



# Digital Transitions for a Comprehensive 3D Documentation: European Trends for Heritage Preservation

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## *Abstract*

The main objective of this paper is to present an overview on standards, procedures and protocols to Cultural Heritage digitization in 3D, based on a critical review of the State-of-the-Art in data capturing, data processing and data storage/access within the overall framework of Heritage Documentation. In fact, achieving a rich and comprehensive digital documentation of the Cultural Heritage has been among the main European challenges since long and the use of 3D has been significantly fostered in last years. Currently we are witnessing the transition from the adoption of 3D in research and high-level scenarios to a more widespread use of these technologies, also requiring a systematic approach to the storage, preservation and access of these 3D digital assets. Latest and most advanced documents and studies on the 3D Digitisation of Tangible Cultural Heritage have been critically analysed. Based on these, major trends have been identified as well as the main areas of next developments have been drafted.

## *Keywords*

Cultural Heritage, 3D documentation, Digital survey, Data accessibility, European research



A 3D point cloud of the seafront and harbour of the island of Hydra, Greece. Graphic elaboration by the authors.

## Introduction

The concept of digital 'transition' involves not only major changes in representation tools and media, but also the development of new common strategies for the creation, enrichment and sharing of 3D models, particularly when the object of survey and representation is cultural heritage [Grilli, Remondino 2019].

In 2018 the European Year of Cultural Heritage was celebrated to recognize the existing interest of Europe on Cultural Heritage. The entire Horizon 2020 framework program invested more than €500 million, in order to start to capitalize on the many research results achieved over the years. After that, with the *Declaration of Cooperation on Advancing Digitisation of Cultural Heritage* [1], signed by 24 EU Member States in April 2019, the joint efforts in European initiatives were even more consistent and articulated on three pillars: the 3D digitization of Cultural Heritage (pillar I); the re-use of digitized cultural resources to foster citizen engagement and innovative use in other sectors (pillar II); enhanced cross-sector, cross-border cooperation and capacity building (pillar III). Following such intention, several activities have been developed both to facilitate the 3D digitization and to offer a common environment for storing, accessing, and using the collected data.

The European Commission tasked the DCHE (Digital Cultural Heritage and Europeana) Expert Group to the development of guidelines on 3D cultural heritage assets. Thus, the Expert Group elaborated a list of 10 basic principles and a number of related tips for each of them geared toward cultural heritage professionals, institutions and regional authorities in charge of Europe's precious cultural heritage. The principles were published in August 2020 [European Commission 2020]. This topic was further investigated in the *Study on quality in 3D digitisation of tangible cultural heritage* [Brunet et al. 2022] that demonstrates how complexity and quality are fundamental considerations in determining the necessary effort for a 3D digitisation project to achieve the required value of the output. In short, the study highlights how there are no internationally recognized standards or guidelines for planning, organising, setting up and implementing a 3D data acquisition project for any size of asset; quality parameters refer to different stages of the 3D digitisation process; and thus, there is a pressing and urgent need for a technical specifications and guidelines [Maietti et al. 2022]. On the other hand, specific actions pursued the achievement of an enhanced valorisation of 3D digital data. Between 2019 and 2020, Europeana established the Task Force *3D Content in Europeana*. The Task Force analysed valuable content on 3D digitization of cultural artefacts at large, in the perspective of their integration in Europeana, also discussing a number of related issues such as, for example, data formats, standards and storage of the models [Europeana 2021]. The effort precluded the explicit need made clear by the Digital Europe Work Programme 2021-2022 [European Commission 2021] foreseeing the creation of Data Space for Cultural Heritage: a European common data space to provide support to the digital transformation of Europe's cultural sector; and foster the creation and reuse of content in cultural and creative sectors. It will build on the current Europeana platform, vastly expanding the current 3D functionalities. It must be noticed that improvement in 3D data management will be not only qualitative but also quantitative, since the *Recommendation on a common European data space for cultural heritage* [2] published by the Commission in November 2021 suggest the 3D digitization of all monuments and sites at risk, and at least 50% of the most visited ones, by 2030.

## Heritage at risk within digital transition

As a matter of fact, the number of threats affecting built heritage and cultural assets is increasing exponentially. The impact of climate change on cultural assets includes risk conditions due to air pollution, intense wind-driven rain, floods and landslides, wind and hurricanes, earthquakes, fire, but also armed conflicts and terrorism [Machat, Ziesemer 2020], and anthropic actions. As a different kind of damage, several small historic centres or cultural sites hardly accessible are facing several forms of abandonment or

are affected by degradation, lack of maintenance and safeguard policies [Maietti 2022]. Every day, a huge number of small historical centres lose their testimonial significance and values due to a lack of conservation actions or enhancement strategies. Often, these already unfavourable conditions are combined with damage due to territorial vulnerability or events such as earthquakes [Vernizzi 2016; Markham et al. 2016].

In this context, the Sendai Framework for Disaster Risk Reduction 2015-2030 works in synergy with other 2030 Agenda agreements, including The Paris Agreement on Climate Change, The Addis Ababa Action Agenda on Financing for Development, the New Urban Agenda, and ultimately the Sustainable Development Goals.

The Sendai Framework sets out four priorities for action:

- Understanding disaster risk, by developing and disseminating awareness, allocating EU funding for specific projects (Priority 1);
- Strengthening disaster risk governance to manage disaster risk, through collaboration among competent authorities, documentation also by using IT tools, such as the digitalisation of archival records and on-site laser scanning, ensuring easy access to required information, stakeholder engagement (Priority 2);
- Investing in disaster risk reduction for resilience, through the establishment of priorities for protecting cultural heritage assets, and the enhancement of education (Priority 3);
- Enhancing disaster preparedness for effective response and to 'Build Back Better' drafting European Standards (Priority 4).

Digitisation of cultural heritage is highlighted within actions foreseen within Priority 2, by encouraging the data collection and wide access. Digital documentation can be a way to reach the so-called 'resilience' that can be defined as the ability of a system, community or society exposed to hazards to resist, absorb, accommodate, adapt to, transform and recover from the effects of a hazard in a timely and efficient manner. This definition includes the preservation and restoration of structures and functions through risk management (figs. 1, 2).

The application of digital surveying technologies is becoming increasingly widespread in documenting historic centres, in particular following disasters [De Marco, Parrinello 2021], making it possible to create databases and three-dimensional models that can be used for different types of analysis of the historic fabric [Balzani, Maietti 2018] and as support for reconstructions or conservation actions. European trends put digital documentation at the

### #Prevention is better than cure

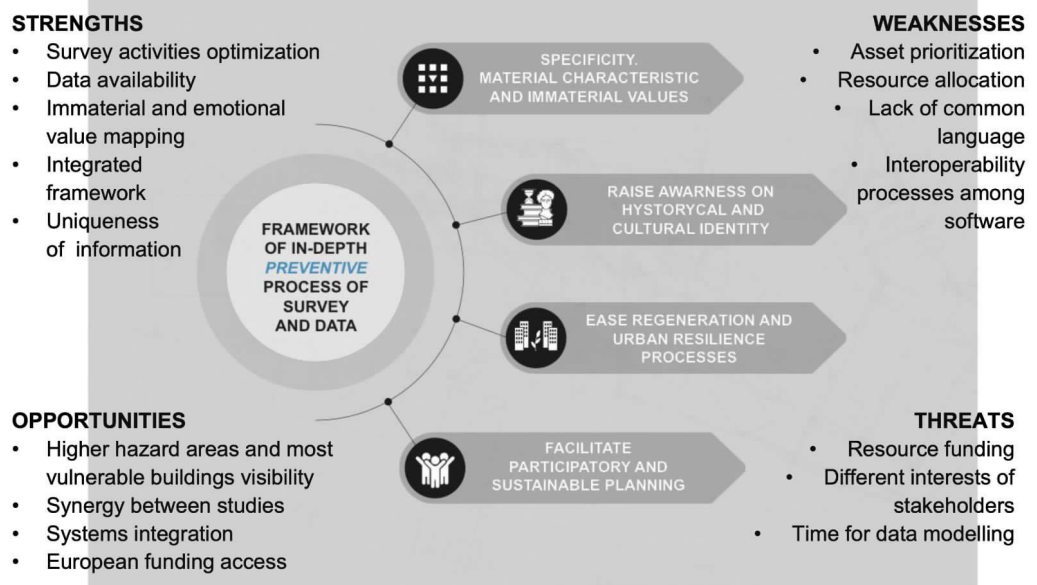


Fig. 1. Analysis diagrams drawn up during the first edition of the Summer School After the Damages in an in-depth study focused on the risk analysis of cultural heritage through advanced digital models. Working group: M. Angelosanti, R. De Marco, A. Huetto Escobar, C. Manapace, F.M. Ugliotti. Tutor: Marco Medici.

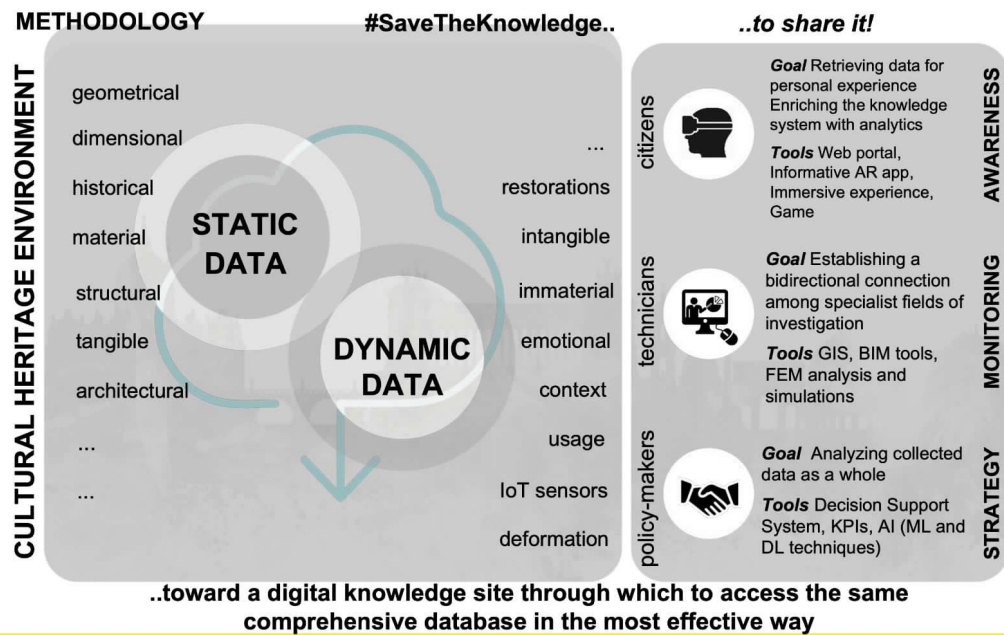


Fig. 2. Analysis diagrams drawn up during the first edition of the Summer School After the Damages in an in-depth study focused on the risk analysis of cultural heritage through advanced digital models. Working group: M. Angelosanti, R. De Marco, A. Huetto Escobar, C. Manapace, F.M. Ugliotti. Tutor: Marco Medici.

centre of strategic actions toward awareness, accessibility and sustainable development, improving the protection, enhancement, conservation and more efficient restoration through high quality digitisation and curation of digital heritage assets [Brusaporci 2017].

### Current studies and trends

The framework presented above contributed to the definition of the ongoing 4CH project. The project, aimed at designing a European Competence Centre for the Conservation of Cultural Heritage, started in January 2021 under the DT-Transformations-20-2020 within the Horizon 2020 program. Its conclusion, foreseen for December 2023, should be followed by the official establishment of the actual Competence Centre. The Centre will then work proactively for the preservation and conservation of Cultural Heritage (CH) providing expertise and advice based on most advanced standards, procedures and protocols for 3D digital documentation.

However, the 4CH project also includes the design and implementation of a pilot cloud-based infrastructure for digital services, enabling the CH community (including software providers) to share competencies and information, and providing a distributed platform to run applications. Most of these needs of the CH community are currently partially satisfied by available solutions. Nevertheless, the project is contributing to CH data organization in terms of types, formats, and technical evaluation parameters (fig. 3). In particular, the documents published by the project define the 4CH approach to data capturing and processing, data management and storage, and data preservation and access, focusing also on metadata management as a tool for the overall data evaluation. In this regard, it's also worth mentioning another report that works in the same direction: the *3D Data Creation to Curation: Community Standards for 3D Data Preservation (CS3DP)*, published in July 2022 [Moore et al. 2022]. It collects the efforts of a large community of librarians, researchers, engineers, and designers in North America. The work includes chapters on best practices for 3D data preservation, management, metadata, legal issues, and access. The recommendations in this work are based on the five-stage digital asset life cycle: Create, Manage, Distribute and Publish, Access and Reuse, Archive. The recommendations on metadata are based on two surveys of stakeholders (creators, publishers, repository managers, etc.) and feedback given during two CS3DP forums. Simultaneously, the other two main actions are starting and will characterize the European panorama of the 3D digital heritage.

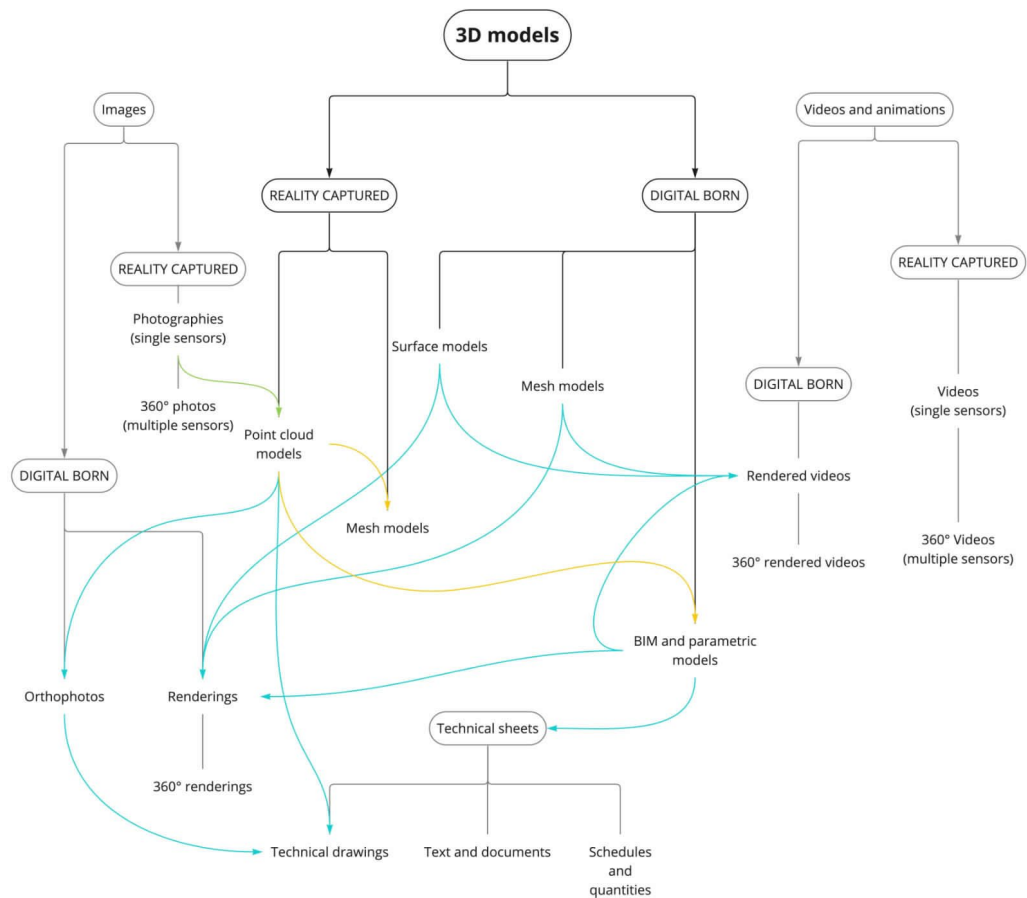


Fig. 3. Schema of digital contents produced in the process of digitization of Cultural Heritage with specific reference to 3D models. Elaboration by the authors within the 4CH project.

1. Common European Data Space for Cultural Heritage (DS4CH): It is the new flagship initiative of the European Commission - DG CNET 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 common European data space for cultural heritage is funded under Digital Europe Programme (DIGITAL) of the European Union and articulated in two sub-initiatives:
  - Data space – deployment – Work to deploy the common Europeana data space for cultural heritage is led by the Europeana Foundation in collaboration with a consortium of 18 partners from nine EU countries. Deployment and maintenance of the common European data space for cultural heritage is split into four work packages: Development and operation of the data space infrastructure, Integration of high-quality data, Capacity building and fostering reuse, Digital services for the public.
  - Data space – supporting projects – 4 projects to facilitate digital transformation and capacity building of the cultural heritage sector within the common European data space for cultural heritage. Projects work to deliver high-quality data, in particular, 3D, for reuse in different sectors, including research, education and creative industries. Projects will enhance the user experience of Europeana.eu by creating new engaging and novel editorials and educational resources. Additionally, they will provide numerous digital opportunities for the cultural sector, educators and the general public to enlarge, use and benefit from this data space for their own professional activities.
2. Collaborative Cloud for Europe's Cultural Heritage: The work on this has just started, with the ex-ante impact assessment on the Collaborative Cloud conducted by eight independent experts and published in May 2022 [European Commission, 2022]. The scope of the platform will be to offer possible higher-level tools and instruments for

storing, accessing, using, and documenting digital twins, for supporting the activities of the digital continuum and for connecting all actors in the digital ecosystem. As stated in the report: "The EC-funded competence centre 4CH could play an important role in the design of a European Collaborative Cloud for Cultural Heritage, since it could contribute to the identification of competences, requirements, and potential integration of existing services; it could also help in selecting experts who might work on the European Collaborative Cloud for Cultural Heritage assessment of tools and services". The Cloud's development will take place under Horizon Europe:

- An Innovation Action for the deployment of the *European Collaborative Cloud for Cultural Heritage* [3];
- A Research and Innovation Actions for the development of *Innovative tools for digitising cultural heritage objects* [4].

## Conclusions and future trends

The analyzed studies addressing the achievement of a rich and comprehensive 3D digital documentation of the Cultural Heritage show the exponential transition toward a comprehensive 3D digital documentation environment within the digital evolution. The importance of a good planning stage for heritage digital documentation is particularly highlighted. Understanding the use cases and the intended use of the digitization, based on the audience requirements, as well as the complexity of the object to be digitised is of utmost importance. In such complexity, following guidelines, delivering on standards, and securing access and preservation allow high-quality results. However, a list of principles on which the next research activities should focus can be drafted here.

To stress the importance of documenting data capturing and processing phases:

- the documentation of the capturing phase is more straightforward in terms of existing protocols and metadata that need to be saved while processing phases still need proper metadata schema (not yet available);
- metadata for the capturing phase can be gathered from the instruments; depending on the brand, type or model of the instrument, results, and schemas may differ; otherwise, metadata could be captured by the use of a tablet (or other devices) on site;
- the processing part is much fuzzier since most of the times technicians don't concentrate their effort in properly documenting them (and the resulting final data can be difficult to re-use and re-interpret out of the original scope);
- metadata for data processing can be even easier to be captured (e.g., directly saving processing steps from the software).

To decide on how metadata should be treated:

- how to treat metadata should be decided in the planning phase and future actions can promote good practices and key elements in the metadata treatment;
- the use of normalized metadata schema, mapping existing ones (or some of those) and plan to cover areas not yet covered (e.g., on data processing), should be fostered;
- the use of specific metadata schema (if it fits the purpose of the digitisation) should prefer those that provide an added value (e.g., integration into Europeana or the future Data Space for CH) or will open to new possibilities.

To propose a common key to handling the complexity:

- in order to not overload the digitization effort and be consistent with the intended use (defined by planning for a specific purpose), 3D digitization actions should be addressed to meet the requirements in terms of quality across the whole workflow;

- actions aimed at the scalability of the digitization will be preferred since the beginning, making choices for improving the quality of the content or its re-usability if they will not affect the overall effort;
- furthermore, correct exploitation of captured metadata will allow proper evaluation of content re-use.

Projects such as the *European Data Space for Cultural Heritage* [5] and the *5D project - Deploying and Demonstrating a 3D cultural heritage space* [6], together with the European Competence Centre on Cultural Heritage becoming operational or upcoming actions in the next European Collaborative Cloud for CH are expected to address these trends in practical applications and provide consistent results in the next future.

The activities and scenarios briefly outlined consider the concept of transition as a foreshadowing of possible futures in which technological development is aimed at creating new knowledge connections, combining traditional and new digital tools with significant impacts on representation.

#### Notes

[1] *EU Member States sign up to cooperate on digitising cultural heritage*, <<https://digital-strategy.ec.europa.eu/en/news/eu-member-states-sign-cooperate-digitising-cultural-heritage>> (accessed 5 December 2022).

[2] *Commission proposes a common European data space for cultural heritage*, <<https://digital-strategy.ec.europa.eu/en/news/commission-proposes-common-european-data-space-cultural-heritage>> (accessed 23 January 2023).

[3] The specific call is *A European Collaborative Cloud for Cultural Heritage* (HORIZON-CL2-2023-HERITAGE-ECCCH-01).

[4] The call is *A European Collaborative Cloud for Cultural Heritage - Innovative tools for digitising cultural heritage objects* (HORIZON-CL2-2023-HERITAGE-ECCCH-01-02).

[5] The deployment of the common European data space for cultural heritage is funded under Digital Europe Programme (DIGITAL) of the European Union. <<https://pro.europeana.eu/page/data-space-deployment>> (accessed 23 January 2023).

[6] *5Dculture - Deploying and demonstrating a 3D cultural heritage space* is a project funded under Digital Europe Programme (DIGITAL) of the European Union. <<https://pro.europeana.eu/project/5dculture-deploying-and-demonstrating-a-3d-cultural-heritage-space>> (accessed 23 January 2023).

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