

IMPULSE

IMmersive digitisation: uPcycling cULTural
heritage towards new reviving StratEgies

Deliverable D3.1:

Ongoing verification of the use of
digital heritage objects within the
emerging platforms



**Funded by
the European Union**

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Education and Culture Executive Agency (EACEA). Neither the European Union nor EACEA can be held responsible for them.

Document Information

Document Identification			
Status	Final	Due Date	31 October 2024
Version	8.0	Submission Date	30 October 2024
Related WP	WP3	Document Reference	D3.1
Related Task(s)	3.1.1	Document Type	Report
Related Deliverable(s)	D3.1(D17)	Dissemination Level	Public
Lead Participant	KU Leuven	Lead Author	Theodora Rontzova
Reviewers	Nele Gabriëls (KU Leuven)	Bohdan Widła (JU)	
	Afroditi Andreou (NKUA)	Charalampos Rizopoulos (NKUA)	
	Andrew Pace (MZ)	Dimitris Charitos (NKUA)	

Author(s)		
First Name	Last Name	Partner
Theodora	Rontzova	KU Leuven
Bruno	Vandermeulen	KU Leuven

Document History			
Version	Date	Modified by	Modification reason
1.0	29/09/2024	Theodora Rontzova	First draft
2.0	30/09/2024	Bruno Vandermeulen	Internal review

3.0	02/10/2024	Theodora Rontzova	Internal reviewer's comments implementation
4.0	03/10/2024	Bruno Vandermeulen	Second internal review
5.0	18/10/2024	Afroditi Andreou, Nele Gabriëls, Andrew Pace, Bohdan Widła, Dimitris Charitos, Charalampos Rizopoulos	Evaluation by the assigned experts
6.0	23/10/2024	Theodora Rontzova	Assigned Experts comments implementation
7.0	23/10/2024	Bruno Vandermeulen	Second evaluation by the assigned experts
8.0	30/10/2024	Łukasz Pieczonka, Żaneta Żegleń	Quality Team approval and final version

Quality Control		
Role	Who (Partner short name)	Approval Date
Deliverable leader	Bruno Vandermeulen (KU Leuven)	29/10/2024
Quality manager	Łukasz Pieczonka (JU)	30/10/2024
Project Coordinator	Żaneta Żegleń (JU)	30/10/2024

Table of Contents

Document Information	1
Table of Contents	3
Abbreviations and Acronyms	5
Executive Summary	6
Introduction	7
Objectives.....	10
<i>Objectives of Work Package 3 (STAND)</i>	<i>10</i>
<i>Objectives of the Task 3.1.1</i>	<i>12</i>
Methodological approaches	14
<i>Selection of literature review type</i>	<i>14</i>
<i>From 2D to Virtual Reality: The concept of data.....</i>	<i>15</i>
Two-Dimensional data	15
Three-Dimensional data.....	17
Four-Dimensional Data/time-based data.....	18
Six-Dimensional data	20
Metadata	21
<i>The 3-phase approach to data lifecycle span</i>	<i>23</i>
Data creation.....	23
Data management	23
Data sharing.....	24
Analysis of findings	27
<i>2D data</i>	<i>27</i>
Literature	27
Standards and guidelines	28
Networks and Projects	31
Immersive environments.....	32
<i>3D DATA</i>	<i>36</i>
Academic literature.....	366
Guidelines.....	37
Projects and Networks	38
Immersive Platforms	39
<i>4D Data.....</i>	<i>41</i>

Academic literature.....	41
Guidelines.....	42
Projects and Networks	433
6D Data.....	46
Academic literature.....	46
Standards and guidelines	47
Projects and Networks	48
Immersive platforms.....	49
Conclusions	51
References.....	53
Scoping sources.....	61
<i>Policy Documents</i>	
<i>Standards</i>	
<i>Projects</i>	
<i>Networks</i>	
<i>Guidelines</i>	
<i>Literature</i>	

Abbreviations and Acronyms

Abbreviation / acronym	Description
2D	Two-Dimensional
3D	Tree-Dimensional
4D	Four-Dimensional
6D	Six-Dimensional
AAC	Advanced Audio Coding
AIFF	Audio Interchange File Format
ALTO	Analysed Layout and text Object
AVCDH	Advanced Video Coding High Definition
AVI	Audio Video Interleave
Cidoc/CRM	Conceptual Reference Model
D17.3	Deliverable number 17 belonging to WP3
DV	Digital Video
EAD	Encoded Archival Description
EC	European Commission
EDM	Europeana Data Model
EU	European Union
exif	Exchangeable image file format
FADGI	Federal Agencies Digital Guidelines Initiative
FLAC	Free Lossless Audio Codec
GLTF	GL Transmission Format
H264	High-Efficiency Video Coding
HOCR	Hierarchical Optical Character Recognition
IIIF	International Image Interoperability Framework
IPTC	International Press and Telecommunications Council
JPG	Joint Photographic Experts Group
Marc	Machine-Readable Cataloguing,
METS	Metadata Encoding and Transmission Standard
MKV	Matroska Video File
Mods	Metadata Object Description Schema
MOV	Apple QuickTime Movie file
MP3	MPEG-1 Audio Layer 3
MP4	MPEG-4 Part 14
MTL	Wavefront Material Template Library
OAIP-MH	Open Archives Initiative Protocol for Metadata Harvesting
OAIS	Open Archival Information System

OBJ	Wavefront Object
PC	Project Coordinator
PDF	Portable Document Format
PLY	Polygon File Format
PS	Photometric Stereo
RDF	Resource Description Framework,
RTF	Rich Text Format
RTI	Reflectance Transformation Imaging
SKOS	Simple Knowledge Organisation System
SfM	Structure from Motion
TIFF	Tagged Image File Format
TXT	Text
USD	Universal Scene Description
US	United States
WAV	Waveform Audio File Format
WMV	Windows Media Video
WP	Work Package

Executive Summary

The following document is the first Deliverable of WP3 within the scope of the IMPULSE project (funded by Horizon Europe). The Deliverable 3.1.(D17) presents an overview of the ongoing verification of the use of digital heritage objects within emerging platforms.

The report is divided into five sections. The first section offers an introduction to IMPULSE, a project that received funding under the Cluster 2 of Horizon Europe dedicated to “Culture, creativity and inclusive society”, specifically the call on: Re-visiting the digitisation of cultural heritage: what, how and why? (HORIZON-CL2-2023-HERITAGE-01-03) (European Commission, 2022). The second section briefly outlines the aims of IMPULSE and then presents the objectives of WP3 with specific emphasis on task 3.1.1, which resulted into the present scoping review of the current literature, best practices, standards, guidelines, projects and platforms in the field of cultural heritage digitisation.

The third section offers an introduction to the selected sources that this report is based upon (academic literature, policy reports and recommendations, standards, guidelines, case studies, projects with a similar theme and immersive environments) and then analyses the methodologic approach followed in the deliverable: namely, our concept of data subdivided in 2D, 3D, 4D (time-based) data, 6D data and metadata, as well as a 3-phase

approach to the data life cycle comprising of data creation, data management and data sharing. This is followed by the main analysis of the findings. The axes of the analysis are the different data types, therefore the current state of art in cultural heritage digitisation is examined separately for each type of data.

The scoping review results into the conclusions, which offers a recap of the principal findings, academic and institutional gaps as well as recommendations for future research directions. Finally, there is an appendix with all the scoping sources used in our review, ranging from academic papers and EU documents to guidelines, standards, EU- funded projects and novel immersive environments dealing with digital heritage artifacts. The scoping review will continue throughout the duration of the project.

It is important to note that while this deliverable maintains academic integrity, the perspective of WP3, and thus this report, is primarily focused on institutional practices. This deliverable aligns with and complements the work developed within the other Work Packages.

Keywords: cultural heritage, digitisation, standards, data management, metadata, data aggregation, 2D data, 3D data, audiovisual data, immersive platforms, virtual reality.

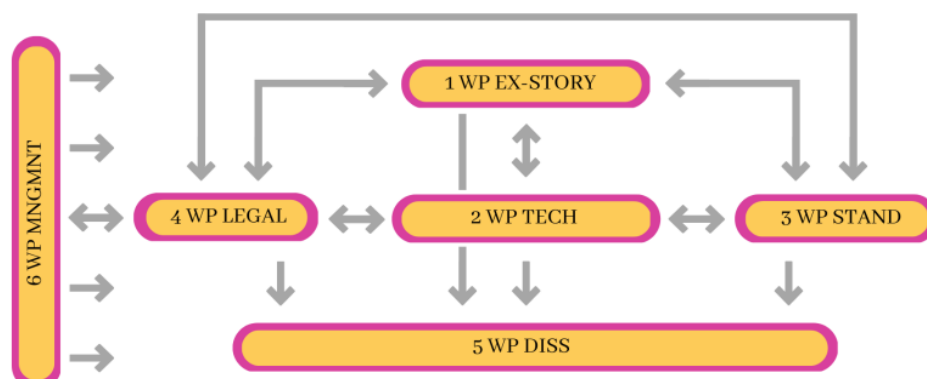
Introduction

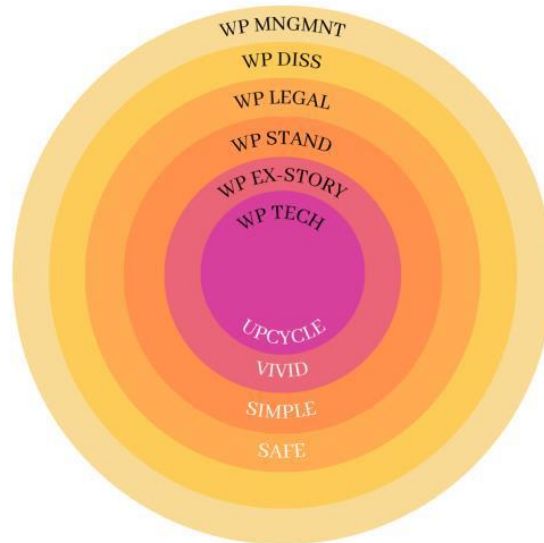
IMPULSE emerged out of the vision of a European immersive digitisation framework, driven by the forces of culture, creativity, storytelling, upcycled technology and safe, simplified standards. The project aims to synthesise innovative, multifaceted solutions and methodologies addressing the digitisation and accessibility processes of the collections that make up digital cultural heritage. These initiatives aim to promote the innovative (re)use of digital cultural heritage, address challenges in platform interoperability and enhance the use of already digitised cultural heritage materials in novel contexts, such as the Metaverse and other immersive platforms. In those platforms, (whether they encompass MR, VR or AR technologies) the upcycling and appropriate reuse of digital assets remains a desideratum that our project will actively address. Additionally, IMPULSE seeks to develop pioneering standardisation protocols and update the legal framework to better tackle contemporary challenges. Ultimately, the end goal of the project is to be achieved through a set of specific, measurable, achievable, realistic and timebound (SMART) specific objectives, which entail:

Solutions that will augment the quantity and range of cultural heritage objects that are displayed through VR/XR technologies. The now easily accessible collections shall act

as a powerhouse for a diverse set of demographic audiences and underrepresented communities, to empower them and help them engage with the topics and themes on display.

- Technological solutions developed within the project that will enable the efficient (re)use of digitised cultural heritage content in novel contexts and immersive environments, with a focus on educational/teaching, artistic and creative dimensions, on par with the three prototypes that are being developed within the project (see IMPULSE proposal).
- Innovative standardisation procedures and simplified strategies specifically targeted towards digitisation processes in emerging platforms, immersive and multi-user fictional environments to achieve easily comprehended formats by deploying existing (technical) standards and metadata/paradata simplification protocols, tailored for the utilisation of education, arts, and the CCSI.
- Legal and organisational frameworks with detailed evaluations of risks and barriers in fields such as the copyrights, database rights, ownership, provenance, personal data protection and other related rights in the field of digital cultural heritage in novel environments. The lack of proper legal frameworks is an identified gap that IMPULSE aims to address, all while working within multiple national jurisdictions (namely the ones of the selected partners, i.e. Poland, Greece, Belgium, Italy, Germany and Malta) aiming to achieve harmonisation.
- Connections among researchers, artists, cultural heritage practitioners and other relevant stakeholders through initiatives such as the IMPULSE Community of Practice (referred to as IMCo), the Hackathon and the three thematic Workshops surrounding it, as well as the Acceleration & Mentoring Hub, all aiming to promote dialogue, co-creation and capacity building in immersive digitisation.





IMPULSE aims to address some of the most pressing gaps in the digitisation of European cultural heritage by building on existing knowledge, the capacity of its partners, and activities and networks. To achieve its stated intentions, the IMPULSE project has conceived a strategic plan which is divided into six distinct yet interconnected Work Packages (WPs). Each WP is indicative of the stated objectives and monitors the progress of the respective research activities and project implementation initiatives.

To conclude, the overarching objective of IMPULSE is to create innovative and comprehensive solutions that foster the digitisation of cultural heritage in a standardised, findable, accessible, interoperable and reusable manner. The project is in equal parts founded on academic research and existing practice, and consists frequently on methodologies specifically fit for each Work Package.

Objectives

Objectives of Work Package 3 (STAND)

Within IMPULSE, Work Package 3 (WP3) emerged out of an organic need for efficient, easy to apply standardisation practices in order to facilitate data sharing across various platforms, and more specifically Multi-User Virtual Platforms.

Without standardisation institutions may face several problems hampering sharing data. Some institutes may be reluctant to adopt certain standards as this comes in pair with sometimes significant long-term changes on systems, digital preservation, data exchange and aggregation. Some institutions may not have elaborate IT or digital resources and are dependent on software tools that have only base standards implemented, which, in some cases, the software vendor will implement to their like with no possibility to adapt.

For well-established file formats and frameworks standards are well-documented, widely adopted, and supported by a substantial user base. In cases where these standards do not adequately address the specific needs of researchers and professionals, it may be necessary to develop supplementary or alternative standards. However, from a sustainability perspective, this approach is not always optimal. It is essential to first examine the foundational standards before considering modifications or alternatives.

When it comes to the digital transition and digitisation, the very basics shall not be underestimated. Correct and efficient standardisation practices in digitisation workflows ensure that the digital representations of heritage objects are consistent, reliable, findable and comparable, both now and in the future. They enable access to and preservation of the data, facilitate sharing and collaboration among stakeholders from different EU countries, disciplines and legal frameworks, and support informed decision-making. Without the appropriate standardisation practices data may become fragmented, inaccessible, and susceptible to loss or misinterpretation over time, compromising its value and significance. Most importantly, standardisation enables the creation of trustworthy data, ensuring it can be (re)used in the broadest manner.

More specifically, standardisation is important in the following areas:

- Consistency: Standardisation ensures that the data is captured, processed, and stored in a consistent manner, reducing the possibility of errors or unreliable datasets.
- Interoperability: Standardisation enables digital heritage data to be shared between different systems and platforms, reducing the risk of data loss, inaccessibility or incomprehension (fuzzy data). Describing the genesis of datasets (equipment, software, algorithms used) will help understanding and interpreting the data.

- Long-term preservation: Standardised data is more likely to be preserved and be accessible in the future, ensuring its long-term availability.
- Improved accuracy: Standardisation provides clear guidelines and protocols for capturing, processing, and storing data, reducing the possibility of human error and improving accuracy.

It is no exaggeration to claim that today, the cultural heritage sector is at the forefront of standardising practices. Within heritage institutes digitisation practices have been revolutionised by the development of ISO standards such as the ISO19264 image quality standards that ensure high quality, consistent data at base level for 2D objects or, on the other end of the spectrum ISO 14721:2012 Reference Model for an Open Archival Information System (OAIS) to name a few.

Practical guidelines based on the ISO 19264 standard have been developed and implemented by national institutes both in Europe (such as the Metamorfoze Preservation Imaging Guidelines) and the US (Federal Agencies Digital Guidelines Initiative, FADGI Guidelines). Many cultural institutions have implemented these guidelines, and by building upon them have generated additional practical workflows for specific contexts, for example the Rijksmuseum manuals for photographing 2D objects material types (manuscripts) or data types (3D data, audiovisual material, compression standards for video or for image). For common data formats standards and guidelines have been developed, but there is a lack for standards deploying advanced imaging techniques such as multi-spectral imaging, multi-light reflectance imaging as they create multimodal datasets.

In terms of metadata, several standards exist for various metadata types, e.g. technical metadata (exif, IPTC); descriptive metadata (Dublin Core, Marc21, Mods, EAD, Cidoc/CRM, Premis, metadata schema for 3D objects) etc. depending on material types, and depending on type of collection: library, archive or museal. For data interoperability and sharing of data and to ensure the information is consistent, accurate and accessible across systems, several models have been developed: Linked Open Data, SKOS, Europeana Data Model (EDM), Schema.org or International Image Interoperability Framework (IIIF). Data preservation guidelines provide information for the long-term preservation and management of digital data, ensuring that information remains accessible and usable: OAIS (Open Archival Information System) Reference Model, ISO 14721:2012.

However, as datasets expand in size at a rapid pace, novel digitisation and imaging techniques emerge, and new digital preservation strategies are constantly developed. While standardisation itself provides clear frameworks, the abundance of different standards that coexist often simultaneously used poses several challenges; this standards “pluralism” hampers interoperability, consistency in classification and cooperation for support and development.

The adoption of standards by cultural institutions remains a challenge. Implementing and conforming to standards can be expensive for institutes with limited budgets, as it is a process that requires specialised technical knowledge and skills. A substantial number of institutes have implemented software tools based on proprietary technology, sometimes making it difficult to share and exchange data with other systems. There is also a resistance to change and a reluctance to share data for a variety of reasons, even more so towards novel immersive environments.

IMPULSE tries to answer these challenges by research on simplifying (meta)data sharing strategies. This move aims to lift away many barriers, as it is easier for different systems and platforms to exchange and (re)use data, reduces the cost and effort of data transformation and data sharing; and opens opportunities for innovation and experimentation, fostering new and creative reuse of digitised heritage. Emerging data sharing platforms should play an important role in streamlining data ingest into their systems, instead of outsourcing this task to content providers. This requires not only existing metadata and technical standards; but also, paradata and other documentation that describe the context and conditions of data creation and (future) data use.

Objectives of the Task 3.1.1

The heritage sector is a pioneer in standardisation practices. However, numerous standards exist across different entities. Due to the complexity of standards, small, mid-sized and even large heritage institutions face challenges when they are called to comply with those standards. The rapid emergence of new immersive platforms further complicates data interoperability and sharing. Standardisation ensures that the digitisation of heritage objects remains reliable and consistent over time, facilitates data access and preservation, promotes sharing and collaboration and aids informed decision-making. The simplification of standards will enhance interoperability for data exchange, improve visibility and foster innovation. WP3 plays a transversal role, by providing input and aligning with the objectives of other Work Packages.

To develop new strategies that will facilitate the sharing of cultural heritage datasets in new European dataspace - such as the newly launched European Collaborative Cloud for Cultural Heritage - it is first necessary to have thorough image of the latest developments in the field. For this reason, WP3's first activity is to undertake a thorough examination of the current digitisation standards and pinpoint the shortcomings and difficulties to provide insight for creating new approaches towards standardisation and emerging platforms such as immersive and multi-user immersive environments.

Task 3.1.1, entitled “Ongoing verification of the use of digital heritage objects within the emerging platforms” consists of a thorough desk examination of the current status of digital heritage representations, which involves evaluating the prevailing standards for data

creation, data preservation, data sharing, established practices, and technologies used. The current state of the art in the field of digitisation standards is marked by a variety of initiatives, reports, and recommendations. A systematic review of these prior efforts is necessary to understand the current landscape and identify gaps in skills, infrastructure and resources, thus providing input for further development and usage in new immersive and multi-user platforms. It is important to note that this task will be approached through the lens of day-to-day digitisation practices within heritage institutions. This effort will form the foundation for continued research throughout the project. In a later stage, emphasis will be placed on the data itself, focusing on its use in the pilot projects developed within IMPULSE and on metadata strategies that enable data sharing. These efforts are in concordance with the other Work Packages within IMPULSE.

Methodological approaches

This section of the document outlines the fundamental methodological approach employed for the examination of the current state of the art in digitisation standards. In accordance with the roadmap and task implementation, the methodology should be validated through the preceding proper research phase and will draw from diverse sources, (qualitative research, questionnaires and targeted interviews, separate case studies culminating into 3 workshops and one Hackathon, research through design). It is anticipated that the preliminary research phase will entail the utilisation of methodologies and instruments by all project Partners.

Selection of literature review type

In order to acquire a systematic overview of the digitisation and standards landscape in cultural heritage, a diverse body of literature has been consulted. First, we consulted a large volume of academic literature (peer-reviewed journals, volumes, conference proceedings) that explored topics such as the safeguarding of cultural heritage in the digital era, the digitisation of tangible cultural heritage and the use of standards in digitisation processes. As the technical developments in the field are advancing at an unprecedented pace, specific emphasis has been given on the literature produced in the past decade and therefore the year of 2014 has been set as a terminus post quem in our research.

Policy documents and consolidated progress reports commissioned by the European Union have also been valuable sources. The uniform standards regarding all types of data and all stages of the data lifecycle encompass all stages of the data lifespan, well-known digitisation standards for 2D data such as FADGI and Metamorfoze, as well as the current metadata standards.

Ad-hoc guidelines and case studies of libraries, archives, museums and other cultural institutions have been among the most important sources, as they demonstrate how the day-to-day application of digitisation practices by cultural practitioners may deviate from the theory presented in academic works. This type of sources, typically residing outside of conventional academic publishing pathways, is better described by the term “grey literature” and was not always easily traceable or retrievable; in fact, the vast majority of relevant case studies or use cases are not represented in institutional repositories, therefore difficult to retrieve and consult.

Digitised cultural heritage is already present in games and immersive platforms. Our scoping review included the study of multi-user virtual environments where cultural heritage content was present, in the cases where the presence of digitised cultural heritage was detectable in the software used. The end goal is to initiate an ongoing verification of the use of digitised

cultural heritage objects in virtual environments, an activity that will serve as the baseline for an iterative process of mapping the overview of new technologies in the fields of data processing and sharing.

Finally, this scoping review attempts to include an extensive inventory of projects and networks that present a high degree of similarity with IMPULSE and deal with topics in (digital) cultural heritage, digitisation, data management and aggregation. The majority of the projects identified have also received funding from the European Commission under cluster 2 “Culture, Creativity and Inclusive Society” in cultural heritage. Following a synergistic approach, IMPULSE seeks to establish appropriate links with related actions funded by Horizon Europe. For this reason, the central coordination unit of IMPULSE along with WP3 have been liaising with the projects funded under the same call (HORIZON-CL2-2023-HERITAGE-01-03), namely REEVALUATE (REEVALUATE, 2024) and DIGICher. Also, to the extent appropriate, we have established contacts with projects within the same theme, but from previous calls and with cultural and academic institutions specialising in digital cultural heritage. This initiative's end goal is to establish a network of shared best practices and resources and to enrich and complement each other's research activities.

From 2D to Virtual Reality: The concept of data

The exploration and analysis of the digitisation landscape and all the factors that influence it had to be studied not only in depth but also on a broad thematic range. In order for WP3 to safely and precisely conduct a desk research examination of the digitisation standards in cultural heritage, the preferred methodological scheme was that of a double axis: that of the data type and that of the 3-phase approach of the data lifecycle. These two axes will be further analysed in the following sub-sections. As the project progresses, the information will be supplemented and if needed refined.

The first axis of our analysis, and that which our interpretation of the findings is based on, is that of the type of data. Data is divided into the categories of 2D, 3D, 4D and 6D data.

Two-Dimensional data

In the context of cultural heritage, two-dimensional (2D) data refers to digital representations of cultural artifacts, sites, or documents captured in two dimensions by camera or scanner. This category includes flat materials such as books; photos in various forms such as prints, negatives, slides; graphic art, maps, etc. and other forms of visual documentation of three-dimensional objects used for conservation, analysis, and dissemination. These 2D datasets are crucial for documenting the appearance and condition of cultural heritage objects, enabling detailed study and monitoring over time (Haddad, 2022). These 2D file formats can also form the basis for the creation of more complex datasets such as Multi-Light Reflectance Imaging (Reflectance Transformation Imaging or Photometric Stereo) or 3D data through

processing algorithm such as photogrammetry 2D data is typically stored in a variety of file formats, depending on the type of data and its intended use. Some of the most common formats are:

File Format	Description	Standard Description Link
TIFF	Tagged Image File Format; a versatile image format that supports a wide range of colour depths, compression schemes, and metadata.	https://www.iso.org/standard/34342.html
JPG	Joint Photographic Experts Group; a lossy image format that is widely used for digital photography due to its high compression ratio and good image quality.	https://jpeg.org/jpeg/index.html
JPG 2000	A newer image format that offers superior compression to JPG while maintaining high image quality, especially for images with high levels of detail or low contrast.	https://jpeg.org/jpeg2000/index.html
PDF	Portable Document Format; a universal file format for viewing and printing documents, regardless of the software used to create them.	https://pdfa.org/pdf-standards/

After deploying specific algorithms such as Optical Character Recognition (OCR) during post-processing image data of digitised documents with text, derivative file formats are created making the text machine readable:

File Format	Description	Standard Description Link
DOCX	Office Open XML; a file format for storing documents created by Microsoft Word, based on XML.	https://learn.microsoft.com/en-us/openspecs/office_standards/ms-docx/b839fe1f-e1ca-4fa6-8c26-5954d0abbccd
TXT	Plain text; a simple format for storing text without any formatting or layout information.	https://www.unicode.org/versions/Unicode14.0.0/UnicodeStandard-14.0.pdf

ODF	The ODF (Open Document Format) is an open, XML-based file format standard for office documents like text, spreadsheets, and presentations, designed to ensure compatibility and long-term access across different software.	https://docs.oasis-open.org/office/v1.2/OpenDocument-v1.2-part1.html
RTF	Rich Text Format; a format for storing formatted text, including fonts, styles, and layout information.	https://en.wikipedia.org/wiki/Rich_Text_Format
ALTO	Automated Layout Extraction; a format for storing the layout information of a document, including the location of text, images, and other elements.	https://www.loc.gov/standards/alto
METS	Metadata Encoding and Transmission Standard; a format for storing metadata about digital objects, including documents, images, and audio files.	https://www.loc.gov/standards/mets/
HOCR	Hierarchical Optical Character Recognition; a format for storing the results of optical character recognition, including the recognised text and its layout information.	https://kba.github.io/hocr-spec/1.2/
PDF	Portable Document Format; a universal file format for viewing and printing documents, regardless of the software used to create them	https://pdfa.org/pdf-standards/

Three-Dimensional data

Three-Dimensional data (3D data) on cultural heritage refers to the digital representation of cultural heritage objects, sites, or practices using three-dimensional technologies. This data is acquired through various methods such as photogrammetry, laser scanning, structured light and 3D modelling, capturing the shape, texture, and spatial relationships of the objects. The purpose of 3D data in cultural heritage is to document, preserve, and present tangible and intangible cultural assets, enabling detailed analysis, virtual restoration and interactive visualisation for educational, research, and conservation purposes (Skublewska-Paszkowska et al, 2022).

3D data is typically stored in a variety of file formats, depending on the type of data and its intended use. Some of the more common formats are:

File Format	Description	Standard Description Link
OBJ	Wavefront Object; a simple 3D model file format that stores 3D geometry, texture coordinates, and normals.	https://fegemo.github.io/cefet-cg/attachments/obj-spec.pdf
MTL	The MTL file format is a companion file to 3D object files (such as OBJ) that defines the material properties of the object's surfaces, including colour, texture maps, and reflectivity, to be used in rendering the 3D model.	https://paulbourke.net/dataformats/mtl/
PLY	Polygon File Format; a versatile format that can store various types of 3D data, including geometry, colours, and normals.	https://people.math.sc.edu/Burkardt/data/ply/ply.txt
FBX	Autodesk Interchange File Format; a versatile format that can store 3D models, animations, and materials.	https://www.autodesk.com/products/fbx/overview
GLTF	GL Transmission Format; a relatively new format that is designed for efficient delivery of 3D content on the web.	https://www.khronos.org/glTF/
USD	The Universal Scene Description (USD) file format is an efficient, scalable system for authoring, reading, and streaming time-sampled scene description for interchange between graphics applications.	https://openusd.org/

Four-Dimensional Data/time-based data

The use of the concept of four-dimensional data (4D data) in the scoping does not relate to the theories of 4D in certain cultural heritage sources referring to the integration of three-dimensional spatial data with the fourth dimension of time. It is important to know that in our scoping review we consider 4D data as time-based media such as audio and audio-visual data, differentiating two-dimensional, three-dimensional and time-based data sources. It should be clarified that 4D data in our study (and the project in general) does not relate to theories of four-dimensional geometries, such as the ones discussed by (Anderson et al, 2013).

Audio-visual data is typically stored in a variety of file formats, depending on the type of data and its intended use. Some of the more common formats are:

Audio

File Extension	Description	Specification Link
MP3	Lossy compression format, widely used due to its small file size.	https://en.wikipedia.org/wiki/MP3
WAV	Lossless compression format, often used for high-quality audio recordings.	https://www.mmsp.ece.mcgill.ca/Documents/AudioFormats/WAVE/WAVE.html
FLAC	Lossless compression format, known for its high compression ratio while preserving audio quality.	https://xiph.org/flac/
AAC	Lossy compression format, commonly used for streaming audio and digital downloads.	https://en.wikipedia.org/wiki/Advanced_Audio_Coding
AIFF	Lossless compression format, primarily used on Apple devices.	https://en.wikipedia.org/wiki/Audio_Interchange_File_Format

Audio Visual

File format	Description	Specification Link
MP4	Most common container format for video and audio, supports various codecs.	https://mp4ra.org/
AVI	Older video container format, supporting various codecs.	https://en.wikipedia.org/wiki/Audio_Video_Interleave
MOV	Apple's proprietary video container format, often used for QuickTime.	https://en.wikipedia.org/wiki/QuickTime_File_Format
MKV	Versatile container format supporting various codecs, including high-quality video and audio.	https://en.wikipedia.org/wiki/QuickTime_File_Format
WMV	Microsoft's proprietary video format, often used for Windows Media Player.	https://en.wikipedia.org/wiki/Windows_Media_Video
AVCDH	High-definition video format, commonly used for camcorders.	https://en.wikipedia.org/wiki/AVCHD
DV	Digital Video format, often used for camcorders.	https://en.wikipedia.org/wiki/DV_(video_format)
H264	High-Efficiency Video Coding (HEVC) standard, widely used for video compression.	https://en.wikipedia.org/wiki/Advanced_Video_Coding
MPEG	Moving Pictures Experts Group, a group of standards organisations that develop	https://en.wikipedia.org/wiki/Moving_Picture_Experts_Group

	standards for audio, video, and related technologies.	
--	---	--

Six-Dimensional data

Within the scoping review we consider six-dimensional data (6D data) as data that has been used within virtual environments, integrating 2D, 3D and/or 4D data and reformatted to dedicated file formats allowing interaction, representation or simulations in the virtual space. This multidimensional methodology allows digitised heritage collections—such as artefacts or reconstructions of historical environments—to be shared in virtual platforms, where the data can be displayed, processed, integrated, and reformatted for different purposes. It enhances the capacity for visualisation, research, and preservation by creating a more comprehensive, immersive, and reusable digital model of cultural heritage.

6D data is stored in a variety of file formats, depending on the source data and its intended use. Some of the more common formats, some also used in 3D, can be found below. Next to these file formats specific software tools are likely to use their own proprietary formats to save and retrieve simulation.

File Format	Description	Standard Description Link
OBJ	Wavefront Object; a simple 3D model file format that stores 3D geometry, texture coordinates, and normals.	https://fegemo.github.io/cefet-cg/attachments/obj-spec.pdf
FBX	Autodesk Interchange File Format; a versatile format that can store 3D models, animations, and materials.	https://www.autodesk.com/products/fbx/overview
glTF	gl Transmission Format; a relatively new format that is designed for efficient delivery of 3D content on the web.	https://www.khronos.org/glTF/
PLY	Polygon File Format, a simple format for storing 3D geometric data.	https://people.math.sc.edu/Burkardt/data/ply/ply.txt
USD	The Universal Scene Description (USD) file format is an efficient, scalable system for authoring, reading, and streaming time-sampled scene description for interchange between graphics applications.	https://openusd.org/
X3D	Extensible 3D (X3D), a platform-independent format for 3D graphics.	https://www.web3d.org/specifications/

VRML	Virtual Reality Modelling Language, an older format for 3D graphics.	https://www.web3d.org/documents/specifications/19776-2/V3.3/index.html
------	--	---

Metadata

Metadata is the foundational element of any successful digitisation project. It is the invisible ecosystem that gives digital objects meaning and context. Without metadata, digitised content in the long run becomes mere dead data of no value.

Administrative metadata details the administrative history of the digital object, including creation date, creator, and copyright information. Contextual metadata describes the content and subject matter of the digital object. Technical metadata provides information about the technical characteristics of the digital object, such as file format, resolution, and size. Paradata records the circumstances surrounding the creation or collection of the digital object(s).

Different types of collections (libraries, museums, archives) have their own metadata requirements and metadata standards vary depending on the type of data being digitised (text, images, audio, video). Different standards exist for each step in the data lifecycle, from creation to preservation.

Developing thesauri and controlled vocabularies ensures consistency and facilitates searching and linking. Metadata enables the aggregation and interoperability of data from various sources. Metadata-driven gateways like the International Image Interoperability Framework (IIIF) provide access to digital content.

Metadata is the key to unlocking the full potential of digitised content. By investing in deploying robust metadata standards and practices, digital heritage becomes FAIR data (Findable, Accessible, Interoperable and Reusable).

Some of the more common metadata standards are:

Metadata Standard	Description	Specification Link
Dublin Core	The Dublin Core Metadata Element Set is a standardised vocabulary of fifteen properties for describing resources.	https://www.dublincore.org/specifications/dublin-core/dcmi-terms/
EDM	The Europeana Data Model (EDM) is an interoperable framework that structures and represents data contributed by various cultural heritage institutions to Europeana.	https://pro.europeana.eu/page/edm-documentation

MARC21	Machine-Readable Cataloguing, a standard for cataloguing library materials.	https://www.loc.gov/marc/
CIDOC/CRM	Conceptual Reference Model, a standard for describing cultural heritage objects.	https://www.cidoc-crm.org/
PREMIS	Preservation Metadata for the Electronic Resources of Libraries and Archives, a standard for describing preservation metadata.	https://www.loc.gov/standards/premis/
Spectrum	A standard for describing digital objects in museums and galleries.	https://collectionstrust.org.uk/spectrum/
MODS	Metadata Object Description Schema, a flexible metadata schema for describing digital objects.	https://www.loc.gov/standards/mods/
EAD	Encoded Archival Description, a standard for describing archival materials.	https://www.loc.gov/ead/
RDF	Resource Description Framework, a framework for representing metadata as a graph of interconnected resources.	https://www.w3.org/TR/rdfa-primer/
METS	Metadata Encoding and Transmission Standard, a standard for describing digital objects and their relationships.	https://www.loc.gov/standards/mets/
IIIF	International Image Interoperability Framework, a framework for delivering images and their associated metadata.	https://iiif.io/
OAIP-MH	Open Archives Initiative Protocol for Metadata Harvesting, a protocol for harvesting metadata from different repositories.	https://www.openarchives.org/OAI/openarchivesprotocol.html
LIDO	The LIDO schema is intended for delivering metadata, for use in a variety of online services, from an organisation's online collections database to portals of aggregated resources, as well as exposing, sharing, and connecting data on the web.	https://cidoc.mini.icom.museum/working-groups/lido/lido-overview/about-lido/what-is-lido/

The 3-phase approach to data lifecycle span

The second pillar of our analysis is the data lifecycle span, divided into a tripartite approach: data creation, data management and data sharing.

Data creation

Concerning digitisation, this phase involves converting information from a physical object into binary data. It is a crucial step in preserving and making information accessible in the digital age. The process includes scanning documents, photographing 3D objects/artefacts, and converting audio and video recordings into digital formats. Our analysis specifically examines academic papers, reports, case studies, and guidelines related to digitisation. This includes exploring standards and best practices for digitisation, as well as the various file formats used to ensure the longevity and accessibility of digital content. Proper digitisation ensures that valuable information is preserved accurately and can be easily accessed and shared in the future. It also lays the foundation for effective data management and sharing. In the data creation phase, standardisation is essential to ensure consistency, reliability,

and interoperability across different systems and platforms. Standardisation in this phase also facilitates easier data exchange and collaboration between different entities, enhancing the overall value and utility of the digitised information. Important to note, however, is that digitisation only converts partial information about the object. Some features are only visible through the application of special techniques such as multi-spectral imaging, multi-light reflectance imaging, or through more analytical techniques such as Macro X-ray Fluorescence Scanning (MA-XRF). These advanced techniques allow for a more comprehensive capture of the object's details, which are crucial for certain types of analysis and research.

Moreover, the data creation phase is not just about the technical process of digitisation but also involves careful planning and documentation. This includes creating detailed records of the digitisation process, the equipment used, and the conditions under which the digitisation took place. Such documentation is vital for ensuring the reproducibility and reliability of the digitised data. It also helps in troubleshooting any issues that may arise during the digitisation process and provides a clear audit trail for future reference.

Data management

This phase focuses on the long-term preservation of digital data. It involves implementing strategies to maintain the integrity and accessibility of data over time. Key aspects include the use of technical and descriptive metadata, as well as paradata. Metadata provides essential information about the data, such as its origin, structure, and context. Paradata, on the other hand, documents the processes and methodologies used to create and manage the data. Both are crucial for ensuring that data remains understandable and usable

in the long term. This phase is particularly relevant to the development of Work Package 3 in year two of the project.

Standardisation plays a pivotal role in this phase. By adhering to established standards for metadata and paradata, organisations can ensure consistency, interoperability, and reliability across different systems and platforms. Standardised metadata facilitates easier data sharing and integration, while also enhancing the discoverability and reusability of data. Moreover, it helps to maintain the authenticity and provenance of data, which is essential for long-term trust and verification.

In addition to metadata and paradata, data management also involves implementing robust storage solutions. This includes using redundant storage systems to protect against data loss, regularly backing up data, and employing data migration strategies to ensure data remains accessible as technology evolves. Effective data management also requires regular monitoring and maintenance to identify and address any issues that may arise.

Furthermore, data management encompasses the development of policies and procedures for data access and use. This includes defining who can access the data, under what conditions, and how the data can be used. Such policies are essential for protecting sensitive information and complying to copyright and other judicial aspects.

Data sharing

Sharing data in the field of cultural heritage is essential for expanding access, discoverability, and interoperability of cultural resources. It allows researchers, educators, and the public to benefit from the wealth of information preserved in digital formats. Our scoping review focused on sources, networks, and projects dealing with data aggregation. Notable examples include Europeana and the upcoming common European data space for cultural heritage (2024). These platforms aggregate cultural heritage data from various institutions across Europe, making it accessible to a wide audience. A significant development in this phase is the upcoming launch of the European Collaborative Cloud platform for Cultural Heritage. This platform aims to enhance collaboration and data sharing among cultural heritage institutions, further improving the accessibility and interoperability of cultural resources.

By adopting common standards for data formats, metadata, and protocols, cultural heritage institutions can ensure that their resources are compatible and easily integrated with other datasets. This not only facilitates seamless data exchange but also enhances the quality and reliability of shared information. Standardisation helps in overcoming technical barriers, enabling diverse systems to communicate effectively. Moreover, it supports the long-term preservation of digital assets by ensuring that data remains accessible and usable over time, regardless of technological changes.

In essence, standardisation is the backbone of efficient data aggregation and sharing, enabling a more connected and collaborative cultural heritage community. Additionally, data sharing initiatives often involve the development of digital platforms and repositories that provide centralised access to cultural heritage data. These platforms typically offer advanced

search and discovery tools, user-friendly interfaces, and various features to support data visualisation and analysis.

It is important to note that data sharing is not limited to making data available online. It also involves engaging with the community. Such engagements help to raise awareness about the available data, encourage its (re)use, and foster a sense of ownership and responsibility among stakeholders.

Finally, data management and data sharing must be accompanied by clear licensing and usage policies. These policies define the terms under which data can be accessed and used, ensuring that the rights of data creators and owners are protected while promoting open access and reuse of data.

It should be underlined here that the research conducted by WP3 is not extensive; the general absence (or difficulty to retrieve) day-to-day digitisation practices in institutional repos set a first caveat in our current scope review. Secondly, and most importantly, the current research document is envisioned to be iterative, and meant to be updated, revised and enriched throughout the project. The current list of sources can be found in the Scoping Sources chapter. Some screenshots from the live document:

Source Title	2	3	4	6	c r e a t i v e	M a n a g e r i a l	S h a r i n g	Reference	Relevance to IMPULSE
European Commission, Expert Group on Digital Cultural Heritage and Europeana (2020). Basic principles and tips for 3D digitisation of tangible cultural heritage for cultural heritage professionals and institutions and other custodians of cultural heritage. https://digital-strategy.ec.europa.eu/en/library/basic-principles-and-tips-3d-digitisation-cultural-heritage		x			x	x	x	https://digital-strategy.ec.europa.eu/en/library/basic-principles-and-tips-3d-digitisation-cultural-heritage	The list contains 10 basic principles for 3D digitisation of tangible cultural heritage, and a number of tips for each of them.
COMMISSION RECOMMENDATION of 27 October 2011 on the digitisation and online accessibility of cultural material and digital preservation (2011/711/EU)								https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32011H0711	The document is about digitizing and preserving cultural heritage in Europe. It discusses the benefits of digitization and the challenges of ensuring access to cultural material. The article also outlines recommendations to address these challenges, such as collaborating with the private sector and promoting the use of open standards. Some important points are that the cost of digitization is high and that there are not always clear policies for preserving digital content.
Common European data space for cultural heritage Annual Report 2022/2023		x				x	x	https://pro.europeana.eu/files/Europeana-Professional/Publications/data-space-annual-report-2022-2023.pdf	The common European data space for cultural heritage is the flagship initiative of the European Commission to accelerate the digital transformation of Europe's cultural sector. The data space builds on the Europeana Digital Service Infrastructure (Europeana DSI) and the Europeana Strategy 2020-2025. The data space is deployed by a consortium of 19 partners from nine EU

Screenshot from the "EU Policy and Reports" scoping sources (see below for the full list)

Project Name	Source Link	2	3	4	6	a	e	a	Relevance to IMPULSE
3D-ICONS	3D-ICONS – 3D Digitisation of Icons of European Architectural and Archaeological Heritage (3dicons-project.eu)	x				x			The goal of the 3D-ICONS project, funded under the European Commission's ICT Policy Support Programme which builds on the results of CARARE (www.carare.eu) and 3D-COFORM (www.3d-coform.eu), was to provide Europeana with 3D models of architectural and archaeological monuments of remarkable cultural importance. The project brought together 16 partners from across Europe (11 countries) with relevant expertise in 3D modelling and digitization. The main purpose of the project was to produce around 4000 accurate 3D models which had to be processed into a simplified form in order to be visualized on low end personal computers and on the web.
4CH	https://www.4ch-project.eu/	x	x			x	x	x	4CH starts on the 1st January 2021 for a duration of three years. The project aims to set up the methodological, procedural, and organizational framework of a Competence Centre 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.
5Dculture	https://www.5dculture.eu/	x				x	x		5Dculture enriches the offer of European 3D digital cultural heritage assets in the data space and fosters their reuse in important domains such as education, tourism and the wider cultural and creative sectors towards socially and economically sustainable outcomes. In particular, the project will: a) deliver high-quality 3D content by identifying and engaging existing datasets from partners' collections focusing on topics of fashion, archaeology and architecture, all of which occupy a central place in the vast cultural heritage of Europe and b) develop several reuse scenarios, which will experiment with the aforementioned assets in their complexity (from high-quality to derivatives) in the following domains:
AI4Culture	https://pro.europeana.eu/project/ai4culture-an-ai-platform-for-the-cultural-heritage-data-space						x	x	The project aims to develop the 'AI4Culture platform', an online capacity building hub for the application of artificial intelligence technologies in the cultural heritage sector. The platform will offer access to a pool of AI-related resources (such as openly labelled datasets for training and testing AI models), a set of deployable and reusable tools and capacity building materials.

Screenshot from the "Projects" scoping sources (see below for the full list)

Source Title	3	4	6	c	M	g	S	References	Relevance to IMPULSE
3D data: Creation to Curation: Community Standards for 3D Data Preservation	x		x	x	x	x		https://www.ala.org/sites/default/files/a/cr/content/publications/booksanddigitalresources/digital/9780838939147_3D_OA.pdf	There has been rapid growth in the production and usage of 3D data over the last decade, yet the preservation* of these data has lagged behind to the detriment of scholarship and innovation. While the need for digital 3D data preservation is widely recognized, the ongoing development of 3D data creation processes and the evolving usage of content still present many open-ended questions about how to ensure the stability and durability of this data type.
3D Digitization in Cultural Heritage Institutions Guidebook	x	x		x				https://www.academia.edu/68906660/3D_Digitization_in_Cultural_Heritage_Institutions_Guidebook	This guide specifically refers to objects, sites, or buildings that are digitized from a real-life counterpart, as few 3D models are born digital, i.e., a 3D object without a real-world counterpart (Flynn 2019b). This guide will primarily address 3D digitization technologies, including what techniques are used for different objects, sites, and settings, which methods are used to avoid or correct troubleshoot problems, and which techniques are best implemented in archives, libraries, and museums, specific to this guide. This guide will also contain references to advanced 2D+ technologies, which are augmented two-dimensional recording technologies that can be combined with 3D technologies to obtain a more accurate and informative image. Community Standards for 3D Data Preservation (CS3DP) initiative to move toward establishment of standards:2 The goal of this work is to identify the broad, shared preservation needs of the whole community, and it is viewed as essential to use a collaborative approach for standards development that promotes individual investment and broad adoption.
3D icons project case studies	x			x				http://3dicons-project.eu/wp-content/uploads/2018/08/Case-Studies-for-Testing-the-Digitisation-Process-Interim-report.pdf	This interim report and the accompanying case studies are being developed as part of 3D ICONS work package 2. The aim of this work is to perform evaluation tests on specific parts of the 3D data collection and 3D data post-processing pipeline that will be set in use in order to preserve the 3D

Screenshot from the "Guidelines and Case Studies" scoping sources (see below for the full list)

Analysis of findings

2D data

Literature

Over the past two decades, the European Union has allocated substantial sums to help cultural heritage institutions digitise and disclose their collections. The funding schemes such as Horizon 2020 and its succeeding Horizon Europe aided to archive and preserve and make these assets accessible for research, innovation and education. Alongside this public investment in digitisation, the past fifteen years have seen the emergence of medium to large-scale programmes of 2D and 3D digitisation led by commercial enterprises as well as public initiatives (European Commission, 2020). Two-dimensional digitisation is perhaps the most standardised and best-documented method of digitisation worldwide and is divided into two main methods: scanning and digital photography (Malaperdas, 2021).

We start from the acknowledgement that there is a substantial amount of literature on the use of 2D data in cultural heritage. Researchers and professionals have explored various aspects of 2D data, including its visualisation, digitisation, standardisation, enrichment, preservation and aggregation. We will therefore highlight some exemplary academic studies before moving to the presentation of guidelines, standards, immersive platforms and projects.

The article of Malaperdas (2021) discusses the analysis of correct digitisation practices for optimal results, with a focus on printed (two-dimensional) materials such as maps, photographs, documents and other cultural relics. The article discusses the technical characteristics of each choice of digital imaging devices and distinguishes different types of quality calculation according to the material to be digitised.

Haddad (2022) offers a comprehensive review of the multidimensional aspects of digital documentation in his study. By emphasising on the particularity of every cultural heritage documentation project and the need for precision and specific teams, he concludes that the use of 2D (and 3D) non-invasive digital visual technologies introduces innovative methods for planning, executing and preserving digital documentation. Collaboration among members from various scientific and professional disciplines is essential (ibid).

In “Why Do We Digitise? The Case for Slow Digitisation” Prescott and Huges (2018) argue for a more deliberate approach to digitising manuscripts. Unlike mass digitisation, slow digitisation emphasises high-resolution imaging and advanced techniques like 3D and hyperspectral imaging to capture the intricate details of manuscripts. This method aims to create a comprehensive digital archive that preserves the multifaceted nature

of the original materials. The authors highlight the importance of contextualising the limitations of digital scholarship and viewing digitisation as an ongoing process rather than a one-time task.

A substantial amount of the university collections of all IMPULSE partners contains natural history artifacts. Brecko and Mathys (2020) offer a comprehensive review of all currently available techniques to digitise 2D+ (and also 3D) collections, with an emphasis on natural history artifacts. 2D+ digitisation provides a pseudo-3D effect extracted from 2D information through techniques such as Multi-Light Reflectance Imaging (Reflectance Transformation Imaging (RTI) or Photometric Stereo (PS)). Following the explanation of the various digitisation methods, subsequent chapters of the paper offer guidance on enhancing the 2D+ and 3D digital replicas of specimens. Techniques are then compared using test specimens, and solutions to prevent digitisation errors are also included. Ultimately, the paper briefly covers the dissemination of results and the data management of the digitised material.

Albeit focused on 3D digitisation, the European Commission's report on quality in 3D digitisation of tangible cultural heritage also provides useful resources on 2D data and digitisation (European Commission, 2020). The document maps the parameters, formats, standards, methodologies and guidelines that pave the way in the digitisation of cultural heritage.

Standards and guidelines

Digitisation in the field of cultural heritage is a several-stage process, and its workflow includes numerous components. These components set standards in the field of digitisation of cultural heritage and can be so fundamental that they have a significant impact on specific processes in cultural heritage institutions (Schilz and Rehbein 2022).

Metamorfoze is the Netherlands' national program for the preservation of paper heritage (thus, two-dimensional), first established in 1997 by the National Library of the Netherlands and the Dutch National Archives. The Metamorfoze Preservation Imaging Guidelines published in 2012 has been a seminal guide for the digitisation of two-dimensional materials such as manuscripts, archives, books, newspapers and magazines. The guidelines may also be applied when digitising photographs, paintings and technical drawings, and should be considered as the image quality standard. The guidelines have attracted wide attention in Europe and beyond, both from the cultural heritage sector as well as the manufacturing industry and are currently used at an international level. The standards document contains information and guidelines on the technical level for image criteria (quality levels, exposure tables), colour space, bit depth, colour accuracy/misregistration, technical targets and technical metadata (Metamorfoze Preservation Image Guidelines, 2012).

FADGI (Federal Agencies Digital Guidelines Initiative) is a collaborative initiative that started in 2007 by the US federal agencies in order to articulate common sustainable practices and guidelines for digitised and born-digital historical, archival and cultural content. The FADGI Technical Guidelines for Digitising Cultural Heritage Materials intends to assist digital heritage imaging professionals and those who design and implement digitisation projects. The guidelines contain information about the FADGI Conformance program, also known as "Star System," that ranges from level 1 (acceptable) to level 4 (best) according to the quality of the final image while prioritising the consistency of the process (Technical Guidelines for Digitising Cultural Heritage Materials, 2023). The guidelines also provide recommendations for preferred file formats and evaluation criteria, appropriate equipment, metadata (descriptive, technical, administrative), quality management and storage recommendations (ibid).

The International Organisation for Standardisation (ISO) has extended its expertise to cultural heritage, photography and archiving systems and issued several technical reports on the best practices for digital image capture of cultural heritage. The Technical Report 19264-1 (2021) sets the standards for system set up and calibration, the imaging system quality analysis procedure, quality characteristics and metrics, and the reporting results. The Metamorfoze and FADGI guidelines allow you to conform to the ISO-standard. The ISO Technical Report 19263-1 (2017-03) analyses the standards for optimal image quality characteristics, test chart technical features, running scale features, colour patch features, image quality levels and principles of image capture and processing. Ultimately, the Technical Report ISO/TR 17321-3 (2017-04) offers user controls and readouts for scene-referred imaging applications.

Several institutions have published specific guidelines and workflows regarding the digitisation of cultural heritage objects by means of 2D data.

As a starting point, the Rijksmuseum offers a manual for the photography of 2D objects, highlighting the importance that all pictures are captured digitally in accordance with international standards to achieve the best digitisation results. An important added value of correct digital image capturing is the increased accessibility of the data for research purposes, and the document offers clear guidelines for cultural heritage photographers on these two topics (Rijksmuseum, 2021/2024).

The International Federation of Library Associations and Institutions (IFLA) has also developed its own digitisation planning guidelines, providing detailed guidelines on the selection of the material, the project design and workflow, the digitisation process and post-capture image processing. Regarding data management, a detailed set of guidelines for descriptive, technical and administrative metadata is also provided, as well as recommendations for the long-term preservation, re-use and dissemination of digital collections (IFLA, 2021).

The National Archives, the official archive and publisher for the UK Government, England and Wales has published an extensive guide on techniques for digitising documents and other materials. The guide provides guidelines about document handling during the scanning process, image capture and quality, file formats, conversion (TIFF to JP2) for digital surrogates, and (embedded) metadata validation (The National Archives, 2023).

Similarly, the National Archives and Records Administration (NARA, United States of America) has issued the Digitisation Quality Management Guide to “help agencies learn about the various aspects of QM in digitisation, including quality assurance and quality control, as well as the role of objective testing and automation in optimising quality control and inspection processes” (National Archives and Records Administration, 2023).

Based on several professional standards and best practice guidelines, the Smithsonian Institution Archives created its own standards/guidelines for digitising still images by following and exceeding the FADGI guidelines (Smithsonian Institution Archives, 2017).

Provenance, the Journal of the Society of Georgia Archivists, provides an interesting case study describing how the photography equipment and set up of San-Francisco State University’s Digital Scholarship Centre were tested and manipulated in order to reach the 4-star tier of the FADGI guidelines. This case study shed light to the daily practices of GLAM institutions; specifically, to how optimal quality digitisation can be reached even with limited photography skills and tools. (Martin, 2022).

The Library of Congress has issued its Recommended Formats Statement for 2024-2025, with specific mentions to textual works, for example books, still images, photographs, cards, fine prints, music scores or other types of documents, either print or digital. The recommended elements include the technical characteristics, faithful representation to the work (applicable to image works) formats, rarity and special features, technological measures, as well as metadata schemes, in a range from “acceptable” to “preferred”. (Library of Congress, 2024).

Finally, several cultural institutions have released their own sets of guidelines regarding the digitisation of cultural objects, either as the result of ad hoc digitisation cases or as general recommendations for fellow cultural practitioners. The outburst of COVID-19 and subsequent multiple quarantines coincide with an increased interest in digitisation practices and production of relevant literature, highlighting the important role of accessibility to cultural heritage in times of crisis.

Moving on to medium or smaller scale institutions, there are some paradigms worth mentioning. The Ontario Museums Association (OMA) and the Government of Canada have assembled and published online a comprehensive digitisation toolkit, comprising of two parts, one for digitising tangible (photographs, negatives, ephemera) and intangible heritage (video

recordings, a type of data we will further analyse below) and one explaining the minutiae of digital preservation. The toolkit aims to assist museums, archives and independent researchers to digitise their existing collections and provide guidelines to implement digital preservation procedures (Ontario Museums Association, 2020).

Although prominent institutions like the Rijksmuseum, IFLA, and the US National Archives have established comprehensive guidelines and standards for digitisation, their implementation varies significantly across cultural heritage institutions. Larger organisations often possess the necessary resources, expertise, and funding to adhere closely to these standards. In contrast, mid-sized and smaller institutions face considerable obstacles, such as limited resources, skills, and infrastructure. This disparity results in a wide gap in the quality and consistency of digitisation practices. As a result, while the guidelines offer a solid framework, their practical application differs greatly, underscoring the need for tailored support and resources to help all institutions achieve high-quality digitisation outcomes.

Networks and Projects

Two-dimensional cultural heritage has been at the heart of many European projects, consortia and networks.

Among the most commonly identifiable organisations dealing with digital cultural heritage is Europeana, a web portal created by the European Union with the goal to provide access to millions of digitised cultural heritage items from institutions across Europe. Although not limited to two-dimensional material (the collection is also rich in audiovisual archives), Europeana hosts a vast collection of digitised 2D data originating from books, newspapers, postcards and photographs. Europeana does not work directly with each institution. Instead, a network of aggregators collects their items and its related data, checks it thoroughly, and enriches it with information like geo-location, or links it to other material or datasets through associated people, places, or topics. (Europeana, 2024).

Regarding the documentation and aggregation phases of digitized data, the Europeana Data Model (EDM) is an interoperable framework that allows the collection, link and enrichment of cultural heritage metadata. As a theoretical data model, it allows data to be presented in different ways according to the practices of the various domains which contribute data to Europeana. The mapping guidelines of the EDM offer guidance to the institutions that want to map their data in compliance with the EDM. These guidelines show which property relates to each class and contain information on the data types that can be used as values, as well as the obligation level of each property. They also include examples of original data and data converted to EDM, showing the distribution of the properties across the classes (EDM Mapping Guidelines, 2017).

PHOTOCONSORTIUM (International Consortium for Photographic Heritage) is a non-profit association whose purpose is the promotion and enhancement of the culture of photography and photographic heritage. It organises and promotes conferences, exhibitions, events and training courses. It is Europeana's main aggregator network, specialised in photographic content. Since 2014 it has rendered accessible over 500.000 photographs from around 50 partners, showcasing famous heritage collections from public institutions and private agencies, and unveiling the previously unknown photographic content of private collectors, small local archives and institutions. Additionally, PHOTOCONSORTIUM offers advice services on digitisation, digital curation, management and aggregation practices (PHOTOCONSORTIUM, 2024). PHOTOCONSORTIUM approaches the concept of digitisation to safeguard the memories and stories stored in cultural heritage objects, and this process naturally brings together complex and heterogenous data associated with digital objects. To leverage on both the volume and quality of this information, new approaches for improved searchability/retrievability and metadata enrichment have been developed (Bachi et al, 2018).

Albeit a field with a demonstrated history, two-dimensional data are still the main topic of research projects, either in Academia or in cultural institutions. TEXTaiLES (TEXTile digitisAtion toolS and mEthodS for cultural heritage) is a recently funded Horizon Europe project dealing with novel methods of digitising textile materials (traditionally classified as two- dimensional) with the assistance of AI- developed tools, aiming to establish a standardised protocol that seamlessly integrates into the ECCCH. The project is expected to take an all-encompassing approach to standardisation, integrate state-of-the-art AI technologies and merge into a 4D multi scale annotation interface, coupled with a digital twin model ([TEXTile digitisAtion toolS and mEthodS for cultural heritage](#) | [TEXTaiLES](#) | [Project](#) | [Fact sheet](#) | [HORIZON](#) | [CORDIS](#) | [European Commission \(europa.eu\)](#))

Moving on to Germany, in 2018, a grant from the Deutsche Forschungsgemeinschaft (German Research Foundation) allowed for the digitisation of all the collection inventories, files, and other associated documentation currently held by the Ethnologisches Museum, dating from the year 1830 up until 1947. The digitisation process was completed this year, and the 1.600 historical documents are accessible to the public. These digitised materials constitute one of the most completely preserved archival holdings within the Staatliche Museen zu Berlin network. As such, they are of use not only for research on topics relating to the history of the museum and its collection, but also for better understanding broader administrative procedures within the museum. (SMB, 2024). A detailed document about the digitisation process is available in German (Ethnologisches Museum, 2024).

Immersive environments

Two-dimensional data is also present in several immersive heritage applications. Cecotti (2022) offers an extensive review of the currently available software dealing with cultural heritage in fully immersive virtual reality. The paper also highlights the progress

in the implementation of applications that provide immersive learning experiences related to cultural heritage, from 360 images to photogrammetry and 3D models. Regarding 2D data, a plethora of cultural heritage immersive environments are in fact 3D representations of 2D models and contain 2D scans of digitised cultural heritage objects. We will indicatively present five case studies.

Great Paintings VR: (released in 2021). Great Paintings VR allows users to browse among more than 1000 famous paintings from the early Renaissance to the beginning of the twentieth century [20]. The images are taken from Wikipedia with many images coming from the Google Art project, in which museums provide content in high resolution for free. Some images were upsampled using artificial intelligence techniques, i.e., deep learning, to increase the quality of the images (Cecotti 2022).



Image 1. Great Paintings VR.

Städel Time Machine: (released in 2016). It is a virtual museum dedicated to Frankfurt's Städel Museum and how it looked in 1878 (Cecotti, 2022). The project has its roots in the 1990s, when historical inventory books were transcribed and painting provenances evaluated for the Old Masters Department's inventory research (Städel Museum, 2016). The app contains 3D reconstructions of paintings.



Image 2. Städel Time Machine.

Mona Lisa Beyond the Glass (released in 2019). It is the first VR experience presented to the public by the Louvre Museum and is conceived as part of the Museum's seminal Leonardo da Vinci exhibition. Mona Lisa: Beyond the Glass reveals the latest scientific research on da Vinci's artistic innovation and his painting techniques and processes through visualisation. (Steam: 2019).



Image 3. Mona Lisa: Beyond the Walls.

Claude Monet- The Water Lily Obsession (released in 2019). This is not a traditional VR museum, but rather a contemplative passive experience that invites the viewer to a journey starting from Claude Monet's Garden and ending up in the exhibition room of the Orangerie Museum, where his large paintings are exposed (Cecotti 2022)



Image 4. Claude Monet- The Water Lily Obsession

IL DIVINO: Michelangelo's Sistine Ceiling (released in 2019): This is a fully immersive VR experience where the user can walk through and learn about the Sistine Chapel ceiling, acquiring a genuine experience of the highest fidelity with high-resolution textures. This application allows the user to step onto Michelangelo's own scaffold and learn about how he painted the ceiling or enter a Vatican conservator's mobile aerial platform to see the ceiling up close and learn about the controversial cleaning (Cecotti 2022).



Image 5. IL DIVINO: Michelangelo's Sistine Ceiling in VR

3D DATA

Academic literature

There is a substantial amount of academic literature on the 3D digitisation of cultural heritage, as the field has gained substantial expansion due to its potential to preserve and document tangible heritage materials.

Pavlidis and Koutsoudis (2022) explain the demanding process of creating digital copies for 3D real-worlds objects, especially when their geometric complexity goes beyond elementary solid shapes. They present an overview of the principal 3D digitisation methods that can be found in scientific literature, namely i) measurement techniques using lasers (i.e. triangulation), ii) shape/ structure from X, iii) traditional approaches (photogrammetry, topography), iv) special techniques (digital holography, X-ray tomography). Each method is analysed according to its individual principles, strengths and weaknesses. Lastly, the paper discusses the influence of object characteristics in the selection and application of the most appropriate methods and particularly on how the objects' size is a decisive factor in cultural heritage 3D digitisation projects.

Gervasi et al. (2022) depart from the detrimental consequences of the pandemic to the cultural heritage landscape and aim to establish a set of best practices defining methods and technologies that will enable the effective digitisation of cultural heritage on a large scale. They focus on the issues that may arise with the manual realisation of works using Blender and Unity software and analyse the digitisation process of the Piazza IV Novembre in Perugia, the Fontana Maggiore, the Republic Square in Foligno, the Palazzo Trinci and the Cathedral of San Feliciano, reaffirming that the photogrammetry technology is able to reconstruct three-dimensional elements and produce very detailed immersive models.

3D Data Creation to Curation: Community Standards for 3D Data Preservation is a volume edited by Moore, Rountrey and Scares Kettler (2022) dealing with the often overlooked and as rapidly developed (as opposed to data creation) sub-field of data preservation. This volume includes surveys of current practices, recommendations for implementation of standards, and identification of areas in which further development is required in the areas of 3D data preservation, management and storage for 3D data, metadata requirements, copyright and legal issues, as well as access and discoverability issues (Moore, Rountray and Kettler 2022).

When it comes to standards, Storeide et al (2023) have issued a review of standards implementation in 3D in cultural heritage. The review aims to underline the current

limitations in implementing 3D workflows for various cultural heritage purposes. 45 projects and institutions are analysed and reviewed, along with the most prominent guidelines for workflows and ways of implementing the 3D data on the web. The review also touches on issues of public accessibility, standardisation and interoperability.

The Commission Recommendation (EU) 2021/1970 on a common European Data Space for Cultural Heritage is to pave the way for a common data space for heritage, enhancing digitisation and preservation efforts by heritage institutions. It encourages member states to develop digital strategies, adopt advanced technologies, and set clear digitisation goals. The recommendation also emphasises partnerships, innovation, and addressing the digital skills gap to help cultural heritage institutions become more resilient in the future. It covers all types of cultural heritage (tangible, intangible, natural, born digital), including all the categories of cultural heritage at risk. (European Commission, 2021)

Guidelines

Concerning three-dimensional data, in the more recent years several institutional guidelines emerged out of day-to-day digitisation practices within cultural institutions, repositories or relevant projects and which may deviate substantially from the academic studies or policy recommendations in the sector.

The European Commission's study on quality in 3D digitisation of tangible cultural heritage is a key document and contains valuable information on 3D data- centered processes. As a practice- based document, the study focuses on the terminology (accuracy and precision), the different multi-sensory and multi-spectral scanning technologies, interviews with professionals as well as standards, data formats and metadata schemes for 3D structures. What is particular in this study is the mention to Extended Reality, the Metaverse, Digital Twins, Artificial Intelligence and Machine Learning (European Commission, 2020).

The Society for Imaging Science and Technology (commonly referred to as imaging.org) is a large platform where technical and academic professionals and users go for knowledge of techniques, processes, and systems for imaging. *The Recommended 3D Workflow for Digital Heritage Practices* is a document that resulted from the International Archiving Conference of 2023. This specific document addresses the concerns in the field of digital heritage by setting out a series of recommendations for establishing a workflow for 3D objects, with focus on long term preservation and dissemination. The recommended workflow consists of components data acquisition, data preservation, data description, data curation and processing, data dissemination, as well as data interoperability, analysis and exploration. Each component is supplemented by suggestions for standards and tools, which are either already common in 3D practices or represent a high potential component

seeking consensus to formalise a 3D environment fit for the Humanities, such as efforts carried out by the International Image Interoperability Framework (IIIF) (Manz et al, 2023).

3D Digitisation in Cultural Heritage Institutions Guidebook (Cieslik, 2020) is a document solely based on the experience of museum professionals. The guide primarily addresses 3D digitisation technologies, including what techniques are used for different objects, sites, and settings, which methods are used to avoid or correct troubleshoot problems, and which techniques are best implemented in archives, libraries, and museums, specific to this guide. Specifically, it consists of sections on a 3D Pipeline of Developing a 3D Model from Raw Data, file formats, metadata preservation and metadata standards.

The Consortium of Academic and Research Libraries of Illinois (CARLI) has published their own guide of best practices for the digitisation of three- dimensional objects. Topics covered in this document include image capture (equipment needed, camera settings, photography techniques) image management, adding compound objects to CONTENTdm, and metadata (descriptive, technical etc.) (CARLI, 2020).

The EUreka 3D project (which will be further analysed below) has issued a set of 3D Digitisation Guidelines based on the European Commission's Report (2020). The guide is specifically aimed at cultural heritage professionals responsible for the digitisation of tangible collections. It outlines and simplifies the recommended methodologies highlighted in the European Commission report (*Study on quality in 3D digitisation of tangible cultural heritage*, 2020). After addressing the issues of quality and complexity, the process of 3D digitisation is mapped in all its stages (project planning, documentation, technical aspects, object analysis, proposed recording methods and tools, agreed levels of accuracy, precision and error, data management, metadata and paradata, and ultimately publication and dissemination strategies).

A partner in several cultural heritage projects, the association "Historic England" provides their own Guide for good practices in Photogrammetric Applications in Cultural Heritage. The guide covers the practical application of photogrammetry in recording cultural heritage, with reference to structure from motion (SfM) techniques. (Historic England, 2017).

Projects and Networks

Regarding the three-dimensional digitisation of cultural heritage, there are many projects aiming to preserve and share cultural artifacts using advanced technologies such as 3D scanning. The field of 3D digitisation has additionally been a constant priority of the European Union, as it is demonstrated by European Commissions' Recommendation on the digitisation and online accessibility of cultural material and digital preservation (2011/711/EU) and the Recommendation on a common European data space for cultural heritage (C/2021/7953). Therefore, several cultural heritage projects centred around 3D digitisation

have received funding from the European Union. Some exemplary projects will be analysed below.

The EUreka 3D project (2023, funded by the Digital Europe Programme of the European Union) addresses the need for facilitating the digital transformation in the sector of cultural heritage by offering capacity building, (re)training and new service to cultural institutions. The project's actions focus specifically on 3D digitisation, accessibility, storage and sharing. To achieve these goals, EUreka 3D engages in a variety of CH institutions in piloting actions that i) set up dedicated cloud-based services for the preservation and management of cultural content, ii) generate high- quality 3D digitisation of selected items and their related metadata and paradata ready to be harvested by Europeana, iii) perform aggregation of the digitised content to the platform of Europeana. The project has so far issued a set of 3D digitisation guidelines (2023), related deliverable reports as well as a milestone achievement report on high quality 3D digitisation within the project. (EUreka 3D, 2024).

5Dculture is a project dedicated to the deployment and demonstration of 3D cultural heritage. 5Dculture enriches existing European 3D digital cultural heritage assets in the data space and fosters their reuse in crucial domains such as education, tourism and the wider cultural and creative sectors, towards socially and economically sustainable outcomes. The project has been delivering high- quality 3D content taken from the datasets of the partners' collections and given focus on the reuse scenario in the domains of fashion, 3D archaeological content, historical buildings and cityscapes.

The project AUTOMATA (AUTOMated enriched digitisation of Archaeological liThics and cerAMics) is a recently- funded Horizon project dealing with 3D digitisation in archaeology. AUTOMATA envisions to transform the time-and-resources-consuming digitisation process by enabling low-cost and time-efficient digitisation. Using AI-augmented robotics and sensors, the project will create 3D models enriched with archaeometric data, providing a practical and cost-effective solution for digitisation. Robotic tools with newly developed AI methodologies will improve the digitisation process of visible and non-visible properties of archaeological finds, enhance the robustness and efficiency of 3D digitisation, improve surface appearance acquisition, and additionally integrate 2D representations. This approach streamlines data acquisition, aided by human-AI collaboration, and, consequently, the collection of big, well-identified data will empower the development of AI models (European Commission, 2024).

Immersive Platforms

In his study, Cecotti (2022) also includes immersive platforms that display three-dimensional digitised cultural heritage objects.

Nefertari: Journey to Eternity (2018). It is an educational immersive environment that guides the player through the tomb of the famous Egyptian queen. The player can explore the dark tomb to look the way it would have over 3000 years ago, with two light-wielding controllers. The player can take a richly detailed and close-up look at painted hieroglyphics, interact with them and receive voiced information. In this application, the player can learn about Nefertari and the most famous Egyptian gods and goddesses. The high-resolution texture and the work for modelling the environment and the lights are key assets of this application (Cecotti 2022).



Image 6. Nefertari: Journey to Eternity.

Guildford Castle VR (2022). Inspired by one of England's oldest castles, this is a roaming, narrative VR experience that allows the user to visit the 14th century version of the castle and surroundings. The VR includes a hyper-realistic digital double of the castle as it stands today, created using state-of-the-art 3D scanning techniques (Historic VR, 2022).



Image 7. Guildford Castle VR.

4D Data

Academic literature

As already discussed above, four-dimensional data (4D data) in cultural heritage may refer to the integration of three-dimensional spatial data with the fourth dimension of time. In our scoping review however we specify 4D data as time-based medium such as audio and audio-visual data to differentiate two-dimensional, three-dimensional and time-based data sources.

In their study on the 4D Reconstruction and Visualisation of Cultural Heritage, Rodríguez-González et al (2017) provide a comprehensive approach for time-varying representations in cultural heritage, analysis and visualisation across different working scales and environments. They map the numerous challenges that 4D modelling entails, as well as the specifications, needs and requirements of the CH community to understand the required levels of 4D model information.

Liew departs from the unique challenges and difficulties that occur during the digitisation of audiovisual material such as the file size, the age of analogue materials, copyright and digital rights issues, and ultimately the lack of proper resources on digitisation and standards. With a specific emphasis on memory institutions, she investigates the experiences of cultural professionals in audiovisual preservation and maintenance. The findings indicate that while some institutions are actively pursuing digitisation, others face significant limitations due to insufficient funding, lack of knowledgeable and skilled staff, and inadequate equipment.

Smaller institutions, in particular, struggle with the absence of standards and the pressure of unrealistic best practices, as they cannot afford specialised equipment or the recruitment and training of specialist staff (Liew, 2019). This study is particularly important in the context of our review, as it highlights the everyday problems and difficulties of cultural professionals when standards and guidelines, albeit existing, are not efficiently discoverable, retrievable and implemented.

Guidelines

When it comes to guidelines for the digitisation, preservation and sharing of audiovisual heritage, the International Association of Sound and Audiovisual Archives (IASA) is a leading professional association concerned with the care, access and long-term preservation of the world's sound and moving image heritage. Its publication venue, the *Journal of the International Association of Sound and Audiovisual Archives* (also known as the IASA Journal) represents the collected research and applied work of the global audiovisual archives community and assembles a rich mass of research studies and case studies on care, access and long-term preservation of the world's sound and moving image heritage.

The IASA Committee on Standards, Recommended Practices and Strategies has been offering generic advice on preservation strategies since 2017, assembled in the "Safeguarding of the Audiovisual Heritage: Ethics, Principles and Preservation Strategy". The document offers guidance on ethical matters, information and safeguarding and the selection of optimal copies, optimal signal retrieval from carriers, preservation of carriers, digital target formats and accuracy, data management, archiving principles, long-term storage and metadata preservation.

IASA has also issued the TC-6 Guidelines for the Preservation of Video Recordings (2019), a document which provides guidelines on video signal, preservation concepts, target formats, video carriers, extraction and workflows for video digitisation.

FIAT/IFTA is the global network of audiovisual archives and a leading association for the professionals engaged in the preservation and exploitation of audiovisual archives. One of the numerous initiatives of the association (along with workshops and grants) is the "Preservation and Migration" Seminar, organised on a yearly basis since 2021. Indicative topics covered in the seminars are the issue of acceptance criteria in the context of massive migration processes (FIAT/ IFTA 2021), the digitisation and digital preservation of cinematographic works (FIAT/ IFTA 2022), the preservation life cycle of audiovisual content (FIAT/ IFTA 2023) and the preservation of authenticity of media archives content (FIAT/IFTA 2024).

Other guidelines concern the management of 4D data. Declercq (2017) presents the Hourglass Model, a framework that allows to redesign the strategies for the creation and reuse of descriptive metadata in audiovisual archives. This model outlines the categories

of metadata creation (manual annotation, production, user generation, automatic extraction) and three categories of use (preservation and collection management, search and retrieval, enhancement and contextualisation). It is suggested that the implementation of the model would have an impact not only on the technical, but also on the organisational and institutional level.

Projects and Networks

The digitisation, preservation and sharing of audiovisual heritage has been welcomed and supported by the European Union. The EU Screen (established in 2009), for example, is a Commission-funded network of European broadcasters and audiovisual archives, media scholars, and technical experts that facilitates engagement with audiovisual archived content through access to their portal. The EUscreen portal offers free access to thousands of archival audiovisual items, bringing together clips that provide an insight into the social, cultural, political, and economic events that have shaped the 20th and 21st centuries.



Image 8. Browsing through the curated collections of EUscreen

The European Film Getaway (EFG, initiated in 2008) is a portal that provides quick and easy access to hundreds of thousands of film history documents held in European film archives and cinemathèques. This initiative is aimed at both scholars and the public and facilitates online access to historical documents by redirecting the user to the archives that hold the originals. The EFG also hosts special collections of films from the First World War period (approx. 3000 titles) and from the post- Second World War Reconstruction period.

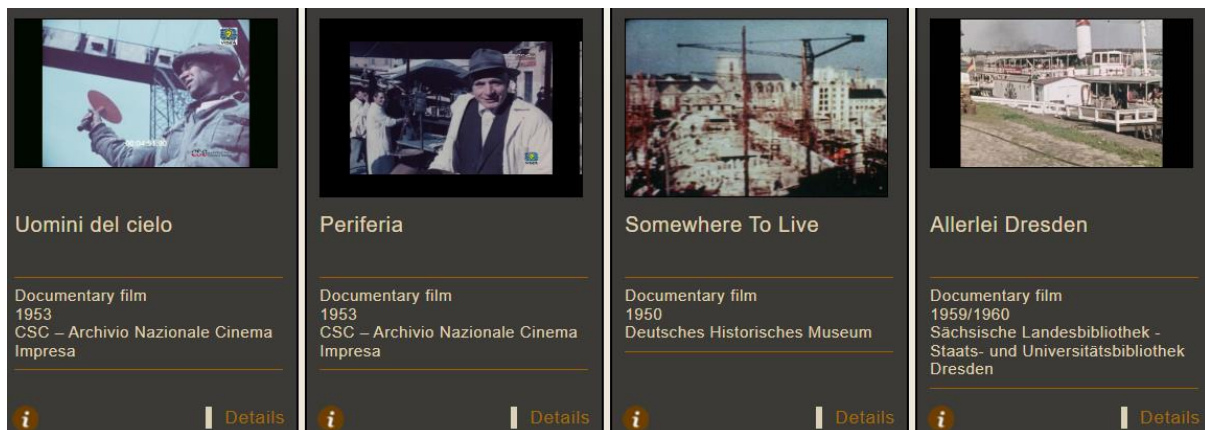


Image 9. A glimpse from the EFG portal on postwar audiovisual material.

Sound and Vision (BEELD & GELUID) is the Dutch institute for media culture. Sound & Vision manages one of the largest digitised media archives in the world, including radio, television, YouTube videos, objects, written press, podcasts and games. The organisation interprets current events from a media- historical perspective, functioning both as a Media Museum and a knowledge institution.



Image 10. The Collection of Sound & Vision on YouTube.

An indicative project that reuses audiovisual heritage for curatorial and memory studies is the “Visual History of the Holocaust. Rethinking Curation in the Digital Age” (Horizon 2020) As a project it aims at the re-evaluation of the visual history of the Holocaust, based on a comprehensive mapping, contextualisation, and reframing of film documents recorded by Allied troops during and after the liberation of Nazi concentration camps. The project develops interdisciplinary approaches that bring together researchers and professionals from various backgrounds and aims to develop novel methods of digital curation, apply technologies such as automated analysis and time-based annotation, create metadata solutions and vocabularies and increase critical awareness. So far “Visual History of the Holocaust” has issued several deliverables about the role of audiovisual heritage

in the ECCCH, databases of literature, digitised films and visual culture materials, metadata integration guides, as well as a digitisation toolkit (VHH, 2024).

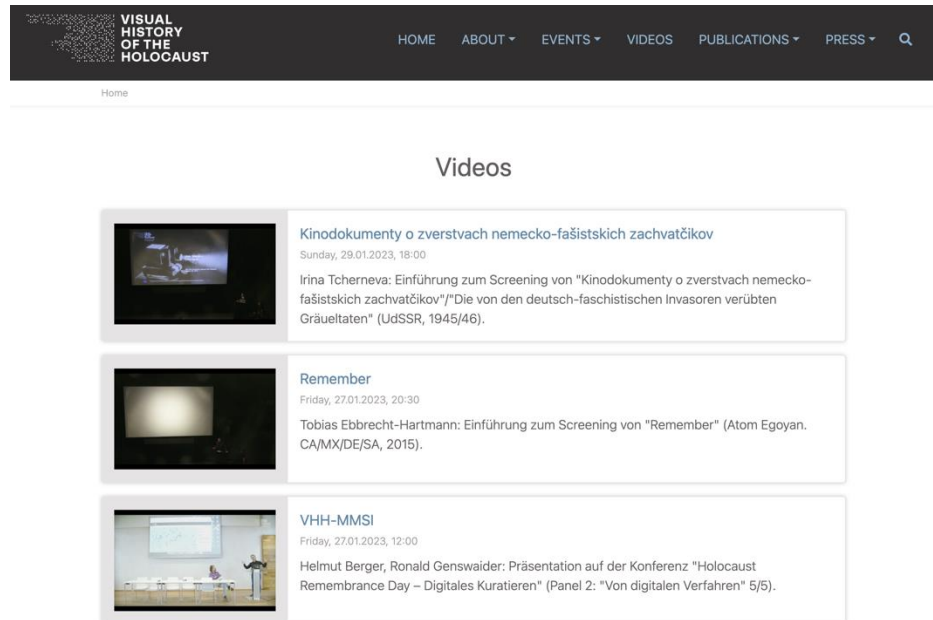


Image 11. Visual History of the Holocaust video archive

E- Kinas (E- Cinema) is a Lithuanian project funded by the European Regional Development Fund that aims to develop advanced electronic services and establish a National Centre of Competence for the Digitisation of Audiovisual Heritage. During the Project, 229 hours of film content stored in the archive was digitised and made available on the Internet, including important events in Lithuania's history in 1988–1992.

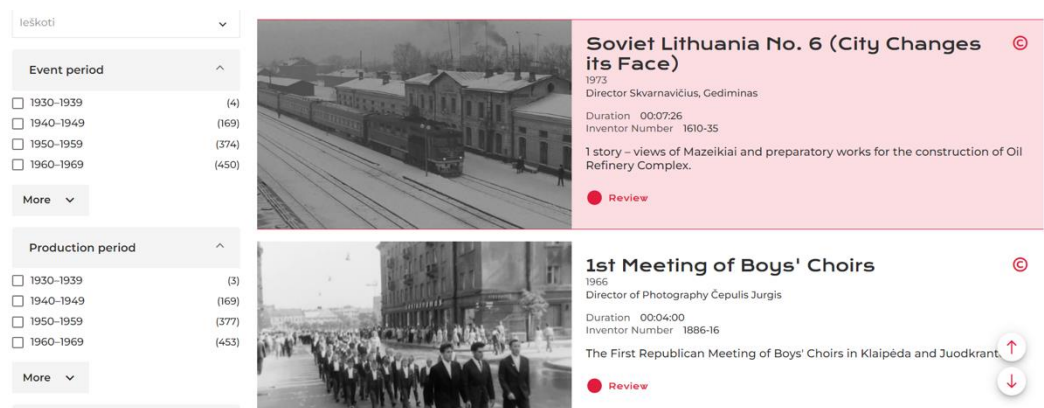


Image 11. The E- Kinas Collection.

Finally, Europeana has its own Europeana Sounds project that run from 2014 to 2017. Comprising of 24 partners, the project gathered sound collections from across Europe

to enrich and aggregate metadata for them to fit them into the Europeana platform and improve constraints caused by copyright issues. The project resulted in the Europeana Music thematic collection, Europeana Radio, policy recommendations, and a task force within IASA.

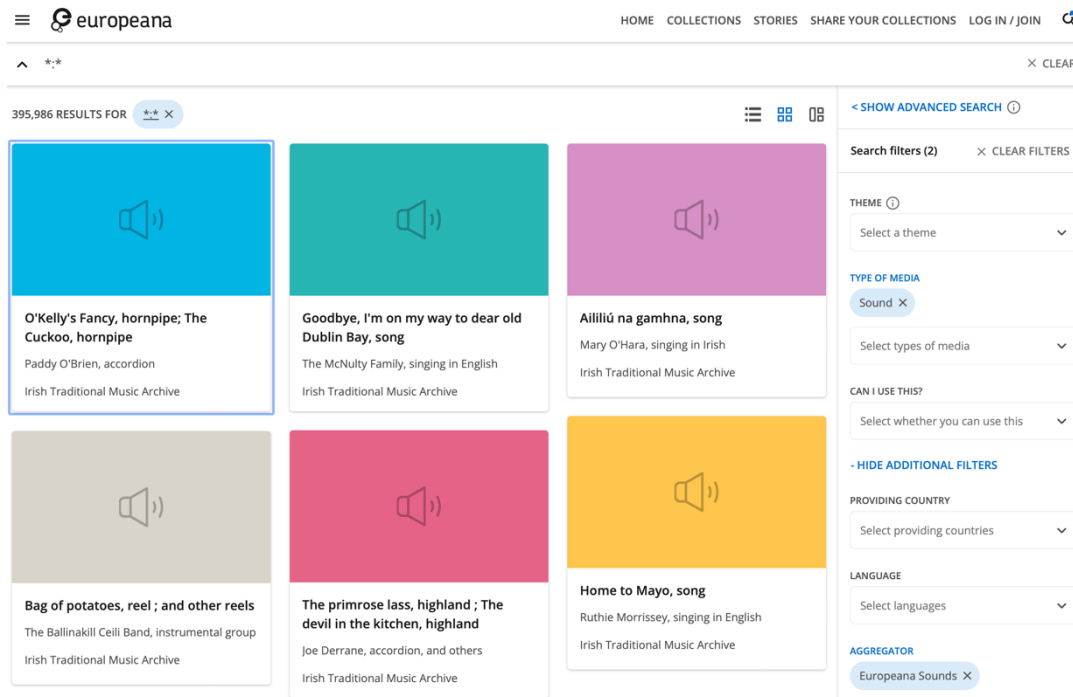


Image 12. The Europeana Sounds collection on Europeana

6D Data

Given the fact that there has been significant growth in virtual reality (VR) applications and immersive environments over the past years, the field of (digital) cultural heritage has not remained unaffected. As the existing 2D, 3D and 4D data types have integrated in the virtual world, the impact of immersive heritage has already started being studied.

Academic literature

Innocente et al (2023) contribute to the debate with a framework study on the use of immersive XR technologies in the cultural heritage domain. This study is a comprehensive literature review that examines case studies utilising fully immersive systems, highlights core characteristics that favour the adoption of these systems over more traditional solutions and addresses existing gaps.

In 2023, an academic conference entirely dedicated to the multiple uses of Extended Reality (XR) was held in Salento. The published proceedings include a separate section for eXtended

Reality and the Metaverse in Cultural Heritage, with topics such as: case studies of VR reconstructions of ancient/medieval monuments, to be featured in immersive platforms, enhanced accessibility in VR, conceptual frameworks for VR integration in museums, VR/AR/XR applications in modern history, education, digital ethnography and many more. (De Paolis et al, 2023).

A thorough review of the software that is currently available that deals with cultural heritage in fully immersive virtual reality is presented by Cecotti (2022). The applications are grouped according to their content (galleries, museums, specific artists or artworks) and according to workload, usability, flow, and potential VR symptoms surveys. Although a lot of progress has been made, the paper highlights the discrepancy between academic scholarship dealing with VR cultural heritage and the actual software available to the public audience.

A more recent article presents a ten-year bibliometric analysis of publications in the field, resulting in a detailed overview of virtual reality (VR), augmented reality (AR), and mixed reality (MR) technologies in cultural heritage. The contribution of this research lies in offering valuable insights for practitioners and researchers, helping them make informed decisions on the use of immersive technologies in heritage contexts. (Zhang et al, 2024).

Standards and guidelines

It is noteworthy that, while the topic of digitised 2D, 3D and 4D data is being increasingly studied in an academic context, the management and sharing of new forms of data that emerge is still unexplored in academic sources. A similar imbalance is observed in policy recommendations, institutional documents and guidelines. However, as it will be shown below, a lot of projects on immersive heritage have received funding very recently and are currently developing material within their deliverable goals, so the landscape may differ soon.

The Metaverse Standards Forum is an independent consortium that provides a venue for cooperation between standards organisations and companies to foster the development of interoperability standards for an open and inclusive metaverse (Metaverse Standards, 2024). Although not creating standards itself, the Forum coordinates requirements and resources to foster standard evolution within relevant domains. It has also initiated a pipeline of Exploratory and Working Groups, carrying out projects such as '3D Asset Interoperability using USD and glTF', '3D Web Interoperability', 'Accessibility in the Metaverse', 'Digital Asset Management', 'Digital Fashion Wearables for Avatars', 'Metaverse Educational Register', 'Interoperable Characters/Avatars', 'Industrial Metaverse Interoperability', 'Metaverse Standards Register', 'Network Requirements and Capabilities', 'Privacy, Cybersecurity & Identity', 'Real/Virtual World Integration' and 'Technical Interoperability and End-User Troubleshooting', 'Volumetric Media Interoperability.' The exploratory groups currently include 'Ethical Principles for the Metaverse', 'XR Device Interoperability.'

Projects and Networks

CAPHE (Communities and Artistic Participation in Hybrid Environment, 2023) a four-year project aiming to investigate, perform and elaborate upon an enhanced model of interaction and somatic participation in hybrid environments that comprise both physical and virtual layers among artists and communities from traditional and virtual cultural backgrounds. The three focus areas of CAPHE are art, education and community, within which the concept of eXtended Reality Participation is being developed. The project makes use of diverse methodologies including field research, interviews and virtual cooperation through the use of Augmented Reality, Mixed Reality and Virtual Reality technologies (CAPHE, 2023).

Five projects that received funding under the same call and share a similar thematic and methodological approach have formed the Digital Cultural Heritage Cluster. Work across the cluster includes digitisation of cultural artefacts, improving the accessibility of cultural objects and spaces, and facilitating engagement with history and culture in a digital age. These projects are namely: MEMENTOES, PERCEIVE, SHIFT, MuseIT and PREMIERE.

- i) MEMENTOES (immersive games for museums as vehicles to engage visitors in empathetic responses): This project addresses how historical information and cultural memory gets lost in today's inflated media environment. MEMENTOES seeks to preserve this valuable information through video games. By pairing three museums focused on historical injustices – the USSR's gulags, wars impacting children, and a mining disaster – with independent game developers, the players will inhabit different perspectives and experience the daily lives of marginalised groups. (MEMENTOES, 2024).
- ii) PERCEIVE (Perceptive Enhanced Realities of Coloured Collections through AI and Virtual Experiences): PERCEIVE seeks to advance the digital capability of scientists and cultural institutions through a service-based AI architecture and toolkit, and by developing a new design theory for on-site and remote VR/AR/MR experiences, based on the concepts of "Care", "Accessibility", and "Authenticity", with and for the creative industries, expanding the access to Cultural Heritage and Art outside museums for wider integration with society. (PERCEIVE, 2024).
- iii) MuseIT (Multisensory, User-centred, Shared cultural Experiences through Interactive Technologies): The core principles of the project are inclusion and equal opportunities for all. Despite critical advances in immersive cultural heritage, structural deficiencies remain lack of accessibility for all, limited opportunities and limited interoperable digital repositories for archiving accessible multisensory cultural assets and related archival structures. The MuseIT project aims to co-design, develop, and co-evaluate a multisensory, user-centred platform for enriched engagement with cultural assets with inclusion and equal opportunity for all as core principles. The MuseIT innovation is rooted in multisensory representations of cultural heritage which extend beyond the visual and auditory senses (MuseIT, 2024).

- iv) PREMIERE (Preserving and enhancing cultural heritage with advanced digital technologies): The overall objective of PREMIERE is to develop and validate a comprehensive ecosystem of digital applications, powered by leading edge AI, XR and 3D technologies, designed to fulfil the needs of diverse end-user communities involved in the main stages of the lifecycle of performing arts productions, including amateur and professional performers, performance art producers and curators, performance art spectators and scholars (PREMIERE, 2024).
- v) SHIFT (MetamorphoSiS of cultural Heritage Into augmented hypermedia assets For enhanced accessibiliTy and inclusion): SHIFT envisions to strengthen the cultural heritage assets and increase the accessibility and usability of artifacts through appealing content representation, enriched user experience, inclusive designing and engaging business models. To achieve these objectives, SHIFT is using new AI technologies, machine learning, semantic representations and haptic interfaces (SHIFT, 2024).

OPENVERSE (2023) is a coordination and support action funded by Horizon Europe. Its overarching goal is to create inclusive, open, and ethically responsible European virtual worlds that will leverage the European Union's technological position in the global arena. OPENVERSE aims to lay the foundational framework for these virtual worlds, combining user co-creation with extended reality technologies, addressing legal and ethical challenges, and guiding future policy and industry standards for globally influential virtual worlds. The guiding objectives of the project are inclusivity, accessibility, interoperability, security, innovation and collaboration (OPENVERSE, 2024).

Immersive platforms

i-MareCulture (Advanced VR, iMmersive serious games and Augmented as tools to raise awareness and access to European underwater CULTURAL heritage) focuses on the naturally unreachable and understudied field of underwater cultural heritage. The project's aim is to raise awareness of Europe's rich underwater heritage by implementing virtual visits, games with immersive technologies and underwater augmented reality. Scope of the project is to design, analyse, develop and validate pioneer applications and systems in the context of Virtual Museums through collaborative and innovative research from a diverse group of scientists, researchers, archaeologists, experts and museums (i-MareCulture, 2018)

MEMORISE (2022) is another project dealing with memory studies and the Holocaust. As most witnesses of the Nazi persecution pass away, MEMORISE aims to keep their memories alive through novel digital storytelling strategies. To do so, the project digitised the diaries, testimonials and recordings of the victims and import them in virtual environments. The plans include the development of a smartphone application that narrates victims' experiences based on augmented reality (AR) solutions to enhance memorial site visitor experiences, as well as a web-based interface that gives access to all materials and supports narrative virtual experiences for everyone.

Outside European Union funding schemes, some higher education institutions also develop their own immersive heritage projects. The University of Amsterdam, for instance, has developed “Virtual Past Places”, a website aimed to give access to the virtual reality rooms created by the 4D Research Lab (also run by the same university). The virtual places present the results of archaeological excavations and give tours within virtual exhibitions (Virtual Past Places, 2024).

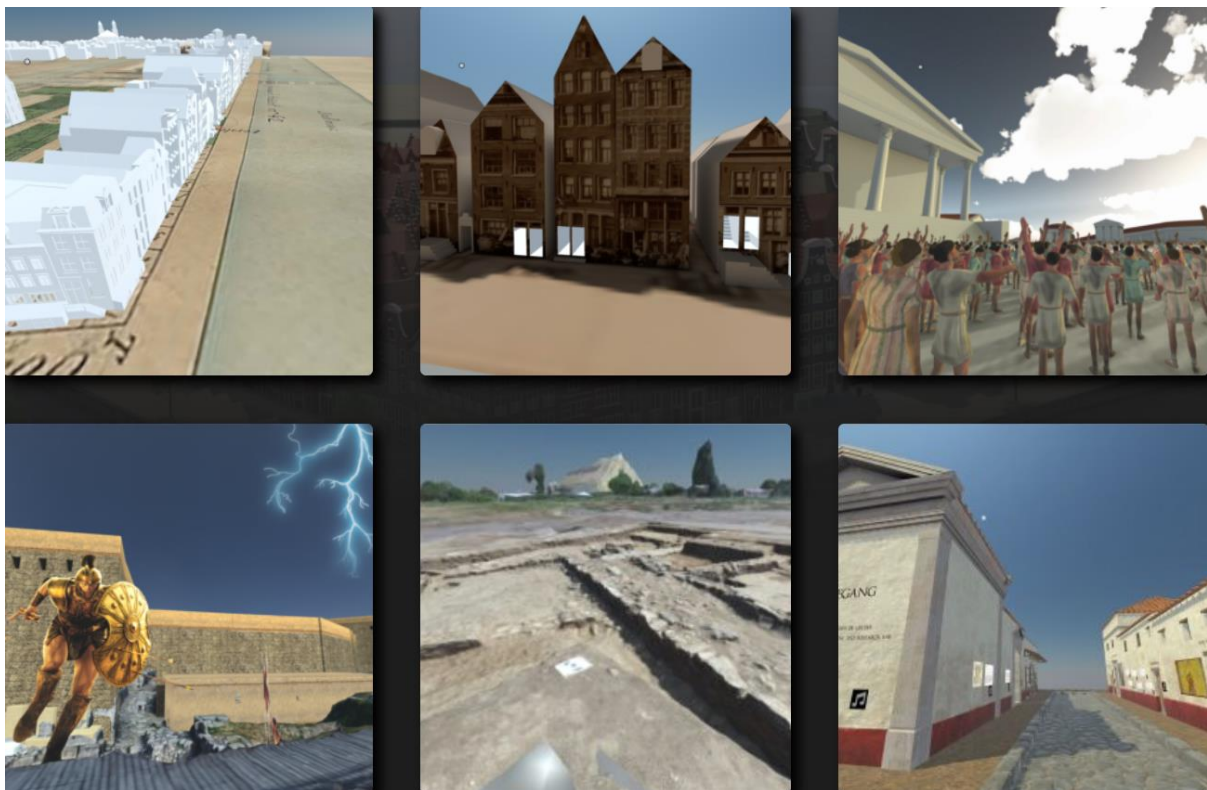


Image 12. Virtual Past Places

The University of Glasgow is developing the Museums in the Metaverse (MIM), a project that will create a two-sided Extended Reality (XR) Cultural Heritage platform that aims to empower diverse visitors to explore cultural assets in new and engaging ways and enable cultural heritage professionals and non-specialist users to create new content. One side of the proposed platform is intended for visitors and the other is for virtual curators, where experts and beginners alike can build enriching and entertaining narratives using (mostly Scottish) objects and virtual environments that have never been placed together in the real world (University of Glasgow, 2023).

Conclusions

The IMPULSE project, as outlined in the document, aims to investigate the digitisation and management of cultural heritage data, particularly focusing on the challenges and opportunities presented by immersive platforms. This report, written from the perspective of a heritage institution, targets professionals and institutions in the field, providing insights and recommendations based on the lens of WP3 on standardisation.

The scoping review provided a wealth of literature and established practices in the management and sharing of 2D, 3D, and 4D data. 2D data has been extensively studied, and there are well-defined standards and methodologies for their digitisation, metadata creation, and sharing. For instance, 2D data creation, is well-supported by standards on file formats and guidelines like the Metamorfoze Preservation Imaging Guidelines and FADGI Guidelines. 3D data (digital models of physical objects) is also moving towards more standardisation with documents such as the *Study on quality in 3D digitisation of tangible cultural heritage* and the guidelines developed in projects like EUreka3D and 3D-ICONS. 4D data, what we consider as time-based media, is also well-documented, particularly in the context of audiovisual materials, with guidelines from organisations like IASA and FIAT/IFTA.

In contrast to the rich literature on 2D, 3D, and 4D data, there is a notable gap in the management and sharing of 6D data. 6D data involves the integration of 2D, 3D, and 4D data within immersive environments, allowing for interactive, immersive and multidimensional experiences. This gap legitimizes the mission of the IMPULSE project, which aims to research new methodologies and standards for 6D data for enhanced sustainability. The lack of established practices and standards for 6D data poses challenges for heritage institutions in terms of management, sharing and digital preservation of their digitised collections to create immersive experiences to engage with the public.

The document identifies a significant discrepancy between theoretical frameworks and practical applications in the field of digitisation. While academic literature often provides theoretical frameworks and highlights specific case studies, their practical implementation at the institutional level is less evident. Developing workflows and implementing processes for -at times fragile and unique- objects in a high-volume and data intensive digitisation facility in a sustainable manner is less evident than it seems, and practical documentation such as guidelines, departmental workflows etc. is hard to find.

It is precisely this grey literature, which includes reports, workflows, step-by-step plans, and other non-peer-reviewed sources, that often contains practical insights and real-world applications that are not captured in academic publications. However, the discoverability of grey literature poses a challenge, as it is not always easily accessible or indexed in conventional academic databases or even published online. It underscores the need

for better integration of theoretical and practical knowledge, and on a broader scale the openness of institutions to share their policy documents, internal documents with workflows, processes, practices, etc.

Metadata is crucial for the management and sharing of digital heritage data, and WP3 will focus on this area in the two following years of the project. For 2D, 3D, and 4D data, there are well-established metadata schemas and practices with specific standards for different collection types (library, archive, museum) and specific standards for each phase of the data life cycle. However, there is again a significant gap in metadata standards, as well as their implementation and searchability when it comes to immersive platforms and 6D data. The lack of standardised metadata for 6D data hampers the ability to make these data findable, accessible, interoperable, and reusable (FAIR principles) on immersive platforms. This gap in metadata standards and implementation is a critical barrier to the effective management and sharing of immersive digital heritage experiences.

The research and scoping review we have conducted is by no means complete and finished, as sources will continue to be added to the references. The ongoing document will serve as a foundation for further development of the IMPULSE project in general, and WP3 in particular. It will allow to build on the findings and address the identified gaps in the future research. The ongoing nature of the review highlights the dynamic and evolving landscape of digital or digitised heritage, where new technologies and methodologies continuously emerge. The IMPULSE project aims to stay at the forefront of these developments, ensuring that heritage institutions can effectively leverage digital technologies to preserve, manage, and share cultural heritage in innovative and impactful ways.

References

5DCulture (2023). Retrieved from: [Home | 5Dculture.eu](#)

Beeld & Geluid (2024). Retrieved from: [Home | The Netherlands Institute for Sound & Vision \(beeldengeluid.nl\)](#)

Brecko, J., & Mathys, A. (2020). Handbook of best practice and standards for 2D+ and 3D imaging of natural history collections. European Journal of Taxonomy, 623. <https://doi.org/10.5852/ejt.2020.623>

CAPHE (Communities and Artistic Participation in Hybrid Environment, 2023). Retrieved from: [CAPHE – Communities and Artistic Participation in Hybrid Environments](#)

Cecotti, H. (2021). *Great Paintings VR*. Available online: https://store.steampowered.com/app/1511090/Great_Paintings_VR/

Cecotti, H. (2022). "Cultural Heritage in Fully Immersive Virtual Reality" *Virtual Worlds* 1, no. 1: 82-102. <https://doi.org/10.3390/virtualworlds1010006>. Retrieved from: [Cultural Heritage in Fully Immersive Virtual Reality \(mdpi.com\)](#)

Cieslik, E. (2020). *3D Digitisation in Cultural Heritage Institutions Guidebook*. Retrieved from: [\(36\) 3D Digitisation in Cultural Heritage Institutions Guidebook | Emma Cieslik - Academia.edu](#)

Consortium of Academic and Research Libraries of Illinois (2020). GUIDELINES FOR THE CREATION OF DIGITAL COLLECTIONS Digitisation Best Practices for Three-Dimensional Objects. Retrieved from: [guidelines for 3D.pdf \(illinois.edu\)](#)

De Paolis, L. T., Arpaia, P., & Sacco, M. (Eds.). (2023). *Extended Reality: International Conference, XR Salento 2023, Lecce, Italy, September 6-9, 2023, Proceedings, Part II* (Vol. 14219). Springer Nature Switzerland. <https://doi.org/10.1007/978-3-031-43404-4>

Declercq, B. (2017). Canalising the Maelstrom of Metadata: Extensions on the Hourglass Model. In *Sustainable Audiovisual Collections Through Collaboration*. Indiana: Indiana University Press.

E- Kinas (2018-) Retrieved from: [About E-Cinema | E-kinas](#)

Emissive, H.V (2019). *Mona Lisa Beyond The Glass*. Available online: https://store.steampowered.com/app/1172310/Mona_Lisa_Beyond_The_Glass/

EUscreen (2009-2024). Retrieved from: [Home - EUscreen](#)

EUreka 3D (2024). Retrieved from: [Home - eureka3d](#)

EUreka 3D (2024). 3D DIGITISATION GUIDELINES: Steps to Success. A guide based on the EU VIGIE2020/654 Study on quality in 3D digitisation of tangible cultural heritage. Retrieved from: [3D-digitisation-guidelines-EUreka3D.pdf](#)

Europeana: [About](#) | [Europeana](#)

Europeana Foundation, (2017). Europeana Data Model –Mapping Guidelines v2.4. Retrieved from: [EDM - Mapping guidelines - Europeana Knowledge Base - Confluence \(atlassian.net\)](#)

Europeana Sounds. Europe's sound heritage at your fingertips (2014-2017). Retrieved from: [Europeana Sounds: Europe's sound heritage at your fingertips! \(eusounds.eu\)](#)

European Commission (2021) [COMMISSION RECOMMENDATION of 10.11.2021 on a common European data space for cultural heritage](#)

European Commision (2024). *AUTOMated enriched digitisation of Archaeological liThics and cerAmics*. Retrieved from: [AUTOMated enriched digitisation of Archaeological liThics and cerAmics | AUTOMATA | Project | Fact sheet | HORIZON | CORDIS | European Commission \(europa.eu\)](#)

European Commission (2024). *TEXTile digitisAtion toolS and mEthodS for cultural heritage | TEXTaiLES* | Project | Fact sheet | HORIZON | CORDIS | European Commission (europa.eu)

European Commission. Directorate General for Communications Networks, Content and Technology. (2020). *Study on quality in 3D digitisation of tangible cultural heritage: mapping parameters, formats, standards, benchmarks, methodologies, and guidelines*. VIGIE 2020/654 Final Study Report. <https://data.europa.eu/doi/10.2759/471776>

European Film Getaway (2008-2024). Retrieved from: [European Film Gateway](#)

Evans, C.; Huston, P.; Bunn, W.; Dixson, E.; Norden, C. (2019). *IL DIVINO: Michelangelo's Sistine Ceiling in VR*. Available online: https://store.steampowered.com/app/1165850/IL_DIVINO_Michelangelos_Sistine_Ceilin_g_in_VR/

Experius VR (2018). *Nefertari: Journey to Eternity*. Available online: [Nefertari: Journey to Eternity on Steam \(steampowered.com\)](https://www.steampowered.com)

Gervasi, O., Perri, D., Simonetti, M., Tasso, S. (2022). Strategies for the Digitalisation of Cultural Heritage. In: Gervasi, O., Murgante, B., Misra, S., Rocha, A.M.A.C., Garau, C. (eds) *Computational Science and Its Applications – ICCSA 2022 Workshops. ICCSA 2022. Lecture Notes in Computer Science*, vol 13382. Springer, Cham. https://doi.org/10.1007/978-3-031-10592-0_35

Government of Canada, (2020). Digital preservation. Retrieved from: [Digital preservation - Canada.ca](https://www.canada.ca)

FADGI [Guidelines: Technical Guidelines for Digitising Cultural Heritage Materials - Federal Agencies Digital Guidelines Initiative \(digitisationguidelines.gov\)](https://www.fadgi.org)

FIAT/IFTA (2021). *PRESERVATION & MIGRATION SEMINAR 2021. Acceptance criteria in the context of massive migration processes*. Retrieved from: [PRESERVATION & MIGRATION SEMINAR 2021 - FIAT/IFTA \(fiatifta.org\)](https://www.fiatifta.org)

FIAT/IFTA (2022). *PRESERVATION & MIGRATION SEMINAR 2022. Film in Television archives. What is to be done?* Retrieved from: [PRESERVATION & MIGRATION SEMINAR 2022 \(fiatifta.org\)](https://www.fiatifta.org)

FIAT/ IFTA (2023). *PRESERVATION & MIGRATION SEMINAR 2023. The Preservation Life Cycle*. Retrieved from: [PRESERVATION & MIGRATION SEMINAR 2023 - FIAT/IFTA \(fiatifta.org\)](https://www.fiatifta.org)

FIAT/ IFTA (2024). *PRESERVATION & MIGRATION SEMINAR 2024. Preserving authenticity of media archives content*. Retrieved from: [PRESERVATION & MIGRATION SEMINAR 2024 - FIAT/IFTA \(fiatifta.org\)](https://www.fiatifta.org)

Government of Canada, (2020). Digitising Intangible Cultural Heritage. Retrieved from: [Digitising Intangible Cultural Heritage : A How-To Guide - Canada.ca](https://www.canada.ca)

Haddad, N. (2022). 3D and 2D Visual Digital Technologies and Cultural Heritage Documentation for Conservation and Monitoring: A Critical Review and Assessment. In: Sergiyenko, O. (eds) *Optoelectronic Devices in Robotic Systems*. Springer, Cham. https://doi.org/10.1007/978-3-031-09791-1_10

Henderson, L. D. (2013). *The fourth dimension and non-Euclidean geometry in modern art*. Revised edition. The MIT Press.

Historic England (2017). *Photogrammetric Applications for Cultural Heritage. Guidance for Good Practice*. Retrieved from: [Photogrammetric Applications for Cultural Heritage | Historic England](#)

Historic VR (2022). *Guildford Castle VR*. Available at: [Guildford Castle VR on Steam \(steampowered.com\)](#)

iMareCulture (Advanced VR, iMmersive serious games and Augmented as tools to raise awareness and access to European underwater CULTURAL heritage, 2018). Retrieved from: [iMareCulture – H2020 funded EU research and innovation project \(imareculture.eu\)](#)

Innocente, C., Ulrich, L., Moos, S., & Vezzetti, E. (2023). A framework study on the use of immersive XR technologies in the cultural heritage domain. *Journal of Cultural Heritage*, 62, 268–283. <https://doi.org/10.1016/j.culher.2023.06.001>

International Association of Sound and Audiovisual Archives, Technical Committee (2017). *The Safeguarding of the Audiovisual Heritage: Ethics, Principles and Preservation Strategy*. Retrieved from: [TC03 English.pdf \(iasa-web.org\)](#)

International Association of Sound and Audiovisual Archives (2019). *IASA- TC6 Guidelines for the Preservation of Video Recordings*. Retrieved from: [IASA-TC 06 Guidelines for the Preservation of Video Recordings | International Association of Sound and Audiovisual Archives \(iasa-web.org\)](#)

International Federation of Library Associations and Institutions (2021). *Guidelines for Planning the Digitisation of Rare Book and Manuscript Collections*. Retrieved from: [Guidelines for Planning the Digitisation of Rare Book and Manuscript Collections – IFLA](#)

ISO/TR 19263-1 (2017-03). *Photography — Archiving systems — Part 1: Best practices for digital image capture of cultural heritage material*. Retrieved from: [ISO TR 19263-1-2017.pdf \(dig4e.com\)](#)

ISO/TS 19264-1 (2021). *Photography — Archiving systems Image quality analysis Part 1* <https://www.iso.org/standard/79172.html>

ISO/TR 17321-3 (2017-04). *Graphic technology and photography — Colour characterisation of digital still cameras (DSCs) Part 3: User controls and readouts for scene-referred imaging applications*. <https://www.iso.org/standard/69475.html>

Liew, C. L. (2019). Digital Audiovisual Heritage: An Exploration of Challenges and A Community-based Approach to Preservation. *Proceedings of the 9th International Conference on Communities & Technologies - Transforming Communities*, 76–80. <https://doi.org/10.1145/3328320.3328367>

Lucid Realities, Studio n 130 (2019). *Claude Monet—The Water Lily obsession*. Available online: https://store.steampowered.com/app/1071170/Claude_Monet_The_Water_Lily_obsession/

Malaperdas, G. (2021). Standards for Digitisation in Cases of Maps, Documents, and other Relics in the Service of Cultural Heritage. *Trends Journal of Sciences Research*, 1(1), 24–32. <https://doi.org/10.31586/ojer.2021.99>

Manz, M., Julien Antoine Raemy, & Fornaro, P. (2023). Recommended 3D Workflow for Digital Heritage Practices. *Archiving*, 20(1), 23–28. <https://doi.org/10.2352/issn.2168-3204.2023.20.1.5>

Martin, M. J. (2022). FADGI on a Budget: Improving Digital Images for Library Staff and Faculty. In Provenance, the Journal of the Society of Georgia Archivists. 38 (1). Retrieved from: FADGI on a Budget: Improving Digital Images for Library Staff and Faculty (kennesaw.edu)

MEMENTOES (immersive games for museums as vehicles to engage visitors in empathetic responses, 2024). Retrieved from: Publications & Deliverables – Mementoes

Memorise, (2022) Retrieved from: MEMORISE (sdu.dk)

Metamorfoze Preservation Imaging Guidelines:
<https://www.metamorfoze.nl/english/digitisation>

Moore, J., Rounry, A., Kettler, H.S. (2022). (eds.). *3D Data Creation to Curation: Community Standards for 3D Data Preservation*. Chicago: Illinois.

MuseIT (Multisensory, User-centred, Shared cultural Experiences through Interactive Technologies, 2024). Retrieved from: What is MuseIT | MuseIT (muse-it.eu)

National Archives and Records Administration, (2023). DIGITISATION QUALITY MANAGEMENT GUIDE. Retrieved from: Digitisation Quality Management Guide (archives.gov)

Ontario Museums Association, (2020). Digitisation Standards. Retrieved from: [Digitisation Standards - An OMA toolkit \(museumsontario.ca\)](https://museumsontario.ca/digitisation-standards)

OPENVERSE (2024). Retrieved from: [Vision and strategy - Open Verse \(open-verse.eu\)](https://open-verse.eu)

Pavlidis, G., Koutsoudis, A. (2022). 3D Digitisation of Tangible Heritage. In: D'Amico, S., Venuti, V. (eds) *Handbook of Cultural Heritage Analysis*. Springer, Cham. https://doi.org/10.1007/978-3-030-60016-7_47

PERCEIVE (Perceptive Enhanced Realities of Coloured Collections through AI and Virtual Experiences, 2024). Retrieved from: [PERCEIVE - Perceptive Enhanced Realities of Coloured collections through ai and Virtual Experiences \(perceive-horizon.eu\)](https://perceive-horizon.eu)

PREMIERE (Preserving and enhancing cultural heritage with advanced digital technologies, 2024). Retrieved from: [The Project - Premiere \(premiere-project.eu\)](https://premiere-project.eu)

Prescott, A., Hughes, L.M., Why do we digitise? The case for slow digitisation. Archive Journal, <http://eprints.gla.ac.uk/165726/>

[PHOTOCONSORTIUM | Europeana PRO](https://photoconsortium.eu)

Rijksmuseum (2021, revised 2024), Photography 2-D Objects Manual - Part I. Retrieved from: [v-2024 eng-manual photography-2d-objects part1b.1cb460d33240.pdf \(foleon.com\)](https://www.rijksmuseum.nl/en/manual-photography-2d-objects-part1b)

Rodríguez-González, P., Muñoz-Nieto, A. L., Del Pozo, S., Sanchez-Aparicio, L. J., Gonzalez Aguilera, D., Micoli, L., Gonizzi Barsanti, S., Guidi, G., Mills, J., Fieber, K., Haynes, I., & Hejmanowska, B. (2017). 4D RECONSTRUCTION AND VISUALISATION OF CULTURAL HERITAGE: ANALISING OUR LEGACY THROUGH TIME. *The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, XLII-2/W3, 609–616. <https://doi.org/10.5194/isprs-archives-XLII-2-W3-609-2017>

Schilz, A., Rehbein, M. (2022). Digitisation of Cultural Heritage. In: Frenz, W. (eds) *Handbook Industry 4.0*. Springer, Berlin, Heidelberg. https://doi.org/10.1007/978-3-662-64448-5_64

SHIFT (Metamorphosis of cultural Heritage Into augmented hypermedia assets For enhanced accessibility and inclusion, 2024). Retrieved from: [About the project – SHIFT \(shift-europe.eu\)](https://shift-europe.eu)

Skublewska-Paszkowska, M., Milosz, M., Powroznik, P. et al (2022). 3D technologies for intangible cultural heritage preservation—literature review for selected databases. *Herit Sci* 10, 3. <https://doi.org/10.1186/s40494-021-00633-x>

Smithsonian Institution Archives, (2017). Digitising Collections. Retrieved from: [Digitising Collections | Smithsonian Institution Archives \(si.edu\)](#)

Staatliche Museen zu Berlin (2024). Ethnologisches Museum. Digitisation of the Historical Archive of the Ethnologisches Museum (1830–1947). Retrieved from: [Digitisation of the Historical Archive of the Ethnologisches Museum | Ethnologisches Museum \(smb.museum\)](#)

Staatliche Museen zu Berlin. (2024). Erweitertes Findbuch zum historischen Archiv und den historischen Sammlungsverzeichnissen im Ethnologischen Museum. Retrieved from: [Findbuch Tektonik.pdf \(smb.museum\)](#)

Städel Museum (2016). Städel Time Machine. Available online: <http://zeitreise.staedelmuseum.de/>

Storeide, M. S. B., George, S., Sole, A., & Hardeberg, J. Y. (2023). Standardisation of digitised heritage: A review of implementations of 3D in cultural heritage. *Heritage Science*, 11(1), 249. <https://doi.org/10.1186/s40494-023-01079-z>

Technical Guidelines for Digitising Cultural Heritage Materials, Third Edition. 2023. Retrieved from: [FADGI Technical Guidelines for Digitising Cultural Heritage Materials 3rd Edition 05092023.pdf \(digitisationguidelines.gov\)](#)

The Library of Congress (2024). Recommended Formats Statement. Retrieved from [Recommended Formats Statement 2024-2025 \(loc.gov\)](#)

The National Archives (2023). Digitisation at The National Archives. Guidance on techniques for digitising documents and other materials. Retrieved from [Digitisation at The National Archives](#)

University of Glasgow, (2023). *Museums in the Metaverse*. Retrieved from: [University of Glasgow - Research - Research units A-Z - Museums in the Metaverse - Museums in the Metaverse](#)

Van Dormolen, Hans (2012). Metamorfoze Preservation Imaging Guidelines. Retrieved from: [Metamorfoze Preservation Imaging Guidelines 1.0.pdf](#)

Virtual Past Places (2024). Retrieved from: [Virtual Past Places – Travel to the past in VR](#)

Visual History of the Holocaust. Rethinking Curation in the Digital Age. (2024). Retrieved from: [Visual History of the Holocaust \(vhh-project.eu\)](#)

Zhang, J., Ahmad, W., & Mageswaran Sanmugam. (2024). The Impact of Immersive Technologies on Cultural Heritage: A Bibliometric Study of VR, AR, and MR Applications. *Sustainability*, 16(15), 6446–6446. <https://doi.org/10.3390/su16156446>

Scoping sources

Policy Documents

Relevant European Policy Documents to Impulse (ongoing scoping, policy documents to be added during the project)

	2D	3D	4D	6D	Data creation	Data Management	Data Sharing	Reference	Relevance to IMPULSE
Source Title									
European Commission, Expert Group on Digital Cultural Heritage and Europeana (2020). Basic principles and tips for 3D digitisation of tangible cultural heritage for cultural heritage professionals and institutions and other custodians of cultural heritage. https://digital-strategy.ec.europa.eu/en/library/basic-principles-and-tips-3d-digitisation-cultural-heritage		x			x	x	x	https://digital-strategy.ec.europa.eu/en/library/basic-principles-and-tips-3d-digitisation-cultural-heritage	The list contains 10 basic principles for 3D digitisation of tangible cultural heritage, and several tips for each of them.

COMMISSION RECOMMENDATION of 27 October 2011 on the digitisation and online accessibility of cultural material and digital preservation (2011/711/EU)							https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32011H0711	The document is about digitising and preserving cultural heritage in Europe. It discusses the benefits of digitisation and the challenges of ensuring access to cultural material. The article also outlines recommendations to address these challenges, such as collaborating with the private sector and promoting the use of open standards. Some important points are that the cost of digitisation is high and that there are not always clear policies for preserving digital content.
--	--	--	--	--	--	--	---	---

Common European data space for cultural heritage Annual Report 2022/2023		x				x	x	https://pro.europeana.eu/files/Europeana_Professional/Publications/data_space_annual_report_2022_2023.pdf	The common European data space for cultural heritage is the flagship initiative of the European Commission to accelerate the digital transformation of Europe's cultural sector. The data space builds on the Europeana Digital Service Infrastructure (Europeana DSI) and the Europeana Strategy 2020-2025. The data space is deployed by a consortium of 19 partners from nine EU countries, coordinated by the Europeana Foundation. The work of the consortium is supported by the Europeana Network Association (ENA), a strong and democratic community with over 4,300 experts working in the field of digital heritage, and the Europeana Aggregators' Forum (EAF), the network of national, domain and thematic aggregators who support cultural institutions providing data. Collaboratively, EF, ENA and EAF form the Europeana Initiative. The data space is overseen by the Member States in the framework of the Commission Expert Group on the common European Data Space for Cultural Heritage (CEDCHE). Deployment and maintenance of the data space is organised in four strands of work: 1. Development and operation of the data space infrastructure 2. Integration of high-quality data 3. Capacity building and fostering reuse 4. Digital services for the public
Cultural heritage: digitisation, online accessibility and digital preservation: consolidated progress report on the		x				x	x	https://digital-strategy.ec.europa.eu/en/library/european-commission-report-cultural-heritage-digitisation-online-accessibility-and-digital	The report is structured in five chapters, each focusing respectively on: 1) how Member States plan, organise, and monitor digitisation of cultural heritage, 2) the scope of promoting public domain status after CH is digitised 3) the digitisation and accessibility of works that are orphan or out of commerce, 4) the quantitative targets achieved by Europeana and 5) the status of digital preservation among member states.

implementation of Commission Recommendation (2011/711/EU)2015-2017								
Digitisation and online accessibility of Europe's cultural heritage and digital preservation.	x			x	x	x	https://op.europa.eu/en/publication-detail/-/publication/ce2f5d67-3a5d-4882-975e-29721cf87fce	This document provides 10 basic tips for the 3D digitisation workflow that are further developed. It is useful for cultural professionals/institutions with no prior expertise to quickly get acquainted with the field.
Getting cultural heritage to work for Europe Report of the Horizon 2020 Expert Group on Cultural Heritage							https://data.europa.eu/doi/10.2777/745666	The digitisation of cultural heritage, whilst initially framed by institutions, is now increasingly a collective process involving community access and collective sharing of knowledge. Citizens' engagement in cultural heritage management and preservation could be further investigated in order to build on the emerging practice through new investment and the use of digital technologies. (p.9)
NUMERIC. Developing a statistical framework for measuring the progress made in the digitisation of cultural materials and content					x		NUMERIC - Publications Office of the EU (europa.eu)	The Numeric study has sought to establish a framework to measure the pace and cost of translating their collections into this rich resource. The study was conducted over two years (May 2007 to May 2009), and this report outlines the findings of a survey conducted among cultural institutions in member states of the European Union; and, based upon this experience, sets out recommendations for monitoring their digitisation activities in future.

Stakeholders' survey on a European collaborative cloud for cultural heritage: report on the online survey results.							x	https://data.europa.eu/doi/10.2777/691331	This survey has been a very successful consultation exercise on the digital transition: more than 1000 detailed replies from people working in relation to Cultural Heritage. The 4 highest prioritised tools among the respondents have in common the aspect of digital interaction: tools for creating, sharing and re-using interactive content on the Cloud (43.3%), tools for AI-assisted metadata enrichment i.e. to make cultural heritage content interoperable (37%), tools for advanced interaction with the digital content of the Cloud (36.4%), and tools for analysing, designing and testing interaction with visitors (33.6%).
Study on quality in 3D digitisation of tangible cultural heritage: mapping parameters, formats, standards, benchmarks, methodologies, and guidelines.	x	x				x	x	https://data.europa.eu/doi/10.2759/471776	Important document, which is particularly relevant to WP1, WP2 AND WP3. This study pays special attention to the fact that 3D digitisation of movable and immovable CH can be an exceptionally complex process, with numerous factors limiting the eventual quality of the 3D CH asset. Parameters such as budget, available time, object location and conditions, accuracy and precision, expertise become significant in setting both the production effort and output standard. At the time of finishing this report, there is a lack of internationally recognised standards or guidelines for planning, organising, setting up, managing, implementing, using paradata or metadata or evaluating CH 3D data acquisition results and projects.

The New Renaissance. Report of the "Comité des Sages " on bringing Europe's cultural heritage online						x	x	https://data.europa.eu/doi/10.2759/45571	The report urges EU Member States to step up their efforts to put online the collections held in all their libraries, archives and museums. It stresses the benefits of making Europe's culture and knowledge more easily accessible. It also points to the potential economic benefits of digitisation, including through public-private partnerships, for the development of innovative services in sectors like tourism, research and education. The report endorses the Digital Agenda's objective of strengthening Europe's digital library, Europeana, and suggests solutions for making works covered by copyright available online.
NEMO: Final report Digitisation and IPR in European Museums								https://www.nemo.org/fileadmin/Dateien/public/Publications/NEMO_Final_Report_Digitisation_and_IPR_in_European_Museums_WG_07.2020.pdf	This is an article about digitisation and intellectual property rights in European museums. It discusses the challenges museums face in digitising their collections and providing online access. The article also discusses the opportunities that digitisation offers museums, such as increased visibility and access. Some of the challenges that museums face include insufficient resources, staff, and equipment.

100 million hours of audiovisual content: digital preservation and access in the PrestoPRIME project			x			x		https://dl.acm.org/doi/10.1145/2039263.2039266	We report preliminary results of PrestoPRIME, an EU FP7 integrated project, including audiovisual (AV) archives, academics and industrial partners, focused on long-term digital preservation of AV media objects and on improving access by integrating media archives with European on-line digital libraries, specifically Europeana. Project outcomes will result in tools and services to ensure the permanence of digital AV content in archives, libraries, museums and other collections, enabling long-term future access in dynamically changing contexts. PrestoPRIME has a special focus on digital preservation in broadcast environments, where very large files of digital video must be preserved at high quality (suitable for future re-use in an AV production environment) in affordable distributed and federated archives. The adoption of standard solutions for digital preservation processes (metadata representation, content storage, digital rights governance, search and access) enables the interoperability of the proposed preservation framework and guidelines. The OAIS model was chosen for the reference architecture, METS is adopted as wrapper for metadata representation, while relevant standards (e.g. from W3C, ISO/IEC and others) are used for content and rights description. Project outcomes will be delivered through a European networked Competence Centre, to gather knowledge and deliver advanced digital preservation advice and services in conjunction with Europeana and other initiatives.
--	--	--	---	--	--	---	--	---	---

Recommendations for Standards and Trusted Audiovisual Repositories		x			x	https://pro.europeana.eu/files/Europeana_Professional/Projects/Project_list/Presto4U/Deliverables/deliverable_d4.3_presto4u_02_01_2015_v5r.pdf	The scope of D4.3 is to provide an overview of the importance of standards in audiovisual preservation and their adoption by the multifarious communities involved in preservation workflows. Even within different institutions, Communities of Practice (CoPs) have common needs and face the same challenges in audiovisual preservation. Standards form the backbone of tools and services responding to the needs of those involved in audiovisual preservation by providing reliable and sustainable frameworks around which services can be developed. This report builds upon the knowledge gathered throughout the duration of the project to present guidelines and recommendations on the use of standards and related best practices for long-term audiovisual preservation
4CH D1.3-Final-survey-of-the-experiences-and-technology-state-of-the-art	x			x	x	Deliverables – 4CH-Project	This report describes the results of Task T1.1 concerning European experiences and best practices in Conservation, Preservation and Valorisation of monuments and sites, and of Task T1.3 concerning the state of the art in relevant technologies. WP1 defines the basis for the achievement of project objective 1, collecting and relating experiences, skills and best practices acquired and implemented so far in the European Countries, with specific reference to EU-funded research. The WP's activities identify innovative approaches in initiatives, policies and strategies for the preservation and conservation of monuments and sites. In this way, it will help define in detail the fields which the Competence Centre will operate on.

D4.3 Updated report on standards and guidelines		x			x	x		https://www.4ch-project.eu/wp-content/uploads/2024/04/D4.3-Updated-report-on-standards-and-guidelines.pdf	This is the final report on standards and guidelines of the 4CH project, an initiative to design and prepare for a European Competence Centre focusing on the preservation and conservation of cultural heritage. This report provides an update on the earlier project reports (D4.1) on standards, procedures and protocols and (D4.2) on training. Its focus is on activities in 4CH to develop training and support services to facilitate the take up of state-of the art ICT technology.
Deliverable 5.1 Report on data management recommendations and guidelines		x				x		https://www.4ch-project.eu/wp-content/uploads/2024/04/D5.1-Report-on-data-management-recommendations-and-guidelines.pdf	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 center 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.

Standards

Relevant Standards to Impulse (ongoing scoping, standards to be added during the project)

Source Title	2D	3D	4D	6D	Data creation	Data	Data Sharing	References	Relevance to IMPULSE
Metadata									
CIDOC/CRM						x	x	http://cidoc.ics.forth.gr/	The CIDOC Conceptual Reference Model (CRM) is a theoretical and practical tool for integrating cultural heritage information. It provides a formal structure for describing concepts and relationships used in cultural heritage documentation, enabling data integration across diverse datasets ¹ . It doesn't define terms but focuses on relationships between entities ² .
Dublin Core Metadata Element Set						x	x	DCMI: Dublin Core™ Metadata Element Set, Version 1.1: Reference Description	The Dublin Core Metadata Element Set is a standardised vocabulary of fifteen properties for describing resources.
Encoded Archival Description						x	x	EAD: Encoded Archival Description (EAD Official Site, Library of Congress) (loc.gov)	Encoded Archival Description (EAD) is an XML standard for encoding archival finding aids, maintained by the Technical Subcommittee for Encoded Archival Standards of the Society of American Archivists, in partnership with the Library of Congress.
Europeana Data Model (EDM)						x	x	https://pro.europeana.eu/page/edm-documentation	The Europeana Data Model (EDM) is an interoperable framework that structures and represents data contributed by various cultural heritage institutions to Europeana.

METS	x				x	x	x	https://www.loc.gov/standards/mets/	The METS schema is a standard test for encoding descriptive, administrative, and structural metadata regarding objects within a digital library, expressed using the XML schema language of the World Wide Web Consortium. The standard is maintained by the METS Board in collaboration with the Network Development and MARC Standards Office of the Library of Congress and started as an initiative of the Digital Library Federation.
LIDO schema							x	https://www.lido-schema.org	LIDO – Lightweight Information Describing Objects is an XML harvesting schema. The LIDO schema is intended for delivering metadata, for use in a variety of online services, from an organisation’s online collections database to portals of aggregated resources, as well as exposing, sharing, and connecting data on the web.
MODS (Metadata Object Description Schema)						x	x	http://www.loc.gov/standards/mods/	Metadata Object Description Schema (MODS) is a schema for a bibliographic element set that may be used for a variety of purposes, and particularly for library applications. The standard is maintained by the Network Development and MARC Standards Office of the Library of Congress with input from users. -- More about MODS
Premis						x	x	PREMIS Data Dictionary for Preservation Metadata, Version 3.0 (Library of Congress) (loc.gov)	The PREMIS Data Dictionary and its supporting documentation is a comprehensive, practical resource for implementing preservation metadata in digital archiving systems. The Data Dictionary is built on a data model that defines four entities: Objects, Events, Rights, and Agents. Each semantic unit defined in the Data Dictionary is a property of one of the entities in the data model.
Resource Description Framework						x	x	https://www.w3.org/RDF/	RDF (Resource Description Framework) is a standard for describing web resources using triples (subject, predicate, object) to facilitate data interchange and interoperability on the web.

Spectrum Standard						x	x	Spectrum – Collections Trust	Spectrum is the UK museum collections management standard, widely used globally. It covers various aspects of metadata, including data identification, quality, spatial information, and distribution
MADS (Metadata Authority Description Schema)						x	x	Metadata Authority Description Schema (MADS) - (Library of Congress) (loc.gov)	The Metadata Authority Description Schema (MADS) is an XML schema for an authority element set that may be used to provide metadata about agents (people, organisations), events, and terms (topics, geographics, genres, etc.). MADS serves as a companion to the Metadata Object Description Schema (MODS) to provide metadata about the authoritative entities used in MODS descriptions. The standard is maintained by the MODS/MADS Editorial Committee with the Network Development and MARC Standards Office of the Library of Congress and input from users.
VRA Core						x		https://www.loc.gov/standards/vracore/	The VRA Core is a data standard for the description of works of visual culture as well as the images that document them. The standard is hosted by the Network Development and MARC Standards Office of the Library of Congress (LC) in partnership with the Visual Resources Association
Darwin Core						x		https://dwc.tdwg.org/	Darwin Core is a standard maintained by the Darwin Core Maintenance Interest Group. It includes a glossary of terms (in other contexts these might be called properties, elements, fields, columns, attributes, or concepts) intended to facilitate the sharing of information about biological diversity by providing identifiers, labels, and definitions. Darwin Core is primarily based on taxa, their occurrence in nature as documented by observations, specimens, samples, and related information.

CDWA (Categories for the Description of Works of Art)						x		https://www.getty.edu/research/publications/electronic_publications/cdwa/index.html	CDWA is a set of guidelines for the description of art, architecture, and other cultural works. CDWA represents common practice and advises best practice for cataloging, based on surveys and consensus building with the user community. CDWA is arranged in a framework to which existing art information data structures may be mapped and new data modelling may be referenced. CDWA is mapped to other standards in the Metadata Standards Crosswalk. An implementation of CDWA is the Cultural Objects Name Authority (CONA). A subset of CDWA is incorporated in Cataloging Cultural Objects, designed for the visual resources community. CDWA advises use of the Getty Vocabularies.
Marc standard						x	x	MARC STANDARDS (Network Development and MARC Standards Office, Library of Congress) (loc.gov)	The MARC 21 Format for Bibliographic Data provides detailed descriptions of data elements used in cultural heritage documentation, enabling integration across diverse datasets ¹ . It covers control fields (e.g., control numbers, dates), variable data fields (e.g., ISBN, call numbers), and includes summaries and abstracts
ALTO								https://www.loc.gov/standards/alto/	The Analysed Layout and Text Object (ALTO) XML Schema was initially developed by the METAe project group for use with the Library of Congress' Metadata Encoding and Transmission Schema (METS). While METS excels in describing the structure of objects, a schema related to the content and layout information of each piece of the object was missing. Claus Gravenhorst, who helped create ALTO for the METAe project, states that:
File Formats									
Tif (Tagged Image File Format)	x					x	x	https://en.wikipedia.org/wiki/TIFF	Tagged Image File Format; a versatile image format that supports a wide range of colour depths, compression schemes, and metadata.

Jpg (Joint Photographic Experts Group)	x				x	x	x	https://en.wikipedia.org/wiki/JPEG	Joint Photographic Experts Group; a lossy image format that is widely used for digital photography due to its high compression ratio and good image quality.
Jpg Pleno (Joint Photographic Experts Group)	x	x			x	x	x	https://jpeg.org/jpegpleno/	A variant of the JPG format designed for capturing high-resolution images with a wider dynamic range.
Jpg 2000 (Joint Photographic Experts Group)	x	x			x	x	x	https://en.wikipedia.org/wiki/JPEG_2000	A newer image format that offers superior compression to JPG while maintaining high image quality, especially for images with high levels of detail or low contrast.
PNG (Portable Network Graphics)	x				x	x	x	https://en.wikipedia.org/wiki/PNG	Portable Network Graphics; a lossless image format that supports transparency and a wide range of colour depths.
PSD (Portable or Personal Storage Device)	x					x		https://en.wikipedia.org/wiki/Portable_Document_Format	Portable Document Format; a universal file format for viewing and printing documents, regardless of the software used to create them.
DNG (Digital Negative)	x				x	x		https://en.wikipedia.org/wiki/Digital_Negative	Digital Negative; a raw image format designed to preserve the maximum amount of image data captured by a digital camera.
GIF (Graphics Interchange Format)	x				x	x	x	https://en.wikipedia.org/wiki/GIF	Graphics Interchange Format; a lossless image format that supports animation and transparency.
PDF (Portable Document Format)	x	x			x	x	x	https://en.wikipedia.org/wiki/Portable_Document_Format	Portable Document Format; a universal file format for viewing and printing documents, regardless of the software used to create them.
MXF (Material Exchange Format)			x			x	x	https://en.wikipedia.org/wiki/Material_Exchange_Format	Material Exchange Format; a container format for storing professional audio, video, and data files.
MKV (Matroska)			x			x	x	https://en.wikipedia.org/wiki/Matroska	Matroska; a container format for storing various types of multimedia data, including video, audio, and subtitles.
MOV			x		x	x	x	https://en.wikipedia.org/wiki/QuickTime	QuickTime File Format; a container format for storing various types of multimedia data, including video, audio, and text.

MPEG-2			x		x	x	x	https://en.wikipedia.org/wiki/MPEG-2	Moving Picture Experts Group-2; a standard for encoding and decoding video and audio data.
AVI (Audio Video Interleaved)			x		x	x	x	https://en.wikipedia.org/wiki/AVI	Audio Video Interleaved; a container format for storing video and audio data.
MP4 (MPEG-4)			x		x	x	x	https://en.wikipedia.org/wiki/MPEG-4	MPEG-4; a standard for encoding and decoding video and audio data.
AAC			x		x	x	x	https://en.wikipedia.org/wiki/Advanced_Audio_Coding	Advanced Audio Coding; an audio codec used for encoding and decoding digital audio.
FLAC (Free Lossless Audio Codec)			x		x	x	x	https://en.wikipedia.org/wiki/FLAC	Free Lossless Audio Codec; a lossless audio codec used for encoding and decoding digital audio.
MP3 (MPEG Layer III Audio Encoding)			x		x	x	x	https://en.wikipedia.org/wiki/MP3	MPEG Layer III Audio Encoding; a lossy audio codec used for encoding and decoding digital audio.
WAV (Waveform Audio File Format)			x		x	x	x	https://en.wikipedia.org/wiki/WAV	Waveform Audio File Format; a lossless audio format used for storing digital audio.
AIFF (Audio Interchange File Format)			x			x	x	https://en.wikipedia.org/wiki/AIFF	Audio Interchange File Format; a lossless audio format used for storing digital audio.
FBX (Filmbox)				x		x	x	https://en.wikipedia.org/wiki/FBX	Filmbox; a 3D model file format used for storing 3D models, animations, and materials.
OBJ (Object File)		x		x		x	x	https://en.wikipedia.org/wiki/Wavefront_obj_file	Wavefront Object; a 3D model file format used for storing 3D geometry, texture coordinates, and normals.
GLTF (GL transmission File)		x		x		x	x	https://en.wikipedia.org/wiki/GLTF	GL Transmission Format; a 3D model file format used for storing 3D models, animations, and materials.
USD		x		X		x	x	https://en.wikipedia.org/wiki/Universal_Scene_Description	Universal Scene Description; a 3D model file format used for storing 3D models, animations, and materials.

PLY		x		x		x	x	https://en.wikipedia.org/wiki/PLY_(file_format)	Polygon File Format; a 3D model file format used for storing 3D geometry, colours, and normals.
Diverse								-	
International Image Interoperable Framework IIIF	x	x	x				x	https://iiif.io/	sharing data in standardised framework
ISO Technical Report 17321-3 Graphic technology and photography — Colour characterisation of digital still cameras (DSCs) Part 3: User controls and readouts for scene referred imaging applications								https://www.iso.org/obp/ui/en/#iso:std:iso:tr:17321:-3:ed-1:v1:en	This document describes a scene-referred (SR) capture-processing mode that could be added to digital still cameras for use by those photographers interested in colourimetrically accurate images of scenes and objects.
ISO Technical Report 19263-1 Photography — Archiving systems Part 1: Best practices for digital image capture of cultural heritage material	x				x	x		https://www.iso.org/standard/64220.html	The purpose of this document is to provide practical guidance on how to apply ISO 19264-1 for cultural heritage imaging of two-dimensional originals. This includes how the image quality analysis is performed, the function of technical target features, and how to adjust/optimize the performance of imaging systems. Additionally, this document illustrates how ISO 19264-1 can be used for selection of appropriate imaging systems and how to establish and maintain image quality in digitisation workflows.

ISO Technical Specification 19264-1 Photography — Archiving systems Image quality analysis Part 1: Reflective originals					x	x	https://www.iso.org/standard/79172.html	There are ISO standards for objectively measuring different performance characteristics of imaging systems, e.g. resolution, noise, dynamic range, tone and colour reproduction (see Clause 2). This document combines all the standards that relate to the imaging systems quality analysis for cultural heritage and defines a tool set to apply them to these devices and workflows. These tools are based on the use of a test chart with multiple technical patterns coupled with software that allows the user to analyse several imaging systems quality characteristics simultaneously and receive comprehensive results. However, these tools are not based on a standardised image quality analysis method, which has caused confusion among users. With the publication of this specification imaging systems quality analysis tools can refer to an ISO document.
Digital Preservation Handbook						x	https://www.dpconline.org/handbook	Digital information is increasingly important to our culture, knowledge base and economy. The Handbook, first compiled by Neil Beagrie and Maggie Jones in 2001, is maintained and updated by the DPC. This full revision (the 2nd Edition) has expanded and updated content to cover over 30 major sections (see Contents). The 2nd edition was compiled with input from 45 practitioners and experts in digital preservation under the direction of Neil Beagrie as managing editor and William Kilbride as chair of the Management and Advisory Boards. The Handbook provides an internationally authoritative and practical guide to the subject of managing digital resources over time and the issues in sustaining access to them. It will be of interest to all those involved in the creation and management of digital materials.

Digitisation: standards landscape for European museums, archives, libraries					x	x	x	https://admin.biodiversitylibrary.org/wiki-archive/mainSpace/files/imp%20athena_digitisation_standards-landscape.pdf	It is the aim of the ATHENA project to support especially museums in providing object data for publication in Europeana. However, it is known that in the museum landscape in particular there is a great variety of standards used. It was therefore necessary to gain an overview of the different standards which are in use with the partners in the ATHENA project. Therefore, a survey has been carried out by Working Group 3 of ATHENA and the results were published within one of the deliverables of the project.
Making 4D: principles and standards for virtual reconstruction in the humanities by the 4D Research Lab		x	x		x	x		https://uva.uva.nl/figshare.com/articles/journal_contribution/4DRL_report_series_1_-_Making_4D_principles_and_standards_for_virtual_reconstruction_in_the_humanities_by_the_4D_Research_Lab/14932461?backTo=%2Fcollections%2F4DRL_Report_Series%2F5503110&file=28965351	In this document, the first instalment of the 4DRL Report Series, we discuss our approach and important related concepts for the creation of 3D models. The use and creation of 3D models for scientific purpose, or simply within an academic context, raises the issue of transparency. Also, in a general context, concern has been raised about the absence of contextual information, and the potential impact of 3D models on the popular perception about the past. As an ethical code that all researchers should adhere to, the scientific process should be fundamentally transparent, and all models should come with para- and metadata. This not only provides the necessary caption and disclaimers to a digital representation, but also opens the models for further research and refinement.

Standards, recommended practices and strategies: the safeguarding of the audio heritage; ethics, principles and preservation strategy			x			x		https://www.iasa-web.org/sites/default/files/downloads/publications/TC03_English.pdf	Through this document, the Technical Committee of the International Association of Sound and Audiovisual Archives seeks to inform the evolving challenge of safeguarding audiovisual heritage by offering these general principles and strategies for preservation. This advice identifies the tasks before us as archives, the nature of the objects for which we are responsible, the potential pitfalls and problem areas of preservation, and it guides the reader to focus on what is most important for their content, to enhance its survival in an unknowable future.
---	--	--	---	--	--	---	--	---	---

Projects

Relevant projects to Impulse (ongoing scoping, projects to be added during the project)

Source Link	Project Name	2D	3D	4D	6D	Data creation	Data Management	Data Sharing	Relevance to IMPULSE
3D-ICONS – 3D Digitisation of Icons of European Architectural and Archaeological Heritage (3dicons-project.eu)	3D- ICONS		x				x		The goal of the 3D-ICONS project, funded under the European Commission's ICT Policy Support Program which builds on the results of CARARE (www.carare.eu) and 3D-COFORM (www.3d-coform.eu), was to provide Europeana with 3D models of architectural and archaeological monuments of remarkable cultural importance. The project brought together 16 partners from across Europe (11 countries) with relevant expertise in 3D modelling and digitisation. The main purpose of the project was to produce around 4000 accurate 3D models which had to be processed into a simplified form to be visualised on low end personal computers and on the web.
https://www.4ch-project.eu/	4 CH		x	x		x	x	x	4CH starts on the 1st of January 2021 for a duration of three years. The project aims to set up the methodological, procedural, and organisational framework of a Competence Centre 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.

https://www.5dculture.eu/	5Dculture		x				x	x	5Dculture enriches the offer of European 3D digital cultural heritage assets in the data space and fosters their reuse in important domains such as education, tourism and the wider cultural and creative sectors towards socially and economically sustainable outcomes. In particular, the project will: a) deliver high-quality 3D content by identifying and engaging existing datasets from partners' collections focusing on topics of fashion, archaeology and architecture, all of which occupy a central place in the vast cultural heritage of Europe and b) develop several reuse scenarios, which will experiment with the aforementioned assets in their complexity (from high-quality to derivatives) in the following domains:
https://pro.europeana.eu/project/ai4culture-an-ai-platform-for-the-cultural-heritage-data-space	AI4Culture						x	x	The project aims to develop the 'AI4Culture platform', an online capacity building hub for the application of artificial intelligence technologies in the cultural heritage sector. The platform will offer access to a pool of AI-related resources (such as openly labelled datasets for training and testing AI models), a set of deployable and reusable tools and capacity building materials. Additionally, the project will customise the platform's components so that they can be reused by cultural heritage institutions in the following scenarios: multilingual text recognition in scanned documents; multilingual subtitles generation and validation; enrichment with information extracted from images and semantic linking; machine translation for cultural heritage metadata. All components will be interoperable with the common European data space for cultural heritage to facilitate data sharing and reusability of cultural content as well as strengthen

								the connection between the data space and cultural heritage institutions.
Animal Mummies < 4D Research Lab	Animal Mummies		x	x		x	x	This project aims at making CT scans of the animal mummy collection from the Allard Pierson available to the wider public. A 3D viewer was developed that allowed museum visitors to interact with volumetric 3D visualisations of the CT data as well as with surface scans of their exteriors.
https://cordis.europa.eu/project/id/101158046	AYTOMATA: AUTOMated enriched digitisation of Archaeological liThics and cerAmics	(x)	x			x		Objects connect us to memories and experiences. They possess biographies that reveal their human relationships. This is why archaeologists focus on material culture, gathering countless archaeological finds to preserve what we can learn and the stories they create for current and future generations. Archaeology unlocks these stories, enabling objects to speak about their origins, uses, and evolution. They offer insights into technology, daily life, relationships, the environment, and human history. Pottery and lithics are common forms of archaeological evidence, holding crucial information. However, documenting and classifying these finds is labour-intensive, it limits our understanding of these objects. While digitisation campaigns have been undertaken, they remain complex, time-consuming, and costly, leaving millions of artefacts inaccessible. AUTOMATA will transform this process by enabling low-cost and time-efficient digitisation. Using AI-augmented robotics and sensors, AUTOMATA will create 3D models enriched with archaeometric data, providing a practical and cost-effective solution for digitisation. Robotic tools with newly developed AI methodologies will improve the digitisation process of visible and non-visible properties of archaeological finds, enhance the robustness and efficiency

								of 3D digitisation, improve surface appearance acquisition, and integrate 2D representations. This approach streamlines data acquisition, aided by human-AI collaboration, and, in turn, the collection of big, well-identified data will empower the development of AI models. This cost-effective technology will democratise access to digitisation, benefiting museums and smaller institutions, aid preservation methods and restorers' work, and foster inclusive knowledge-sharing via a dedicated crowdsourcing platform. Finally, the data collected by AUTOMATA will ensure seamless integration of data into the ECCCH Cloud and facilitate data sharing and innovative usage strategies by CCIs.
https://www.caphe.space/	CAPHE		x	x	x			CAPHE is a multinational four-year research project whose aim is to investigate, perform and elaborate upon an enhanced model of interaction and somatic participation in hybrid environments that comprise both physical and virtual layers among artists and communities that come from traditional and virtual cultural backgrounds.
https://www.uu.se/en/departments/research/research-projects/ongoing-projects/capture	Capture					x	x	CAPTURE investigates what information about the creation and use of research data (that is, paradata) is needed and how to capture enough of that information to make the data reusable in the future. The wickedness of the problem lies in the practical impossibility of documenting and keeping everything, and the difficulty to determine how to capture just enough. The empirical focus of CAPTURE is archaeological and cultural heritage data, which stands out by its extreme heterogeneity and rapid accumulation due to the scale of ongoing development-led archaeological fieldwork. Within and beyond this specific context, CAPTURE develops an in-depth understanding of how paradata is being created and used today

									and elicits methods for capturing paradata. CAPTURE tests new methods in field trials and synthesises the findings in a reference model to inform the capturing of paradata. Enabling data-intensive research using heterogeneous research data stemming from diverse origins.
https://pro.europeana.eu/project/digicher	DIGICHer					x	x	x	Cultural heritage (CH) digitisation brought great opportunities to preserve, maintain and promote it. Yet, it also triggers challenges in terms of representation and content exhibition. This becomes particularly pressing in the context of CH of minorities. Overall, this reduces participation and inclusion of minorities, hindering equitable representations of diverse values in digitisation, leading to increased risks of misuse of digital CH. DIGICHer tackles these challenges by providing new understanding on key legal and policy, socio-economic and technological factors governing digitisation of minorities' CH. Following the citizen science and co-creation approach DIGICHer develops a novel scalable framework and methods to promote equitable, diverse and inclusive practices, verified via user-centric approaches through pilots with three minority groups in the EU: the Sámi, the Jewish and the Ladin people with a further exploitation in other minorities groups. On these bases, it develops recommendations for policy and decision makers, as well as CH institutions, and delivers methods for decision support to monitor the field of digital heritage with specific regards to its diversity long-term.

https://www.smb.museum/en/whats-new/detail/extensive-digitisation-of-the-historical-archive-at-the-ethnologisches-museum/	Digitisation of the Historical Archive of the Ethnology Museum of Berlin	x					x	In 2018, a grant from the Deutsche Forschungsgemeinschaft (German Research Foundation) allowed for the digitisation of all the collection inventories, files, and other associated documentation currently held by the Ethnologisches Museum, dating from the year 1830 up until 1947. In early 2024, the process of digitising this material as completed, and they were published online, with some 1,600 historical documents being made available, comprising a total of 588,000 pages. The documents that are now accessible to the public online include important written material and inventories that shed light on the often-complicated context in which the collection was acquired. With this digitisation project, the Ethnologisches Museum is providing researchers with direct and independent access, regardless of their location, to the museum's historical collection documentation. A near-complete reconstruction of the historical holdings of the collection is now available to all interested parties.
https://www.e-kinas.lt/apie-ekinas	e kinas			x		x	x	The aim of the project – to modernise the activities of the E-cinema information system by creating and developing advanced electronic services based on it, adapting the system to mobile devices and establishing a National Centre of Competence for the Digitisation of Audiovisual Heritage. The equipment for digitisation, digital restoration, storage and online presentation of films was upgraded during the implementation of the Project. Currently, LCVA is the only place in Lithuania digitising films in 4K resolution. During the Project, 229 hours of film content stored in the archive was digitised and made available on the Internet, including important events in Lithuania's history in 1988–1992.

https://cordis.europa.eu/project/id/101157364	ECHOES					x	x	x	ECHOES aims to create the European Collaborative Cloud for Cultural Heritage (ECCCH) as a shared platform for heritage professionals and researchers to access data, innovative scientific and training resources and advanced digital tools co-developed by the heritage community according to their specific needs. ECHOES will bring together fragmented communities of the Cultural Heritage (CH) field, which consists of various actors from different sectors and disciplines, into a new community around the Digital Commons. Going beyond the strict focus on assets and the mere digitisation of Heritage, ECHOES intends to generate a visionary paradigm shift in the CH field. Adopting a holistic approach, ECHOES will also enable digitising the existing knowledge of Heritage objects, whether tangible or intangible. It will create a digital environment enabling collaborative analysis of CH assets, facts, and phenomena. In this environment, actors – humans or Artificial Intelligence – can develop their interpretations, thereby enriching the knowledge of CH and their surroundings. The digital environment proposed by ECHOES will empower users to interact with, manipulate and enrich Digital Twins, leading to new, jointly developed scientific knowledge. The ECCCH built by ECHOES is anchored in the principles of Open Access and Open Science. It thus promotes inclusion and democratises access to knowledge and digital assets, which are understood as public goods by and for all. This digital environment will allow the creation of a new generation of heritage objects, the Digital Commons, which are semantically rich and collectively produced – we see this as “the heritage of tomorrow”. At the end of the project, ECHOES will deliver a single platform to integrate results of EU
---	--------	--	--	--	--	---	---	---	---

									and national projects on CH. The ECCCH will be sustainable thanks to its inclusive legal entity, which will be created before the end of ECHOES.
https://eu-enigma.eu/	eu- enigma						x	x	ENIGMA - EU-funded project - shall achieve excellence in the protection of Cultural Goods and artefacts from man-made threats by contributing to identification, traceability, and provenance research of Cultural Goods as well as by safeguarding and monitoring of endangered heritage sites.

https://eureka3d.eu/	Eureka3D		x			x	x	x	The EUreka3D project addresses the growing need of enabling the digital transformation of the Cultural Heritage (CH) sector. Museums, galleries, libraries, archives and archaeological sites need to review and modernise their internal processes from digital capture to end-user access and re-use. They need to re-train their personnel to cope with the new digital responsibilities and roles; to review their infrastructure capacity, in particular regarding the ability to process 3D contents; to generate a novel holistic documentation of the digital objects. The existing services of the Europeana platform is a good starting point to support sharing and re-use, but an integration with more advanced, powerful and safe services is needed to answer to the demand of small institutions. To achieve this goals, the project will engage a variety of CHIs in a piloting action that will set-up dedicated cloud-based services for the management and preservation of cultural contents in a safe and IP-mindful environment generate high-quality 3D digitisation of selected items and their related para-/metadata ready to be harvested to Europeana perform aggregation of the new contents to the Europeana platform and exemplification of few cases for use and re-use in unique areas such as Education.
https://www.timemachine.eu/5dculture-deploying-and-demonstrating-a-3d-cultural-heritage-space/	From 3D to 5D:		x	x	x	x	x	x	An international consortium composed of 12 partners has embarked on a mission to enrich the offer of existing 3D digital cultural heritage repositories and incite their re-use in education, tourism and multi-faceted cultural and creative sectors. Central to 5Dculture is the expansion of three-dimensional cultural heritage content into two additional, pivotal dimensions: the source content domain and target reuse domain dimension.

https://www.glam.ox.ac.uk/digital-strategy#collapse399061	GLAM Programme	Digital	x				x	x	The Digital Strategy provides a high-level vision of how the Gardens, Libraries and Museums (GLAM) can harness technology to support research and teaching, engage the public nationally and internationally with Oxford University's globally significant collections, and enhance the management and preservation of the collections through digital means.
https://www.heritageresearch-hub.eu/arche-home/about-arche/	Heritage Hub	Research	x			x	x	x	The Cultural Heritage Research and Innovation landscape has changed significantly over the past few years. New political, technological and socio-economic parameters put emphasis on improving protection, conservation and restoration efficiency of European cultural heritage with green technologies, as well as developing and further exploiting high quality digitisation, open access and curation of digital assets. The need also exists to enhance the innovation potential and competitive edge of the Cultural and Creative Sector (CCS) to drive sustainable growth and job creation against global competition. Responding to these challenges, the project will develop a pan European framework for a holistic approach to cultural heritage research and innovation, by creating the Alliance for Research on Cultural Heritage in Europe (ARCHE), a spearheading coordination network of researchers, innovators, heritage professionals, institutional bodies and citizens. The objective is to engage all cultural heritage actors in Member States / Associated Countries in the co-design of research and innovation strategies and roadmaps that lead to research and innovation initiatives requiring multidisciplinary approaches and skills. A detailed assessment of research and innovation gaps and needs for the next decade will be the basis for designing

										a Strategic Research and Innovation Agenda (SRIA) for joint programming aiming to increase awareness of heritage and European sense of belonging. A new purpose-built governance structure will be proposed that will effectively involve existing networks and new partners from relevant scientific disciplines and industries. It will also promote intensive and wide-ranging collaboration between cultural heritage, the arts, and the CCS. The SRIA and governance structure will be tested in a pilot operation in the third and final year.
--	--	--	--	--	--	--	--	--	--	--

https://imareculture.eu/	i- MareCulture		x		x	x			Project's i-MareCulture scope is to raise public awareness of European identity by focusing on maritime cultural heritage, which by default bridges different civilisations. In particular, i-MareCulture aims in bringing inherently unreachable underwater cultural heritage within digital reach of the wide public by implementing virtual visits, serious games with immersive technologies and underwater augmented reality. Scope of the project is to design, analyse, develop and validate pioneer applications and systems in the context of Virtual Museums through collaborative and innovative research from a diverse group of scientists, researchers, archaeologists, experts and museums.
https://www.re3data.org/repository/r3d100012361	IANUS datenportal	x	x				x	x	IANUS is a DFG-funded project to set up a national research data center for archeology and ancient science in Germany.
https://indices-culture.eu	inDICES						x	x	inDICES is conceived as a project that aims to empower policymakers and decision-makers in the Cultural and Creative Industries to fully understand the social and economic impact of digitisation in their sectors and address the need for innovative (re)use of cultural assets.
https://indices-culture.eu	inDICES								What stands in the way of XR adoption in the cultural heritage sector? How might we create meaningful interactions with heritage in immersive environments? This use case, led by the Netherlands Institute for Sound & Vision, aims to tackle these questions by introducing a format for reusable immersive storytelling and social XR-powered workflow for immersive experience production. This will improve communication between design companies and heritage organisations during the creation process and make immersive experiences an attractive and sustainable storytelling format.

https://mementoes.eu/	Mementoes			x	x	x			MEMENTOES brings together museum experts and game developers to create gaming experiences that immerse players in the past. The project seeks to help users learn about historical injustice, develop empathy with marginalised groups, and draw conclusions about issues of today.
https://memorise.sdu.dk/	MEMORISE		x			x	x	x	More and more victims of Nazi persecution and eyewitnesses of the Holocaust pass away. To keep their memories alive, it is therefore imperative to develop new strategies to tell their stories to younger generations. MEMORISE will make use of digital technology to digitise diaries of victims, testimonials and other materials that inhere memories, and make them accessible to the general public in new forms. Our plans include the development of a novel smartphone app that narrates victims' experiences based on diaries, augmented reality (AR) solutions to enhance memorial site visitor experiences and a web-based interface that gives access to all materials and supports narrative virtual experiences for everyone. MEMORISE will develop an infrastructure to help process 80,000+ holocaust related items to make them persistently accessible to the general public, create a suite of digital tools for presenting, narrating and engaging with Heritage of Nazi Persecution (HNP) in new ways, create semi-automated, AI-based services in the form of (1) a data processing pipeline to process materials in different languages, and (2) an AI engine to recommend individualised content for each user. MEMORISE will also create a toolkit of best practices (data processing, curation, knowledge graph creation, narration & interactive visual exploration, & 3D modelling) to accelerate digital tool usage in cultural heritage & adjacent industries.

https://www.muse-it.eu/	MuseIT				x	x		x	The MuseIT project aims to co-design, develop, and co-evaluate a multisensory, user-centered platform for enriched engagement with cultural assets with inclusion and equal opportunity for all as core principles. The MuseIT innovation is rooted in multisensory representations of cultural heritage which extend beyond the visual and auditory senses.
https://www.gla.ac.uk/research/az/museumsmetaverse/headline_1027031_en.html	Museums in the Metaverse			x	x			x	The Museums in the Metaverse (MiM) project will create a ground-breaking two-sided Extended Reality (XR) Cultural Heritage platform that aims to empower diverse visitors to explore cultural assets in new and engaging ways; enable cultural heritage professionals and non-specialist users to create new content; and explore models of use to support sustainable economic and cultural growth.
https://www.open-verse.eu/	Openverse				x				The vision of the OPENVERSE project is to create inclusive, open, and ethically responsible European virtual worlds, enhancing the European Union's technological sovereignty in the global arena. Its strategy involves integrating diverse technological expertise, fostering collaborative innovation, and ensuring interoperability, privacy, and security in digital environments. OPENVERSE aims to lay the foundational framework for these virtual worlds, combining user co-creation with extended reality technologies, addressing legal and ethical challenges, and guiding future policy and industry standards for globally influential virtual worlds.

https://www.parthenos-project.eu/	PARTHENOS project						x	x	PARTHENOS is a consortium of national research organisations (e.g. CNR, Italy and INRIA, France), cultural heritage institutions and existing Research Infrastructures (as listed in the previous answer), which in turn often consist of many member organisations based across Europe. The project is led by PIN Scrl, a research and educational public body organised as a consortium formed by the University of Florence and local institutions. There are fifteen other partners. You can visit each of the participating organisations via this web page: http://www.parthenos-project.eu/consortium/ The acronym PARTHENOS stands for “Pooling Activities, Resources and Tools for Heritage E-research Networking, Optimisation and Synergies”. It is inspired by Athena Parthenos, the Greek goddess of wisdom, inspiration and civilisation.
https://perceive-horizon.eu/	PERCEIVE		x				x	x	PERCEIVE aims at advancing the digital capability of scientists and cultural institutions through a service-based AI architecture and toolkit, and by developing a new design theory for on-site and remote VR/AR/MR experiences, based on the concepts of “Care”, “Accessibility”, and “Authenticity”, with and for the creative industries, expanding the access to Cultural Heritage and Art outside museums for wider integration with society.

https://www.photoconsortium.net/european-ds4ch/	Photoconsortium	x	x						The common European Data Space for Cultural Heritage is the new flagship initiative of the European Commission to accelerate the digital transformation of Europe's cultural sector and foster the creation and reuse of content in the cultural and creative sectors. The project builds on and expands the existing functionalities and services of the Europeana DSI Digital Service Infrastructure. The new service is provided by a consortium of 19 partners, coordinated by the Europeana Foundation.
https://premiere-project.eu/	premiere		x		x	x			The overall objective of PREMIERE is to develop and validate a comprehensive ecosystem of digital applications, powered by leading edge AI, XR and 3D technologies, designed to fulfil the needs of diverse end-user communities involved in the main stages of the of the lifecycle of performing arts productions, including amateur and professional performers, performance art producers and curators, performance art spectators and scholars.
https://wasp-hs.org/project/quantifying-culture-a-study-of-ai-and-cultural-heritage-collections/	Quantifying Culture						x		The project group are setting out to investigate both how AI is currently applied and what its future potential might be for digital cultural heritage collections. The project aims to show how critical perspectives can be used for Swedish cultural heritage collections, in a context where AI is used to label archival material. The technology is reminiscent of that used for computer facial recognition or automatic online translation, for example. Various archives and collections from the 19th and 20th centuries from collaborating partners serve as the basis for the researchers' work. They want to demonstrate how descriptions of visual and textual material generated through AI

									and ML can be adapted to make them inclusive and avoid adherence to standardised narratives from a single perspective.
ROOTS (radici-icc.it)	RADICI								RADICI represents the prototype of a management process between research centers and universities, for the design of an Infrastructure and a Competence Shop functional to trigger supply chain processes based on the digitalisation and accessibility of cultural heritage. Through co-design and the active participation of the cultural and creative companies involved, the aim is to promote the interconnection between information from different archive sources, the interaction between data producers and consumers and the growth of skills and future competences.

https://reevaluate.eu/	REEVALUATE		x						EVALUATE is a HORIZON EUROPE project that aims to provide a holistic solution to the challenges of Cultural Heritage (CH) digitisation management, that enables collaboration, boosts creative reuse and promotes democratic and inclusive prioritisation and contextualisation. After assessing the current pitfalls and opportunities of CH digitisation, the project will develop a modular framework that facilitates each stage of a digitised artefact's life cycle (prioritisation, contextualisation, storage, collaboration and reuse) through a set of technological enablers, free versions of which will be made available by the consortium for integration to the ECCCH. The whole framework is centered around the participation of all involved stakeholders, to whom it provides enablers to express their view on CH artefacts but also to reuse them effectively. AI techniques will be employed throughout the framework to assist the manual contextualisation, to improve prioritisation through public sensing, to visualise creative ideas of reuse, to propose collaborations and cases for reuse, and to validate the context of the reused artefacts. The framework also deals with the secure storage of the digitised artefacts and frames the intellectual property rights through CH object tokenisation and the introduction of smart contracts for reuse. The framework also comes with a standardised semantic representation of the artefact's metadata to improve its accessibility and discoverability and enable automated discovery of digitised CH object misuses. The aforementioned enablers of REEVALUATE can be used separately or as whole depending on the needs of the CH institution. REEVALUATE will provide a toolset to the European CH sector for managing their digitised collections effectively,
---	------------	--	---	--	--	--	--	--	--

										opening the process to the society and potentially empower the creation of societal value, through the creative reuse of digitised CH.
--	--	--	--	--	--	--	--	--	--	--

https://shift-europe.eu/	SHIFT					x	x	x	The project is strategically conceived to deliver, by advancing beyond the state-of-the-art, a set of loosely coupled technological tools that offers cultural heritage institutions (CHI) the impetus to stimulate growth and communicate new experiences to all citizens (including people with disabilities) by embracing the latest technological innovations, inartificial intelligence, machine learning, multi-modal data processing, digital content transformation methodologies, semantic representation, linguistic analysis of historical records, use of haptics interfaces
https://steccihorizoneu.com/	STECCI								The project's aim is to produce innovative and sustainable protection strategies for cultural heritage from the climate change (CC) impact and consequential natural hazards, environmental pollution, and anthropogenic threats. By means of an interdisciplinary approach, the future of medieval tombstones (bos. stećak., stećci, pl.) and similar stone monuments across Europe will be assessed in the context of a changing climate, more precisely under two climate scenarios (SSP2-4.5 and SSP5-8.5) in three periods: 2021-2040 (near-term), 2041-2060 (medium-term), and 2081-2100 (long-term), as per IPCC. The unique shapes, ornaments, inscriptions, cultural and documentary values, and medieval roots have singled out stećci as a tangible phenomenon included on the UNESCO World Heritage list. STECCI will use state-of-the-art research equipment, digital technologies, the newest approaches in social sciences, and conservation practice excellence to achieve the set objectives based on demo cases, which will be translated and applicable beyond Europe.

https://cordis.europa.eu/project/id/101158328	TEXTaiLES: TEXTile digitisAtion tooLs and mEthodS for cultural heritage	x	x	x		x		TEXTaiLES goal is to redefine the digitisation of Cultural Heritage (CH) textile objects and the development of AI-based processing tools, aiming to establish a standardised protocol that seamlessly integrates into the ECCCH. By studying past and present practices in textile digitisation, we methodically explore their strengths and limitations. This comprehensive assessment, enriched by contributions from co-designer groups across various use cases, helps us identify the essentials of textile digitisation. Our approach to standardisation is all-encompassing. We develop advanced tools that address the entire digitisation life cycle of textile objects, focusing on non-destructive methods. Using robotic, cost-effective multi-sensor solutions, we ensure the preservation of artefacts during digitisation, complemented by reliable data analysis workflows. Innovation lies within the core of TEXTaiLES. We integrate state-of-the-art AI technologies to shed light on the intricate details of textiles. From revealing their weaving patterns and microstructures to identifying degradation factors, our AI-driven toolkit offers in-depth insights. It further excels in motion modelling, dynamics, and the reconstruction of fragmented or lost objects. All these capabilities merge into a groundbreaking 4D multi-scale annotation interface, coupled with a digital twin model and enhanced by human-in-loop interactions. Our commitment to the CH community remains strong. We aim to embed the tools and techniques developed by TEXTaiLES into archaeological research, facilitated by the ECCCH. By supporting interdisciplinary research communities and providing upskilling opportunities, we aim to raise the textile CH domain to new heights.
---	---	---	---	---	--	---	--	---

https://thesceneproject.eu/	The Scene Project		x			x	x	x	The SCENE project (running from 02/2023 until 01/2026) is designed to enhance the European filmmaking industry's global competitiveness. It leverages semantically cognitive AI technologies and tangible/intangible European Cultural assets, aligning with European values and policies. SCENE revolutionises the entire film-making pipeline, introducing innovations such as high-quality 3D models of European cultural sites and multi-dimensional knowledge graphs. It facilitates efficient simulation and assessment mechanisms for production and post-production, as well as privacy-preserving interaction between stakeholders and the audience. SCENE promises a groundbreaking proof-of-concept prototype, set to propel the film industry into a new era post-COVID on scientific, commercial, business, and policy fronts. SCENE project will combine cutting-edge technology with a commitment to social responsibility and sustainability. From AI-based audience scouting, distribution mechanisms, and blockchain for IPR protection to 3D representations of monuments, the project is revolutionising the industry while respecting the values of the European Bauhaus.
https://thesceneproject.eu/	The Scene Project								Building a globally competitive European film industry through AI and cultural heritage.
https://www.timemachine.eu/	Time Machine	x	x	x					Time Machine is aiming to join Europe's rich past with up-to-date digital technologies and infrastructures, creating a collective digital information system mapping the European economic, social, cultural and geographical evolution across times. In the proposed approach, digitisation is only the first step of a long series of extraction processes, including document segmentation and understanding enhanced

									by Augmented/Virtual Reality (AR/VR) applications, leading to simulations of hypothetical spatiotemporal 4D reconstructions.
https://www.vi-mm.eu/	ViMM		x				x		ViMMPlus builds on the results of the Virtual Multimodal Museum (ViMM) ve Coordination and Support Action (CSA), funded under the EU Horizon 2020 programme, bringing together Europe and the world's leading public and private sector organisations working on DCH, supporting high quality policy development, decision making, competence building and the use of technical advances.
Virtual Past Places – Travel to the past in VR	Virtual Past Places		x	x	x	x	x		Virtual Past Places is a website aimed to give access to the virtual reality rooms created by the 4D Research Lab in Mozilla hubs. Hubs is the open-source virtual reality platform by Mozilla, which can be used to design your own scenes, and use them as virtual meeting rooms. The virtual spaces created by us are used to present the results of archaeological or historical research, give guided tours or as virtual museum exhibitions.
https://www.vhh-project.eu/	Visual History of the Holocaust			x		x	x	x	The EU Horizon 2020 project “Visual History of the Holocaust: Rethinking Curation in the Digital Age” (2019–2022) explores the potentials as well as the limitations of digital technologies in the ongoing effort to preserve, analyse and communicate historical evidence of the Holocaust, and in particular audiovisual records. It is coordinated by the Ludwig Boltzmann Institute for Digital History (Vienna), in close collaboration with the Austrian Film Museum (Vienna).

Networks

Relevant Networks to Impulse (ongoing scoping, networks to be added during the project)

Network Name	Link	Short Description
4D Research Lab, (UVA)	https://4dresearchlab.nl/	The 4D Research Lab facilitates researchers from different disciplines in the Humanities who have specific spatial and architectural i.e. three-dimensional questions that cannot be answered with traditional methods, nor have the knowledge of 3D modelling programs and computing facilities. The Lab offers these computers and computational specialists to support the analysis of transformations in the built environment. The 4D Research Lab has 3D scanner, drones and specialised software and hardware at its disposal.
Archives portal	Archives Portal Europe Homepage	Archives Portal Europe makes myriads of archives dispersed on the territory available in one click, anywhere in the world: it brings together descriptive records from more than 30 countries, in more than 20 languages (and 5 different alphabets), and from a large variety of institutions: national archives, community archives, parish archives, university archives, corporate and private archives. The portal currently holds information on around 7000 archival institutions, of which over a thousand actively contribute with content, and it holds more than 280 million archival descriptive units - however, it is constantly expanding to make more material available for research.

AthenaPLUS	Athena Plus - Michael Culture Association (michael-culture.eu)	AthenaPlus will build on the successful experience developed by the previous ATHENA project – where LIDO and the ATHENA Ingestion Server and Mapping Tool (MINT), widely used across the Europeana’s ecosystem of projects including the ongoing Linked Heritage project were developed, in order to further advance and complete the effective infrastructure and tools developed to support museums and other cultural institutions in their work to making available digital content through Europeana.
CARARE	http://www.carare.eu/	CARARE (Connecting Archaeology and Architecture in Europe) aims to advance professional practice and foster appreciation of the digital archaeological and architectural heritage through the promotion for the public benefit of digitisation, connection, enhancement, and use of digital content nationally and internationally.
Community Standards for 3D Data Preservation (CS3DP)!	https://cs3dp.org/	A radically inclusive, interdisciplinary community of librarians, researchers, engineers and designers who collaborate to develop better and more intuitive digital 3D data preservation practices.
Crowd Heritage	CrowdHeritage	CrowdHeritage is an open platform where cultural heritage institutions can share their collections’ metadata that need a fix or enrichment, and everybody can contribute to improve them. Cultural institutions will exploit the wisdom and power of the crowd to make their digital collections more discoverable and contributors will get their share of glory and some gratitude back! Start joining a campaign now or contact us if you want to set-up your own.

Digital Preservation Coalition	https://www.dpconline.org/	The Digital Preservation Coalition enables members to deliver resilient, sustainable and useful long-term access to digital content and services, helping them to access and use digital materials beyond the limits of technical obsolescence, media degradation and organisational change.
Eu Screens	https://euscreen.eu/	Euscreen offers free access to thousands of archival audiovisual items. Our collection provides insight into the social, cultural, political, and economic events that have shaped the 20th and 21st centuries.
European Film gateway	European Film Gateway	EFG - The European Film Gateway is the aggregator for the film archive domain. In addition to aggregating data for Europeana, EFG also makes the consolidated metadata from its providing archives accessible through its own portal at www.europeanfilmgateway.eu . EFG features collections from its currently 58 contributing archives and works actively to improve data and to make available new collections on a regular basis. EFG represents partners from more than 25 countries, giving access to over 700,000 film historical documents as preserved in European film archives and cinémathèques: photos, posters, programs, periodicals, censorship documents, rare feature and documentary films, newsreels and other materials.
Europeana Sounds	http://www.eusounds.eu/	Prior to the project, tens of thousands of audio items dating back to the invention of the first sound recorders were waiting to be discovered in numerous museums, archives and libraries throughout Europe. 24 partners decided to take up the challenge to gather those sound collections, to enrich and aggregate metadata for them to fit on one online platform, europeana.eu , to improve the domain constraints caused by copyright, to innovate with user-friendly tools, and last but not least, to communicate about the project and its outcomes.

FIAT/IFTA	https://fiatifta.org/about/executive-council/	The World's leading professional association for those engaged in the preservation and exploitation of audiovisual archives
Heritage Research Hub	https://www.heritageresearch-hub.eu/	The Joint Programming Initiative on Cultural Heritage and Global Change (JPI CH) was created in 2010 based on an instrument launched by the European Commission. It is a Member-State-driven initiative bringing together national research funding organisations, ministries, and research councils from Europe to address societal challenges in the European Research Area (ERA) frame.
Imaging Wiki	https://www.conservation-wiki.com/wiki/Category:Imaging	Welcome to the AIC Imaging Wiki! The Imaging Wiki, started by the AIC Imaging Working Group, aims to establish an online platform that shares information about conservation imaging techniques and encourages users to share imaging resources, case studies, and workflows. The Wiki is intended to be a dynamic resource for the community and like all Wiki's, the site's content is a collaborative work-in-progress.
Impact Center of Competence	https://www.digitisation.eu/	The IMPACT Centre of Competence in Digitisation is a not-for-profit organisation, comprised of public and private institutions, with the mission to make the digitisation of historical printed text "better, faster, cheaper". It provides tools, services and facilities to further advance the state-of-the-art in the field of document imaging, language technology and the processing of historical text.

International Association of Sound and Audiovisual Archives (IASA)	https://www.iasa-web.org/about-iasa	The International Association of Sound and Audiovisual Archives (IASA) was established in 1969 in Amsterdam to function as a medium for international cooperation between archives that preserve recorded sound and audiovisual documents. IASA has members from 70 countries representing a broad palette of audiovisual archives and personal interests which are distinguished by their focus on particular subjects and areas, e.g. archives for all sorts of musical recordings, historic, literary, folkloric and ethnological sound documents, theatre productions and oral history interviews, bio-acoustics, environmental and medical sounds, linguistic and dialect recordings, as well as recordings for forensic purposes.
Metaverse	https://metaverse-standards.org/	Metaverse standards
Michael Culture Association (MCA)	https://michael-culture.eu/	Michael Culture Association (MCA) is a trans-sectoral and trans-domain European network, gathering more than 200 public and private organisations from all over Europe and beyond, for the preservation, the promotion and the valorisation of heritage and digital cultural contents, and its communities. MCA provides knowledge, tools and services for cultural institutions and the general public, to support the role of cultural heritage as a pillar of inclusive and sustainable European societies.
Museu	http://www.museuhub.eu	MUSEU is an accredited aggregator of Europeana and the reference point for European museums and other cultural institutions hosting museum collections in the field of digital cultural heritage and aggregation for Europeana. Over the years, it has provided Europeana with access to over 5.5 million records from around 350 museums from across Europe. MUSEU is run by experts working for the MICHAEL Culture Association, and it benefits from a big network of experts in digital cultural heritage. It has established a network of National Contact Points that were appointed in past projects to function as mediators between MUSEU and contributing local institutions.

PHOENIX - Parallel Heritage of European Universities	https://www.una-europa.eu/calendar/phoenix-parallel-heritage-of-european-universities	The target of the PHOENIX project is to focus on specific case studies involving external partners to our universities to investigate on how university heritage could be shared among wider, non-academic audiences. All eight members of the Una Europa consortium have been collaborating to this project during the academic year 2020/2021.
Photoconsortium	http://www.photoconsortium.net	PHOTOCONSORTIUM is Europeana's domain aggregator specialised in photographic content, and since 2014 has made accessible in Europeana over 500,000 photographs from around 50 partners, showcasing famous heritage collections from prestigious public institutions and private agencies, and unveiling hitherto unknown photographic content from crowdsourcing campaigns, private collectors and smaller local archives.
PrestogCenter	https://prestocentre.org/	Best practices for digitising video and audio materials
SOUND & VISION	https://www.beeldengeluid.nl/en	The Netherlands Institute for Sound & Vision is a leading knowledge institute in the field of media culture and AV archiving. We initiate research that makes our media heritage available and searchable. We follow relevant innovations in media archiving, participate in research projects and experiment with new technology. We work together with scientists and heritage professionals. We share knowledge and experience in national and international networks.
The Imaging Wiki	https://www.conservation-wiki.com/wiki/Category:Imaging	Welcome to the AIC Imaging Wiki! The Imaging Wiki, started by the AIC Imaging Working Group, aims to establish an online platform that shares information about conservation imaging techniques and encourages users to share imaging resources, case studies, and workflows. The Wiki is intended to be a dynamic resource for the community and like all Wiki's, the site's content is a collaborative work-in-progress.

Guidelines

Relevant Guidelines to Impulse (ongoing scoping, guidelines to be added during the project)

Source Title	2D	3D	4D	6D	Data creation	Data Management	Data Sharing	References	Relevance to IMPULSE
3D data: Creation to Curation: Community Standards for 3D Data Preservation		x		x	x	x	x	https://www.ala.org/sites/default/files/acrl/content/publications/booksanddigitalresources/digital/9780838939147_3D_OA.pdf	There has been rapid growth in the production and usage of 3D data over the last decade, yet the preservation* of these data has lagged to the detriment of scholarship and innovation. While the need for digital 3D data preservation is widely recognised, the ongoing development of 3D data creation processes and the evolving usage of content still present many open-ended questions about how to ensure the stability and durability of this data type.

3D Digitisation in Cultural Heritage Institutions Guidebook	x	x			x		https://www.academia.edu/68906660/3D_Digitisation_in_Cultural_Heritage_Institutions_Guidebook	This guide specifically refers to objects, sites, or buildings that are digitised from a real-life counterpart, as few 3D models are born digital, i.e., a 3D object without a real-world counterpart (Flynn 2019b). This guide will primarily address 3D digitisation technologies, including what techniques are used for different objects, sites, and settings, which methods are used to avoid or correct troubleshoot problems, and which techniques are best implemented in archives, libraries, and museums, specific to this guide. This guide will also contain references to advanced 2D+ technologies, which are augmented two-dimensional recording technologies that can be combined with 3D technologies to obtain a more accurate and informative image. Community Standards for 3D Data Preservation (CS3DP) initiative to move toward establishment of standards. ² The goal of this work is to identify the broad, shared preservation needs of the whole community, and it is viewed as essential to use a collaborative approach for standards development that promotes individual investment and broad adoption.
3D icons project case studies		x			x		http://3dicons-project.eu/wp-content/uploads/2018/08/Case-Studies-for-Testing-the-Digitisation-Process-interim-report.pdf	This interim report and the accompanying case studies are being developed as part of 3D ICONS Work Package 2. The aim of this work is to perform evaluation tests on specific parts of the 3D data collection and 3D data post-processing pipeline that will be set in use to prepare the 3D content by the partners. The evaluation is based on the implementation of five 3D digitisation case studies followed by a critical assessment and analysis of important properties and key factors of each 3D digitisation project. Several key 3D digitisation methodologies are applied in each case study and their advantages and disadvantages are discussed in detail.

3D-ICONS: D7.3-Guidelines and Case Studies		x			x		https://zenodo.org/records/1311797#.W1XnMdhKh7M	Documentation of the digitisation, modelling and online access pipeline for the creation of online 3D models of cultural heritage objects.
A Guide to Approaching Audiovisual Digitisation for Artists and Arts and Culture Organisations							https://www.bavc.org/wp-content/uploads/2019/07/BAVC-Guide-To-Audiovisual-Preservation-2019.pdf	The paper discusses the preparation of a collection before digitisation, the stewarding of files post-digitisation, and which tasks are best left to a digitisation vendor. The paper also discusses common errors found in all parts of digitisation and preservation workflows, and methods for selecting a preservation file format. Finally, the paper discusses updates made to BAVC's tape preparation and digitisation workflows which were enabled by the funding from Mellon. These workflow updates were informed by data collected by BAVC technicians throughout the digitisation process and are being shared to help advance the general expertise in the field of audiovisual preservation.

AN UPDATE ON AS-07: MXF APPLICATION SPECIFICATION FOR MOVING IMAGE ARCHIVING AND PRESERVATION			x		x	x		https://www.iasa-web.org/sites/default/files/iasa_journal_42_part5.pdf	The Federal Agencies Digitisation Guidelines Initiative (FADGI) is an inter-agency activity led by the Library of Congress with membership from eighteen U.S. federal government agencies.²¹ FADGI includes two working groups. The Still Image Working Group develops guidelines and tools that pertain to the scanning of materials that can be reproduced as still images (often with accompanying texts), e.g., books, photos, manuscripts, and maps. The Audio-Visual Working Group develops guidelines and tools that support the digitisation of sound recordings, video, and motion picture film. This article describes an activity of the FADGI Audio-Visual Working Group: the development of an MXF digital format Application Specification²² dubbed AS-07. The Material eXchange Format (MXF) is a container format (aka wrapper) for digital moving image and audio media, standardised by the Society of Motion Picture and Television Engineers (SMPTE). The AS-07 profile will specify a constrained version of MXF, intended to serve as the wrapper for a preservation target format, i.e., the digital format that you digitise or transcode “to” when producing a master file for an archive. Although picture encodings—the other main part of the target format—are not our main thrust, they are referenced in the specification and discussed in this article.
---	--	--	---	--	---	---	--	---	---

AUDIOVISUAL ARCHIVES: AN ESSAY ON THE POLICIES OF ACCESS TO AUDIOVISUAL ARCHIVES FOR ACADEMICS, TEACHERS, RESEARCHERS, AND STUDENTS			x		x	x	x	https://www.iasa-web.org/sites/default/files/iasa_journal_42_part11.pdf	The year is 2013. The issue highlighted thirteen years ago in Oslo is still on the agenda of international conferences and seminars. The main goal of presenting a paper on the same issued evaluated in 2000 is to see if changes have taken place among the most important libraries and archives that have dominated the debate and the agenda of international conferences throughout the last thirteen years. Most of these archives are still members of FIAT/IFTA, IASA, and BAAC. The question I asked thirteen years ago was, "Access for university studies, a national responsibility: yes, or no?" Twenty-five members answered negative to the question, which meant that none of the archives were advocates for a policy for those who wanted to use the collections for university studies. Sixty-nine members gave a positive answer to the question, stating yes, we do support university studies. The Norwegian Broadcasting Corporation (NRK) was one of the institutions that answered no to this question in 2000. It is of great importance to study the reasons why twenty-five archives said they did not have a positive approach to academic studies in 2000 and to compare these reasons to information gathered in 2013. Has there been any change over these thirteen years
Bodleian Libraries, University of Oxford. Imaging Guidelines for the Digitisation of Rare and Special Materials	x	x			x	x		Barrett, J. (2021). <i>Imaging Guidelines for the Digitisation of Rare and Special Materials</i> . Oxford: England.	This report aims to 1) provide a readable interpretation of the available guidelines for the benefit of non-specialists; 2) evaluate the Bodleian's performance against the guidelines to serve as an example for peer institutions; 3) present a set of modified guidelines adhered to by the Bodleian and explain the tools and methods used to meet them.

Canalising the maelstrom of metadata: extensions on the Hourglass Model			x			x	x	https://publish.iupress.indiana.edu/read/sustainable-audiovisual-collections/section/54039112-c044-4d97-a08c-e697fea75f64	This article presents the Hourglass Model, a theoretical framework allowing to redesign the strategies for the creation and use of mainly descriptive metadata in audiovisual archives. The model outlines four main categories of metadata creation (manual annotation by archivists, metadata coming from production, user-generated metadata, and automatically extracted metadata) and three main categories of use (preservation and collection management, search and retrieval, and enhancement and contextualisation). Archives can plan an effective and efficient metadata strategy by connecting one or more creation methods with one or more purposes.
CARARE aggregation services		x		x		x	x	https://www.carare.eu/en/training/3d-and-virtual-reality/	CARARE works with state heritage authorities, museums, libraries, research teams, digital archives, companies and individuals to share the digital archaeological and architectural heritage internationally for education, research and enjoyment. CARARE collaborates with Europeana, the cultural heritage platform, and with ARIADNE Plus the archaeology research infrastructure.
Carli GUIDELINES FOR THE CREATION OF DIGITAL COLLECTIONS		x			x	x		https://www.carli.illinois.edu/sites/files/digital_collections/documentation/guidelines_for_3D.pdf	This document serves as a comprehensive guide for libraries and archives to create digital collections of three-dimensional artifacts.
CCO (Cataloguing Cultural Objects)								https://www.vraweb.org/cco	Cataloging Cultural Objects (CCO) is a manual to help you describe, document, and catalog cultural artifacts (like art and architecture) and visual media that represent them.

Creating Metadata Practices for Digital Resources	Best for A/V			x			x	https://www.iasa-web.org/sites/default/files/iasa_journal_43_part6.pdf	The University of Illinois Library is in the process of creating new and updated metadata best practices documentation for digital audiovisual (A/V) resources to augment guidelines established in 2007. The goal has been to create documentation that is simple enough to provide general guidelines to the entire campus community while ensuring the integrity of the metadata submitted with A/V resources to the library that work for both the access and the preservation of resources created and purchased by the campus. The library underwent a research phase that spanned a period of several months, interviewing stakeholders and surveying the current state of the art in the broader metadata landscape. After the research phase, it was decided to limit the scope of the recommendations to a set of required and optional metadata elements only, leaving the choice of schema selection to the ingesting repository systems. However, recommendations for potential schemas have also been included for reference. Further recommendations have been made for automated metadata extraction tools such as MediaInfo22 and Jhove23 that will increase the level of metadata uniformity in the digital A/V resources currently being created and managed by the campus, while facilitating submission to the library's preservation repository. This paper will outline the findings from the research phase and share the new and updated library's Digital A/V Metadata Best Practices.
---	--------------	--	--	---	--	--	---	---	---

Cultural Heritage Imaging: Photogrammetry					x		https://culturalheritageimaging.org/Technologies/Photogrammetry/	Fundamentally, photogrammetry is about measurement: the measuring of the imaging subject. To perform high-quality photogrammetric measurement, the photographer capturing the photogrammetry data set must follow a rule-based procedure. This procedure will guide users regarding how to configure, position, and orient the camera towards the imaging subject in a way that provides the most useful information to the processing software and minimises the uncertainty in the resulting measurements. These measurements will be as good or as poor as the design of the measurement structure, or lack thereof, that underlies the collection of the photographic data. Recent technological advances in digital cameras, computer processors, and computational techniques, such as sub-pixel image matching, make photogrammetry a portable and powerful technique. It yields extremely dense and precise 3D surface data with an appropriately limited number of photos, captured with standard digital photography equipment, in a relatively short period of time. In the last five years, the variety and power of photogrammetry and related processes have increased dramatically.
Digital Imaging for Photographic Collections	x				x		https://www.cultura.gob.es/planes-nacionales/eu/dam/jcr:7e9458c1-8258-4459-9e71-60f7a3598c96/digital-imaging-photographic-collections.pdf	Digitisation of photographic collections

DIGITAL LEARNING AND EDUCATION IN MUSEUMS INNOVATIVE APPROACHES AND INSIGHTS	x	x			x	x	x	https://www.ne-mo.org/fileadmin/Dateien/public/Publications/NEMO_Working_Group_LEM_Report_Digital_Learning_and_Education_in_Museums_12.2022.pdf	In the fifteen case studies selected, which are based on in-depth expert interviews with museum professionals, ranging from directorsto educators and staff in digital capacities, and with experts from the tech world, and which took place between April and March 2023, we review the concepts of the projects, background information, identify objectives, challenges and obstacles, learning benefits, and institutional approaches to digital learning, and present major takeaways and recommendations from the interviewed professionals. The collection of these case studies is followed by key findings drawn from interviews and desk research that will be useful for the community of museum practitioners and policymakers interested in fostering digital engagement, learning and education in the cultural heritage sector.
DIGITAL PHOTOGRAPHY FOR OBJECT DOCUMENTATION	x				x			https://www.archives.gov/files/preservation/heritage-science/digital-photography-for-object-documentation.pdf	Photography for object documentation.
Digitisation at the National Archives	x				x	x		https://cdn.nationalarchives.gov.uk/documents/information-management/digitisation-at-the-national-archives.pdf	The document provides The National Archives' standards for digitising records, covering scanning processes, image quality, file formats, metadata, and validation. It distinguishes between digitised records and digital surrogates for legal preservation.
DIGITISATION QUALITY MANAGEMENT GUIDE	x				x			Digitisation Quality Management Guide (archives.gov)	The NARA Digitisation Quality Management Guide 2023 outlines best practices for digitising records, emphasising quality management (QM), quality assurance (QA), and quality control (QC) to ensure digital records are authentic, accurate, and usable for future generations.

Eureka3D project: 3D Digitisation Guidelines		x			x		https://eureka3d.eu/3d-digitisation-guidelines/	This guide is designed to help anyone on their 3D digitisation journey. It is specifically aimed at Cultural Heritage professionals who are considering, or in the middle of, digitising their cultural heritage collections using three dimensional models. It outlines and simplifies the recommended standards highlighted in the EU VIGIE Study 2020/654 (Study on quality in 3D digitisation of tangible cultural heritage, published April 2022) and written in response to the EU recommendation (EU 2021/1970 on a common European data space for cultural heritage, published November 2021) for Member States to digitise all moments and sites at risk in 3D by 2030. This guide has been created within the framework of Eureka3D an EU project co-funded by the European Union (grant no. 101100685).
Europeana Publishing guide for 3D content		x			x	x	https://europeana.atlassian.net/wiki/space/EF/pages/2365227031/Publishing+guide+for+3D+content	List of sources on publishing 3D content to Europeana.
FADGI on a Budget: Improving FADGI on a Budget: Improving Digital Images for Libraries	x	x			x	x	https://digitalcommons.kennesaw.edu/provenance/vol38/iss1/2/	This case study describes the photography equipment and setup of San Francisco State University's Digital Scholarship Center, and the testing and manipulation of these elements to reach the 4-star tier of the Federal Agencies Digital Guidelines Initiative (FADGI) technical guidelines. It describes how, with a few tools like a colour target and image analysis software, cultural heritage digitisation units with limited photography skills can markedly increase the quality of their digital images with experimentation, creativity, and the photography equipment they already have.
FIAT/ IFTA 2021 Preservation and Migration Seminar			x			x	https://fiatifta.org/seminar/preservation-migration-seminar-2021/	Acceptance criteria in the context of massive migration processes.

FIAT/ IFTA 2022 Preservation and Migration Seminar			x			x	https://fiatifta.org/seminar/preservation-migration-seminar-2022/	Film in television archives. What can be done?
FIAT/ IFTA 2023 Preservation and Migration Seminar			x			x	https://fiatifta.org/seminar/preservation-migration-seminar-2023/	The Preservation Life Cycle.
FIAT/ IFTA 2024 Preservation and Migration Seminar			x			x	https://fiatifta.org/seminar/preservation-migration-seminar-2024/	Preserving Authenticity from media archives content.
FIAT/IFTA 2020 Preservation and Migration Guide			x			x	https://fiatifta.org/commissions/preservation-and-migration-commission/	This document, the Background Document, is the last one of a set of three, which makes a guide, issued by the International Federation of Television Archives FIAT/IFTA, to help everyone who considers writing a tender for the outsourced migration of content from physical audiovisual carriers. The first document, Introduction Document, provides a general introduction, in the form of a list of questions and answers. The second document, Overview Document, gives detail on the tendering procedure itself, discussing elements that are independent of most legal constraints, specific from country to country.

Glam3D Digitise		x			x	x	x	https://glam3d.org/digitise	This publication is designed to be both an introduction and reference to your digital 3D content creation process. Once you move beyond this introduction, this paper begins by providing you context around Open Access. That section explains what Open Access is and how using an Open Access approach can help you structure your successful digital content program. It will also help you appreciate why Open Access is critical to a successful digital content process.
Government of Canada: Digital Preservation	x		x			x		Digital preservation - Canada.ca	This manual assists museums, archives and independent researchers in digitising their existing collections of intangible heritage-related material. Aside from providing step-by-step digital transferring instructions, it also offers definitions for heritage-related terminologies, as well as a significant number of technological terminologies. While this digitisation guide aims to be user-friendly, familiarity with basic audio/visual equipment and media software is a prerequisite. Digitisation instructions are provided for both Windows and Mac operating systems.
Government of Canada: Digitising Intangible Cultural Heritage	x		x		x	x		Digitising Intangible Cultural Heritage: A How-To Guide - Canada.ca	This manual assists museums, archives and independent researchers in digitising their existing collections of intangible heritage-related material. Aside from providing step-by-step digital transferring instructions, it also offers definitions for heritage-related terminologies, as well as a significant number of technological terminologies. While this digitisation guide aims to be user-friendly, familiarity with basic audio/visual equipment and media software is a prerequisite. Digitisation instructions are provided for both Windows and Mac operating systems.

Guidelines for Planning the Digitisation of Rare Book and Manuscript Collections	x				x	x	x	https://www.ifla.org/wp-content/uploads/2019/05/assets/rare-books-and-manuscripts/rbms-guidelines/guidelines-for-planning-digitisation.pdf	While many libraries have procedures in place for participating in “mass digitisation” projects, the needs of unique, rare, and non-print format materials require special consideration and different procedures. One of the purposes of these guidelines is to address this gap. These guidelines are intended for anyone who is involved in planning a digitisation project for rare and unique materials including library leaders who are proposing projects, librarians and researchers who are planning and executing projects, and funding organisations that are considering supporting the digitisation of special collections.
Guidelines for Planning the Digitisation of Rare Book and Manuscript Collections	x				x	x		https://www.ifla.org/wp-content/uploads/2019/05/assets/rare-books-and-manuscripts/rbms-guidelines/guidelines-for-planning-digitisation.pdf	These guidelines are intended for anyone who is involved in planning a digitisation project for rare and unique materials including library leaders who are proposing projects, librarians and researchers who are planning and executing projects, and funding organisations that are considering supporting the digitisation of special collections.
GUIDELINES FOR THE CREATION OF DIGITAL COLLECTIONS		x			x	x		https://www.carli.illinois.edu/sites/files/digital_collections/documentation/guidelines_for_3D.pdf	The sections of the document provide guidance on the processes of creating digital images from three-dimensional objects and making them accessible online via a digital object management system such as CONTENTdm.

Handling and Storage of Audio and Video Carriers			x			x	restricted access	Although the methodology of audiovisual long-term preservation by digitisation had been universally accepted by the end of the 20th century, there remains a considerable part of the audiovisual legacy that is still stored on its original carriers. The main reason is obviously the lack of funds. But also lacking is a sense of urgency to complete the digitisation of content. There is an ever-decreasing time window to complete the digitisation process before the small pool of equipment in operable condition required for the replay of traditional formats vanishes. Today, this window is estimated to be between 10 to 15 years, which makes the provision of optimal storage conditions imperative. This is particularly important for archives in hot and humid climatic zones. The purpose of this publication is to assist stakeholders to optimise storage conditions as an interim measure before professional long-term preservation through digitisation can be funded and organised.
Historic England. Photogrammetric Applications for Cultural Heritage. Guidance for Good Practice		x				x	Photogrammetric Applications for Cultural Heritage Historic England	This guidance covers the practical application of photogrammetry in recording cultural heritage, with particular reference to structure from motion (SfM) techniques. The audience for this document includes survey contractors, archaeological contractors, voluntary organisations and specialists.

IASA-TC 06 Guidelines for the Preservation of Video Recordings			x			x	restricted access	Archives hold original video recordings in a range of types, from media-dependent, carrier-based analogue videotapes to computer-file-based digital recordings. The appropriate preservation treatments for this array reflect the variation in the source recordings. For analogue videotapes, for example, digitisation is called for. Meanwhile, examples of digital file-based recording may require rewrapping into a fresh file "wrapper" or a combination of digital transcoding and rewrapping. When complete, IASA-TC 06 will cover the full range of topics in the preceding paragraph, as well as provide advice on shooting ethnographic, documentary, and oral history video footage in a manner that maximises its "preserve-ability".
Library of Congress Recommended Formats Statement 2024-2025	x	x	x	(x)		x	https://www.loc.gov/preservation/resources/rfs/RFS%202024-2025.pdf	The Recommended Formats Statement (RFS) has reached a milestone 10-year anniversary since it was first launched in 2014. It remains an important tool for both the Library of Congress but also the wider community who seek to create, collect and preserve published works in all forms. The resource has evolved over its lifespan to reflect not only changing priorities and capabilities but also its impact on the cultural landscape.

LONG-TERM ASSET STORAGE ARCHIVE AND PRESERVATION WITH AXF			x			x	https://www.iasa-web.org/sites/default/files/iasa_journal_42_part6.pdf	Many media organisations today—from broadcasters to post houses to sports teams to national archives—are still working in a hybrid content workflow that relies on legacy videotape and film-based assets alongside file-based ones. Automated solutions currently exist to rationalise the economics and technical aspects of migrating these legacy assets to digital files en masse, so media organisations do have an automated way of not only preserving those assets for the long term, but making them easier to access, manage, and market. Moving legacy assets from analog to digital and operating within a completely file-based workflow is an obvious way to improve efficiency, but once the analog-to-digital migration has happened, how can an organisation ensure those assets are accessible, backed up, and protected.
Metamorfoze Preservation Imaging Guidelines	x				x		https://www.metamorfoze.nl/sites/default/files/documents/Metamorfoze_Preservation_Imaging_Guidelines_1.0.pdf	Guidelines for digitisation of 2D heritage.

NEMO Practical Guide Digital Basic Cataloguing 10 Principles						x	https://dev.ne-mo.org/fileadmin/Dateien/public/Publications/NEMO_Report_Working_Group_Digitalisation-and-IPR_Digital_Basic-Cataloguing_12.22.pdf	fields of work undertaken by museums – collecting and documenting, researching, preserving and communicating – digitisation has changed many things. If museums take the leap to open their collections digitally, both within but also separate from the museum itself as an established institution, it is important to develop basic criteria and procedures to integrate this with a holistic approach in already ongoing processes. At first sight, publishing these recommendations on the fundamentals of digital information processing in 2022 may seem a bit late. But whereas many museums have developed their digital potential on diverse levels, others have just begun to tackle these topics, especially in the last two years, when the Covid pandemic challenged them to do so. To reach the full potential of digitalisation in museums and to open collections to a broad audience for re-use, the groundwork the basic cataloguing provides the base to develop these levels of digitalisation. Even though this publication primarily addresses the elementary area of basic collecting, the developments described are relevant in many other areas too. Considering ongoing changes, however, they require constant review in terms of content and technology.
Ontario Museum Association (OMA) Toolkit	x		x		x	x	https://resources.museumsonario.ca/lesson/template-digitisation-standards/	This manual assists museums, archives and independent researchers in digitising their existing collections of intangible heritage-related material. Aside from providing step-by-step digital transferring instructions, it also offers definitions for heritage-related terminologies, as well as a significant number of technological terminologies. While this digitisation guide aims to be user-friendly, familiarity with basic audio/visual equipment and media software is a prerequisite. Digitisation

									instructions are provided for both Windows and Mac operating systems.
PARTHENOS Guidelines to FAIRify data management and make data reusable						x		https://zenodo.org/records/2668479#.XXYdfC1abUo	This guide offers a series of guidelines to align the efforts of data producers, data archivists and data users in humanities and social sciences to make research data as reusable as possible. The guidelines result from the work of over fifty PARTHENOS project members. They were responsible for investigating commonalities in the implementation of policies and strategies for research data management and used results from desk research, questionnaires and interviews with selected experts to gather around 100 current data management policies (including guides for preferred formats, data review policies and best practices, both formal as well as tacit).

PHOTOCONSORTIUM: opening up the riches of Europe's Photographic Heritage	x	(x)	(x)			x	x	https://www.photoconsortium.net/wp-content/uploads/2017/08/Euromed-2018-Photoconsortium-paper-revised-14-8-2018-v1.pdf	Digitisation and crowdsourcing actions are fostered by the European Union for enhancing access and citizens' participation in culture and research. Several experiences are demonstrating how tangible and intangible heritage is moving nowadays from the concept of representing objects to that of safeguarding memories and stories related to those objects. This process means to have richer, more complex and heterogeneous metadata associated to digital objects. To leverage on such richness of information, new approaches for improving searchability/retrievability of digital resources, storytelling and reuse are developing. Also, dealing with crowdsourced contributions of various types poses new challenges for curation and preservation methods in heritage institutions and across separated repositories, where linked objects and resources lie. PHOTOCONSORTIUM, the international consortium for photographic heritage, is exploring the potential of technologies, which can make possible to enrich metadata and utilise photographic heritage at best for different purposes in education, creative industry, and research.
Principles of Seville. International Principles of Virtual Archaeology		x			x	x		http://sevilleprinciples.com/	The principles discussed below aim to provide practical applications of the principles of the London Charter to improve its implementation in the field of archaeological heritage, including industrial archaeological heritage, simplifying and organising its bases sequentially, while at the same time offering new recommendations considering the specific nature of archaeological heritage in relation to cultural heritage.
Recommended 3D Workflow for Digital Heritage Practices		x				x	x	https://library.imaging.org/archiving/articles/20/1/5	This paper addresses the concerns of the digital heritage field by setting out a series of recommendations for establishing a workflow for 3D objects, increasingly prevalent but still lacking

									a standardised process, in terms of long-term preservation and dissemination.
Rijksmuseum Manual for the Photography of 3D objects.	x							https://colostateprofessionalpractices.weebly.com/uploads/5/8/8/5/58856297/rijksmuseum_manual-3d.pdf	The Rijksmuseum Manual for the photography of 3D objects gives an overview of the way in which the Rijksmuseum studios photograph object groups. The manual provides instructions about the different lighting setups for photographing objects which fall into one of two categories: standing objects or lying objects. We use examples of photographs to illustrate which perspectives and object-specific images are chosen. The Rijksmuseum came to the consensus that object photography of the collection must comply with the following quality standards: • The object always has a neutral background. • The object is of paramount significance and readable, in other words, all the objects' specific characteristics are clearly visible. • All objects are always photographed from the same perspective, in consultation with the conservator or curator.
Rijksmuseum. Instruction manual for photographing 2D objects.	x							https://assets.foleon.com/eu-central-1/de/uploads-7e3kk3/109/manual-2d-2021_v6.8c8ade34970e.pdf	The manual concerns photography of 2-dimensional objects.
Archiving	x	x	x	x	x	x	x	https://library.imaging.org/archiving/volumes	Access to the open access repository of the Archiving conference papers.

SHARE: a guide to digitisation	x				x		digitisation-FINAL-FULL.pdf (sharemuseumseast.org.uk)	This resource is designed to be used in one of two ways, as a digital desktop document or as a printed document. The resource contains hyperlinks to take you to the relevant places within the resource when using it as a desktop document, but these are labelled in such a way so that you will still be able to follow it in a printed version.
Smithsonian Institution Archives: Digitising Collections	x		x		x	x	https://siarchives.si.edu/what-we-do/digital-curation/digitising-collections	To broaden access to the Archives' collections, and reduce the impact of frequent handling, the Archives is digitising its most valuable and used collections. High-resolution surrogates of the Archives' digitised collections are created and available online for researchers, scholars and the public to view, and download for personal and educational purposes. A portion of our digitised holdings are placed in the Smithsonian Transcription Center where volunteers help to transcribe these original, handwritten documents online.
The Metropolitan Museum of Art. Scene Referred Colour Managed Image Capture Workflow							https://www.conservation-wiki.com/w/images/5/5f/Met_SceneReferred_LR_Workflow_V1_0.pdf	This document will present the framework of a custom calibrated colour managed Adobe Lightroom photographic workflow that will work with any camera that produces a RAW file and any lighting set-up to produce digital image files that are, within the limits of the camera sensor's capabilities, consistently accurate based on objective standards.
The safeguarding of the audio heritage: ethics, principles and preservation strategy			x			x	https://www.iasa-web.org/IASA_TC03/TC03_English.pdf	This document constitutes a revision of earlier versions of IASA-TC 03 issued in September 2001 and February 1997. The revision is a consequence of the most recent developments in digital audio archiving. The document has also taken account of IASA-TC 04, Guidelines on the Production and Preservation of Digital Audio Objects, published in 2004. Accordingly, TC 03 concentrates on the principles while TC 04 provides detailed explanations of the practical consequences of TC 03.

Literature

Relevant Academic Literature to Impulse (ongoing scoping, literature to be added during the project)

	2D data	3D data	4D data	6D data	Data creation	Data	Data Sharing	Reference	Relevance to IMPULSE.
Title									
Archivist in the machine: paradata for AI-based automation in the archives						x	x	Franks, P. (2023). Archivist in the machine: Paradata for AI-based automation in the archives. <i>Archival Science</i> , 23(2), 275–295. https://doi.org/10.1007/s10502-023-09408-8	The visualisation of 3D data and virtual models using a headset is extremely important in sharing and learning about the history of a place. The integration of XR in 3D reconstruction is a very powerful learning tool. full-quality data and measurements cannot be used directly for visualisation due to the actual limitations of game engines and hardware processing power, introducing the need for additional data preparation processes.

A framework study on the use of immersive XR technologies in the cultural heritage domain.			x			x	Innocente, C., Ulrich, L., Moos, S., & Vezzetti, E. (2023). A framework study on the use of immersive XR technologies in the cultural heritage domain. <i>Journal of Cultural Heritage</i> , 62, 268–283. https://doi.org/10.1016/j.culher.2023.06.001	There are several techniques for 3D survey that can be used for VR applications, such as digital photogrammetry or 3D scanning by laser or structured light projection systems. These techniques involve capturing data on the subject's geometry and texture, which are then processed and optimised to create a 3D model suitable for VR. The instruments employed for a 3D survey are very diverse in their purposes and functions. These include devices that allow to acquire very accurate geometric data. Bringing Back Lost Heritage into Life by 3D Reconstruction in Metaverse designed for small to medium-sized objects, at the micrometer level of accuracy. For large objects or areas other types of instruments are available, such as laser scanners that present long ranges and thus offer the possibility of obtaining geometric information at the architectural level or even over very large areas. The choice of an instrument depends on the needs in terms of precision and accuracy but also on the characteristics of the object to be surveyed from the point of view of size and material.
Bringing Back Lost Heritage into Life by 3D Reconstruction in Metaverse and Virtual Environm	x						Yara Jamil Alkhatib ^{1(B)} , Anna Forte ¹ , Gabriele Bitelli ¹ , Roberto Pierdicca ² , and Eva Malinverni ² . (n.d.). <i>Bringing Back Lost Heritage into Life by 3D Reconstruction in Metaverse and Virtual Environments: The Case Study of Palmyra, Syria</i> .	The paper highlights the transformative role of metaverse technologies in preserving cultural heritage, particularly in the face of conflict and destruction. By digitally reconstructing ancient sites like the Palmyra theater, we can offer immersive experiences that allow users to explore lost heritage and recognise our duty to safeguard cultural treasures.

ents: The Case Study of Palmyra, Syria								
Paradata and transparency in virtual heritage.	x			x	x	x	Bentkowska- Kafel, A. Denard, H (eds.) (2016). <i>Paradata and transparency in virtual heritage</i> . https://doi.org/10.4324/9781315599366	By focusing on 3D visualisation as a valid methodology, the volume addresses challenges faced by archaeologists, cultural historians, computer scientists, and ICT practitioners. The concept of “paradata” is central, documenting interpretative processes to enhance reliability and peer review.
Survey and literature study to provide insights on the application of 3D technologies in objects conservation and restoration	x						Acke, L., De Vis, K., Verwulgen, S., & Verlinden, J. (2021). Survey and literature study to provide insights on the application of 3D technologies in objects conservation and restoration. <i>Journal of Cultural Heritage</i> , 49, 272–288. https://doi.org/10.1016/j.culher.2020.12.003	A general state of the art is given concerning the adoption of 3D models in CH and for virtual reconstruction of missing parts in conservation-restoration work. Although an increased use of 3D technologies is noticed in research, preservation, dissemination and conservation-restoration, the opinion, experience and concerns of the restorer on the application of 3D technologies in their work is unclear. The conservation community was therefore asked to complete an online questionnaire, and a literature study provided 65 case studies to demonstrate the practical use of 3D technologies for loss compensation. The results of the questionnaire showed a positive trend towards 3D technologies in restoration projects. This article and the accompanying mind maps can as such assist the restorer in decision-making when considering using 3D technologies in restoration projects.

Access to digital cultural heritage: innovative applications of automated metadata generation.					x	x	Ivanova, K., Dobрева, M., Stanchev, P., & Totkov, G. (Eds.). (2012). <i>Access to digital cultural heritage: Innovative applications of automated metadata generation</i> . Plovdiv University Publishing House. https://doi.org/10.1016/j.culher.2020.12.003	This volume contains chapters on Digitisation standards, initiatives and institutions, Open-Access Initiatives across the worlds, Data Management, Metadata extraction and Generation. It also provides case studies from cultural institutions.
Cultural heritage information: artefacts and digitisation technologies	x			x			Terras, M., Ruthven, I., & Chowdhury, G. G. (2015). Cultural heritage information: artefacts and digitisation technologies. In <i>Cultural Heritage Information: Access and Management</i> (pp. 63–88). Chapter, Facet.	This chapter scopes out the background to the current digitisation environment, giving an overview of the methods and approaches involved. It points to current developments, highlighting the use of both two- and three-dimensional capture methods for the creation of digital surrogates of objects and artefacts, indicating the potential for further development in the sector, whilst drawing attention to current issues faced when digitising objects and artefacts, including cost, sustainability, impact evaluation and expectation management in the changing information environment. Best practice in newer areas of digitisation, such as 3D capture and printing, or the use of multi-spectral imaging, is still being investigated, and it will continue to be the case that as new technologies emerge their affordances should be explored for the particular use requirements of the cultural and heritage sectors.

Extended Reality: International Conference, XR Salento 2023, Lecce, Italy, September 6-9, 2023, Proceedings, Part II	x	x						De Paolis, L. T., Arpaia, P., & Sacco, M. (Eds.). (2023). <i>Extended Reality: International Conference, XR Salento 2023, Lecce, Italy, September 6-9, 2023, Proceedings, Part II</i> (Vol. 14219). Springer Nature Switzerland. https://doi.org/10.1007/978-3-031-43404-4	The volume is structured in three chapters, and each includes case studies of the application of eXtended Reality in 1) Cultural Heritage, 2) Health and Medicine, 3) the Industrial Field. It can be especially relevant for WP1.
Handbook of best practice and standards for 2D+ and 3D imaging of natural history collections	x	x			x	x		Brecko, J., & Mathys, A. (2020). Handbook of best practice and standards for 2D+ and 3D imaging of natural history collections. <i>European Journal of Taxonomy</i> , 623. https://doi.org/10.5852/ejt.2020.623	Almost all the techniques currently available to digitise a natural history collection in 2D+ and 3D are listed herein. The techniques are explained in a way that even one without any knowledge on the subject may understand their principle. The strong and weak points of the techniques are discussed, and an overview of suitable collections and specimens are given for each one of them. Also, plenty of examples already digitised with each technique are provided together with the links to visualise them in 3D. After explaining all the different digitisation options, the subsequent chapters provide information on how to improve the 2D+ and 3D digital twins of the specimens and techniques are compared to each other by means of test specimens. These give a fast overview of the capabilities of the digitisation techniques. Possible solutions to avoid digitisation errors are equally provided.

3D Research Challenges in Cultural Heritage III		x					https://doi.org/10.1007/978-3-031-35593-6	1. Challenges related to the digitisation of CH objects and transforming them to digital/virtual twins 2. The interplay of geometry and semantics for CH 3. The organisation of large 3D databases in CH 4. Handling 3D data in CH over the Internet and using mobile devices 5. Presenting CH content in 3D to the general public 6. Contributing to the research efforts of CH professionals 7. Reconstruction of CH objects from virtual to real and their 3D production and use.
Journal of Cultural Heritage. Survey and literature study to provide insights on the application of 3D technologies in objects conservation and restoration		x				x	Acke, L., De Vis, K., Verwulgen, S., & Verlinden, J. (2021). Survey and literature study to provide insights on the application of 3D technologies in objects conservation and restoration. <i>Journal of Cultural Heritage</i>, 49, 272–288. https://doi.org/10.1016/j.culher.2020.12.003	Although the main concerns are justified as there are many challenges to overcome, reassurance or first answers to these concerns have been found in the varied applications of 3D technologies presented in the case studies. The arguments pro and con 3D technologies, possible solutions for the mentioned concerns and further research possibilities are subsequently presented in informative mind maps. This article and the accompanying mind maps can as such assist the restorer in decision-making when considering using 3D technologies in restoration projects.

Standardisation of digitised heritage: a review of implementations of 3D in cultural heritage		x			x			Storeide, M. S. B., George, S., Sole, A., & Hardeberg, J. Y. (2023). Standardisation of digitised heritage: A review of implementations of 3D in cultural heritage. <i>Heritage Science</i> , 11(1), 249. https://doi.org/10.1186/s40494-023-01079-z	This review aims to underline the current limitations in implementing 3D workflows for various cultural heritage purposes. Prominent and recurring issues with standardisation, interoperability, and implementation is highlighted and scrutinised. The review is concluded with a discussion on the current utilisations of 3D data for cultural heritage purposes, along with suggestions for future developments.
Advances in Digital Cultural Heritage (International Workshop Funchal, Madeira, Portugal, June 28, 2017. Revised Selected Papers)	(x	(x	(x	(x	(x	(x	(x	Marinos Ioannides, João Martins Roko Žarnić, Veranika Lim (Eds.). (2017). <i>Advances in Digital Cultural Heritage</i> . https://doi.org/10.1007/978-3-319-75789-6	The main objective of the workshop was to present recent developments and applications of IT technologies for cultural heritage preservation, namely: 1. Demonstration of the advantages of new-generation equipment for mapping, digital survey, and documentation of heritage assets and sites Presentation of technologies for digitalisation, optimal documentation, and information sharing on cultural heritage 2. Tools and procedures for social interaction enhancing, fostering awareness, and participation 3. Rising of the knowledge level in the domain of IT applications for cultural heritage preservation 4. Usage of virtual reality for better understanding and learning on cultural heritage. The aim of this book is to contribute to the knowledge concerning the usage of IT technologies in cultural heritage preservation and management, through proper documentation as well in fostering citizens' engagement. The book is a valuable state-of-the art source for future studies, empowering further research and professional activities, supported by the presented digital cultural heritage experiences of the contributing authors.

Heritage Science and Cultural Heritage: standards and tools for establishing cross-domain data interoperability	x	x	x	x	x	x	x	Castelli, L., Felicetti, A. & Proietti, F. Heritage Science and Cultural Heritage: standards and tools for establishing cross-domain data interoperability. Int J Digit Libr 22, 279–287 (2021). https://doi.org/10.1007/s00799-019-00275-2	This paper describes a system for documenting scientific data produced in Heritage Sciences. The system is built around a general meta-model, flexible enough to provide descriptions, in a formal language, of the datasets produced by scientific research. Resulting metadata can be re-encoded and published in multiple formats. The underlying metadata schema is inspired by CIDOC CRM principles for data modelling and maintains a full compatibility with CIDOC CRM ontology to capture provenance and foster interoperability with Cultural Heritage information. The use of a wide set of thesauri and controlled vocabularies guarantees internal coherence at data and metadata level. Applicability tests are underway at different institutions and a set of user interfaces has been designed to simplify and speed up the process of data gathering and metadata definition.
---	---	---	---	---	---	---	---	--	--

3D data: Creation to Curation: Community Standards for 3D Data Preservation	x		x	x	x	x	Jennifer Moore, Adam Rountrey, and Hannah Scates Kettler (last) (Ed.). (2022). <i>3D Data Creation to Curation: Community Standards for 3D Data Preservation</i> .	While there has been rapid growth in the creation and use of 3D data over the last decade, the ongoing development and evolving usage of these data have left many unresolved questions about their stability, durability, and long-term accessibility. 3D Data Creation to Curation: Community Standards for 3D Data Preservation collects the efforts of the Community Standards for 3D Data Preservation (CS3DP) initiative--a large practicing community of librarians, researchers, engineers, and designers--to move toward establishment of shared guidelines, practices, and standards. Using a collaborative approach for standards development that promotes individual investment and broad adoption, this group has produced a work that captures the shared preservation needs of the whole community. Chapters cover best practices for 3D data preservation, management, metadata, legal issues, and access. Beginning with surveys of current practices, the authors provide recommendations for implementing standards and identify areas in which further development is required. A glossary of key terms and acronyms is included for easy reference.
Safeguarding Cultural Heritage in the Digital Era – A Critical Challenge				x	x	x	Wagner, A., de Clippele, MS. Safeguarding Cultural Heritage in the Digital Era – A Critical Challenge. <i>Int J Semiot Law</i> 36, 1915–1923 (2023). https://doi.org/10.1007/s11196-023-10040-z	This paper explores the disruptive impact of digitisation on cultural heritage preservation, focusing on the challenges posed by intellectual property rights, access, and enforcement. It emphasises the need to balance innovation and preservation in the digital landscape, addressing issues such as copyright complexities, the commodification of cultural knowledge, and the Western-centric bias in policy shaping. By fostering global cooperation, cultural sensitivity, and public awareness, we will aim at achieving an inclusive and sustainable approach to safeguarding our diverse cultural heritage in the digital era.

Strategies for the Digitalisation of Cultural Heritage		x		x	x			Gervasi, O., Perri, D., Simonetti, M., Tasso, S. (2022). Strategies for the Digitalisation of Cultural Heritage. In: Gervasi, O., Murgante, B., Misra, S., Rocha, A.M.A.C., Garau, C. (eds) Computational Science and Its Applications – ICCSA 2022 Workshops. ICCSA 2022. Lecture Notes in Computer Science, vol 13382. Springer, Cham. https://doi.org/10.1007/978-3-031-10592-0_35	Various aspects that play a crucial role in the digitisation of artifacts will be discussed, with a focus on the issues involved in the manual realisation of works using Blender and Unity software. For demonstration purposes, two very popular use cases in the Umbria region of Italy are presented: “Piazza IV Novembre” in Perugia with the magnificent “Fontana Maggiore”, the “Palazzo dei Priori” and the Duomo on one side and the Republic square in Foligno on the other, with the Duomo, the Bishop’s house and the Diocesan Museum, the Town Hall and “Palazzo Trinci”. The first realisation was carried out using photogrammetry techniques, the software Blender and Unity, while the second was carried out exclusively with Blender and Unity.
3D digitising of cultural heritage		x			x			Pieraccini, M., Guidi, G., & Atzeni, C. (2001). 3D digitising of cultural heritage. Journal of Cultural Heritage, 2(1), 63–70. https://doi.org/10.1016/S1296-2074(01)01108-6	In this paper, the authors briefly review the state of the art of the 3D acquisition and digitising techniques applied to heritage. The main focus is on motivations, issues and technical specification of the 3D digitising of heritage artworks. Different digitising technologies currently available for this specific application have been evaluated and tested, with application to a pair of case studies, showing that 3D digitising technologies are sufficiently developed for extensive application in the field of cultural heritage.

Methods for 3D digitisation of cultural heritage		x			x				Pavlidis, G., Koutsoudis, A., Arnaoutoglou, F., Tsioukas, V., & Chamzas, C. (2007). Methods for 3D digitisation of Cultural Heritage. Journal of Cultural Heritage, 8(1), 93–98. https://doi.org/10.1016/j.culher.2006.10.007	Complete digital recording of Cultural Heritage is a multidimensional process. It depends highly on the nature of the subject of recording as well as the purpose of its recording. The whole process involves the three-dimensional digitisation, digital data processing and storage, archival and management, representation and reproduction. In this paper we briefly review methods for three-dimensional digitisation that are applicable to cultural heritage recording.
--	--	---	--	--	---	--	--	--	--	--

A web information system for the management and the dissemination of Cultural Heritage data						x	x	Meyer, É., Grussenmeyer, P., Perrin, J.-P., Durand, A., & Drap, P. (2007). A web information system for the management and the dissemination of Cultural Heritage data. <i>Journal of Cultural Heritage</i> , 8(4), 396–411. https://doi.org/10.1016/j.culher.2007.07.003	Safeguarding and exploiting Cultural Heritage induce the production of numerous and heterogeneous data. The management of these data is an essential task for the use and the diffusion of the information gathered on the field. Previously, the data handling was a hand-made task done thanks to efficient and experienced methods. Until the growth of computer science, other methods have been carried out for the digital preservation and treatment of Cultural Heritage information. The development of computerised data management systems to store and make use of archaeological datasets is then a significant task nowadays. Especially for sites that have been excavated and worked without computerised means, it is now necessary to put all the data produced onto computer. This allows preservation of the information digitally (in addition with the paper documents) and offers new exploitation possibilities, like the immediate connection of different kinds of data for analyses, or the digital documentation of the site for its improvement. Geographical Information Systems have proved their potentialities in this scope, but they are not always adapted to the management of features at the scale of a particular archaeological site. Therefore, this paper aims to present the development of a Virtual Research Environment dedicated to the exploitation of intra-site Cultural Heritage data. The Information System produced is based on open-source software modules dedicated to the Internet, so users can avoid being software driven and can register and consult data from different computers. The system gives the opportunity to do exploratory analyses of the data, especially at spatial and temporal levels. The system is compliant to every kind of Cultural Heritage site and allows management of diverse types of data. Some experimentation has been done on sites managed by the Service of the National Sites and Monuments of Luxembourg.
---	--	--	--	--	--	---	---	--	---

Harvesting community annotations on 3D models of museum artefacts to enhance knowledge, discovery and re-use						x	x	Hunter, J., & Gerber, A. (2010). Harvesting community annotations on 3D models of museum artefacts to enhance knowledge, discovery and re-use. Journal of Cultural Heritage, 11(1), 81–90. https://doi.org/10.1016/j.culher.2009.04.004	Many cultural heritage organisations responsible for providing access to large online collections recognise the potential value that social tagging systems can add to their collections. Projects such as Steve. Museum aim to give online users a voice in describing the content of publicly held collections of digital heritage, through online social tagging and annotation tools. However, there are a number of unresolved challenges associated with re-using community tags, aggregating them within the museum's authoritative metadata stores and incorporating them within museum “metasearch” services. Although social tagging sites provide simple, user-relevant tags, there are issues associated with the quality of the metadata, the scalability compared with conventional indexing systems and a lack of interoperability across social tagging and annotation systems. In this paper, we propose an integrated system that overcomes many of the limitations of social tagging systems and maximizes their potential value-add within the context of museum collections. The Harvesting and Aggregating Networked Annotations (HarvANA) system firstly enables communities to attach tags/annotations to digitised 3D museum artefacts through web-based annotation services. The annotations/tags are represented using a standardised but extensible Resource Description Framework (RDF) model and an ontology-directed folksonomy. This approach facilitates interoperability between tags/annotations. Secondly, the system uses the Open Archives Initiative Protocol for Metadata Harvesting (OAI-PMH) API to automatically harvest the annotations/tags from distributed community servers. The harvested annotations are aggregated with the authoritative museum metadata in a centralised metadata store. The HarvANA system provides a streamlined, interoperable, scalable approach that enables cultural organisations to leverage community enthusiasm for tagging and annotation, augment their institutional metadata with community tags and enhance their discovery and browse services over 3D models.
--	--	--	--	--	--	---	---	--	---

Archives in motion: Concrete steps towards the digital disclosure of audiovisual content		x	x		x	x		Hauttekeete, L., Evens, T., De Moor, K., Schuurman, D., Mannens, E., & Van De Walle, R. (2011). Archives in motion: Concrete steps towards the digital disclosure of audiovisual content. <i>Journal of Cultural Heritage</i> , 12(4), 459–465. https://doi.org/10.1016/j.culher.2011.04.004	Various authors have stressed the need for an adequate archiving and preservation policy of audiovisual material, given its cultural, historical, juridical, social and economic value. In view of the sustainable preservation of audiovisual material, the opening up of the archive is seen as a real challenge. Various aspects, such as requirements concerning formats, metadata standards and legal implications, need to be considered. Furthermore, different types of users should be able to consult the archive in a user-friendly way, a factor which should not be neglected. This article studies and discusses the current situation in Flanders regarding the digitisation and disclosure of the Flemish audiovisual cultural heritage, comprising the audiovisual material in the archives of different Flemish institutions, including broadcasters, (post-) production companies, government institutions and cultural organisations. Based on 45 qualitative interviews, a SWOT analysis is created to assess the strengths, weaknesses, opportunities and threats concerning the digitisation and disclosure of the audiovisual archive. Moreover, this environmental analysis includes some recommendations concerning the future preservation of this audiovisual cultural heritage.
--	--	---	---	--	---	---	--	--	--

Integrate d documen tation protocols enabling decision making in cultural heritage protectio n						x	Kioussi, A., Karoglou, M., Labropoulos, K., Bakolas, A., & Moropoulou, A. (2013). Integrated documentation protocols enabling decision making in cultural heritage protection. <i>Journal of Cultural Heritage</i> , 14(3), e141–e146. https://doi.org/10.1016/j.culher.2013.01.007	Documentation on cultural heritage assets is an indispensable part of an overall strategy for cultural heritage protection. Sustainable conservation and management are not feasible without a systematic data collection and registration that identifies the history of the monument, its architectural attributes, preservation state and its possible alterations during its entire lifetime. Integrated documentation protocols for data collection and organising are developed that built upon certain documentation procedures, encompassing all parameters relating to the monument. These were developed based on the current documentation methodologies survey, revealing the prerequisite main attributes of such protocols, and the need to incorporate quality control principles. Their structure follows a three-level classification of data that reflect the overall information to be documented at an increasing complexity. They constitute a solid basis for any knowledge-based decision-making process to establish priorities of cultural heritage protection, through the use of specific necessity indices that utilize the information collected and stored.
---	--	--	--	--	--	---	---	---

Audiovisual production, restoration-archiving and content management methods to preserve local tradition and folkloric heritage						x	Dimoulas, C. A., Kalliris, G. M., Chatzara, E. G., Tsipas, N. K., & Papanikolaou, G. V. (2014). Audiovisual production, restoration-archiving and content management methods to preserve local tradition and folkloric heritage. <i>Journal of Cultural Heritage</i>, 15(3), 234–241. https://doi.org/10.1016/j.culher.2013.05.003 The current work focuses on the implementation of audiovisual production technologies for preservation and demonstration of local tradition and Cultural Heritage (CH). A methodological framework is proposed for the production, digitisation, authoring and presentation of audiovisual (AV) content, related to traditional music and dances. The production chain involves content restoration, description and management of archived material, direction of documentary biographies, demonstration of folk customs and filming of chore-theatrical acts, aiming at creating historical, informative and educational video entities. User-friendly interactive environments are employed by means of media browsing menus and multilingual narration, utilising new AV authoring. The proposed methodology has been implemented on the occasion of a folk-heritage multilingual DVD video production and its enhanced Web-TV edition¹. The paper brings forward novel theoretical, technical and mostly methodological guidelines in preserving and disseminating CH, using state of the art AV production technologies.
---	--	--	--	--	--	---	---

The Complexity and Quality in 3D Digitisation of the Past: Challenges and Risks	x	x			x		Ioannides, M., & Patias, P. (2023). The Complexity and Quality in 3D Digitisation of the Past: Challenges and Risks. In M. Ioannides & P. Patias (Eds.), 3D Research Challenges in Cultural Heritage III (Vol. 13125, pp. 1–33). Springer International Publishing. https://doi.org/10.1007/978-3-031-35593-6_1	This paper is focusing on the exceptional results of the EU Study (VIGIE2020/654) to map the parameters, formats, standards, benchmarks, and methodologies relating to 3D digitisation of tangible cultural heritage (CH). The overall objective of the paper is to further the quality of 3D digitisation process by enabling cultural heritage professionals, institutions, content-developers, stakeholders, and academics to define and produce high-quality digitisation standards for tangible cultural heritage assets. This study identified for the first time in this domain, key parameters of the digitisation process, estimated the relative complexity and how it is linked to technology, its impact on quality and its various factors. It will also present standards and formats used for 3D digitisation, including data types, data formats and metadata schemas for 3D structures.
Advanced Technologies in Digitising Cultural Heritage		x			x		https://www.mdpi.com/journal/applsci/special_issues/digitising_cultural_heritage#info	Current advances in technologies (e.g., linked data, virtual/augmented/extended reality, chatbots and digital storytelling), when combined with fundamental technological fields, such as artificial intelligence and machine learning, create new opportunities to explore innovative technological solutions for the effective (re)use of digital cultural heritage assets. This Special Issue aims to spotlight cutting-edge research in technology-driven cultural heritage, as well as help in the alignment of these endeavors.

Safeguarding Cultural Heritage in the Digital Era – A Critical Challenge	(x)	x				x	Wagner, A., & De Clippele, M.-S. (2023). Safeguarding Cultural Heritage in the Digital Era – A Critical Challenge. International Journal for the Semiotics of Law - Revue Internationale de Sémiotique Juridique, 36(5), 1915–1923. https://doi.org/10.1007/s11196-023-10040-z	This paper explores the disruptive impact of digitisation on cultural heritage preservation, focusing on the challenges posed by intellectual property rights, access, and enforcement. It emphasises the need to balance innovation and preservation in the digital landscape, addressing issues such as copyright complexities, the commodification of cultural knowledge, and the Western-centric bias in policy shaping. By fostering global cooperation, cultural sensitivity, and public awareness, we will aim at achieving an inclusive and sustainable approach to safeguarding our diverse cultural heritage in the digital era.
Photogrammetric texture mapping: A method for increasing the Fidelity of 3D models of cultural heritage materials		x			x		Dostal, C., & Yamafune, K. (2018). Photogrammetric texture mapping: A method for increasing the Fidelity of 3D models of cultural heritage materials. Journal of Archaeological Science: Reports, 18, 430–436. https://doi.org/10.1016/j.jasrep.2018.01.024	Accurately recording information is the single most important stage of an archaeological project. The biggest technological improvement to documentation techniques in the last 15 years has been the spread of various 3D digitization technologies, such as computer vision photogrammetry and 3D laser scanning. These technologies have allowed archaeologists to quickly and accurately capture and reconstruct the geometry and colors of the subjects being studied. Each of the various methods for 3D digitization of cultural heritage materials has advantages and disadvantages, such as processing speed, cost of equipment, and the accuracy of the captured data. Laser scanned data is among the most accurate geometrical data available in modern scanning techniques, but it lacks in its ability to accurately capture textures and diagnostic coloration information. Photogrammetric data produces highly detailed photographic textures on models, but the geometric data tends to be of a lower definition than the laser scanned data. In this paper, the authors discuss a new methodology that combines the advantages of computer vision photogrammetry with those of laser scanning by applying the photographic textures produced with photogrammetry to the geometric data obtained from laser scanning. This method allows archaeologists to achieve the best possible fidelity 3D models for interpretation and study.

Digitisation and Sharing of Collections: Museum Practices and Copyright During the COVID-19 Pandemic	x			x	x	x	Klinowski, M., & Szafarowicz, K. (2023). Digitisation and Sharing of Collections: Museum Practices and Copyright During the COVID-19 Pandemic. International Journal for the Semiotics of Law - Revue Internationale de Sémiotique Juridique, 36(5), 1991–2019. https://doi.org/10.1007/s11196-023-09986-x	This article concerns the conflict between copyright and museums' digitisation and online sharing of collections. This issue has recently become particularly important in connection with the COVID-19 pandemic. The authors outline the concept of a virtual museum and present the most important copyright provisions in EU law that may create obstacles for cultural institutions in realising virtual counterparts. To perceive copyright as the main obstacle in the process of digitisation and online sharing of collections is not unusual. Hence, the article briefly presents legal framework of the European copyright applicable to such situations. The authors argue that although copyright offers a range of possibilities for museums interested in digitising their collections, at the same time it is responsible for a chilling effect, resulting in fear of potential infringement and liability. The authors conclude that the EU's development of new legislation, coinciding with the need for digitisation and online sharing of cultural heritage caused by the pandemic, has favored public interest at the expense of creators' rights, but still lacks satisfactory legal tools for effectively allowing cultural institutions to digitise and share their collections.
--	---	--	--	---	---	---	---	--

Standards for Digitisation in Cases of Maps, Documents, and other Relics in the Service of Cultural Heritage	x	x			x			Malaperdas, G. (2021). Standards for Digitisation in Cases of Maps, Documents, and other Relics in the Service of Cultural Heritage. Trends Journal of Sciences Research, 1(1), 24–32. https://doi.org/10.31586/ojer.2021.99	This paper discusses the analysis of correct digitisation practices to follow for maximum performance of the technique. Although it is written for cases that fall within the broader context of culture and cultural heritage, it is ultimately about writing rules that are not limited to the above-mentioned cases, but can be used in more general situations, particularly printed materials. This paper will therefore discuss the technical characteristics of the choice of digital imaging devices and distinguish the types of quality calculation in the different cases of digitised text, digitised manuscript, digitised maps, and photographs.
--	---	---	--	--	---	--	--	--	--

metadata enriched system for the documentation of multi-modal digital imaging surveys						x	Pamart, A., De Luca, L., & Véron, P. (2022). Metadata enriched system for the documentation of multi-modal digital imaging surveys. <i>Studies in Digital Heritage</i>, 6(1), 1–24. https://doi.org/10.14434/sdh.v6i1.33767 In the field of Digital Heritage Studies, data provenance has always been an open and challenging issue. As Cultural Heritage objects are unique by definition, the methods, the practices and the strategies to build digital documentation are not homogeneous, universal or standardised. Metadata is a minimalistic yet powerful form to source and describe a digital document. They are often required or mandatory at an advanced stage of a Digital Heritage project. Our approach is to integrate since data capture steps meaningful information to document a Digital Heritage asset as it is moreover being composed nowadays from multiple sources or multimodal imaging surveys. This article exposes the methodological and technical aspects related to the ongoing development of MEMoS; standing for Metadata Enriched Multimodal Documentation System. MEMoS aims to contribute to data provenance issues in current multimodal imaging surveys. It explores a way to document CH oriented capture data sets with a versatile descriptive metadata scheme inspired from the W7 ontological model. In addition, an experiment illustrated by several case studies, explores the possibility to integrate those metadata encoded into 2D barcodes directly to the captured image set. The article lays the foundation of a three parted methodology namely describe - encode and display toward metadata enriched documentation of CH objects.
---	--	--	--	--	--	---	---

Photogrammetry and macro photography. The experience of the MUSINT II Project in the 3D digitising process of small size archaeological artifacts		x						Marziali, S., & Dionisio, G. (2017). Photogrammetry and macro photography. The experience of the MUSINT II Project in the 3D digitising process of small size archaeological artifacts. <i>Studies in Digital Heritage</i> , 1(2), 298–309. https://doi.org/10.14434/sdh.v1i2.23250	The MUSINT II project was created to publicize and promote the Minoan glyptic, a little-known archaeological heritage. Its contents were designed to involve both specialists and a general public (adults and children). The project focuses on the 3D digitalisation of seventeen very small (about 15mm diameter) seals, stored in the archives of the National Archaeological Museum of Florence. The digitalisation of these artifacts required a high-quality resolution technique capable of capturing their morphology and decorative motives and, at the same time, appeal to the educational targets. For this reason, the Structure from Motion (SfM) Photogrammetry was chosen. This technology makes it possible to obtain three-dimensional reproductions from random photographs made by non-dedicated devices, but the tiny-object survey required specific instruments and skills. A macrophotography technique was applied together with a specific workflow to obtain high quality photogrammetric models and to save time in acquiring and processing images. With this methodology, 3D models of high metric precision mesh and maximum colour fidelity textures were obtained. This process delivers results of high-level detail for low capital costs and minimal acquisition and processing time.
Virtually Real or			x						Virtually Real or Really Virtual: Towards a Heritage Metaverse.

Really Virtual: Towards a Heritage Metaverse									
Cultural Heritage in Fully Immersive Virtual Reality				x	x				Cecotti, H. (2022). Cultural Heritage in Fully Immersive Virtual Reality. <i>Virtual Worlds</i>, 1(1), 82–102. https://doi.org/10.3390/virtualworlds1010006 Fully immersive virtual reality (VR) applications have modified the way people access cultural heritage—from the visiting of virtual museums containing large collections of paintings to the visiting of ancient buildings. In this paper, we propose to review the software that are currently available that deal with cultural heritage in fully immersive virtual reality. It goes beyond technologies that were available prior to virtual reality headsets, at a time where virtual was simply the synonym of the application of digital technologies to cultural heritage. We propose to group these applications depending on their content—from generic art galleries and museums to applications that focus on a single artwork or single artist. Furthermore, we review different ways to assess the performance of such applications with workload, usability, flow, and potential VR symptoms surveys. This paper highlights the progress in the implementation of applications that provide immersive learning experiences related to cultural heritage, from 360 images to photogrammetry and 3D models. The paper shows the discrepancy between available software to the general audience on various VR headsets and scholarship activities dealing with cultural heritage in VR.

4D RECONSTRUCTION AND VISUALISATION OF CULTURAL HERITAGE : ANALISING OUR LEGACY THROUGH TIME	x	x		x	x		Rodríguez-González, P., Muñoz-Nieto, A. L., Del Pozo, S., Sanchez-Aparicio, L. J., Gonzalez-Aguilera, D., Micoli, L., Gonizzi Barsanti, S., Guidi, G., Mills, J., Fieber, K., Haynes, I., & Hejmanowska, B. (2017). 4D RECONSTRUCTION AND VISUALISATION OF CULTURAL HERITAGE: ANALISING OUR LEGACY THROUGH TIME. The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, XLII-2/W3, 609–616. https://doi.org/10.5194/isprs-archives-XLII-2-W3-609-2017 Temporal analyses and multi-temporal 3D reconstruction are fundamental for the preservation and maintenance of all forms of Cultural Heritage (CH) and are the basis for decisions related to interventions and promotion. Introducing the fourth dimension of time into three-dimensional geometric modelling of real data allows the creation of a multi-temporal representation of a site. In this way, scholars from various disciplines (surveyors, geologists, archaeologists, architects, philologists, etc.) are provided with a new set of tools and working methods to support the study of the evolution of heritage sites, both to develop hypotheses about the past and to model likely future developments. The capacity to “see” the dynamic evolution of CH assets across different spatial scales (e.g. building, site, city or territory) compressed in diachronic model, affords the possibility to better understand the present status of CH according to its history. However, there are numerous challenges in order to carry out 4D modelling and the requisite multi-data source integration. It is necessary to identify the specifications, needs and requirements of the CH community to understand the required levels of 4D model information. In this way, it is possible to determine the optimum material and technologies to be utilised at different CH scales, as well as the data management and visualisation requirements. This manuscript aims to provide a comprehensive approach for CH time-varying representations, analysis and visualisation across different working scales and environments: rural landscape, urban landscape and architectural scales. Within this aim, the different available metric data sources are systemized and evaluated in terms of their suitability (PDF) 4D RECONSTRUCTION AND VISUALISATION OF CULTURAL HERITAGE: ANALISING OUR LEGACY THROUGH TIME. Available from: https://www.researchgate.net/publication/313945854_4D_RECONSTRUCTION_AND_VISUALISATION_OF_CULTURAL_HERITAGE_ANALISING_OUR_LEGACY_THROUGH_TIME [accessed Aug 05, 2024].
--	---	---	--	---	---	--	--

Challenges of digital preservation for cultural heritage institutions			x		x	x	x	Evens, T., & Hauttekeete, L. (2011). Challenges of digital preservation for cultural heritage institutions. Journal of Librarianship and Information Science, 43(3), 157–165. https://doi.org/10.1177/0961000611410585	This article elaborates four major issues hampering the sustainability of digital preservation within cultural heritage institutions: digitisation, metadata indexes, intellectual property rights management and business models. Using a case-study approach, the digitisation of audiovisual collections within the performing arts institutions in Flanders (Belgium) will be scrutinised, providing an overview of the state-of-the-art preservation and access. The analysis shows that digital preservation policies in most organisations are underdeveloped and that archives suffer from deterioration and technological obsolescence.
---	--	--	---	--	---	---	---	---	--

Digital Audiovisual Heritage: An Exploration of Challenges and A Community-based Approach to Preservation			x		x	x		Liew, C. L. (2019). Digital Audiovisual Heritage: An Exploration of Challenges and A Community-based Approach to Preservation. Proceedings of the 9th International Conference on Communities & Technologies - Transforming Communities, 76–80. https://doi.org/10.1145/3328320.3328367 While some of the challenges of digitising audiovisual are common to other types of digitisation, there are a few factors that present unique difficulties: the relatively large file size of audiovisual materials that place greater demands on storage and bandwidth, dealing with proprietary formats, obsolescence of analogue materials and playback equipment, complex copyright and digital rights management, relatively under-developed and evolving standards and, lack of freely-available and reliable resources about audiovisual digitisation and preservation. This research investigates the experiences and perspectives of staff working with audiovisual materials in the memory sector. The objective is to gain insights into the challenges and issues they face, particularly in terms of preserving and maintaining long-term digital access to audiovisual heritage. The questions guiding this research are: • What challenges do memory institutions staff encounter with audiovisual preservation? How are these challenges dealt with? • Do memory institutions take part in collaborative activities to preserve audiovisual materials? If so, in what capacity? The sampling aimed to include participants from the three main types of memory institutions (i.e. archives, libraries and museums) and to involve participants from different types of entities who were involved in managing audiovisual heritage material, from large national, government-funded institutions to smaller, council- or community-funded ones. The findings show that while there is active digitisation in some institutions, in others, their ambitions and efforts are limited by the lack of funding, dedicated staff with the necessary knowledge, skills and experience, and inadequate equipment. The lack of standards and unrealistic or unachievable best practices were mentioned as potential hinder by a number of participants from smaller institutions which could not afford to invest in specialised equipment and recruitment of specialist staff or in providing training for staff. There was the sense of perceived imbalance between large, well-funded and smaller institutions which are less endowed, with larger institutions setting benchmarks that were unachievable for their smaller, less well-resourced counterparts. Participants from smaller
---	--	--	---	--	---	---	--	--

institutions saw the value in a community-based approach to facilitate collaboration on preservation projects as it was unrealistic for them to acquire the skills and to develop the necessary infrastructure on their own.

3D Digitisation of Tangible Heritage		x			x					Pavlidis, G., & Koutsoudis, A. (2022). 3D Digitisation of Tangible Heritage. In S. D'Amico & V. Venuti (Eds.), Handbook of Cultural Heritage Analysis (pp. 1363–1404). Springer International Publishing. https://doi.org/10.1007/978-3-030-60016-7_47 Digitisation of tangible entities is the process that focuses on the transformation of the real world and its features to a virtual world, the digital world of computing devices. This virtual world comes along with a typical set of rules, benefits, limitations, and opportunities. As this world is mathematically digital, every virtual entity is discretised and quantised, being only an approximation of its real counterpart, or “source,” or “parent.” Digitised tangible entities run a parallel life, potentially a life with no ending, as the most apparent benefit of the virtual world is the long-lasting presence. Since tangible heritage entities constitute the most radiant examples of human civilisation, they are the obvious targets for digitisation. Particularly, since these entities are of three dimensions (3D), their digitisation should also follow the 3D world representation; let us forget the fourth dimension, time, in this case, since this is the dimension that can be “frozen” with 3D digitisation. 3D digitisation of precious entities not only safeguards them in the virtual world but also opens up new horizons for presentation, knowledge dissemination, research and study, conservation, and even physical duplication. In order for these horizons to actually open, human ingenuity with long-lasting and painstaking research and development resulted a number of 3D digitisation methods, all targeting the best possible result in terms of an accurate virtual replication. This is the focus of this chapter, in which an attempt is made to explain the ideas and inner workings of the various 3D digitisation methods that have been invented during the last half of the twentieth century and the beginning of the twenty-first.
--------------------------------------	--	---	--	--	---	--	--	--	--	--

Digital Documentation Management of Cultural Heritage		x				x	Marinković, B., Šegan Radonjić, M., Novaković, M., & Ognjanović, Z. (2022). Digital Documentation Management of Cultural Heritage. In S. D’Amico & V. Venuti (Eds.), Handbook of Cultural Heritage Analysis (pp. 2133–2155). Springer International Publishing. https://doi.org/10.1007/978-3-030-60016-7_74	In this chapter, the focus will be on applications of metadata in the process of cultural heritage documentation management with an aim to ensure its preservation, presentation, and availability over a longer time period. We describe a procedure for the establishment of a single metadata scheme on the level of national cultural institutions, which would be interoperable and compatible with broadly accepted international schemes and standards. The proposal takes into consideration official guidelines and recommendations on digitisation of cultural heritage in the Republic of Serbia and makes a step towards the establishment of a national information system for management and preservation of data on cultural property.
---	--	---	--	--	--	---	--	--

New Photogrammetric Systems for Easy Low-Cost 3D Digitisation of Cultural Heritage	X			X					Morita, M. M., Loaiza Carvajal, D. A., & Bilmes, G. M. (2022). New Photogrammetric Systems for Easy Low-Cost 3D Digitisation of Cultural Heritage. In S. D'Amico & V. Venuti (Eds.), Handbook of Cultural Heritage Analysis (pp. 1439–1464). Springer International Publishing. https://doi.org/10.1007/978-3-030-60016-7_49 The MUSINT II project was created to publicise and promote the Minoan glyptic, a little-known archaeological heritage. Its contents were designed to involve both specialists and a general public (adults and children). The project focuses on the 3D digitalisation of seventeen very small (about 15mm diameter) seals, stored in the archives of the National Archaeological Museum of Florence. The digitalisation of these artifacts required a high-quality resolution technique capable of capturing their morphology and decorative motives and, at the same time, appeal to the educational targets. For this reason, the Structure from Motion (SfM) Photogrammetry was chosen. This technology makes it possible to obtain three-dimensional reproductions from random photographs made by non-dedicated devices, but the tiny-object survey required specific instruments and skills. A macrophotography technique was applied together with a specific workflow to obtain high quality photogrammetric models and to save time in acquiring and processing images. With this methodology, 3D models of high metric precision mesh and maximum colour fidelity textures were obtained. This process delivers results of high-level detail for low capital costs and minimal acquisition and processing time.
--	---	--	--	---	--	--	--	--	--

Data Curation: How and Why. A Showcase with Re-use Scenarios .						x	Gerth, P., Sieverling, A., & Trognitz, M. (2017). Data Curation: How and Why. A Showcase with Re-use Scenarios. Studies in Digital Heritage, 1(2), 182–193. https://doi.org/10.14434/sdh.v1i2.23235	IANUS is funded by the German Research Foundation (DFG) with the objective to build up a digital archive for archaeology and ancient studies in Germany. A first three-year phase of conceptual work is now being followed by a second, in which the concepts get implemented and the data center begins its operational work. Data curation is essential for preservation of digital data and helps to detect errors, aggregate documentation, ensure the reusability of data and in some cases even add further functionality and additional files. This paper will present the workflow of data curation based on a data collection about European vertebrate fauna and will exemplify the different data processing stages at IANUS according to the OAIS model – from its initial submission until its final presentation on the recently established data portal. One aspect of this will be the discussion of the archival information package. To enable and ease the reusability of research data, it is useful to enrich the data. This includes the GIS integration of geographic information and re-utilisation of bibliography. Finally a re-use scenario of research data stored in the IANUS repository will be presented that offers researchers a unified search and discovery facilities over several distributed and heterogeneous datasets by using Semantic Web technologies.
--	--	--	--	--	--	---	---	---

Archiving the Past While Keeping up with the Times						x	x	Gilissen, V., & Hollander, H. (2017). Archiving the Past While Keeping up with the Times. <i>Studies in Digital Heritage</i>, 1(2), 194–205. https://doi.org/10.14434/sdh.v1i2.23238	The e-depot for Dutch archaeology started as a project at Data Archiving and Networked Services (DANS) in 2004 and developed into a successful service, which has ever since been part of the national archaeological data workflow of the Netherlands. While continuously processing archaeological datasets and publications and developing expertise regarding data preservation, various developments are taking place in the data landscape and direct involvement is necessary to ensure that the needs of the designated community are best met. Standard protocols must be defined for the processing of data with the best guarantees for long-term preservation and accessibility. Monitoring the actual use of file formats and the use of their significant characteristics within specific scientific disciplines is needed to keep strategies up to date. National developments includes the definition of a national metadata exchange protocol, its accommodation in the DANS EASY self-deposit archive and its role in the central channelling of information submission. In international context, projects such as ARIADNE and PARTHENOS enable further developments regarding data preservation and dissemination. The opportunities provided by such international projects enriched the data by improving options for data reuse, including allowing for the implementation of a map-based search facility on DANS EASY. The projects also provide a platform for sharing of expertise via international collaboration. This paper will detail the positioning of the data archive in the research data cycle and show examples of the data enrichment enabled by collaboration within international projects.
--	--	--	--	--	--	---	---	---	--

3D and 2D Visual Digital Technologies and Cultural Heritage Documentation for Conservation and Monitoring: A Critical Review and Assessment	x	x			x			Haddad, N. (2022). 3D and 2D Visual Digital Technologies and Cultural Heritage Documentation for Conservation and Monitoring: A Critical Review and Assessment. In O. Sergiyenko (Ed.), Optoelectronic Devices in Robotic Systems (pp. 257–288). Springer International Publishing. https://doi.org/10.1007/978-3-031-09791-1_10	During the last few decades, Cultural Heritage (referred to as “CH”) documentation, tools and techniques have undergone a noticeable shift in revealing how and why it is at risk and what can be done to mitigate these risks. This chapter reviews the state-of-the-art 3D and 2D visual digital computer-based technologies for CH documentation techniques and discusses and presents a critical review and investigation from data collection to data sharing for conservation. It discusses the following questions. Does CH documentation indeed contribute to the conservation process, and what is needed to increase its use and practice? How does it define in the context of conservation and monitoring? Who is the CH documentation project team? Is there a need for sharing documentation standards or guidelines? Will digital visual technology completely replace the traditional CH documentation and more labour-intensive methods? Or there is a need to integrate digital visual documentation techniques within the traditional hand survey techniques? Finally, how should we evaluate, deal with and choose digital visual technologies for CH documentation?
Digitisation of Cultural Heritage	x	x			x	(x)	(x)	Digitisation of Cultural Heritage. (2022). In A. Schilz & M. Rehbein, Handbook Industry 4.0 (pp. 1193–1212). Springer Berlin Heidelberg. https://doi.org/10.1007/978-3-662-64448-5_64	Like almost all sectors, institutionalised cultural memory is subject to major changes due to digitisation. Three areas are of central importance here: digitisation of cultural goods as technical digitisation in the narrower sense, meaning analog-to-digital conversion of cultural artifacts as a prerequisite to the comprehensive concept of digitisation; the creation of digital access to these digitised objects; and the transformation of processes in the management and performance of institutional tasks within the sector.

IMPULSE

IMmersive digitisation: uPcycling cULTural heritage towards new reviving StratEgies



ALMA MATER STUDIORUM
UNIVERSITÀ DI BOLOGNA



L-Università
ta' Malta



Heritage
Malta



FILMUNIVERSITÄT
BABELSBERG
KONRAD WOLF



HELLENIC REPUBLIC
National and Kapodistrian
University of Athens



Funded by
the European Union