EUreka3D

GOOD PRACTICES FOR THE 3D DIGITISATION OF CULTURAL HERITAGE

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European Union's REKonstructed content in 3D

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1. Introduction

EUreka3D is the acronym for *European Union's REKonstructed content in 3D*, a project co-funded by the Digital Europe Programme of the European Union. The publication in your hands, entitled "EUreka3D: Good Practices for the 3D Digitisation of Cultural Heritage" is the final booklet of the project.

The two-year-long project started on 1 January 2023 and will finish at the end of 2024. EUreka3D is nearing completion, synthesising results and findings, drawing conclusions, and making recommendations based on the research and outputs arising. The project is thus at the point of reflecting considering how and what the team did (e.g., digitisation pilots, Data Hub implementation, capacity building efforts, networking, collaborations), what went well (and less well), what worked in terms of methods and engagement, and what strategies were employed to mitigate any unexpected challenges. The strength of the knowledge produced is expected to influence the validity and transferability of the results to cultural managers, practitioners at the city/regional level, and policymakers, and to inform future research.

The EUreka3D consortium consists of nine partners, complementary in their roles, representing the whole value chain to provide the necessary technical support services, operational text-bed, pilot coordination, dissemination, and communication. Photoconsortium International Association is the project's coordinator and a Europeana-accredited aggregator for photography. Since 2016, it has participated in the Data Space for Cultural Heritage initiative (formerly Digital Service Infrastructure) and is deeply engaged in the reuse of digital cultural collections, especially in education and cultural tourism. Three work package leaders (Cyprus University of Technology, EGI Foundation, and CRDI Centre for Image Research and Dissemination of the Municipality of Girona), one cloud provider (Cyfronet of the University of Krakow), the world-leading R&D and innovation hub imec (Belgium), the Research Centre of Bibracte-EPCC (France), and the Museo della Carta di Pescia (Italy) are members of the EUreka3D consortium. Complementarily, the Europeana Foundation participates in EUreka3D to provide its advice and to guarantee the compliance of the project's actions with the Data Space.

The EUreka3D proposal addresses the needs of the Cultural Heritage (CH) sector to run its digital transformation. Coming from a decades-long process of information-sharing initiatives, the advent of digital transformation has imposed an overall rethinking of the underlying work processes and business models. In this transformation, not all institutions have achieved the same level of maturity towards the new digital environments; much work still needs to be done, particularly within smaller institutions. Museums, galleries, libraries, archives, and archaeological sites face several challenges in this regard and must:

- Review and modernise internal processes from digital capture to end-user access.
- Reconsider the reusability of digital assets created.
- Re-train personnel to cope with new responsibilities and roles.
- Review infrastructure, in particular regarding the ability to process 3D content.
- Generate novel forms of holistic documentation of digital cultural objects.

EUreka3D delivered a vast programme of capacity-building actions illustrated in the following chapters, which will remain available online as a project legacy.

From a technical point of view, the digital transformation of CH demands a move towards a comprehensive, integrated, cloud-based IT infrastructure that reaches beyond individual institutions and focuses on networked services and interoperability. The project implemented the EUreka3D Data Hub, a digital service centre, where the CH institutions can access a virtual space of knowledge and can use storage and computing resources to manage their 3D assets. The EUreka3D Data Hub relies on a European cloud-based and safely authenticated environment that makes it easier and more accessible for institutions to create, manage, archive, preserve, and share digitised objects, with a primary concern on 3D records.

From a content perspective, EUreka3D's focus has been on the process of creating high-quality datasets. These are directly beneficial to CHIs and offer new digital opportunities for promoting collections, creating virtual site visits, offering valuable building blocks for history reconstructions, and providing reliable content for novel applications and services in the cultural tourism, education, and learning domains. Furthermore, CH items at risk of decay or loss due to various reasons (physical deterioration of supports, the impact of climate change, damage by human attacks, natural disasters, etc.) demand urgent interventions enhanced through digital techniques. These new digitisation measures serve to preserve documental, movable, and built heritage and boost opportunities, including:

- scientific research
- supporting preservation and restoration objectives
- planning of new environmentally sustainable solutions for premises hosting heritage masterpieces
- enabling creative reuse
- supporting the process of identity building in Europe.

Figure 1. Video still from the EUreka3D presentation video, available on www.eureka3d.eu and on EUreka3D YouTube channel. EUreka3D Consortium

Unfortunately, many institutions believe the barriers towards 3D digitisation are too high and often limit the sharing of their collections to photographic representations published on their website or social media. EUreka3D developed an onboarding leadership to provide CHIs -of any size- strong support, advanced ICT services, knowledge about 3D digitisation, and novel participatory services for users.

The EUreka3D project engaged the partners of the EU-funded project together with a wider group of CH institutions in a range of piloting actions that delivered:

1. The set-up of the EUreka3D Data Hub, a dedicated cloud-based service for the management and preservation of cultural content in a safe and IP-mindful environment (ref. to Chapter 2 for further information).
2. The high-quality 3D digitisation of selected items and their related para- and meta-data, generated in compliance with the recommendations of the EU VIGIE Study 2020/654 on quality of digitisation (ref. to Chapter 3 for further information).
3. The aggregation of the new contents to Europeana.eu, complemented by galleries and editorials (ref. to Chapter 12 for further information).
4. Wide dissemination through webinars, reports, presentations at international conferences, a project website, and a dedicated blog hosted by digitalmeetsculture.net magazine (ref. to Chapter 4 for further information).

The work realised in EUreka3D has been carried out mindful of the need to deliver factual results and the social challenges faced in the continuous effort to promote European culture. The European CH landscape contains a plethora of small institutions, many of which struggle with the digital transformation process due to a lack of both knowledge and ICT resources. This gap becomes even more relevant when digitisation efforts are looking to 3D technology solutions where in-depth expertise about standards, procedures, and costly infrastructure is needed. In particular, the digitisation of local heritage from the different regions throughout Europe is vital to preserving the authentic spirit of regional heritage

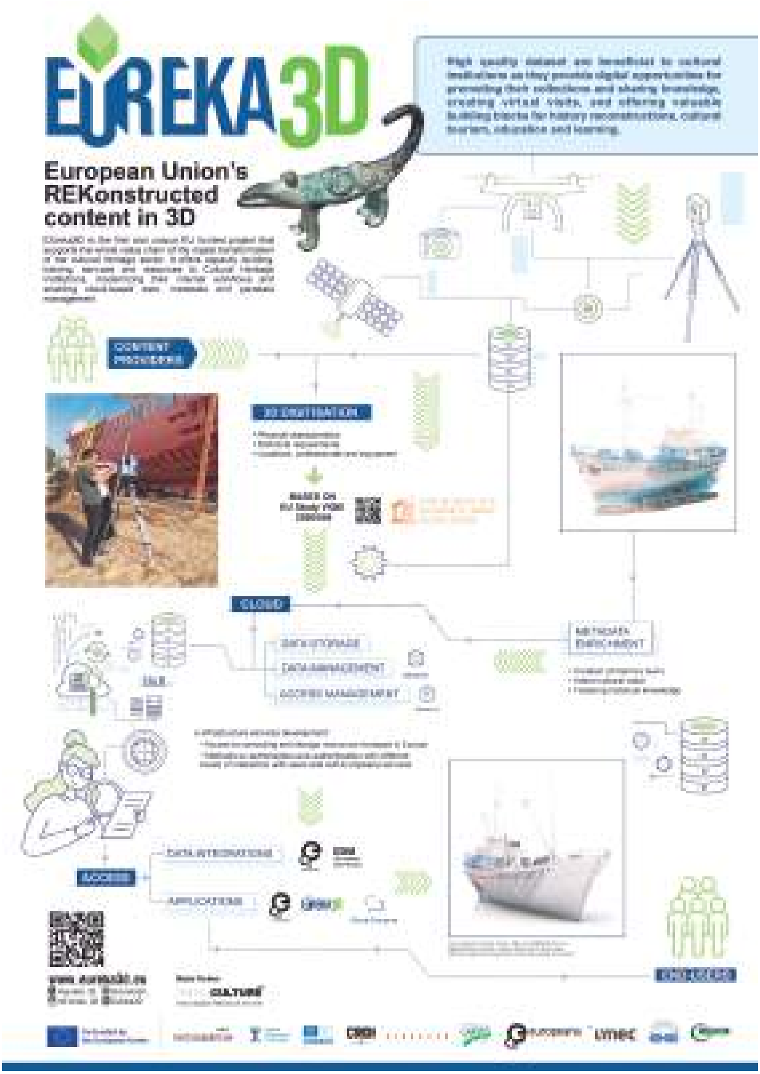

Figure 2. Dissemination poster about the EUreka3D's journey of 3D digitisation, from content providers to end-users. EUreka3D Consortium

assets, many of which risk remaining disconnected from the general digital transformation process. Furthermore, the secure digital infrastructure of the EUreka3D Data Hub features powerful authentication and authorisation federated mechanisms allowing secure control of access to cultural resources, contributing to streamlining the services for hosting and management of 3D content and delivering a safe environment for Cultural and Creative Industry initiatives and actors. In addition, 3D modelling is also applicable to understanding the building where CH collections are held, providing a better understanding of sustainable operations, for example, in the study and development of energy-saving solutions.

The story of EUreka3D does not end with the completion of the EU-funded project. It continues with *EUreka3D-XR*, the acronym of the *European Union's REKonstructed content in 3D to produce XR experiences*, the new project co-funded by the Digital Europe Programme of the EU (starting in February 2025), capitalising on the results of EUreka3D and exploring the opportunities of extended reality and artificial intelligence in the CH domain.

Antonella Fresa
PHOTOCONSORTIUM,
EUreka3D Project Coordinator

2. The EUreka3D Data Hub

The EUreka3D platform implements the services and Data Hub offered to CHIs and end-users. Figure 3 shows the platform location within the overall EUreka3D workflow map. The first stage of this workflow is the **Capture** phase, where the physical object is digitised with the help of special equipment (cameras, sensors, laser scans, etc.). The results of this process are classified into three categories:

1. **File Data**: containing the raw material output of the digitisation process including: the processed 3D models, 2D data (such as textures), video, audio, and text.
2. **Metadata**: containing information about the physical and digitised object.
3. **Paradata**: containing information related to the digitisation process itself and covering a wide range of details; responsibility for the digitisation, weather conditions, cameras used and their configuration (shutter speed, aperture, etc.), in accordance with best practice recommendations.[1]

The Capture phase is addressed in Section 3.

Once these data categories are collected, they are moved to the EUreka3D Data Hub, represented by the **Cloud** phase of Figure 3. There are three main components in the Data Hub:

1. **Authorisation and Authentication**: which protects 3D objects from manipulation or unauthorised access (discussed in Section 2.1).
2. **Data Management**: which stores, organises, shares and publishes data (discussed in Section 2.2).

1 See EUreka3D Digitisation Guidelines publication for more details https://eureka3d.eu/3d-digitisation-guidelines/

3. **Compute power**: which supports the visualisation of 3D models (discussed in Section 2.3).

These three components constitute an important aspect for the success of EUreka3D's goal of digital transformation within the Cultural Heritage sector.

Figure 3. Flow chart of EUreka3D, from digitisation to delivery to end-users

Once the data has been moved into EUreka3D's Data Hub, it is ready for the final stage of the EUreka3D workflow: the **Delivery** phase depicted in Figure 3. The figure presents two main delivery options:

1. **The Europeana Portal**:[2] which provides a user interface for the discovery of digital cultural heritage assets. Publishing on this Portal is explained in Section 2.5.
2. **The direct download of data**: which is very useful for professionals to use and manipulate digital content locally.

The publishing of open data is supported by the European initiative B2HANDLE,[3] an EUDAT service to provide Persistent Identifiers (PID).

The following sections will briefly discuss the different parts of the platform.

2 https://www.europeana.eu/en
3 https://www.eudat.eu/service-catalogue/b2handle

2.1. AUTHENTICATION AND AUTHORISATION

This component deals with the security mechanisms to protect 3D objects and other data assets from manipulation and unauthorised access. **Authentication** is the process of identifying who the user is, whereas **Authorisation** is the process of checking what the user can do in the system. In EUreka3D, both are done through EGI Check-in,[4] a federated identity and access management system that is part of the EOSC Access Federation.

Check-in covers two main aspects in EUreka3D:

1. It is the crucial layer that ensures that data is secure and can only be viewed and manipulated by the intended audience. It identifies users and supports underlying systems to make authorisation decisions based on the permissions granted to the user.
2. To use some functionalities from EUreka3D, such as uploading data, users must join the EUreka3D Community. Check-in supports the management of the EUreka3D Community, providing a clear flow of user registration and allowing the organisation of users into different groups and roles.

2.2. DATA MANAGEMENT

Data collection, processing and sharing constitute the backbone of the EUreka3D Data Hub, so data management is a central activity in EUreka3D. At the core of this, we find the distributed data management system of EGI (named EGI DataHub),[5] a based on a high-performance data management solution named OneData.[6] This is a comprehensive data solution that provides both a user-friendly Web interface and an Application Programming Interface (API), through which users can easily upload any type

4 https://www.egi.eu/service/check-in/
5 https://www.egi.eu/service/datahub/
6 https://onedata.org/

of data file, associate metadata to it in different formats, share individual files and full directories, assign persistent identifiers (PIDs) and many more. The data management system is fully integrated with EGI Check-in, the service described in Section 2.1, so it can benefit from its authentication and authorisation capabilities, thus enabling data access restrictions based on the groups created inside the EUreka3D Community. Hence, the Content Provider can decide which data to make accessible to different users.

Cloud storage is allocated to provide remote storage capacity for multiple 3D models in original formats. These are often large files consisting of 3D data, texture images and other supporting files. Cloud storage makes this flexible and scalable as the need for more storage increases during the project.

The Web interface, shown in Figure 4, allows users to upload files easily with a file dialogue or by simply dragging and dropping. Users can organise files in directories and navigate them as if it was a local drive. EUreka3D facilitates the creation of a predefined structure for organising 3D projects so that, following this convention, users know what to expect when sharing data. Files and directories can be tagged with metadata that can be retrieved and used to manage them.

Figure 4. The Web interface of EGI DataHub

2.3. COMPUTE POWER

Additional computing resources are provided in EUreka3D with cloud technologies. Traditionally, the computing hardware infrastructure that supports software applications has run on independent physical servers that were purchased, installed and managed by the organisations behind such applications. This process highlighted several problems, as it was costly and time-consuming, required specialised expertise, required the upgrade of servers when they became outdated and was susceptible to hardware failure, resulting in unacceptable application downtime. Cloud technologies are used to address these problems. They have been made possible by recent advances in computing and have become a common trend in recent decades as organisations have transitioned from physical servers to cloud environments.

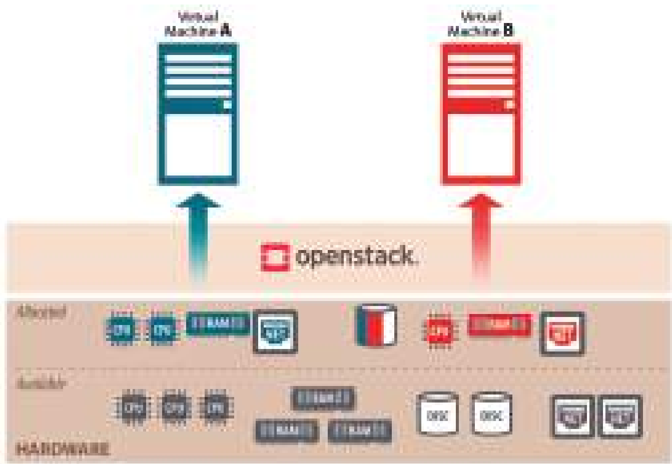

Figure 5. Simplified view of hardware allocation

With cloud technologies, servers and other hardware components are managed as virtual elements; they are no longer in the organisation's premises, but hosted by a cloud provider and are maintained by the cloud provider. Being virtual components means that servers can be requested and served almost instantaneously and on-demand, which helps to easily overcome hardware failures. This virtual allocation of servers is done through **Virtual Machines (VM)**, which are software components that run over physical hardware and emulate and provide the functionality of a physical computer system. Figure 5 depicts an oversimplified version of the hardware allocation: there is a pool of physical hardware resources available in the cloud provider. When a user requests a server, a VM is created by the cloud software (OpenStack in this case) and appropriate hardware resources are assigned to it. Resources can be added and removed on demand as needed, which enables a more efficient use of hardware resources.

EUreka3D is supported by cloud-based virtual servers provided by the Federation of the EGI Cloud Compute,[7] using a user-friendly name to access the machine provided by the EGI Dynamic DNS service.[8] The primary use of this computing power is to execute code that provides a basic 3D viewer for the visualisation of 3D objects. This viewer accepts a wide range of 3D formats with the ultimate goal of enabling the display of 3D objects on the end-user's computer. An example of rendering is shown in Figure 6.

Figure 6. Rendering of a 3D model for the EUreka3D logo

7 https://www.egi.eu/service/cloud-compute/

8 https://docs.egi.eu/users/compute/cloud-compute/dynamic-dns

2.4. PUBLISHING IN EUROPEANA

One of the main features of EUreka3D is the option to use its platform to publish content in Europeana, a European initiative to promote Europe's digital cultural heritage.

Europeana offers a portal that gathers metadata of cultural collections of heritage digital objects and embeds its visualisation and user search, making it an extremely useful source to discover cultural heritage content. The EUreka3D solution is able to make the metadata relating to the stored 3D models available to Europeana for harvesting and subsequent publication and referencing. The process is depicted in Figure 7. Step (1) of the figure shows a Content Provider uploading the data, metadata and paradata in the cloud (as discussed in Section 2.2). Then, in order to proceed with publication in Europeana, the Content Provider must publish a 3D model as Open Data, creating its metadata and obtaining a Persistent Identifier (PID). The metadata in EUreka3D uses the Europeana Data Model (EDM),[9] and the PIDs are obtained from the European initiative B2HANDLE.[10]

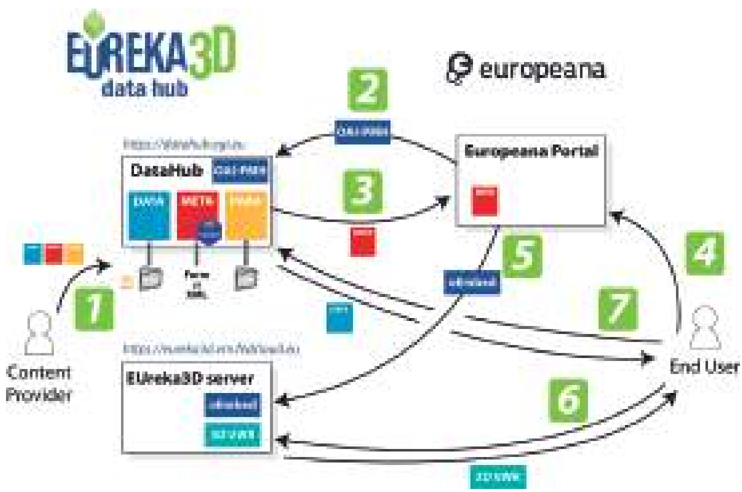

Figure 7. The interactions between the EUreka3D Data Hub and the Europeana Portal

9 https://pro.europeana.eu/page/metadata
10 https://www.eudat.eu/service-catalogue/b2handle

Once published by the Content Provider into the EUreka3D Data Hub, any external system, including Europeana systems, can access the model. In Step (2) of Figure 7, the Europeana systems access and request the metadata of the Open Data objects, which are subsequently returned in Step (3). This data exchange is achieved via the OAI-PMH protocol.[11] The Europeana Portal stores the metadata in its local database, which is used to render the Web pages accessed by the end-user.

Step (4) of Figure 7 represents an end-user who finds a 3D model on the Europeana portal, which uses the *oEmbed* protocol that references the EUreka3D server, as depicted in Step (5). This server has been discussed in Section 2.3. In Steps (6) and (7), the Europeana portal enables the user device to obtain the necessary software for the 3D viewer and the 3D object, respectively, so that it can be rendered on the user screen. An example of the result is shown in Figure 8, where an object from EUreka3D is displayed in the Europeana Portal, with its metadata and a render of the 3D model.

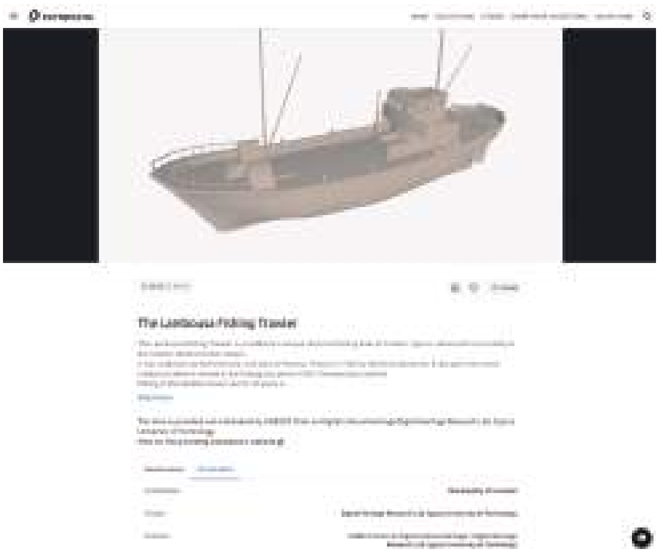

Figure 8. The object from EUreka3D "The Lambousa Fishing Trawler" shown in the Europeana Portal

11 Open Archives Initiative Protocol for Metadata Harvesting.

2.5. IN SUMMARY

This chapter illustrated the main functionalities made available by the EUreka3D project to support Cultural Heritage Institutions in sharing their 3D collections, addressing the many challenges associated with the ingestion, processing, aggregation and delivery of 3D content that stem from high-quality 3D digitisation projects. All this is achieved in a secure environment ensuring the safety of the data and the full control of the data owner. The components of the Data Hub have been designed and assembled to provide user-friendly mechanisms to manage these categories of assets, creating a good user experience both on the side of the CHIs sharing CH content, and on the side of the professionals, researchers, educators, citizens and the CH communities who access it for various purposes of use and reuse. Ultimately, the EUreka3D solution and its components proved to be effective and successful, as witnessed by case studies and feedback from users illustrated in the next sections of this booklet.

3. 3D Digitisation Guidelines: Steps to Success

As an outcome and capacity building resource in the project, openly available to all professionals, researchers and students, this is a guide designed to help anyone on their 3D digitisation journey. It is specifically aimed at CH professionals who are considering, or in the middle of, digitising their CH collections using three dimensional models.

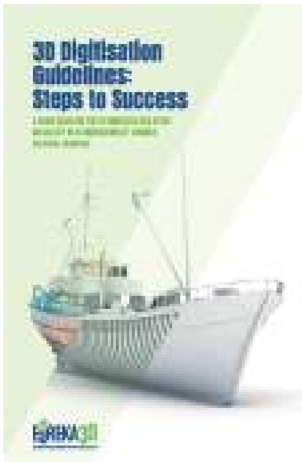

Figure 9. Cover of the 3D Digitisation Guidelines - EUreka3D Consortium

The guideline outlines and simplifies the recommended standards highlighted in the EU VIGIE Study 2020/654 (Study on quality in 3D digitisation of tangible CH, 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.

The guide directly references the VIGIE 2020/654 Study, which identified all relevant elements for successful 3D digitisation of CH, classifying them by degree of complexity and purpose or use. The study also looked at what determines the quality of a 3D digitisation project and produced an inventory of existing formats, standards, guidelines and methodologies used by the industry at time of publication.

The guideline produced by EUreka3D to support CHIs in implementing 3D digitisation devises a project plan and measures levels of Complexity in-line with the following steps based on the four step methodology of the VIGIE 2020/654 Study: *Project Planning*, *Documentation and site work*, *Production and Delivery*, and finally *Archive and preserve*. The Digitisation Guidelines help navigate in the relevant parts of the VIGIE Study and accompany users in understanding the framework and complexity of a 3D digitisation project.

DOWNLOAD THE 3D DIGITISATION GUIDELINES AND THE FULL VIGIE STUDY 2020/654:

Figure 10. Postcard promoting the 3D Digitisation Guidelines, distributed in various events - EUreka3D Consortium

4. Training and capacity building

In the new digital realm and the wider adoption of 3D digitisation in CH, museums, galleries, libraries, archives and archaeological sites need to review their internal processes and digitisation workflows, from digital capture of their collections to end-user access and re-use. There is also a need to re-train staff to cope with new responsibilities and roles; to review their infrastructure, in particular regarding the ability to process 3D contents; and to generate new forms of holistic documentation of digital cultural objects. In this light, the EUreka3D training programme was created to cover these needs and to strengthen the European CH sector to address the challenges of 3D digitisation. The effort on capacity building has been designed and delivered taking into account the well established Europeana Capacity Building Framework as the landmark term of reference for supporting the knowledge creation and sharing in the CH community.

Figure 11. *3D in Cultural Heritage*, the first EUreka3D public conference. Rome, 6 June 2023

Specifically, EUreka3D has provided an online and onsite training and capacity building programme to CHIs and CH professionals, on a variety of key topics including high-quality standards of 3D digitisation, advanced metadata management, use of the digital infrastructure resources, and aggregation to Europeana. The programme has developed training materials, resources, webinars and hands-on demonstrations and assistance, all of which is available as open resources on the project's website. This wide outreach programme has been running since June 2023 and will continue until December 2024, targeting CHIs, partners, stakeholders and collaborators. The main scope of the programme aimed at improving knowledge and skills in digital transformation among CH professionals, but also served to engage stakeholders in 3D digitisation including service providers, CH researchers, and educators.

The main topics and areas of knowledge at the core of the capacity building programme include:

- The challenges and needs for creating 3D content in good quality and reusable.
- The quality guidelines for CH digitisation and the innovative initiatives in 3D and the CH sector.
- The common understanding of paradata and its application to 3D documentation.
- The development of the EUreka3D Data Hub and the management of 3D CH datasets.
- The focus on formats, authenticity and preservation for 3D digitisation of CH content.

Figure 12. *EUreka3D Data Hub*, online demo event. Brussels, 15 December 2023

The capacity building action in EUreka3D unfolded across two major efforts:

1. The project delivered resources and capacity building activities leveraging the expertise of consortium partners and the experiences gained in the pilot digitisation action carried out by the four Content Providers in the project, widely illustrated in the following chapter as case studies.
2. The project activated a Stakeholders Group and collaborations with relevant networks, to maximise the outreach of the training and dissemination activities. A prime example of this is certainly the double series of webinars organised in collaboration with ICA, the International Council on Archives, that ran in 2023 and 2024, reaching out to thousands of heritage professionals all over the world. Similarly, the strong connections with the Europeana initiatives led to participation in various events and conferences, allowing a large community of potential users to access EUreka3D resources and capacity building events. Other scientific key conferences such as the biannual EuroMed on digital CH by partner CUT, Image&Research Conferences by CRDI and the EGI annual conference on e-infrastructures showcased the EUreka3D project to experts and specialists on 3D digitisation and holistic documentation of 3D cultural content.

The capacity building programme has been endorsed by a marketing plan, necessary to address each target group with information tailored to its interests and through the channels suiting best the purpose of communication. It must be noted that the capacity building aims are deeply linked to communication and dissemination activities, not only for reaching the appropriate audience, but also to make all these resources available online to serve as a knowledge base providing a lasting legacy of the project.

Figure 13. EUreka3D's took part in the TwinIt! Europeana high-level event. Brussels, 14 May 2024

Knowledge shared within the project's framework can be found in various resources:

- The project's website includes a Capacity Building webpage[12] collecting the training activities and a Resources webpage.[13]
- The project's YouTube channel collects the available training activities in a common playlist.[14]
- Europeana Pro blogs written by the EUreka3D Consortium disseminate the knowledge intended for professionals in the CH sector.
- The 3D Digitisation Guidelines: Steps to Success[15] has been one of the core activities of the dissemination and capacity building aims of the project. This publication simplifies the recommended standards highlighted in the EU VIGIE Study on quality in 3D digitisation of tangible CH, and is designed to help anyone on their 3D digitisation journey.

All project outcomes are summarised in this booklet, which presents the entire journey of EUreka3D, and were also

12 https://eureka3d.eu/capacity-building/
13 https://eureka3d.eu/resources/
14 https://www.youtube.com/playlist?list=PLI032Y25p243f4o1BzgnffSfcqkW3Lo0K
15 https://eureka3d.eu/3d-digitisation-guidelines/

showcased in the EUreka3D final conference[16] in Girona, Spain on 13 December 2024.

Yet the need for developing 3D digitisation skills and building capacity in the cultural sector and for the sharing and reuse of quality content created continues. In this regard the continuation project EUreka3D-XR will start in February 2025 with a new programme of events and resources extending the work undertaken today and made available to the whole community.

CAPACITY BUILDING WEBPAGE

16 https://eureka3d.eu/final-conference/

5. EUreka3D case studies

INTRODUCTION

The CH sector is very varied and not homogeneous, both in terms of types of institutions and level of digital knowledge. Cultural heritage itself is a very wide concept, including intangible and tangible heritage. Specifically, in the case of tangible heritage the spectrum of objects range from small museal artefacts preserved in controlled environments to open air monuments and archaeological sites. This variety is reflected in the EUreka3D consortium: each of the Content Providers involved in EUreka3D has a unique profile, with different collections, level of expertise in digitisation, and capacity of staff. The providers' journeys in the EUreka3D project are collected and illustrated in case studies, where the experience, reflections on methodologies, workflows, challenges and solutions of each institution, is illustrated for other practitioners and CHIs to take inspiration from:

- **Cyprus University of Technology**: a hi-tech university highly specialised in digitisation and 3D documentation, appointed to digitise three monuments of Cypriot heritage.
- **Bibracte EPCC**: a national archaeological site and museum preserving objects and the excavations and remnants of a celtic town in France.
- **CRDI/Ajuntament de Girona**: a municipal archive that manages AV collections and collaborates with museums in the city of Girona.
- **Museo della Carta di Pescia**: a small museum and documental archive in Italy, at the dawn of their digital transformation.

ALL THE 3D ASSETS DIGITISED WITHIN EUREKA3D BY THE FOUR CONTENT PROVIDERS ARE AVAILABLE ON EUROPEANA:

5.1. CYPRUS UNIVERSITY OF TECHNOLOGY

CUT digitised and shared with the EUreka3D project three important monuments in Cyprus: the oldest fishing trawler of Cyprus, called "Lambousa"; the Holy Cross / Timios Stavros in Pelendri village (UNESCO WH site), and the Monastery of Panayia Chrysorrogiatissa in Paphos district (a monument under risk). Particularly, the work on the Lambousa Fishing Trawler digitisation was exceptionally complex and was used as a best practice and case study in the EUreka3D project.

The Lambousa Fishing Trawler, a significant vessel for Cypriot Fishery tradition, was built in 1955 at Perama, Piraeus by Dimitrios Zacharias, and in 1965 it arrived in Famagusta, Cyprus. The boat was in a decayed condition and the Municipality had to proceed with refurbishment works. The coordinator of the Lambousa Fishing Trawler's digitisation is Limassol Municipality, which is also the stakeholder. Upon request of the stakeholder, CUT digitised the boat before restoration, during the restoration and after the boat was refurbished. During the digitisation, CUT was in a close collaboration with the team, which undertook the refurbishment works, such as the underwater archaeologist, naval engineers, and the marine contractor. This collaboration was crucial in order to understand the overall components of this vessel, to have access to the site, and receive feedback from the results of our work and how we can further proceed with the detailed digitisation. A photogrammetric survey was held by a team of two members of CUT and an external contractor, which is a topographer. The TLS survey was made by CUT staff and other experts specialised in Laser Scanning. The post-processing of the point cloud results was made by a member of the CUT team, with the creation of 3D NURBS models, and naval architectural drawings with a Level of Detail (LOD) 400. Further detail for this case study will be described in the following section.

The church of the Holy Cross is a three-aisled basilica with a dome, which is an UNESCO world heritage site, with Byzantine wall paintings created from the 12th century up to the 14th century by four different painters. This church was built in three phases. Firstly, it was a single-aisle dome chapel built in 1178, which also included wall paintings. The church was then destroyed and only the apse remained, which was included within the new church that was built at the start of the 14th century. In the second half of the century, the north chapel was constructed, and in the 16th century the south chapel. The Church was digitised with the aim of digitally preserving the history of this monument through a holistic approach, which includes both its internal and external survey. The HBIM model created includes material and structural details of all the components of this heritage building. Furthermore, architectural drawings are also created that can be used for research by architects, civil engineers, archaeologists, and historians. The textures mesh model of the exterior also includes a topographic survey, which provides details regarding the building and its surrounding mountainous landscape. The interior textured mesh model is also important because it indicates all the wall paintings in high-resolution. The main stakeholder of the Holy Cross Church is the Municipality of Limassol, and the coordinator for the digitisation is CUT. The topographic and external photogrammetric survey was done by a team of three people, one of whom is an external contractor. The Terrestrial Laser Scanning (TLS) and internal photogrammetry was done by three members of the CUTs Digital Heritage Research Lab (DHRLab). The results from the survey were processed for the creation of an HBIM LOD 400 model as well as a photogrammetric mesh model by two members of the DHRLab.

The Monastery of Panayia Chrysorrogiatissa in Paphos, was established in 1152. The Katholikon (main Church), and the rest of the surrounding buildings were constructed at the end of the

18th century. The major stakeholder of the Monastery of Panayia Chrysorogiatissa is the Municipality of Paphos, and the coordinator for the digitisation is CUT. The digitisation was done from all CUT members as well as other specialists. The Department of Antiquities was also involved and present during digitisation. Two photographers participated and documented the procedure. In addition, representatives of the Bishop of Paphos and the District of Paphos, attended. A group of CUT undergraduate students followed the process and attended the digitisation.

The Monastery comprises several buildings such as the church, museum, library, dormitories, dining rooms, conference centre, kitchens, old winery, and cellars which are spread along four levels. Overall, there are 180 spaces and rooms, as well as the surrounding area. For the purpose of digitising the entire Monastery, both the interior and exterior of each space had to be scanned, with a total of 276 scanning positions. This was a time consuming procedure where each position was selected carefully so that no space was missing from the survey. Furthermore, the registration and alignment of the point clouds was a laborious procedure as well due to the vast amount of data of 88 GB which had to be processed.

5.1.1. LAMBOUSA FISHING TRAWLER: ESTIMATING THE COMPLEXITY OF A DIGITISATION PROJECT

The Municipality of Limassol, which is the main stakeholder of the Trawler, requested from CUT to holistically document the boat through advanced digitisation methods for the purpose of preserving its history. This commission was part of a long-standing collaboration between the CUT and the Municipality of Limassol, and was conducted as a best practice case in the context of the EUreka3D project. Specifically, the stakeholder’s requirements were: the creation of point cloud data, 3D NURBS models, naval architectural drawings with a Level of Detail (LOD) 400, and the realisation of an online platform to provide further knowledge through an eBook and educational games. In addition, as a way to disseminate the results and foster use and reuse of the data, the publication in Europeana portal was considered highly important.

The complexity estimation according to the expected result commissioned by the stakeholder was made according to the VIGIE 2020/654 Study, using an App currently under development at CUT (the Paradata App) which assisted as for documenting the paradata of the digitisation. This includes recording data about the stakeholder's requirements, object, project, team, environment, software and hardware. Paradata is important because it records the conditions in which the digitisation project happened, for future reference. The following Figures 14 to 19 include further details of the documented paradata, where the orange colour in the indicator shows the level of complexity of each element according to our estimation.

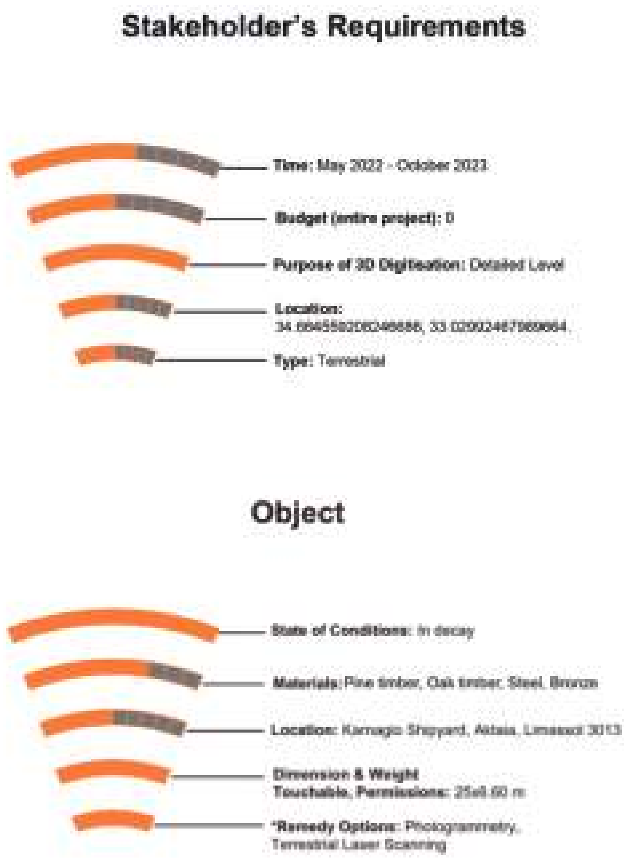

Figure 14. Estimation of complexity for Stakeholder's requirements and Object

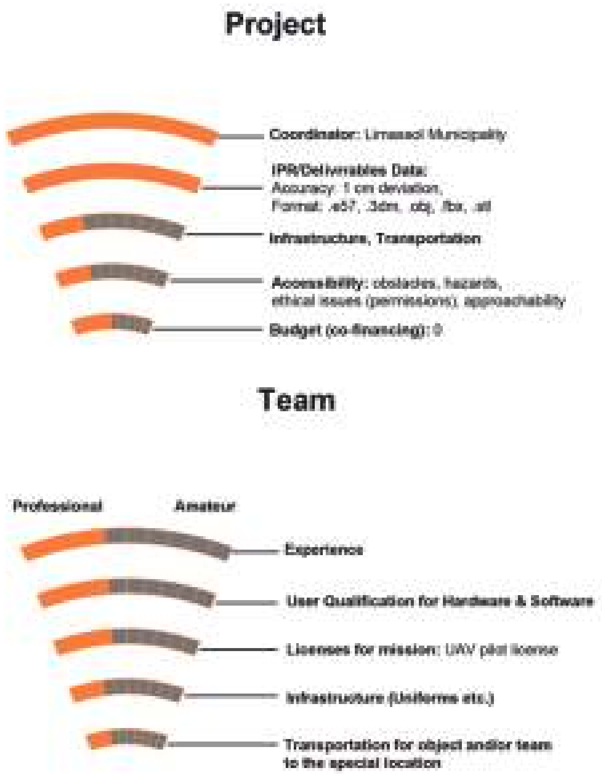

Figure 15. Estimation of complexity for Project and Team

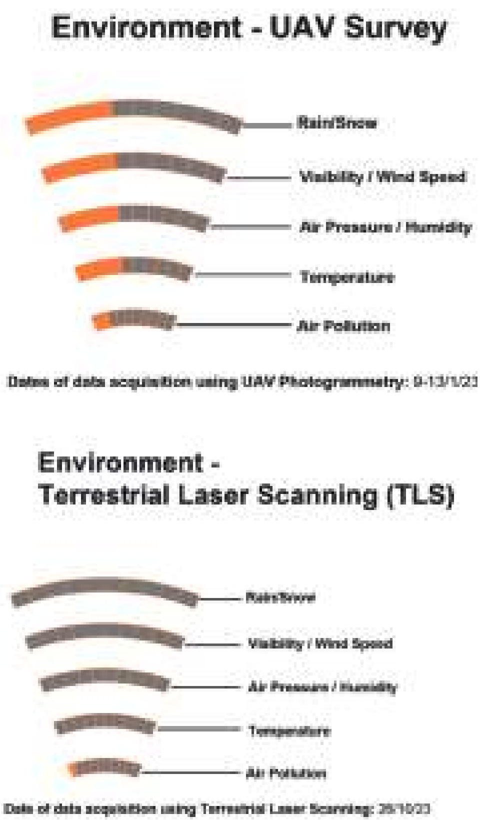

Figure 16. Estimation of complexity for Environmental conditions of UAV and TLS Survey

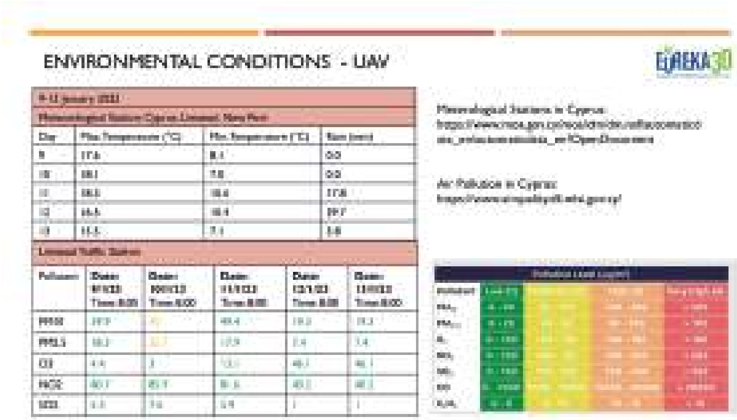

Figure 17. UAV Environmental data

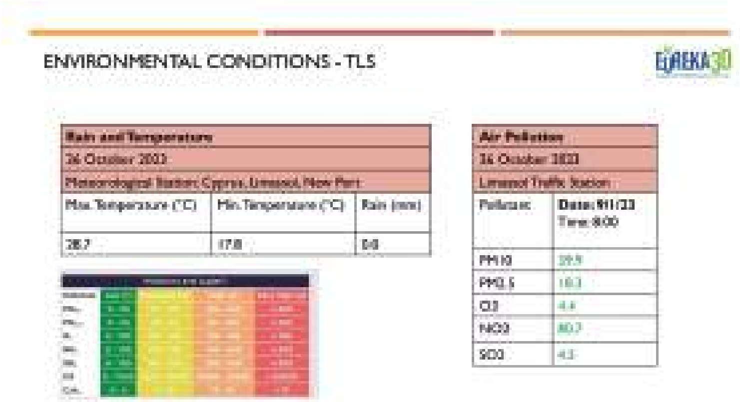

Figure 18. TLS Environmental data

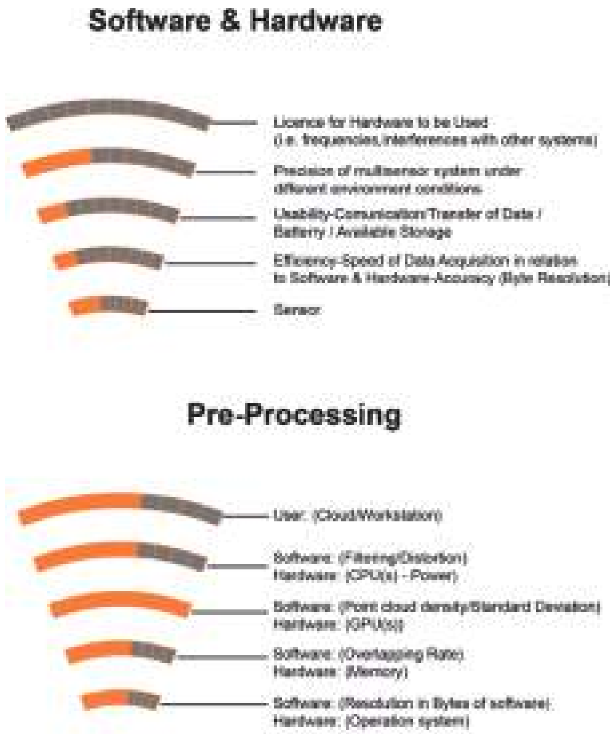

Figure 19. Estimation of complexity for Software, Hardware and pre-processing

5.1.2. FROM DIGITISATION OUTDOOR TO POST-PROCESSING FOR THE CREATION OF THE 3D MODEL

The digitisation of this Trawler began in January 2023 when a UAV photogrammetric survey was created of the exterior (figure 20). The results of this survey include a georeferenced textured mesh model with 27,363,867 faces. In addition, a survey was conducted in October 2023 through TLS, during the restoration works of the vessel. The purpose was to capture the geometry of the timber frames, deck beams, keel, and stern. The result of this survey led to 14,164,403 points (figure 21-23). Furthermore, the photogrammetric mesh was processed in CloudCompare to obtain the vertices and downsample them to 5,000,346 points (figure 24). Moreover, an alignment was made of the TLS with the photogrammetric point cloud (figure 25), to let the formation of a total point cloud that can be processed for generating the 3D model.

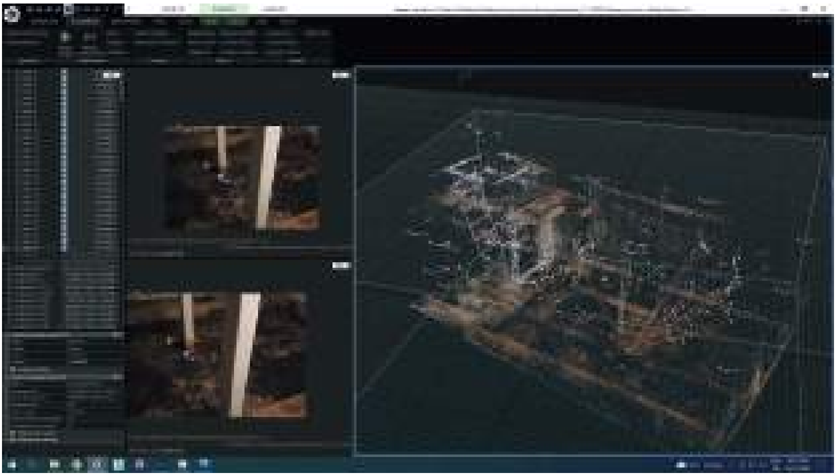

Figure 20. UAV Photogrammetric survey

Figure 21. Laser Scanner settings

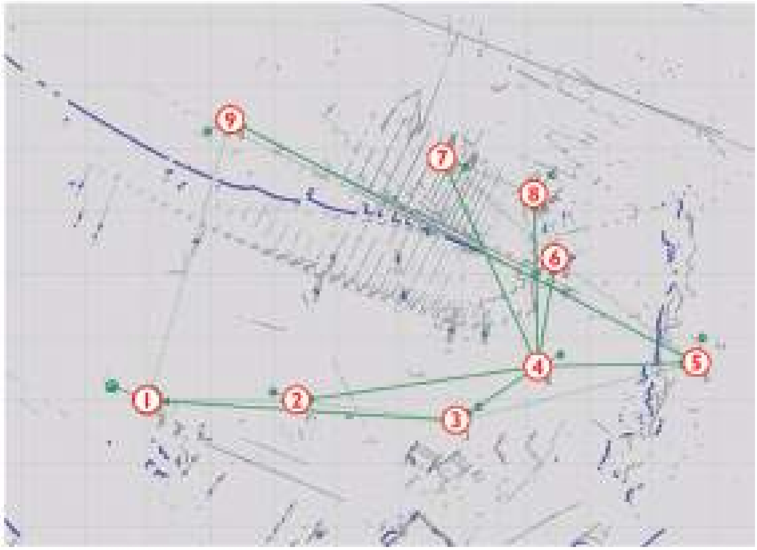

Figure 22. Scanning positions

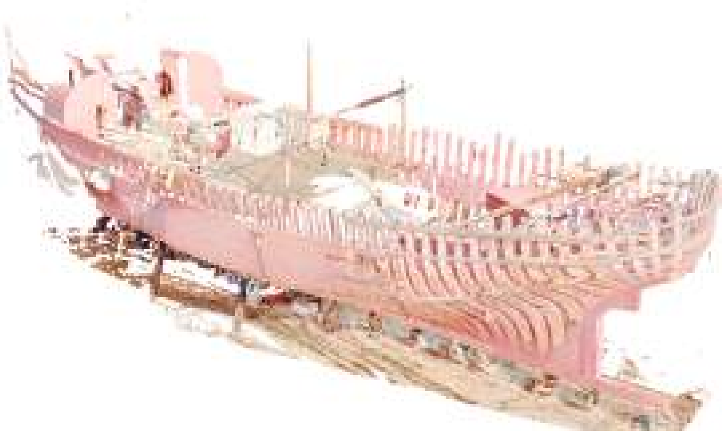

Figure 23. TLS Point Cloud result

Figure 24. UAV Photogrammetric Point Cloud

A processing of the point clouds was made in CAD software, to produce closed 3D NURBS geometries of all the components of the vessel. At the beginning, vertical cloud sections were created and the corresponding splines were drawn which resulted in a network of curves for the hull (Figure 26). Furthermore, the solid surface of the hull is made, based on these curves. This allowed the further creation of the deck, frames, deck beams, railcap, keel, and stern. Additionally, the rest of the elements such as the fishhold, cabin, and mast are produced by the tracing of curves across the point cloud. The axonometric 3D drawing of the boat can be seen from Figure 27, and the exploded axonometric with all 440 components from Figure 28. The deviation analysis which includes the accuracy of the NURBS geometry compared to the point cloud is visible from Figure 29.

Figure 25. Aligned TLS and Photogrammetric point clouds

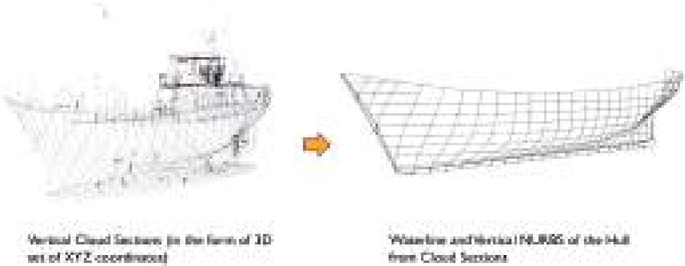

Figure 26. From vertical cloud sections to NURBS curves

Figure 27. 3D Axonometric of the trawler

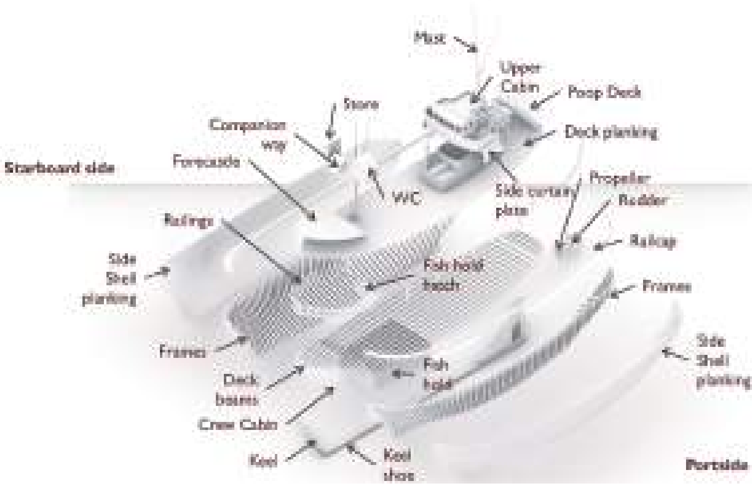

Figure 28. 3D Exploded Axonometric of the trawler

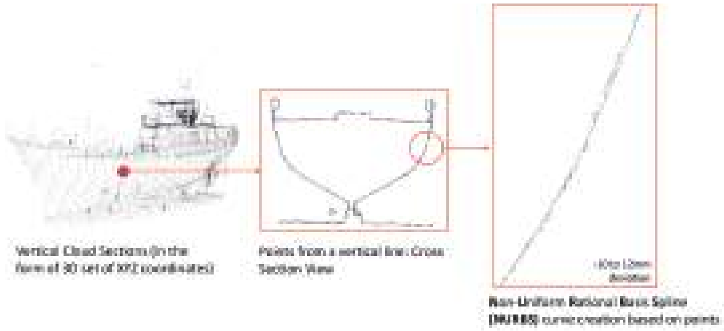

Figure 29. Deviation Analysis

The Naval Architectural drawings were created in CAD software based upon the 3D Model. In particular, the sections, elevations, and plans of the 3D Model were cleaned and annotations were added. The naval lines, plan view and longitudinal section drawings are indicated at Figures 30-32.

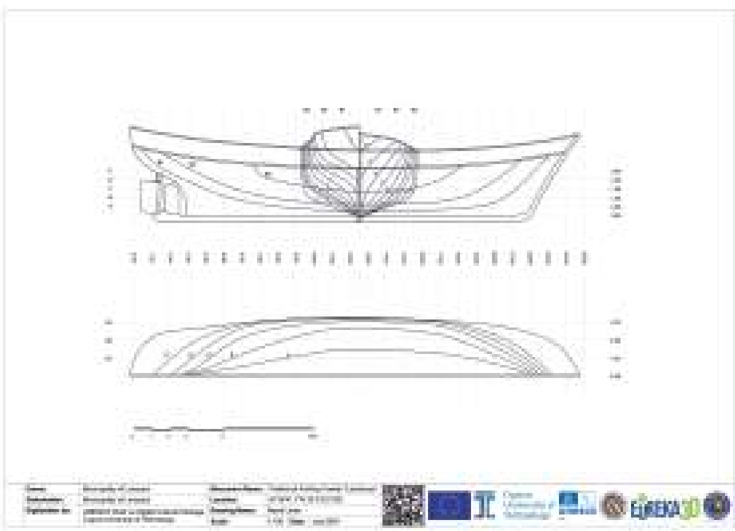

Figure 30. Naval Lines

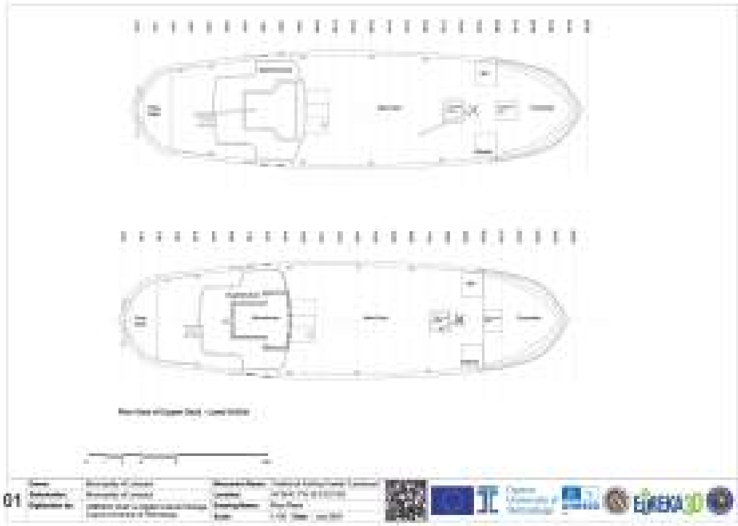

Figure 31. Plan View

Figure 32. Longitudinal Section

The deviation of the boat's geometry, prior to the restoration and after, had to be detected to justify the precision of the restoration works. This analysis is indicated in Figure 33. The quality was estimated according to the VIGIE 2020/654 Study, using the Paradata App. This includes the 3D, texture, scale, and material. The spectral and structural health monitoring were not required by the stakeholder as part of the digitisation process and therefore their charts are not applicable for inclusion. The following Figures 34 and 35 include further details to the quality estimation. Table 1 includes the list of materials and their corresponding type and component, and Figure 36 shows an example of an image of the frames with the corresponding pathology when the vessel was in a decayed condition.

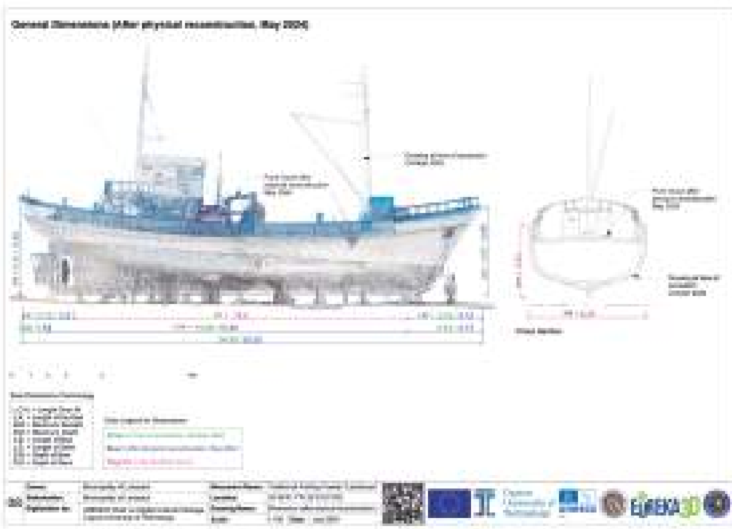

Figure 33. Deviation of physical reconstruction compared to the vessel at time of accession

Figure 34. Estimation of quality for 3D and Texture

Figure 35. Estimation of quality for Scale and Material

Table 1: List of the Trawler's materials, types and components

MATERIALS	TYPE	COMPONENT
Wood	Pine Timber	Frames, Deck beams, Planking, Keel
	Oak Timber	Keel shoe
Metal	Steel	Side curtain plate, engine, mast, wire ropes, screws, nails
	Bronze	Propeller

Figure 36. Timber frames and their corresponding pathology

5.1.3. CHALLENGES OF DIGITISATION

There were a range of challenges that we encountered during the digitisation process. Throughout the UAV photogrammetric survey, the boat was in a vacant condition and covered with a plastic film. It was cleaned carefully, and the plastic film was removed to capture its geometry efficiently. Furthermore, the shipyard is located in an area outside of the city centre, where a dirt road had to be used to access it. The TLS survey was done during the reconstruction works, and a special permission had to be given to CUT from the stakeholder. In addition, the scaffolding, tools and wooden remaining parts had to be removed in order to clean the area surrounding the vessel. This allowed the laser scanner to be positioned to a close distance from the boat, and allow a clean point cloud outcome as a result without any significant noise. Further challenges were evident for the processing of the point cloud data for the creation of the 3D Model. In particular, this vessel consists of a complex free-form geometry, where Non-uniform rational B-spline (NURBS) curves had to be created based on point cloud slices. This procedure was critical for creating a precise hull geometry of the boat where the rest of the timber structure is based on. Another challenge is the size of the .OBJ model which is 1.5 GB due to the high complexity of the geometry. For the visualisation of the model from EUreka3D Data Hub 3D Viewer, a reduction of the polygons had to be done in Blender software with the addition of wood texture as well. This led to the outcome of a .GLB file with 160 MB size, and therefore the model was able to be visualised through our online 3D Viewer. The .OBJ file is considered as the raw model that can be used for further simulations especially from Engineers, while the .GLB can be used for the gaming industry, and for online visualisation.

5.1.4. SHARING THE TRAWLER AS OPEN ACCESS DATA

For the aggregation of the heritage objects to Europeana, certain rights had to be given from the stakeholders and owners. In particular for the three objects, in the light of enabling the widest possibilities of use and reuse, the CC BY-SA 4.0[17] licence was granted.

The data management platform, developed specifically for EUreka3D and coordinated by partner EGI, is used for storing the data in the cloud and aggregating it to Europeana. In particular, all of the raw data from the digitisation, as explained in previous paragraphs, is uploaded in this platform. In order to do that we had to register to authorization service (Check in), and join the EUreka3D Community. After registration, initial tests were uploaded and shared using the demo version of the platform. This was done in collaboration with EGI where feedback was provided to them regarding the efficiency of the platform and reports on certain issues that we came across. Feedback, mostly related to the workflow of uploading and sharing data, was discussed through weekly meetings and solutions were provided by EGI, thus enabling an iterative development and improvement of the EUreka3D Data Hub functionalities. Furthermore, the 3D Viewer adapted and integrated in the platform by EGI was also tested which was a major challenge due to the great amount of data of the .OBJ model developed due to its geometrical complexity.

17 https://creativecommons.org/licenses/by-sa/4.0/deed.en

Specifically, the 3D viewer was unable process the raw data and therefore this had to be modified in order to reduce its size and manage its efficient 3D online visibility.

During the demo version we managed to aggregate the Lambousa Fishing Trawler into Europeana. This was achieved using the tools of EUreka3D Data Hub, which allowed the model to be published as open data: a Persistent Identifier (PID from B2HANDLE) was associated to the digital object, then the metadata was added based on the EDM. This dataset was then shared with Europeana through the harvesting of information via the OAI-PMH protocol. After that, the record appeared on the Europeana portal. Along with metadata, we managed to include a URL link that leads to the paradata reports that we generated from the Paradata App. Also, the raw data from the digitisation is available for downloading through a shared link generated from EUreka3D Data Hub. This URL link is also available from the metadata. This metadata can be consulted via the following link.[18] The EUreka3D Data Hub with the raw data is shown in Figure 37; the metadata as they appear in the Data Hub in Figure 38; the 3D viewer on the Europeana portal in Figure 39 and the metadata in the Europeana portal in Figure 40.

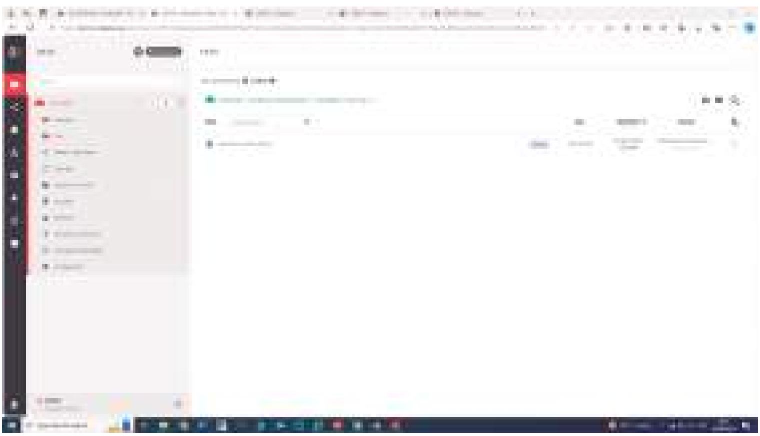

Figure 37. EUreka3D Data Hub platform

18 https://demo.onedata.org/ozw/onezone/i#/public/shares/2a642bf73bba6e98641118896b1a16cbcha546

Figure 38. Metadata as displayed in the EUreka3D Data Hub

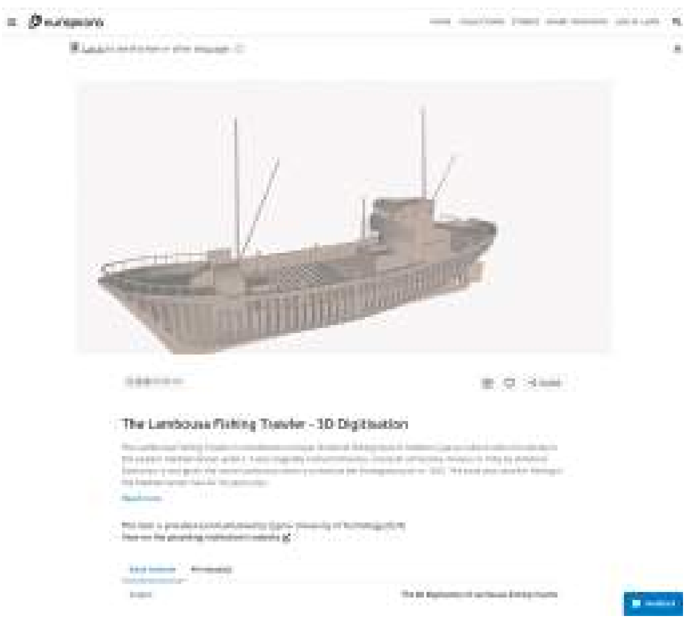

Figure 39. The record as appearing on Europeana, with the object showcasing in the embedded 3D Viewer provided via the EUreka3D Data Hub

Figure 40. Europeana record, showcasing all metadata

5.1.5. ADDITIONAL CONSIDERATIONS

Even though the digitisation of this trawler is part of the EU-Funded project EUreka3D, and no cost was charged to the stakeholder, an estimation was made to indicate a possible cost for our own reference. This estimation is based on similar case studies of fishing trawlers' data acquisition which include the digitisation, processing, and preparation for ingestion. According to this, the overall cost is estimated at €40,000.

The digital model is published in the Europeana portal via the EUreka3D Data Hub workflow, this allows efficient visibility and, from an educational perspective, encourage a wider recognition of Cyprus's maritime heritage, while preserving European cultural history. Further details on the holistic documentation approach of this boat can be found on elambousa.eu, a platform which allows the user to learn the history of this vessel, through educational games, virtual tours and an eBook.

Through the EUreka3D project, we had the opportunity not only to digitise in high detail the above-mentioned monuments, but also to deliver our data to the public domain through an efficient workflow. Specifically, our aim is to provide knowledge and an understanding of the history behind those monuments and this can only be achieved through their aggregation and publication in Europeana.

5.2. BIBRACTE

Bibracte provided 500 3D scans of furniture, structures, and terrain from the archaeological site of Mont Beuvray (Burgundy, France) to the EUreka3D project. These scans cover various periods, ranging from the Gallic oppidum (fortified settlement) seat of the Aedui tribe from the end of the 2nd to the late 1st century BC, to more recent occupations, such as the Cordeliers convent. The latter, established in the 14th century in the Pâture du Couvent district, was frequented by Franciscans until the end of the 17th century. The scientific partners of the establishment are involved in all stages of the production, use, and dissemination of these 3D scans, which are divided into three distinct collections aimed at supporting archaeological research and enriching the visitor experience on the site and in the museum.

The acquisitions were carried out in controlled environments, ensuring the precision and quality of the data produced. The mathematical treatments applied for the reconstruction of the 3D models benefited from the expertise of Bibracte's scientific partners to ensure the rigour and accuracy of the process.

For each 3D model, two sets of metadata have been produced:

1. The first set documents the production of the file by indicating the method employed, the equipment used, the type of data produced, the type of mesh, the number of polygons that the

model has, the number of points of the model, the scale, the resolution, the name of the operator, the name of the editor, the volume of the file produced, and its format.

2. The second set provides information about the 3D modelled object with a title and description, supplemented by a theme, a subject, a material, a chronology, a location, a scientific supervisor, and a bibliography.

To improve the indexing of the produced files, specific thesauri have been implemented and aligned with web pivot thesauri such as Getty, Library of Congress,[19] PerioDO,[20] GeoNames,[21] and VIAF.[22] This approach will facilitate research and access to information, making the data more usable for researchers and the general public. In addition to the 3D models, supplementary documentation (drawings, photos, reports, etc.) has been deposited in repositories that provide permanent links. These documents are integrated into the metadata accompanying the 3D models, thus offering a complete and contextualised view of the artefacts and excavations.

The integration of the French protocol of the Conservatoire national 3D into the digitisation process ensures the long-term archiving of the produced 3D models. In partnership with Archéovision[23] in Bordeaux (CNRS, France), this protocol ensures the longevity of the data and its future accessibility within the framework of the valorisation of models published on the Europeana portal.

5.2.1. 3D DIGITISATION OF COLLECTION OBJECTS

This collection includes 130 artefacts representative of the material culture of the oppidum of Bibracte, a fortified city from the 1st century BC located on Mont Beuvray. These objects illustrate

19 https://www.loc.gov/librarians/controlled-vocabularies/
20 https://perio.do/en/
21 https://www.geonames.org/
22 https://viaf.org/
23 https://archeovision.cnrs.fr/

various aspects of Gallic life, ranging from agriculture to weaponry, including art, hygiene, building materials, and means of transport.

The *Collection Objets* was created with the technical support of the Maison des Sciences de l'Homme et de l'Environnement (MSHE) Claude-Nicolas Ledoux (Besançon, France), which has a structured light object scanner operating on an Atos Core system developed by GOM. This scanner projects precise models of parallel fringes onto the object and measures the deformation of these fringes on the object's surface based on known beam paths. The deformation is recorded by two cameras operating on the principle of stereoscopy. Two scanner heads, with a distance between the two stereoscopic sensors ranging from 85 to 150 mm, measure the fringe spacing. The small head scans up to 3 microns, offering a smaller field of view but higher resolution. The large head has a wider field of view but lower resolution (7 microns). The scanned volumes rarely exceed 1 m^3. The produced files take the form of meshes.

Some objects are less suitable for this range of scanners, such as a terracotta antefix, which has too many reliefs and cavities, and therefore irregularities. Additionally, certain materials interfere with digitisation due to their reflective surfaces, such as glass, ceramic pastes with certain inclusions (e.g., quartz), or metal restored with resins or electrolysis. This results in sometimes incomplete measurement data, with holes and erratic triangles. The acquisition time varies from a few hours to several days, depending on the size and complexity of the objects. The texture (colorimetry) of the model is obtained by photogrammetry, in addition to the scanner.

Three examples from this Collection singular are provided:

HELMET REUSED AS A FOUNDRY LADLE (INV. 2001.32.258.1)

Figure 41. Helmet reused as a foundry ladle. The object and its 3D model

If Bibracte was the stage for key episodes of the Gallic Wars, it suffered no battles. The relative rarity and dispersal of weapons and military accessories discovered seem to confirm that Bibracte was frequented by soldiers but not exposed to their conflicts. Among these militaria, a helmet of the “Port” type (named after a Swiss site), worn by Roman legionaries and recognisable by its repoussé eyebrow arches, seems at first glance to be part of this site’s history. However, the nature of the context of its discovery, a metal craftsman’s workshop, and the detailed observation of its shape reveal that the object was transformed to serve a purpose other than protecting a soldier’s head.

As metal is a precious resource, it is frequently recycled; for example, this iron helmet found a new life as a foundry ladle.

Keywords: Armament (warrior); Helmet; Iron
Chronology: 1st century BC
Location: Bibracte, Mont-Beuvray. The Côme Chaudron district
Excavation: Guillaumet, Jean-Paul (CNRS, Dijon, France)
Bibliography: 2001 - Research program on Mont Beuvray. Intervention n°514
(L 21.5 cm; W 19 cm; H 11.5 cm - Bibracte Museum)

SPOUT IN THE SHAPE OF A BOAR'S HEAD (INV. 2003.34.116.1)

Figure 42. Spout in the shape of a boar's head. The object and its 3D model

This bronze spout, in the shape of a boar's head, probably equipped a jug or basin that could have been used for libations or drinking. It was covered in a residential sector at the centre of the site, near the PC15 platform, interpreted as a Gallic public space.

This object attests that luxury tableware, particularly that linked to the banquet whose ritual had spread from Greece to Rome and then to the Celtic world, was not always imported from Mediterranean regions but could be manufactured locally and inspired by Gallic motifs, such as the boar. The stretched head and large tusks, the bulging eyes, and the very developed ears evoke the animal in an attacking position.

The boar, although rarely consumed by the Gauls, enjoyed great prestige among them, as evidenced by its frequent representations. It is invariably the boar that adorns military insignia, as shown by the few preserved examples and their numerous representations on Gallic coins and on the sculpted trophies of Roman monuments. The strident war horn of the Gauls also invariably bears a threatening boar's head bell with an open mouth and erect ears.

Keywords: Metal tableware; Pouring spout; Alloy
Chronology: 1st century BC
Location: Bibracte, Mont-Beuvray. The PC14 terrace
Excavation: Vitali, Daniele (University of Bologna, Italy)
Bibliography: 2003 - Research program on Mont Beuvray. Intervention n°551
(L. 4.5 cm - Bibracte Museum)

BOTTLE WITH PAINTED DECORATION DEPICTING A DEER (INV. 985.5.8.39)

Figure 43. Bottle with painted decoration depicting a deer.
The object and its 3D model

This fragment of a ceramic bottle, featuring a deer between vertical friezes, testifies to the skill of Gallic potters. Made from fine clay, this object was decorated before firing with white kaolin flats. Oxidative firing allowed them to be fixed. This type of pottery, typically Gallic, was very widespread in the 2nd century and at the beginning of the 1st century BC.

Keywords: Pottery; Bottle; Terracotta
Chronology: 1st century BC
Location: Bibracte, Mont-Beuvray. The Porte du Rebout
Excavation: Buchsenschutz, Olivier and Guillaumet, Jean-Paul (École Normale Supérieure and CNRS, France)
Bibliography: 1985 - Research program on Mont Beuvray. Intervention n°11
(H 17 cm; W 6.6 cm - Bibracte Museum)

5.2.2. 3D RECONSTRUCTION: COLLECTION MORPHOMÉTRIE

This collection includes 120 theoretical 3D models of ceramic vessel shapes. These models allow for the visualisation and calculation of reference morphometric parameters, thus facilitating the identification of sherds found on the site by archaeologists.

The *Collection Morphométrie*, initiated by Josef Wilczek, doctor of the University of Burgundy and the University of Masaryk in Brno (Czech Republic) and associate professor of digital archaeology at Sorbonne University / Centre André Chastel (Paris, France), was created using an EinScan-SP scanner from Shining 3D. Composed of 120 models, this collection aims to document the morphometric criteria of Bibracte ceramics in 3D, in reference to the typology published in 2021 (Barrier, Luginbühl 2021).[24]

Designed specifically to serve as a morphometric comparison reference, the collection assists archaeologists in the typological identification of newly scanned 3D sherds. Thanks to this reference, newly scanned ceramic fragments can be systematically compared to existing models, facilitating their identification and classification. Over time, these new sherds will enrich the reference collection, making it increasingly relevant and comprehensive. In other words, each newly identified and integrated sherd increases the quality and reliability of this tool, thereby refining future archaeological research.

Currently, a first algorithm already allows several operations on a newly scanned sherd: orientation, creation of 2D drawings (linear drawing and photography), measurements (diameters, volumes, percentages of vessel conservation, etc.). A second algorithm allows finding the best morphological match (rim, body, base) with the 3D reference collection models.

An example from this collection is provided:

24 https://catalogue.frantiq.fr/cgi-bin/koha/opac-detail.pl?biblionumber=731963

BOTTLE BT1A

Figure 44

Tall, closed shape, with a height greater than 1.5 times the maximum diameter. Narrow opening (usually less than 10 cm) and generally developed neck. Annular base, sometimes raised (pedestal).

Keywords: Pottery; Bottle; Bottle Bt1a
Category: Regional fine ceramics - PEINTA
Chronology: 1st century BC
Presumed functions: serving and consuming liquids
Authors: Barrier Sylvie; Luginbühl Thierry; Wilczek, Josef
Bibliography: The ceramic tableware of Bibracte; Morphometrics of Second Iron Age ceramics - strengths, weaknesses, and comparison with traditional typology

5.2.3. DOCUMENTING AN ARCHAEOLOGICAL SITE: COLLECTION TERRAIN

This collection includes 250 terrain models from the archaeological site, documenting the history of archaeological research on Mont Beuvray. These models, primarily orthophotographs, provide an overview of the different excavation phases and discoveries made over the years.

The *Collection Terrain* reflects the continuous adaptation of archaeological methods to advances in digital technologies. Ortho-images, also known as orthomosaics or orthophotographs, derived from photogrammetry, have gradually replaced traditional paper millimetre-scale drawings of archaeological remains in plan, section, and elevation. This technique allows for the measurement of 3D scenes from 2D photographic data. However, the proper practice of this process involves mastering a set of knowledge and techniques during the acquisition and processing phases. Resulting from mathematical processing, the base image is recomposed pixel by pixel: optical distortions of the lens are corrected, all pixels respect a perfectly vertical viewing axis, each pixel is associated with coordinates, and the ground relief and the curvature of the earth are taken into account. The principles of photogrammetry also allow for the production of point clouds describing the captured scene in a three-dimensional form, as in the example of the masonry cellar of the domus PC2. However, this possibility is little exploited at Bibracte, as it does not provide more information than an orthomosaic, while requiring longer processing time and generating larger files.

The collection brings together 250 models that document the history of archaeological research on Mont Beuvray and the technological evolution of the practice of photogrammetry applied to archaeology. In collaboration with the UMR 6249 Chrono-environnement (Besançon, France) and as part of the doctoral thesis of Quentin Verriez (2023, University of Burgundy, UMR 6298 ArTeHis), the experiments conducted each year at Bibracte have led to a complete methodological process for the production of an orthomosaic from several digital photographs. The entirety of this process has been published in open access.[25]

An example is provided:

25 https://books.openedition.org/pufc/5078

MASONRY CELLAR OF THE DOMUS PC2

Figure 45. Masonry cellar of the domus PC2. The archaeological site and its 3D terrain model

The site of Bibracte, the capital of the Gallic people of the Éduens, was occupied from the end of the 2nd century BC until the beginning of the 1st century AD. This occupation is particularly materialised by buildings first constructed in earth and wood, according to the Gallic technique, and then, from the middle of the 1st century BC, in masonry, according to the Roman construction mode. Throughout the oppidum, buildings are regularly remodelled or even rebuilt, with a succession of 3 to 4 buildings on the same site being the norm at Bibracte.

The residential district of the Parc aux Chevaux, the largest flat area on Mont Beuvray, occupied at the end of the period by domus organised according to typically Roman plans, is representative of this succession of buildings. Thus, the domus PC2, built on a vast artificial terrace, rests on imposing masonry foundations that have allowed the preservation of vestiges prior to its construction. Its extensive exploration since 2016 has revealed a complex stratigraphic scenario that spans the entire 1st century BC.

- The initial occupation (first quarter of the 1st century BC), explored so far in a fragmentary manner, is manifested by several pit structures, without any characterised architectural remains.
- The following state (2nd quarter of the 1st century), is characterised by a set of timber-framed buildings, one of which was associated with a wooden cellar.
- During the 3rd quarter of the 1st century, these buildings were remodelled or replaced by new constructions, some of which (terrazzo floors, lime-plastered walls, terracotta tiles) already show clear Italian influences. This sequence ends with the construction of a masonry cellar near the wooden cellar of the previous phase.

All these structures are covered by the construction of the stone domus in the last quarter of the 1st century BC.

The digitisation of the masonry cellar, carried out following its excavation in 2016, aimed to document a structure representative of the transition between Gallic and Roman construction modes, as well as to preserve its memory in the face of the material impossibility of conserving the vestiges of this cellar in situ.

Location: Bibracte, Mont-Beuvray. The domus PC2
Excavation: Field school, Bibracte
Bibliography: 2016 - Research program on Mont Beuvray. Intervention n°848

5.2.4. USE, REUSE AND DISSEMINATION OF 3D

The overarching goal for Bibracte in advancing digital transformation of its collections is to offer visitors an enriched experience through the discovery of archaeological methods and work, through permanent scientific documentation that contributes to the preservation and valorisation of archaeological heritage.

The reuse of our models by other stakeholders and external parties take several forms depending on the professionals concerned, with different expected impacts. General communication and promotion of the collections through various types of channels (newsletter, social media, press release), and targeted communications for education, tourism, and research professionals is an integral part of Bibracte's strategy, also conducted via our professional networks.

Beyond their interest for the scientific community and for the preservation of heritage, a diversified use of the produced 3D models is envisaged, both in valorisation (promotion and mediation) and training, in several forms: in situ, off-site, and remotely.

The in situ use on the archaeological site has already been initiated on the panel of the domus PC2: a QR code has been added to allow the visualisation of the digitisation of the masonry cellar. This provision will continue for 3D models of the archaeological site and emblematic objects from the different excavated sectors, through site panels and complements to La Boussole de Bibracte.[26] An application for smartphones has been developed to offer an enhanced discovery of the archaeological site with 55 georeferenced points of interest, three of which already benefit from enriched content (360° and restitutions).

The presentation of 3D models, when in the museum, is particularly interesting as they complement the view of the real objects by allowing access to non-visible parts (back, interior, etc.). Therefore, the guides of Bibracte are able to enrich the presentation of these objects to visitors by using these digitisations on a tablet.

26 https://www.bibracte.fr/la-boussole-de-Bibracte

The 3D models can also be used off-site, for example during tourist fairs to present some emblematic views and objects of the archaeological site and the museum, and also by mediators and guides who work on the territory. These new resources will also be an asset for Educational Artistic and Cultural Actions in classrooms, allowing for the complementary discovery of the collections. Moreover, they will be particularly relevant for conducting actions aimed at disabled audiences in retirement homes, hospitals, or prisons.

Remote use will be based on the website www.bibracte.fr, particularly through two existing devices: the Bibractothèque,[27] an online space that offers several hundred resources (photographs, videos, audio content, publications, etc.) concerning the archaeological site and the collections of the Bibracte museum, and the Virtual Gallery,[28] which, through data visualisation, invites internet users to explore the collections of the Bibracte museum. This exploration can be done freely, by navigating from one object to another through semantic links, or in a guided manner, by following the museum's tour.

Another crucial sector for the expected reuse of the 3D collections is education, in which Bibracte already deploys an intensive effort in training. The training sessions for teachers and mediators, normally organised at Bibracte and in other heritage sites as part of the Pôle de Ressources pour l'Éducation Artistique et Culturelle "Patrimoine archéologique", will benefit from these 3D models. Thus, the training organised in November 2023 on the theme of the raw materials of archaeological objects could not yet benefit from these models. However, its re-edition planned in Dijon in early 2025 will be able to integrate them to demonstrate the interest of 3D models of archaeological objects for better understanding the material and manufacture of objects through the marks left by their shaping.

Interactive 3D models present many advantages in the school context. They allow students to study the representations of objects in all their dimensions to better understand their manufacture,

27 https://www.bibracte.fr/bibractotheque
28 https://www.bibracte.fr/galerie-virtuelle

uses, and facilitate the observation of any decorations. This more detailed and interactive study offers more advantages than that of a simple photograph, while allowing access to all faces of an object without having to handle it. The expected impact is significant as it concerns all French teachers. In addition to the mediation, training, and communication actions indicated, we will approach the managers of Foxar,[29] an application and library of educational 3D models designed with the Ministry of Education, to propose integrating some of our models to allow for greater use.

Teachers can use our 3D models profitably in their history, art history, ancient languages and culture, visual arts, and technology courses. For example:

- The entire set of 3D models from Bibracte can illustrate the CM1-CM2 history program “And before France?: Traces of ancient occupation - Celts, Gauls, Greeks, and Romans”.
- Those of the helmet ladle, other militaria, vestiges and objects testifying to relations with the Roman Empire and more broadly the Mediterranean world, such as the pouring spout, for the 6th grade history program “The Roman Empire - Conquest, Roman peace, and Romanization” as well as those of 4th and 3rd grade in ancient languages and cultures “The Roman Empire: The army and the Pax Romana and ‘Mediterranean world - Rome, Greece, Gaul: exchanges and influences’”.
- Those of animal representations for the 6th grade visual arts program “Plastic representation and presentation devices: Resemblance and Visual Narration”.
- Those objects made of wood, ceramic, metal, etc. for the 6th grade history of arts program “Identifying the technical and formal characteristics of a work of art through observation: Identify the materials. Retrieve the forms” and in visual arts “The materiality of plastic production and sensitivity to the constituents of the work: The physical qualities of materials”.
- Those of the archaeological site and several objects from the museum for the 5th grade history of arts program “Arts and

29 https://foxar.fr/

societies (antiquity and Middle Ages): City - Architecture - Myths - Representations".

Finally, the 3D models available on Europeana offer the advantage of being easily integrated into the construction of e-learning activities on Historiana, the platform made available for teachers and students to access digital cultural collections and resources. The use of the helmet ladle model will enrich an existing activity on the theme of archaeological looting. Created as part of the Erasmus+ PITCHER project (Preventing Illicit Trafficking of Cultural Heritage: Educational Resources), this activity explains how the object and its archaeological context complement each other (the discovery site of the helmet, a workshop, allowed understanding its final function) and that this information is destroyed when the object is looted. Other themes are also envisaged for new activities, such as "Construction methods in Celtic Europe", "Raw materials, exchanges, and craftsmanship in Celtic Europe", "Animal decorations in Celtic Europe", etc. These activities will be based on the archaeological site and the collections of the Bibracte museum, particularly the mentioned case studies, complemented by other European examples, to invite teachers to propose these activities to their classes.

Europeana Galleries dedicated to each of these topics will collate the most relevant 3D models chosen by a teacher assigned to the Bibracte museum.

As for the sector of cultural tourism, the use of our 3D models by tourism professionals can be of particular interest to local tourism offices to promote Bibracte on their websites, as well as nearby accommodations, also for their websites but also to enrich the slideshows that some present inside their accommodations. They can also be used by departmental and regional tourism bodies. The expected impact is significant, as these various uses can trigger a visit to the archaeological site and the museum.

Furthermore, professionals in the Cultural and Creative Industries may also be interested in reusing our models in multimedia creations, video games, etc.

5.3. CRDI

5.3.1. THE 3D DIGITISATION OF THE PRE-CINEMA COLLECTION

The experience in digitising the photographic and audiovisual collections of the CRDI has yielded highly appreciated results from the audience in previous projects and experiences. The digital transformation of the archive has been a lengthy process that has provided significant professional learning while also representing a substantial change in the way the organisation interacts with its working environment. The archive is primarily a space for preservation and physical storage, but it is also a space for discovery, knowledge, experimentation, and creation. The amplification of these values is closely associated with the technological possibilities of the moment, increasingly well used by a sector that has also learned how to transform itself.

On this journey, we must now consider the possibilities offered by 3D digitisation, which allows the representation of volumetric elements to provide a faithful representation for analysis, research, and entertainment. The digitisation of 99 daguerreotypes from the collection in 2022 was CRDIs first experience in this regard. This endeavour served to explore the benefits of 3D digitisation in the heritage field but also to identify the challenges posed by such an initiative.

The EUreka3D project has precisely addressed these challenges and made progress in the right direction, enabling this technology to accelerate a small new revolution in the process of CH transformation. As explained in this publication, archives and heritage institutions in general face the challenge of achieving high-quality digital reproduction that goes beyond the proper selection and application of technology. It requires skilled professionals, a working methodology, the ability to analyse the complexity of the objects to be reproduced, and criteria to assess the results. We also face the challenge and the commitment of making these materials accessible, which requires not only well-documented objects, something we are already skilled at, but also a specific infrastructure that meets access, security, authenticity, and custody needs.

Finally, we have the challenge of preservation, which goes beyond the provision of the aforementioned infrastructures and requires the adoption and selection of file formats, and above all, rich documentation of the production context, meaning paradata documentation.

These are the challenges that CRDI has had to face within the framework of this project, which we explain below in order to share an experience that we believe can be beneficial for other institutions with similar characteristics. The work carried out has been possible within the framework of an European project and thanks to the valuable contribution of top-level technological partners who have validated the entire process. The resulting 3D assets, accessible on the portal, allow critical assessment and research. In this sense, we believe that the CRDI's experience in this project constitutes a case study to be considered by other projects or CH institutions following the same approach.

5.3.2. PREPARATORY WORKS

This case study focuses on the 3D digitisation of 50 objects from the Cinema Museum in Girona, using digital photogrammetry. The work was carried out by CRDI over the course of two years, from 2023 to 2024.

Figure 46. Exhibition rooms at Museu del Cinema - Col·lecció Tomàs Mallol, where 3D digitised objects within EUreka3D are exhibited

The first step was to select 50 objects for digitisation as a representative sample of the heritage elements preserved at the Cinema Museum, showcasing the diversity, quality, and uniqueness of an extensive cinematographic heritage. All items are movable objects and were digitised indoors, within the facilities of the Museum. The objects belong to the following categories: image projection, capturing and viewing still images of the real world, image animation, optical illusions and visual tricks, and amateur cinema. Below is a list of the digitised objects grouped into these five categories (Tables 2-6):

Table 2. Projection of images

IDENTIFIER	NAME	DESCRIPTION
MC00604	Magic lantern Lapierre (1875 ca.)	This is one of the most popular models of magic lanterns produced by Lapierre.
MC00613	Magic lantern (1903).	This magic lantern for domestic use, with a ceramic body and beautiful illustrations.
MC01111-1	Magic lantern slide (1870 ca.)	Glass slide for magic lantern of the choreutoscope type, made by the English firm Charles Baker.
MC02557	Magic lantern slipping slide (1840-1875)	Glass slides for a magic lantern with moving images.
MC05948	Phantasmagoria magic lantern (1850 ca.)	It was the first model of lantern mass-produced for commercialisation.
MC07155	Magic lantern that depicts a polychromed Chinese Mandarin (1875 ca.)	A rare example of a magic lantern for family use.
MC15176	Magic lantern Lerebours et Secretan (1849)	Extraordinary specimen of magic lantern for phantasmagoria shows (phantoscopes).
MC27790	Magic lantern Lapierre (1890 ca.)	This is one of the most embellished and worked-out models of the Lapierre factory.

IDENTIFIER	NAME	DESCRIPTION
MC08001	Bronze figures of a travelling magic showman and showwoman (1880 ca.)	
MC3248	Film projector Lumière (1897)	
MC00210	Film projector Pathé baby super (1926)	An amateur cinema projector model commissioned by Pathé Cinéma. They used 9.5 mm film.
MC00448.jpg	Film projector Eastman Kodak Co. 16 mm (1923-1926)	The first camera and projector of the 16 mm film format.
MC00804	Film projector Ambroise François Parnaland (1898).	This was a rare projector for 35 mm films with Lumière perforation.

Table 3. Capturing and viewing still images of the real world

IDENTIFIER	NAME	DESCRIPTION
MC02057-1	Travel photographic camera (1890 ca.)	Travel camera for 24 x 18 cm plates.
MC02122	Camera obscura (1800 ca.)	
MC02132-02	Medicine cabinet with chemical products for developing daguerreotypes. It belongs to a laboratory for daguerreotypes Lerebours. (1850 ca.)	
MC02132-03	Device for securing daguerreotype plates for polishing. It belongs to a laboratory for daguerreotypes Lerebours. (1850 ca.)	
MC02132-04	Mercury box for developing daguerreotypes. It belongs to a laboratory for daguerreotypes Lerebours. (1850 ca.)	
MC02132-05	Alcohol lamp. It belongs to a laboratory for daguerreotypes Lerebours. (1850 ca.)	

IDENTIFIER	NAME	DESCRIPTION
MC02132-05	Mercury pot. It belongs to a laboratory for daguerreotypes Lerebours. (1850 ca.)	
MC02132-06	Support for heating or drying the daguerreotype plate. It belongs to a laboratory for daguerreotypes Lerebours. (1850 ca.)	
MC02132-08	Box for sensitising a daguerreotype plate with vapours of iodine crystals. It belongs to a laboratory for daguerreotypes Lerebours. (1850 ca.)	
MC02132-09	Colour palette. It belongs to a laboratory for daguerreotypes Lerebours. (1850 ca.)	
MC02134	Daguerreotype camera (1850 ca.)	
MC07649	Photographic camera Eastman Kodak núm.1 (1888)	It is the first photographic camera that used a roll of celluloid.
MC03262	Studio photo camera Voigtländer & John (1860-1880)	
MC01147	Peep show box, polyorama panoptique (1849)	Device for family use.
MC01163	Peep show box (1775-1825)	Peep show box to observe an optical view placed inside it.
MC01165	Statuette of a peep show box showman with woman and child (1757-1766)	
MC01275-1	Peep show box for translucent photographs (1866 ca.)	
MC02190	Stereoscopic photograph viewer Negretti & Zambra (1860 ca.)	
MC02192	Stereoscopic photograph viewer taxiphote, by Jules Richard (1900 ca.)	

IDENTIFIER	NAME	DESCRIPTION
MC00762	Film camera NBell & Howell (1939)	One of the most used cameras by war reporters during World War II.
MC00791	Film camera-projector Gaumont (1897 ca.)	
MC00837	Film camera-projector Jules Carpentier. Cinématographe Lumière (1896)	
MC00859	Film camera Pathé Cinéma (1908)	A 35 mm camera.
MC00426.jpg	Film camera Eastman Kodak Co. Cine-Kodak, model A (1923)	The first camera and projector of the 16 mm film format.
MC00558.jpg	Tinfoil phonograph, by Eugène Ducretet (1881)	This machine could record and reproduce sound.

Table 4. Animation of images

IDENTIFIER	NAME	DESCRIPTION
MC01332	Filoscope (1898)	The filoscope, which is also called a flick book or flip book, was a novelty item to animate a drawn or photographic image.
MC01360	Mutoscope Gaumont (1898)	The mutoscope was based on the technique of the folioscope.
MC01292	Kinora (1911 ca.)	It was the most popular way in Britain for watching movies at home.

Table 5. Optical illusions and visual tricks

IDENTIFIER	NAME	DESCRIPTION
MC00964	Phenakistoscope (1868)	This type dispensed with the use of the mirror to observe the images.
MC01114	Zograscope (1790 ca.)	Optical device used in the family setting to observe optical views.

IDENTIFIER	NAME	DESCRIPTION
MC10841	Zoetrope (1914-1925)	Mounted on a turned wooden foot.
MC01247	Toy shadow theatre. Ombres chinoises (1920 ca.)	

Table 6. Amateur cinema

IDENTIFIER	NAME	DESCRIPTION
MC01701	Toy cinema projector (1933)	Film projector for children that used a system similar to that of mutoscopes to create a moving image.
MC01750	Toy cinema projector (1942)	The projector used a 35 mm wide opaque paper film.
MC04782	Toy cinema projector NIC (1931)	The first cartoon projector, manufactured by a Catalan company, designed to be used by children.
MC06430	Toy cinema projector NIC (1932)	Children's film projector manufactured by the American company NIC Projector Company.

CRDI was committed to digitise all these objects and so, the next step was to contract a company working with the appropriate technology for 3D digitisation and the capacity to accomplish with the requirements written at VIGIE 2020/654 Study for quality digitisation. For this reason, we issued a tender, which was awarded to La Tempesta Media, a comprehensive digital services company that creates, designs, and develops digital mediation and new media tools for CH, knowledge, and content-based organisations and their communities. They have a multidisciplinary team, including developers, designers, documentalists, humanists, and social scientists, working throughout Europe, with offices located in downtown Barcelona.

Figure 47. Cinematographic camera. Bell & Howell, 1940. Museu del Cinema - Col·lecció Tomàs Mallol. Digitised model by CRDI - Ajuntament de Girona, in collaboration with La Tempesta Media EUreka3D project/CRDI-Ajuntament de Girona

Before starting with digitisation, we have to consider the legal issues, especially those related to intellectual property rights (IPR) as it determines the reuse. It should be noted that these rights referring to creativity are similarly regulated in different European countries. In all countries signatories of the Berne Convention, 70 years after the death of the author the works belong to the public domain.

In this case study, there are no copyright issues related to these objects, as the original ones that could be protected for the Spanish law are all in the public domain. For this reason, we labelled them with the PDM from the Creative Commons licences.[30] Therefore, they cannot be subject to restrictions because of rights issues. However, it is possible and reasonable for the private sector to charge for the acquisition of a digital 3D reproduction. It is important to consider that in the private sector there is a business around the heritage and that these companies invest in the processing and preservation of this heritage. Therefore, they must be economically sustainable and so the business model differs necessarily from centres financed with public funds, like CRDI.

30 http://creativecommons.org/publicdomain/mark/1.0/deed.ca

Once the digitisation company was decided, it was time for coordination with the Museum staff, in order to reduce as much as possible, the logistical effort of the stakeholders. This implies establishing the data capture days and determining which items should be digitised on each journey. This was a subject of great matter, as the objects are part of the permanent exhibition of the Museum. So, the time the collection objects spent out of the exhibition rooms and showcases should be minimised.

5.3.3. OBJECT'S COMPLEXITY ANALYSIS

To understand the complexities of digitisation, we organised a technical visit to the collection facilities with all the stakeholders and mainly the professionals responsible for the 3D digitisation. The aim of the visit was to observe and analyse the environment and the objects to be digitised, to plan the data capture process, and to anticipate any potential issues or difficulties.

The first task was therefore a detailed study of the materials composing the objects, and in this sense, it was necessary to prepare a conservation report on the materials by a restorer. In order to accomplish this conservation report, we created a descriptive sheet with detailed information on the various components of each object. For wood, technical details described colour, grain, fibre, and texture, with a classification to distinguish between coniferous and leafy types, along with information on finishes. For metals, the sheet specified whether they were magnetic or not, the type (iron, steel, copper alloy, etc.), and information on finishes. Regarding paper and cardboard, we made distinctions between handcrafted and industrially produced materials, with categories including coated, vegetable, newsprint, cardboard, photosensitive, and details on finishes (priming and protective layers, polychromy, printed, manual, etc.). For glass, the classification focused on differentiating lenses, mirrors, and plain glass. Additionally, for all materials, the descriptive sheet included observations to describe nuances and the conservation status of each piece.

With this report, we were able to anticipate potential difficulties during digitisation, especially considering that reflections from metals and the transparency of glass would be the primary challenges to address. These difficulties would require extensive work during the post-processing phase to reconstruct the mesh and textures, ensuring that the final model for dissemination had the most accurate appearance and material behaviour possible.

To increase efficiency with the process, we grouped the objects to be digitised based on their measurements. Objects exceeding 50 cm on any side were labelled as “large”. This distinction was crucial as it affected the data capture method. Images of large items had to be taken by orbiting around the object, while smaller objects could be captured on a rotating base. In an 8-hour session, we could capture a maximum of two large objects. Small and medium-sized objects, depending on their details and complexity, required up to one hour and a half each, averaging five objects per day. This timeframe only refers to the capturing process.

Other factors could also affect the quality of the digitisation. The main issue was that some objects had movable parts. Under the supervision of the museum conservators, these parts were fixed so that they didn’t move, without damaging the objects.

Following the visit, the professionals from the digitisation company identified the most suitable equipment and tools for the entire digitisation process, taking into account the conservation requirements and the specific characteristics of the museum collection. With this preparation, they were ready to deploy the digitisation equipment in the museum’s workspace to streamline the process.

5.3.4. DIGITAL CAPTURE AND PROCESSING

Two professionals from La Tempesta Media participated in the core processes of the project: preparation, photographic capture, and post-processing. The team comprised a photographer and a 3D photogrammetry technician, who worked in continuous coordination with the CRDI and Cinema Museum staff. Photographing the museum objects is a labour-intensive task for the photographer, primarily due to the previously mentioned challenges related to the objects' materials. Using photogrammetric techniques to build a 3D model requires capturing images from various angles and positions, repeatedly rotating the object to minimise reflections and glare. Another major challenge is the varying sizes and thicknesses of the museum objects, which sometimes have moving parts. Effectively applying the photogrammetric technique addressed these challenges, yielding optimal results efficiently. Below is a detailed list of instructions executed for data acquisition, grouped into three core processes, provided by La Tempesta Media professionals.

Figure 48. 3D digitisation process of pre-cinema collection of the Cinema Museum in Girona using photogrammetry by CRDI - Ajuntament de Girona

Preparation tasks

- Equip the camera with a polarising filter to minimise light reflections.
- Set appropriate illumination for the object.
- Adjust the manual camera settings:
  - Fix the ISO to the lowest possible value (100) to avoid digital noise.
  - Use higher f-values to achieve a high depth of field for sharp images, resulting in better mesh and texture quality.

  - Set the exposure time as short as possible to reduce digital noise. However, for larger or highly reflective objects, longer exposure times are necessary due to softer lighting.
- Place the scale bar next to the object for use in digitally scaling the model later.

Photographic capture

- Take photos of the object from all angles, ensuring at least 66% overlap between consecutive images. Objects without restrictive issues (such as fragility or physical instability) should be turned or laid down so that the part in contact with the surface can also be digitised.
- For large and highly detailed objects, use the focus stacking technique. This means taking multiple images from the same viewpoint, each with the focus set at different distances. This additional process was implemented to achieve improved final results, particularly in mesh details and texture quality.

Post-processing and data storage

- Import the RAW image data to the hard drive and store it in the corresponding folders.
- Rename all images with their corresponding IDs, and identify the ColorChecker calibration images. Label colour calibration images as ID_colorchecker_01 and ID_colorchecker_02. Rename the rest of the images as ID_0001, ID_0002, ID_0003, etc.
- Convert the ColorChecker image containing the colour scale into DNG format, as the software does not recognise Canon's proprietary CR2 file format.
- Create the camera colour profile, name it under the corresponding ID_profile, and store it in the RAW folder.
- Develop the RAW images into JPEG format using Adobe Camera RAW, assigning the colour profile and white balance beforehand.
- Save the JPEG images in their corresponding folder. Identify focus-stacking images and set them apart.

- Process the focus stacking images in Adobe Photoshop. From each point of view, only one image should remain. For example, if four photos were taken from the same camera position with different focusing points, the result should be one final image that merges and stacks the sharp parts of the photos while discarding the blurry ones. Save the resultant JPEG with the other images, indicating the original photos it is composed of. For instance, if an image is a result of stacking ID_0025, ID_0026, and ID_0027, the merged photo will be named ID_0025-27.
- Upload all the JPEG images into the Agisoft Metashape file. If the object was turned upside down or laid down during the data capture process, the images should be separated into different “Chunks” (the software’s term for work layers) to maintain consistent alignment between the object and the environment.
- Align the images, build the mesh, and apply the textures. If there is more than one “Chunk”, this process must be repeated, initially masking the environment to eliminate inconsistencies.
- Once the model is textured, it is ready for export. This will be the RAW 3D model, called “Master”. The export is done in the .OBJ format. Considering the complexities of the collection, the “Master” model often contains some mesh irregularities, distortions, and holes.
- The next step is to automatically decimate the RAW model in Metashape, setting the polygon count to 150,000, creating the “Low resolution” model. UV mapping and textures must be rebuilt. Export it to its corresponding folder.
- Import the “Low resolution” model into the 3D modelling software Blender. Manual post-processing is performed to correct irregularities, close holes, remove noisy polygons, and reconstruct metallic, glass, lenses, and reflective surfaces.
- Export the model and import it back into Metashape. Then, reproject the texture and UV map, a post-processing technique for photogrammetry known as texture reprojection.
- Export the 3D model in .OBJ format to the Dissemination folder.
- Conduct a second layer of non-destructive post-processing, preserving the previous post-processed model labelled as

"dissemination basic". Apply PBR materials to give the object a photorealistic appearance with lighting, adjusting values such as roughness, transmission, metallic, or alpha channel, among others. Export the resultant 3D model in .GLB format, naming the file to indicate the added PBR material, such as "lens" or "glass".

- The final step is video rendering. This process is done in Blender, which has excellent rendering engines. Set an environment and illumination beforehand. The environment is designed as a grayscale pattern to maintain the CH item's context. The video includes tracing camera movements and animations, initially showing an overall preview of the object followed by close-up views of its unique features and details.
- Export the output as an .MP4 file. If necessary, make further adjustments using video editing software DaVinci Resolve.

For the data storage, there was a need of 1.5 TB (a total of 46.182 files). All of this data is preserved at the Girona City Council repository, an infrastructure owned by the City Council and managed by the IT Department. The servers are already used for digital archiving and so, they accomplish well with all authenticity, security and preservation requirements.

Regarding the organisation of all these data, the files have been organised in folders using the object IDs as main identifiers. Each model has a unique name based on its ID, which is also included in the name of all its dependent folders and files.

Every item has an initial layer of five main folders, where data is separated according to its type:

- 01_ID_Dataset: contains image data in RAW and JPEG formats.
- 02_ID_Process: contains the photogrammetry software native file format (Agisoft Metashape, .PSX), with the entire saved process.
- 03_ID_Exports: contains the 3D models in three separate folders:
  - 01_ID_Master: contains the unaltered 3D RAW data, with no post processing. This means that, due to the presence of glass, metals, and mirrors, the mesh geometry and

    textures may contain unwanted holes and irregularities. Exported in .OBJ format.
  - 02_ID_Low_resolution: Contains the same model, but decimated to 150,000 polygons. This is the optimised RAW data. Exported in .OBJ format.
  - 03_ID_Dissemination: Contains the 3D model optimised and ready for publication. It includes manually adjusted post-processing. Typically, the model has two versions: one without material behaviour adjustments (metal, glass, roughness, etc.), labelled as "basic", and one with those adjustments, labelled as "lens" or "glass" to indicate its alterations. Exported in .OBJ format, and also in .GLB format for models with material adjustments, as .GLB saves transmitting materials such as lenses.
- 04_ID_Postprocess: Contains the 3D modelling native file format (Blender, .blend). The extent of post-processing work varies depending on the model's complexity. This folder includes the dissemination model and the video rendering process.
- 05_ID_Render: Contains the rendering video in .MP4 file format.

Regarding digitisation costs, the project allocated a subcontracting budget of €15,000, dedicated exclusively to these tasks of capturing and post-processing the images of the heritage objects. The Girona City Council's tender outlined all the technical requirements agreed upon in the project. Two companies participated in the process, both possessing the necessary technological capabilities and proven experience. Ultimately, the contract was awarded to La Tempesta Media S.L. for €13,000.

5.3.5. PARADATA AND METADATA

Paradata becomes a main issue for a project like this and so, following the VIGIE 2020/654 Study report recommendations, we gathered all the technical information regarding the tools for digitisation, the process, the professionals working on it and the environmental conditions for the capture. In the text below, we just provide the specific information regarding equipment and software used for digitisation and editing. The complete set of paradata was published in Europeana with a specific document related to each object.

Data capture equipment

- Reflex camera: Canon EOS 5DS with Full Frame CMOS sensor (36 x 24 mm), 50.6 megapixels.
- Camera lens: Canon EF 50mm f/1.4.
- BENRO Camera Tripod 1.45m max extension.
- NEEWER LED panel bicolour CRI 96+, 3200-5600K (2 units). Individual continuous lighting of each object for its photographic reproduction.
- BENRO UD 58 MM. Polarising filter to minimise light reflections. Reflections interfere with the processing of the model, bringing digital noise and errors in photo alignment.
- Remote Control camera trigger.
- AOMDOM Branché: Electric Semi-Automatic Remote Control Rotation Base. 42 cm, 100 Kg max weight. It speeds up the digitisation process for the small and medium size objects.
- Study Lightbox Orangemonkie Foldio 3 (60 x 60 cm). This box is to give the proper lighting to the object and minimise hard shadows. With the lightbox we could fake the background as wanted and made possible shorter exposure times while working with high f numbers.
- ColorChecker Passport Photo 2. Colour and Grey Scale Charts.
- Scale bar: necessary to semi-automatically scale the 3D model, as the regular algorithm has no accurate auto measures.

Hardware

- ASUS TUF GAMING F15 computer: 32 GB RAM, Intel Core i5, Nvidia GEFORCE RTX 3050. The processing computer. For photogrammetry and 3D modelling high processing capacity computers are needed.
- SanDisk SD card 128 GB. Deep memory card to store +4000 RAW images.

- WD Elements 4 TB capacity. Hard Drive to store all the data, as 3D projects are dense in weight.
- WD Elements 2 TB capacity. Backup Hard Drive to keep the data as emergency backup.

Software

- ColorChecker Camera Calibration. Specific software of the Colour and Grey Scale Chart, used to calibrate the accurate colours, which are identified by Computer Vision and translated into a colour code, known as colour profile.
- Microsoft Power Rename: Windows extension to rename *en masse* high numbers of files and folders, to match them with the object IDs.
- Adobe DNG Converter. Used to convert RAW proprietary files (CR2) to exchangeable formats (DNG).
- Adobe Camera Raw. Used to apply grey and colour calibration and convert DNG to JPEG.
- Adobe Photoshop. Used for photo stacking to enhance photo alignment and textures.
- Agisoft Metashape. Specific photogrammetry software to align photos, build 3D mesh and apply textures.
- Blender. Open-Source Software to edit the web publishing 3D Models (dissemination) and produce video renderings and animations.
- DaVinci Resolve. Used to edit the video renders, as a post processing tool.

Metadata is essential for the understanding of the object, otherwise all the efforts for a quality digitisation are meaningless. It is important to work using international standards for archives, museums and sites. However, for a project like this, the main reference is the EDM. Local catalogues need to fit with EDM schema and they also need to be enriched using skosified vocabularies,[31] for hierarchical and semantic relations and multilingualism. CRDI bases its enrichment

31 https://www.w3.org/2001/sw/wiki/Skosify

in the use of AAT (Art and Architecture Thesaurus), from the Getty Institute, and Wikidata.

Publishing on Europeana involves a process that includes metadata mapping and transformation through intermediate software that converts local metadata into EDM. For this project, the partners from EGI Foundation developed a schema and a tool for converting metadata to EDM and publishing it on Europeana. However, for partners already publishing in Europeana, such as CRDI, which has been using MINT -an infrastructure managed by Photoconsortium and owned by National Technical University of Athens (NTUA)- for over twelve years, the process is slightly different. In these cases, the process begins with the publication of an XML file formatted according to the structure and metadata standards agreed upon in the project. Metadata is then converted to EDM through mapping conducted in the MINT system. The process concludes when Europeana harvests the metadata and publishes it in its catalogue.

From this process, it is evident that an initial structuring of metadata based on universal standards and a high level of expertise in describing heritage objects significantly facilitates the work. Expertise in handling museum objects and adherence to standard references are essential foundations for successfully navigating the process.

5.3.6. DISSEMINATION AND REUSE

To better understand the use and reuse of pre-cinema objects, it is important to consider the approach of the Cinema Museum's permanent exhibition. The exhibition system goes beyond merely showcasing the most significant parts of the collection; it aims to be interactive, engaging, and educational. To achieve this, the exhibition features various audiovisual projections and staged presentations that give visitors a sense of historical visual shows and the images that were projected during the pre-cinema and early cinema periods. Replicas of the artefacts allow visitors to handle them and learn more about their mechanisms. Many devices feature digitised images that replicate the functionality of the objects in an educational and entertaining manner, with some interactive touchscreens enabling visitor engagement.

This approach ensures that the exhibition is accessible and appealing to all audiences, regardless of age, cultural background, language, or level of interest in cinema. It offers a universal narrative on the roots of our audiovisual culture, making it a recommended experience for everyone.

Figure 49. Camera for photography studio. Manufacturer unknown, ca. 1860-1880.
The original object, the 3D model reconstruction, and the digitised model by CRDI - Ajuntament de Girona, in collaboration with La Tempesta Media.
EUreka3D project/CRDI-Ajuntament de Girona

The overarching goal of the Museum of Cinema goes beyond its permanent exhibition. Its ultimate aim is to boost dissemination, education, and research on cinema and imagery in general. To fully achieve this goal, 3D digitisation is becoming increasingly crucial. It offers numerous opportunities for research and provides a more realistic approach to digital representation. Digitisation plays a key role in understanding and educating about the history of moving images, cinematographic techniques, and the evolution of cinema and photography. This is achieved through conservation, research, interpretation, and online exhibition, facilitated by the EUreka3D platform. This platform enables interaction with both researchers and end-users, aiming to reach a broader audience with more content than ever before.

5.3.7. CONCLUSION

Based on the experience and lessons learned from this case study, we can highlight three key aspects that should be considered for any 3D digitisation project undertaken by an archive or museum:

1. **Scientific Approach to 3D Digitisation**: 3D digitisation is a scientific process that requires careful measures to optimise work quality based on existing technology. Preparatory tasks, such as complexity analysis, are critical and influence the final outcome. A thorough preliminary study of working conditions is essential for achieving optimal results and objectifying work quality. In this context, having a technological partner is crucial. For this project, CUT has been the leading partner, and the VIGIE 2020/654 Study has served as our guide for ensuring quality digitisation.
2. **Understanding of the heritage objects**: The technical evolution of pre-cinema objects has had significant impacts on the social use of imagery. Detailed knowledge of the originals being digitised is vital for successful reproduction. The Pre-Cinema Collection allows us to trace and understand the development of motion picture technology and its associated shows. These objects provide insight into how moving images were represented before cinema and detail the technical processes leading to the invention of the cinematograph in 1895. It is essential to remember that the heritage is the core of the project, and technological innovations are meaningful only when they benefit this heritage.

3. **Reusability of 3D Digital Objects**: The 3D digital objects resulting from digitisation offer significant potential for reuse. Due to their nature, different parameters for dissemination and reuse need to be considered compared to traditional digital archives. This requires a new approach and an understanding that we are at the beginning of this evolving field. As we move forward, it is important to establish infrastructure, develop methodologies, and collaborate with technological partners. The approach taken during the EUreka3D project has yielded satisfactory results and encourages us to pursue new projects to advance the use of this technology, always keeping in mind the need for continuous innovation in the heritage sector.

5.4. MUSEO DELLA CARTA

Museo della Carta di Pescia (Pescia Paper Museum) holds a rich heritage of paper goods consisting of watermarked paper moulds, watermark waxes, punches, watermarked metal sheets, for a total of about 7.000 pieces, witnessing the history of paper manufacturing in Tuscany. These goods, which became part of the Museum's collections thanks to a private donation, document the relationships that the local paper factory named 'Antiche Cartiere Magnani di Pescia' had with companies, famous people, banks, insurance companies, foreign states in over three centuries of activity from the mid-eighteenth century to the 2000s.

In 2008, in agreement with the superintendency of Florence and the Central Institute for Cataloguing and Documentation in Rome, we started a pilot project, the first in Italy, for the inventory and cataloguing of these goods, followed by a number of in-depth research projects on a selection of ca. 30 of these historical items, in particular the watermarked paper moulds, which today constitute the first part of our online catalogue.

The watermarked paper moulds are very special objects and were used in the past to produce handmade watermarked paper, as we still do today in the Museo della Carta di Pescia, which is located in a completely intact and original eighteenth-century paper mill. The moulds are made of a wooden frame and a metal sheet on which the watermark was sewn with silvered copper wire.

As mentioned, Museo della Carta di Pescia was the first institution to have inventoried and catalogued these assets, also digitising in 2D a selection of the most relevant ones, but had never before created 3D models of its collections and therefore had no previous experience in this area. The EUreka3D project was therefore an experimental path, allowing the creation of two 3D models of two watermarked paper moulds, and in this way enabled the Museo della Carta di Pescia to acquire skills and evaluate all the positive aspects of digital models.

The Museum is primarily a place of conservation, study and exhibition of the collections but thanks to this project it has been possible to increase research, analysis and broaden the use of these goods.

In addition to the tools and machinery for paper production, the Museo della Carta di Pescia also received as a donation the Historical Archive of the Magnani Paper Mills of Pescia, which was placed under constraint by the superintendence in 1979. The documents are now located inside the Museum in a wing of the Le Carte Paper Mill built specifically for this purpose.

The Historical Archive of the Magnani Paper Mills is one of the most important Italian company archives and is made up of approximately 700 linear metres of documentation. A 2D digitisation action on these assets was initiated already before the EUreka3D project, and continued with the final aim to offer about 5,000 documents for publication online and in Europeana.

5.4.1. PREPARATORY WORKS

This case study focuses on the 3D digitisation of two watermarked paper moulds, complemented with additional work in 2D digitisation and sharing of a selection of documents from the Magnani Historical

Archives. The 3D objects followed entirely the EUreka3D workflow and were eventually uploaded and shared to Europeana via the EUreka3D Data Hub and services. The collection of 2D assets was uploaded onto an existing platform, previously created by Museo della Carta di Pescia thanks to other public and private funding, and eventually published in Europeana by using the aggregation route via the MINT mapping tool software from partner Photoconsortium.

The first step was to identify two objects in the collections of watermarked paper forms that were significant in relation to the history of handmade paper production in our area and a small part of the Archive documentation that was equally significant. The choice fell on the watermarked paper mould with the images of Napoleon and Maria Luisa of Austria, made in 1812, and the watermarked paper mould with the image of an anchor and the letters "E" and "S", made specifically for Ettore Serra (La Spezia, 1890 - Rome, 26 December 1980) in 1923 and which was used to create paper for the first edition of Porto Sepolto by Giuseppe Ungaretti (Alexandria, Egypt, 8 February 1888 - Milan, 1 June 1970). As for the documentation, attention was mainly focused on the volumes containing the letters sent by the Magnani company to its customers all over the world.

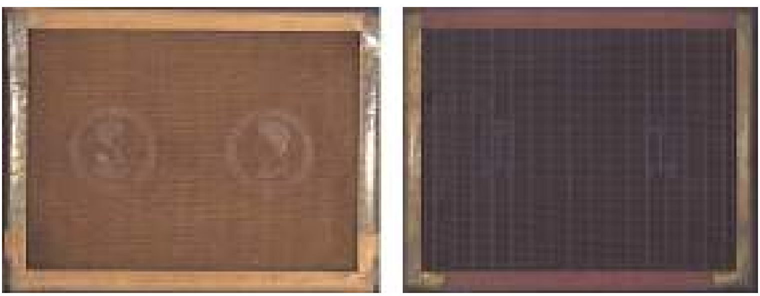

Figure 50. Watermarked paper moulds: Profile portraits of Napoleon Bonaparte and his wife Maria Luisa of Austria made in 1812. Anchor and the letters "E" and "S", made specifically for Ettore Serra in 1923 Museo della Carta di Pescia

The Museum has entrusted the 3D digitisation of the two watermarked paper forms and the additional 2D digitisation of the documents to the company Space Spa of Prato, which has a proven track record and many years of experience in this sector and has worked for the largest Italian museums and beyond.

Although the collection is under the constraint of the competent superintendencies, it is the exclusive property of the Museo della Carta di Pescia, ad thus, with prior agreement of the competent authorities, it was possible to proceed quickly both with regard to the identification of the assets to be digitised and with regard to their actual digitisation.

It was therefore possible to minimise the time the two watermarked moulds remained outside the Museum's storage facilities, and similarly the historical documentation existed, the Magnani Historical Archive for a brief period.

5.4.2. THE DOCUMENTS OF THE MAGNANI HISTORICAL ARCHIVE

The digitisation activity involved a very high quality digital copy of historical documentation, through the production of PDF files from archival papers and the digital file was acquired exclusively with a planetary scanner. Regarding the optical resolution, three images of different formats were created for each digitised page thus generating files of different resolutions and colour depths to be used for archival purposes and sharing. The digitisation activity was carried out respecting, both in the equipment and in the procedure, the quality standards required for the preservation of the paper originals.

In fact, only professional planar scanners were used, capable of acquiring 24-bit colour, allowing for highly legible images. These scanners have cold light illumination units that ensure maximum quality and preservation of the original. The operational flow that was developed for the execution of the digitisation work of the documentary material ranged from checking and calibrating the scanners before starting the daily activity to the verification on the monitor of each individual image produced. For each digitised image, indexing was performed. During the processing phases, the management software automatically verified the correctness and consistency of the data necessary to generate the XML file that would be needed afterwards to enable publication of the collection in Europeana, highlighting any anomalies or errors and possibly interrupting the workflow to make any corrections.

5.4.3. 3D DIGITISATION OF TWO WATERMARKED PAPER MOULDS

The Museo della Carta di Pescia has carried out the 3D digitisation of the two watermarked paper moulds mentioned above with the support of the company Space Spa of Prato.

The digitisation of the two paper moulds was created using photogrammetry, for which a portable photographic studio was set up consisting of light boxes of suitable size, equipped with supports and rotating plates, lighting systems and digital cameras.

The photographic shooting of the took place following a general procedure:

- positioning of the object on the shooting set, with the aid of suitable supports;
- preparation, positioning and adjustment of the lights based on the specific characteristics of the object by the operator;
- white balance through reference targets and tools for colour profiling, to guarantee correct colour reproduction;
- execution of the number of shots at pre-established angles on both the horizontal and vertical axes in order to capture all the details of the object in a systematic way.

The acquisition took place via a notebook connected to the camera using the camera's acquisition software. Each acquired image was viewed in real time on a calibrated and profiled monitor.

The final 3D models have the following specifications and formats:

- .OBJ or .PLY or .STL for the geometry of the model;
- .JPG or .TIFF or .PNG for the high resolution textures associated with the model.

Acquisition systems

The equipment used can be described as follows:

- Nikon D750 digital camera with tripod, Nikkor macro-professional 60 mm lens, live viewing from PC;
- Sony alpha7r IV camera, Sony macro-professional 90 mm and 24-70 mm lenses;
- ColorChecker Passport Photo 2 target (colour balance);
- complete kit of Paleo3D metric bars, for the correct sizing of the finds (any size).

Setup for movable goods:

- small, medium and large Cubelite light boxes;
- Lupo Dayled 2000 Pro and Lupo Superpanel Dual Color with relative stands, diffusers and use of satin paper to attenuate direct lighting sources;
- rotating platform with indication of the degrees of rotation, on which to place the goods.

Acquisition and post-production software:

- Remote acquisition software: Nikon Camera Control Pro; Sony Imaging Edge Desktop;
- Adobe Photoshop; Adobe Bridge; Adobe Camera RAW;
- X-Rite i1photo pro calibration and profiling software;
- Proprietary software associated with the photorealistic 3D laser scanner used;
- Bentley ContextCapture (photogrammetric 3D reconstructions and hybrid scans/photogrammetry);
- 3Dflow 3DF Zephyr (photogrammetric 3D reconstructions);
- CloudCompare / Meshlab (modifications and optimization of the final 3D model);
- Blender / Cinema4D (modifications and optimisation for consistency of the final 3D model).

Figure 51. 3D digitisation process using photogrammetry at Museo della Carta

Metadata and paradata are fundamental aspects in a digitisation project like EUreka3D and therefore it was necessary to operate following the recommendations provided by VIGIE 2020/654 Study report and the internationally recognised standards for museums and archives. The complexity of the paradata for the 3D digitisation for each object was made available as a report and published as open information in EUreka3D Data Hub and also included as a link in the records published in Europeana.

5.4.4. ADDITIONAL DEVELOPMENTS DERIVING FROM THE EUREKA3D EXPERIENCE

The Museo della Carta di Pescia, as mentioned, created with public and private funds a dedicated platform for remote consultation of the documentation, which was developed in the years 2022-23 by the company Lunet di Lucense. In the scope of the publication of the collection in Europeana as part of the tasks of the EUreka3D project, an external assistant archivist was hired to transfer the documents onto the platform. This additional member of staff was hired thanks to partial funding from the Fondazione Cassa di Risparmio di Pistoia e Pescia and with some of the Museo's own funds, for a period of 12 months.

Additionally, in the scope of granting interoperability with a more careful analysis of the platform, in relation to the needs of transferring the metadata to Europeana and of granting the needs of interoperability with the SAN (National Archive System) of the Italian Ministry of Culture, some changes and upgrading of the existing platform were needed, to modernise, upgrade and innovate the infrastructure. Such an upgrade of the platform was made possible in the context of an initiative called “La Memoria del Futuro” by the Sistema Museale Pistoiese (SIMUP), of which the Museo della Carta di Pescia is a founding member. This initiative was supported by the Tuscany Region and was partly co-financed by the Fondazione Cassa di Risparmio di Pistoia e Pescia.

This experience witnesses how a virtuous path was enabled, starting from the EUreka3D project co-funded by significant funding from the European Commission, to activate further collaborations and find other sources forms of funding to implement innovation, technological developments and digital transformation in the Museo della Carta, so as to obtain the best possible result.

5.4.5. DIGITAL TRANSFORMATION TO ENHANCE PAPER HERITAGE

Paper goods are a very little known type of heritage, and also the techniques of creating the sheet of handmade paper, now and in the past, are not in the attention of the general public. To fully understand the efforts that the Museo della Carta di Pescia has made also within the EUreka3D project, it is necessary to underline the overall commitment that our institution is facing to preserve and pass on the ancient art of handmade paper, leveraging both digitisation and digital innovation and more traditional actions towards preserving and sharing this type of heritage.

Figure 52. 3D reconstruction process of a watermarked paper mould model

The Museo della Carta di Pescia is located inside an intact eighteenth-century paper mill, and not only is committed to showing these collections and preserving the documents of the Magnani historical archive, but for years it has been carrying out a project for the recovery of the intangible heritage of the communities who worked in the mill, by the foundation of a company, the Magnani Pescia Company, which has resumed the creation of products in handmade watermarked paper.

In this way, visitors to the Museum not only get closer to the very important history of our territory but can see before their eyes the creation of a sheet of watermarked paper and learn the importance of the paper support, within an approach that makes the visit accessible, engaging and suitable for all types of visitors and allows for education in the rediscovery of handmade paper, while promoting historical research and a broader knowledge of the collections.

> *For our institution and the ambitious goals that we aim to, the aspect of digitalisation is increasingly crucial because it allows us to obtain a previously unthinkable dissemination of the collections and the themes that the Museum values, also enabling a greater diffusion of the knowledge related to handmade paper.*

In this light, the EUreka3D project and the publication of collections in Europeana will enable greater outreach and interaction with researchers and end-users, thus allowing the Museum to increase the international visibility and expose its contents to an even wider audience.

As a result of all these efforts, in consideration of the integrity of the heritage location, the presence of collections and historical archives and last but not least all these activities carried out by the Magnani Company founded by the Museum, our institution is now part of an initiative called Paper Mills of Europe, aiming at the UNESCO recognition for this manufacturing tradition and connected heritage. The project was included in the UNESCO Tentative List in April 2024.

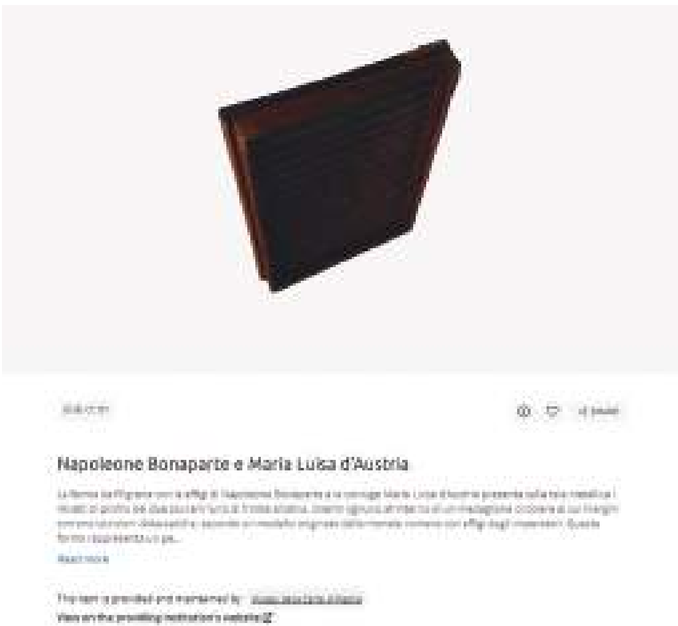

Figure 53. Exploration of the 3D digitised paper mould from Museo della Carta on Europeana

6. Collaborations with external partners

EUreka3D has been a groundbreaking project in the realm of CH digitisation, especially given the current efforts in implementing 3D for heritage collections.

Not only the project has successfully connected and supported partner institutions in their efforts to preserve and share cultural collections by creating and sharing high-quality 3D models, but it has also enabled new collaborations and positive impacts with institutions that were not originally part of the project.

This is demonstrated by the many collaborations established with cultural institutions both large and small, across Europe, which asked to be included in the EUreka3D Stakeholder Group and, in various cases, also to test the EUreka3D platform. Such active participation is evidence of the need for practical implementation of 3D digitisation within the CH sector and one that EUreka3D has been able to respond to. While the CH sector undoubtably seeks to explore 3D digitisation as a method to extend their reach to audiences and detail their inventories, it must be remembered that the sector is under pressure at a national level from the European Commission recommendation of 2021[32] to have all heritage at risk and 50% of the most visited sites nationally digitised and available by 2030 (with 40% -i.e. 15% of national heritage assets- of those targets met by 2025).

Upskilling the CH sector in digitisation techniques is one part of the equation. Improvements in both accessibility to and quality of results for digital 3D data acquisition in terms of techniques, software and

32 See Commission Recommendation of of 10.11.2021 on a common European data space for cultural heritage https://digital-strategy.ec.europa.eu/en/news/commission-proposes-common-european-data-space-cultural-heritage. For individual Member States expected digitisation effort refer to the report Annex.

hardware have significantly reduced the cost of digitisation. Quality of digitisation still remains a concern but for the vast majority of cases digitisation at the object level[33] is achievable and affordable either through in-house development or out-sourcing to specialised companies. The real challenge comes after digitisation: once the 3D model exists in the form of a set of files, it is necessary to store it safely, to visualise it effectively, and to make it available and retrievable for interested users. This is critical to the goal of making CH assets available for reusability and exploitation.

EUreka3D offers a very welcome "one-stop-shop" solution to these challenges, allowing to store, manage, visualise and share 3D objects. Moreover, the project provides added value granting data storage in servers located in Europe, and permitting easier access to Europeana thanks to the full integration of the respective services. In this light, the EUreka3D platform and Data Hub is being used by associated partners to upload and share test collections, such as the Medelhavsmuseet (Museum of Mediterranean and Near Eastern Antiquities) in Sweden, who offered a selection of 3D models of Cypriot heritage from the museum's collection, or INSPAI Girona with a collection of five selected 3D objects, and the RAMS Regionaal Archeologisch Museum a/d Schelde in Belgium publishing in Europeana their first collection of thirteen models. Also, the Department of Architecture of KU Leuven is currently developing a case study about sharing in Europeana 3D reconstructions of lost buildings from the XIII century. Another case of using EUreka3D to support a newly launched digitisation project is being carried on by the Basilica del Pi in Barcelona, where the statues adorning the cathedral are currently being digitised and will be made available in Europeana via the EUreka3D platform. Other interested organisations who are testing the EUreka3D platform for supporting their collections are the project Giravolt by GENCAT Barcelona and the TENKIKER technology centre in the Basque country. The experience and feedback of these external

33 It must be recognised that the digitisation of a single object is different to the digitisation of a whole collection, which vary in its complexity and cost.

collaborations complement the iterative testing of the platform and workflow that is done by EUreka3D Content Providers.

In addition to cultural institutions who are eager to use EUreka3D services, the network of collaborations and engaged stakeholders who participate in the project includes technology providers and research institutions, such as Archéosciences Bordeaux, the Digital Humanities Lab at the University of Basel, the NALIS (National Academic Library and Information System) Foundation in Bulgaria, the University of Cologne, and projects in education and cultural tourism, like ARTEST, Mnemosyne, INCULTUM and SECreTOUR. The interaction with these stakeholders helps the iterative development of solutions and tools at the service of CH institutions to reuse and promote their heritage collections in 3D to a variety of audiences. Other large organisations with which EUreka3D collaborates to reach out to the community of cultural institutions in Europe include ICA, the International Council on Archives, meemoo, the Flemish Institute for Archives, and Museovirasto, the Finnish Heritage Agency, under the Ministry of education and culture. Finally, the close relationships with the Europeana initiative and satellite network of communities, projects, aggregators and content providers are further strengthened by presentations and participation in capacity building and outreach events.

Through its innovative approach and resources, EUreka3D deployed the power of cloud services and tools in bringing together a wide range of organisations and professionals, who share a common goal and challenge of preserving CH in 3D for future generations.

HENDRIK HAMEEUW, CONSERVATOR, REGIONAAL ARCHEOLOGISCH MUSEUM A/D SCHELDE (RAMS, BELGIUM)

As a small regional museum, with limited resources, collaborating with and having easy access to durable digital infrastructures is crucial. For our 3D digitisation programme this applies in particular. The effort to produce and manage this type of digital content of archaeological objects is time-consuming and challenging. Crucial incentives to be able to rely on a sustainable platform such as EUreka3D developed, that offers broad possibilities to disseminate the assets and associated (meta)data of our collections to a variety of end-users. RAMS enthusiastically joined the test phase of the Data Hub and estimates that the developed path will provide a boost for the future storage and structured access to all sorts of 3D content.

CLARA SILVESTRE COLOMER, ARCHIVIST, INSPAI CENTRE DE LA IMATGE DIPUTACIÓ DE GIRONA

Collaborating with the EUreka3D project has helped us to get into the study of 3D digitisation and to undertake for the first time a digitisation of this type of some of the photographic objects preserved by our institution. EUreka has managed not only to train and offer knowledge in this field but also to advance in the path of digital transformation and offer useful and interesting solutions that address the current challenges of sustainability, traceability (collecting data, metadata and paradata) and interoperability. Thanks to the Data Hub platform developed within the framework of this project, INSPAI will be able to share and host its 3D models in a common space and ensure not only access to this heritage but also its preservation and reuse.

ALBERT SIERRA REGUERA, PROGRAMA GIRAVOLT, AGÈNCIA CATALANA DEL PATRIMONI CULTURAL

For the Giravolt program, collaborating with EUreka3D is a privilege. We share many working methods with them, but they have made progress in an area that is crucial for us: the management and workflow of all the files generated during digitisation, along with their metadata and paradata. With nearly 600 3D models and growing every year, we need solutions like this to manage and publish our collection.

7. The Data Space for Cultural Heritage

Europeana is the steward of the European common data space for cultural heritage (hereafter also referred to as 'the Data Space'). It is to be a sovereign data ecosystem - an open and resilient commons for the users of European cultural data.

Sovereign in that we give control of data to the data's owners, rather than vested interests, and that we house our data in European systems under European law.

An ecosystem in which we nurture interconnected applications, communities (including the Europeana Network Association, the Europeana Aggregators' Forum, the European Commission, Member States, GLAM organisations, etc.) and data as a federated whole.

Open and resilient in that we emphasise "open" models of sharing and innovation, which also promote the development of flexible and adaptive systems.

And a commons in that we design and manage the system around a nucleus of shared, "open" values for enjoyment and benefit of a community.

Europe's implementation of data spaces is in its infancy. The European common data space for cultural heritage is one of 14 data spaces being created by the European Commission - each with its own unique character but each united by the Commission's vision of a flourishing next-generation data ecosystem for the European Union.

The goal of the data space for cultural heritage is to create a sustainable and trusted ecosystem that dramatically broadens the scope of participation in Europe's cultural heritage and which cultivates the idea of culture as a civic good.

Figure 54. Homepage of the European common data space for cultural heritage website

Achieving this will require a cohesive and determined network -and a taste for risk taking if we are to extend the boundaries of established practice, particularly if we are to think more boldly about our definition of CH; our relationship to climate action and social change; and if we are to empower young people and previously underrepresented communities as co-creators and co-owners of the Data Space.[34]

EUreka3D fits squarely into the Data Space, especially when we look at how the European Commission defines the importance of the Data Space:

> *To enable cultural organisations and Member States to reach wider audiences, create more immersive and innovative experiences, and to* “empower cultural heritage institutions in their digital transformation”.
>
> *To encourage Member States to ramp-up their participation in Europeana, preserve and give access to culture at risk, and increase the size and scope of Europeana digital cultural collections.*

34 M.P. Edson, 2023.

To foster the reuse of content, create new forms of artistic expression and new ways of engaging with and enjoying digital content, and increase public participation in culture.

All of the above points are challenges that EUreka3D aims to face. Wider audiences are reached by offering new types of content in new formats: 3D. More immersive and innovative experiences can only be created with high-quality freely reusable 3D objects. Cultural Heritage Institutions are brought into the fold of an evolving Europe that increasingly is looking at virtual worlds, by continuing the digital transformation of these institutions to deal with 3D digitisation, preservation, and access. EUreka3D helps the Member States reach their ambitious 3D digitisation goals[35] by providing knowhow, tools, and a digital platform as part of the Data Space marketplace.[36]

EUreka3D takes part in the data space by sharing its outcomes, its tools, and its capacity building resources with the wider GLAM community. It does so through updates and news posts both on its own website[37] and on Europeana Pro.[38] It also aims to inspire others into using and reusing 3D objects by publishing narratives and writing stories[39] using the 3D objects that were scanned and made available throughout the project by project partners.

35 https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32021H1970
36 https://eureka3d.eu/eureka3d-data-hub/
37 https://eureka3d.eu/resources/
38 https://pro.europeana.eu/tags/3d
39 https://www.europeana.eu/en/stories?tags=3d

8. Impact, Sustainability and future of EUreka3D

It would be fair to say that 3D digital transformation of the cultural heritage sector is in a nascent phase of development. As such, the EUreka3D project was formed in a 3D landscape which did not adhere to formal standards, with multiple formats and technical solutions, and a variety of hosting platforms that appeal to generic 3D modelling, with a network of systems that were not interoperable.

For the CH sector the importance of the 3D digital transformation has become urgent, as stated in the EU recommendation to digitise in 3D all CH at risk by 2030.

With this as a starting point the EUreka3D project set out to help CHIs of all levels, and also SMEs, with their 3D Digitisation journey and it identified 3 impact points.

1. Using the EU VIGIE Study 2020/654[40] as the EU recommended best practice for the entire workflow of 3D Digitisation Transformation, we guided the project's content partners and shared the knowledge of this standard to the wider CHI community to produce and promote a consistent output of high quality 3D digital assets with correctly annotated metadata and paradata in order for users of 3D models, present and future, to be able to use reliable records of cultural memory.
2. The project created pilot cloud resources, services and tools, referred to as the EUreka3D Data Hub, to serve as a secure and dedicated repository for CH with the capacity to handle, display and disseminate high resolution digitised 3D models, with quality metadata and paradata, to act as a proof of concept

40 https://digital-strategy.ec.europa.eu/en/library/study-quality-3d-digitisation-tangible-cultural-heritage

system supporting the European data space for cultural heritage.

3. The Capacity Building webinars, workshops and blogs all served as a knowledge centre for all aspects of the 3D digital transformation of CH, to be discussed, shared and recorded as an information resource.

Above this, the EUreka3D project formed an Advisory Board of experts in the field of 3D digitisation to ensure that the right questions were being asked and the resulting methodology was being adhered to maximise the impact of the project.

In addition to the 3 key impact points, the resulting 3D models produced in the project were supplied to Europeana. This touched on different aspects of all 3 points. Firstly, the 3D models, metadata and paradata were produced in-line with impact point 1. Secondly, these models were stored on the Pilot EUreka3D Data Hub which needed to be interoperable to display and link with Europeana. Thirdly, what is the impact of having high quality 3D models available to stakeholders such as educators, researchers, curators, archaeologists, and the tourism sector?

8.1. THE FINDINGS

When approaching impact point 1. the project asked the question "can CHIs easily adopt the EU VIGIE Study 2020/654[41] guidelines to produce high quality 3D digital models?" i.e. creating a behavioural change in their workflows. The simple answer to this question is yes, because the Content Providers partner in the project produced their promised number of 3D models which were validated by the work package leader, CUT an expert in the field and the author of the EU VIGIE Study 2020/654. The key points that arose during this investigation was the lack of understanding and importance placed on paradata, and the level

41 https://digital-strategy.ec.europa.eu/en/library/study-quality-3d-digitisation-tangible-cultural-heritage

of depth covered by the full EU VIGIE Study 2020/654 resulted in it being hard to follow. One outcome aiming at addressing such challenges was a keen focus on paradata kept during the capacity building activities of the project, to ensure this knowledge point was discussed and shared amongst external stakeholders to increase the prevalence of paradata in future models. It was also found that Europeana did not display paradata information in full, and as a result the project recommended key paradata fields to be incorporated for the benefit of both producers and users of 3D models, and a link to the full paradata report for each object to be displayed in the Europeana portal. In regards to the complexity of the EU VIGIE Study 2020/654, the project identified that more typical scenarios for 3D digitisation, for the target stakeholder group of small or medium CHIs, was controlled indoor environments. It was also found that many CHIs are likely to contract an external 3D digitisation company rather than invest in costly equipment and professional in-house staff which may only be needed for a limited period of a defined project. Using this information the EUreka3D project created a simplified version of the EU VIGIE Study 2020/654 called *3D Digitisation Guidelines: Steps to Success*; this tangible guide not only assists CHIs with the 3D digitisation transformation workflow but also equips the CHIs with the questions, procedures and basic knowledge to plan and undertake a complete 3D digitisation project, whether they are handling everything in-house, or more likely, with the assistance of external contractors. As this guide was produced as a result of the project's digitisation process it was not available to the Content Providers partners in the project to follow, but feedback following its publication validated that it is a valuable tangible document to support impact point 1 of the project.

The EUreka3D Data Hub was successfully developed and deployed as a pilot action, and the content partners successfully uploaded their models which were then harvested directly to Europeana. As a proof of concept, the Pilot ticked the impact objectives. The EUreka3D Data Hub is an EU funded and based system dedicated to CH which proved important, often essential, for CHIs from EU Member states. It incorporated secure single sign on (SSO) with organisation credentials, reducing the chances of system violations by bad actors. The system was developed to not only handle the files of the 3D models but integrated metadata and more importantly (and uniquely) paradata compliant, with the EU VIGIE Study 2020/654 and interoperable with Europeana. Additional time was spent investigating 3D viewers/visualisers that would allow users to display 3D models directly from the platform. The EUreka3D project identified and incorporated the most versatile viewer available but the varying standards and formats currently available for 3D can be challenging, particularly for ultra high resolution models to be displayed accurately, in the same level of detail, for users. Overall the Pilot EUreka3D Data Hub has proved that it can be a cost-effective (competitively priced) platform for CHIs to securely store and manage their digitised assets and is ready to be developed further to deliver impact to CHIs who are currently delaying their 3D digitisation due to the reasons above.

EUreka3D was heavily weighted towards capacity building, serving as a knowledge gathering and sharing project, supporting the 3D digital transformation of CHIs to provide consistent high quality 3D models that users could trust. As such it engaged broadly, not only in Europe but with global networks, such as the International Council of Archives. It achieved this dissemination in a number of different formats including webinars, workshops, blogs and Europeana pro-blogs as well as social media channels, a dedicated e-newsletter and the project website. The quantitative data validated that the reach of the project surpassed the anticipated goal set at its inception. Topics were driven by the Advisory Board, internal project findings, expertise of the partners, and feedback from external partners. This all helped to deliver a programme to target the stakeholder needs for the 3D digital transformation. The impact of this knowledge sharing is more predictive, only time will tell how well the standards and recommendations have been followed and whether the 3D ecosystem for CH is consistently producing high quality digitisation that is proving to be, not only fit for purpose, but also used by the external stakeholder groups that have been identified. What we do have is evidential feedback that the various activities of the project have been valuable as a resource and will indeed assist the digitisation journey of CHIs. In addition, we have also received some evidence of use as a direct result of the CH digitised within the project. Together with the tangible material produced by EUreka3D the knowledge resources stored on the project website and via Europeana will provide a sustainable resource and lasting impact for a number of different stakeholders interested in 3D.

8.2. WHAT IS THE LASTING LEGACY AND FUTURE FOR EUREKA3D?

The legacy of EUreka3D lies heavily in the knowledge base that was created and disseminated via the project website and the blogs and pro-blogs published on Europeana. This will continue to serve as an information resource to CHIs leaving a lasting impact for the future. In addition, a consortium has been formed to take forward the work of EUreka3D into a project called EUreka3D-XR (starting 1 February 2025). This project will develop a set of new tools, offering shared web applications which are designed to help with the automatisation and standardisation involved with the generation of XR and AR experiences. The project will continue to engage stakeholder communities to share their knowledge and skills, giving access to datasets and transforming cultural contents (2D, 3D, video, texts, maps, stories) into innovative XR scenarios, thus resulting in more and better available digital cultural content for any type of re-use. The impact for CHIs as content users means they will be able to re-use the high-value datasets published by providers (other CHIs) and interact with XR contents co-created with and by colleague institutions and cultural professional, this will result in more culturally important content being available and used in more diverse ways. Both these impacts are expected to increase the rate, and enhance the quality, of digital 3D transformation by CHIs, supporting the EU's recommendation to digitise all of the at-risk objects in 3D by 2030.

9. Conclusions

EUreka3D was privileged to have the chance to promote standards and disseminate best practice in relation to the 3D digital transformation. In the two year duration of the project, EUreka3D produced a number of tangible results, most notably the high quality 3D models digitised in accordance with the EU VIGIE Study 2020/654 which have been made available to users on Europeana linked direct from high resolution files stored on the Pilot, the EUreka3D Data Hub. This secure platform was created as a proof of concept but is already a viable option to contribute to the Data Space for Cultural Heritage as an EU based platform that handles high resolution 3D models, metadata and paradata which is interoperable to Europeana and potentially others systems. The EUreka3D Data Hub was also developed with a viewer to allow 3D models to be viewed directly and is capable of handling other types of files providing CHIs with a cloud-based solution as an affordable alternative to the ongoing expense of maintaining in-house systems.

By monitoring the digitisation journey of the project partners and building carefully networked capacity building events, the EUreka3D project learnt and developed activities that focused on the most pressing issues in this early phase of the 3D Digital Transformation. All of this information was collated into a knowledge base held sustainably in the project website eureka3d.eu together with an informative series of blogs and pro-blogs on Europeana. When building best practice and promoting standards, EUreka3D found a significant gap in the understanding and value of paradata, we advise that CHIs should prioritise and record paradata during their digitisation journey by downloading the full EU VIGIE Study 2020/654 or by following

Steps to Success in the simplification guidelines[42] produced in the EUreka3D project.

Finally, we invite you to follow us in EUreka3D-XR, the follow on project which will explore Cross Reality (XR) and Augmented Reality (AR) applications that are now available to be exploited using the latest 3D models, just like those produced in EUreka3D.

Figure 55. Webinar participants' provenance (countries marked in brown) to the *Webinars: Paradata, Metadata and Data for 3D acquisition in cultural heritage* (8 April and 17 May 2024), co-organised by UNESCO Chair on Digital Cultural Heritage at Cyprus University of Technology and EUreka3D

42 https://eureka3d.eu/3d-digitisation-guidelines/

10. Presentation of the project partners

PHOTOCONSORTIUM: project's coordinator

Photoconsortium is the Europeana accredited aggregator for photography. Since 2016 it has participated in the Europeana DSI series of projects for the maintenance and improvement of the Europeana portal and successfully participated in various generic service projects of the Connecting Europe Facility (CEF) Programme, to enrich the Europeana collections. In addition to a deep knowledge of the Europeana aggregation mechanisms and strategy, and to the embedment in the various working groups of the Europeana network, Photoconsortium as an association adds value to EUreka3D in force of its network, comprising over 30 members representing the whole CH sector.

Cyprus University of Technology

Cyprus University of Technology (CUT) is national representative of Cyprus in the Commission Expert Group on the common European Data Space for Cultural Heritage (CEDCHE) expert group, as well as member of DARIAH. CUT participates in EUreka3D with its Laboratory on 3D digitisation where the EU Study on quality in 3D digitisation was developed and the coordinator of ViMM and ViMM Plus projects was conducted. In addition to leading WP2, CUT has shown the reusability of its existing 3D models as case studies and proof of concept demonstration and continues to contribute to the EUreka3D pilot as Content Provider.

CRDI - Ajuntament de Girona

CRDI, the Centre for Image Research and Dissemination, is the image archive of the Municipality of Girona. Based on the accumulated knowledge, and under the framework of participation in the European projects Europeana Photography and Athena Plus (2012-2015), CRDI undertook the development of a working methodology focused on the search for image quality which, together with the preservation and digitisation policy, made it possible to contribute thousands of digitised documents to the Europeana portal. CRDI also participated in two preservation projects: Preforma and the Canadian InterPARES, and in the 3D project WEAVE. In the context of the EUreka3D pilot, CRDI undertook advanced 3D digitisation of 50 objects selected from the pre-cinema collection at the Cinema Museum in Girona. CRDI holds expertise on metadata curation and management, which has formed an integral part of the EUreka3D capacity building programme. CRDI is also responsible for the communication of the project activity.

Bibracte

Bibracte EPCC, a key actor of the French archaeological community, is the managing organisation of a permanent archaeological research program and custodian of the scientific archives produced on the eponymous site since the beginning of excavations in the 1860s. Bibracte owns a unique capital of information to explore new ways of using digital technologies throughout the archaeological process, from taking data in the field to sharing it with all the users concerned. Bibracte has provided new digital content both from its own collection and its partners at the Centre national de la Recherche scientifique to the EUreka3D project. In total 500 3D cultural objects ranging from stratigraphic ground models to animal bones have been digitised and available for publication in Europeana.

Museo della Carta

The Museo della Carta is set in Pescia, Tuscany, an area where paper production and manufacturing has been an established economic activity for centuries. The collection includes moulds, filigree waxes, punches, metal sheets and stamps for a total of

7,000 pieces. The Museum embodies the situation of a high number of smaller CHIs who own interesting heritage collections and are bravely taking their steps on the digital transformation route. Museo della Carta is a typical example of the type of CHI the EUreka3D project intended to engage with and support in its digitisation efforts. The Museum has significantly benefited from the cloud-based services and tools, through training and capacity building in digitisation, and from accessing aggregation services and knowledge for inclusion of its CH assets in Europeana. The Museum participated in the EUreka3D pilot creating high-quality 3D models of selected handmade paper moulds along with complementary documents, successfully published in Europeana as an example a holistic approach to heritage documentation.

EGI Foundation

The EGI Foundation (also known as Stichting EGI and abbreviated as EGI.eu) is a not for profit foundation established under the Dutch law to coordinate the EGI Federation (abbreviated as EGI), an international collaboration that federates the digital capabilities, resources and expertise of national and international research communities in Europe and worldwide. The main goal is to empower researchers from all disciplines, including digital cultural heritage, to collaborate and to carry out data- and compute-intensive science and innovation. EGI Foundation has been coordinating a federation of 200+ data centres across ~50 countries since 2010, and brings substantial experience in building, maintaining, and growing complex multi-provider federations. During the EUreka3D project EGI provided access to its resources, exploiting the services provided by its affiliate partner Academic Computer Centre CYFRONET.

Europeana Foundation

Europeana Foundation is an EU initiative that empowers the cultural heritage sector in its digital transformation, developing expertise, tools and policies to embrace digital change and encourage partnerships that foster innovation.

Complementary to all the roles played by the other partners, the Europeana Foundation (EF) participates as beneficiary in EUreka3D to provide its advice on a series of key aspects. On one hand, EF advice guarantees the compliance of the project's actions, and in particular the new digital environment designed in WP3 and tested in WP2, with the existing Europeana CSP (e.g. access to links, secure connections and in general the correct implementation of the EPF). On the other hand, EF contributes to assess the sustainability of the technical services produced in EUreka3D, to identify the benefits that can derive for future Data Space for Cultural Heritage and EF will also contribute to training, impact assessment and communication activities, providing access to its existing channels and networks.

Cyfronet

Cyfronet is the Academic Computer Centre of the University of Science and Technology AGH of Krakow, one of the federated infrastructural service providers of EGI. It provides data and computational resources for storage and processing of the 3D content: up to 300 TB storage, 20 CPU cores and 40 GB RAM to run the pilot. Secure data access and management is provisioned by the OneData software (https://onedata.org) developed at AGH, offering variety of integration options (REST, S3, POSIX, OAI-PMH), a workflow system for scalable and reproducible data processing as well as intuitive Graphical User Interface for data and metadata management.

imec

imec's core research team ETRO (Department of Electronics and Informatics of the Vrije Universiteit Brussel) is the world-leading R&D and innovation hub in nanoelectronics and digital technologies and focuses on sensors, image and multi-dimensional signal processing applied in various sectors such as medical imaging, media systems, industrial processing and digital heritage. It comprises demand-driven and fundamental research, aiming to deliver unique solutions leveraging cross-boundary expertise in micro-electronics & photonics, hardware-software co-design and networks & systems. imec-ETRO-VUB has a long-standing expertise in digital imaging and video processing for medical imaging, media systems, industrial processing and digital heritage. In EUreka3D, imec acted as a bridge between the technical partners and cultural institutions, fostering the dialogue that led to the iterative development of IT solutions in response to users' needs.

11. Testimony from Advisory Board members

Monika Hagedorn-Saupe
(German Association for Information and knowledge (DGI) and German representative in Expert Group on a common European Data Space for Cultural Heritage)

Paradata and 3D documentation in general is a challenge for CHIs, because it is an innovation of their workflows and implementing innovation can be difficult. EUreka3D is working to show the added value and benefits of innovations that will motivate CHIs to embrace it, highlighting the added value that this additional work on documentation is bringing in terms of digital transformation.

Costas Papadopoulos
(Maastricht University)

Many CHIs use Sketchfab to host and share their 3D models, but this has various implications to take into account. To provide an equivalent but safer solution as EUreka3D project aims to do is of high value for CHIs. The challenge on sustainability is important to be addressed, especially in the area of granting maintenance and continuation for e-infrastructure dedicated to Social Sciences and Humanities, where we witness a quite high degree of fragmentation, with many projects and institutions developing tools and standards. There is a great need to encourage interoperability and connections and to create common platforms.

Isto Huvila
(Uppsala University)

Integrating the paradata element in the CHIs workflow is of the utmost importance, and the EUreka3D methodology and tools are offering a big contribution with this, particularly regarding 3D content -but it is relevant for 2D collections also. The needs and requirements of different stakeholders are key to identify user specifications in terms of what type of data and information they need to record and to share to the public. The EUreka3D project seems to be in a perfect position to develop a standard relating to the integration of paradata, taking into account the user's context and expected target areas of use and reuse of the 3D data.

Eleanor E. Fink
(American Art Collaborative Linked Open Data Program)

EUreka3D is like a comet blazing a trail across the Cultural Heritage universe lighting the way for institutions to collaborate, create common platforms, and interoperability on a global scale. It has been an honour to serve as an advisor for a project that has exceeded its goals and is providing the cultural heritage community with the much needed and previously missing set of standards for paradata and 3D documentation. What until recently has been a "garden of weeds" now has the potential of being a "Garden of Eden".

Dominik Lukas
(University of Chicago)

The partial treatment of the different technical aspects of information is a virulent issue when working through the process from data capture to the publication of a final model on whatever existing platform. More often than not, important parts of the potential metadata -leave alone the semantic annotation of legacy data or even paradata- are falling by the wayside and resulting data products are generally found lacking in these respects. Missing aspects then either require reintegration in the aftermath or will simply remain left out. With EUreka3D's "holistic" approach of integrating "all data" within the process, at the moment when they actually occur and taking the inclusion of paradata seriously, will provide an exemplar for the future development of EUreka3D and beyond. It will be crucial to attempt defining the metadata standards a practitioner has at their disposal and how these are integrated in the workflow, as these decisions might become a foundation for how the lack of paradata standards are to be tackled as well. EUreka3D's approach to think the standardisation of these elements bottom up by having the technical process and the actual practitioner in mind, gives an exciting perspective on future solutions not only for publishing 3D models, but research data in general.

12. Editorials

Creating and promoting editorial that highlights relevant narratives of European history and culture is crucial to valorise digitised CH objects. In the end, it's the stories that these objects harbour and elicit that really matters in furthering social cohesion throughout Europe and putting a spotlight on Europe's rich history and culture. EUreka3D's contribution to the editorial oeuvre of Europeana.eu has been particularly impressive. It leverages newly 3D digitised objects from institutions across Europe to highlight heritage from different viewpoints, both literally and figuratively.

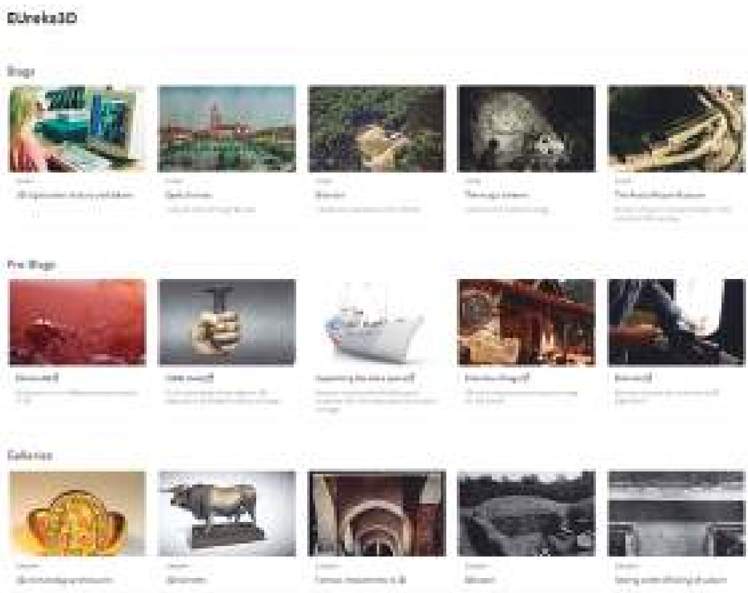

Figure 56. Screenshot of collected EUreka3D blogs on Europeana

EUreka3D editorial covered a wide range of topics, from the history of the archaeological site of Bibracte, to the evolution of magic lanterns, phantasmagoria and other machinery, over historical 20th Century fishing vessels in the Mediterranean up to how Cypriot villages were saved from ruin through 3D digitisation.

Additionally, EUreka3D has passed on its technical knowledge and research outcomes gained during the project through capacity building blogs on Europeana Pro, in addition to the other capacity building described earlier in this booklet. The Europeana Pro capacity building resources will be an invaluable resource for any CHI or grassroots preservation effort to learn from the EUreka3D project and apply best practices when it comes to digitising, creating metadata and paradata, and giving access to CH in 3D.

WEBPAGE COLLECTING ALL EDITORIAL FROM EUREKA3D:

13. Acknowledgments

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PARTNERS

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