Deliverable 5.1

Report on data management recommendations and guidelines

Deliverable Report n. D5.1: Report on data management recommendations and guidelines. draft, issue date 11 December 2023.

Grant agreement number:	**101004468**
Project acronym:	**4CH**
Project title:	**Competence Centre for the Conservation of Cultural Heritage**
Funding Scheme:	**H2020**
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Title:	D5.1 Report on data management recommendations and guidelines
Issue Date:	11 December 2023
Produced by:	DANS-KNAW, ICCU, UNIBO, PIN, CYI, ATHENA, INP, TECNALIA, CARARE

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Version:	Final
Reviewed by:	Maria Terese Natale
Approved by:	Board of Directors
Dissemination:	Public

Colophon

4CH Competence Centre for the Conservation of Cultural Heritage
D5.1 Report on data management recommendations and guidelines

Document History

- 12.06.2023: Version 0.1.

  Structure and headings, first version of some of the background text (René van Horik).

- 04.07.2023: Notes and links added (René van Horik).

- 19.07.2023: Existing text edited, text and image added (René van Horik).

- 23.08.2023 Text edited and added (René van Horik).

- 29.08.2023 Text edited and added (DANS multiple authors).

- 05.09.2023 Text and figure added (e.g., workflow) (multiple authors, Vicky Dritsou).

- 30.09.2023 Substantial contributions added, editing of these (multiple authors, UNIBO and INP contributions).

- 13.10.2023 Contribution added (ICCU, Claudio Prandoni).

- 19.10.2023 Data Management Plan contributions added and edited (PIN, CYI).

- 23.10.2023: Revised structure implemented (Pascal Flohr), new document.

- 24.10.2023 Content copied into new structure in new document (Pascal Flohr).

- 26.10.2023 Tecnalia contribution added.

- 26.10.2023 - 09.11.2023

  Substantial new text and figures, editing (multiple authors, e.g. Serena Orlandi, Claudio Prandoni, Rafaella Santucci, Pascal Flohr, Kate Fernie, Florentina Ghemut, Vicky Dritsou, René van Horik, Nicola Amico, Valentina Vassallo). Review by Hella Hollander.

- 10.11.2023 Version 1.0 for internal review

- 26.11.2023 Minor improvements on version 1.0 for internal review

- 06.12.2023 Document review by MCA

- 08.12.2023 Addressing of review comments, lay-out, copy-editing by PF

List of acronyms and abbreviations

- 4CH CC: 4CH Competence Center
- AgID: Agency for Digital Italy
- AI: Artificial Intelligence
- CAE: Culture Action Europe network
- CC: Competence Centre (can also mean Creative Commons)
- CC BY-NC 2.0: Creative Commons Attribution-NonCommercial 2.0 Generic licence
- CEDCHE: Commission Expert Group on the Common European framework.
- CH: Cultural Heritage
- CIMEC: Centre for Informatics, Memory and Cultural Synthesis (Romania)
- CoE: Council of Europe
- CS3DP: Community Standards for 3D Preservation (working group)
- DCHE: Digital Cultural Heritage and Europeana
- DMP: Data Management Plan
- DOI: Digital Object Identifier
- EC: European Commission
- ECCCH: European Collaborative Cultural Heritage Cloud
- EOSC: European Open Science Cloud
- ERA: European Research Area
- EU: European Union
- EuroHPC JU: The European High Performance Computing Joint Undertaking
- EuroQCI: European Quantum Communication Infrastructure
- FAIR: Findable, Accessible, Interoperable and Reusable
- FAQs: Frequently Asked Questions
- GDPR: General Data Protection Regulation
- ICAR: Central Institute for Archives (Italy)
- ICBSA: Central Institute for Sound and Audiovisual Heritage (Italy)
- ICCD: Central Institute for the Catalog and Documentation (Italy)
- ICCU: Central Institute for the Union Catalogue of Italian Libraries and Bibliographic Information (Italy)
- ICDP: Italian National plan for the digitisation of cultural heritage
- ICT: Information and Communication Technologies
- INP: National Institute of Heritage (Romania)
- MAR: Multi-Annual Roadmap
- NRRP: National Recovery and Resilience Plan

- PDF: Portable Document Format
- PID: Persistent Identifier
- PND: Piano nazionale di digitalizzazione del patrimonio culturale
- RAN: National Archaeological Repertory (Romania)
- R&D: Research and Development
- RDM: Research Data Management
- RRF: Recovery and Resilience Facility
- SDGs: Sustainable Development Goals
- SMEs: Small and medium-sized enterprises
- SRIA: Strategic Research and Innovation Agenda
- UNESCO: United Nations Educational, Scientific and Cultural Organization
- VR: Virtual Reality
- WP/s: Work Package/s

Definitions

Digitisation: conversion of the analogue to the digital.

Digitalisation: the conversion of processes to use digital technologies.

Other definitions have been inserted in footnotes where relevant.

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Executive summary

The 4CH project aims to prepare the establishment of an international **Competence Centre (CC) on the digitisation, preservation and valorisation of cultural heritage objects**. In this 4CH competence centre digital data will play an important role, especially 3D models of cultural heritage objects. This report covers data management aspects related to 4CH. Data management concerns the handling and organisation of data throughout its life cycle, from creation to storage and reuse. This report constitutes the results of Work Package 5 "Data Management" of the 4CH project.

This deliverable aims to provide recommendations and guidance specific to 4CH users and the digital cultural heritage assets they produce, use, and manage. Broad groups of users are defined and analysed with respect to their data management needs, building on work done in Work Package 1 of the 4CH project. An extensive list of user needs and related issues is presented that can be broadly classified as needs for standards, services and knowledge. This user oriented approach is taken forward in this deliverable taking into account that the formulated recommendations are clustered around three user groups: practitioners, policy makers and managers.

The FAIR principles (Findable, Accessible, Interoperable, Reusable) are very important building blocks of data management policies, practices and services. Data Management Plans (DMP) are a prominent instrument to formulate and apply the FAIR principles.
Several tools and services exist that support the creation of a DMP. Aspects are, among others, the application of persistent identifiers (PIDs), standard file formats and metadata schemas, as well as the role of trustworthy repositories that facilitate the durable storage and access of data.
Numerous tools and services are available to assist in creating a DMP. Key considerations include the implementation of PIDs, adherence to standard file formats and metadata schemas, and the involvement of reliable repositories that enable the long-term storage and retrieval of data.
Examples of the application of the FAIR principles for the 4CH target group concern the recommendation to use preferred file formats, specific metadata schemas, and controlled vocabularies and thesauri.

The analysis of European-level policies and guidance documents on cultural heritage digitisation focused keenly on significant initiatives that impact data management, such as the European Strategy for Data, the European Open Science Cloud (EOSC), and European Data Spaces. This examination aimed to construct a foundational framework to inform the 4CH recommendations. Additionally, the research explored the primary means, including institutions and funding, by which Member States implement these directives nationally. This was further enriched by an in-depth look at Italy and Romania—countries represented by 4CH partners—highlighting the necessity for the future Competence Centre (CC) to recognize and accommodate the diverse national landscapes within the EU.

Based on the user needs classification, the standards and services to implement the FAIR principles and the (inter)national data management strategies, policies and initiatives recommendations can be formulated.

1 Introduction

The 4CH project[1] (2021-2023) aims to set up the methodological, procedural, and organisational framework of a Competence Centre for the Conservation of Cultural Heritage, able to seamlessly work with a network of national, regional, and local cultural institutions, providing them with advice, support and services focused on the preservation and conservation of historical monuments and sites. During such preservation and conservation work, which can be costly and time-consuming, large amounts of digital data are produced. Managing this data well, to ensure integrity during the work and long-term preservation of valuable datasets afterwards, is key. Work Package (WP) 5 therefore focuses on data management, with which we mean the organisation of data, from before the start of the project through to the archiving for long-term preservation.[2] As such, WP5 contributes to the achievement of Project Objective 4 related to the development of best practices that maximise the impact of digital transformation in the Cultural Heritage (CH) sector (Fig. 1.1).

1.1 Aims, objectives, and methods of WP5

The aim of WP5 is to provide users with specifications on data management in relation to digital cultural heritage assets.[3]
This therefore includes management of data beyond the 4CH platform itself, i.e. data of repositories of:
- the future Competence Centre (CC),
- managers,
- cultural heritage practitioners (who are producing datasets and their metadata that (will) form part of these repositories).

WP5 aims to provide recommendations and guidelines about data management to increase interoperability among individual repositories that will form part of the future CC, so that metadata can be easily and meaningfully integrated on its platform and so that the integrity of the datasets and other assets can be implied. Data management is also one of the topics on which the future CC will be able to provide consultancy, develop training activities, and/or release recommendation documents and guidelines.

WP5 has three main objectives, divided over three tasks and addressed in an integrated manner by this deliverable:

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[1] See https://www.4ch-project.eu/.

[2] E.g., https://www.tudelft.nl/en/library/research-data-management/r/manage/the-goal-of-data-management (accessed November 1, 2023); See also Medici, M. & Fernie, K. (2022). D4.1. Report on standards, procedures and protocols. Zenodo. https://doi.org/10.5281/zenodo.7701529.

[3] The 4CH Grant Agreement, p. 20, specifically mentions "data management in relation to the digitisation of cultural heritage assets", but considering the wider aims of the 4CH projects, its users, and their needs, we take this more broadly to include all digital cultural heritage assets.

- Providing a comprehensive overview on the recommended procedures and guidelines for data creation, management and use, ensuring FAIR data (Task 5.1).
- Assessing policies for recommendations on data reuse and exploitation, like the way access to CH repositories is managed and the definition of reuse licences (Task 5.2).
- Defining the criteria for data validation, quality level assessment and the procedures for their preservation (Task 5.3).
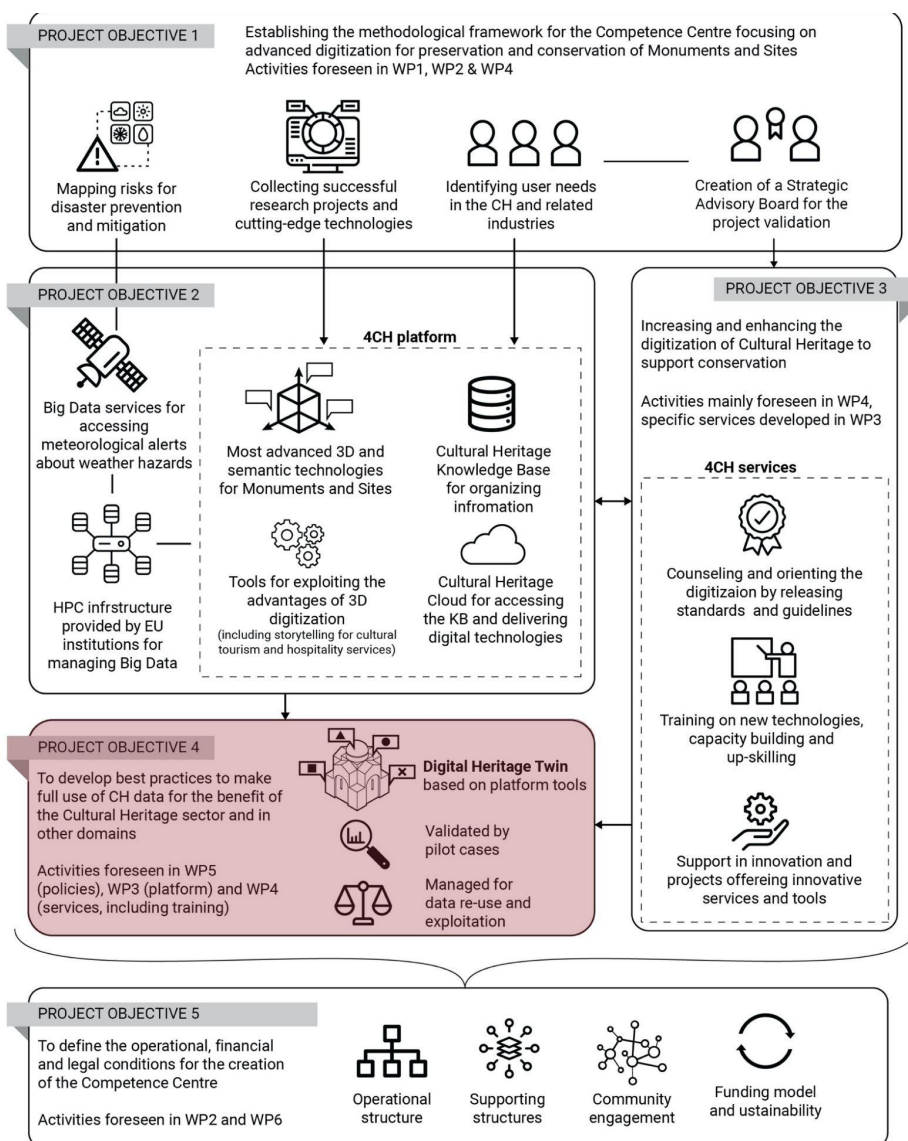
Figure 1.1. Overview of the 4CH project objectives. WP5 is related to Project Objective 4 (graphic elaboration from the diagram reported in the 4CH project proposal, PART B, p.6).

The aim of this document is to report on the work done by WP5, focusing on practical recommendations. While giving context and background, we aim for this document to be an operational tool, which can be consulted by 4CH and future CC users to improve their data management and find out where to find additional information.

To this end, we first, after introducing data management (section 1.2), focus on who the user groups are and what their needs are in relation to data management (section 1.3). After having set out this framework, chapter 2 focuses on cultural heritage-specific recommendations regarding data management during all parts of the data life cycle, from planning, creation, and use (Task 5.1) to long-term preservation (Task 5.3). This chapter is mostly relevant to cultural heritage practitioners, but also, for example, for repository managers: what requirements should be met by a dataset in order for it to be considered of good quality and what are the roles of the practitioner and the repository? In chapter 3 the focus is on policy makers and managers: what are existing policies on digital cultural heritage and how can repositories connected to the CC and other related organisations best align to these? The national case studies of Italy and Romania provide an in-depth analysis of how policies developed at European level are applied at a national level, presenting specific initiatives related to the management of cultural heritage data and/or digitisation projects/initiatives with the aim of taking into account the national differences that exist throughout the EU. Because data management will also be a service of the CC, beyond these recommendations, chapter 4 outlines how a data management workflow could be integrated in the CC. Chapter 5, finally, provides an overview of all recommendations for each broad user group.

We have built on the other 4CH project outputs, and especially on:
- D1.2 "Initial report on user needs", to assess user needs relevant to data management.[4]
- D3.1 "Design of the CH cloud and 4CH platform", to gain information, among other things, on 3D data types, relevant file formats, evaluation parameters, existing and newly created software, and related policies and requirements.[5]
- D4.1 "Report on standards, procedures and protocols", that contains workflows, guidelines and protocols, standard procedures, and relevant metadata for each of the project/data life cycle phases.[6] This deliverable is of major importance for the current document, and we recommend that all readers also refer to D4.1.

In addition, our information has been largely based on extensive literature reviews as well as on community inputs, such as during the workshop 'Shaping the World of 3D'.[7] Works like "3D data

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[4] Cortis, D. (2022). D 1.2 Initial report on user needs. Zenodo. https://doi.org/10.5281/zenodo.7488371
[5] Medici, M., Costantini, A. & Niccolucci, F. (2022). D3.1 Design of the CH Cloud and 4CH platform (1.0). Zenodo. https://doi.org/10.5281/zenodo.7701438.
[6] Medici, M. & Fernie, K. (2022). D4.1 Report on standards, procedures and protocols (1.0). Zenodo. https://doi.org/10.5281/zenodo.7701529.
[7] The 4CH workshop "Shaping the world of 3D" took place on 29 June 2023 at DANS-KNAW in the Hague and brought together experts on 3D data management in the Dutch research landscape. The workshop report can be found at: https://doi.org/10.5281/zenodo.10200379 (Flohr et al. 2023).

creation to curation: community standards for 3D data preservation" by the CS3DP (Community Standards for 3D Preservation) working group have been especially helpful.[8]

1.2 Data management and the FAIR principles

Data management concerns the organisation of data during all stages of a project from planning to accessing and reusing (Figure 1.2). As is now generally accepted, good data management is important to work efficiently, ensure the integrity of one's work and to create added value to the data.[9] Good data management allows, for example, for reliable verification and reproducibility of results, and enables reuse of the data. This is key, since collecting and processing digital cultural heritage data can be costly and time consuming (for example, making a high-resolution 3D model of a monument or site) and cannot always be repeated (for example, if the monument or site is no longer there).
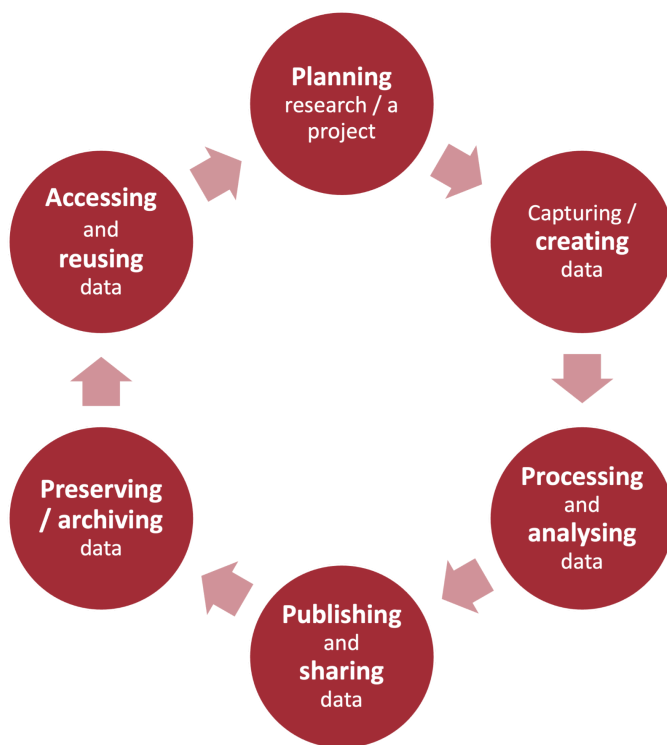
Figure 1.2 Data life cycle (based on UKDS Data life cycle and 4CH D4.1 digital asset life stages, although the latter has five stages in a somewhat different order: create, manage, distribute and publish, access and reuse, archive).

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[8] Moore, J., A. Rountrey & Scates Kettler, H. (eds). (2022). 3D data creation to curation: community standards for 3D data preservation. Association of College and Research Libraries, https://cs3dp.org/books/, see also https://cs3dp.org/.

[9] See e.g. TU Delft (n.d.). 'The goal of data management', https://www.tudelft.nl/en/library/research-data-management/r/manage/the-goal-of-data-management (accessed 6 November 2023); CESSDA Training Team (2017-2022). 'Benefits of Data Management', https://dmeg.cessda.eu/Data-Management-Expert-Guide/1.-Plan/Benefits-of-data-management (accessed 1 November, 2023).

There are many aspects to a data management strategy, relating to one or more of the data life cycle stages (Figure 1.2):

- Data: what type and size of data will you be collecting, in what file format?
- Storage and sharing during the project: where will you store the data during the research, who will have access and how is this regulated?
- Security: how often will you back up your data and how?
- Documentation and metadata: how will you document your data? What metadata will you document, what metadata standards will you use?
- Organisation and versioning: what folder structure and file naming will you use, what is your versioning strategy?
- Sensitive data and privacy: Are there sensitive data issues? How do you regulate access to sensitive data?
- Sharing: How and where will you share and publish your data?
- Long-term preservation: How and where will you archive your data?
- Reuse: What licence will you use?

All aspects of your data management strategy should be documented during the planning stage in a **Data Management Plan (DMP)**, which is a formal, 'living' document that provides a framework for how to handle your data during and after your project.[10]

Making data available for **reuse** is a key result of good data management and has the other advantages of enhancing visibility of the project, and increased transparency and reproducibility of the results.[11] The **FAIR principles** set out guidelines with the goal of making data reusable and are aimed at **both humans and machines**.[12] In a world with ever increasing volumes of data, it is not feasible to focus on human readability of data only here would we be, for example, without search engines and web page search functions?

FAIR stands for Findability, Accessibility, Interoperability, and Reusability. Brinkman et al.[13] summarise this as follows (own emphasis and additions):

- **Findability** facilitates the discovery of data by humans and computer systems. This requires the description and indexing of data and metadata. To do so, you should assign *persistent identifiers* (PIDs) (such as the Digital Object Identifier (DOI) for publications or an ORCID iD for persons), *cite* (research) data, provide *rich metadata*, using existing metadata schemas, use keywords, and use versioning of datasets.
- **Accessibility** is about how to access the data, possibly including authentication and authorization. Metadata should remain accessible even when data is no longer accessible, so people, institutions or publications can be tracked down. An open, free, and universally

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[10] Universiteit Utrecht (n.d.), https://www.uu.nl/en/research/research-data-management/guides/data-management-planning.

[11] Verburg, M. et al. (2023). Making qualitative data reusable. Zenodo. https://doi.org/10.5281/zenodo.8160880.

[12] Wilkinson, M.D. et al. (2016). The FAIR Guiding Principles for scientific data management and stewardship. Scientific Data 3(1): 160018. https://doi.org/10.1038/sdata.2016.18.

[13] Brinkman, L. et al. (2023). Open Science: A Practical Guide for Early-Career Researchers. Zenodo. https://doi.org/10.5281/zenodo.7716153.

implementable access protocol, like HTTP(S), and standardised exchange protocols, like SWORD or OAI-PMH, should be used.

- **Interoperability** means that the data (or metadata) can be integrated with other data and systems. The data needs to interoperate with applications and workflows for analysis, storage, and processing. You should use formal, broadly applicable language, and use *standard metadata schemas and vocabularies* and qualified references. The use of *open and commonly used (/preferred) file formats* also aids interoperability.
- **Reusability** increases data reuse by specifying usage *licences*. Without a licence it is not possible to know if and how data can be reused. The metadata should clearly indicate the provenance (e.g. the author(s), organisation(s)) of the data so that it is clear how reliable / 'good' the data is and where to go with any (reuse) questions. For the reuse of the data it is also necessary to make it clear what your data mean, for example through providing codebooks and by using naming conventions.

What is important to realise is that **'FAIR' is not the same as 'open'.** Sharing data openly improves their reusability considerably, but also when data cannot be open (think of personal or other sensitive data, commercial, or security data) it can be made 'FAIR' by making rich metadata available so that the existence of the data is clear. The adagio is "as open as possible, as restricted as necessary".

Good data management is key to FAIR data and in this deliverable we will make recommendations as to how to make data FAIR, specifically in the context of digitisation of cultural heritage. In chapter 2 we make specific recommendations as to how to manage your cultural heritage data in a good and FAIR way.

Further reading

While this document summarises the main, general aspects of FAIR data management, it is recommended to familiarise yourself to a larger extent with this theme. There are many guides on good data management, especially in relation to (FAIR) research data management (RDM). These guidelines are generally applicable to any data management, and we recommend consulting these to familiarise yourself with the general principles. For this we refer to useful guides like "Essentials for Data Support"[14] and the "Data Management Expert Guide".[15] Regarding the FAIR principles, the full list of principles can be found in the paper by Wilkinson et al.,[16] and there are many excellent overviews of the FAIR principles (e.g. GO FAIR n.d.; FAIR-Aware tool) and how you can apply them to your (research) data,[17] or other outputs like software[18] or vocabularies.[19] The "Guidelines to

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[14] RDNL (n.d.), https://datasupport.researchdata.nl/en/about-the-course.

[15] CESSDA Training Team (2017-2022). DMEG, https://dmeg.cessda.eu/Data-Management-Expert-Guide.

[16] Wilkinson et al. (2016). The FAIR Guiding Principles for scientific data management and stewardship, https://doi.org/10.1038/sdata.2016.18.

[17] https://www.go-fair.org/ and https://fairaware.dans.knaw.nl/.

[18] Chue Hong et al. (2022). FAIR Principles for Research Software (FAIR4RS Principles) (1.0). Zenodo. https://doi.org/10.15497/RDA00068.

[19] Cox et al. (2021). Ten simple rules for making a vocabulary FAIR. PLOS Computational Biology 17(6): e1009041. https://doi.org/10.1371/journal.pcbi.1009041; Franc, Y.L. et al. (2022). D2.8 FAIR Semantics Recommendations Third Iteration. https://doi.org/10.5281/zenodo.6675295.

FAIRify data management and make data reusable" by the PARTHENOS project give twenty practical guidelines for data creators and users as well as repositories or research infrastructures.[20]

1.3 Users and target groups and their data management needs

As is clear from section 1.2, data management is a broad topic, about which much guidance already exists. This deliverable aims to provide recommendations and guidance specific to 4CH users and the digital cultural heritage assets they produce, use, and/or manage. Therefore, we first briefly recall in this section who they are (as defined in Deliverable 1.2), in what broader user groups relevant to data management we can divide them, and define what their data management needs are, based on the user needs analysis published in Deliverable 1.2.[21]

The following user categories are distinguished by 4CH:[22]
1. Public and/or private heritage institutions responsible for managing monuments and sites.
2. Decision-makers and national public bodies (i.e. ministries) promoting policies and strategies for conservation, preservation and digitisation.
3. Professionals and SMEs providing services or products for preservation, conservation and restoration.
4. Associations, NGOs, local communities and citizens aiming at maintaining and communicating cultural heritage.
5. Companies from the creative industry producing heritage-based content, apps, games, education and tourism services.
6. General and educational users and visitors, tourists.
7. Museums curators.
8. Professional researchers.

For the management of digital cultural heritage assets, the user categories can be clustered in three broad groups:[23]
- Cultural heritage practitioners, implementing data management procedures.
- Managers, ensuring that sound and FAIR data management practices are followed in the project or repository.
- Policy makers, with the knowledge of which networks and initiatives should be joined to ensure optimal data management.

To assess the data management needs of 4CH users, the results reported in Deliverable 1.2 "Initial report on user needs" were used. This report addresses a total of 25 user needs related to innovative approaches in initiatives, policies and strategies for the preservation and conservation

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[20] Hollander et al. (2018). PARTHENOS Guidelines to FAIRify data management and make data reusable, https://doi.org/10.5281/zenodo.2668479.

[21] Cortis (2022). D 1.2 Initial report on user needs, https://doi.org/10.5281/zenodo.7488371.

[22] Cortis (2022). D1.2, https://doi.org/10.5281/zenodo.7488371.

[23] See also 4CH training user groups as defined in Orlandi et al. (2023). Deliverable 4.2 - Report on service deployment and training, https://doi.org/10.5281/zenodo.7898350, p. 77.

of monuments and sites, the fields in which the Competence Centre will operate. Of these 25 user needs, seven are strongly linked to data management and another five are related to it (Table 1.1).

Table 1.1 User needs related to data management. Source: own elaboration, from D1.2.

User needs linked to data management:	Other user needs related to data management:
1. UN01. Optimised and time-saving procedures for data capturing and processing 2. UN12. Facilitate digital models sharing and information exchange 3. UN18. Provision of infrastructure and services for data sharing, access, and re-use 4. UN19. Availability of tools to gather and integrate diverse digital materials, archive them appropriately and make the information accessible 5. UN21. Long-term preservation framework for large volumes of digital data 6. UN22. Availability of digital archiving standards 7. UN23. Reuse and recontextualization assessment standards	1. UN04. The need of society to be actively involved in cultural heritage activities, not only as an observer but also as a creator 2. UN09. Creating immersive, populated, interactive reconstructions of archaeological sites to enhance users' experiences 3. UN10 The need of high-resolution interactive 3D visualisation tools 4. UN16. Time upgradable 3D modelling 5. UN17 Visually organise 3D digital archives by the display of different levels of information

From these twelve user needs, which are either strongly linked or related to data management, the 'user pains' associated with data management have been extracted and classified according to each broad user category (managers, practitioners, policy makers) (Table 1.2). User pains represent obstacles that users encounter while performing their actions and tasks.

Table 1.2. User pains per user category. More information about the user pains can be found in D1.2. Source: own elaboration from D1.2.

MANAGERS	
User category (D1.2)	**User pain**
Public and/or private heritage institutions responsible for managing monuments and sites	Lack of an integrated point of access to cultural heritage resources.
	Difficulties in using or adapting to new or different software and hardware.

	Lack of tools required for cultural heritage documentation: organised and coordinated storage and management of historical data (including time periods), easy analysis and query, 3D modelling of irregular shapes, etc., and constant updating of information and processing of different data.
	Need to improve the quality of collections' metadata.

PRACTITIONERS

User category (D1.2)	User pain
Professional researchers	Lack of knowledge of and tools for easy sharing of visual resources and to support remote visual analysis.
	Lack of quality in metadata contents in most of the cases; difficulty in accessing metadata contents due largely to limited user's knowledge on the content of the metadata; heterogeneity of the data at the level of schemas which makes the access even more difficult.
	More researchers with various backgrounds (e.g. material scientists) aspire to integrate the aspect of 3D virtualization within their work but there are limitations concerning the amount of the data that have to be managed.
	Need to combine knowledge base features with content management and information retrieval (IR) technologies
	The lack of tools tailored for CH requirements: organised and coordinated storage and management of historical data, easy analysis and query, time management, flexibility, user-friendliness, etc.
	Lack of integration and incomplete access to digital resources.
	Lack of integrated point of access to cultural heritage resources.
Companies from the creative industry producing heritage-based content, apps, games, education and tourism services	Need for acquisition of digital models of existing architecture and related spatial elements from various content providers.
Professionals and SMEs providing services or products for preservation, conservation and restoration	Lack of management of multiple data sources and type of information, imperfect synchronisation and a lack of understanding between those collecting the information and the researchers.
	Low-cost software on the commercial market that does not match the rigorousness of classical photogrammetric methods.
Associations, NGOs, local communities and citizens aiming at maintaining and communicating cultural heritage	Lack of integration and incomplete access to digital resources.
	Lack of solutions enabling to cover the whole processing chain that ranges from content creation and digital archiving to content publishing and sharing.

Museum curators	Need to keep contents accessible in their integrity and intelligible according to their meaning; to cope with the incrementality and the need for continuous updating, in order to improve accuracy according to new available documents.
	Lack of enough digital information explaining the content available.
	Need to understand the users and uses of digital collections by applying a new type of assessment lens.

POLICY MAKERS	
User category (D1.2)	**User pain**
Decision-makers and national public bodies (i.e. ministries) promoting policies and strategies for conservation, preservation and digitisation	Lack of shared regulatory references and guidelines as far as semantic data are concerned.
	Need to create a single information space, where the data and the services owned by European heritage institutions can be discovered and accessed through a single search facility.
	Inexistence of shared library for historical elements.
	Lack of management of multiple data sources and type of information, imperfect synchronisation and a lack of understanding between those collecting the information and the researchers.
	Lack of integration of technology.
	The availability of digitisation tools is limited to experts and highly costly.
	Financial cost and legal practices such as copyright.
	Need for integration and enrichment of semantic attributes. Current lack of semantic enrichment of heritage 3D models.
	Large amount of data to capture.
	Limited data interoperability.

The "user pains" as provided in Table 1.2 can be clustered around a number of data management needs, each related to one or more of the stages of the data management process (Fig. 1.3; see section 1.2 and Fig. 1.2 for an explanation of these stages).
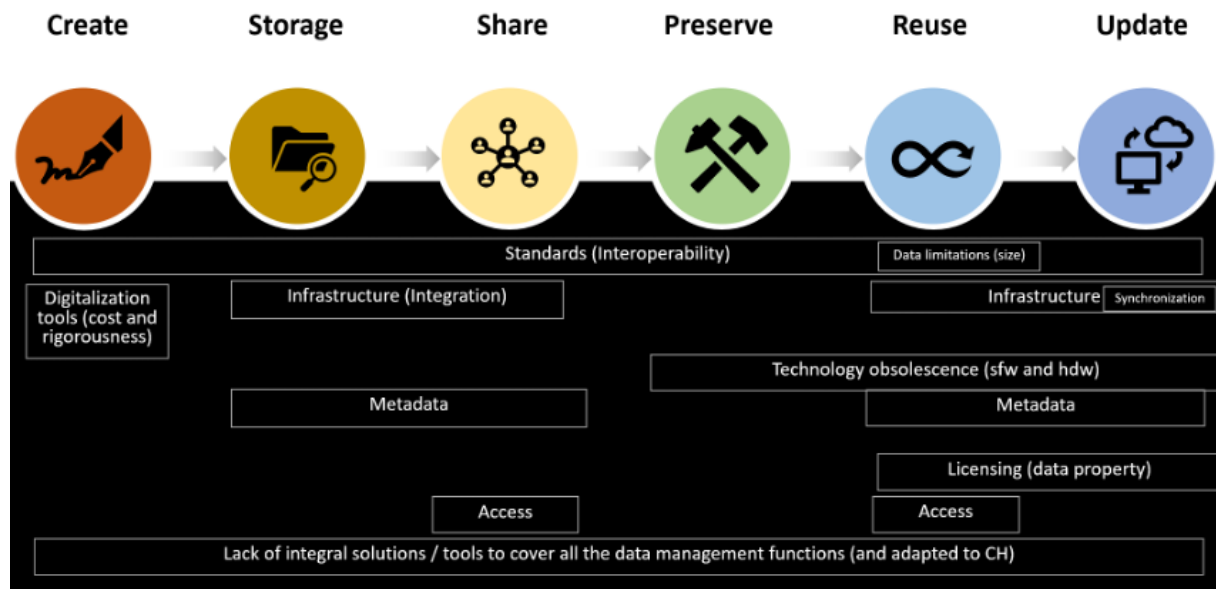
Figure 1.3 Data management needs identified for the different data stages.

For each of these, an explanation of the main user needs, as based on the 4CH analysis, is provided below. Together with data management topics identified as key through literature research (including D4.1) and by the community (e.g., in the 'Shaping the World of 3D' workshop), these user needs form the framework of recommendations for data management provided in chapter 2 of this deliverable.

Standards: There is a lack of internationally accepted standards for some types of digital cultural heritage, such as 3D data objects. This results, for example, in different data sources and formats, different metadata schemas, different vocabularies and thesauri, and so on. This relates not only to data creation but also to storage and sharing, and affects data interoperability and the preservation, reuse and update of digital cultural heritage assets. Recommendations regarding cultural heritage standards are discussed in the next chapter (with file formats discussed in section 2.4.2, metadata standards in section 2.5.2, and vocabularies in section 2.5.3).

Digitisation tools: Multiple digitisation tools, like for 3D digitisation, are available. These tools can be expensive and while some are more straightforward, others require training and expert skills. Some low-cost software is available but it does not match the rigorousness of classical photogrammetry methods that provide the highest quality.

Lack of integrated solutions / tools to cover all the data management functions: There are no integrated tools or solutions that cover all stages of the process, and other existing tools are not adapted to cultural heritage requirements (organised and coordinated storage and management of historical data, easy analysis and query, flexibility, user-friendliness, etc.).

Infrastructure: There is a lack of data curation infrastructure solutions that integrate different formats (multiple data sources and type of information), with a good synchronisation and enough information for data reuse. Some digital cultural heritage dataset can have large file sizes, such as

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certain 3D models, which complicates long-term storage and reuse. Recommendations regarding (long-term) ***storage infrastructure and repositories*** are discussed in section 2.3.

Metadata: Rich metadata is key for data management, for storage, retrieval, access, and reuse (see also the introduction to FAIR data management in section 1.2). There is a need to improve the access, the quality and the homogenization of cultural heritage resources metadata. Recommendations regarding metadata are discussed in section 2.5.

Accessibility: There are different access problems affecting especially sharing and reuse of data. Firstly, currently there is no integrated point of access to cultural heritage content (a shared library, a common European heritage space, etc.). However, chapter 3 covers some new developments in this field, mainly in the policy field. Secondly, it is difficult to give complete access to cultural heritage contents (because of the lack of integration, the lack of standard formats and metadata, the large size of certain content, or licensing issues derived from proprietary software/tools), and also to make them accessible in their integrity and intelligible according to their meaning.

Technology obsolescence: The different technologies employed (hardware and software) for data creation, storage and sharing are directly related to its preservation, reuse and update. The fast obsolescence of technology could threaten the survival of digital heritage resources. A key recommendation in this respect is related to the use of 'preferred' ***file formats*** (see section 2.4.2).

Licensing: The use of proprietary software for digital content creation affects its reuse and update, hindering the access to the data. Lack of clarity regarding copyright, ownership, and reuse rights hinders the reuse of data. Recommendations regarding licensing are covered in section 2.6, while policies on this topic are discussed in chapter 3.

These topics and the data management recommendations relevant to 4CH users are discussed in chapter 2. Integrated points of access to cultural heritage (meta)data and services are discussed in chapter 3.

2. FAIR data management

This chapter looks at how to manage cultural heritage data in line with the FAIR principles. The basics of data management and the FAIR principles were described in chapter 1, which also discusses the pain points and the most pressing needs for 4CH users. This chapter focuses on the practical aspects and how to plan for "FAIR" data management. This chapter is most relevant to those responsible for creating and storing data and other digital cultural heritage assets, like professionals, researchers, museum curators, project managers, and data curators and managers at repositories.[24]

2.1 Data Management Plans (DMPs)

During the planning stages of any project, careful consideration of the data that will be produced and how it will be managed saves time later. Producing a DMP at the outset provides a framework setting out how data will be handled at all stages, from data capture to depositing with an archive and later reuse. The DMP is a living document that should be reviewed at key stages in the project.[25]

DMPs are extremely important for good data management, as they not only ensure the proper organisation and management of data, but also enhance the transparency and reusability of project outcomes. They are critical tools for ensuring that data are collected, processed, stored, and shared in a responsible and efficient manner. DMPs are increasingly important as projects become more data-intensive and as funding agencies and publishers require data sharing.[26]

2.1.1 What should a DMP contain?

A DMP should include information on:
- Key project details, including key identifiers, project name, type, and purpose.
- Relevant people involved in data creation, responsibility, and management.
- What data will be created, collected, and processed by the project.
- Which methodology and data standards will be used.
- How data will be managed and documented through each project stage.
- Any ethical or legal issues.
- How the data will be stored, secured, accessed, and backed up during the project.
- The intended archive repository, and the processes for data selection and deposition.
- Whether data will be shared/made open access and any restrictions that may need to be applied to data sharing.
- Who is responsible for data management.

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[24] See also http://www.snf.ch/SiteCollectionDocuments/FAIR_principles_translation_SNSF_logo.pdf for respective roles.

[25] Digital Repository Ireland (n.d.). 'Research Data Management'. https://dri.ie/research-data-management/.

[26] Harvard University (n.d.). 'Data Management Plans'. https://datamanagement.hms.harvard.edu/plan-design/data-management-plans.

Data management for cultural heritage involves a range of activities and processes that aim to ensure the accessibility, reliability, and longevity of digital and non-digital cultural heritage assets. These assets may include 3D models, digitised images, videos, texts, and audio recordings, as well as physical artefacts, documents, and oral traditions. A DMP for cultural heritage must take into account the evolving technological and societal contexts. As technology advances, new methods for storing, managing, and accessing data become available. Similarly, societal attitudes towards cultural heritage can change over time. Regular reviews allow DMPs to be flexible and adaptable to accommodate these changes.[27] In writing and updating a DMP, it is further important to take into account the various relevant stakeholders, such as cultural institutions, researchers, government agencies, and the public, and to specify their requirements; it is, however, the organisation that leads the project that is responsible for the implementation of the DMP.

2.1.2 DMP tools

Several online tools have been developed to support the creation of DMPs. A list and specification of these can be found in appendix 2. The main benefit of using a DMP template is that the user has the option to by default comply with the DMP components, and only if not applicable has to explain deviations from it. This saves time and guides the DMP creator through the process.

2.1.2.1 The ARIADNEplus DMP tool

Here we focus on a specific implementation of a DMP for archaeological research, the ARIADNEplus DMP tool.[28] Firstly, because it adheres to the Science Europe guidance, which presents core requirements for DMPs and includes a DMP evaluation rubric to support DMP review.[29] Moreover, the ARIADNEplus DMP tool was developed with archaeology in mind, and as such is also relevant to the broader field of cultural heritage (with some adjustments/additions).

The ARIADNEplus DMP Researcher Template for Archaeological Datasets adheres to the structure defined in the Horizon 2020 Guidelines. This template is aligned with the FAIR Data Management principles established by the European Commission, ensuring that research data becomes publicly accessible. Its primary purpose is to support Horizon 2020 beneficiaries in improving the discoverability, accessibility, interoperability, and reusability of their research data, ultimately enhancing the scientific quality of funded projects. The template consists of a series of questions organised into the following sections:

1. Data Summary (e.g., data set description)
2. FAIR Data
   2.1. Making data Findable (including provisions for metadata, e.g., persistent identifiers, naming conventions, metadata standards).

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[27] Bruseker et al. (2017). Cultural Heritage Data Management: The Role of Formal Ontology and CIDOC CRM. Pp. 93-131 in Vincent et al., https://doi.org/10.1007/978-3-319-65370-9_6.

[28] Hollander et al. (2022). D3.3 Final report on policies and strategies. Zenodo. https://doi.org/10.5281/zenodo.7510597; the templates and guidance can be accessed at https://vast-lab.org/dmp/index.html (accessed 6 November 2023).

[29] Science Europe (n.d.). 'Research Data Management'. https://scienceeurope.org/our-priorities/research-data/research-data-management/.

      2.2.   Ensuring data is openly Accessible (e.g., via a repository).

      2.3.   Promoting data Interoperability (e.g., through the use of standardised vocabularies).

      2.4.   Enhancing data Reusability (e.g., by clarifying licensing).

3.   Allocation of resources

4.   Data security

5.   Ethical aspects

6.   Other

Protocol for Archaeological Data Management	ARIADNEplus DMP Researcher Template for Archaeological Datasets	Horizon Europe Template for Archaeological Datasets
Visit	Visit	Visit
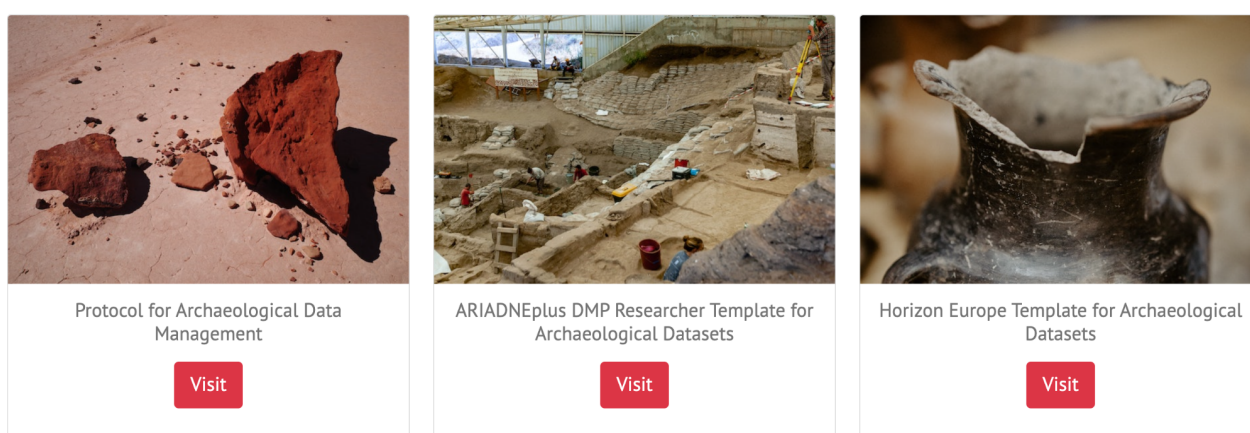
Figure 2.1 The ARIADNEplus DMP Tool with its three facets: guidance based on Science Europe recommendations (Protocol for Archaeological Data Management) and two templates, one adhering to Horizon 2020 requirements and the other to Horizon Europe requirements (https://vast-lab.org/dmp/index.html).

The ARIADNEplus DMP Tool[30] provides three accessible modules from the homepage, enabling users to choose on the basis of their specific needs. In addition to the template based on Horizon 2020 requirements, there is also a template according to the Horizon Europe requirements and a protocol based on Science Europe guidance (Fig. 2.1). Once users choose the appropriate template, they are directed to the corresponding page and receive guidance on how to answer questions by following links to relevant sections of the online guidance document. Additionally, users have the option to download templates for reference or offline use before entering information into the online tool.

The online interface has been designed to streamline the DMP creation process, incorporating user-friendly and intuitive features. Researchers encounter questions divided across consecutive pages, accompanied by a progress bar that serves as the central point of reference. This comprehensive view of the model's components guides users step by step, providing estimates of the time required for completion.

Each page categorises related thematic questions as mandatory or optional, with informative pop-ups available to assist users in their completion. Should any mandatory elements required for DMP submission remain unfinished, they will be highlighted in red on the progress bar.

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[30] The ARIADNEplus DMP Tool is accessible at: https://vast-lab.org/dmp/index.html (last accessed 2 November 2023).

Upon completing the compilation process, users can choose to download the DMP's information in PDF and JSON formats. The JSON format allows users to save their work progress, without personal user data having to be collected or stored. The questionnaire compilation can be paused at any point by downloading the JSON file containing the current data. This file can later be loaded within the online interface to continue and complete the task.

Alternatively, if the questionnaire compilation is considered final, the data within the file will serve as a valuable, machine-readable version of the DMP for future revisions or updates. Each template can be independently completed and saved as a standalone document. However, given the varying levels of detail among templates, such as the broader Domain Protocol template compared to the more detailed ARIADNEplus DMP analysis, interlinks have been established between the templates to provide additional information on specific topics.

The ARIADNEplus Training Hub also provides extensive guidance and educational resources covering the entire research data life cycle, including one-page guides, online training modules, and instructional videos.[31]

2.2 Key FAIR data management aspects

Data management for cultural heritage involves a range of activities and processes that aim to ensure the accessibility, reliability, and longevity of digital and non-digital cultural heritage assets. This section looks at how to apply the FAIR principles to your data management plans.

2.2.1 Findability

The aspects of your data management plan which support findability are:
- How data will be documented and the key identifiers.
- Which data standards will be used and how they will be implemented.

The focus here is on:
- Ensuring the creation of **metadata** (data documentation) that is sufficient for the data to be found, understood by others, and reused. Creation of rich metadata improves the discoverability of your data.
- Ensuring the creation of a unique identifier which is as persistent as possible. Creation of a **persistent identifier** (PID) gives a long-lasting reference which enables the data to be findable in the future.

Your Data Management Plan should specify which identifiers to use, what metadata and paradata will be captured, according to which metadata schema(s), by whom, and at which stages in the project.

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[31] https://training.ariadne-infrastructure.eu/defining-and-implementing-a-data-management-plan-dmp/ (accessed 23 October 2023).

2.2.2 Accessibility

The aspects of your data management plan which support accessibility are:
- Identifying which archive repository you will use and where the data will be stored.
- How the data can be retrieved – will it be online or available via a protocol?
- Clarifying any ethical or legal issues.

The focus here is on:
- Where the data will be stored and how it will be made accessible.

Your Data Management Plan should name the repository where the data will be deposited and account of any requirements the repository has for deposits. For example, the repository may specify the metadata required to be delivered with the data. It is more efficient to take these requirements into account early in the project life than trying to capture information at the end when data is prepared for deposit.

2.2.3 Interoperability

The aspects of your data management plan which support interoperability are:
- What data will be created, collected and processed by the project.
- Which methodology and data standards will be used.

The focus here is on:
- Making sure that the data can be connected with other data.
- Implementation of data standards for metadata and paradata.
- Use of controlled vocabularies, ontologies and Linked Data.
- APIs.

Your Data Management Plan should identify who is responsible for the data documentation, which standards to follow and what forms/systems to use when capturing the metadata and paradata. It should cover who is responsible for maintaining data quality, for validating data input and for training the people involved in the project's standards.
APIs provide a technical machine-to-machine interface to the data and are generally provided by the repository where data is deposited for archiving. APIs should conform to established standards (such as OAI-PMH) and support interoperability with key infrastructures (such as the Common Data Space for Cultural Heritage and key research data infrastructures, see chapter 3).

2.2.4 Reusability

The aspects of your data management plan which support reusability are:
- Ethical or legal issues.
- Whether the data will be shared and/or made available under licence.
- Data formats.

The focus here is on:

Making sure that data is made available with a clear licence, so that others know what they are allowed to do with a dataset.

- Making sure that metadata is available, so that others know your data exists even where access is currently restricted (or under embargo).
- Making sure that the content is capable of integration into other resources (where the licence permits) to realise new projects.

Your data management plan should identify who is responsible for clearing any legal or ethical issues and under which conditions (licences) the data is made available for reuse. A clear licence lets others know what they are allowed to do with a dataset.

2.2.5 PARTHENOS guidelines to FAIRify data management

When deciding on your data management strategy and filling in your DMP, it is useful to make use of existing guidelines to check how to practise good and FAIR data management. As mentioned in chapter 1, there are multiple useful generic guidelines on this topic, and as mentioned earlier in this chapter, there are multiple DMP tools and templates (see appendix 2 and section 2.1). We specifically recommend the use of the twenty practical guidelines by the PARTHENOS project (table 2.1).[32]

Table 2.1 PARTHENOS guidelines to FAIRify data management and make data reusable. Target audience (in their terms): Data producers & users (DPs & DUs); research infrastructures and data archives (RIs & DAs). Source: Parthenos (2019).

Guidelines	Target audience
1. Invest in people and infrastructure	DPs & DUs; RIs & DAs
Findable:	
2. Use persistent identifiers	DPs & DUs; RIs & DAs
3. Cite research data	DPs & DUs; RIs & DAs
4. Use persistent author identifiers	DPs & DUs; RIs & DAs
5. Choose an appropriate metadata schema	DPs & DUs; RIs & DAs
Accessible:	
6. Choose a trustworthy repository	DPs & DUs; RIs & DAs
7. Clearly state accessibility	DPs & DUs; RIs & DAs
8. Use a data embargo when needed	DPs & DUs; RIs & DAs
9. Use standardised exchange protocols	RIs & DAs
Interoperable	
10. Establish well documented machine actionable APIs	RIs & DAs
11. Use open well-defined vocabularies	DPs & DUs; RIs & DAs
12. Document metadata models	RIs & DAs
13. Prescribe and use interoperable data standards	DPs & DUs; RIs & DAs
14. Establish processes to enhance data quality	DPs & DUs; RIs & DAs
15. Prescribe and use future-proof file formats	DPs & DUs; RIs & DAs
Reusable	
16. Document data systematically	DPs & DUs
17. Follow naming conventions	DPs & DUs; RIs & DAs
18. Use common file formats	DPs & DUs; RIs & DAs
19. Maintain data integrity	DPs & DUs; RIs & DAs
20. Licence for reuse	DPs & DUs; RIs & DAs

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[32] Hollander et al. (2019). PARTHENOS Guidelines to FAIRify data management and make data reusable. https://doi.org/10.5281/zenodo.3368858.

2.2.6 Applying the FAIR principles to your digital cultural heritage assets: what more do you need to know?

The PARTHENOS guidelines (see section 2.2.5), in combination with our basic knowledge of how the FAIR principles should be applied (sections 2.2.1-2.2.4), are an excellent starting point, relevant to both practitioners and repository or research infrastructure managers. Some of the guidelines are self-explanatory, and guidance text is supplied by PARTHENOS. For some of these it may, however, be useful to add additional guidance and recommendations regarding how to apply the guideline and/or how to specifically do this in cultural heritage.

Firstly, as was clear from the 'user pains' described in section 1.3, *infrastructural challenges* are present for the access, storage, and preservation of some cultural heritage datasets, like 3D data. What is the best place to store your cultural heritage data in the short and in the long term? How do you choose a repository, and as a repository, how do you ensure that you facilitate a FAIR storage place? And what should you store and in which *file format* to ensure long-term preservation of your valuable data? We will look at these questions in sections 2.3 and 2.4, respectively.

It was also clear from the 'user pains' that **international** *standards* are not always available. There is, for example, not one accepted international standard for 3D metadata,[33] so that on the one hand metadata (and paradata) essential for the reuse of a dataset is not available and on the other the use of different standards, ontologies, and vocabularies leads to a diverse and not very interoperable collection of datasets (see also section 1.3). *Metadata and vocabularies* for cultural heritage are further discussed in section 2.5.

Finally, section 2.6 gives guidelines and recommendations concerning *rights and licences*.

2.3 Digital repositories: Where to store your data?

The FAIR principles refer to long-term data storage; where your data will be stored so that it can be preserved for the long term and made accessible now. But how do you find the right repository for your cultural heritage data? In this section you find more information on digital repositories in general.

2.3.1 Choosing a repository

Firstly, it is important to note that storing your data for the long term at all is the most important aspect here. Nonetheless, some minimum factors are important when choosing a repository. To be fully FAIR-compliant, a repository:

- should allow for rich and indexed **metadata** with community-accepted controlled vocabularies;
- use **open protocols and standards**;
- assign **Persistent Identifiers** (PIDs) to each dataset.

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[33] European Commission (2022),
https://digital-strategy.ec.europa.eu/en/library/study-quality-3d-digitisation-tangible-cultural-heritage.

- The datasets should also be **curated**, for example monitoring and updating file formats where appropriate so that the files remain accessible in the long term.

As partly mentioned in section 2.2, rich metadata aids data discovery, allows linking to related important information (like other data and publications), and can remain available even if the data can not be published, or is retracted or deleted (although note that the latter should ideally not happen). PIDs also facilitate data discovery and identification, enable data search, citation, and retrieval, and support versioning. It is further important that data access conditions and usage licences are clearly defined, and are available in a machine-readable format.

When choosing a repository, make sure that these criteria are met. A good way of assessing if a repository meets such requirements, as well as others that are key for long-term preservation, is that the repository has a certification: such repositories should ensure the integrity and long-term preservation of your data; they are therefore often referred to as 'Trustworthy'.[34] Appendix 3 gives a list of frameworks, requirements, and certifications for repositories to consider. As a potential depositor, look out for CoreTrustSeal, nestor-Seal DIN 313644, or ISO 16363 certification labels on the repository website.[35] For repositories, we recommend to have at least the CoreTrustSeal core certification, or to work towards this (more information in Appendix 3).

There are many repositories available and it can be difficult to know which one to choose. It is advised (e.g., CESSDA DMEG)[36] to prioritise repositories as follows:
1. A Trusted domain-specific repository. The advantage is that such a repository will have relevant metadata fields and can advise on, and curate, data types specific to the domain. An example is the DANS Data Station Archaeology, which focuses on archaeological datasets (and has archaeology-specific metadata fields).[37]
2. An institutional or recommended repository.
3. A (Trusted) general purpose repository. An example is Zenodo, but note that there is no certification and guarantee of long-term preservation (i.e., no curation).
4. Find your own repository at re3data registry[38] , taking into account the above requirements.

In the future, national nodes of the 4CH CC will be points of advice (see also chapter 4).

In the remainder of this section, we will look into more depth at repositories and long-term preservation.

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[34] You may also see the term 'TDR' or 'Trustworthy Digital Repository'.

[35] "The CoreTrustSeal certification is envisioned as the first step in a global framework for repository certification which includes the extended level certification (nestor-Seal DIN 31644) and the formal level certification (ISO 16363)" (https://www.coretrustseal.org/about/ (last accessed 7 November 2023).

[36] CESSDA Training Team (2017-2022), https://dmeg.cessda.eu/Data-Management-Expert-Guide/6.-Archive-Publish/Data-publishing-routes (last accessed 7 November 2023).

[37] See https://dans.knaw.nl/en/data-stations/archaeology/ (last accessed 17 November 2023).

[38] https://www.re3data.org/

2.3.2 What are digital repositories and what do they offer?

A repository refers to a digital collection of organised data, encompassing crucial details such as provenance, access rights, and data quality information. It incorporates a search and retrieval interface and is specifically designed to cater to a community, whether distributed or centralised.

Digital repositories help to create, manage, and display collections of any type of file, such as books and documents, images, audio, video, and 3D files. A digital archive aims to provide permanent, or indefinite long-term, preservation of digital information.

Several digital repository systems exist to build such applications. Some of them are free and open-source software digital repository systems often used in the cultural heritage field to manage those specific multidisciplinary assets. Prominent examples of software for repository data management include Omeka,[39] Islandora,[40] DSpace,[41] and DataVerse,[42] each offering a range of features to support various aspects of CH data management.

One essential feature of digital repositories is ***metadata management***. These platforms provide robust tools and workflows to facilitate the creation, organisation, and enrichment of metadata describing and managing CH data. They typically support standard metadata schemas and offer customisable metadata templates, allowing cultural heritage institutions to ensure consistency and interoperability in describing their digital assets.

Versioning is another crucial capability provided by digital repositories. Maintaining different versions of CH data is vital for preserving its integrity and tracking changes over time. Digital repositories offer version control mechanisms that enable users to manage and access multiple iterations of the same dataset. This functionality ensures that a historical record of modifications is retained and can be referenced if needed, supporting research, documentation, and the traceability of changes made to CH data.

Access control is a critical aspect of digital repositories, as it ensures that CH data is appropriately protected and made accessible to authorised individuals or groups. These platforms offer robust access control mechanisms, allowing repository administrators to define user roles, permissions, and restrictions. This ensures that only authorised users can edit or download specific datasets, safeguarding intellectual property rights, sensitive materials, or restricted resources, while general users can view, search and retrieve data.

Understanding the requirements and limitations of the chosen repository at an early stage streamlines the collection of metadata and the organisation and formatting of files. It ensures that the data collection strategy aligns with the preservation strategy.

Furthermore, digital repositories often support interoperability through ***standardised protocols*** and application programming interfaces (APIs). This interoperability enables seamless integration with other systems and services, facilitating the exchange of data, cross-referencing, and the creation of interconnected narratives using diverse CH datasets. Interoperability promotes collaboration, knowledge sharing, and the ability to build comprehensive digital experiences and

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[39] See https://omeka.org
[40] See https://islandora.ca
[41] See e.g. https://dspace.lyrasis.org/
[42] See https://dataverse.org/

research environments. The OAIS reference model acts as a de-facto standard that is used on a large scale for digital preservation.[43] The OAIS model is widely used as a foundation stone for a wide range of digital preservation initiatives. The model can be considered as a conceptual framework informing the design of system architectures, such as digital repositories. An important aspect of the OAIS reference model is the "Designated Community", defined as "an identified group of potential consumers who should be able to understand a particular set of information. The Designated Community may be composed of multiple user communities''.

2.3.3 The state of digital repositories for cultural heritage

Over the last years, there has been a big change in cultural heritage concerning the introduction of digital processes in this field. This change can be observed in many aspects of the cultural heritage domain: digitisation of libraries and archives, digital preservation of artefacts, and creation of web applications for the visualisation of sites and museum items, to name just a few examples of this transformation. Digital technologies have affected ways of documentation, preservation, and communication, and also helped researchers and cultural heritage practitioners in their daily work. Indeed, the digitisation of cultural heritage has become a common practice since new tools and instruments have made capturing, preserving, and publishing widely accessible. In this vein, all the digitised data are in urgent need to be preserved. That is the reason why in the last few years there has been an increasing tendency towards the digital archiving of all the resources produced in the field of cultural heritage.

Different European countries have attained varying degrees of digitalisation and employ diverse approaches to digital preservation. On the one hand, certain countries lead the way in large-scale activities, either as a result of their national archives being digitised or because they are using technology more frequently, which has led to the creation of born-digital data. However, some countries are lagging behind others in terms of digitising their archaeological and cultural heritage legacy. There are many reasons for this difference, but the main cause is often a lack of knowledge, resources, and coordination at the national level in relation to the process and financing sources. Issues arise in both circumstances. For example, the large-scale production of digital data necessitates interoperable and readily accessible digital data for the field's community, as well as sustainable management to prevent the risk of obsolescence in the future. Furthermore, future issues with the lack of digitised data are unquestionably foreseeable. Analogue, human-generated data, for instance, are more easily lost due to a variety of anthropogenic and natural causes, making them challenging to manage and make accessible to the community. Digital data saved in older systems, formats, and technologies can also have similar problems, particularly if it is badly organised or completely not organised.[44]

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[43] The Open Archival Information System' (OAIS) reference model is an ISO standard, published as ISO 14721:2012 (see https://www.iso.org/standard/57284.html). The OAIS specification is also available online at: https://public.ccsds.org/pubs/650x0m2.pdf (accessed 28 August 2023).

[44] Vassallo et al. (2023). The state of the art of digital archiving for archaeology in Cyprus. Internet Archaeology 63. https://doi.org/10.11141/ia.63.5.

In general, the development of digital collections and archives, organised in repositories, has increased in the last few decades as a result of both public and private initiatives.[45] They result both from public and private funding initiatives. These kinds of preservation initiatives through repositories either are led by universities and research centres, museums and cultural heritage institutions, or by a collaboration between them. In terms of content, there is considerable variability: repositories dedicated to archives and libraries, archaeology or specific disciplines under that domain (e.g., numismatic, inscriptions); some focus on monuments; others are dedicated to art in general or to specific fields of the domain (e.g., religious art, art galleries). The type of material in terms of format is similarly diverse, including texts, documents, images and 3D data.

In regard to national repositories, the recent survey carried out by 4CH Task 4.1 "Survey on 3D repositories''[46] is reused here to investigate several aspects concerning the archival state of the art in cultural heritage and some of the current tendencies. The assessment of both European and extra-European digital repositories shows that there is a lack of national archiving systems for cultural heritage or they are only recently developing them. A recent effort within the COST Action SEADDA (Saving European Archaeology from the Digital Dark Age),[47] dedicated to the analysis of the current state of the art of digital national archiving for cultural heritage and archaeology in Europe, similarly underlined that tendency. The results of the investigations showed again that within some countries there is fragmentary digital archiving, with cases of private or emerging national repositories, while few countries have examples of organised, mature and standardised digital repositories at the national level. The integrated analysis shows that the majority of the cultural heritage repositories tend to archive 2D resources and sometimes associate them with 3D content. In contrast, digital repositories dedicated only to 3D items are much rarer. A point highlighted by these analyses is that most cultural heritage institutions and professionals have not completely interiorised the digital component yet, and they do not really exploit its full capabilities. For instance, common standards accessible to a broader public are missing, and the need for digitisation is increasing. For this reason, the EU is calling for actions to pave the way for a 'Common European Data Space for Cultural Heritage',[48] promoting preservation and valorisation through 3D digitisation of Cultural Heritage, creation of high-quality data flow, and data reuse.

The analysis carried out on the T4.1 survey shows that most of the repositories taken into consideration are organised through *metadata*. However, there is no further information on the type of metadata used (or why they are not used), if they are standard metadata schemas and semantics (e.g., Dublin Core, Lido, CIDOC CRM) or if a few fields to describe the items have been

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[45] Hawkins (2022). Archives, linked data and the digital humanities: increasing access to digitised and born-digital archives via the semantic web. Archival Science 22: 319-44. https://doi.org/10.1007/s10502-021-09381-0.

[46] Medici and Fernie (2022). D4.1 Report on standards, procedures and protocols. https://doi.org/10.5281/zenodo.7701529.

[47] The COST Action SEADDA (CA18128) was funded by the European Union to investigate and face a number of challenges connected to digital change in archaeology (https://www.seadda.eu/). The mentioned effort was published in two dedicated issues in the Internet Archaeology journal: the first issue (58, 2021) "Digital Archiving in Archaeology: The State of the Art" (https://intarch.ac.uk/journal/issue58/index.html) was followed by a second issue (63, 2023) "Digital Archiving in Archaeology: Additional State of the Art and Further Analyses''. (https://intarch.ac.uk/journal/issue63/index.html).

[48] Europeana pro (2022), https://pro.europeana.eu/page/common-european-data-space-for-cultural-heritage.

employed. In general, beyond the directions given by the FAIR principles in using metadata structures (see sections 1.2, 2.1, and 2.5), there are no rules or guidelines on the specific schemas to use in digital repositories since the choice is either connected to the type of data to describe, the specific domain and the needs of the repository's users (both those who created it and those that will use it).

Finally, attention has been directed towards the establishment of regulations and guidelines on metadata quality assessment and metadata completeness in CH repositories. The metadata quality assessment is treated by Bellini & Nesi (2013) to support institutions to assess the quality of their repository defining a Quality Profile for their metadata schema and identifying the Completeness, Accuracy and Consistency as High-level metrics.[49] Similarly, more recently, after a few previous attempts,[50] Lorenzini et al. (2021) proposed the automatisation of metadata quality analysis and completeness taking into consideration the metadata creation process, aggregation process and context.[51] Indeed, existing works on metadata quality either focus on one dimension, or concern specific repositories or metadata schema/profiles. The article presents the first results related to 'completeness', which is computed as the ratio of filled elements with respect to a metadata profile. Several variables should be taken into account (e.g., the elements that are mandatory and those that are optional, the context and the domain of a collection, as well as the preferences of curators when evaluating completeness).

All these regulations and guidelines are strictly connected to the evaluation of the digital repositories' trustworthiness (Appendix 3).

2.3.4 Recommendations

For data creators and data managers:
- Deposit your data in a 'Trustworthy' digital data repository.
- Ideally, use a domain-specific (i.e., cultural heritage or archaeology-focused) repository that provides services for a "designated community" such as domain specific metadata and licence services. As an alternative, institutional or generic repositories can be used, and/or you can find a repository on re3data.org.

For organisations that provide repository services:
- Make sure you meet the requirements of being a 'Trustworthy' digital repository.
- Certify your services, e.g. by attaining a CoreTrustSeal.

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[49] Bellini and Nesi (2013). Metadata quality assessment tool for open access cultural heritage institutional repositories. Pp. 90-103 in Nesi & R. Santucci (Eds).

[50] Margaritopoulos et al. (2012). Quantifying and measuring metadata completeness. Journal of the American Society for Information Science and Technology 63(4): 724–37. https://doi.org/10.1002/asi.21706; Ochoa and Duval (2009). Automatic evaluation of metadata quality in digital repositories. International Journal on Digital Libraries, 10(2–3): 67–91; Király (2015). A metadata quality assurance framework. Göttingen: Gesellschaft für wissenschaftliche Datenverarbeitung mbH Göttingen; Ostojic et al. (2017). The curation module and statistical analysis on VLO metadata quality. Selected papers from the CLARIN Annual Conference 2016. Linköping Electronic Conference Proceedings 136: 90–101. https://ep.liu.se/ecp/136/007/ecp17136007.pdf.

[51] Lorenzini et al. (2021). On assessing metadata completeness in digital cultural heritage repositories. Digital Scholarship in the Humanities 36, Supplement 2: ii 182–88. https://doi.org/10.1093/llc/fqab036 .

2.4 What to store for long-term preservation and reusability?

2.4.1 What to store for reusability?

A dataset typically includes the data that were generated for certain research or a project and which supports its findings. Data should be suitable for reuse and therefore sufficiently documented. Temporary data, concept documents, and non-definitive files are not data intended for reuse and should be removed from a dataset before depositing.

Datasets are collected when the process of generating data is finished and will typically consist of processed data. It may depend on the needs of the project or of the audience if it is desirable to also include raw data for archiving/publication and full reproducibility, but practicalities must be taken into consideration - the dataset needs to be manageable and overseeable. There may also be limits to the amount of data a repository can store or easily disseminate, while repositories may also charge the user by deposit size and here a project's budget can be limiting. Therefore it is important to balance what needs to be stored for optimal verification, reproducibility, and reuse of a dataset with what is possible to be stored in terms of for example space and cost. The good - better - best division of Moore et al. is useful in this respect, keeping in mind one should always go for at least 'good', or the minimum required for reproducibility and reuse, and ideally for 'best'.[52]

Recommendations (for data creators, depositors, also relevant for repositories):
- Consider the (future) audience: for research you need different, generally more, than for visualisation or 3D printing. For 3D data good guidance for different levels of users is available in Moore et al.[53]
- Consider what you need to preserve for the long-term already during data creation and data processing, as it will not be possible to produce the relevant paradata and metadata afterwards.
- As a minimum, store for the long-term any (raw) data and/or processed files (e.g., the original photographs and point cloud) as well as metadata and paradata (e.g., the instrument settings or environmental conditions) that are needed to reproduce the final result (e.g., the 3D model).
  - Metadata and paradata can, depending on the file type, be embedded or added as a separate file (or both, see section 2.4.2).
- If at all possible, keep, and make available, the raw data. If this is in a proprietary format, include a conversion into a non-proprietary format (see section 2.4.2).

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[52] Moore et al. (2022). 3D data creation to curation.
[53] Moore et al. (2022). 3D data creation to curation, pp. 35-36.

2.4.2 File formats

Application of specific file formats is preferred because they offer a better long-term guarantee in terms of three criteria: usability, accessibility, and sustainability.[54] If the file formats are i) widely used, ii) have open specifications, iii) are independent of specific software, developers, or vendors, then the produced files are more easily accessed and can be reused for a longer time. It is important to note that even though in practice it can be hard or even not possible to meet all three criteria, it is necessary to proceed with implementing as much as possible all three of them, balancing between desires and constraints There may be options to convert a non-open file format to an open one - here, it is, however, important to assess if all information is retained. As mentioned in section 2.4.1, metadata should always be available in an open format; however, when converting from an original proprietary format into an open format, information may be lost. Only keeping the proprietary format is also not ideal, as not everyone may have access to the software or it may become obsolete. If possible (in terms of costs, for example) one should keep both the original, proprietary format and the open format.

The file formats used in cultural heritage are also used in other disciplines, and recommendations of preferred file formats have been compiled by, for example, DANS and UKDS.[55] Preferred formats specific to cultural heritage types of data have also been compiled by, for example, Archeological Data Service (ADS).[56] A summary of preferred formats for 3D data is presented in Table 2.2. Generally recommended are ASCII-based files for point coordinates and commonly used, ideally open file formats. Formats like Autodesk FBX (.fbx), Blender (.blend), or 3D PDF (.pdf) are generally considered non-preferred for long-term preservation.[57]

Table 2.2 Preferred formats for 3D data (different types) based on DANS,[58] ADS,[59] and inputs from the community at the workshop 'Shaping the World of 3D'. See also UKDS for recommended and other acceptable formats in general (but no recommendations are included for 3D file formats).[60]

Format	Extension	Included on preferred format list	Remarks
WaveFront Object	.obj	DANS	ADS: for wireframed or textured models

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[54] DANS (2023), https://dans.knaw.nl/en/file-formats/ (version of 30 March 2023).

[55] DANS (2023), https://dans.knaw.nl/en/file-formats/;
https://ukdataservice.ac.uk/learning-hub/research-data-management/format-your-data/recommended-formats/;
More information about individual file formats can be found at https://www.nationalarchives.gov.uk/PRONOM/
(accessed 21 October 2023).

[56] Trognitz et al. (2016). Archaeology Data Services Guides to Good Practice, 3D models, file formats, Available at:
https://archaeologydataservice.ac.uk/help-guidance/guides-to-good-practice/data-analysis-and-visualisation/3d-models/creating-3d-data/file-formats/.

[57] For other purposes preferred file formats may differ, see for example the Sketchfab guidelines: Sketchfab (2022),
https://help.sketchfab.com/hc/en-us/articles/202508396-3D-File-Formats.

[58] DANS (2023), https://dans.knaw.nl/en/file-formats/.

[59] Trognitz et al. (2016). Archaeology Data Service Guides to Good Practice, 3D models, file formats.

[60] UKDS (n.d.),
https://ukdataservice.ac.uk/learning-hub/research-data-management/format-your-data/recommended-formats/
(accessed 3 November 2023).

Polygon file format	.ply	DANS	ADS: ASCII version suitable if file content is clearly documented
X3D	.x3d	DANS, ADS	ADS: recommended for complex 3D content
COLLADA	.dae	DANS	ADS: recommended where X3D is not an option
Standard Tesselation Language	.stl	ADS	ADS: ASCII format suitable for very basic datasets
Virtual Reality Modelling Language	.wrl, .vrml, .wrz	ADS	ADS: now replaced by X3D
Autodesk Drawing Interchange Format	.dxf	ADS	ADS: only suitable for preservation of native CAD datasets
glTF	.gltf; .glb	4CH workshop	
Draco	.drc	4CH workshop	
LASer	.laz /.las	4CH workshop	
Industry Foundation Classes	.ifc	4CH workshop	

Recommendations for practitioners:
- At least for long-term storage, use file formats that are frequently used, have open specifications, and are independent of specific software (preferred file formats).
- If converting from a proprietary to a non-proprietary format, check if all information is retained; if not, archive both formats (if possible).

Recommendations for repositories:
- Clearly communicate what these preferred file formats are for the data type(s) of interest and offer guidance (and if possible assistance) in conversion as well as about avoiding potential (meta)data loss.
- Realise that it is not always possible to have a preferred file format. Express a clear file format policy which steers practitioners to the use of preferred formats. If original data are submitted in other formats and cannot be converted, we recommend accepting this format to ensure completeness of the datasets.
- Conversions from one format to another may result in loss of functionality or other aspects of the data. This is especially true for 3D data formats. If conversions are deposited or provided by the repository, if possible also archive the original data.
- Ensure that your policies regarding file formats are shaped by input from practitioners, who possess insights into the software and formats they employ and the reasons behind their choices. Workshops and conferences serve as excellent platforms for engaging with practitioners

2.5 Metadata

Metadata (data about data) allows humans and machines (e.g., search engines and search functions in catalogues) to **find** the right datasets and to inform the user about their **reusability** by adding provenance and licence information. Metadata should always be openly available, even if the data are not, and can also be accessible even if the data itself can't be (anymore), while metadata can more easily be made interoperable even if the data it contains is not. It is clear that metadata is key for FAIR data. The PARTHENOS guide states, for example, "choose an appropriate metadata schema". But what is an appropriate metadata schema for your digitised or born-digital cultural heritage data? And how do you get these metadata in or attached to your dataset?

To start with the latter, the opportunities depend on the type of data. For all datasets it holds that if you store them in a repository, the repository should have a mechanism to assign metadata. There are also file types that can contain metadata, think for example about images with EXIF information included. It is a good idea to (also) put your metadata and other (descriptive) information in a READme file or similar, if you need to add information that can not be captured in standardised metadata fields. While this is not machine-readable (as repository metadata should be), at least others (humans) will be able to understand what you did.

In order for your data to be well findable and reusable, the metadata should contain the following:
- Project information: Scope, goals, date, general methods and techniques.
- Dataset information:
  - Title
  - Provenance: Who created it (creator) and how (from which sources, in what context, what methods, model information), version
  - Cultural heritage object information, for example the period/dating, the type of object/structure/site, etc.
  - Access information: what are the access and reuse rights?
- File information: What is the file type/format, 'codebook'/data dictionary: what terms are used (controlled vocabulary/thesaurus), what do abbreviations mean, how are blanks indicated, etc.

D4.1 and Moore et al. give an excellent and detailed overview of metadata recommendations for each project stage.[61]

2.5.1 Metadata schemas

To be interoperable with other projects and repositories, it is good practice to use a standard **metadata schema**, and repositories will normally do this. Firstly, there are **general metadata schemas**, which include general metadata elements that apply to virtually all datasets and other digital objects, like 'author(s) / 'creator(s)', 'date', 'language' and 'description'. An example is the Dublin Core metadata schema[62] which includes metadata fields that are virtually always offered by repositories.

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[61] Medici and Fernie (2022). D4.1 Report on standards, procedures and protocols.
[62] https://www.dublincore.org/specifications/dublin-core/dces/

Domain-specific metadata schemas are specific to disciplines (like cultural heritage) or to professions (such as libraries, museums, archives and so on). These schemas may incorporate general elements but allow for more specific and detailed descriptions of resources. As mentioned, there is no single internationally accepted standard for all aspects of cultural heritage. As described in D4.1, based on workshops for the community held by the Parthenos project and the Europeana Network Association, as well as by the 4CH workshop 'Shaping the World of 3D', the following metadata schemas are most relevant and used in cultural heritage: CIDOC CRM and its extension CRMdig, LIDO, Smithsonian, CARARE, Europeana EDM. These and several other relevant ones are described in Table 2.3, and additional information can be found in D4.1.[63]

Table 2.3 Recommended metadata schemas for cultural heritage use (source: D4.1)

Name	Characteristics, themes, focus	Link
ARCO	Museums, 3D models of museum artefacts.	
CARARE 2.0	Monuments, buildings, landscape areas; 2D and 3D. Application profile of MIDAS with extensions to support the EDM and the CIDOC CRMdig.	https://pro.carare.eu/en/introduction-carare-aggregation-services/carare-metadata-schema/
COSCH	Spatial and spectral recording of material cultural heritage.	https://link.springer.com/chapter/10.1007/978-3-319-75789-6_5
CIDOC CRMdig	Provenance of digital objects; 2D and 3D. Extension of CIDOC CRM.	https://cidoc-crm.org/crmdig/
Europeana Data Model (EDM)	Metadata from museums, libraries, archives, galleries (GLAM); various types of digital models including 3D (but limited coverage?)	https://pro.europeana.eu/page/edm-documentation
INCEPTION H-BIM	BIM model and CH information, architectural; 3D.	https://link.springer.com/chapter/10.1007/978-3-030-12960-6_23
LIDO	Museums, museum objects	https://cidoc.mini.icom.museum/working-groups/lido/lido-overview/about-lido/what-is-lido/
Mainzed	3D capturing processes	https://heritagesciencejournal.springeropen.com/articles/10.1186/s40494-021-00561-w#Sec31
METS	Digital libraries	https://www.loc.gov/standards/mets/
PARTHENOS	extension of CIDOC CRM and CRMdig for research infrastructure aggregators.	https://cidoc-crm.org/Resources/parthenos-entities-research-infrastructure-model
Smithsonian	Museum 3D programmes	https://dpo.si.edu/blog/smithsonian-3

[63] Medici and Fernie (2022). D4.1 D4.1 Report on standards, procedures and protocols, p. 71-73.

3D metadata model		d-metadata-model
STARC	2D and 3D. CARARE 1.0, CRMdig	

Recommendations for practitioners:

- Apply an existing cultural heritage-specific metadata schema to document your metadata; preferably use a repository that allows you to add these metadata to your dataset, but if not possible, make sure to add the metadata recommended by the schema yourself (e.g., as a CSV or XML file, see section 2.5.2).

Recommendations for repositories:

- Integrate cultural heritage-specific metadata schema in your repository.

2.5.1.1 Cultural heritage metadata schemas and their use in repositories

For what concerns the analysis of metadata and their use for 3D content (in relation to the analysis carried out by the T4.1 survey), 4CH T5.3 compiled an annotated bibliography in order to identify existent directions and guidelines on the topic. The material collected covers a time frame of circa ten years to show the trend developed during the selected period. Starting from the 2006 London Charter[64] that gave the first guidance on the topic, one of the first publications dedicated to directions in Virtual Heritage is offered by Bentkowska-Kafel et al. (2012).[65] The publication stresses the recognition of three-dimensional visualisation as a constructive, intellectual process and proper historical research and communication methodology. Intellectual transparency of visualisation-based research is addressed from different perspectives reflecting the theory and practice of respective disciplines. It is recommended to document paradata in conjunction with concrete research results, ideally as an essential component of virtual models, and to maintain it beyond the lifespan of the technology supporting visualisation.

Considering that during the period in question CH repositories started to grow and 3D data started to be included, the publication by Bentkowska-Kafel et al., together with the one by D'Andrea & Fernie (2013),[66] gave support to the entire process. D'Andrea & Fernie propose a metadata schema for 3D cultural objects to support the description and management of CH repositories aggregating 3D cultural items. In particular, the schema, which builds on earlier work in the CARARE project,[67] focuses on fostering the adoption of a clearer approach to describe the features of cultural objects, the techniques and the methodologies chosen for digitisation as well as the reasons behind a digital object's creation. The paper describes provenance in the CIDOC CRMdig schema[68], the

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[64] London Charter (2009), https://www.london-charter.org/.
[65] Bentkowska-Kafel et al. (2012). Paradata and transparency in virtual heritage. Ashgate Publishing.
[66] D'Andrea, A. & Fernie, K. (2013). CARARE 2.0: A metadata schema for 3D cultural objects. Pp. 137-43 in Digital Heritage International Congress (DigitalHeritage). Marseille: IEEE.
https://doi.org/10.1109/DigitalHeritage.2013.6744745
[67] https://www.carare.eu (accessed 15 October 2023).
[68] https://www.cidoc-crm.org/crmdig/ (accessed 15 October 2023).

paradata principles of the London Charter, and how provenance and paradata could be relevant to the strategy of Europeana[69] for more efficient reuse and increased usability of the resources online. In that regard, throughout the selected period until today, Europeana has in fact invested effort in developing its data model (Europeana Data Model - EDM[70]) for collecting, connecting and enriching the descriptions provided by its content providers, as well as in working on the various facets of the data quality challenge over time with a particular focus on reuse and discovery of cultural heritage objects.

A more recent publication by Blundell et al. (2020) is dedicated to metadata requirements, especially for 3D data, and provides recommendations for metadata based on the digital asset lifecycle steps (create, manage, publish, access/reuse, and archive).[71] It also provides a table of recommended metadata fields along with future needs, such as annotation metadata and metadata for accessibility, discovery and use of datasets, as well as data quality/suitability, reuse and reproducibility. The need for better metadata and paradata is underlined by a growth of publications on the topic, such as the one by Huvila (2022).[72] The publication draws attention to the need for a better and more systematic understanding and documentation of paradata, namely the contexts of creation, curation and use of research data to make it useful and usable for users in the future and to specific obstacles that make the capturing of paradata especially difficult. The article underlines that diverse users and uses of data and collections should be considered when describing processes rather than assuming that descriptions are stable in time and space. Similarly, in the direction of establishing some regulations, specifically for 3D data preservation, another publication by Moore et al. (2022) underlines the need to move towards the establishment of shared guidelines, practices, and standards.[73] Covering best practices for 3D data preservation, management, metadata, legal issues, and access, the authors provide recommendations for implementing standards and identify areas in which further development is required.

2.5.2 Capturing metadata and paradata

As a cultural heritage practitioner, how do you go about adding metadata and paradata? Firstly, it is vital to create the necessary documentation during the stages in the project workflow (capture, processing, etc), and not wait with adding metadata until the end of the project.

Metadata may sometimes be added directly to a file during capture or data processing, for example to glTF or Draco files (see also section 2.4.2 on file formats). Paradata may also be

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[69] https://www.europeana.eu.

[70] https://pro.europeana.eu/page/edm-documentation (accessed 15 october 2023).

[71] Blundell et al. (2022). Metadata requirements for 3D data. In Moore, J., A. Rountrey & H. Scates Kettler (Eds), 3D data creation to curation: community standards for 3D data preservation. Chicago: Association of College & Research Libraries.

[72] Huvila (2022). Improving the usefulness of research data with better paradata. Open Information Science 6(1): 28–48. https://doi.org/10.1515/opis-2022-0129.

[73] Moore et al. (2022). 3D data creation to curation: community standards for 3D data preservation.

integrated in your results (e.g. 3D scanning results). Other examples are software where annotations on for example 3D modelling decisions can be added.[74]

However, such metadata does not fulfil the FAIR principles for accessibility. It is essential to provide structured metadata with your dataset in an open format such as an XML file (preferably) or CSV file. You may also provide a "Read-me.txt" file to explain your dataset. Most repositories will require project level and dataset/collection level metadata to support discovery and data management, domain-specific metadata may be an option.

Efforts to create necessary metadata and paradata for 3D data in cultural heritage and archaeology for each of the different research project phases (see Fig. 1.2) have been going on for at least two decades now, and have recently led to two useful overviews of required and recommended metadata for 3D datasets (Medici and Fernie 2022; Moore et al. 2022). The challenge remains to get these integrated and accepted widely. In addition, infrastructural challenges remain as to how and where to document and publish the metadata.

Recommendations for CH practitioners:
- Use rich metadata containing information on the project, the cultural heritage object, the provenance and access rights
- Use a relevant, standard metadata schema
- Clearly document your metadata and paradata in your files and as structured data in READ-ME files, CSV files, spreadsheets or similar open format.

Recommendations for repositories and research infrastructures:
- Offer besides generic metadata standards, also domain-specific standards.
- Encourage depositors to add rich metadata and support them in doing so.
- Encourage depositors to add XML, CSV, and/or READ-ME TXT files specifying their metadata and paradata and support them in doing so.

2.5.3 Controlled vocabularies and thesauri

To achieve interoperability of metadata and data, it is important to use standardised metadata schemas and community-accepted terms (related to specific metadata fields, such as geographic terms). It may be tempting to use your own terminology, as it will fit your data perfectly, but it subsequently becomes a lot of work to combine multiple datasets by 'mapping' the terms to each other. It is therefore an important recommendation to use existing lists, controlled vocabularies, thesauri or ontologies,[75] also known as "Knowledge Organisation Systems". A register of these systems is provided by the Bartoc system.[76] If you cannot find a term there that you really need,

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[74] Such as currently in development by the eScience Center in the Netherlands, or as possible in a City Engine script (City Engine is proprietary software, however).

[75] If you would like to know more about ontologies, this PARTHENOS online training course is a useful resource: https://training.parthenos-project.eu/sample-page/formal-ontologies-a-complete-novices-guide/ (PARTHENOS project n.d., probably 2019).

[76] The Basic Register of Thesauri, Ontologies & Classifications (BARTOC) is a database of Knowledge Organization Systems and KOS related registries and can be found at: https://bartoc.org/.

why not consider contacting the owner of the vocabulary to see if they can add the term? Another factor that enhances the FAIRness of existing vocabularies is that if you choose a generally accepted one, it often comes with a PIDs attached to their terms thus being machine-readable.

Relevant generic examples of standardised terms that can be used to increase the quality and interoperability of metadata are:
- ISO639 for languages[77]
- Geonames for modern place names[78]
- Wikidata for any term or concept[79]

Specific to cultural heritage, international (examples only):
- Getty Art and Architecture Thesaurus (AAT)[80]
- Getty's Union List of Artist Names (ULAN)[81]
- Getty Thesaurus of Geographic Names (TGN)[82]
- Pleiades for ancient place names[83]
- PeriodO for cultural period names (time periods).[84] This is not strictly a list, vocabulary, or thesaurus, but rather a tool (in the form of a large CSV file) to look up how others have used period names and how they have defined them.

There are also relevant national examples of vocabularies, which are often mapped to international standards. Examples are the Archaeological Basis Register (ABR) in the Netherlands and FISH in the UK. During the planning phase of your project, when your decide on where you will deposit your data, it is a good idea to check which vocabularies your chosen repository uses: to see if they use (inter)national standard vocabularies, and to integrate the terms of these vocabularies into your (meta)data from the start. The DANS Data Station Archaeology, for example, uses terms from the Archaeological Basis Register.[85]

Relevant vocabulary tools for cultural heritage are the ARIADNE Vocabulary Matching Tool and the Dutch/partial English Network of Terms:
- Mapping: ARIADNE Vocabulary Matching Tool.[86] Based on the AAT. This tool lets you search for a term and establish relationships with (mapping to) related terms. This is then not a

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[77] See e.g. the entry of this list in the Bartoc registry: https://bartoc.org/en/node/20287.
[78] www.geonames.org and https://bartoc.org/en/node/1674
[79] https://www.wikidata.org/
[80] https://www.getty.edu/research/tools/vocabularies/aat/index.html
[81] https://www.getty.edu/research/tools/vocabularies/ulan/index.html
[82] https://www.getty.edu/research/tools/vocabularies/tgn/about.html
[83] https://pleiades.stoa.org
[84] https://perio.do
[85] These terms are in Dutch, but have been mapped to the English and international vocabulary of the AAT by the ARIADNE project.
[86] https://vmt.ariadne.d4science.org/vmt/vmt-app.html (accessed 1 November 2023).

tool for finding concepts (although the search function is handy for this, but focused on the AAT only), but for making mappings, to work towards Linked Open Data.[87]

- Finding: Termennetwerk or Network of Terms, example of a local (Dutch) tool to find terms ("termen"), also available in English (although it returns Dutch search results). A term can be entered and the relevant thesauri and vocabularies are indicated.[88] Terms from 23 different sources, including the Getty's AAT, Wikidata, Geonames, and several Dutch vocabularies and thesauri, are related to.

Recommendations for practitioners:
- Use generic as well as cultural heritage-specific controlled vocabularies and thesauri to capture your metadata and data content.

Recommendations for repository managers:
- Besides generic metadata schema and their relevant vocabularies, supply cultural heritage-specific controlled vocabularies for the metadata fields.

2.6 Copyright and Licences

Digitisation of cultural heritage requires an understanding of copyright and other rights which can exist in the original content and creative digital content. Copyright law is country specific but is built on international principles. There are differences in detail between countries, for example in the types of work which are covered, the duration of the copyright and in the exceptions to copyright for cultural heritage.

Content acquired by museums, libraries, archives, galleries and researchers may be subject to copyright. Under copyright law there is a clear legal and ethical responsibility to respect others' copyright and to recognise rights to privacy, performer's rights and so on.[89] Thus an important activity under FAIR data management is clearing the rights in a collection of data. This may involve research to:

- Evaluate the data in the collection - which may include both born digital and digital surrogates (of paintings, drawings, sculptures, photographs, films, recordings, books, diaries, newspapers, buildings, archaeological monuments, archival documents)
- Clarify if there are works in the collection which are in copyright
- Identify the copyright owners (normally the creators of the work - artists, staff, contractors, companies, volunteers, private individuals) where possible
- Contact the copyright owners if still alive, or contact heirs if the author died less than 70 years ago) to seek their permission/agreement to release the work under licence.
  - Copyright protection is temporary, once the period has expired the work automatically falls under the public domain.

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[87] https://vmt.ariadne.d4science.org/vmt/vmt-help.html (accessed 1 November 2023).

[88] https://termennetwerk.netwerkdigitaalerfgoed.nl/ (accessed 1 November 2023).

[89] With reference to https://pro.europeana.eu/event/clearing-rights-in-collections-part-1 and https://naomikorn.com/resources/licensing-and-rights-clearance-resources/ (accessed 12 October 2023).

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○ Where a rights holder is unknown or cannot be traced the item may be treated as an Orphan Work, in such cases it is important to document attempts to contact the rights holder.

It is important to note that the rise of digitisation has led to active discussion among policy-makers and legal experts on intellectual property rights in digital cultural content. The 2019 EU directive on copyright in the Digital Single Market, implemented by Member States in their national laws, sets out new provisions for cultural heritage institutions among others these include:[90]
1. A mandatory exemption for preservation copies;
2. Allow text and data mining; and
3. Make it clear that digital reproductions of public domain works are not subject to copyright or related rights. The wording of the article covers both 2D and 3D reproductions.

In the case of digitising in 3D, the digital content may be considered as either a simple reproduction (e.g. a photo-realistic model of a cultural heritage object) or an original work in itself (e.g. a reconstruction of a monument or building).

Clearing the rights in a collection can take time, particularly where a cultural heritage institution is digitising items in its permanent collection. For this reason it is important to build in rights clearance at the start of a project. In terms of data management it involves:
● Documenting attempts to contact rights holders
● Documenting permissions given by rights holders in writing
● Keeping a record of any licencing terms
● Having a strategy in place for orphan works
● Having a strategy in place for other legal issues, such as GDPR.

Establishing a licence that sets out the permissions for re-use of the digital content, is an important aspect of the FAIR principles. It helps users to understand who holds the rights in the content and the rights holder's policies on re-use. Using a standardised and unambiguous statement of the legal rights and policies helps to make these understandable for a wide audience and overcome national barriers.[91]

Europeana and the Common European Data Space for Cultural Heritage promotes the use of a set of 14 standardised rights statements. These express the copyright status of a digital object and provide information under which conditions it can be used in clear and simple language. The rights statements are machine readable and support interoperability under the FAIR principles. The rights statements available are either Creative Commons licences or from the Rights Statement consortium and comprise (see Table 2.4).

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[90] Europeana, What will the new EU copyright rules change for Europe's Cultural Heritage Institutions: https://pro.europeana.eu/post/explainer-what-will-the-new-eu-copyright-rules-change-for-europe-s-cultural-heritage-institutions#public-domain (accessed 16 October 2023).
[91] Hollander et al. (2019). PARTHENOS D3.1.

Table 2.4 14 standardised rights statements promoted by the European Data Space for Cultural Heritage

Statement	Note
The Creative Commons CC0 1.0 Universal Public Domain Dedication (CC0) http://creativecommons.org/publicdomain/zero/1.0/	CC0 is used to waive all the rights in a Digital Object. By applying this waiver, all possible existing rights in the content and the Digital Object are waived, and they can be used by anyone without any restrictions.
The Public Domain Mark (PDM) http://creativecommons.org/publicdomain/mark/1.0/	The Public Domain Mark (PDM) is applied to content that is no longer protected by copyright, worldwide. Objects that are labelled as being in the public domain can be used by anyone without any restrictions.
Creative Commons - Attribution (BY) http://creativecommons.org/licenses/by/4.0/	The CC BY licence lets others distribute, remix, tweak, and build upon the licensed work, even commercially, as long as they attribute the creator as described in the licence. CC BY is recommended to enable access, discovery and use of licensed works.
Creative Commons - Attribution, ShareAlike (BY-SA) http://creativecommons.org/licenses/by-sa/4.0/	The CC BY-SA licence lets others remix, tweak and build upon the licensed work, even for commercial purposes, as long as they attribute the creator as described in the licence, and licence their adaptations of the work under the same terms. All new works based on the original licensed work will carry the same licence, so any derivatives will also allow commercial use.
Creative Commons - Attribution, No Derivatives (BY-ND) http://creativecommons.org/licenses/by-nd/4.0/	The CC BY-ND licence lets others redistribute the work, and to make commercial and non-commercial use of the work as long as no alteration is made to the work and the creator is attributed according to the specifications of the licence.
Creative Commons - Attribution, Non-Commercial (BY-NC) http://creativecommons.org/licenses/by-nc/4.0/	The CC BY-NC licence lets others remix, tweak, and build upon the licensed work for non-commercial use. Any new works created and based on your work must be attributed to the creator as specified in the licence, and may be available for non-commercial use only.
Creative Commons - Attribution, Non-Commercial, ShareAlike (BY-NC-SA) http://creativecommons.org/licenses/by-nc-sa/4.0/	The CC BY-NC-SA licence lets others remix, tweak, and build upon the licensed work for non-commercial use as long as they attribute the creator of the work under the terms specified in the licence, and licence new creations under identical terms.
Creative Commons - Attribution, Non-Commercial, No Derivatives (BY-NC-ND) http://creativecommons.org/licenses/by-nc-nd/4.0/	The CC BY-NC-ND licence is the most restrictive of the six Creative Commons licences, only allowing others to download the licensed works and share them with others as long as they attribute the creator as specified in the licence, but users cannot change the work in any way or use it commercially.
No Copyright - non commercial re-use only (NoC-NC)	The NoC-NC statement is applied to public domain works which have been digitised as an outcome of a

http://rightsstatements.org/vocab/NoC-NC/1.0/	public-private partnership, where the terms of the contractual agreement limit commercial use for a certain period of time.
No Copyright - Other Known Legal Restriction (NoC-OKLR) http://rightsstatements.org/vocab/NoC-OKLR/1.0/	The NoC-OKLR statement is for use with public domain works that are subject to known legal restrictions other than copyright which prevent their free re-use.
In Copyright (InC) http://rightsstatements.org/vocab/InC/1.0/	The InC statement is for use with in-copyright works which are freely available online and where re-use requires additional permission from the rights holder(s).
In Copyright - Educational Use Permitted (InC-EDU) http://rightsstatements.org/vocab/InC-EDU/1.0/	The InC-EDU statement is for use with in-copyright works for which the rights holder(s) have allowed re-use for educational purposes only.
In Copyright - EU Orphan Work (InC-OW-EU) http://rightsstatements.org/vocab/InC-OW-EU/1.0/	The InC-OW-EU statement is for use with works that have been identified as an Orphan Work in line with the requirements of the national law implementing the Orphan Works Directive.
Copyright Not Evaluated (CNE) http://rightsstatements.org/vocab/CNE/1.0/	The CNE statement is for use with works where the copyright status has not been evaluated. The use of this rights statement in the context of Europeana is discouraged. We encourage you to undertake a copyright evaluation before making works available online.

Recommendations for practitioners (data creators, data depositors) with respect to copyright and licences are:
- Familiarise yourself with relevant copyright law and make sure you have got the rights to share the data.
- Always make clear under what licence (or other terms) your digital dataset can be used and reused.
- Choose one of the 14 recommended rights statements (see Table 2.4), because they are generally known and understood and are machine readable. Use a licence as open as possible, to enable reuse.

Recommendations for repositories:
- Enable the use of the 14 rights statements (for data; add others for, for example, software).
- Recommend the use of open licences where possible.

2.7 Use cases

This chapter concludes with two examples of archiving 3D data in practice, illustrating how data management activities can help to make cultural heritage digital assets more FAIR.

2.7.1 An archaeological photogrammetry legacy dataset in proprietary format

In a case study involving the dataset curation for a PhD research on photogrammetric modelling of primarily rock-cut chamber tombs,[92] several steps were undertaken to reduce storage requirements and ensure long-term interoperability. First, permission to store the data in a repository was obtained from a data steward representative of the legal data owner, the university where the PhD was conducted. Files were then prioritised for storage and included geographical coordinates for grid control points in .txt format, photogrammetric models created using Agisoft Photoscan (now Metashape[93]), and more than 40,000 digital images that formed the basis for the 3D models.

The dataset was submitted to the repository provided by DANS.[94] The metadata had already been entered in September 2020 into the then-current EASY archiving system as a placeholder with the intention to send the data to DANS afterwards. The dataset was described via a depositing module in Qualified Dublin Core metadata fields.

When this dataset was taken as a case study for the 4CH project, the data had not been sent to DANS yet due to miscommunication at the end of the research project. The data could be retrieved from a laptop and personal harddrive but not without some effort, as an obsolete login and lapsed IT support for the semi-managed laptop prevented direct access. Eventually the data could be retrieved, but the difficulties emphasised the importance of directly storing data intended for dissemination in a secure and accessible repository.

Large volumes of data can be difficult to disseminate via an archiving system. The amount of files and the total size which users can directly download can be limited, a large quantity of files may make it difficult to browse the dataset content, and direct storage via an archiving system may also be more costly than alternatives, such as tape storage. This case study includes over 450 GB storage and more than 60.000 files for the original 3D model data and photographs. These files were archived separately on secure storage servers with a clear link to the published dataset. The dataset includes file lists of the data which are stored outside of the archiving system. Users can obtain access to the data.

The original 3D data was generated with Agisoft Metashape software resulting in proprietary .psx and .psz file formats for the models. The Agisoft software was chosen on a project level as the preferred tool for training researchers in 3D architectural documentation, and alternative options were not explored until after the project's end.[95] Considering preferred formats guidelines and principles to disseminate the data as much as possible in open, non-proprietary format, options for exporting the data to alternative file formats were investigated as part of the deposit cycle with

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[92] Turner, D. R. (2020). Grave Reminders: Comparing Mycenaean tomb building with labour and memory. Sidestone Press. https://www.sidestone.com/books/grave-reminders.

[93] See https://www.agisoft.com/.

[94] Turner, D.R. (2020). Dataset: Mycenaean tomb construction in Attica and Achaea (southern Greece, 1600 - 1000 BC). DANS Archaeology Data Station. https://doi.org/10.17026/dans-zyb-y9cy.

[95] https://setinstone.eu/ (accessed 7 November 2023).

DANS. The Agisoft Metashape software has the option to export the data in the Polygon File Format (.ply), which can be identified as a preferred file format for 3D models. The free 30-day trial version of Agisoft Metashape was used to convert the proprietary files. Unlike the original Agisoft data, the PLY files were archived within the archiving system for direct dissemination.
The dataset was published on a CC-BY 4.0 licence.

2.7.2 A large 3D dataset for a master thesis archived in good contact with the repository

In May 2023, DANS was contacted by a student of Archaeology at Leiden University, who was finishing her studies with research on *Investigating the limits of 3D scanning and modelling*[96] for which she created large 3D models of Bronze Age swords in Artec .a3d file format, inquiring about depositing the data and if there were issues regarding the volume or the formats used. DANS first asked about options for exporting the models in a preferred file format, to which the student responded that she could and would deliver the models in Wavefront Object (.obj) and the Polygon File Format (.ply). DANS agreed to archive both the preferred formats and the original data (for full authenticity and reproducibility) and also invited the student to participate in the workshop 'Shaping the World of 3D', which she did. At the workshop, she mentioned that she had stopped trying to upload the data because the upload module of the archiving system could not handle very large files. DANS contacted her afterwards and provided her with a secure file transfer link to deposit the data files. The student could then submit the dataset. DANS added the preferred formats before publication.[97] Because of their size and relatively lesser need for direct dissemination, the original Artec files were archived separately on secure storage servers with a clear link to the dataset. The dataset includes a message that users can contact DANS in order to obtain access to the original Artec files.

Subsequently, DANS also had one of their programmers look into the uploading module and enhanced its capabilities for uploading large data files.

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[96] Huisman, M. (2023). Investigating the limits of 3D scanning and modelling: Studying the visibility of impact fractures on 3D models of Gündlingen swords. Master thesis Archaeology (MA/MSc). https://hdl.handle.net/1887/3639999.
[97] Huisman, M. (2023). 3D models accompanying Master thesis: Investigating the limits of 3D scanning and modelling. https://doi.org/10.17026/AR/MNLSIC, DANS Data Station Archaeology, V1.

3. European and National digital heritage strategies, policies, and initiatives

This chapter describes relevant strategies developed and promoted at the European level concerning the enhancement and management of cultural heritage digital resources. The objective is to answer a series of research questions: How do different EU countries deal with digital strategies? Which policies and initiatives are available? What is common? What is different? An overall framework of reference has been developed starting from an overview on policies and main initiatives concerning data management, which introduces a focus on how Member States are tackling the challenge of digitisation, looking in particular at what is reported in their National Recovery and Resilience plans, considered as a common field of comparison. Two specific countries, Italy and Romania (both represented by 4CH partners), are analysed as case studies with the aim of understanding the paths undertaken - in line with European policies - and the tools/strategies adopted, paying particular attention to the topics of WP5, such as data management, guidelines for further data re-use, FAIR principles, and regulations (e.g., copyright).

The research presented hereafter helps to lay the groundwork for the 4CH recommendations on "Strategies and policies for the digitisation of cultural heritage", in particular on data management planning. It is aimed at policy and decision makers in public institutions, in particular ministries supporting preservation and digitisation policies. The recommendations are also relevant to cultural heritage managers who oversee monuments and sites in public and private institutions.

3.1 European policies and initiatives for cultural heritage digitisation and data management

3.1.1 European policies

At the European level, digital transformation in the field of cultural heritage is a challenge addressed by several programmes and policy documents. The framework is defined within which Member States should operate in terms of commitment to digitisation, online access to cultural material, preservation of digital resources through the use of the best cutting-edge technologies to enhance knowledge and visibility, development and training of the necessary skills, as well as citizens' involvement, and collaboration with other sectors such as education, sustainable tourism, and the cultural and creative industries.

The main initiatives undertaken by the European Commission Directorate General for Communications Networks, Content & Technology[98] in the areas of digitisation, online access to cultural material and digital preservation to supplement Member States' policies are extensively described: The 'Recommendation on digitisation and online accessibility and digital preservation of

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[98] DG Communications Networks, Content & Technology (2023), https://commission.europa.eu/about-european-commission/departments-and-executive-agencies/communications-networks-content-and-technology_en (accessed 10 November 2023).

cultural material' (2011/711/EU),[99] the 'Declaration of Cooperation on advancing the digitisation of cultural heritage'[100] (launched at the Digital Day 2019[101]), and the list of principles and tips for 3D digitisation of tangible cultural heritage published on September 2020[102] - as asked by 27 signing Member States to the European Commission's Expert Group on Digital Cultural Heritage and Europeana (DCHE Expert Group),[103] or the Public consultation on the opportunities offered by digital technologies for the culture heritage sector (June 2020),[104] jointly with several funding opportunities.[105] These measures continued on the path opened in 2018 by the European Year of Cultural Heritage (2018) – followed in 2019 by the 'European framework for action on cultural heritage' report[106] - and the communication on 'A New European Agenda for Culture'.[107]

The 4CH project itself - aimed at the definition of the methodological, procedural and organisational framework for the establishment of a 'Competence Centre' for the preservation and conservation of European cultural heritage - is part of the preliminary funding initiatives that fall within this policy framework, financed under the Horizon 2020 program "Societal Challenges 2014-2020 - Europe In A Changing World - Inclusive, Innovative And Reflective Societies".[108] The future CC will contribute to the growth in both the quantity and quality of digitised monuments and documents, thereby promoting improved utilisation, sharing and reuse, as well as strengthening coordination between the various players in the sector and improving the skills of potential users.

More recently, the objective of accelerating the digitisation process of monuments and sites at risk by 2030 is supported by the creation of a common 'European Data Space'[109] (see section 3.1.2.3 for more details): a platform capable of enabling access, sharing, re-use and preservation of high-value data and digital assets, the implementation of which will be monitored by a commission of experts

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[99] European Commission (2011). Commission Recommendation of 27 October 2011 on the digitisation and online accessibility of cultural material and digital preservation, https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32011H0711.

[100] European Commission (201). EU Member States sign up to cooperate on digitising cultural heritage, https://digital-strategy.ec.europa.eu/en/news/eu-member-states-sign-cooperate-digitising-cultural-heritage.

[101] European Commission (2019). Digital Day 2019, https://digital-strategy.ec.europa.eu/en/events/digital-day-2019.

[102] European Commission (2020). Expert Group on Digital Cultural Heritage and Europeana, Basic principles and tips for 3D digitisation of cultural heritage, https://digital-strategy.ec.europa.eu/en/library/basic-principles-and-tips-3d-digitisation-cultural-heritage.

[103] European Commission. Expert Group on Digital Cultural Heritage and Europeana (DCHE), 2017-2021, https://digital-strategy.ec.europa.eu/en/policies/europeana-digital-heritage-expert-group.

[104] European Commission (2020. Public consultation on opportunities offered by digital technologies for the culture heritage sector, https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/11837-Digitisation-and-online-access-of-cultural-material-and-digital-preservation-evaluation-/F_en.

[105] European Commission. Digital cultural heritage, https://digital-strategy.ec.europa.eu/en/policies/cultural-heritage.

[106] European Commission (2019). European framework for action on cultural heritage, 2019, https://op.europa.eu/en/publication-detail/-/publication/5a9c3144-80f1-11e9-9f05-01aa75ed71a1.

[107] European Commission (2018). A new European agenda for culture - SWD(2018) 267 final, https://culture.ec.europa.eu/document/a-new-european-agenda-for-culture-swd2018-267-final.

[108] European Competence Centre for the preservation and conservation of Monuments and Sites, https://cordis.europa.eu/programme/id/H2020_DT-TRANSFORMATIONS-20-2020 (accessed 10 November 2023).

[109] European Commission (2021). Digibyte, Commission proposes a common European data space for cultural heritage, https://digital-strategy.ec.europa.eu/en/news/commission-proposes-common-european-data-space-cultural-heritage.

representing all Member States.[110] Four main strands of work describe its main operative objectives in terms of deployment and maintenance, summarised in the corresponding work packages: development and operation of the data space infrastructure; integration of high-quality data, reusable and accessible data in the data space; capacity building and fostering reuse; digital services for the public.

The 'European Cultural Heritage Cloud'[111] represents another initiative that will work in tandem with the Data Space, supporting these ambitions: it is a digital infrastructure/platform - currently under preparation and funded under the Horizon Europe program - that will connect cultural heritage institutions and professionals across the EU, improving collaboration and innovation in digitisation, study and preservation of cultural heritage assets.

In addition to the Recommendations on the Data Space (released in November 2021)[112] and the Heritage Cloud, the European Commission has launched the 'Twin it! 3D for Europe's culture'[113] campaign (kicked-off on 21 June 2023), inviting the 27 EU Ministries of Culture to select and submit one 3D digitised cultural heritage asset of high technical quality to the common European Data Space for cultural heritage deployed by the Europeana initiative. The pan-European 3D collection will be showcased in spring 2024 and could include cultural heritage at risk among the most physically visited monuments, buildings, and sites, or belonging to a category with low levels of digitisation, directly supporting the recommendations goals.

A more detailed and specific focus on the initiatives and tools developed at European level on data management is reported in the following section.

> *Insights for 4CH Data Management recommendations concerning (European) digitisation policies for cultural heritage*

The policies, initiatives, recommendations and guidance documents developed at European level define the **general framework of reference** with respect to which the future CC will have to operate and draft its recommendations.

4CH recommendations to **cultural heritage managers** and **policy makers concerning policies at European level may include** the research and **update** on measures implemented for the cultural

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[110] European Commission (2021). Register of Commission Expert Groups and Other Similar Entities, Commission Expert Group on the common European Data Space for Cultural Heritage (E03800), https://ec.europa.eu/transparency/expert-groups-register/screen/expert-groups/consult?lang=en&groupID=3800.

[111] The Cultural Heritage Cloud, 2022,https://research-and-innovation.ec.europa.eu/research-area/social-sciences-and-humanities/cultural-heritage-and-cultural-and-creative-industries-ccis/cultural-heritage-cloud_en.

[112] European Commission (2021). Commission Recommendation of 10.11.2021 on a common European data space for cultural heritage, https://digital-strategy.ec.europa.eu/en/news/commission-proposes-common-european-data-space-cultural-heritage.

[113] Europeana pro (2023). Twin it! 3D for Europe's culture, https://pro.europeana.eu/page/twin-it-3d-for-europe-s-culture.

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heritage sector (e.g., documents, requirements, repositories, projects, financing initiatives, shared templates, networks, recommendations, etc.) with a particular reference to digitalisation, in order to align and integrate measures and activities with such European policies.

Another important aspect to address is the **integration between the main digitalisation policies at European level with other on-going initiatives** (e.g., the European Green Deal and the New European Bauhaus[114]) or **other promoted by relevant association/institutions/networks** (e.g., Europeana, UNESCO, ICOMOS, Europa Nostra, etc.), fostering the implementation of actions in the cultural heritage domain which pursue/address further objectives/challenges[115] - for instance, the achievement of the Sustainable Development Goals[116] (e.g., to reduce energy consumption, to contribute to mitigating climate change, to reduce social inequalities, etc.).

3.1.2 European initiatives concerning data management

3.1.2.1 A European Strategy for Data

The digital landscape in Europe is undergoing rapid evolution, driven primarily by initiatives from the Directorate General Connect Communications Networks, Content and Technology.[117]

Recognizing the centrality of data in shaping the future, the European Commission embarked on a mission to identify and introduce key regulatory measures and initiatives. These initiatives were chosen based on their potential to address immediate challenges, set global standards, and foster a harmonious digital ecosystem across the continent. Each initiative was deemed pivotal either because of its far-reaching impact on data governance, its ability to enhance data-sharing practices, or its promise in ensuring that the digital transformation of Europe remains aligned with the values of its citizens.

Key data management initiatives of the European Commission include:

● **General Data Protection Regulation (GDPR)**: Enacted in 2018, GDPR is a comprehensive data protection legislation that has set a new global standard for data privacy. It empowers European citizens with rights over their personal data and sets stringent requirements for

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[114] The New European Bauhaus, 2020 - ongoing, https://new-european-bauhaus.europa.eu/index_en.

[115] See, for instance: Europa Nostra and ICOMOS, European Cultural Heritage Green Paper, 2021, https://issuu.com/europanostra/docs/20210322-european_cultural_heritage_green_paper_fu ; Europa Nostra, Cultural Heritage as an integral dimension of the "New European Bauhaus" initiative, 2020, https://www.europanostra.org/cultural-heritage-as-an-integral-dimension-of-the-new-european-bauhaus-initiative/; Europeana pro, New European Bauhaus, https://pro.europeana.eu/page/new-european-bauhaus (accessed 10 November 2023).

[116] See, for instance: ICOMOS, Heritage and the Sustainable Development Goals: Policy Guidance For Heritage And Development Actors, 2021, https://openarchive.icomos.org/id/eprint/2453/13/ICOMOS_SDGPG_2022%20-%20FINAL3.pdf.

[117] EC Directorate General Connect Communications Networks, Content and Technology, https://commission.europa.eu/about-european-commission/departments-and-executive-agencies/communications-networks-content-and-technology_en (accessed 10 November 2023).

businesses.

- **Data Governance Act**: Proposed to foster data sharing within the European Union, this legislation addresses the available data's quality and the relationships among data holders, data users, and data intermediaries.
- **Open Data Directive**: This refines the legislative framework on public sector data, enabling greater access and reuse of public sector data and documents.
- **Digital Services Act**: Although broader in scope, this legislation deals with the roles of online platforms and safeguards users' fundamental rights, including the rights to privacy and protection of personal data.

At the heart of this transformation lies Europe's broader strategy for data[118], aiming to capitalise the vast potential of data within the Digital Single Market.[119] The strategy envisions an organised ecosystem, wherein data flows seamlessly across borders while upholding the security, rights, and privacy of European citizens.

As data becomes pivotal to Europe's trajectory, the European Commission has crafted an extensive roadmap for the upcoming decade, dubbed "Europe's Digital Decade."[120] This roadmap underscores data, technology, and infrastructure as key focal points.

Beyond economic goals, the strategy seeks to synchronise digital progress with broader societal and environmental ambitions, including the Sustainable Development Goals (SDGs)[121] and achieving a climate-neutral Europe by 2050.[122]

The Digital Europe Programme[123]'s progress from 2021-2022 through 2023-2024 mirrors this commitment. The Programme emphasises digital capabilities while actively addressing emerging challenges and significant global events, such as the COVID-19 pandemic and the complexities of the Ukraine-Russia situation.

Key among the Programme's endeavours are initiatives like the European Digital Innovation Hubs network[124] and the EuroHPC JU[125]'s national HPC Competence Centres.

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[118] EC (2023), https://digital-strategy.ec.europa.eu/en/policies/strategy-data.

[119] European Council (2020), https://www.consilium.europa.eu/en/policies/digital-single-market/.

[120] EC (n.d.), https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/europe-fit-digital-age/europes-digital-decade-digital-targets-2030_en (accessed 10 November 2023).

[121] UN, https://sdgs.un.org/goals.

[122] https://www.eea.europa.eu/policy-documents/ec-2020-2050-long-term-strategy (accessed 10 November 2023).

[123] EC (n.d.), https://digital-strategy.ec.europa.eu/en/activities/digital-programme (accessed 10 November 2023).

[124] https://european-digital-innovation-hubs.ec.europa.eu/home (accessed 10 November 2023).

[125] https://eurohpc-ju.europa.eu/index_en (accessed 10 November 2023).

The Programme showcases varied initiatives, transitioning from the EuroQCI[126] Initiative to the Secure Connectivity[127] Initiative, and branching further to the Open Science Cloud[128] and Data Space[129] Initiative. Prioritising modern digital technologies, these areas stand out as primary development regions, offering robust support to SMEs, particularly in economically challenged areas.

Subsequent sections delve into the aforementioned Open Science Cloud and Data Space initiatives.

3.1.2.2 EOSC - European Open Science Cloud

In the evolving landscape of research and innovation, the European Union is also forging a cohesive path to harness the transformative potential of Open Science.[130] The overarching ambition is to refine the quality of research by enhancing transparency and reproducibility, and ensuring that its benefits reverberate through industry and society, propelling economic growth.

Within the broader framework of European data management initiatives, the European Open Science Cloud (EOSC)[131] stands as a pivotal effort by the European Union. It operates within the European Research Area (ERA)[132], embodying the European Commission's vision to ensure access and reuse of data generated from publicly-funded research.

Governance of the EOSC is jointly managed by the EOSC Association[133], the Steering Board of Member and Associate States, and the European Commission. Collectively, they align research and innovation efforts, ensuring a cohesive approach.

Financial support for EOSC is sourced from the European Commission's Horizon Europe programme and Member/Associate Countries' national contributions, both adhering to the vision established by the Strategic Research and innovation Agenda (SRIA)[134] and Multi-Annual Roadmap

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[126] EC (n.d.). The European Quantum Communication Infrastructure (EuroQCI) Initiative, https://digital-strategy.ec.europa.eu/en/policies/european-quantum-communication-infrastructure-euroqci (last accessed 11 December 2023).

[127] https://www.europarl.europa.eu/thinktank/en/document/EPRS_BRI(2022)72944 (accessed August 2023, link not available on 11 December 2023).

[128] EC (n.d.). European Open Science Cloud, https://research-and-innovation.ec.europa.eu/strategy/strategy-2020-2024/our-digital-future/open-science/european-open-science-cloud-eosc_en (accessed 11 December 2023).

[129] EC (n.d.), https://digital-strategy.ec.europa.eu/en/policies/strategy-data (last accessed 11 December 2023).

[130] EC (n.d.). Open Science, https://research-and-innovation.ec.europa.eu/strategy/strategy-2020-2024/our-digital-future/open-science_en (last accessed 11 December 2023).

[131] EOSC Portal, https://eosc-portal.eu/ (accessed 10 November 2023).

[132] EOSC Portal, https://eosc-portal.eu/ (accessed 10 November 2023).

[133] EOSC Association, https://eosc.eu/ (accessed 10 November 2023).

[134] European Partnership (2022). EOSC - SRIA v1.1, https://eosc.eu/wp-content/uploads/2023/08/SRIA-1.1-final.pdf.

(MAR).[135] In practice this means the EOSC is realised through a series of consecutive and contemporaneous projects.

Recognized by the Council of the European Union, EOSC acts as a primary tool for enhancing the European Research Area. It integrates effectively with the broader European data strategy[136], representing a key sector in the wider European data space, enabling a step change across scientific communities and research infrastructures towards. Particular objectives established by the SRIA for the EOSC are:

- Open: Creating a multi-disciplinary environment for finding, sharing, seamlessly accessing, and reusing research objects produced along the research lifecycle (e.g., data, methods, software, publications) and services. These should be 'as open as possible, as restricted as necessary'.
- FAIR: Developing a "Web of FAIR (Findability, Accessibility, Interoperability and Reusability) data and services"
- Federated: Build on existing infrastructures and services, forming a federated 'system of systems'

Full deployment of the EOSC aims to lead to higher research productivity, new insights and innovations, as well as improved reproducibility and trust in science. The MAR foresees a fully functional and integrated EOSC by 2027.

OpenAIRE Services for EOSC[137]

OPENAIRE is a pivotal player in the realm of open scholarly communication, functioning as a dedicated Scholarly Communication Infrastructure. Its primary mission is to conceive and manage a variety of services tailored to the ethos of Open Science. Furthermore, OPENAIRE is aligned with the Principles of Open Scholarly Infrastructure, ensuring a commitment to transparency, accessibility, and the advancement of scholarly communication.

In the framework of EOSC, OpenAIRE implemented services that are part of the EOSC Core and they are the following:

- **OpenAIRE Guidelines**: A metadata schema fostering the exchange of information aligned with FAIR (Findable, Accessible, Interoperable, and Reusable) principles.

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[135] European Partnership (2023). EOSC - Multi-Annual Roadmap, https://eosc.eu/wp-content/uploads/2023/08/MAR_2025-27_draft.pdf.
[136] https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/europe-fit-digital-age/european-data-strategy_en (accessed November 10, 2023).
[137] Refer to OPENAIRE's insights on EOSC for detailed information: https://www.openaire.eu/openaire-and-eosc (accessed 10 November 2023) .

- **PROVIDE Dashboard**: A comprehensive platform for registering and validating data sources while ensuring compliance with contemporary standards.
- **UsageCounts**: A tool for collecting usage metrics for data sources, such as views and downloads, which also provides standardised reports.
- **OpenAIRE Graph**: A global and open database mapping out connections between publications, data, software, citations, metrics, funders, and more.
- **EXPLORE Dashboard**: A search engine designed for the discovery of interlinked research.
- **Open Science Observatory**: An observatory focused on the uptake and implementation of Open Science across Europe.

OpenAIRE Scholarly Communication Services for EOSC Exchange: OpenAIRE offers a suite of services geared towards helping researchers publish and disseminate their findings, aiding research managers in monitoring research outcomes and policies, and assisting trainers in sourcing and reusing Open Science-related materials.

National Open Access Desks (NOADs)

OpenAIRE operates a vast network comprising 37 NOADs spread across member and associated countries. These desks serve as a nexus for knowledge exchange, supporting both the EC's and national Open Science directives throughout Europe. The NOAD personnel, who are entrenched in various institutions like HEIs, data centres, and funding agencies, provide expert advice on Open Science at the national level.

Roles and Responsibilities of NOADs:

- **Support & Train**: Develop and offer materials along with hands-on support to educate various stakeholders in the Open Science ecosystem.
- **Align Policies**: Help organisations and nations establish policies that cater to local requirements while leveraging commonly adopted toolkits and policy models.
- **Monitor Open Science**: Track and document the adoption of Open Science practices across Member States, providing detailed insights via country-specific pages.
- **Operate Infrastructure**: Participate in and shape national Open Science infrastructure through dedicated services.

3.1.2.3 European Data Spaces

A key component of a seamlessly integrated digital Europe is the strategy for European 'Data Spaces.[138]' These are envisioned as secure and standardised environments where data can be shared, accessed, and used, enhancing the potential for cross-border and cross-sectoral collaborations. By fostering a culture of sharing and collaboration while ensuring data sovereignty and trust, data spaces are set to be the bedrock upon which Europe's digital future will be

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[138] https://digital-strategy.ec.europa.eu/en/policies/strategy-data (accessed 10 November 2023).

constructed. In this context, the European Data Space emerges as a flagship initiative, evincing Europe's commitment to leveraging the pivotal potential of data in the service of its citizens.

In this context, the European Commission has recently advanced a recommendation focusing on the establishment of a unified European data space dedicated to cultural heritage[139]. This initiative underscores the pressing necessity of digitising cultural heritage assets, particularly given the increasing threats to their preservation. A pivotal component of this initiative is the charge to Member States to hasten the digitisation of a vast range of cultural assets, with a specific emphasis on sites that are either at risk of deterioration or those that attract significant tourist traffic. By 2030, the goal is to have digitised all vulnerable monuments and sites, along with half of the most popular tourist destinations.

The Europeana platform[140] will serve as the backbone of this data space. Through this platform, an array of cultural institutions from museums to archives will be equipped to disseminate and repurpose digitised cultural assets. Cultural artefacts of all types will benefit from this initiative, with services ranging from 3D renderings of historical sites to high-resolution scans of iconic works of art.

Recent events have underscored the critical importance of digitally preserving our cultural landmarks. The devastating fire at Notre-Dame Cathedral serves as a stark reminder of the vulnerabilities inherent in our historical sites. Furthermore, the pervasive lockdowns during the pandemic era accentuated the imperative of ensuring that cultural heritage remains accessible in virtual formats. Tragically, in the wake of the conflict following the invasion of Ukraine by Russian troops, the very fabric of Ukraine's cultural heritage is at risk. Beyond the inexpressible human cost and displacement of millions, monuments, artworks, and historical remnants are under threat, endangering the history and identity of the Ukrainians. As an immediate response, 4CH launched the SUM – Save the Ukraine Monuments initiative[141]. This urgent endeavour aims to digitally document Ukrainian cultural heritage, ensuring its memory endures and aiding future restoration efforts post-conflict. Approved by the EU Commission, the initiative proceeds with the collaboration, endorsement, and support of various EU cultural institutions and organisations. Monitoring mechanisms for these preservation initiatives have been set in place, with Member States required to report their progress biennially and an expert group designated to oversee their implementation. These efforts are part of a broader European strategy to develop similar data spaces in other critical sectors.

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[139] The European Commission (EC) has initiated the development of a unified data space focused on cultural heritage. Supported by the Digital Europe programme, this initiative was officially unveiled in the Commission Recommendation C(2021)7953, dated 10 November 2021. In the progression towards actualizing this initiative, a tender was opened on 10 April 2022. Consequently, a consortium of 19 partners, led by the Europeana Foundation and representing 9 EU countries, secured the service contract, which became operational on 20 September 2022.

[140] https://www.europeana.eu/en (accessed 10 November 2023).

[141] https://www.4ch-project.eu/sum/ (accessed 10 November 2023).

Common Data Space for Cultural Heritage[142] - Specifics

Key features of the European Data Space for Cultural Heritage are the following:

- **Objective:** Highlighting the EC's commitment to the digital renewal of Europe's cultural sector, this initiative offers a channel for European cultural heritage institutions to circulate their digitised content, replete with superior metadata. Notably, it integrates state-of-the-art 3D depictions, promoting broader reutilization of this digital content and emphasising its socioeconomic potential.
- **Strategic Pillars:** Anchored in the Europeana Digital Service Infrastructure, it aligns with the Europeana Strategy 2020-2025. It is envisioned to synergize with pertinent European, national, and regional endeavours, ensuring standardised cultural heritage data access.
- **Collaboration:** The project is bolstered by the Europeana Network Association (ENA)—comprising 3,500+ digital heritage experts. The Europeana Aggregators' Forum (EAF) further supports by assisting cultural institutions in data provisioning.
- **Management and Oversight:** Managed by Member States within the Commission Expert Group on the Common European (CEDCHE) framework.

Operational Components:

- **Data Space Infrastructure**: Development and management of core data infrastructure, coupled with innovation.
- **High-Quality Data Integration:** Guaranteeing a consistent stream of top-tier, reusable, and accessible data.
- **Capacity Building and Data Usage**: Enhancing expertise in digital cultural heritage and promoting widespread data use.
- **Public Digital Services:** Engaging the public through enhanced accessibility and interaction with digital cultural heritage.
- **Consortium Composition**: The project includes diverse stakeholders like the Europeana Foundation, AIT Austrian Institute of Technology GmbH, Capgemini Nederland B.V., and many others.

> ***Insights for 4CH Data Management recommendations concerning European digitisation initiatives for cultural heritage:***

Given the advancements and focus on data-driven initiatives by the European Commission and the emerging importance of digital transformation in the cultural heritage sector, we highly recommend that **cultural heritage managers** and **policy makers** consider the following actions, in order to join/cooperate with them:

Engage with the European Open Science Cloud (EOSC):

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[142] https://digital-strategy.ec.europa.eu/en/news/deployment-common-european-data-space-cultural-heritage (accessed 10 November 2023).

- **Training Webinars:** Attend or organise training sessions on how to utilise the EOSC platform, understand its benefits, and contribute to its repositories.
- **Memorandum of Understanding (MoU):** Sign a formal agreement with EOSC to ensure regular collaboration, data sharing, and joint research ventures.
- **Research Collaborations:** Partner with EOSC for joint research projects, especially those that focus on digital preservation, transparency, and accessibility.

Participate in the European Data Space for Cultural Heritage:
- **Workshops:** Attend or initiate workshops focusing on best practices for digitisation, archiving, and data sharing within the European Data Space framework.
- **MoU:** Formalise collaborations by signing a MoU detailing the roles, responsibilities, and contributions of each party.
- **Data Sharing Agreements:** Clearly define the terms under which data will be shared, ensuring adherence to GDPR and other relevant regulations.

Leverage the Europeana Platform:
- **Training Programs:** Enrol in training programs offered by Europeana to understand the platform's functionalities and how it can benefit cultural heritage preservation.
- **Integration Tools:** Utilise tools and APIs provided by Europeana to integrate with their platform, enabling seamless data transfer and sharing.

Collaborate with the Europeana Network Association (ENA) and the Europeana Aggregators' Forum (EAF):
- **Network Meetings:** Participate in regular meetings and conventions hosted by ENA and EAF, ensuring active engagement and knowledge exchange.
- **Collaboration Agreements:** Draft agreements detailing collaboration areas, from data sharing to joint events and publications.

Align with the Strategic Research and innovation Agenda (SRIA) and Multi-Annual Roadmap (MAR):
- **Stakeholder Consultations:** Attend consultations to voice the needs and priorities of the cultural heritage sector, ensuring alignment with broader European objectives.
- **Joint Strategy Development:** Work closely with SRIA and MAR teams to co-develop strategies that cater to the unique needs of the cultural heritage sector.

Monitor and Engage with OPENAIRE:
- **Knowledge Exchange Forums:** Attend forums or roundtable discussions that OPENAIRE may host, focusing on EOSC insights and related initiatives.

- **Collaborative Publications:** Partner with OPENAIRE for joint publications, sharing findings, insights, and recommendations related to digital cultural heritage.

Other Collaboration Tools:
- **Collaborative Platforms:** Use tools like Microsoft Teams, Slack, or Trello for real-time collaboration and project management.
- **Joint Funding Proposals:** Collaborate on drafting proposals for securing funds from European bodies, ensuring projects have the financial backing they need.
- **Public Awareness Campaigns:** Join forces to run campaigns that highlight the importance of digital preservation and the initiatives undertaken. This can help in gaining public support and potentially attract more funding or resources.

In conclusion, as Europe moves decisively towards a digital future, cultural heritage managers and policy makers must ensure the continent's rich cultural history is preserved, showcased, and made accessible. For an effective collaboration between 4CH and EOSC, it's crucial that 4CH embraces a vision that emphasises the FAIR principles. By aligning with such pivotal initiatives, they can leverage the best of technology and innovation to realise these objectives.

3.2 National policies and initiatives

Policies and initiatives implemented at national level by Member States have been investigated to highlight how they are addressing the topic of digitisation in cultural heritage areas. The results of this investigation constituted the basis for the issues about data management planning addressed by this Deliverable.

A special lens, useful to understand the most recent and 'operational' strategies and policies envisioned by the single EU countries, is represented by the National Recovery and Resilience Plans (NRRPs) elaborated by Member States within the 'Recovery and Resilience Facility' (RRF)[143] - the temporary instrument at the base of the NextGenerationEU's plan.[144] Through the Facility, the EC raises funds by borrowing on the capital markets (issuing bonds on behalf of the EU) and offers large-scale financial support for ambitious reforms and investments undertaken by Member States. The aim is mitigating the social and economic impact of the Coronavirus pandemic and making EU economies more sustainable, resilient and better prepared for the challenges posed by the green and digital transitions. The EC created a useful monitoring tool – the 'Recovery and Resilience Scoreboard'[145] – assessing and informing on how the implementation of such measures and actions is progressing. The Scoreboard displays the impact of the RRF on six policy pillars (Green transition; Smart, sustainable and inclusive growth; Social and territorial cohesion; Health and

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[143] EC (2021). Recovery and Resilience Facility, https://commission.europa.eu/business-economy-euro/economic-recovery/recovery-and-resilience-facility_en.
[144] EC (2021). NextGenerationEU, https://commission.europa.eu/strategy-and-policy/eu-budget/eu-borrower-investor-relations/nextgenerationeu_en.
[145] EC (n.d.). Recovery and Resilience Scoreboard, https://ec.europa.eu/economy_finance/recovery-and-resilience-scoreboard/index.html (accessed 10 November 2023).

economic, social and institutional resilience; Digital transformation). The 'Digital transformation'[146] pillar covers reforms and investments in digital technologies, infrastructures and processes, digitisation of public services, the development of basic and advanced digital skills, measures supporting digital-related R&D and the deployment of advanced technologies. The implementation of the RRF is also monitored through a series of thematic analyses providing a summary of the policies embraced and implemented by the EC, and presenting an overview of the reforms and investments included in the Recovery and Resilience Plans of Member States (for each country the main measures implemented are highlighted). Among others, the thematic analysis include: '*Digital skills and education*'[147], covering measures related to digital skills strategies, digital upskilling in the population and workers, digitalisation of educational institutions, improvement of educational contents/resources, teaching methods, etc. allowing citizens to access digital/online services and opportunities; and '*Culture and Creative Industries*'[148], informing on reforms and investments supporting the cultural sector and its digital transition. The documents describe the measures envisaged to ensure digital transition, in particular through investments finalised at supporting the digitisation of the cultural and media sectors; the production and distribution of digital contents; digitisation of CH and major cultural services to improve accessibility; capacity building of cultural actors and operators by providing them with digital skills.

The comparative reports - even if dating back to April 2022 – supported the collection of useful data on policies in the digital cultural heritage sector, and aimed at the enhancement of digital skills and digitisation in education and training.

Additional info, with a specific focus on cultural sector, was collected thanks to the report (prepared in November 2021 and published in January 2022) developed under the coordination of the Culture Action Europe (CAE) network, informing on the countries which have explicitly foreseen interventions to support the cultural and creative sectors in their plans.[149]

By cross-referencing and integrating the information collected and published, what emerges is that a significant number of Member States have incorporated in their Recovery and Resilience Plans a range of actions supporting the cultural sector (partly including measures related to tourism) and its digital transition. Several countries have included legislative reforms and have planned investments to support the digitisation, production, accessibility and dissemination of content. Almost all Member States have planned funding linked to the development and improvement of digital skills in the population.

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[146] EC (n.d.). RRF - Digital transformation pillar, https://ec.europa.eu/economy_finance/recovery-and-resilience-scoreboard/digital.htm (accessed 10 November 2023).

[147] EC (2022). Recovery and Resilience Scoreboard, Thematic analysis: Digital skills and education, https://ec.europa.eu/economy_finance/recovery-and-resilience-scoreboard/assets/thematic_analysis/scoreboard_thematic_analysis_digital_skills.pdf.

[148] EC (2022). Recovery and Resilience Scoreboard, Thematic analysis: Culture and Creative Industries, https://ec.europa.eu/economy_finance/recovery-and-resilience-scoreboard/assets/thematic_analysis/scoreboard_thematic_analysis_culture.pdf.

[149] Culture Action Europe, the European Cultural Foundation, and Europa Nostra (2021). Culture in the EU's national recovery and resilience plans, https://digitallibrary.cultura.gov.it/wp-content/uploads/2022/01/NRRPs_analysed_digital.pdf.

In order to complete the general framework, the review of national policies concerning the digital heritage sector also included information on previous and on-going initiatives (implemented beyond the NRRPs): the data collected mainly refers to what provided by 'The Compendium of Cultural Policies & Trends' online information and monitoring platform.[150] This project, started in 1998 by the Council of Europe's (CoE) Steering Committee for Culture, collects, reviews and informs on policy standards in different areas of European national cultural policies (the historical development, present structure, financial aspects, specific sectors and on-going debates), targeting a broad audience of policy makers and administrators, arts institutions and networks, researchers and documentation professionals, journalists and students. The Compendium provides an overview of the most important aspects of each countries' cultural policy including the main objectives of the policy, governance, fundings and legislation system. The web platform allows the retrieving and the consultation of data on one or more countries, selecting comparative topics, for instance 'Digital policy and developments' (under the 'Current cultural affairs' domain).[151]

The information on the different countries does not have the same level of updating and detail, however it supported the data collection for the implementation of the general framework on digital heritage policies at national scale.

The integration of the research results collected thanks to the different sources mentioned above led to the draft of a list of measures, investments and initiatives (reported below) that can be considered as directly and indirectly relevant for the CH digitisation area and data management of digital resources, consistent with EU recommendations, and shared among different Member States.

- Development of a **national (digitisation) strategy/plan** for Cultural Heritage including recommendations, standards and guidelines.
- **Institution of cloud and software infrastructure or platform/s for digital resources; development of digital services and digital content production; use of innovative technologies (AI, big data, VR, etc.)**.
- Measures addressing **copyright framework**.
- Enhancement of **digital skills, training, education and capacity building**.
- **Increase of digitisation of cultural services, digital collections, contents, assets and resources supporting digital transition and improve accessibility to culture**.
- **Renovation, restoration, energy efficiency and removal of physical barriers of cultural heritage assets** (including museum, theatres, libraries, etc.) **and historical buildings.**[152]

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[150] The Compendium of Cultural Policies and Trends, https://www.culturalpolicies.net/ (accessed 10 November 2023).
[151] The Compendium of Cultural Policies and Trends, Compendium Country Directory, https://www.culturalpolicies.net/database/search-by-filter/ (accessed 10 November 2023).
[152] This latter category was included considering that such actions can benefit (in general) from digital technologies and services, the digitalisation of the project management process, as well as from the availability of digital documentation.

These key actions include some investments planned as part of the National Recovery and Resilience Plans, and other previous or on-going projects: more detailed information on the actions implemented by individual countries is reported in a table available as appendix 4.

> *> Insights for 4CH Data Management recommendations concerning (national) digitisation policies for cultural heritage:*

4CH's mission envisages that the future CC will be able to seamlessly work with a network of national (but also regional and local) cultural institutions, providing them with advice, support and services focused on the preservation and conservation of monuments and historic sites. Data management/planning and related aspects are certainly among the topics on which the CC will have to provide support and guidance.

The collection of updated information on national initiatives and actions could also serve as good practice for other Member States, so as to **create networks among the various countries** to share experiences and knowledge.

National nodes may bring the same type of contribution within the individual countries, **collecting information and offering an overview** of relevant services, facilities and opportunities available (e.g. standards, data storage, technical expertise, digital services, network of experts, heritage communities and public programmes, training and educational offer, dissemination events, grant and internship, etc.). The overview can be used, facilitating exchange and collaboration **between the users involved** at the various levels (regional and local), or even **mapping specific requirements**.

Experience like that of the 'The Compendium of Cultural Policies & Trends', the Scoreboard or the report by the Culture Action Europe network, constitute examples of interest for the activities of the future CC, with which it could align and contribute with a more specific focus on aspects related to the digitisation of cultural heritage (e.g. dissemination, events, training, publication of periodic thematic reports).

As well as at European level, the CC - in particular through its national nodes - will have to recommend to **cultural heritage managers** and **policy makers** the promotion of continuous updating and sharing of the measures implemented for the cultural heritage sector at national scale (e.g., documents, requirements, repositories, projects, financing initiatives, shared templates, networks, recommendations, guidelines, plans, etc.) with a particular reference to digitalisation; the alignment and integration of national measures with European policies.

In terms of specific actions (at national level) concerning **data management**, 4CH recommendations should include the **promotion of specific initiatives** (when/if not yet foreseen), such as, for instance: development of cultural heritage digitisation plans, investments and resources for the creation of repositories for long term data management, supporting digital services, recommendations to promote data management planning by institutions and projects, training, upskilling and capacity building to foster awareness on the work and practices involved

> (e.g., documentation, file naming, version control, preparation for deposit, legal, data sharing and access, etc.).

3.2.1 National Initiatives from Italy and Romania: case studies

Policies, strategies and initiatives adopted in the Digital Heritage field have been deepened for two specific case studies – represented by 4CH partners – focusing on specific topics particularly relevant for the WP5 objectives including, for instance, digitisation plans, data management planning, data repositories, and FAIR principles compliance. For each case study, a general overview of the policies/strategies implemented is presented, completed with a focus on one or more specific tools/initiatives/measures foreseen on the above-mentioned aspects. This overview allowed collecting useful insights for 4CH recommendations about how policies developed at European level are or should be applied at a national level, and pointing out the importance of taking into account the national differences that exist throughout the EU. In particular, the Italian case study has been addressed considering that the first 4CH National Node will be hosted in this country.

3.2.1.1 Italy

The cultural heritage digitisation background

The Italian commitment in the digitalisation path started in 2019 with the creation of the Central Institute for the digitisation of Cultural Heritage, named 'Digital Library'[153]: an institution with scientific, financial, organisational and accounting autonomy[154] aimed at coordinating and promoting the Cultural Heritage digitisation programs of the Ministry of Culture.

The mission of the *Digital Library* is to guide the institutions responsible for Cultural Heritage – including museums, libraries, etc. - towards digital transformation, defining the necessary reference framework within which each organisation will be able to redesign its own path of transition. The aim is to improve the management/governance of protected assets, redefine the methods of interaction with cultural heritage, and develop innovative models of value creation according to an ecosystem logic.

The main tasks of the *Digital Library,* through its own institutes, are:
- developing the 'National plan for the digitisation of cultural heritage' (ICDP) and ensure its implementation;
- coordinating and promoting digitalisation programs of the cultural heritage;
- developing the census on the state of art concerning digitisation of cultural heritage and related digital services;

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[153] Decree of the President of the Council of Ministers of 2 December 2019, n. 169, articles. 33, 35, https://www.gazzettaufficiale.it/eli/id/2020/01/21/20G00006/sg.
[154] Ministerial decree 3 February 2022, n. 46, chapter I and IV, https://www.beniculturali.it/comunicato/dm-46-03022022.

- expressing mandatory opinion on the initiatives of the Ministry of Culture regarding digitalisation, providing support to institutes for the implementation of projects for the digitalisation of cultural heritage;
- coordinating initiatives aimed at ensuring the cataloguing of cultural heritage assets;
- direct and control the main bodies of the Ministry (the Central Institute for Archives - ICAR, the Central Institute for Sound and Audiovisual Heritage - ICBSA, the Central Institute for the Catalog and Documentation - ICCD, the Central Institute for the Union Catalogue of Italian Libraries and Bibliographic Information - ICCU);
- carrying out activities of study, research, technical coordination, consultancy, promotion and training in the methods of knowledge, cataloguing and digitalisation of cultural heritage;
- managing national information systems and offering services for the enhancement of cultural heritage and the dissemination of knowledge.

Another aspect to mention concerning Italian national policies - strictly connected with digital transformation in the Cultural Heritage and the digital humanities fields - is represented by digital competences and skills. One of the institutions that deals with this challenge - created in 2021 - is the 'School of Cultural Heritage and Activities Foundation' (Fondazione Scuola Beni Attività Culturali): an international and non-profit institute for training, research and advanced studies within the competences of the Ministry of Culture (that is founding member).[155]

The Italian National Plan for the Digitisation of Cultural Heritage (ICPD) - 2022-2026
The tasks of the Digital Library include developing the 'National Plan for the digitisation of Cultural Heritage' (ICPD).[156] The plan defines the basis of the National Plan for the Digitisation of Cultural Heritage 2022–2023 strategy of the Italian Ministry of Culture in the digital transformation process for the five-year period 2022-2026, based on the concept of a cultural ecosystem which involves institutions, cultural operators and cultural and creative industries.
The ICPD represents both the methodological and operational reference for implementing the actions linked to the investment 'Digital strategy and platforms for cultural heritage' - foreseen in the Italian National Recovery and Resilience Plan (NRRP)[157] – which includes digitisation activities and projects in museums, archives, libraries and places of culture, as well as the creation of a national digital infrastructure to collect, integrate and preserve digital resources.

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[155] Fondazione Scuola Beni Attività Culturali, https://www.fondazionescuolapatrimonio.it/ (accessed 10 November 2023).
[156] National Plan for the Digitisation of Cultural Heritage 2022–2026. https://docs.italia.it/italia/icdp/icdp-pnd-docs/it/v1.0-giugno-2022/index.html. See also the Executive Summary in EN, https://digitallibrary.cultura.gov.it/wp-content/uploads/2023/06/PND-Executive-Summary-ENG.pdf.
[157] National Recovery and Resilience Plan, Mission 1 - Digitalisation, innovation, competitiveness, culture and tourism; Component C3: culture and tourism, https://www.governo.it/sites/governo.it/files/PNRR.pdf (accessed 10 November 2023).

The ICPD as a unique programmatic document is divided into three main sections that provide the vision[158], the strategy[159] and guidelines for digitisation processes (divided into five main technical-operational annexes[160]), completed by more general information on objectives, end-users, background, structure of the document, key words, bibliography and essential regulatory references.

Documents can be consulted and downloaded from the official web pages of the *Digital Library* Institute, from the open government platform for accessing the digital documents of the Public Administration *Docs Italia*, and from GitHub: a condition favouring a major involvement in the democratisation process of knowledge on the activities of cultural heritage digitisation.[161]

In addition to this, the drafting of the national digitisation plan and the guidelines was carried out through a public participatory process - divided into four main phases of publication of the plan, public consultation, consultation of the stakeholders, launch of the technical tables (April 2021 - June 2022) - involving various subjects/stakeholders both internal and external to the Ministry of Culture. The participants contributed to outlining a theoretical and methodological framework on which to base the strategic vision and provide operational tools. The objective was to facilitate the creation of a cultural, technical and scientific context necessary for the implementation of digital transformation from an ecosystem perspective.[162]

The Guidelines for the digitisation of Cultural Heritage certainly represent a crucial component of the plan: they indicate and suggest useful methodologies and procedures for addressing the challenges related to the implementation of digitisation processes, provide informative and non-prescriptive references, and outline a technical and methodological and bibliographic framework. Each of the five technical-methodological documents, to be kept by the ICDP periodically updated in terms of regulations, methods, standards and technological progress, focuses on a specific aspect of digitalisation practices.

The paperworks include, in particular:

1. **digitisation guidelines**: they define the approaches and procedures for the creation, documenting and archiving of digital objects. The document provides a methodological and technical basis to the staff who follow the planning and management of digitisation projects in cultural institutes.

2. **Guidelines for drafting the Data Management Plan** (DMP): they aim to define the path to build the DMP that specifies how to describe, analyse, archive, share and preserve the data coming from cultural heritage digitisation projects and existing databases.

3. **Guidelines for the acquisition, circulation and reuse of digital reproductions**: they clarify the rules governing the acquisition, circulation and reuse of reproductions of cultural assets

[158] Italian National Plan for the Digitisation of Cultural Heritage (ICPD) 2022–2023: the vision, https://digitallibrary.cultura.gov.it/visione/.

[159] ICPD: the strategy, https://digitallibrary.cultura.gov.it/strategia/ (accessed 10 November 2023).

[160] ICPD:guidelines, https://digitallibrary.cultura.gov.it/linee-guida/ (accessed 10 November 2023).

[161] Marras (2022). *Le associazioni MAB e il Piano nazionale di digitalizzazione*, Biblioteche oggi 40(8), https://doi.org//10.3302/0392-8586-202208-004-1.

[162] Digital Library, *National Plan for the Digitisation of Cultural Heritage: the participation process*, https://digitallibrary.cultura.gov.it/il-processo/ (accessed 10 November 2023).

in the digital environment. The document frames the reference regulatory context, providing operational tools.

4. **Guidelines for the classification of digital products and services**: they identify and describe the different taxonomies and mappings of processes, and services mentioned in the National Plan for the Digitisation of Cultural Heritage, starting from the different types of cultural heritage and their valorisation potential.

5. **Introduction to the methodology for digital maturity assessment**: the document guides the ability to analyse the initial level of digital maturity, understood as a fundamental opportunity for a cultural institute, and knowledge base on which to base the entire digital transformation project.

The guidelines are primarily aimed at personnel from cultural institutions directly involved in digital transformation processes, providing a multi-level operational framework for decision-making, strategic support, planning, and execution.

A focus on ICDP Guidelines for drafting the Data Management Plan
Considering the objectives and focus of this deliverable, special attention was paid to the operational-technical document related to the Data Management Planning.

The ICDP recognizes the value of planning the management of digitisation projects and databases, taking into consideration all phases of the process, as well as the awareness that such data in itself represents an 'heritage asset' to be 'managed' and preserved in the long term.

The DMP as a tool contributes to this objective by documenting how data is created, collected, managed, stored, and exploited as part of a data management or digitisation project. The purpose of planning the management of data and digital objects is to guarantee their 'safety' in the various phases - from production, to archiving/conservation and/or publication/sharing - and to describe the technologies, methodologies and methods used in the definition and creation of the digital project. This approach applies to the different types of data produced by the activity of cultural institutes: data coming from new or previous digitisation actions of cultural heritage, research products, and various kinds of digital documents.

The Guidelines were drafted starting from a previous guidance document, the 'National guidelines for the valorisation of public information assets'[163] developed by the Agency for Digital Italy (AgID).[164]

The document, in its preliminary published version, aims to introduce the data management methodology, supporting its concrete field experimentation. The ICDP will keep the document updated and will define, in a next phase, the operational tools necessary to make the compilation of the DMP a systematic method for the presentation and completion of digitisation projects.

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[163] AgID, *National Guidelines for the Enhancement of Public Information Assets*, https://www.dati.gov.it/linee-guida-valorizzazione-patrimonio-informativo-pubblico (accessed November 10, 2023).
[164] Agency for Digital Italy (https://www.agid.gov.it/) is the national technical agency of the Presidency of the Council of Ministers (Italy) which has the task of guaranteeing the achievement of the objectives of the *Italian Digital Agenda by the* Italian Minister for Public Administration (*https://www.funzionepubblica.gov.it/digitalizzazione/agenda-digitale*), and contributing to the diffusion of the use of information and communication technologies, promoting innovation and economic growth.

The Guidelines are introduced by a section that briefly illustrates the main objectives of a DMP followed by the explanation of the role of the DMP in the National digitisation Plan, in particular clarifying the levels of institutional governance in data management: policy definition (Digital Library), collection and data curation (central institutes of the Ministry), production, management and valorisation of data (peripheral institutes of the Ministry). The availability of various templates is mentioned in the document, and it is clarified that the one proposed represents just one of the possible ways of formalising the necessary information. The model, following an experimentation phase, will be later implemented in a web tool available to the Italian National Institutes.

The main sections of the document reflect the process to follow:

1. **Definition of a clear internal data governance** with the identification of roles and responsibilities, which takes into account consolidated processes and needs of the various offices involved.
2. **Preliminary activities** to **obtain the necessary information** for the compilation of the DMP: data census, legal analysis of the sources, analysis of access and licensing policies, conservation and historicization system.
3. **Structure of the proposed Data Management Plan,** divided into: an institute sheet (which contains general information relating to the organisational aspects of the institute and the levels of responsibility), and one or more 'project sheets' (which contain the information details relating to each specific project).

   Concerning this last point, the **project sheet template**[165] proposed - with the function of describing all aspects of the project (administrative, types of data and metadata, respect quality requirements, accessibility, reuse, conservation, safety, etc.) - is divided into the following sections which detail the different steps (Fig. 3.1):

   - **'Administrative information'** section: describes the project, the people and offices who are responsible for data management.
   - **'Data' section**: describes the types and formats of the data produced, collected and stored within the project.
   - **'Metadata' section**: describes the standards and schemes of metadata referenced by the project and the formats in which they are represented.
   - **'Data quality and documentation' section**: describes the measures which must be followed in order to ensure the quality of the data and metadata relating to them.
   - **'Open data and FAIR principles' section**: describes the measures taken to ensure the accessibility and reuse of data.
   - **'Ethical and legal aspects' section**: describes the resulting ethical aspects from the project and how they are addressed.

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[165] ICDP Project Sheet Template, https://github.com/icdp-digital-library/allegati-pnd/blob/main/piano_gestione_dati/Scheda%20Progetto_griglia_da_compilare.pdf (accessed 10 November 2023). The main sections of the project sheet, although clustered in a different way, match with the ones of the tool developed by ARIADNE Plus https://vast-lab.org/dmp/index.html : Data Summary; FAIR Data (Making data Findable; Ensuring data is openly accessible; Promoting data interoperability; Enhancing data reusability); Allocation of resources; Data security; Ethical aspects.

- **'Data archiving and preservation' section**: describes the measures taken to archive and preserve data.
- **'Data Security' section**: describes the measures taken to ensure data security and protection of personal data.

Some detailed and operational indications are also provided for each section of the sheet project.
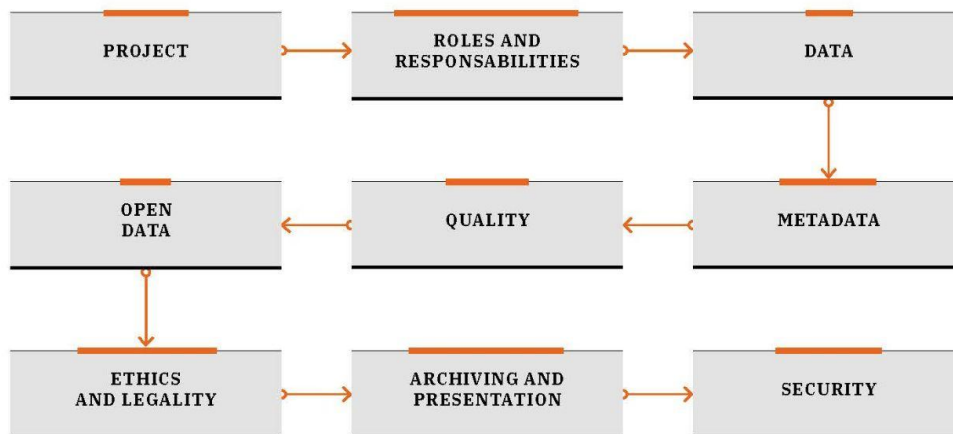
Figure 3.1. Synthesis of sections constituting Data Management Plan (source: ICPD 2022-2023, Executive summary document, p. 12).

4. **Available tools for compilation of the DMP**, in particular: an editable PDF data management plan grid to support the compilation of the digitisation projects, an example of a DMP compiled to describe the Management Plan of data from two specific projects. The above-mentioned tools will be replaced by a semi-automatic system in a next phase of ICDP implementation.

5. **Relevant legislation** for the drafting of the DMP, which includes: Italian and European[166] regulatory references, and other national guidelines.[167]

6. **Annex - FAQs on open data,** accompanying the document, which can be used to structure the publication of data. In particular, it provides support in choosing the licence for the data of an open type, in the analysis of any cost aspects of the data and in their publication in portals for greater standardisation of this process.

> *Insights from the Italian case-study for 4CH Data Management recommendations concerning (national) digitisation initiatives for cultural heritage:*

The future CC will have to be **updated on the measures implemented for the cultural heritage sector at national scale**, in order to **collaborate in consolidating relevant aspects** consistent with policies at European level, and to **recommend the alignment with such policies**, and or **broadening the national perspective**.

The **Italian case study** presents useful insights for 4CH recommendations to **cultural heritage managers, policy makers (but also DMP users and cultural heritage practitioners as final beneficiaries)** on policies at national level, in particular for the following aspects:

- The presence of a **public institute** with scientific, financial, organisational and accounting autonomy connected to the Ministry of Culture, with the **task of coordinating activities in the field of digitisation** of Cultural Heritage (the *Digital Library*).
- The development of a **national digitalisation strategy** - based on an ecosystem concept, considering the different actors involved in the process - that provides guidance both at a **methodological (vision and strategy) and operational (guidelines) leve**l.

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[166] In particular EU regulations mentioned are: COMMISSION REGULATION (EC) No 1205/2008 of 3 December 2008 implementing Directive 2007/2/EC of the European Parliament and of the Council as regards metadata; COMMISSION REGULATION (EU) No 1089/2010 of 23 November 2010 implementing Directive 2007/2/EC of the European Parliament and of the Council as regards interoperability of spatial data sets and services; REGULATION (EU) 2016/679 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 27 April 2016 on the protection of natural persons with regard to the processing of personal data and on the free movement of such data, and repealing Directive 95/46/EC (General Data Protection Regulation); DIRECTIVE (EU) 2019/1024 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 20 June 2019 on open data and the re-use of public sector information (recast); COMMISSION IMPLEMENTING DECISION (EU) 2019/1372 of 19 August 2019 implementing Directive 2007/2/EC of the European Parliament and of the Council as regards monitoring and reporting; COMMISSION NOTICEGuidelines on recommended standard licences, datasets and charging for the reuse of documents(2014/C 240/01); COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS A European strategy for data COM(2020) 19.2.2020 ; Council conclusions of 21 May 2014 on cultural heritage as a strategic resource for a sustainable Europe(2014/C 183/08); COMMISSION RECOMMENDATION (EU) 2021/1970 of 10 November 2021 on a common European data space for cultural heritage.

[167] ICDP (2022). Guidelines for drafting the Data Management Plan, *List of Regulatory references*, https://docs.italia.it/italia/icdp/icdp-pnd-dmp-docs/it/v1.0-giugno-2022/normativa-di-riferimento.html.

- Guidelines are mainly aimed at **cultural institution staff** directly involved in digital transformation processes, but also at providing a multi-level operational framework for **decision-making, planning and execution support**.
- The inclusion in the general plan/strategy of **specific guidelines** on the DMP (thus underlining its importance), which cover various aspects and provide, in particular, a recommended template - with the aim of transforming it into a tool that could facilitate its use.

3.2.1.2 Romania

Evolution of cultural heritage digitisation practices and policies in Romania

The current practices in the digital heritage domain in Romania are based, as expected, on international policies and guidelines, but they are also highly relying on the results and experiences of previous digitisation projects conducted locally on several occasions over time. The lack of a coherent national digital strategy for cultural heritage that imposed a data management plan, has led to a rather heterogeneous situation of the digitised cultural heritage assets. More recent projects and initiatives, such as the *E-cultura: Digital library of Romania*[168] project, and the National strategy for the protection of historical monuments formulated between 2022-2032, offered recommendations for data management and named the institutions that should be responsible for the official administration and coordination - INP holding a key-role among them.

Romania was amongst the first countries to implement an official policy of computerised evidence and management of cultural heritage, starting with a digital cultural centre established in 1978, placed under the subordination of the National Museum of History of Romania, to digitise the national cultural patrimony. A few years later, in 1981, this centre was transformed into the Computing Centre for Culture, subordinated to the communist Ministry of Culture, called the Council of Culture and Socialist Education. The purpose of its activity remained the same: the design and management of databases as tools for the documentation and computerised records of cultural heritage.

After the fall of the communist regime, in 1991, this Computing Centre was transformed into CIMEC (Centre for Informatics, Memory and Cultural Synthesis), an extra-budgetary public institution with legal personality, directly subordinated to the Ministry of Culture. A new change of status occurred in 1998, when CIMEC became the Institute for Cultural Memory.

In 2011 CIMEC was transformed as a directorate within the newly established National Institute of Heritage (INP), where it continues its mission, although with a reduced staff.

Beginning with the 2000s, The Ministry of Culture has enacted several laws regulating the obligations to record cultural artefacts and monuments. The most important legal acts that were issued during this period are:

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[168] E-cultura project, https://www.umpcultura.ro/e-cultura.

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- the Government Ordinance 43/2000 on the protection of the archaeological heritage[169], which stipulates that CIMEC is to be the administrator of the databases for the digital inventory of the archaeological heritage;
- Law no. 182 of October 25, 2000, on the protection of the movable national cultural heritage[170], establishing a digital repository of the movable heritage;
- Law no. 422 of the 18th of July 2001 on the protection of historical monuments.[171]

The emergence of a national digitisation strategy in Romania in 2015 (Digital Agenda for Romania 2020[172]) represented the premise for the realisation, by the Ministry of Culture together with a team from INP, of a project financed by Cohesion Fund, the *E-cultura project. The Digital Library of Romania*. This project had two major objectives: 1. the development of the IT platform for the shared catalogue and for the digital library portal. It will manage the database containing the metadata of the cultural resources, including resources not exposed online yet). 2. The online exposure of over 550,000 cultural resources (texts, images, audiograms, videograms, 3D digital objects), of which about 200,000 are to be exhibited also in Europeana. At the end of the project, the number of culture heritage objects digitised was over 700,000.
Every action related to digitising cultural heritage stemmed from the intention to contribute to its preservation. Additionally, there was a desire for the resources held by different institutions to be accessible to the general public free of charge.
After the E-cultura project concluded, the National digitisation Centre was established as a unit within the National Institute of Heritage. This centre will carry on the project's initiatives, including the upkeep of the *culturalia.ro* platform and the ongoing digitisation of cultural resources.

National strategy for the protection of historical monuments 2022-2032
In Romania, there is a strategy, still awaiting to be adopted, for the preservation of monuments, which outlines directions for integrated and sustainable data management of monuments and historical heritage[173].
The National Strategy for the Protection of Historical Monuments 2022-2032, conducted last year, outlines several action-oriented directions for establishing integrated databases that incorporate digital information on historical monuments. This initiative is deemed necessary in response to identified deficiencies in presenting monument information to the public, including:
- limitations,

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[169] ORDONANŢA nr. 43 din 30 ianuarie 2000 privind protecţia patrimoniului arheologic şi declararea unor situri arheologice ca zone de interes naţional, https://cimec.ro/legislatie/Og43-2000-Republicare-2007-04-25.pdf.

[170] LEGE nr. 182 din 25 octombrie 2000 privind protejarea patrimoniului cultural naţional mobil, Monitorul Oficial nr. 259 din 9 aprilie 2014, https://cimec.ro/Legislatie/L-182-2000-Patrimoniu-mobil-republicata-2014.pdf.

[171] LEGEA nr. 422 din 18 iulie 2001 privind protejarea monumentelor istorice, Monitorul Oficial nr. 938 din 20 noiembrie 2006, https://cimec.ro/Resurse/Legislatie/Legea-422-2001-republicata-2006.pdf.

[172] Strategia Naţională privind Agenda Digitală pentru România 2020, https://epale.ec.europa.eu/sites/default/files/strategia-nationala-agenda-digitala-pentru-romania-20202c-20-feb.2015.pdf.

[173] Strategia naţională privind protejarea monumentelor istorice, http://www.cultura.ro/prelungire-termen-strategia-nationala-privind-protejarea-monumentelor-istorice (accessed September 2023).

- fragmentation,
- difficult access,
- outdated information.
- a low level of digitisation,
- lack of interoperability,
- inefficient information collection,
- lack of coordination among institutions and bodies responsible for this domain.

These issues have caused delays in the processes of identifying, locating, and clearly defining the boundaries of monuments within a particular area or region.

Moreover, these issues result in a lack of knowledge about property regimes and owners, delays in updating cadastral documentation, as well as in recording the historical monument status in the land register. Additionally, there is low accessibility to public and private archives containing information and resources related to historical monuments.

The expected results of this strategy are the up-to-date knowledge of the situation of historical monuments, in order to make informed decisions, as well as achieving digitisation, accessibility, and interoperability of data. The strategy also insists on the continuous enhancement of knowledge pertaining to historical monuments. The FAIR principles are reflected in this strategy.

Among the key concepts, the basis of this strategy includes digitisation and open data in the protection of cultural heritage. In addition to this, the first General Objective of the Strategy is the Integrated and sustainable management of data on historical monuments and immovable cultural heritage.

The strategy insists on the creation of a national, integrated database of national heritage, a centralised IT system that is accessible to the public. This system should identify and use available local and national databases that include relevant information on historical monuments and immovable cultural heritage and integrate them into the centralised IT system. A methodological guide and a general interdisciplinary thesaurus of terms will be produced as supporting tools of this action.

Several action points support the principle of reuse:
- realisation and implementation of a data mining system to make data accessible for inventory, record keeping, monitoring and management of heritage;
- expanding and updating the public mode of the centralised IT system to allow access to all interested groups to the different categories of public information.

It is considered the collection of data through a multi-year program that would identify the interested groups and that would result in the inventory of the monuments and of the archaeological sites likely to be classified, proposed through General Urban Plans, as well as to identify the objectives likely to be included in the UNESCO Indicative List.

All these programs would be managed by strengthening the capacities of the county directorates for culture and the INP, but also by collaborating with universities and civil society.

digitisation and integrated management of archives containing information about monuments is another direction of action, which initially involves the identification of relevant institutions and funding bodies and the establishment of collaborative procedures. This action will be followed by

the creation of an inventory of relevant document categories, which includes the degree of digitisation of these documents and the interconnection of all public or private digital archives.

Special attention is also paid to the centralization and digitisation of the studies that were the basis for the classification of historical monuments, as well as the substantiation studies of urban planning documentation and interventions on historical monuments. A digital archive of these documents is being considered.

Data management for the National Archaeological Repertory (RAN) created by INP

In Romania, there is no nationally adopted policy that establishes a Data Management Plan. As a result, INP, an institution with a legal obligation to ensure the research and documentation of cultural heritage, had to develop and enforce its own practices for digitisation with the aim of managing, preserving, and disseminating various heritage and research data and metadata.

Legislation introduced in 2000-2001 explicitly designates the National Archaeological Repertory and the List of Historical Monuments, two crucial tools for documenting archaeological and monumental heritage in Romania, to function as digital repositories.

Thus, the National Archaeological Repertory (RAN) was established as far back as 2000 as a database intended to manage the recording of archaeological sites through the registration of metadata extracted from various specific sources: research reports, archives, maps, images, measurements, specialised literature, etc.

Unfortunately, the legislation governing the operation of the RAN did not require professional archaeologists to transmit this data to INP, which had to obtain it on its own. It was only in 2022 that the legislation regulating archaeological research in Romania was amended to require institutions conducting archaeological research to send their research reports to INP to support the updating of the RAN. However, there is currently no specific regulation for safeguarding the entirety of the data produced through archaeological research that remain in the custody of researchers, stakeholders or beneficiaries without specifying a particular form of curation.

To at least save a portion of the data produced by archaeologists, both for preservation and to update and enrich the RAN, INP initiated the retrieval of archaeological research reports and archaeological studies conducted for general urban development plans.

These reports are being digitised and will be indexed in a database. Currently, several digitisation projects are underway for the archives of archaeological reports held by county cultural directorates, which are institutions under the Ministry of Culture that authorise archaeological research.

All information and data obtained directly from specialists or from archives, literature etc. are stored in INP's local servers secured by back-ups. Unfortunately, the reduced budget of the institution does not currently allow other more sophisticated solutions, such as Cloud computing services or back-ups on servers placed in other geographical locations that could protect data in case of any disasters.

Concerning the copyright issues for the data found in RAN, they are protected by the CC BY-NC 2.0 licence, meaning that everyone can copy and redistribute the material in any medium or format, also to remix, transform, and build upon the material. The conditions are to give appropriate credit, provide a link to the licence, and indicate if changes were made. The material cannot be used for commercial purposes.

As a result of Directive No. 1024/2019[174] on open data and the reuse of public sector information, INP has begun preparing a request to the Ministry of Culture to create a legal framework for the centralization and digital archiving of all data generated through archaeological research in a public repository managed by INP.

A similar situation exists for the List of Historical Monuments, which was established as a repository based on data created through activities related to the documentation and restoration of historical monuments. Although the law states as mandatory the transmission of this data to INP for the purpose of updating the List of Historical Monuments and creating an inventory of historical monuments, this has not been effectively implemented. As a result, these data have not been centralised and archived and are only preserved in the archives of the authorising institutions, without being accessible to the public.

> **> *Insights from the Romanian case-study for 4CH Data Management recommendations concerning (national) digitisation initiatives for cultural heritage***

Romania's case can be useful in order to comprehend thoroughly the actual needs of a country that has yet to work on its official digital strategy for cultural heritage assets. The existent situation in such countries can introduce a different perspective on the issues that need to be addressed by an international CC such as 4CH.

The Romanian case presented here can provide insights on issues such as:

- The way the legislation is needed to impose digitisation and digital archiving of the cultural heritage, in particular the archaeological heritage.
- The way the European funds and the European regulations boosted the digitisation of archives and cultural resources.
- The need to strengthen the cultural institutions that contribute to the digitisation of cultural heritage.
- The attention that needs to be paid to the training of culture managers so that they acquire digital skills.
- The need to ensure adequate storage space for data retention.

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[174] DIRECTIVA (UE) 2019/1024 A PARLAMENTULUI EUROPEAN ȘI A CONSILIULUI din 20 iunie 2019 privind datele deschise și reutilizarea informațiilor din sectorul public
https://eur-lex.europa.eu/legal-content/RO/TXT/PDF/?uri=CELEX:32019L1024&from=EN.

4. Data management as a 4CH service

The 4CH project has developed tools and services that have the intention to become part of the CC. Examples are the 4CH Knowledge Base (KB), the Cultural Heritage Cloud and the 4CH platform. The design and development of targeted training is also an example of a 4CH service.[175] All services have a pilot or prototype status and require management and maintenance for the long term. In this chapter we focus on the 4CH Knowledge Base (KB) with respect to its potential role to support data management tools and services.

4.1 Workflow for Knowledge Base Data Management

4CH relevant data, either generated through the project or acquired from other sources, are maintained and managed centrally at the 4CH Knowledge Base (KB). The KB forms a semantic graph that enables the indexing, organisation, integration and publication of data in an efficient manner ensuring its findability, accessibility, interoperability and reusability. More precisely, the KB is designed to accept, ingest and integrate descriptive metadata of content relevant to the Competence Centre, providing a single access point for information retrieval. Resources contained within it are expected to be of different types and complexity. An indicative, but non-exhaustive, list of resource types that content providers may submit to the KB includes scientific texts, 3D models, historical maps and drawings, restoration techniques, earth and environment data, geographic systems, databases, software, multimedia, standards and models, services, training material.

Access to the KB for data ingestion and population, that result in the data management organisation of a knowledge graph, is described in Figure 4.1 as a specialised workflow of the abstract model introduced in D4.2. This is in line with the workflows developed in WP4 that express the rules to access services of the CC (see *D4.2 Report on service deployment and training*). The workflow describes the sequence of actions required to be performed by a content provider that requests remote access to the online service of data ingestion to the KB without charging fees.

The workflow specialisation is expressed as a UML[176] activity diagram with three swimlanes. These distinguish the actions required to be performed by the content provider, the CC in an automatic way, and the CC interactively. Within the abstract model introduced in D4.2, the action describing the *use of service* is highlighted due to its complexity: it constitutes a complex action requiring a service-specific workflow to describe it in detail. This becomes evident when also considering the complexity of the services offered by 4CH, namely the management of the KB, digitisation and 3D modelling technique finder, monitoring services for environmental risks, microservices for assisted metadata generation, for text processing, for macro-XRF analysis etc. In the specialisation illustrated in Figure 4.1, where we deal with the specific service of KB data management, this

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[175] See Orlandi et al. (2023), D4.2.

[176] UML stands for Unified Modeling Language, it is a way to visually represent systems. See for example https://en.wikipedia.org/wiki/Unified_Modeling_Language (accessed 24 October 2023).

complex action is expanded according to the detailed steps required to be followed (highlighted in purple background).
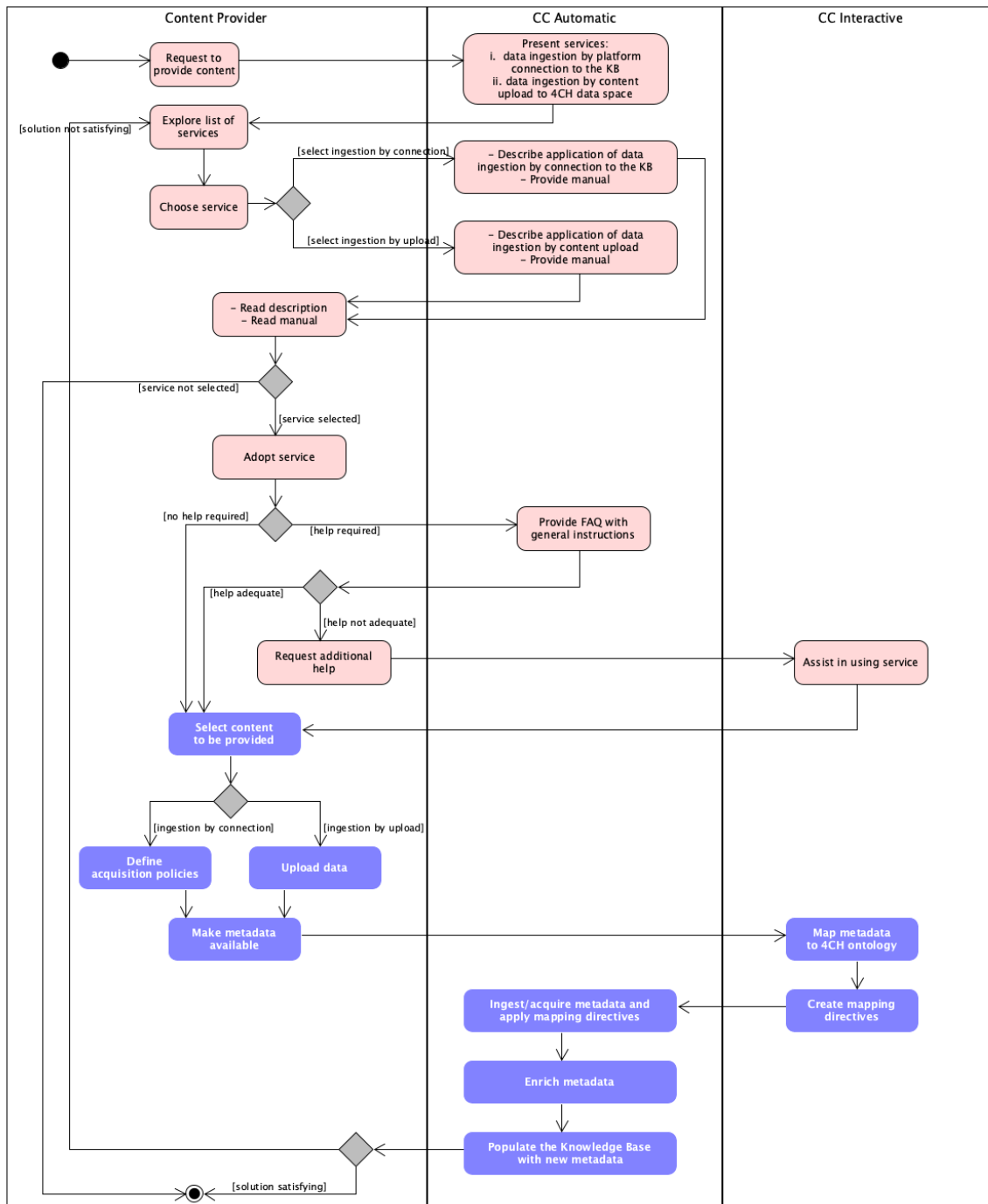

Figure 4.1 Specialised workflow for KB Data Management. CC = competence centre, here referring to 4CH.

5. Summary of recommendations and 4CH solutions

This chapter contains a summary of the recommendations and guidelines for the management of data objects that are created and (re)used in relation to the activities of the CC (and beyond). The aim of these recommendations and guidelines is to keep data objects usable for the long term taking into account a wide range of issues, such as the selection and provision of data objects for "designated communities", the alignment of data management policies with relevant national and international initiatives, the tools and services that help to make the data objects FAIR, and the role of a DMP to provide guidance for users of the tools and services of the CC. Implementing the recommendations and guidelines requires support, for example by being able to call on data stewards and data management services such as repository services.

The recommendations are classified according to a number of user groups as distinguished in the 4CH project. A distinction is made between 3 user groups.

- Cultural Heritage **Practitioner** applying data management procedures, creator, user and depositor of data.
- Cultural Heritage **Policy maker**, decision-maker and national public bodies (i.e. ministries) promoting policies and strategies for conservation, preservation and digitisation, with the knowledge of which networks and initiatives should be joined to ensure optimal data management.
- Cultural Heritage **Manager,** public and/or private heritage institutions responsible for managing monuments and sites, ensuring the implementation of sound and FAIR data management practices.

5.1 Recommendations for practitioners

For **practitioners,** national and international strategies, policies and initiatives for cultural heritage are not of primary importance. Their activities build upon the policies and provide them with a context of practical tools and services. The FAIR principles, however, as covered in chapter 2 of this deliverable provide relevant recommendations and guidelines that are summarised here.

- Create a DMP based on a template that addresses the FAIR principles. It is recommended to use a DMP template (if available) that aligns with the common practice of a similar project. Use an online DMP tool to create and maintain the DMP. Apply the guidelines provided in Table 2.1 and consult the list of actions to make data FAIR, such as use standards and use services that mint PIDs for a wide range of objects.
- Follow the PARTHENOS and section 2.2.1-2.2.4 general guidelines on how to make your data FAIR (see sections 2.2.1 to 2.2.5).

Recommendations on where to store your data for long-term preservation (see section 2.3):

- Deposit your data in a 'Trustworthy' digital data repository.
- Ideally, use a domain-specific (i.e., cultural heritage or archaeology-focused) repository that provides services for a "designated community" such as domain specific metadata and licence services. As an alternative, institutional or generic repositories can be used, and/or you can find a repository on re3data.org.

Recommendations on what to store for reusability (see section 2.4):

- Consider the (future) audience: for research you need different, generally more, than for visualisation or 3D printing. For 3D data good guidance for different levels of users is available in Moore et al.[177]
- Consider what you need to preserve for the long-term already during data creation and data processing, as it will not be possible to produce the relevant paradata and metadata afterwards.
- As a minimum, store for the long-term any (raw) data and/or processed files (e.g., the original photographs and point cloud) as well as metadata and paradata (e.g., the instrument settings or environmental conditions) that are needed to reproduce the final result (e.g., the 3D model).
  - Metadata and paradata can, depending on the file type, be embedded or added as a separate file (or both, see section 2.4.2).
- If at all possible, keep, and make available, the raw data. If this is in a proprietary format, include a conversion into a non-proprietary format (see section 2.4.2).
- At least for long-term storage, use file formats that are frequently used, have open specifications, and are independent of specific software (preferred file formats).
- If converting from a proprietary to a non-proprietary format, check if all information is retained; if not, archive both formats (if possible).

Recommendations on metadata, metadata schemas, and vocabularies (see section 2.5):

- Apply an existing cultural heritage-specific metadata schema to document your metadata; preferably use a repository that allows you to add these metadata to your dataset, but if not possible, make sure to add the metadata recommended by the schema yourself (e.g., as a CSV or XML file, see section 2.5.2).
- Use rich metadata containing information on the project, the cultural heritage object, the provenance and access rights
- Use a relevant, standard metadata schema
- Clearly document your metadata and paradata in your files and as structured data in READ-ME files, CSV files, spreadsheets or similar open format.
- Use generic as well as cultural heritage-specific controlled vocabularies and thesauri to capture your metadata and data content.

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[177] Moore et al. (2022). 3D data creation to curation, pp. 35-36.

Recommendations on rights and licences (see section 2.6):
- Familiarise yourself with relevant copyright law and make sure you have got the rights to share the data.
- Always make clear under what licence (or other terms) your digital dataset can be used and reused.
- Choose one of the 14 recommended rights statements (see Table 2.4), because they are generally known and understood and are machine readable. Use a licence as open as possible, to enable reuse.

5.2 Recommendations for policy makers

Recommendations for cultural heritage **policy makers** in relation to European and National Digitisation strategies, policies and initiatives for cultural heritage:

- Align activities with existing European and National Cultural Heritage digitisation policies and data management initiatives: always be updated and report on such policies in order to work/move in synergy with their recommendations, and to coordinate ambitions in relation to the "ecosystem" of which you are part of, and the role you play (or can potentially play) in the process of digitising cultural heritage.
- Strengthen (at European and national level) the cross-disciplinary coordination among the main actors involved - institutions, network of experts, researchers, heritage communities, etc. - through standards, guidelines, recommendations, and other joint facilities that facilitate exchange and collaboration.
- Promote and support (at national level) the implementation of Cultural Heritage digitisation strategy and plans, initiatives, funding opportunities, and campaigns for conservation, preservation and valorisation of CH assets through digitisation.
- Support (at national level) the improvement of digital skills and expertise in practitioners directly involved in the digitisation process (e.g. through educational activities, training, dissemination, etc.).
- Promote the integration between the main digitalisation policies at European level with other initiatives (e.g., the European Green Deal and the New European Bauhaus), supported by relevant association/institutions/networks (e.g., Europeana, UNESCO, ICOMOS, Europa Nostra, etc.), fostering the implementation of actions in the cultural heritage domain which pursue/address further objectives/challenges - for instance, the achievement of the Sustainable Development Goals.

With respect to FAIR data management recommendations for **policy makers** the main data management recommendations are:

- Encourage and promote the application of open data principles in cultural heritage data initiatives, by requiring a DMP that supports the FAIR data principles and linking it to project funding requirements.
- Encourage and promote services that support the uptake of FAIR data management, e.g. by defining policies that stimulate the appointment of data stewards and strengthen the position of trustworthy repositories.

5.3 Recommendations for managers

Recommendations for **managers of cultural heritage repositories** in relation to facilitating and conducting FAIR data management:

- At a minimum, your repository should:
  - allow for rich and indexed **metadata** with community-accepted controlled vocabularies;
  - use **open protocols and standards**;
  - assign **Persistent Identifiers** (PIDs) to each dataset.
  - **Curate** the data for long-term sustainability (see section 2.3).
- Make sure you meet the requirements of being a 'Trustworthy' digital repository (see section 2.3).
- Certify your services, e.g. by attaining a CoreTrustSeal (see section 2.3 and appendix 2).
- Provide guidelines on what to store for optimal reusability (see section 2.4.1).
- Regarding file formats:
  - Clearly communicate what these preferred file formats are for the relevant data type(s) and offer guidance (and if possible assistance) in conversion as well as on potential (meta)data loss.
  - Realise that it is not always possible to have a preferred file format. Express a clear file format policy which steers practitioners to the use of preferred formats. If original data are submitted in other formats and cannot be converted, we recommend accepting this format to ensure completeness of the datasets.
  - Conversions from one format to another may result in loss of functionality or other aspects of the data. This is especially true for 3D data formats. If conversions are deposited or provided by the repository, if possible also archive the original data.
  - Have your policies on file formats informed by input from practitioners, as they know which software and which formats they are using and why. Workshops and conferences are ideal platforms to engage with practitioners.
- Regarding **metadata and metadata schemas**:
  - Offer besides generic metadata standards, also domain-specific standards (see section 2.5, especially 2.5.1).
  - Encourage depositors to add rich metadata and support them in doing so.

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- Encourage depositors to add tabular file formats or READ-ME files specifying their metadata and paradata and support them in doing so.
- Besides generic metadata schema and their relevant vocabularies, supply **cultural heritage-specific controlled vocabularies for the metadata** fields (see section 2.5.3).
- Enable the use of the 14 **rights statements** (for data; add others for, for example, software). Recommend the use of open licences where possible.

Recommendations for cultural heritage **managers** in relation to European and National Digitisation strategies, policies and initiatives for cultural heritage:

- Consider to cooperate and join existing European Initiatives (For further details see paragraph 3.1.2), in particular:
  - Engage with the European Open Science Cloud (EOSC);
  - Participate in the European Data Space for Cultural Heritage;
  - Leverage the Europeana Platform;
  - Collaborate with the Europeana Network Association (ENA) and the Europeana Aggregators' Forum (EAF);
  - Align with the Strategic Research and innovation Agenda (SRIA) and Multi-Annual Roadmap (MAR);
  - Monitor and Engage with OPENAIRE;
  - Exploit benefits from other collaboration tools (Collaborative Platforms, Joint Funding Proposals, Public Awareness Campaigns).

- Foster (at national level) the development and the use - highlighting the benefits - of services and tools supporting digitisation process, in particular: Data Management Planning and the related aspects; investments and resources for the creation of repositories for longer term data management; digital services; recommendations for data management planning by institutions and projects; training; upskilling and capacity building to foster awareness on the work and practices involved (e.g., documentation, file naming, version control, preparation for deposit, legal, data sharing and access, etc.).

- Explore, inform and promote (at European and national level) relevant services, facilities and opportunities available that can be used, facilitating exchange and collaboration (e.g. standards, data storage, technical expertise, digital services, repositories , network of experts, research infrastructure, heritage communities and public programmes, training and educational offer, dissemination events, grant and internship, financing initiatives, models/templates, etc.)

FAIR data management recommendations relevant for data **managers** basically means to translate data management policies (as covered in the previous section) for practical use, the practitioners.

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6 Appendices

Appendix 1 - Tools to create Data Management Plans

The table below contains an overview of online services that can be used to create and manage a DMP, and that have integrated Science Europe Guidance.[178]

Name	Description	Provider	Software
	ARGOS is an open and extensible service that simplifies the management, validation, monitoring, and maintenance of Data Management Plans (DMPs). It allows researchers, managers, supervisors, and others to create actionable DMPs.	OpenAIRE	OpenDMP
ARIADNEplus DMPtool	ARIADNEplus project has used the archaeological community 'know-how ' together with experience and results of the PARTHENOS project to establish a DMP template catered to the Research Data Management of archaeological data and a DMP tool storing and providing this Template to researchers.	PARTHENOS / ARIADNEPlus	own software
Data Stewardship Wizard	Data Stewardship Wizard (DSW) is indeed a software tool designed to assist organisations in managing their data effectively. It ensures compliance with data governance policies and regulations. It helps data stewards and data owners define, document, and implement data management processes and policies.	ELIXIR CZ and ELIXIR NL	own software
DMPtool	The DMPTool is a widely used tool in the US region that provides a collection of templates and guidance for researchers to create their Data Management Plans (DMPs). It helps researchers meet the requirements of funders and institutions.	The University of California Curation Center	DMPRoadmap
DMPonline	DMPonline is a tool for creating, reviewing, and sharing data management plans (DMPs) that comply with institutional and funder requirements. It is provided by the Digital Curation Centre (DCC), an organisation dedicated to supporting institutions and researchers in managing and preserving digital research data.	DCC	DMPRoadmap

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[178] Europe, Science. 'Research Data Management'. Science Europe.
https://scienceeurope.org/our-priorities/research-data/research-data-management/.

DPM OPIDoR	DMP OPIDoR is a tool that assists researchers in the development and implementation of data and software management plans. It is accessible to the scientific community within the Higher Education and Research sector and its French or international partners. It is developed as part of an international collaboration focused on the open-source software, DMPRoadmap.	CNRS	DMPRoadmap
RDMO	The Research Data Management Organiser (RDMO) is a tool that supports the systematic planning, organisation, and implementation of data management throughout a research project	DFG (German Research Foundation)	own software
DAMAP	DAMAP is a tool for creating data management plans (DMPs) which is currently in development at TU Wien and TU Graz. The project was recently featured in the FAIRsFAIR Implementation Stories.	TUWien	own software
EasyDMP	easyDMP is a service that offers researchers, especially those with minimal experience in data management, a simple way of creating a Data Management Plan (DMP). It's designed to help researchers who work with and generate data to have a data management plan (DMP).	EUDAT	OpenDMP
DMP Canvas Generator	The DMP Canvas Generator is a tool for scientists who are applying for funding from the Swiss National Science Foundation (SNSF). It simplifies the process of creating Data Management Plans (DMPs) by providing a structured web form with seven sections that guides users through defining the data management requirements for their SNSF-funded projects.	Vital-IT	OpenDMP

Appendix 2 - Standards, frameworks, and certifications for Trustworthiness of Digital Repositories

Several standards and frameworks have been developed to guide the assessment of the trustworthiness of digital repositories:

- The **TRUST Principles for digital repositories** provide a common framework to facilitate discussion and implementation of best practices in digital preservation by all stakeholders.[179] The TRUST Principles are Transparency, Responsibility, User focus, Sustainability and Technology.
- The **Core Trustworthy Data Repositories Requirements** reflect the core characteristics of trustworthy data repositories, such as organisational infrastructure, digital object management, technical infrastructure, and security.[180] The Core Trustworthy Data Repositories Requirements are developed and used by CoreTrustSeal for core-level certification of data repositories (see below).
- **DIN 31644 "Criteria for trustworthy digital archives"** is a German standard that provides a set of criteria for the setup and management of all institutions aiming to preserve information in digital form.[181] It does not focus solely on Libraries, museums and other memory institutions.
- The **Trusted Digital Repository (TDR) framework**, developed by the International Council on Archives (ICA), provides a set of criteria for assessing the trustworthiness of digital repositories for long-term preservation.[182] It focuses on areas such as organisational infrastructure, digital object management, preservation planning, access, and security. TDR underlies ISO 16363 certification, which ensures that repositories meet high standards for the preservation of digital records and archives (see below).

Certifications for digital data repositories (long-term preservation):
- **CoreTrustSeal**: A core level certification based on the Core Trustworthy Data Repositories Requirements. It is based on a self-assessment (with evidence provided) by the repository of sixteen requirements, which is then reviewed by CoreTrustSeal. The requirements focus on the organisational infrastructure (e.g., what is the mission and scope of the organisation, how is rights management done, what happens if funding were to stop?), digital object management (e.g., what are workflows, what is the preservation plan?), and information

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[179] Lin, D., Crabtree, J., Dillo, I. et al. The TRUST Principles for digital repositories. Sci Data 7, 144 (2020). https://doi.org/10.1038/s41597-020-0486-7

[180] https://www.coretrustseal.org/why-certification/requirements/ (accessed 7 November 2023).

[181] DIN 31644:2012-04. Information und Dokumentation - Kriterien für vertrauenswürdige digitale Langzeitarchive. Beuth Verlag. https://dx.doi.org/10.31030/1854419 and https://www.beuth.de/de/norm/din-31644/147058907 (accessed 7 November 2023).

[182] https://www.crl.edu/archiving-preservation/digital-archives/metrics-assessing-and-certifying/iso16363 (accessed 7 November, 2023)

technology and security.[183] CoreTrustSeal is envisioned as the first step for repository certification, with the more extensive nestor-Seal DIN 31644 and the ISO 16363 as next steps.[184]

- **nestor-Seal DIN 31644**. The Nestor Seal for Trustworthy Digital Archives provides an extended self-assessment process on the basis of the DIN 31644 standard (see above).[185]
- **ISO 16363** is the most extensive certification for Trustworthy repositories, based on an audit.[186] It is based on the Trusted Digital Repositories framework.[187]

These standards and certifications provide a framework for auditing and certifying digital repositories, ensuring they meet the necessary criteria for data preservation and accessibility. They are periodically reviewed and updated to reflect new technologies and requirements.

Choice of CoreTrustSeal: why is this relevant for 4CH CC?

We recommend that repositories or national nodes of the future CC have at least a CoreTrustSeal certification (or are working towards this). This certification is highly relevant for the 4CH CC community for several reasons:

1. Data Integrity and Preservation: CoreTrustSeal requirements ensure that repositories have mechanisms in place to maintain data integrity, preserve data over the long term, and guarantee its accessibility. This aligns with the conservation aspect of 4CH CC, ensuring the longevity and usability of CH data.
2. Transparency and Metadata Quality: CoreTrustSeal emphasises transparent policies, clear metadata guidelines, and accurate documentation, which are vital for effective communication and understanding of CH data. Clear and high-quality metadata supports the communication objective of 4CH CC by enabling researchers, professionals, and the public to discover and comprehend the CH resources.
3. Collaboration and Cooperation: CoreTrustSeal encourages collaboration and cooperation among repositories, fostering a culture of trust, mutual support, and the sharing of best practices. This aligns with the cooperation aspect of 4CH CC, as it facilitates the exchange of knowledge, resources, and experiences among cultural heritage professionals.
4. Reliable Access and Openness: CoreTrustSeal requirements address access policies, rights management, and open access principles, ensuring that CH data stored in repositories is accessible to the intended audiences while respecting intellectual property rights. This supports the openness aspect of 4CH CC, promoting wider access, engagement, and creativity with cultural heritage.

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[183] CoreTrustSeal Standards and Certification Board. (2022). CoreTrustSeal Requirements 2023-2025 (V01.00). Zenodo. https://doi.org/10.5281/zenodo.7051012

[184] https://www.coretrustseal.org/about/ (accessed 7 November 2023).

[185] https://www.langzeitarchivierung.de/Webs/nestor/EN/Zertifizierung/nestor_Siegel/siegel.html (accessed 7 November 2023).

[186] http://www.iso16363.org/

[187] https://www.crl.edu/archiving-preservation/digital-archives/metrics-assessing-and-certifying/iso16363

Other Assessment tools

- **Levels of Digital Preservation** is a resource providing information for those that wish to build a digital preservation program.[188] A matrix with four maturity levels for the themes of storage, integrity, control, metadata, and content is provided.
- "The **DPC Rapid Assessment Model (DPC RAM)** is a digital preservation maturity modelling tool that has been designed to enable DPC RAM homerapid benchmarking of an organisation's digital preservation capability."[189]

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[188] https://ndsa.org/publications/levels-of-digital-preservation/ (accessed 7 November, 2023).
[189] https://www.dpconline.org/digipres/dpc-ram (accessed 7 November, 2023).

Appendix 3 - EU National digitisation strategies and initiatives - overview

The table integrates the research results on policies at a national level in European Countries regarding policies on digitisation of Cultural Heritage with respect to some macro areas:

- Development of a National (digitisation) strategy/plan for Cultural Heritage including recommendation, standards and guidelines;
- Institution of cloud and software infrastructure or platform(s) for digital resources;
- Development of digital services and digital content production;
- Use of innovative technologies (AI, big data, VR, etc.);
- Measures addressing copyright framework;
- Enhancement of digital skills, training, education and capacity building;
- Increase of digitisation of cultural services, digital collections, contents, assets and resources supporting digital transition and improve accessibility to culture;
- Renovation, restoration, energy efficiency and removal of physical barriers of cultural heritage assets (including museums, theatres, libraries, etc.) and historical buildings.

These key actions include some investments planned as part of the National Recovery and Resilience Plans, and other previous or on-going projects.

Below are the unique identification codes of the Member Countries used in the table (ISO 3166-1 alpha-2)

Austria	AT		Italy	IT
Belgium	BE		Latvia	LV
Bulgaria	BG		Lithuania	LT
Croatia	HR		Luxembourg	LU
Cyprus	CY		Malta	MT
Czechia	CZ		The Netherlands	NL
Denmark	DK		Poland	PL
Estonia	EE		Portugal	PT
Finland	FI		Romania	RO
France	FR		Slovakia	SK
Germany	DE		Slovenia	SI
Greece	GR		Spain	ES
Hungary	HU		Sweden	SE
Ireland	IE			

Actions/initiatives		AT	BE	BG	HR	CY	CZ	DK	EE	FI	FR	DE	GR	HU	IE	IT	LV	LT	LU	MT	NL	PL	PT	RO	SK	SI	ES	SE
																					EU Member States							
Development of a **National (digitization) strategy** /plan for Cultural Heritage including recommendation, standards and guidelines	NRRPs [1]-[2]-[3] > 5 out of 27 19 %	AT					CZ									IT					NL [6]			RO				
	Previous or on-going [4] – [5]	AT			HR		CZ	DK	EE			DE			IE			LT	LU		NL			RO	SK	SI		
Institution of cloud and software infrastructure/platforms for digital resources; development of digital services and digital content production; use of innovative technologies (AI, big data, VR, etc.)	NRRPs [1]-[2]-[3] > 9 out of 27 33%		BE				CZ						GR			IT		LT			NL					SI	ES	SE
	Previous or on-going [4] – [5]	AT			HR	CY	CZ	DK	EE	FI	FR	DE				IT	LV	LT			NL		PT	RO		SI		
Measures addressing **copyright framework**	NRRPs [1]-[2]-[3] > 2 out of 27 7%				HR																						ES	
	Previous or on-going [4] – [5]				HR						FR																	
Enhancement of digital skills, training, education and capacity building	NRRPs [1]-[2]-[3] > 24 out of 27 89%	AT	BE		HR	CY		DK	EE	FI	FR	DE	GR		IE	IT	LV	LT	LU	MT	NL		PT	RO	SK	SI	ES	SE
	Previous or on-going [4] – [5]	AT	BE													IT												
Increase of digitisation of cultural services, digital collections, contents, assets and resources supporting digital transition and improve accessibility to culture.	NRRPs [1]-[2]-[3] > 15 out of 27 56%	AT	BE	BG	HR						FR			HU		IT	LV	LT			NL		PT	RO		SI	ES	
	Previous or on-going [4] – [5]	AT		BG	HR	CY			EE						IE	IT	LV	LT			NL			RO	SK	SI	ES	
Renovation, restoration, energy efficiency and removal of physical barriers of cultural heritage assets (including museum, theatres, libraries, etc.) **and historical buildings.**	NRRPs [1]-[2]-[3] > 10 out of 27 37%	AT			HR						FR		GR			IT	LV						PT	RO	SK	SI		
	Previous or on-going [4] – [5]																											

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[1] Culture Action Europe, the European Cultural Foundation, and Europa Nostra, CULTURE IN THE EU'S NATIONAL RECOVERY AND RESILIENCE PLANS, 2021 (https://digitallibrary.cultura.gov.it/wp-content/uploads/2022/01/NRRPs_analysed_digital.pdf)

[2] EC, Recovery and Resilience Scoreboard, Thematic analysis: Digital skills and education, 2022 (https://ec.europa.eu/economy_finance/recovery-and-resilience-scoreboard/assets/thematic_analysis/scoreboard_thematic_analysis_digital_skills.pdf).

[3] EC, Recovery and Resilience Scoreboard, Culture and Creative Industries, 2022 (https://ec.europa.eu/economy_finance/recovery-and-resilience-scoreboard/assets/thematic_analysis/scoreboard_thematic_analysis_culture.pdf).

[4] The Compendium of Cultural Policies and Trends, Compendium Country Directory, Custom Report 'Current cultural affairs/ Digital policy and developments' (https://www.culturalpolicies.net/wp-content/plugins/pdf/pdfCustom.php?cid=3,5,6,7,8,9,10,11,12,13,15,16,19,18,20,21,23,45,25,30,31,32,37,36,38,39,28&tid=,8&rso=c); Web page section: https://www.culturalpolicies.net/database/search-by-filter/; (https://www.culturalpolicies.net/database/search-by-country/.

[5] The Compendium of Cultural Policies and Trends, Compendium Country Directory, Custom Report 'Current cultural affairs/ 'Other main cultural policy issues' (https://www.culturalpolicies.net/wp-content/plugins/pdf/pdfCustom.php?cid=3,5,6,7,8,9,10,11,12,13,15,16,18,19,20,21,45,25,31,30,32,36,37,38,39,28&tid=,13&rso=c). Web page section: https://www.culturalpolicies.net/database/search-by-country/.

[6] The Netherlands, in partnership with the Dutch Digital Heritage Network (Netwerk Digitaal Erfgoed) – currently managing all digital preservation activities in the country - is developing a system of national facilities and services for improving the visibility, usability, and sustainability of digital heritage (https://netwerkdigitaalerfgoed.nl/en/), responding to the objectives of National Digital Heritage Strategy 2021-2024 (https://netwerkdigitaalerfgoed.nl/wp-content/uploads/2022/05/National-Digital-Heritage-Strategy-2021-2024.pdf), focusing on the use of state-of-the-art technology (such as artificial intelligence and big data) in making digital heritage available.