation (EU) 2021/1970).

Article 6 of Chapter II of the Recommendation states that by 2030 member states should digitize in 3D all monuments and sites at risk and the 50% of those that are most physically visited. Furthermore, by 2025, member states should aim to achieve 40% of these overall 2030 digitization goals.

For Italy, this translates into impressive numbers and incredibly short implementation times. Although the percentage of 3D assets to be realized by 2025 is lowered to 15% of the 2030 target in the tables attached to the recommendations, the corresponding figures for the objectives to be achieved indicate:

– 2,047,960 3D digital assets by 2030 (the total for the 27 member countries is 16,007,034)
– 307,194 assets in 3D by 2025 (2,401,055 in the EU total)

The extreme precision in accounting for assets leaves room for the feeling that there hasn't been sufficient exploration of the feasibility of an operation of such magnitude.

A policy focused on digitizing cultural heritage using advanced digital technologies and based on the belief that "3D digitization with the highest level of detail may even be a necessity, for example for conservation and restoration purposes" (Commission Recommendation (EU) 2021/1970, page 3, point 10) entails a complex journey in fields that are still only partially explored.

Already in the Horizon 2020 Work Programme 2014–2015, titled "Europe in a Changing World: Inclusive, Innovative and Reflective Societies," specifically in the call *REFLECTIVE-7-2014: Advanced 3D modelling for accessing and understanding European cultural assets*, the strategic research objective was outlined as the development of *New methods and tools for automated 3D modelling and analysis beyond simple digital reconstruction.*

The call text emphasized that "The 3D representations should go beyond current levels of visual depictions, support information integration/linking, shape-related analysis, and provide the necessary semantic information for in-depth studies by researchers and users."

The proposal through which the Inception project secured funding aimed at the realization of innovative methodologies and tools in 3D modelling. Achieving this objective involved:

– Enhancing the efficiency of three-dimensional data capturing procedures and devices, especially their suitability and aptitude for physical cultural resources and assets: cultural heritage sites, historical architectures, archaeological sites, and artifacts characterized by non-conventional characteristics, location, and geometries.

- Optimizing hardware and software instruments for an easy scan system, rapid capture of main features/geometric data, and automated data output in an H-BIM (Historic Building Information Modelling) environment.
- Developing a standard for managing 3D point cloud data at multiple scales, ranging from artifacts, buildings, to the environment and infrastructure.
- Defining an open-standard format and semantic ontology to generate high-quality, reliable, and interoperable models of H-BIM.
- Implementing a multilevel database of 3D semantic models oriented towards various use cases, such as understanding, enhancement, promotion, management, and enjoyment of cultural heritage, as well as supporting conservation and restoration works.

The Inception project, concluded in 2019, successfully achieved the set objectives, producing results that met the expectations of the European Commission and aligned with the digitalization policies of cultural heritage. At the same time, the research highlighted the challenges in the three-dimensional modelling processes and the work that still needed to be done to streamline and reduce the time and cost of the three phases of 3D digitization processes: capturing, data processing, and modelling.

Regarding the capturing procedures, the innovations developed in the Inception project, coupled with advancements in laser scanning and photogrammetric technologies, have led to significant improvements in terms of speed, result quality, and cost containment. However, many challenges still remain for the data processing and modelling phases.

In recent years, research has primarily focused on key areas. One of these areas concerns the development of semantic segmentation systems for point clouds, working on algorithms and techniques that can accurately classify and label elements within a point cloud.

Another area of interest involves exploring the applications of machine learning and deep learning technologies to expedite the modelling process of H-BIM models, aiming to automate and simplify the generation of detailed 3D models based on data acquired through laser scanning or photogrammetric surveys (the so-called scan-to-BIM procedures).

Advancements in these fields can significantly reduce processing time and costs, making it possible to achieve the enormous number of digital assets referenced in the November 2021 Commission Recommendation.

It will also be necessary to adopt a scalable approach in the digitization process, which entails defining different levels of quality standards for 3D digital resources based on their usage and purpose.

Such an approach can promote an inclusive strategy in collecting existing 3D assets and producing new ones, enabling the reuse of already available models for appropriate purposes, improving, and standardizing ongoing ones and optimizing the production of new ones.

To achieve this, rules and principles must be established to initiate and govern the digitization process (AA.VV. 2022). For example, criteria and guidelines should be developed for:

- Classifying the processes and stages of 3D model production.
- Classifying the digital assets produced based on different acquisition techniques.
- Classifying existing digital objects based on acquisition techniques, quality, data reliability and, whenever possible, aligning them with standards for new digitizations.
- Defining standards and quality levels related to resolution, accuracy, and precision for both acquisition and modelling processes.
- Classifying formats and establishing data interoperability criteria.
- Defining procedures and metadata models.

Contributing to the development of these rules and principles, as well as initiatives to harmonize them at the European level, is one of the tasks of the European Competence Centre for the Conservation of Cultural Heritage, which we will address in a later paragraph.

Crucial, finally, is the implementation and development, already underway, of digital service infrastructures for cultural heritage devoted to data storage, access, and exchange according to FAIR principles.

9.4 European Digital Research Infrastructures

Among the main issues addressed in recent years in the debate on the digital transition of cultural heritage, the need to continue developing and consolidating the creation of digital infrastructures, which, by adding and cooperating with existing operational ones, facilitate access and utilization of data and services, is of particular importance.

The European Commission has promoted several initiatives in the European Strategy Forum on Research Infrastructures (ESFRI) roadmap, and some of these have subsequently led to the establishment of ERICs (the European Research Infrastructure Consortia).

The European Strategy Forum on Research Infrastructures (ESFRI) was established in 2002 with the mandate from the EU Council to support a coherent and strategic approach to defining research infrastructure policies in Europe. Its goal is to facilitate multilateral initiatives that lead to the better use and development of research infrastructures at the European and international levels. In 2006, ESFRI published its first roadmap, which has since been regularly updated to construct and develop the next generation of pan-European research infrastructures. In the ESFRI 2018 Roadmap, new proposals were presented with a significant or substantial character of digital research infrastructure. ESFRI also established a Strategy Working Group on Data, Computing, and Digital Research Infrastructures (SWG DIGIT) to

evaluate these proposals, thus completing the series of SWGs for the identified areas of research infrastructure in the roadmap.

The 2021 roadmap now includes 41 European research infrastructures that have already been established and 22 projects in the preparatory phase. The total investment in these structures exceeds 20 billion euros.

The European Research Infrastructure Consortia (ERICs) is a specific legal form that allows for the creation and management, based on guidelines provided by the Commission, of new or existing research infrastructures of European interest.

Another important initiative is the European Open Science Cloud (EOSC), promoted by the European Commission in 2015 and aimed at building an infrastructure that offers users a range of services that encourage the adoption of open science principles. EOSC began its activities in November 2018, providing access to services through the EOSC portal.

The most focused infrastructures in the area of cultural heritage preservation, documentation, and management are E-RIHS "European Research Infrastructure for Heritage Science" (https://www.e-rihs.eu/) and DARIAH "Digital Research Infrastructure for the Arts and Humanities" (https://www.dariah.eu/), the latter with the legal form of ERIC.

The mission of E-RIHS, whose partnership brings together 16 Countries (15 EU member states plus Israel), is to provide access to expertise, data, and technologies and network European facilities within the scientific community dealing with cultural heritage. In 2016, E-RIHS entered the roadmap of the European Strategic Forum for Research Infrastructures (ESFRI) and is currently in phase 2 of the implementation process.

The objective of DARIAH is to offer a range of services and activities focused on research communities to help develop national initiatives and transnational research in the field of digital arts and humanities. DARIAH emerged as a research infrastructure in the ESFRI Roadmap in 2006. This was followed by the preparatory phase project funded by the seventh Framework Program, "Preparing DARIAH" (2008–2011). The DARIAH partnership, which took the legal form of ERIC in 2014, includes 17 countries (Austria, Belgium, Croatia, Cyprus, Denmark, France, Germany, Greece, Ireland, Italy, Luxembourg, Malta, the Netherlands, Poland, Portugal, Serbia, and Slovenia).

Finally, within the framework of these initiatives, the following are included:

- The creation of a common European Data Space to host and make 3D digital assets findable, accessible, interoperable, and reusable (FAIR principle).
- The implementation of a European Cultural Heritage Cloud to ensure interoperability and accessibility of digitized cultural assets.

These two initiatives were, respectively, launched between 2022 and 2023 by the Directorate-General for Communications Networks, Content and Technology (also called DG Connect), and the Directorate-General for Research and Innovation.

The first initiative is part of a broad program of initiatives and research projects aimed at creating such infrastructures within the scope of the "Digital Europe Program," established by Regulation (EU) No. 2021/694 of the European Parliament and of the Council on April 29, 2021. These initiatives follow the Recommendation of November 10, 2021, on a common European data space for cultural heritage.

In April 2022, the Directorate-General for Communications Networks, Content and Technology launched a call for tenders for the deployment of a Common European Data Space for Cultural Heritage. The initiative is part of the "European strategy for data" aimed at the creation of Common Data Spaces in strategic economic sectors and areas of public interest (COM (2020) 66 final, Brussels, 19.2.2020) to accelerate digital transformation and implement the Commission's vision for Europe's digital transformation by 2030.

The goals of the Data Space focus on developing an infrastructure that will ensure online access to European Cultural Heritage data will make high-value datasets, particularly 3D datasets, available for scientific research, preservation, and restoration, and create new opportunities for virtual access to museums, libraries, galleries, and heritage sites.

From September 2022, a Consortium of 19 partners, led by the Europeana Foundation, is working on the "Common European Data Space for Cultural Heritage", the new EU flagship initiative to accelerate the digital transformation of the cultural heritage sector and foster the reuse of digitized cultural heritage in various fields such as education, research, and tech. The project envisages the definition of data governance structures compatible with relevant EU legislation and such as to guarantee, in a transparent and fair manner, the rights to access and process data while ensuring its availability, quality, and interoperability.

The program initiated by the DG Research and Innovation for the establishment of the European Collaborative Cloud for Cultural Heritage, which has been allocated a budget of 110 million euros until 2025 by Horizon Europe, aims to build a unique digital infrastructure that enables transdisciplinary and large-scale collaboration among operators and institutions working in the field of cultural heritage across the EU through cutting-edge digital tools.

The "Report on a European Collaborative Cloud for Cultural Heritage" (Brunet et al. 2022), prepared by independent European experts, laid the groundwork for the preparation of calls for proposals for the period 2023–2025.

The report outlines the general motivations and criteria for the creation and development of the Cloud infrastructure considering the current state of the cultural heritage sector.

The first two calls dedicated to the European Collaborative Cloud have been published in Section 5 "Culture, Creativity, and Inclusive Society" of the Work Programme 2023–2024 of the EU research and innovation framework program for 2021–2027, Horizon Europe.

9.5 A European Competence Centre for Cultural Heritage: The 4CH Project

In 2020, the European Commission funded the research project "4CH – Competence Centre for the Conservation of Cultural Heritage" (www.4ch-project.eu/) under the Horizon 2020 Program.

The 4CH project, which started in January 2021, has the main objective of designing and establishing a Competence Centre focused on preserving cultural heritage. The Centre will offer knowledge through consulting and support activities, as well as services to national and regional heritage agencies, cultural institutions, professionals, and citizens (Fig. 9.1).

The 4CH project aims to promote advanced ICT solutions, including 3D digitization, which have significant potential to document, monitor, mitigate, and prevent damage caused by natural degradation, human activities, and disasters. The 4CH project will design and implement the ICT infrastructure of the Competence Centre, primarily based on the integration of 3D H-BIM (Heritage Building Information Modelling) services implemented in the European project INCEPTION and subsequently developed by the eponymous start-up (www.inceptionspinoff.com/), a spin-off of the University of Ferrara.

These services will provide semantic, three-dimensional reconstructions with temporal evolution capabilities. Additionally, the Competence Centre will utilize a Cultural Heritage Cloud, which serves as an open and collaborative digital infrastructure. This platform will provide access to repositories of data, metadata, standards, and guidelines. By leveraging these resources, the ICT services of the Competence Centre can benefit from big data management and analysis services.

The Competence Centre will be based on a European cooperation system consisting of digital and physical infrastructure and transnational networks, with the aim of going beyond the sphere of research and development and supporting the market and policy for the dissemination of processes, services, and products for the preservation of cultural heritage.

The organizational structure of the Competence Centre will be divided into three levels.

First level (European Competence Centre): A Board of Directors composed of Founders (consortium partners of 4CH and an expert for each Thematic Department) and Members (one delegate for each National Coordination Centre) will be supported by an Advisory Board. The decisions of the Board of Directors will be implemented by the Executive Committee (selected members responsible for managing the Competence Centre with operational tasks) and the respective Thematic Departments, defined based on the most relevant topics for the safeguarding and preservation of heritage, providing support within their thematic area and transferring the requests of national task forces.

Second level (Network): The National Coordination Centres will constitute the structure responsible for providing services related to the Thematic Departments. Each participating member state in the Competence Centre will have its own

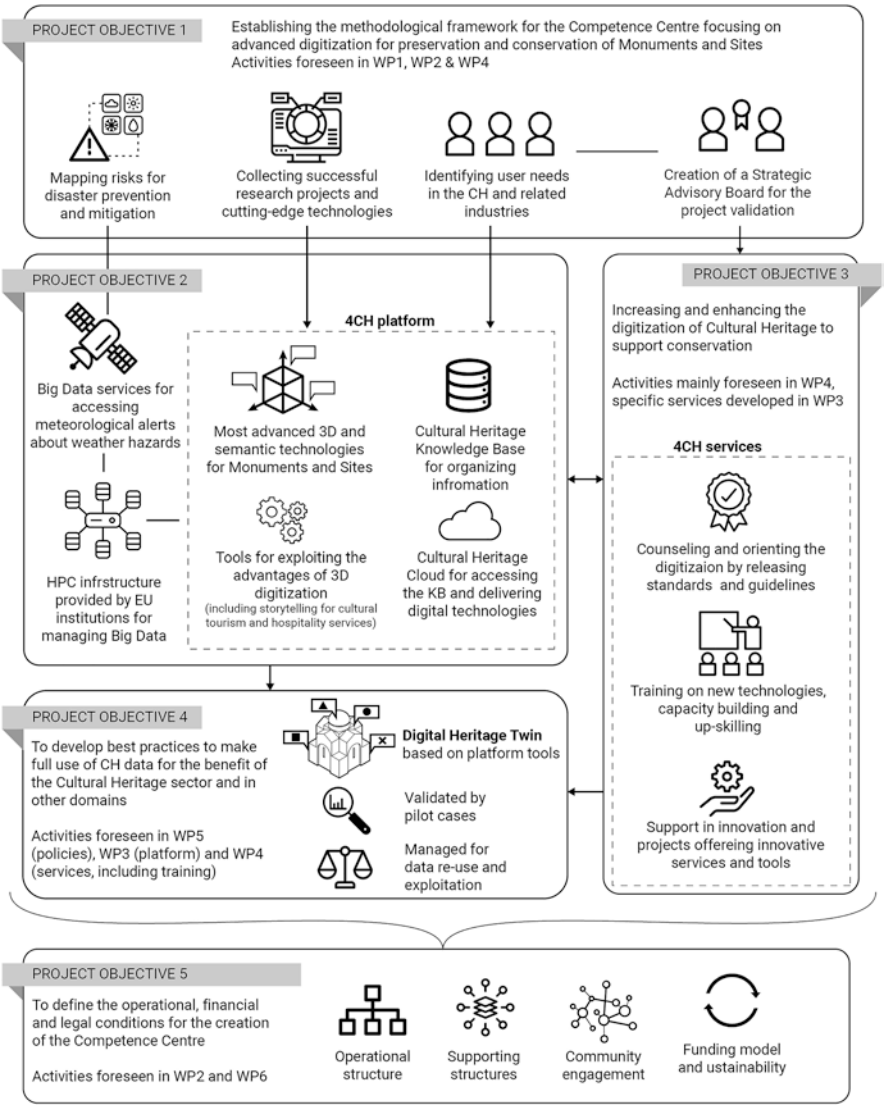

Fig. 9.1 4CH project objectives and related actions to achieve them

National Coordination Centre that will receive tools, guidelines, and directives from the Executive Committee. Each National Coordination Centre will be assisted by a National Advisory Committee, which will have a strategic role in defining services in terms of feedback and input on ongoing trends and alignment with European and national policies, gathering market needs, businesses, and public administration, providing input on national and global technological innovations, and sharing national technological roadmaps.

Third level (Community): Member states interested in joining the project will locally promote the activities of the Competence Centre to attract new members for the National Community of Cultural Heritage Competence. This community is intended as a network structure that includes both regional and metropolitan entities as well as local ones. The Community will involve entities such as public and private institutions, professionals, SMEs, policymakers, decision-makers, and training institutes within the EU or related to community issues, with expertise in cultural heritage in the fields of research, development, and/or training and education. It will contribute to gathering information and data on user needs, as well as local best practices, knowledge, and successful experiences.

The National Coordination Centres, as "connecting" structures between the European Competence Centre and public and private institutions in the cultural heritage sector, will play a strategic role in the ongoing digital transition process in the various member states.

The Centres act as the "gateway" to the services of the European Competence Centre and function as operational structures through which the European body provides its services. They are configured as "National Competence Centres" operating at the local level, integrating the expertise of the European organization with a deeper understanding of the unique characteristics of the cultural heritage of their own country.

Each member state will establish its own National Coordination Centre simultaneously with joining the European Competence Centre, receiving tools, guidelines, and directives from the Executive Committee of the European body.

The creation of the National Coordination Centre involves preliminary work to adapt and align the guidelines, procedures, protocols, and standards developed by the various thematic departments of the European Competence Centre to the specificity of national norms, policies, and laws.

Each National Coordination Centre will be supported by a National Advisory Board composed of experts, researchers, and technical and economic operators in the Cultural Heritage sector. The National Advisory Board will be represented in the Advisory Board of the European Competence Centre and will assist the National Coordination Centre in identifying and configuring the services offered—directly or on behalf of the European Competence Centre—in relation to the national context, including:

- Conservation and safeguarding policies of heritage.
- Management, processing, and access policies for data collected and produced in the analysis and documentation phase.
- Requirements and priorities of public and private institutions operating in the cultural heritage sector.
- Market and industry needs.
- Intervention strategies and priority framework.

Each National Coordination Centre will operate on the ground through a network of local structures that will form a community (referred to as the "third level" of the organizational structure of the European Competence Centre in the research project). This community will be composed of regional and metropolitan institutes and entities, local administrations, and public and private institutions.

The community, consisting of operational structures distributed across the territory and organized according to the needs of the Competence Centre and the relevance of the involved parties, will be responsible for:

- Collecting data and documentation on entities, conservation status, risk exposure, and accessibility of cultural heritage sites within their territorial jurisdiction.
- Organizing the collected documentation in relation to a prioritized scale of actions or interventions to be carried out at each site.
- Submitting the material to the National Coordination Centre and establishing coordination methods with the sections or departments of the Centre.

The establishment of networks of entities and institutions operating in the cultural heritage sector will immediately activate certain functions of the Centre while leaving those related to accessing the services of the Competence Centre on standby.

Without altering the competencies, organization, and roles of national entities and structures, the National Competence Centres will focus and concretize their coordination activities on specific areas, such as:

- Harmonizing protocols and standards underlying the digitization process of heritage in relation to national legislative and procedural frameworks.
- Transitioning from traditional databases to semantic-based platforms characterized by data interoperability, information interconnection, multi-level data access, and easier future integration with services being defined in the 4CH project.

9.6 Conclusions

The digitization of cultural heritage is a complex process; research in the sector needs to face new challenges and continue to expand collaboration between different disciplines (Sonkoly & Vahtikari 2018).

It's necessary to develop new technologies and methods that can improve the quality and efficiency of the tools and procedures involved in the digitization process.

Despite significant advances in recent years, there is still much to do. It's important to continue to invest in research and development, to train cultural heritage professionals in new technologies. Policies and strategies for conservation and valorization must focus in this direction without forgetting, of course, that digitization is only a tool that can add resources but not replace the physical conservation and care of cultural heritage, especially architectural heritage.

The European Commission is investing significant resources in the digital transition of cultural heritage, recognizing digitization as a strategic objective for the conservation and valorization of this extremely valuable resource, both economically and socially. The digitization of cultural heritage is not only a technical issue but also a cultural and social one. It's necessary to ensure that the digitization process respects and valorizes cultural diversity, guaranteeing as wide access as possible to digital technologies.

In this sense, the FAIR principles (findability, accessibility, interoperability, and reusability) play a fundamental role. The application of these principles allows more efficient management of digital resources, facilitating their discovery, access, integration, and analysis by different users and applications.

Progress in the field of 3D digitization is significant, particularly those in the field of data acquisition procedures. The innovations developed in European projects in recent years, especially advancements in laser scanning and photogrammetric technologies, have led to significant improvements in terms of speed, quality of results, and cost containment. These advances have allowed us to overcome many of the technical challenges associated with the digitization of cultural heritage, making the process more accessible and feasible.

However, challenges remain in the stages of data processing and modelling. The need to manage large volumes of data, the complexity of 3D modelling, and the lack of standardization are all issues that require further attention. More research and development are needed in areas such as semantic segmentation systems for point clouds, the application of machine learning and deep learning technologies, and the use of artificial intelligence to accelerate the H-BIM modelling process. It is also necessary to frame the digitization process in a multi-scale approach and promote the implementation of semantic platforms supported by an adequate digital infrastructure, which allows creating an interconnected data space dedicated to cultural heritage.

The multi-scale approach and the development of digital infrastructures will allow us to collect and make accessible and interoperable a large part of the already available 3D digitized resources, organizing them according to different levels of resolution and complexity. This involves defining different levels of quality standards for 3D digital resources based on their use and purpose. Such an approach promotes an inclusive strategy in the collection of existing 3D resources and in the production of new ones. It allows for the reuse of already available models for appropriate purposes, improving and standardizing those in progress and optimizing the production of new ones.

To achieve this goal, rules and principles must be established to initiate and govern the digitization process. This requires a commitment from all stakeholders, including policymakers, cultural heritage professionals, and the scientific community.

This principle-based work is underway in the 4CH project and, in the future, the activities of the Competence Centre for Cultural Heritage that will be established based on the research results. The Competence Centre will be assigned a significant role in promoting advanced ICT solutions, including 3D digitization, for cultural heritage preservation.

To this end, the 4CH project includes the design of the ICT infrastructure of the Competence Centre, mainly focused on integrating services related to the development of 3D resources. The establishment of networks of entities and institutions operating in the cultural heritage sector will activate some functions of the Centre, concentrating its coordination activities on specific areas such as the harmonization of protocols and standards underlying the digitization process of heritage.

References

AA.VV (2022) Study on quality in 3D digitisation of tangible cultural heritage: mapping parameters, formats, standards, benchmarks, methodologies, and guidelines, VIGIE 2020/645, final study report. Publications Office of the European Union, Luxembourg

Brunet P, De Luca L, Hyvönen E, Joffres A, Plassmeyer P, Pronk M, Scopigno R, Sonkoly G (2022) Report on a European collaborative cloud for cultural heritage. European Commission, European Commission, Directorate-General for Research and Innovation, Laxemburg

Commission Recommendation of 10.11.2021 on a common European data space for Cultural Heritage, Brussels, 10.11.2021, C (2021) 7953

Ministero della Cultura, Piano Nazionale di digitalizzazione del patrimonio culturale, 2022–2023, Versione 1.1

Sonkoly G, Vahtikari T (2018) Innovation in cultural heritage research. For an integrated European Research Policy. Publications Office of the European Union, Luxembourg

Wilkinson M, Dumontier M, Aalbersberg I et al (2016) The FAIR guiding principles for scientific data management and stewardship. Sci Data 3:160018. https://doi.org/10.1038/sdata.2016.18