D2.1 Digitisation report and pilot's best practice

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EXECUTIVE SUMMARY

This document reports on the work conducted within the EUreka3D project to enable the participating content providers to deploy a high quality digitisation process of their selected cultural artefacts. The resulting digitised content aligns with the recommendations of the EU VIGIE 2020/654 Study on Quality in 3D Digitisation of Tangible Cultural Heritage. Additionally, the process involved testing and adopting the EUreka3D data management platform which was developed for storage, file management, visualisation, and sharing of the digital artefacts.

This overall action, also referred to as the EUreka3D Pilot, aims at establishing 3D-specialised workflows, tools and best practices that innovate the way Cultural Heritage Institutions (CHIs) create, manage, enrich and share cultural heritage objects in 3D. As a final result of the action, the collections created in the project and managed on the EUreka3D platform will be aggregated and published on the Europeana website and made available as open data by the end of the project (December 2024), as foreseen in the Grant Agreement. These collections, the Data Hub with its services, and the tools created during EUreka3D project will be maintained, reused and expanded in the context of the continuation project EUreka3D-XR (start date 1/2/2025) and in the framework of the common European data space for cultural heritage and its future developments.

The EUreka3D content providers committed to digitise a varied range of different cultural heritage objects:

- CUT: Three (3) high quality models of Cypriot heritage have been digitised and prepared for aggregation to Europeana: (a) the byzantine monument Holy Cross / Timios Stavros in Pelendri village (UNESCO WH site), (b) the Chrysorrogiatissa Monastery in Paphos district (a monument under risk) and (c) the oldest fishing trawler of Cyprus, called “Lambousa”, which has also been contributed as part of the TwinIt! campaign. In addition to these 3 models, a selection of artefacts of Cypriot heritage, digitised in 3D in cooperation with the Museum of Mediterranean and Near Eastern Antiquities in Stockholm, Sweden, has been uploaded in the EUreka3D Data Hub for aggregation to Europeana.
- CRDI: Fifty (50) objects of pre-cinema and equipment were digitised, the corresponding 3D models are being prepared for upload in the EUreka3D Data Hub. In addition to these, an existing collection of 3D digitised daguerreotypes has been uploaded in the EUreka3D Data Hub for aggregation to Europeana.
- BIBRACTE: Two hundred and fifty (250) records, including museum objects and typological 3D models of ceramic tableware, have been digitised by the Bibracte Museum. An additional 250 photogrammetric terrain models of the archaeological site are also being prepared and documented for addition in the EUreka3D Data Hub and publication in Europeana.
- MUSEO DELLA CARTA: Two (2) ancient paper moulds digitised in 3D with photogrammetry, the corresponding 3D models are uploaded in the Data Hub.

All the objects were digitised, either with in-house expertise or by outsourcing, taking into account the recommendations of the VIGIE 2020/654 Study, and the 3D models generated by the digitisation were verified by the experts of WP2 Leader CUT, ensuring a high quality result. In addition to the technical verifications on the models, the requirements of the Europeana Publishing Framework for content and metadata quality were addressed so as to produce collections to be aggregated in the Europeana portal that match the tier 2+ (for content) and tier A+ (for metadata).

The EUreka3D content providers were fully supported in all the phases of the pilot action, by dedicated discussions in progress meetings, hands-on demonstrations and labs, and one-to-one interactions. This support action was jointly delivered by the WP Leader CUT and the other partners Photoconsortium, EGI, Cyfronet, IMEC and Europeana Foundation for their respective areas of actions and expertise. This effort with the EUreka3D providers is complemented by a wider activity in capacity building, offered publicly to any interested CHI and includes webinars, training materials, and dedicated assistance and collaboration. A number of institutions (not partner in the project) established cooperation agreements with EUreka3D for learning about and testing the platform, in some cases also receiving dedicated assistance via teleconference, such as INSPAI Girona, the project Giravolt by GENCAT Barcelona, the Medelhavsmuseet (Museum of Mediterranean and Near Eastern Antiquities) in Sweden, the RAMS Regionaal Archeologisch Museum a/d Schelde in Belgium. The experience and feedback of these external collaborations complements the testing of the platform and workflow done by EUreka3D content providers.

1. Introduction

This deliverable illustrates the work of partners that participate as content providers in the pilot, under the coordination of WP2 leader Cyprus University of Technology (CUT) and also in collaboration with other consortium partners.

The activities include 3D digitisation of selected objects according to quality requirements: metadata and paradata preparation; use of the EUreka3D platform to manage the collections and share them in Europeana. All processes were accompanied with hands-on training, capacity building actions and dedicated discussions to improve and innovate the content providers' internal workflows and knowledge.

The core content of this deliverable is organised in two main sections:

- A description of the work performed in 3D digitisation, management and sharing of heritage collections in the EUreka3D pilot. Specific information about the support provided in order to grant high quality in processes and results, and specific information related to the outcomes of digitisation action, for each of the 4 content providers.
- As a demonstration of the best practices promoted in the project for 3D digitisation, a case developed by WP leader CUT Cyprus University of Technology on the digitisation of the Lambousa Fishing Trawler is provided in detail. The Lambousa Trawler case was finalised and demonstrated already on the occasion of the TwinIt! celebration event in Brussels on 14th May 2024, and included in the TwinIt! collection of 3D objects in Europeana as the only record provided in the campaign by a Digital Europe Programme funded project.

The document is composed of the following chapters:

1. Introduction
2. The EUreka3D pilot on digitisation, management and sharing of 3D collections
3. High quality digitisation best practice: the Lambousa Fishing Trawler by CUT
4. Conclusions

2. THE EUREKA3D PILOT ON DIGITISATION, MANAGEMENT AND SHARING OF 3D COLLECTIONS

The EUreka3D project developed a piloting action including four cases showing how 3D digitisation offers new ways to stimulate interest in cultural heritage. This is achieved by enabling the creation of more advanced heritage collections to represent not only cultural objects but also the stories and memories associated with them.

The digitisation action in the project is based on the recommendations and guidance provided in the VIGIE 2020/654 Study on Quality in 3D Digitisation of Tangible Cultural Heritage[1]. This milestone document is produced by the European Commission to support a scientific approach in the production of high quality 3D models of cultural heritage objects and sites. The Study was coordinated by CUT Cyprus University of Technology who is EUreka3D WP leader for 3D digitisation and capacity building (WP2). In the context of the EUreka3D project, a guidance was developed to help content providers and other stakeholders navigate the complex VIGIE Study and better understand it. These 3D Digitisation Guidelines[2] were created in May 2024 and made available as a printed booklet and online resource.

Four project partners undertook 3D digitisation of a diverse range of objects, from museum artefacts to archaeological objects and sites. All followed the technical specifications based on the VIGIE 2020/654 Study. These models and the associated information (metadata and paradata) are managed and shared in the EUreka3D Data Hub, a cloud-based platform where the project is currently testing and making available to institutions who wish to access services and tools to manage and publish their 3D collections.

Such holistic methodology addressing all the steps of the best 3D digitisation, metadata and paradata documentation, file management, visualisation and sharing represents the added value produced by EUreka3D project: in practical terms, the project created a comprehensive ("one-stop-shop") approach that covers the entire journey and needs of CHIs, based on federated cloud and services set in Europe that grant a safe and flexible data management.

The new 3D collections created by the EUreka3D content providers will be aggregated by October 2024 for publication in Europeana, the European platform displaying digitised heritage. The collections are compliant with the EPF Europeana Publishing Framework to grant high quality, corresponding to EPF tier 2+ for content and tier A+ for metadata. Additionally, each object is provided with a Permanent Identifier (PID) and made available as open data: as such, the objects will be openly available for various types of reuse, especially for education and research purposes, thus enriching the common European data space for cultural heritage.

These collections, the Data Hub with its services, and the tools created during EUreka3D project will be maintained, reused and expanded in the context of the continuation project EUreka3D-XR, planned to start on 1st February 2025 and in the framework of the common European data space for cultural heritage and its future developments.

The providers' journeys in the pilot action are collected and illustrated in case studies for other institutions to take inspiration from, showcasing how the advanced 3D collections can be reused to enhance storytelling and knowledge sharing. The case studies will be presented in the project's final booklet, available at the end of the project in December 2024, together with reflections on the impact delivered by the project.

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

[2] https://eureka3d.eu/3d-digitisation-guidelines/

2.1 SUPPORTING ACTIONS FOR HIGH QUALITY DIGITISATION PROJECTS AND WORKFLOW

The EUreka3D consortium joint forces coordinate and provide guidance on the work done by the partners that participated as content providers in the pilot, in order to guarantee not only high quality digitisation for 3D items, but also a smooth workflow that supports and innovates the existing CHIs' practices.

This complex workflow is graphically illustrated in Figure 1 below, which is comprised in three main phases:

- Capture: the actual digitisation process for the cultural objects and the creation of data, metadata and paradata.
- Cloud Infrastructure: where produced files (data, metadata and paradata) are uploaded on the cloud and safely accessible with different levels of authorisation for access, with open access policy preferred.
- Delivery: the models are visualised in a viewer compatible with Europeana, the metadata are inputted and converted in the Europeana Data Model, and the paradata are linked as open access files. At the end of this phase, aggregation to Europeana and publication in the europeana.eu website eventually happens.

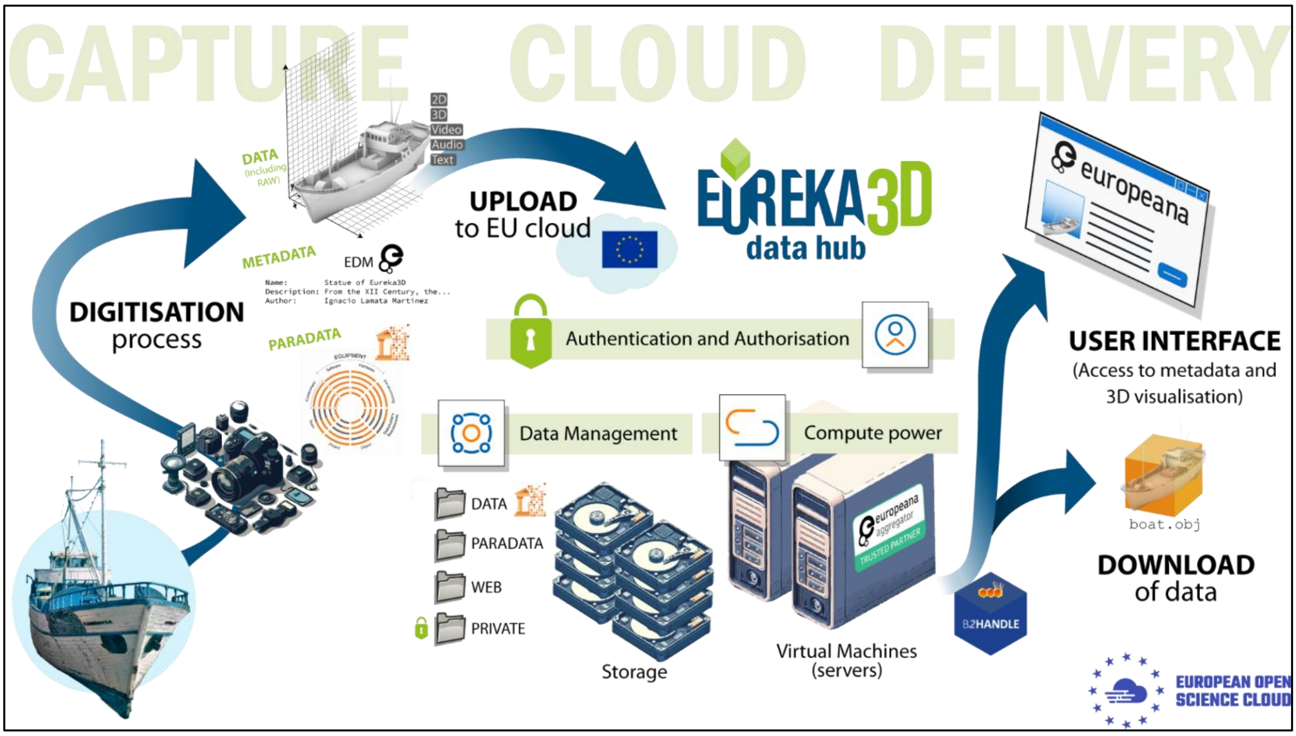


Figure 1: The EUreka3D infrastructure workflow.

The content providers in EUreka3D were fully supported by the consortium partners in all the phases of the pilot action, by dedicated discussions in progress meetings, hands-on demonstrations and labs, and one-to-one interactions, including:

- awareness raising and understanding of VIGIE Study2020/654 on Quality in 3D Digitisation of Tangible Cultural Heritage, also creating 3D digitisation guidelines based on the Study that help users to efficiently digitise their heritage objects. (CUT, Photoconsortium)
- consultation service and joint discussions about 3D digitisation practice, modelling, formats (CUT, imec, EGI)
- quality checks on samples of the digitised objects, providing constructive feedback and advice when needed (CUT)
- training on paradata, also with inputs from external experts (CUT)
- demonstration of the new App, currently under development at CUT, that supports the estimation of complexity and quality for 3D digitisation projects and the creation of paradata files (CUT)
- co-creation of requirements for the Data Hub and the viewer (EGI with imec and CUT)
- training on the use of AAI facility of the EUreka3D Platform, setting different levels of access for different categories of users (EGI and Cyfronet)
- training on the use of storage and file management of the Data Hub (EGI and Cyfronet)
- training on the EDM and metadata mapping (Photoconsortium and Europeana Foundation)
- training on the EPF (Photoconsortium and Europeana Foundation).

In addition to supporting the four content providers in building capacity and knowledge in order to generate high quality digitisation, a number of associated partners and other stakeholders took part in a training programme of online and onsite events, and can access anytime useful resources and knowledge, shared on the project website. Additionally, external CHIs showed a more focused interest in testing the EUreka3D Data Hub and workflow by using their objects; individual one-to-one training and assistance on the use of the platform basing on their specific requests and interests was provided by EGI and Photoconsortium. Their experience and feedback is precious to the iterative development of the Data Hub and to the definition of user needs about 3D digitised objects in the CH community.

Noteworthy examples to-date are:

- INSPAI Girona: interested in testing a viewer different from Sketchfab to visualise their 3D models
- Giravolt/GENCAT: interested in file management, particularly in the AAI system for granting different level of access to data
- Museum of Mediterranean and Near Eastern Antiquities: willing to aggregate a collection of 3D objects in Europeana using the one-stop-shop approach of EUreka3D workflow
- RAMS Regionaal Archeologisch Museum a/d Schelde: willing to aggregate a collection of 3D objects in Europeana using the one-stop-shop approach of EUreka3D workflow

2.2 Overview of the digitisation action per provider

2.2.1 CRDI – Ajuntament de Girona (ES)

Objects: 3D collection of 50 pre-cinema heritage equipment and objects as representative samples of the heritage elements preserved at the Cinema Museum. It showcases the diversity, quality, and uniqueness of an extensive cinematographic heritage (Figure 2).

Aims: The overall aim of the Museum of Cinema goes beyond the permanent exhibition. Its ultimate goal is to promote dissemination, education and research on cinema and imaging in general. To fully achieve this aim, 3D digitisation is becoming crucial, as it opens plenty of opportunities for research but also for a more realistic approach in digital representation.

Having detailed 3D models, it will support the Museum in boosting the visitors' engagement. For example, by creating 3D printed replicas of the objects, to be used by visually impaired visitors, or to view internal parts and fragile mechanisms; by creating new virtual scenarios onsite and enriched experiences for online visitors; and by giving access to a complete and realistic vision of the cultural object with all the knowledge associated with it.

Estimation of complexity and quality: digitisation of movable museum objects in a controlled environment, outsourced to a specialised company, following an open tender created following the specification of the VIGIE 2020/654 Study.

Methodology, equipment and other technical data about the 3D digitisation:

Photogrammetry

- Equipment
  - Reflex camera: Canon EOS 5DS with Full Frame CMOS sensor (36 x 24 mm), 50 megapixels.
  - Optics Canon EF 50mm f/1.4.
  - Individual continuous lighting of each object for its photographic reproduction. NEEWER bicolor LED lighting panel CRI 96+ 3200-5600K (2 units)
  - Polarising and reflective filters to ensure that there are no reflections that interfere with the processing of the model. BENRO UD 58 MM filter.
  - 360-degree ball joint, AOMDOM Branché: for automatic photography 42 cm, 100 Kg maximum.
  - Study background (white or black) to ensure there is no interference of objects. Orangemonkie Foldio 3 light box.
  - Colour and grey chart: ColorChecker Passport Photo 2
- 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 in bulk 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 used 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.

- Methodology (post-processing)

- Convert the colour checker image containing the colour scale into DNG format, as the software does not recognize 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.
- Process the focus stacking images in Adobe Photoshop.
- Upload all the JPEG images into the Agisoft Metashape file.
- Align the images, build the mesh, and apply the textures.
- 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.
- 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 texturisation must be rebuilt. Export it to its corresponding folder.
- Import the “Low resolution” model into the 3D modelling software Blender.
- 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.”
- The final step is video rendering. Export the output as an MP4 file.

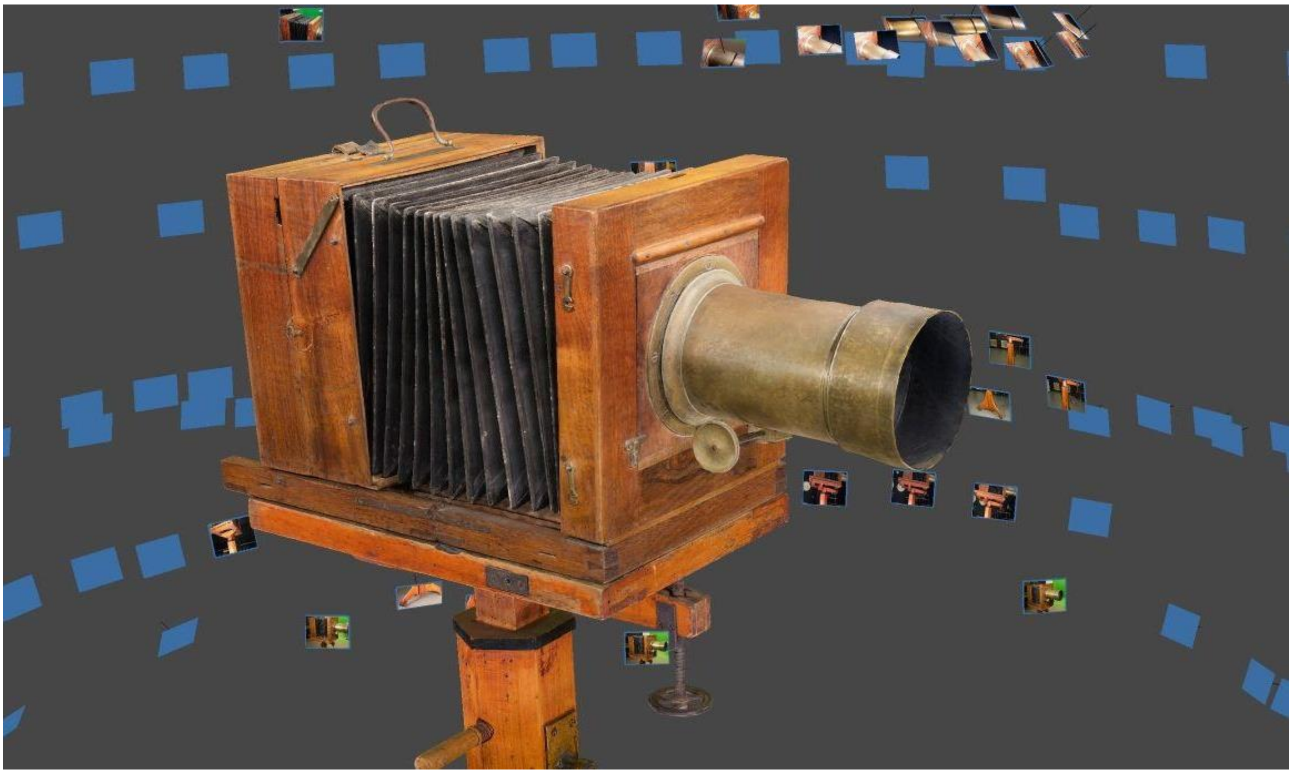


Figure 2: Photogrammetric model as an example of a pre-cinema object.

Management and sharing of heritage collection data:

The models for cinema and precinema objects are uploaded in EUreka3D Data Hub. It includes a master version in OBJ format, with associated files for texture, and a zip file version to be used for visualisation in the EUreka3D viewer, in order to have objects correctly and quickly visualised in the Europeana portal. EDM-compliant metadata and paradata information are currently being added to the objects to proceed with PIDs assignment and then tests for Europeana aggregation.

In addition, objects specifically digitised for the EUreka3D project, an existing collection of 3D models of daguerreotypes by CRDI, are also uploaded in EGI Data Hub, mainly for testing purposes. The collection is expected to be updated and republished in Europeana together with the newly digitised objects.

2.2.2 Bibracte (FR)

Objects: a selection of archaeological artefacts (Figure 3) representative of the material culture of the oppidum of Bibracte, a fortified city from the 1st century BC located on the present-day Mont Beuvray (Burgundy, France). The 130 selected objects illustrate various aspects of Gallic life, ranging from agriculture and armament to art and hygiene, including construction materials and means of transport. In addition to digitising the objects to support research and visitor engagement at the site and museum, Bibracte focuses on creating 120 theoretical 3D models of ceramic vessel shapes. These models allow for the visualisation of reference morphometric parameters, thus facilitating the identification by archaeologists of shards found on the site. Finally, Bibracte documents a selection of 250 terrain models of the archaeological site.

Aims: the remains discovered at the site of Bibracte are often fragmentary, and the knowledge they provide about Gallic life is the result of numerous studies, analyses, and comparisons with other sites. The objective is to associate each digitisation with relevant studies, analyses, and comparisons, using permanent links, to enable visitors to gain a better understanding of Gallic life through complete and accessible documentation. The ultimate goal is to offer visitors an enriched visiting experience through the discovery of archaeological methods and work, via permanent documentation that contributes to the preservation and enhancement of the archaeological heritage.

Estimation of complexity and quality: in-house digitisation of movable artefacts in a controlled environment and reconstruction of models, leveraging the expertise of scientific partners in the research program on Mont Beuvray, notably those from the MSHE Claude Nicolas Ledoux in Besançon (France) and the Sorbonne University in Paris (France). Selection and production of orthophotographs documenting the excavation stages of the main excavation sectors on the site. Integration of the protocol of the Conservatoire national 3D into the digitisation process to ensure the long-term archiving of the 3D models produced (in partnership with Archéovision, Bordeaux). Implementation of specific thesauri and alignment with web pivot thesauri (Getty, Library of Congress, PerioDO, GeoNames, VIAF) to improve the indexing of the produced files. Deposit of ancillary documentation (drawings, photos, reports, etc.) accompanying the 3D models in repositories that provide these documents with permanent links to include them in the metadata accompanying the 3D models.

Methodology, equipment and other technical data about the 3D digitisation:

- **Laser scanning ATOS (GOM)**

- The kit contains two ATOS heads of different sizes and characteristics.
    - ***ATOS Core 185***
        - Measuring Area: 185 x 140 mm
        - Working Distance: 440 mm
        - Point Spacing: 0.07 mm
        - Point Spacing: 0.07 mm
        - Sensor Dimensions: 361 x 205 x 64
    -
    - ***ATOS Core 80***
        - **Measuring Area**: 80×60 mm
        - **Working Distance:** 170 mm
        - **Point Spacing**: 0.03 mm
        - **Sensor Dimensions**: 206 x 205 x 64
- **Einscan SP**
    - Precision: ≤0.05 mm
    - Minimum Volume: 30 × 30 × 30 mm
    - Maximum Volume: 1200 × 1200 × 1200 mm
    - Single Capture Range: 200 × 150 mm
    - Speed: < 4 s < 1 min
    - Point Distance: 0.17 mm - 0.2 mm
    - Texture Capture: Yes
    - Camera Resolution: 1.31 Mega Pixels
    - Light Source: White Light

The 3D Scan equipment and artefact are visible from Figure 4

Figure 3: Textured mesh models from a selection of archaeological artefacts representative of the material culture from the oppidum of Bibracte.

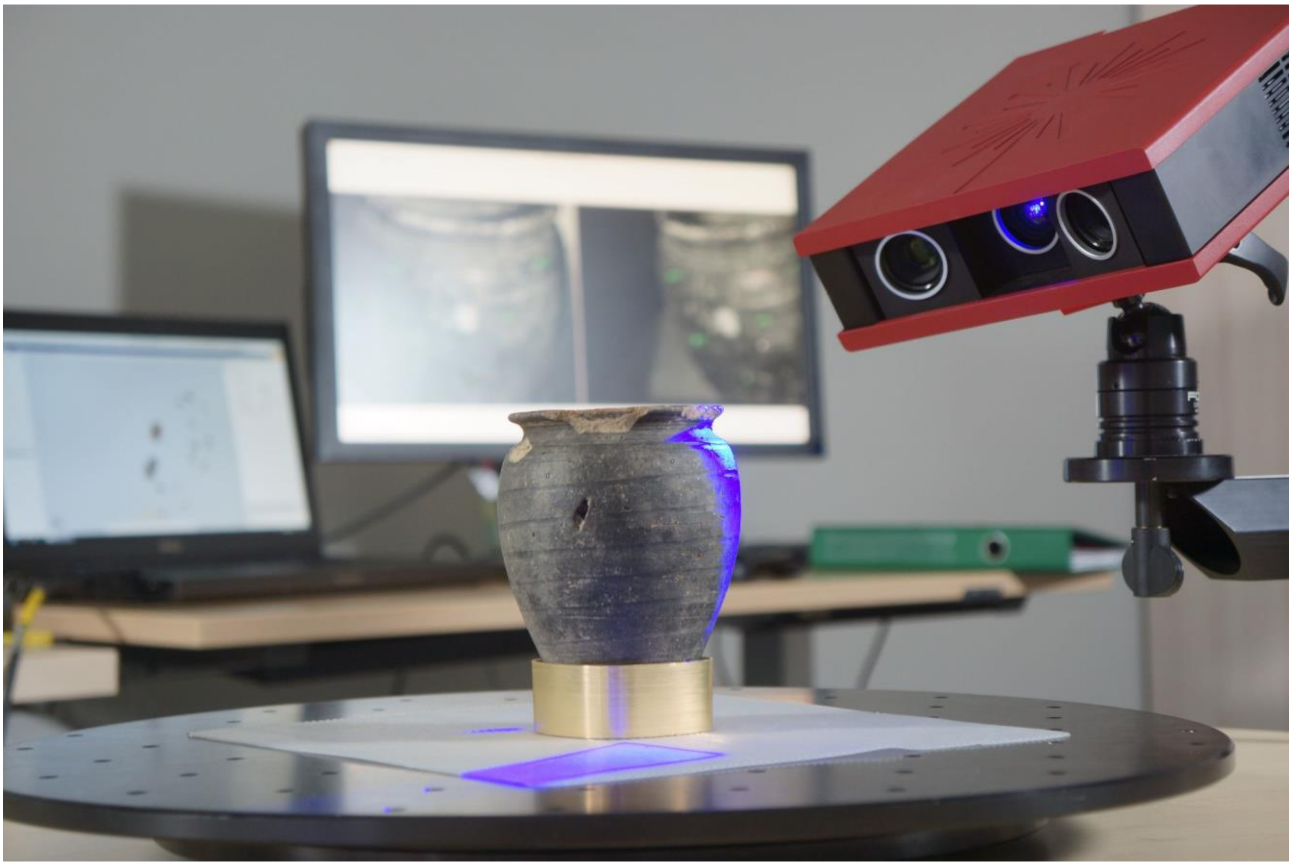


Figure 4: 3D Scanning process of an artefact.

- Orthophotographic surveying using photogrammetry as applied to archaeological heritage (Figure 5)

A photograph to be used in photogrammetry must fulfil two conditions: it must be sharp and well exposed. The photos must cover all of the scene and all the desired viewing angles. One must always allow for a sizable overlap between neighbouring photos so that common features can be found when assembling the model.

  - Equipment: drone quadcopter DJI Phantom 4 Pro with softwares DGI GO and DJI GS Pro (https://www.dji.com/fr)
  - Software: MicMac (short for *Multi Image Correspondance, Méthodes Automatiques de Corrélation*) is a comprehensive photogrammetry software programme providing numerous possibilities for the creation of 3D models and multi-scale orthoimagery. Its architecture is based upon a set of tools, autonomous but interdependent "packages", available via an open-source CECILL-B licence. The original author, Pierrot Deseilligny, began development of the software in 2003 at the IGN. Thereafter, the project opened up, and it now involves a dozen French and European partners (Rupnik *et al.* 2017). Official documentation is centralised on an online *wiki* managed by the ENSG: https://micmac.ensg.eu . Since the programme is free, development has enjoyed multiple contributions. The *wiki* is also open access. This allows for the updating of what is a relatively comprehensive documentation, even if the amount of available data is not always the same on every page.

- Process (Figure 6):
  - **Tie points (homologous points)**: The first software step consists of recomposing the general puzzle of the scene by finding the connections between the photos, often using the SIFT algorithm to identify common points regardless of resolution, blur, scale, viewpoint, and brightness. The image pairs with the best correlation scores are retained to obtain a complete view of the scene projected into a local 2D coordinate system.
  - **Camera calibration and orientation**: Once the photos are assembled, it is necessary to estimate the position of each one to define the theoretical 3D space of the scene. For this, a bundle adjustment algorithm first determines the intrinsic characteristics of the camera (calibration) and then the angle and distance of the sensor relative to the photo (external orientation), thus adding the Z dimension to the local coordinate system.
  - **Tie points projection (sparse cloud)**: for every visible (homologous) point on each image pair, the position (X, Y and Z coordinates) of these points is calculated and plotted in a 3D space. The assemblage of homologous points constitutes the first viewable 3D point cloud (Figure 7).
  - **Point cloud geopositionning**: The point cloud is still plotted in a local coordinate system. In order to shift to a Coordinate Reference System (CRS) must be established within the photographed area before acquisition, each one being visible on a minimum of two photos. Thereafter they must be identified on the images so that the software can set the point cloud within a georeferenced 3D space. Before obtaining the final geometry, it is necessary to refine the calibration and orientation of the cameras based on the defined CRS to improve the precision of the point cloud.
  - **Point cloud densification**: This step, called dense multi-stereoscopic correlation, is calculated iteratively from subsampled images, methodically increasing the resolution with each iteration. This multi-scale/multi-resolution method enhances the robustness of the correlation calculation between images and increases the speed of the process.
  - **Orthomosaic computation**: every point of the cloud is ascribed exact X, Y and Z coordinates that can be plotted on a grid. The image is thus no longer the initial distorted phot but the results of a new calculation in which every pixel is a square in the grid. The optical distortions are removed to produce an orthophoto.
  - **Orthomosaic composing**: to compose an orthomosaic, isn't enough to simply juxtapose the orthophotos, as this would result in visible boundaries between the images. The final step involves merging the orthophotos through radiometric equalisation, which homogenises the colours between neighbouring images.

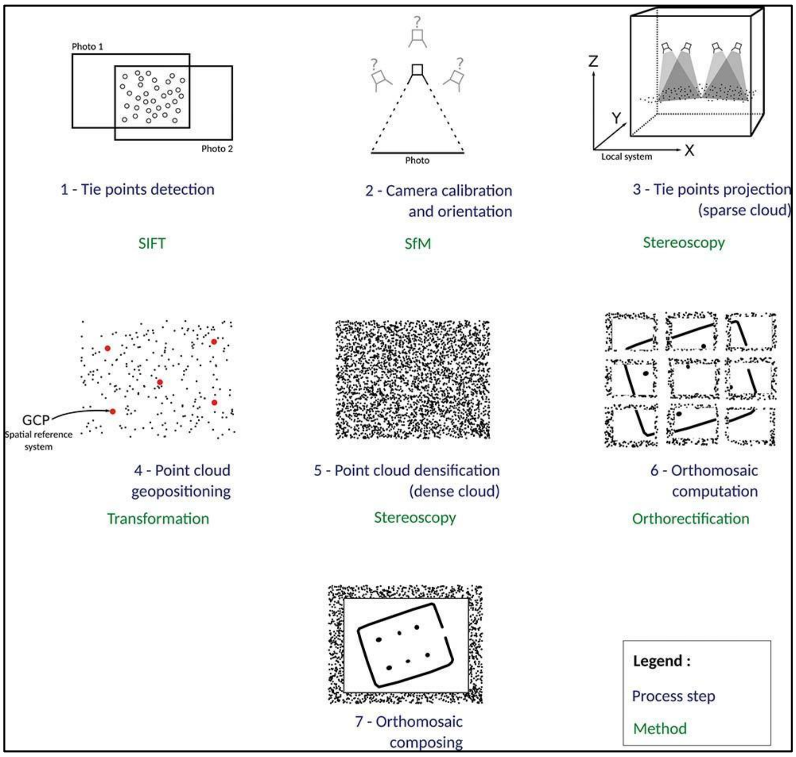


Figure 5: production process of an orthomosaic
(Verriez 2023, https://doi.org/10.4000/books.pufc.50785)

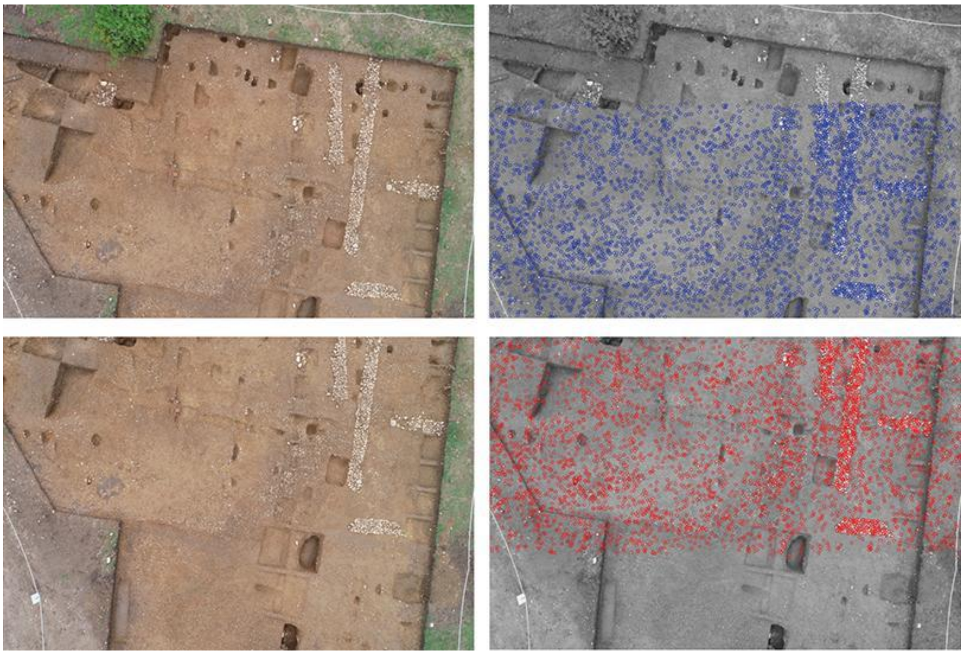


Figure 6: tie-points between two neighbouring images. Bibracte, PC14 platform, 2021
(Verriez 2023, https://doi.org/10.4000/books.pufc.50785)

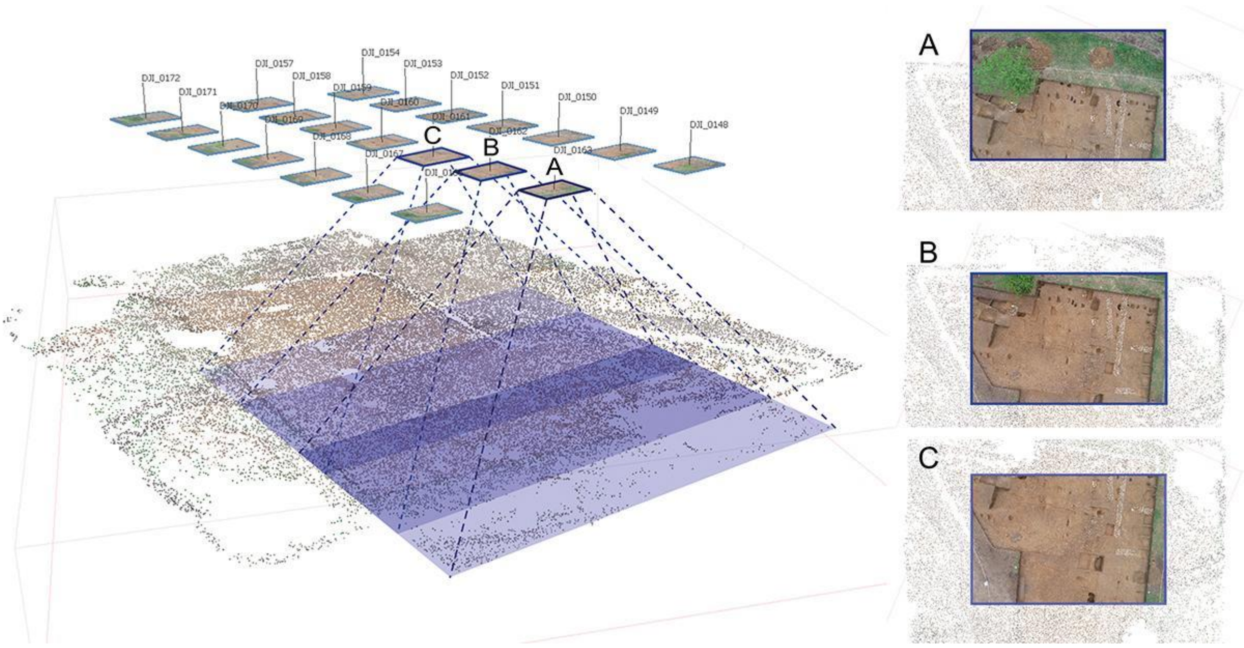


Figure 7: projection of tie-points in 3D space. Bibracte, PC14 platform, 2021
(Verriez 2023, https://doi.org/10.4000/books.pufc.50785)

Management and sharing of heritage collection data:

The different models in their respective formats, with all associated files and respective metadata and paradata files, are being uploaded in EGI Data Hub, also verifying the correct visualisation of the different types of 3D objects in the viewer. Once the records are uploaded and the process is fully completed, PIDs will be assigned to the objects and EDM-compliant metadata will enable the publication of the records as open access data in the Europeana platform.

2.2.3 Museo della Carta (IT)

Objects: Two outstanding representative collection items of ancient paper moulds, a type of heritage almost unknown related to the traditional paper manufacturing industry.

- Model 1: Napoleon Bonaparte and Maria Luisa of Austria - VIEW
- Model 2: Ettore Serra for Il porto sepolto - VIEW

Aims: This institution in Tuscany preserves complete and original tools related to all the working phases and set up of paper production, as a witness of a traditional economic activity in the area, which continues nowadays. The Museum is set in a former paper mill which was restored and transformed into an exhibition space and a modern archive. The collection of tools, paper moulds and historical archival documentation of the paper mill Magnani are not only a specific example of tangible heritage, but also bring the intangible values and history of the local community. In particular, the 3D digitisation of paper moulds enables users to virtually handle and examine in detail very fragile heritage items, which cannot be accessed otherwise.

Estimation of complexity and quality: digitisation of movable museal objects in a controlled environment, outsourced to a specialised company, following a call for offers and technical specifications compliant to the VIGIE 2020/654 Study.

Methodology, equipment and other technical data about the 3D digitisation:

Photogrammetry

- Equipment
  - Camera: Sony ILCE-7RM4 (Fotocamera full-frame α7R IV 35 mm)
  - Optics: FE 24-70mm f/2.8 GM II
  - Exposure:
    - model 1: 1/5 sec., f/13, ISO 200
    - model 2: 0,8 sec., f/22, ISO 160
  - Focal length: 24mm
  - Resolution: 9504x6336
  - Colour: RGB
  - Depth: 16 bit
  - Brightness Value:
    - model 1: 3.31
    - model 2: 5.47
  - Study background:
    - model 1: Green screen with rotating plate
    - model 2: Box cubelite with rotating plate and wooden support
  - Lighting:
    - model 1: Natural light
    - model 2: Lupo professional lights
- Photogrammetry software:
  - Software used for processing the images: 3DF Zephyr Lite 7.507
    - model 1: number of points: 210.020; number of triangles: 293.845; number of textures: 1
    - model 2: number of points: 427.376; number of triangles: 553.581; number of textures: 1
  - Number of images and their resolution: 48 images for 9504x6336 each
  - Software used for post-processing: Cinema 4D
  - Outcome: textured mesh
- File formats generated: OBJ, MTL, JPEG
- Challenges faced during digitisation: the major challenge in digitising the objects was the threadlike, filiform structure of the central grid, difficult to be photographed and rendered.
- How the VIGIE 2020/654 Study was used in order to estimate the complexity and quality, as well as capturing the paradata: access to the VIGIE 2020/654 Study and guidance on the main aspects to be considered in order to estimate the level of complexity of the digitisation and to assess the expected quality in relation to the available budget were provided to the service provider in one-to-one meetings prior the digitisation to happen. Quality checks on the two finalised models were done by partner CUT in compliance with the recommendations of the VIGIE Study. A set of paradata was collected by the service provider and shared in association with the two models.

The photogrammetry equipment with the corresponding artefact digitised can be seen in Figure 8. Furthermore, the point cloud data is shown in Figure 9 and the mesh result in Figure 10.

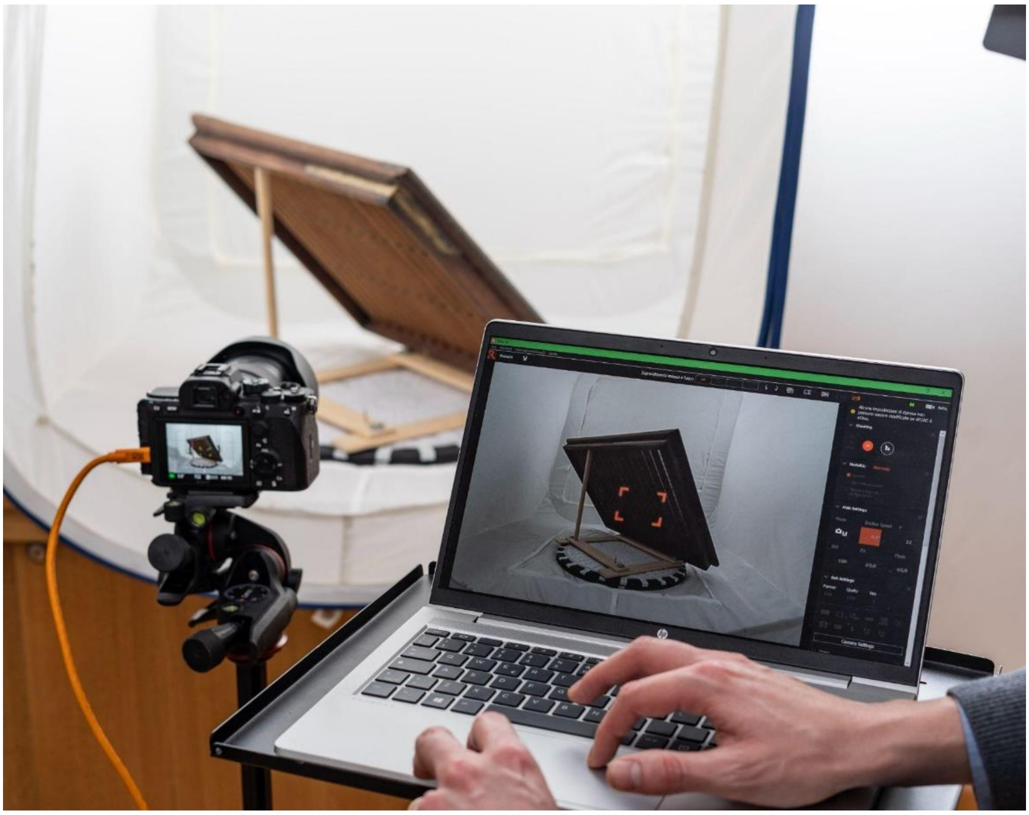


Figure 8: Digitisation process indicating the photogrammetric equipment used.

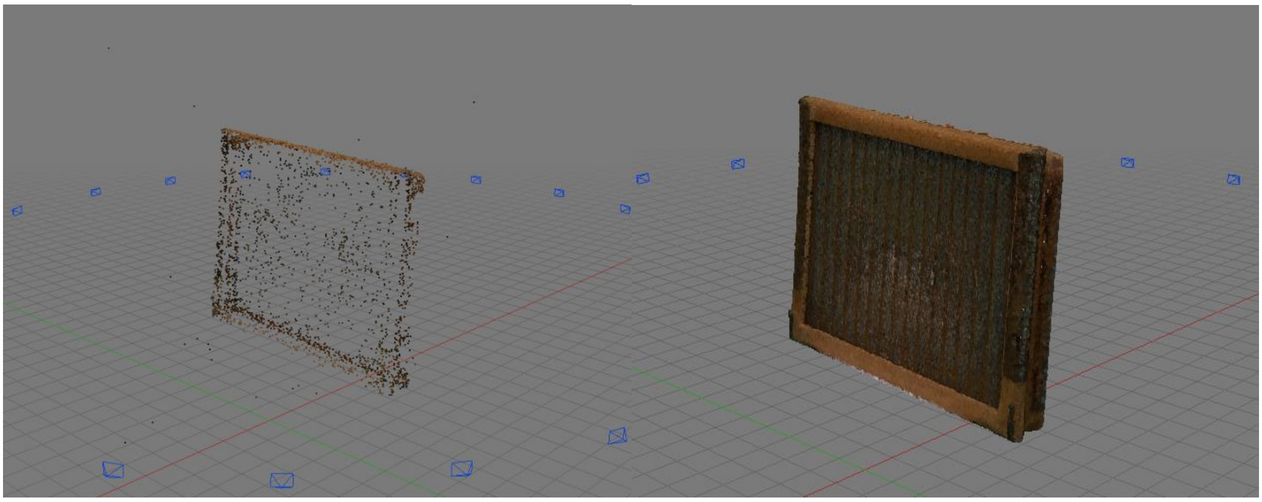


Figure 9: Point cloud results of an ancient paper mould.

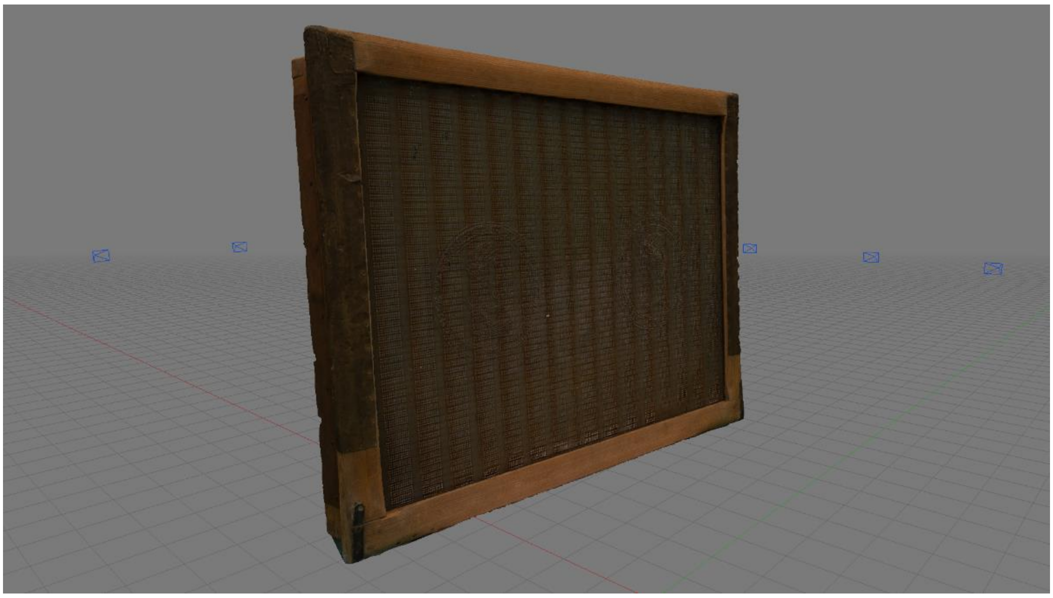


Figure 10: Textured mesh results of an ancient paper mould.

Management and sharing of heritage collection data:

The two models in OBJ format, with associated files for texture, are uploaded in EGI Data Hub, together with EDM-compliant metadata and a file containing the paradata collected for each object. The objects correctly visualise in the viewer that is compatible with the Europeana portal. PIDs have been assigned to both objects which are published as open access data. Rounds of verifications conducted in collaboration with the Europeana data processing team have been made to ensure that the aggregation of the metadata to the Europeana Portal through the production version of the platform is successful.

In addition to the 3D digitisation, the provider digitised, catalogued and prepared ca. 5,000 documents from the Magnani Historical Archive, witnessing archival company documentation and correspondence between Magnani paper company and its worldwide customers, and other artworks and oeuvres on paper that belong to the Museum's collections. These 2D contents are also being shared in Europeana.

2.2.4 CUT Cyprus University of Technology (CY)

Objects: High quality models of Cypriot heritage: (A) the Holy Cross / Timios Stavros in Pelendri village (UNESCO WH site), (B) the Monastery of Panayia Chrysorrogiatissa in Paphos district (a monument under risk) and (C) the oldest fishing trawler of Cyprus, called "Lambousa".

Object A

Title: The Holy Cross / Timios Stavros church in Pelendri village (UNESCO WH site)

History of the monument: The church of the Holy Cross is an UNESCO world heritage site, with byzantine wall paintings created from the 12th century up to the 14th century by 4 different painters. Furthermore, this Church was built in three faces. 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.

Aims: The aim is to digitally preserve the history of this monument through a holistic approach which includes both its internal and external survey through TLS and photogrammetry, the creation of an HBIM LOD 400 model, textured mesh models of both the interior and exterior. 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 includes also 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.

Estimation of complexity and quality: Estimation of complexity and quality was made based on the VIGIE 2020/654 Study, using the beta version of the Paradata App, which is an android application developed from CUT. Figure 8 indicates the radial charts of this estimation. The orange colour indicates the amount of complexity and quality. This amount is based on the paradata such as, pre-processing, stakeholder's requirements, object, project, team, environment, software and hardware.

Methodology, equipment and other technical data about the 3D digitisation:

Aerial and Terrestrial Photogrammetry (On-site digitisation date: 25/05/2023)

- Equipment
    - DJI Phantom 4 pro (UAV, Exterior Image capture)
    - Sony A7iii (Interior Images)
    - Leica Viva GS15 (GPS, RTK)
    - Leica FlexLine TS06plus (Total Station)
- Photogrammetry Software
    - Reality Capture
        - External photogrammetry
            - 158 external Images were processed in JPG format and with a Resolution of 5472 x 3648 px of each image.
            - 158 images aligned with a total of 474,049 tie points
            - Point cloud Results: RGB Point Cloud with 13,962,634 points
            - Mesh Results: Textured mesh model with 27,820,560 faces
    - Reality Capture
        - Internal photogrammetry
            - 1463 Internal images were processed in JPG format and with a Resolution of 6000 x 4000 px of each image.
            - 1274 images aligned with a total of 3,567,316 tie points
            - Mesh Results: Textured mesh model with 471,200,00 faces

Terrestrial Laser Scanning (TLS), (On-site digitisation date: 25/05/2023)

- Equipment
    - Z+F IMAGER 5016
        - 27 scan positions internally and externally
- TLS Software
    - Z+F Laser Control Software
        - Registration of 27 cloud to cloud scans

        - Point Cloud Result: 88,290,000 points
- Software used for post-processing
    - Autodesk Recap
        - Registration and Alignment of photogrammetry with TLS georeferenced point cloud
    - Autodesk Revit: Creation of a Heritage Building Information Modelling (HBIM) model traced over the aligned point cloud. The point cloud data from recap is synchronised with revit.

File formats generated: E57,RCP, RVT, IFC, OBJ, STL

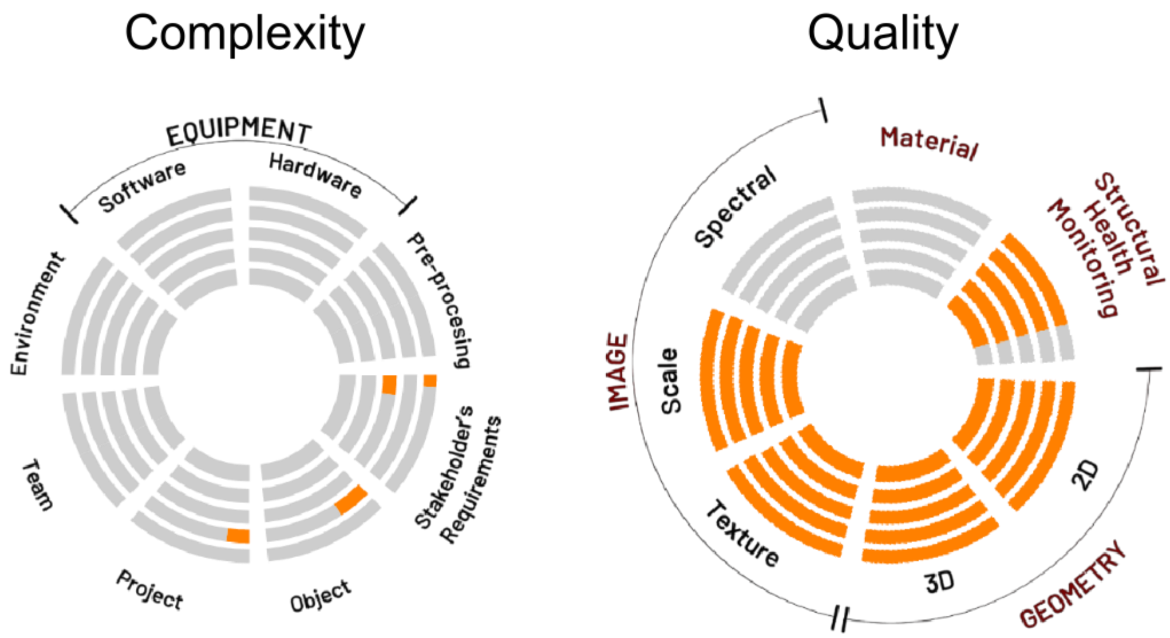


Figure 11: Church of the Holy Cross estimation of Complexity and Quality.

The aligned point clouds can be seen in Figure 12, the point cloud compared to the HBIM model in Figure 13, and the axonometric section of the current HBIM Model in Figure 14. The interior photogrammetric results indicating the byzantine wall paintings can be seen from the overall model in Figure 15 and from a closer view that is indicated in green dashed line which is towards the Christ Pantokrator and the west part of the Apse (Figure 16).

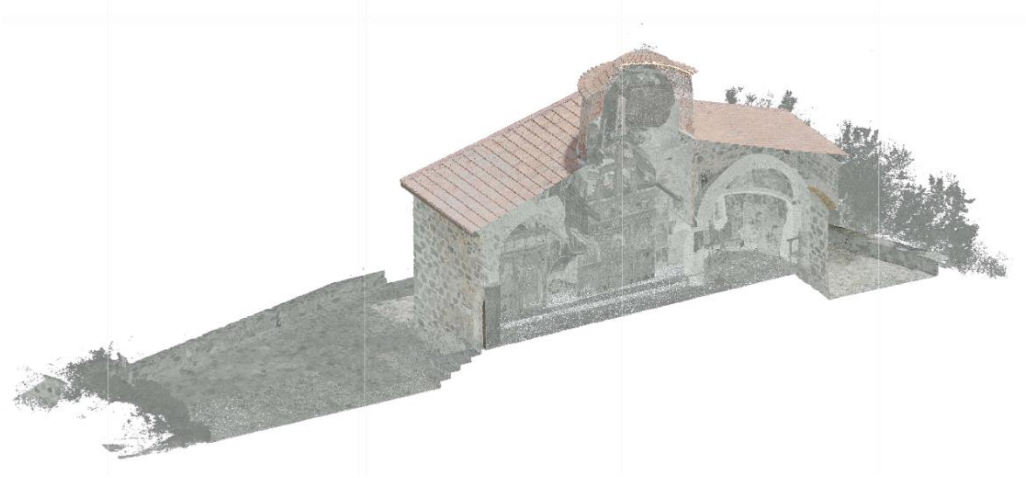


Figure 12: Aligned Point cloud result of the Holy Cross Church.

Figure 13: Axonometric section of the HBIM result compared to the point cloud of the Holy Cross Church.

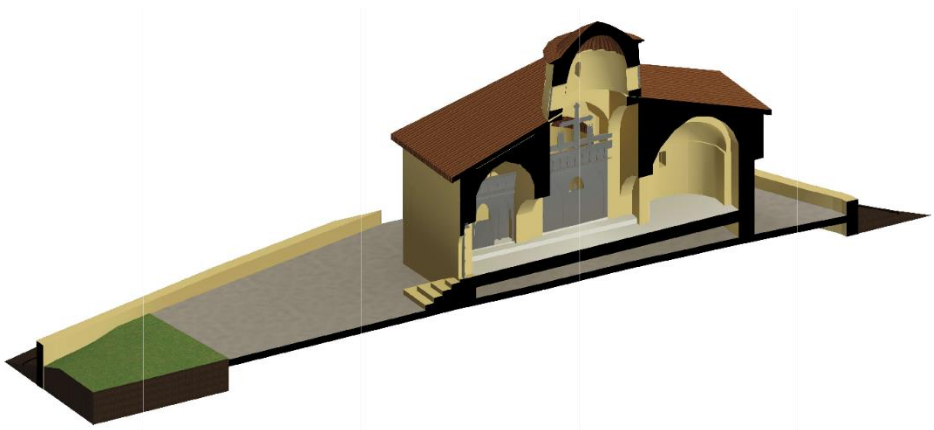


Figure 14: Axonometric section of the HBIM result of the Holy Cross Church.

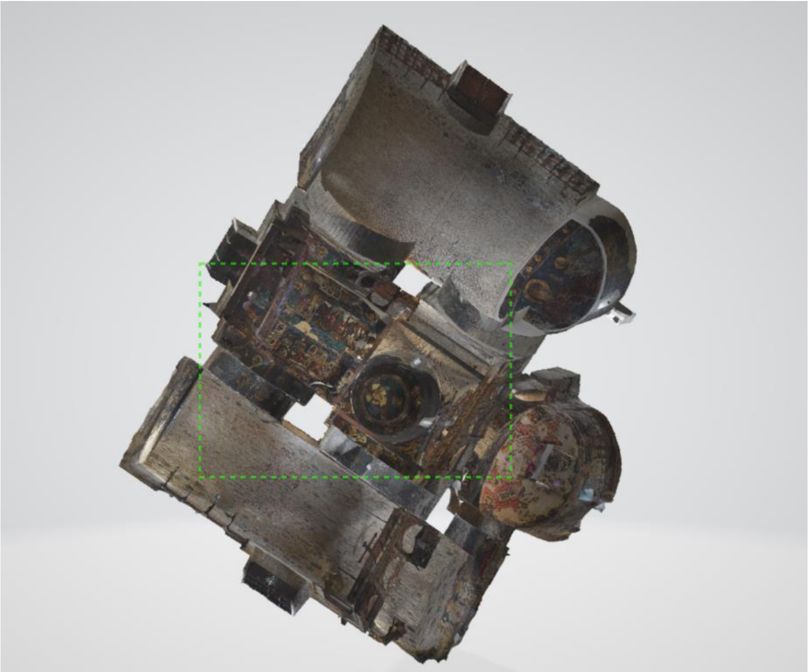


Figure 15: Overall interior photogrammetric model indicating the byzantine wall paintings.

Figure 16: The Christ Pantokrator and the west part of the Apse wall paintings from the interior photogrammetric mesh model.

OBJECT B

Title: Monastery of Panayia Chrysorrogiatissa in Paphos district (a monument under risk)

Aims: The stakeholder of this monument, the Metropolis of Paphos, asked CUT to digitally document this important Monastery under risk. The aim is the capturing of point cloud data through a digital survey for the creation of an HBIM LOD400 which includes all the building components as well as a set of architectural drawings. This monument is under risk and therefore its documentation could be used by architects, civil engineers, archaeologists and historians for its efficient restoration.

Estimation of complexity and quality: Estimation of complexity and quality was made based on the VIGIE 2020/654 Study. The paradata from this estimation consists of the environmental conditions, the condition of the object, the purpose of the digitisation, its materials, deliverables data, and the experience of the professionals who undertook the digitisation. Figure 14 shows the radial charts of this estimation.

Methodology, equipment and other technical data about the 3D digitisation:

Aerial Photogrammetry (On-site digitisation date: 21/11/2021 - 26/11/2021)

- Equipment
  - DJI PHANTOM 4 RTK
- Photogrammetry Software
  - Pix4D
    - 108 Images were processed with a Resolution of 5472 x 3648 px of each image.
    - Tie points: 26,454
    - Point cloud Results: RGB Point Cloud with 39,481,128 points

Terrestrial Laser Scanning (TLS), (On-site digitisation date: 21/11/2021 - 26/11/2021)

- Equipment
  - 4 Laser Scanners, type Z+F IMAGER 5016 - 390
    - 276 scan positions
- TLS Software
  - Z+F Laser Control Software
    - Registration of 276 cloud to cloud scans with a result of 306,408,872 points
- Software used for post-processing
  - Autodesk Recap
    - Registration and Alignment of photogrammetry with TLS georeferenced point cloud. The overall point cloud contains 345,890,000 points.
  - Autodesk Revit: Creation of a Heritage Building Information Modelling (HBIM) model traced over the aligned point cloud. The point cloud data from recap is synchronised with revit.

File formats generated: E57,RCP, RVT, IFC, OBJ, STL

- Challenges faced during 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 is eliminated 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.

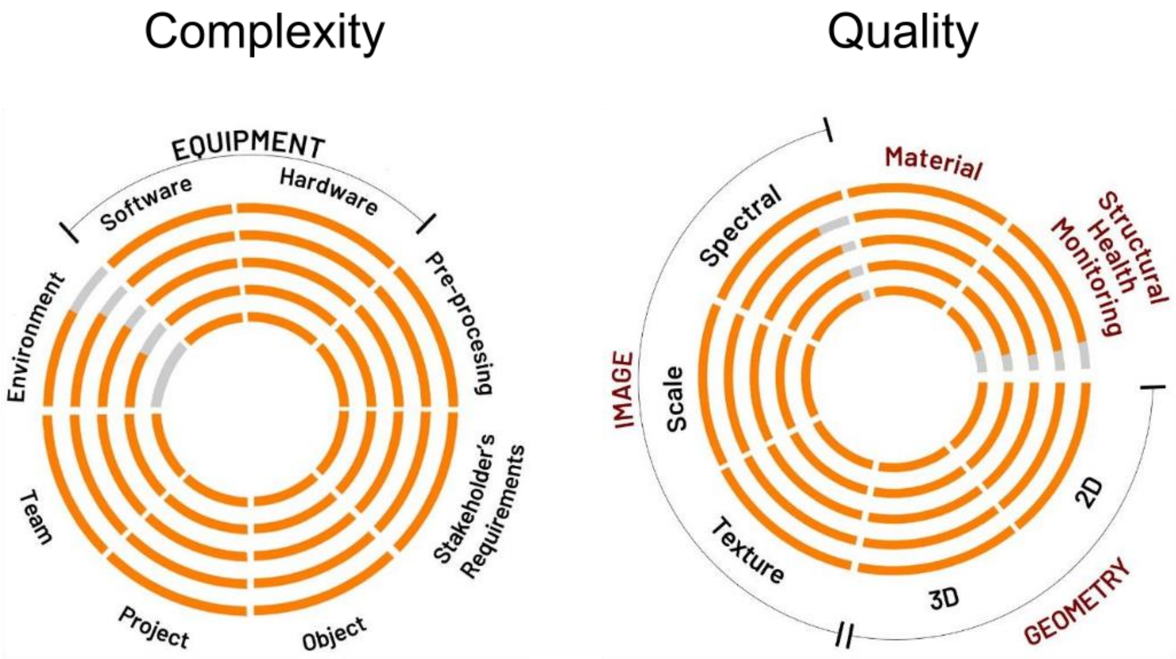


Figure 17: Monastery of Panayia Chrysorrogiatissa estimation of Complexity and Quality.

The aligned point clouds are shown in Figure 18, the point cloud compared to the HBIM model in Figure 19, and an axonometric section of the current HBIM Model in Figure 20.

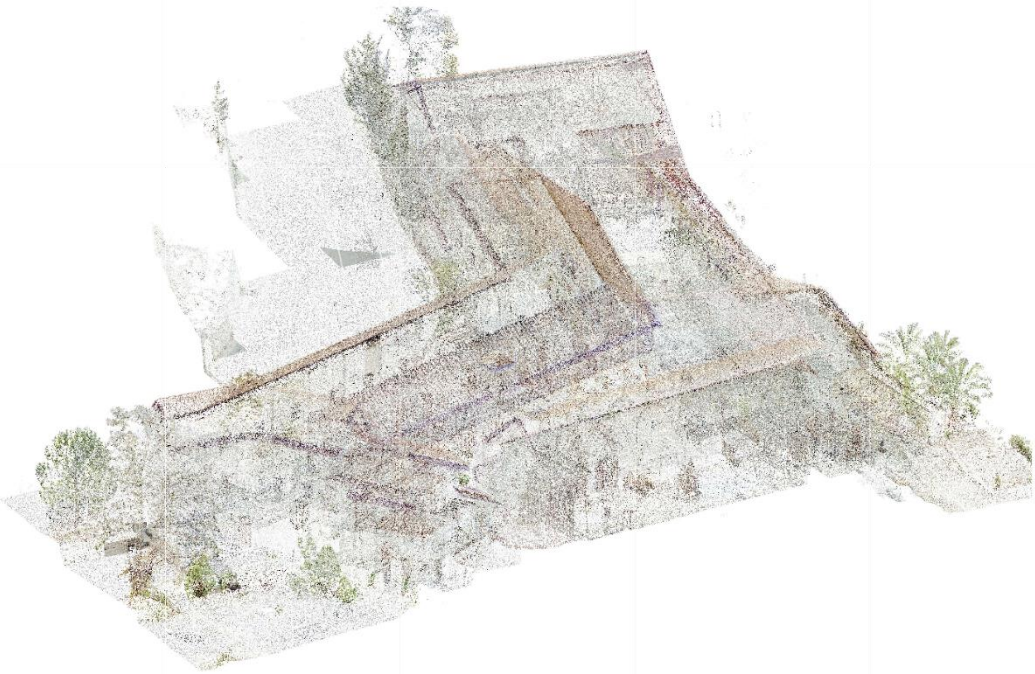


Figure 18: Aligned Point cloud result of the Monastery of Panayia Chrysorrogiatissa.

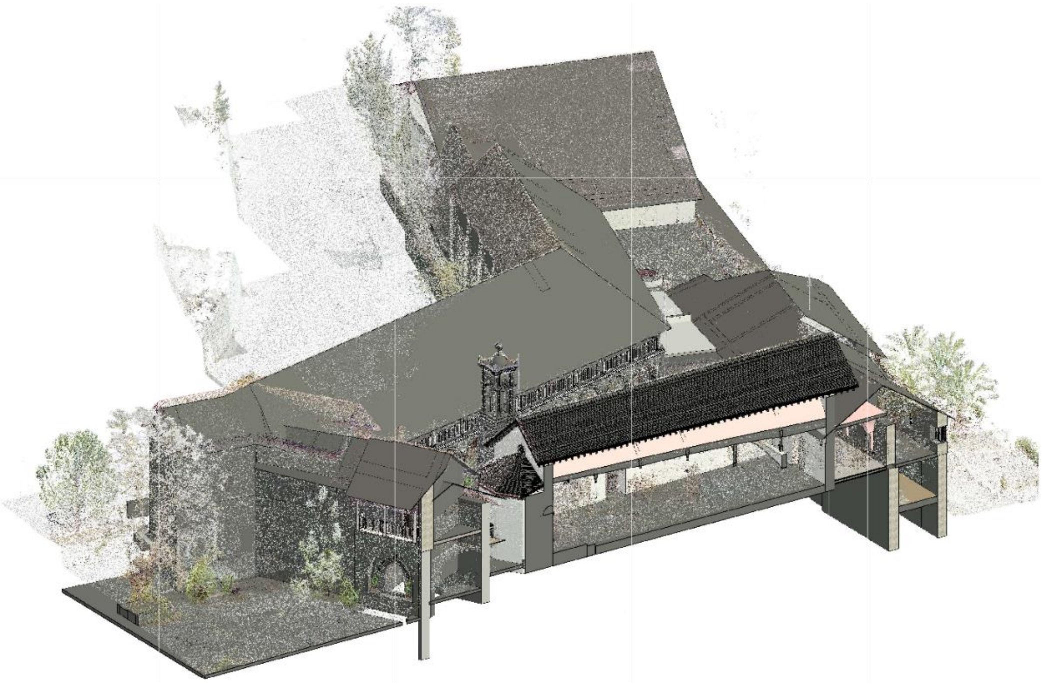


Figure 19: Aligned Point cloud with HBIM model results of the Monastery of Panayia Chrysorrogiatissa.

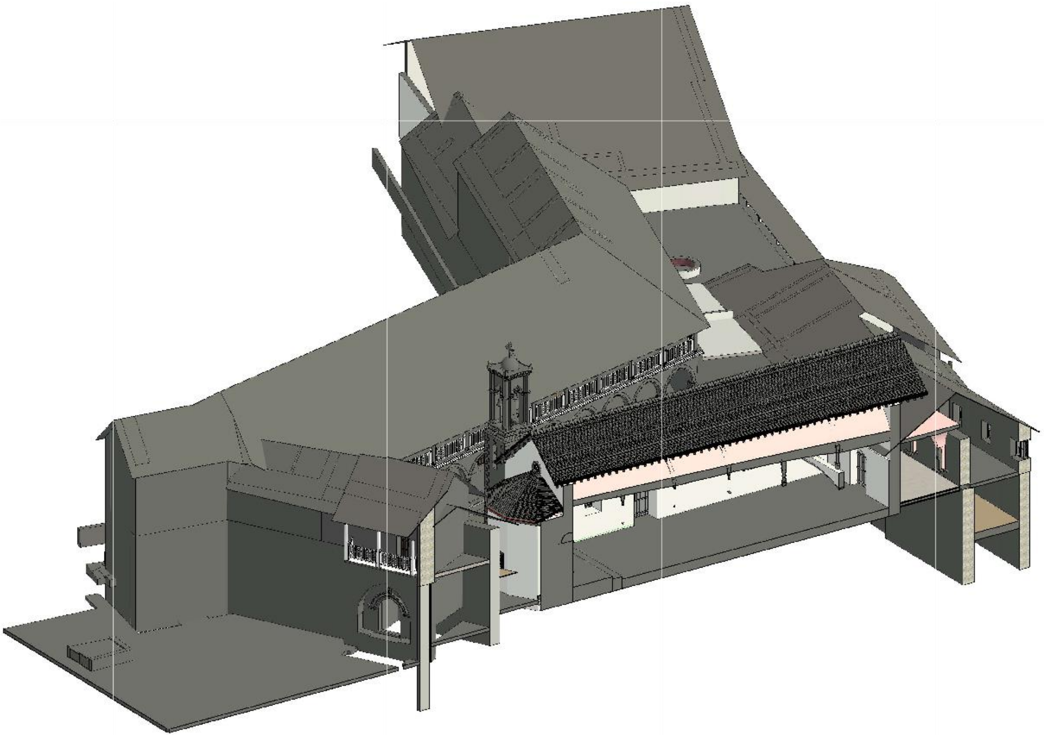


Figure 20: HBIM Model result of the Monastery of Panayia Chrysorrogiatissa.

OBJECT C

Title: The Lambousa Fishing Trawler: The oldest fishing trawler of Cyprus

Aims: The aim is to obtain a high detail digitisation of the fishing trawler in order to include not only the point cloud and mesh from the initial digitisation, but further results such as 3D Nurbs and Brep closed geometries of all the components of the boat. The digital model is published in Europeana platform from the datahub workflow, and this lets its efficient visibility and educational perspective, encouraging 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 such as a 3D puzzle where the trawler can be constructed within the shipyard according to a variety of difficulty levels.

Estimation of complexity and quality: Estimation of complexity and quality was created according to the VIGIE 2020/654 Study, using the Paradata App. Figure 18 includes the radial charts of this estimation, with paradata such as the environmental conditions, the condition of the object, the purpose of the digitisation, its materials, deliverables data, and the experience of the professionals who undertook the digitisation.

Methodology, equipment and other technical data about the 3D digitisation:

Aerial and Terrestrial Photogrammetry (On-site digitisation date: 9-13/1/2023)

- Equipment
    - Terrestrial: Sony A7 IV Mirrorless Camera
        - Effective Megapixels (millions): 33 megapixels

        - Total Pixels: 34.1
        - Pixel Size: 5.12µm
        - Max Resolution: 7008 x 4672
        - Sensor Format: 33 MP full-frame (35.9 x 24.0mm) BSI Exmor R CMOS sensor
        - Sensor Size: 35.6 x 23.8 mm
        - Lens Mount: Sony E
        - ISO Sensitivity: Stills: ISO 100-51,200 (expandable to ISO 50 to ISO 204,800), Video: ISO ISO 100-51,200 (expandable to ISO 100-102,400)
    - Aerial: DJI Mini 3 proTerrestrial
        - Effective Pixels: 48 MP
        - Camera Type: 4K: 3840×2160@24/25/30/48/50/60fps
        - Flight Time: 34 mins (with Intelligent Flight Battery) and 47 mins (with Intelligent Flight Battery Plus
        - ISO Range: Video: 100-6400 (Auto), 100-6400 (Manual), Photo: 100-6400 (Auto), 100-6400 (Manual)
- Photogrammetry software:
    - Reality Capture 1.2.2 Tarasque: 1100 Images were processed in JPG format and with a Resolution 4000 X 2250 px of each image.
    - Initial Results: A textured mesh model with 27,363,867 faces

Terrestrial Laser Scanning (TLS), (On-site digitisation date: 26/10/2023)

- Equipment
    - Z+F IMAGER 5016
        - Real-time registration on-site
        - Measurement range: 0.3m … 365m (ambiguity interval)
        - Range resolution: 0.1mm
        - Data acquisition rate: Max. 1.1 million pixel/sec
        - Linearity error: ≤ 1 mm + 10 ppm/m
        - Range noise: 0,25 mm rms
        - HDR Camera
            - Type: HDR, automatic, up to 11 exposures
            - Recording time: approx. 2 min, parallax free
            - Focus area: 1m - ∞
            - Panorama resolution: ca. 80 MPixel
- Equipment settings on site
    - Resolution: High: 6.3mm for 10m, and Medium: 12.6mm for 10m
    - HDR Mode
    - The scanner was placed in 9 positions and the focus area was the Stern of the boat
- TLS software
    - Z+F Laser Control Software
        - Start Processing: Apply filters, Run registration, Generate colour scan
        - Register Settings: Do registration, find connections, use cloud to cloud, use compensator information, adjustment
- Software used for post-processing
    - CloudCompare

        - Processing the vertices of the mesh and reducing them to 5,000,000 coloured points. This allows the efficient processing of the points within CAD software.
        - Alignment of photogrammetry with TLS point cloud
    - Rhinoceros 7: This software along with Grasshopper plugin, where used for processing the point cloud data using algorithmic and manual methods for the creation of nurbs curves, and solid 3D geometries. This also led to the creation of Naval Architectural Drawings. The data is exported in OBJ, STL, and FBX format.
    - Blender: Import of OBJ model into Blender, and the reduction of polygons through Select mode, Select the objects, Edit Mode, selection of all faces, then Mesh, Cleanup, Limited Dissolve with 1 degree angle suggested for the hull geometry. Then wood texture is added to the model. After that, the model is exported as GLB format in order to be used within the online 3D Viewer.
- File formats generated: E57, 3DM, OBJ, MTL, STL, FBX, GLB, STL
- Challenges faced during digitisation: During the photogrammetric survey, the Fishing Trawler was in a decayed condition and covered with plastic film. It was cleaned carefully, and the plastic film was removed to allow the capturing of the images from the UAV and Terrestrial camera. As regards to TLS, this was done during the Reconstruction of the Trawler and therefore the surrounding scaffoldings had to be removed to allow the capturing of the point cloud data.

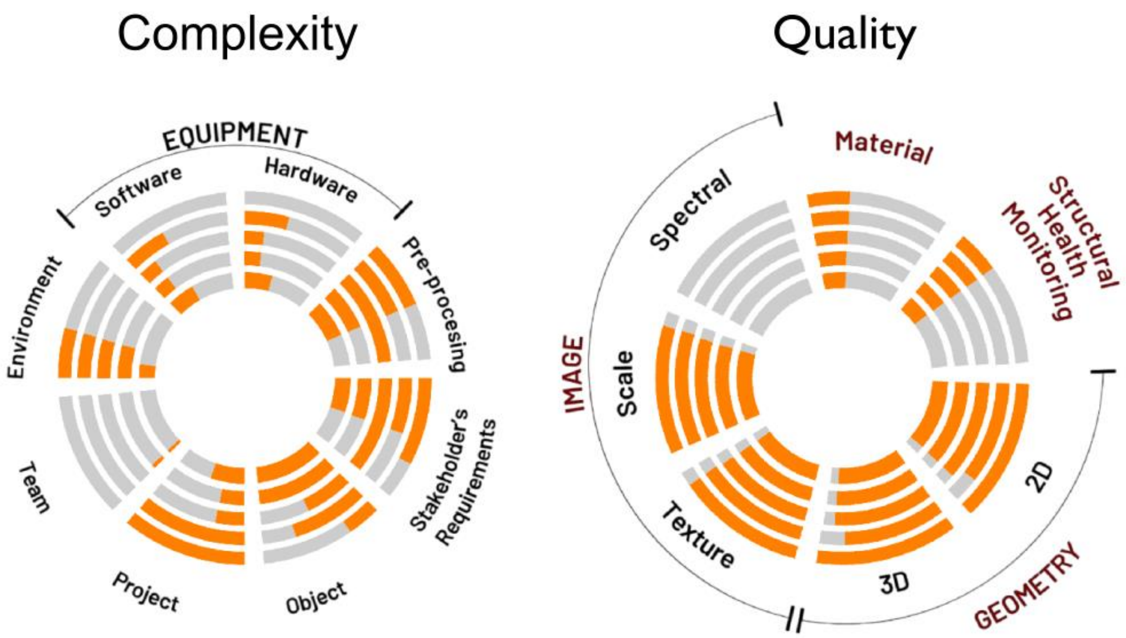


Figure 21: Lambousa Fishing Trawler estimation of Complexity and Quality based on VIGIE 2020/654 Study.

Management and sharing of heritage collection data:

The HBIM model of the Church of the Holy Cross as well as the OBJ files are uploaded in EGI datahub. Moreover, a test has been made for the aggregation of the metadata to the Europeana Portal through the production version of the platform. The point cloud data and HBIM model of the Monastery of Panayia Chrysorrogiatissa are uploaded in EGI Datahub. As regards to the Lambousa Fishing Trawler, all the required datasets are uploaded, shared and successfully aggregated to the Europeana portal. Further details regarding this, can be seen at the following chapter.

3. High quality digitisation best practice: the Lambousa Fishing Trawler by Cyprus University of Technology (CUT)

This chapter describes the work achieved at CUT regarding the digitisation and aggregation of the Lambousa Fishing Trawler. Specifically, the digitisation process according to VIGIE 2020/654 Study is described with details such as the estimation of the complexity and quality, the overall methodology used according to the concept of the memory twin, the post-processing of the point cloud results for 3D modelling, and the aggregation of the results to Europeana. The Lambousa Fishing Trawler was presented and demonstrated as best practice during the high level TwinIt! event in Brussels on 14 May 2024, organised by the European Commission and Europeana Foundation in the presence of European authorities and Ministries of Culture from all over Europe.

3.1 Lambousa Fishing Trawler, introduction

The Lambousa Fishing Trawler has a great historical importance in the maritime of Cyprus. It was built in 1955 at Perama, Piraeus by Dimitrios Zacharias, and its initial name was Omonoia. When it arrived in Famagusta port in 1965, its new owner renamed it “Lambousa” which is the ancient Greek name of the village “Lapithos”. This trawler has a length of 25-metres with a 48-ton capacity and a maximum speed of 10 knots, and it was operating for 50 years along the mediterranean sea. Lambousa is one of the remaining traditional fishing trawlers in Cyprus, and is no longer built neither in Cyprus nor in Greece. The vessel stopped its fishing activity in 2004, due to the decision of the Republic of Cyprus to remove a range of vessels to preserve marine life. Furthermore, it was given to the Municipality of Limassol by the Fisheries Department, where a decision was made to repurpose it as a floating museum. To achieve this, restoration and reconstruction works had to be done to restore the trawler from its decayed condition. This restoration was funded by the European operational program 'Sea'[3], and the reconstruction works began in January 2023 and finished in May 2024. The Municipality of Limassol which is the stakeholder of this vessel requested from CUT to holistically document the fishing trawler, 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, in the context of the EUreka3D project. Specifically, the requirements were, the creation of point cloud data, 3D NURBS models, and naval architectural drawings with a Level of Detail (LOD) 400.

Methodology

The overall methodology is based on the concept of the Memory Twin developed by CUT. This method goes beyond the notion of a Digital Twin, through the integration of paradata, metadata and data. Data refers to the digital content such as the 3D model, paradata relates to the processes and tools used for creating the data, and metadata relates to the information that explains the digital content. Figure 22, indicates the workflow of the Memory Twin, which starts from the requirements of the stakeholder/stakeholders, which define the digital tangible objects under study. Moreover, the gathering of data is done through digitisation processes such as a digital geometrical survey with the integration of knowledge from experts as well as from current publications. This information gathering process leads to the paradata, metadata, and data that can then be analysed to provide knowledge ready for Aggregation to Europeana and to the National Aggregators' online platforms. The digitisation part from this workflow is based on VIGIE 2020/654 Study.

[3] https://www.moa.gov.cy/moa/opf/opf2014.nsf/index_en/index_en?OpenDocument

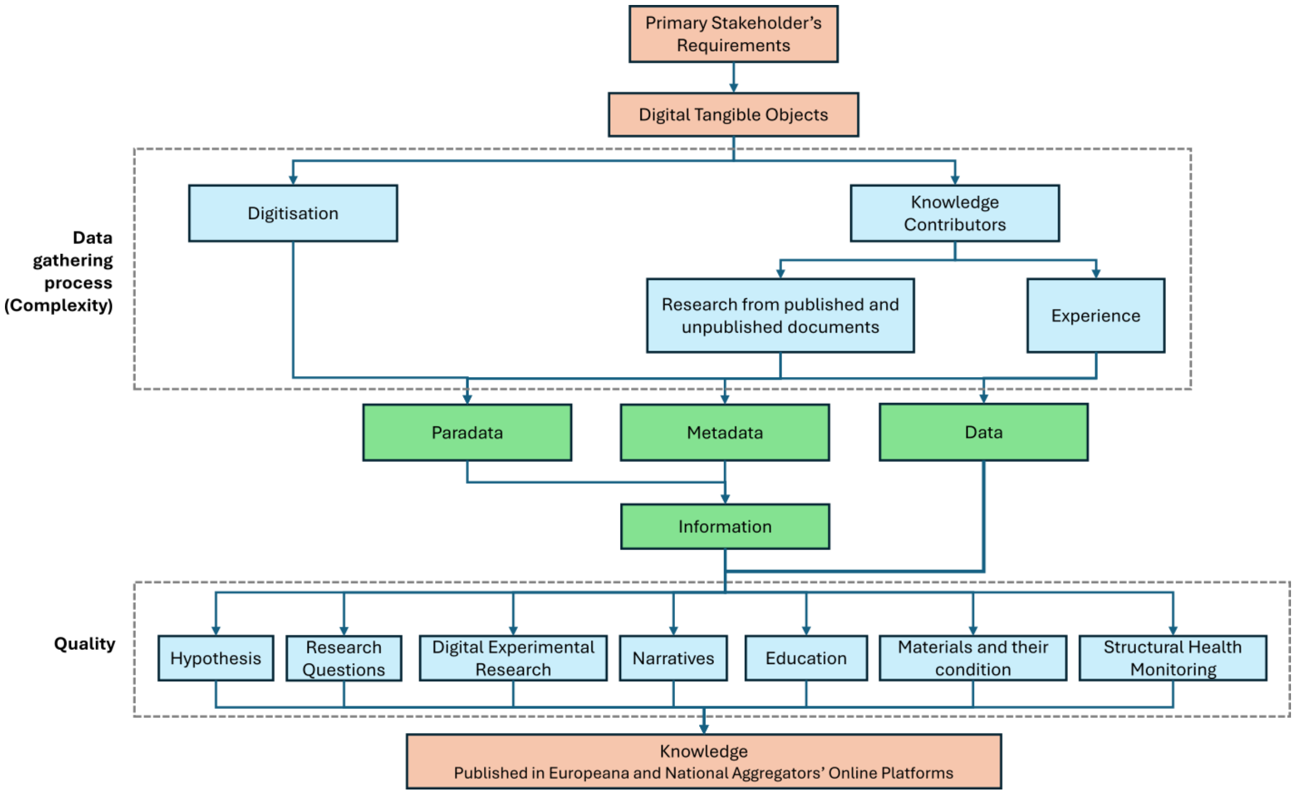


Figure 22: Memory twin workflow diagram.

Estimation of Complexity of the Digitisation

The Complexity was estimated according to the VIGIE 2020/654 Study, using the Paradata App which assisted as for documenting the paradata of the digitisation. This includes the stakeholder's requirements, object, project, team, environment, software and hardware. The following Figures 23 to 28 include further details of the documented paradata.

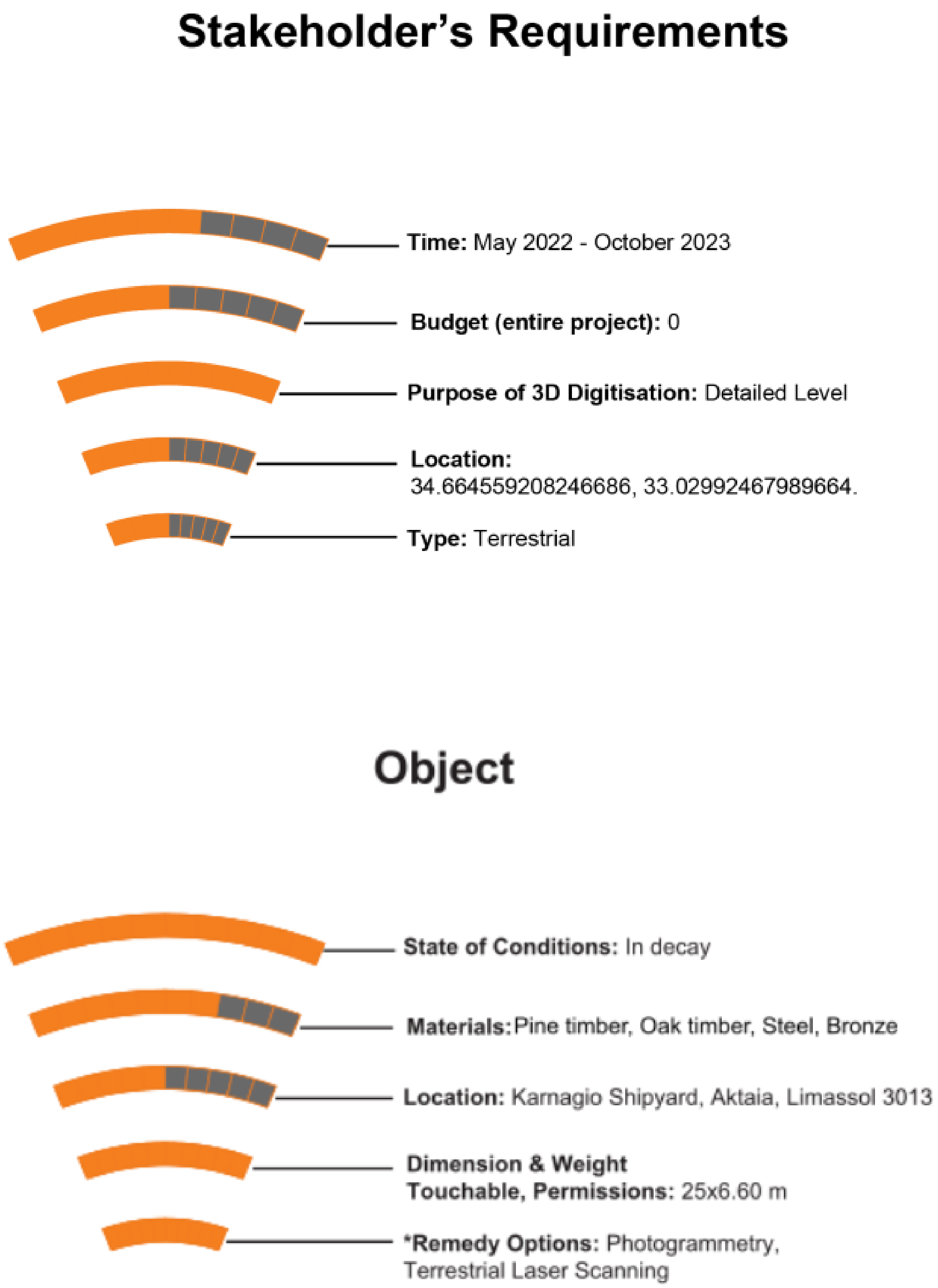


Figure 23: Estimation of complexity for Stakeholder's requirements and Object.

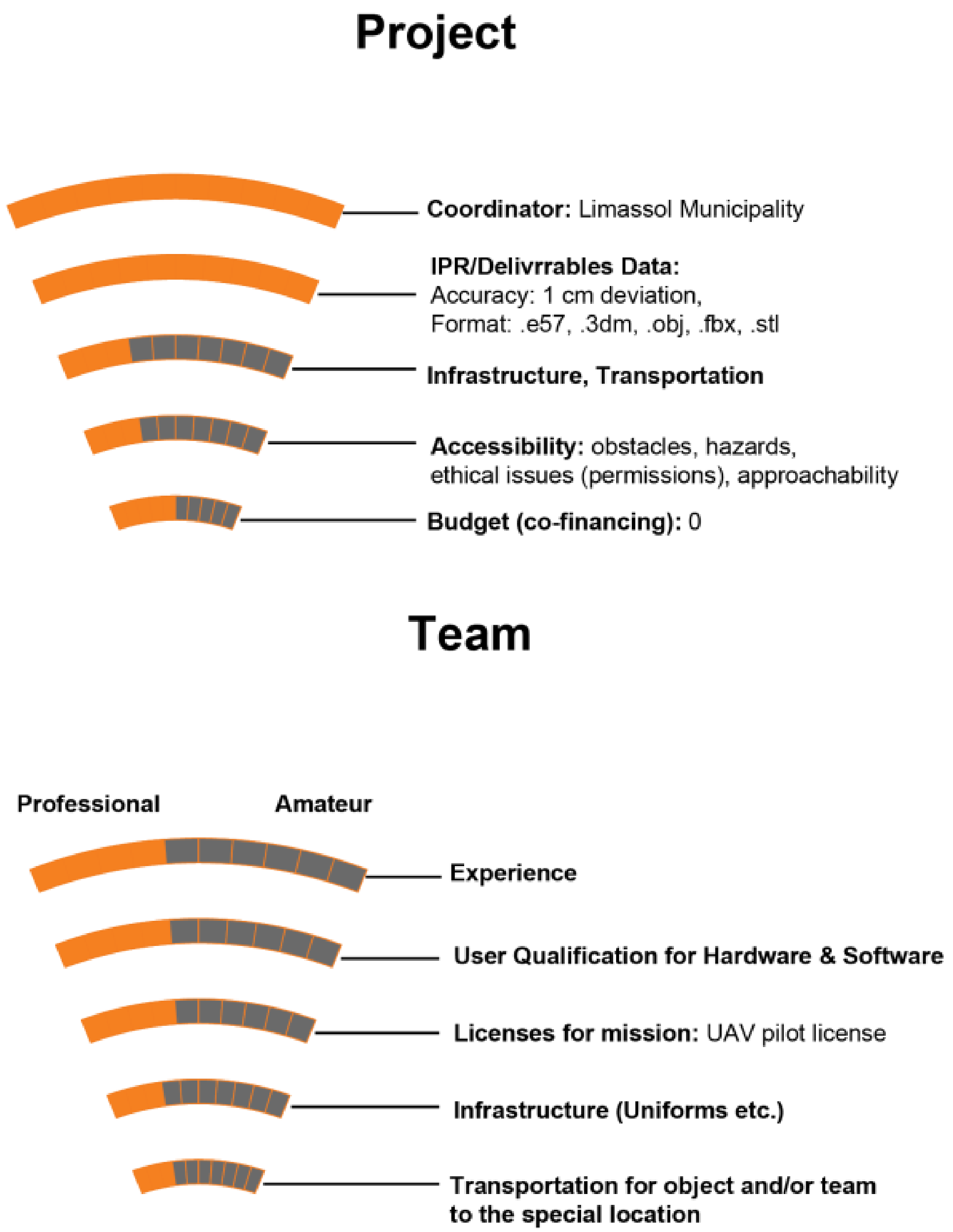
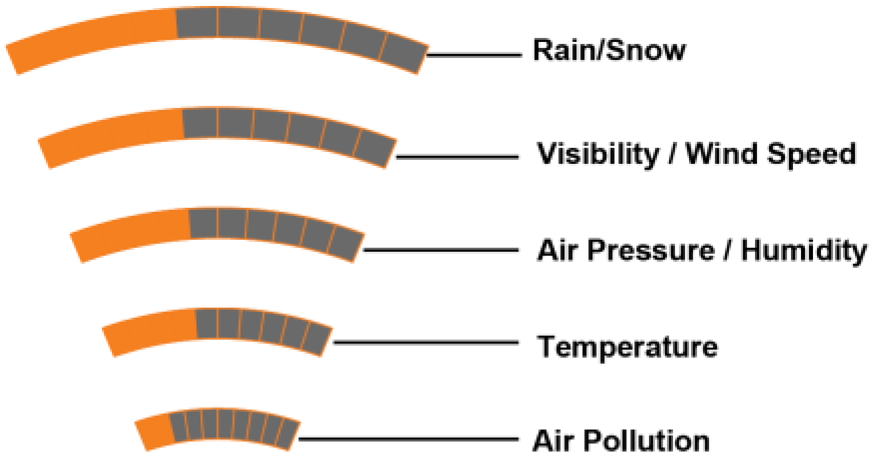


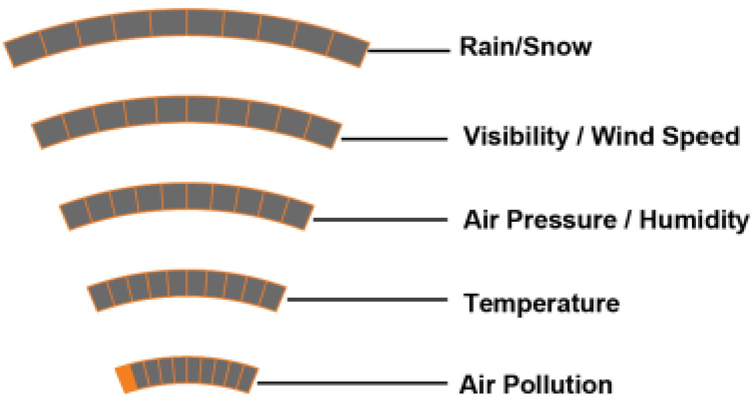
Figure 24: Estimation of complexity for Project and Team.

Environment - UAV Survey



Dates of data acquisition using UAV Photogrammetry: 9-13/1/23

Environment - Terrestrial Laser Scanning (TLS)



Date of data acquisition using Terrestrial Laser Scanning: 26/10/23

Figure 25: Estimation of complexity for Environmental conditions of UAV and TLS Survey.

9-13 January 2023			
Meteorological Station: Cyprus, Limassol, New Port			
Day	Max. Temperature (°C)	Min. Temperature (°C)	Rain (mm)
9	17.6	8.1	0.0
10	18.1	7.0	0.0
11	18.3	10.6	17.8
12	16.5	10.4	39.7
13	15.5	7.1	3.8

Limassol Traffic Station					
Pollutant	**Date: 9/1/23** Time: 8:00	**Date: 10/1/23** Time: 8:00	**Date: 11/1/23** Time: 8:00	**Date: 12/1/23** Time: 8:00	**Date: 13/1/23** Time: 8:00
PM10	39.9	70	49.4	19.3	19.3
PM2.5	18.3	25.7	17.9	7.4	7.4
O3	4.4	3	13.1	46.1	46.1
NO2	80.7	85.9	81.6	40.2	40.2
SO2	4.5	7.6	3.9	1	1

Meterological Stations in Cyprus:
https://www.moa.gov.cy/moa/dm/dm.nsf/automaticdata_en/automaticdata_en?OpenDocument

Air Pollution in Cyprus:
https://www.airquality.dli.mlsi.gov.cy/

Pollution Level (μg/m³)				
Pollutant	Low (1)	Moderate (2)	High (3)	Very High (4)
PM_{10}	0 - 50	50 - 100	100 - 200	> 200
$PM_{2.5}$	0 - 25	25 - 50	50 - 100	> 100
O_3	0 - 100	100 - 140	140 - 180	> 180
NO_2	0 - 100	100 - 150	150 - 200	> 200
SO_2	0 - 150	150 - 250	250 - 350	> 350
CO	0 - 7000	7000 - 15000	15000 - 20000	> 20000
C_6H_6	0 - 5	5 - 10	10 - 15	> 15

Figure 26: UAV Environmental data.

Rain and Temperature		
26 October 2023		
Meteorological Station: Cyprus, Limassol, New Port		
Max. Temperature (°C)	Min. Temperature (°C)	Rain (mm)
28.7	17.8	0.0

Pollution Level (μg/m³)				
Pollutant	Low (1)	Moderate (2)	High (3)	Very High (4)
PM_{10}	0 - 50	50 - 100	100 - 200	> 200
$PM_{2.5}$	0 - 25	25 - 50	50 - 100	> 100
O_3	0 - 100	100 - 140	140 - 180	> 180
NO_2	0 - 100	100 - 150	150 - 200	> 200
SO_2	0 - 150	150 - 250	250 - 350	> 350
CO	0 - 7000	7000 - 15000	15000 - 20000	> 20000
C_6H_6	0 - 5	5 - 10	10 - 15	> 15

Air Pollution	
26 October 2023	
Limassol Traffic Station	
Pollutant	**Date: 9/1/23** Time: 8:00
PM10	39.9
PM2.5	18.3
O3	4.4
NO2	80.7
SO2	4.5

Figure 27: TLS Environmental data.

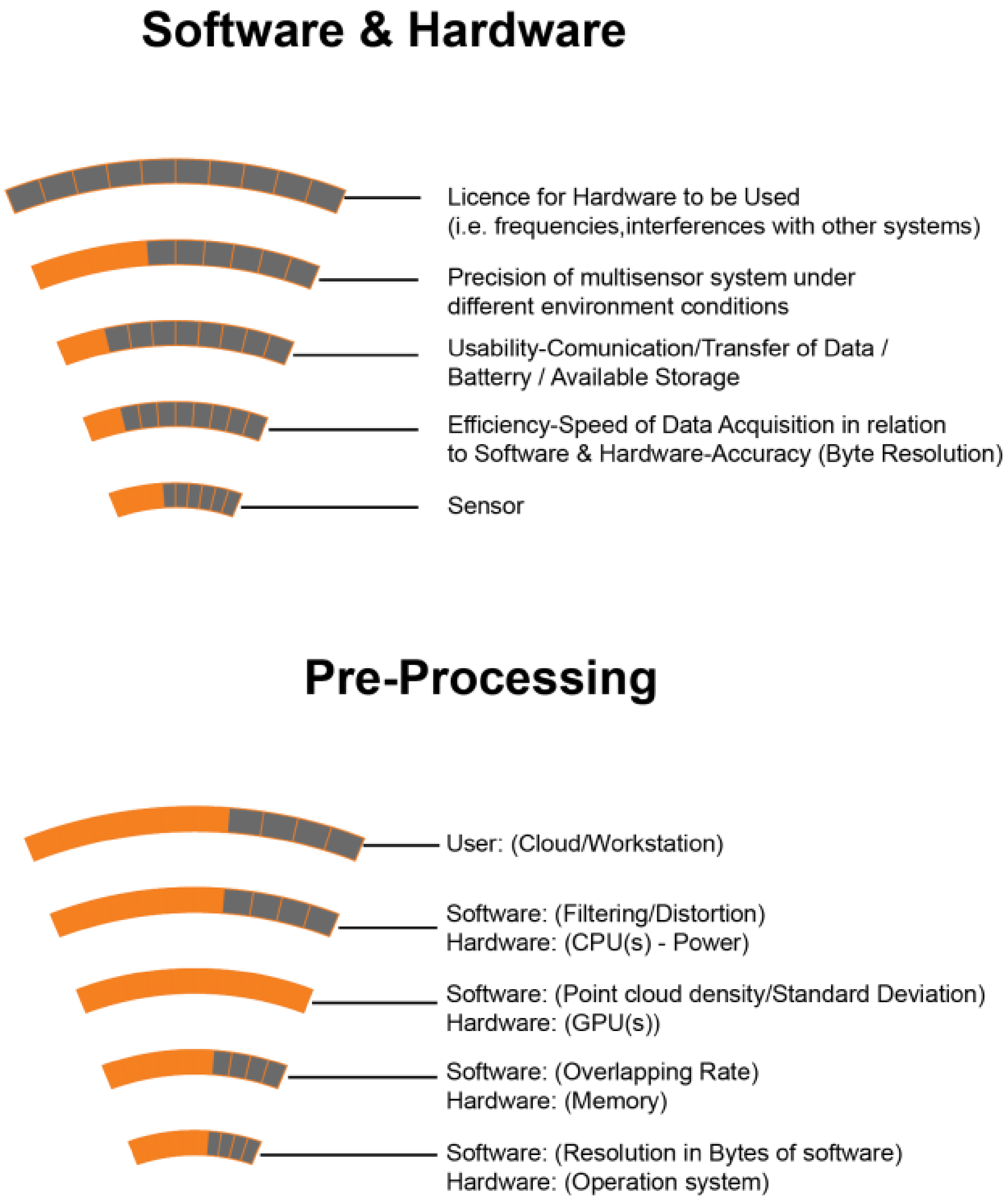


Figure 28: Estimation of complexity for Software, Hardware and pre-processing.

The digitisation started in January 2023 when a UAV photogrammetric survey was made to the exterior of the trawler. The outcome of this geometrical survey provided a georeferenced textured mesh model with

27,363,867 faces. Further to this an additional survey was made in October 2023, through TLS, while the trawler was still under restoration. This was done in order to capture the geometry of the timber structural elements, such as the frames, deck beams, keel, and stern. The outcome of this survey provided 14,164,403 points. In order to be able to process the data of the photogrammetric mesh, CloudCompare was used to derive the vertices and downsample them to 5,000,346 points. Furthermore, these points were then aligned with the TLS point cloud, to allow the creation of the overall point cloud to be further processed for creating the 3D model.

Post-processing of point cloud data for the creation of the 3D model

The point clouds were then processed in CAD software, with an aim to create closed 3D NURBS geometries that include all the components of the trawler. Initially, vertical cloud sections were made and splines were modelled based on these sections, for creating a network of curves for the hull (Figure 36). Moreover, the surface of the hull is created, and its offset allowed the solid geometry to be made. Based on this hull geometry, the deck, frames, deck beams, railcap, keel, and stern are made. In addition, the rest of the components such as the fishhold, cabin, and mast are created through the tracing of curves over the point cloud. Figure 37 indicates an axonometric 3D drawing of the boat, and Figure 35 includes the exploded axonometric with all 440 components modelled. A deviation analysis has been done as well to indicate the precision of NURBS geometry compared to the point cloud (Figure 39).

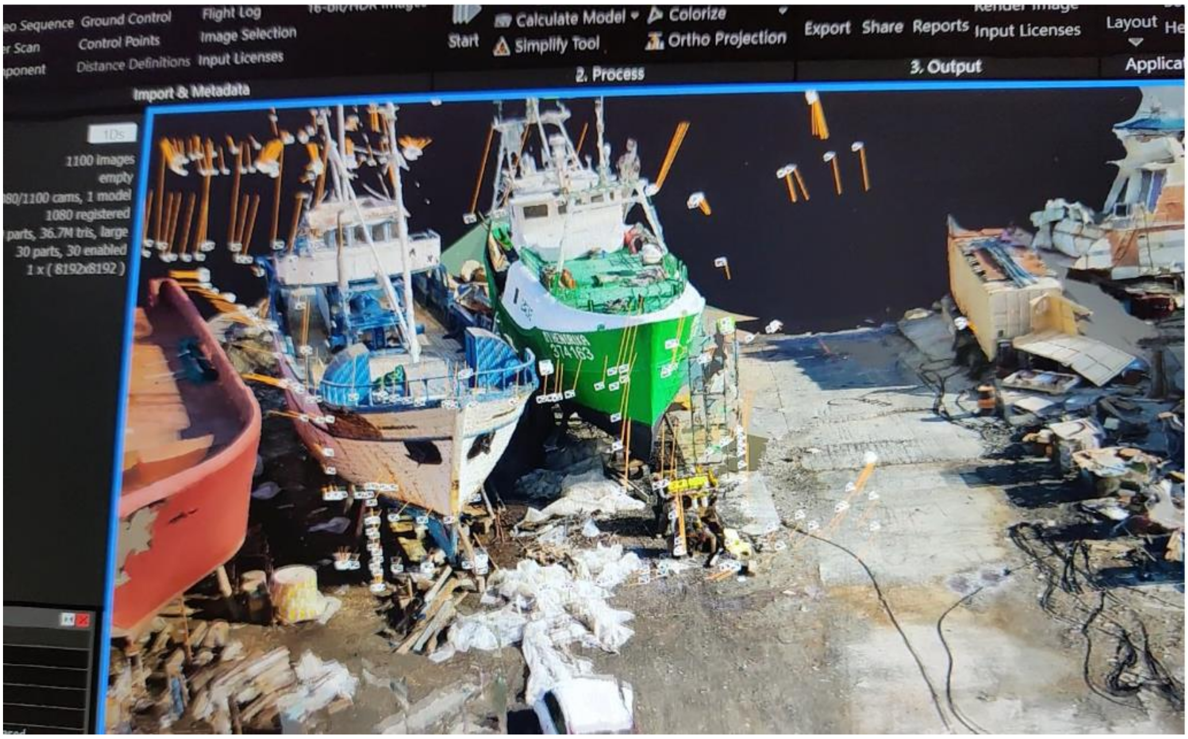


Figure 29: UAV Photogrammetric survey.

Figure 30: UAV Photogrammetric Point Cloud.

Figure 31: TLS survey on site.

High Resolution Settings

Medium Resolution Settings

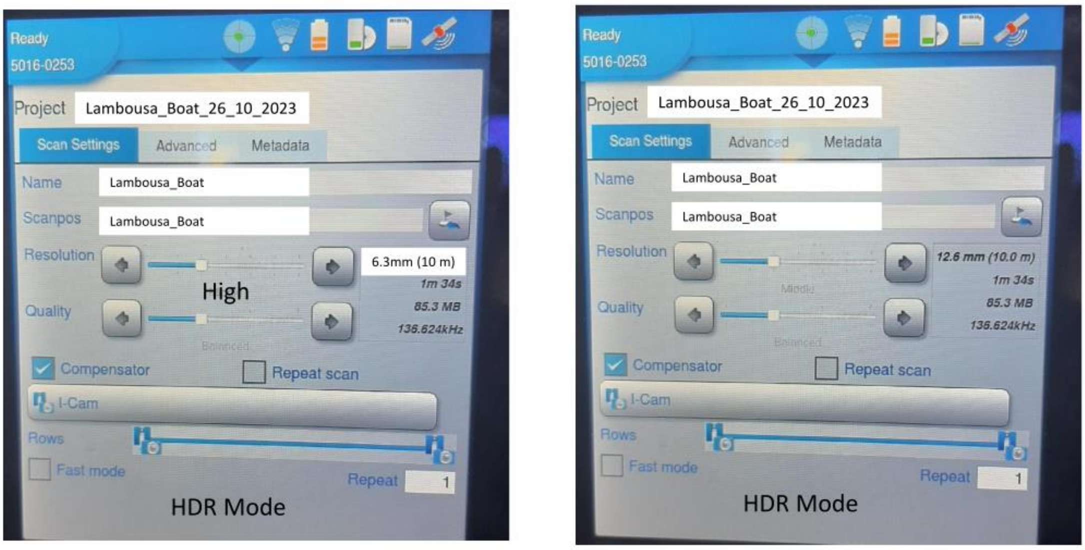


Figure 32: Laser Scanner settings.

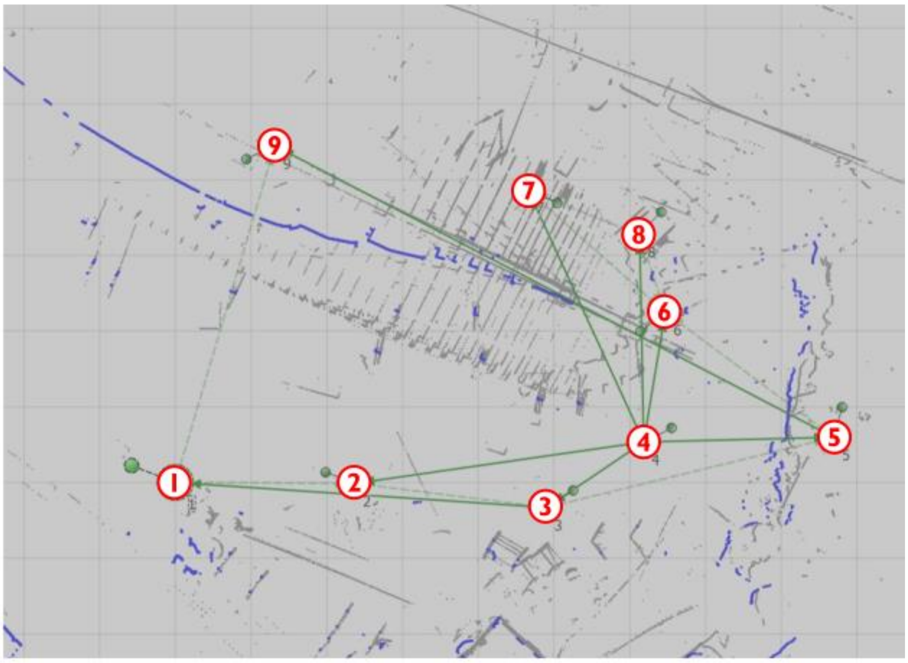


Figure 33: Scanning positions.

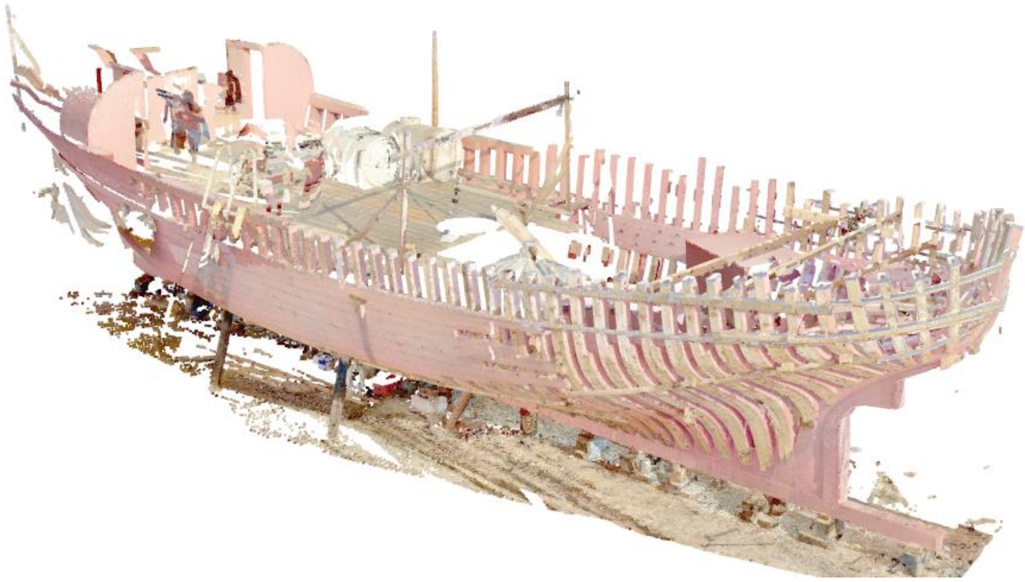


Figure 34: TLS Point Cloud result.

Figure 35: Aligned TLS and Photogrammetric point clouds.

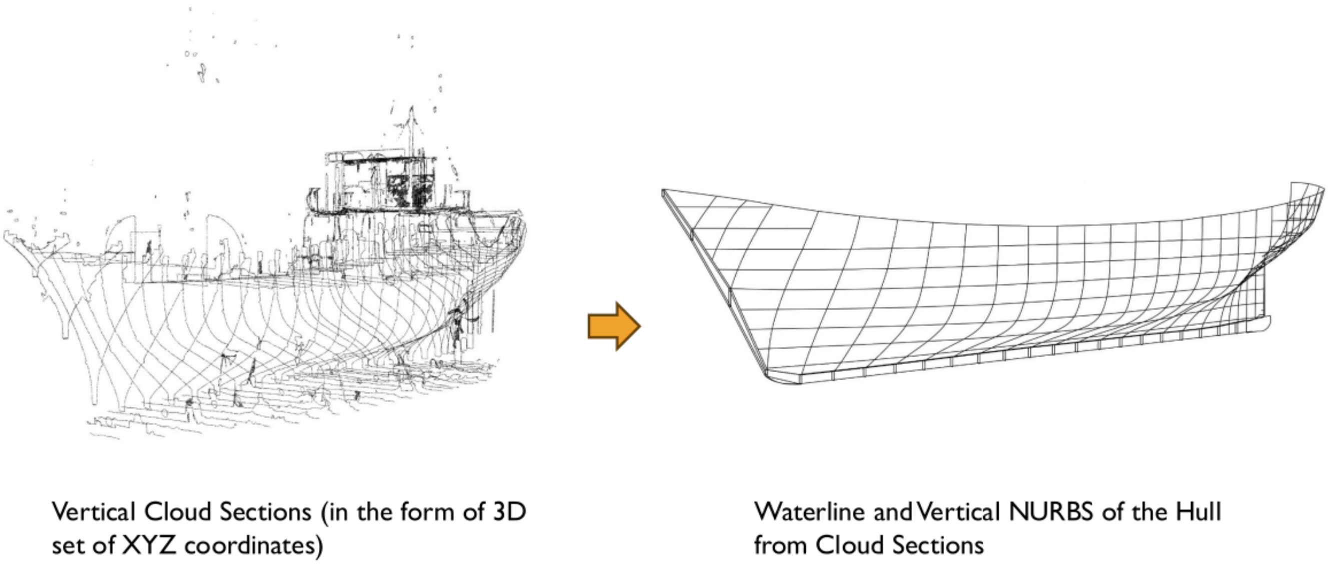


Figure 36: From vertical cloud sections to NURBS curves.

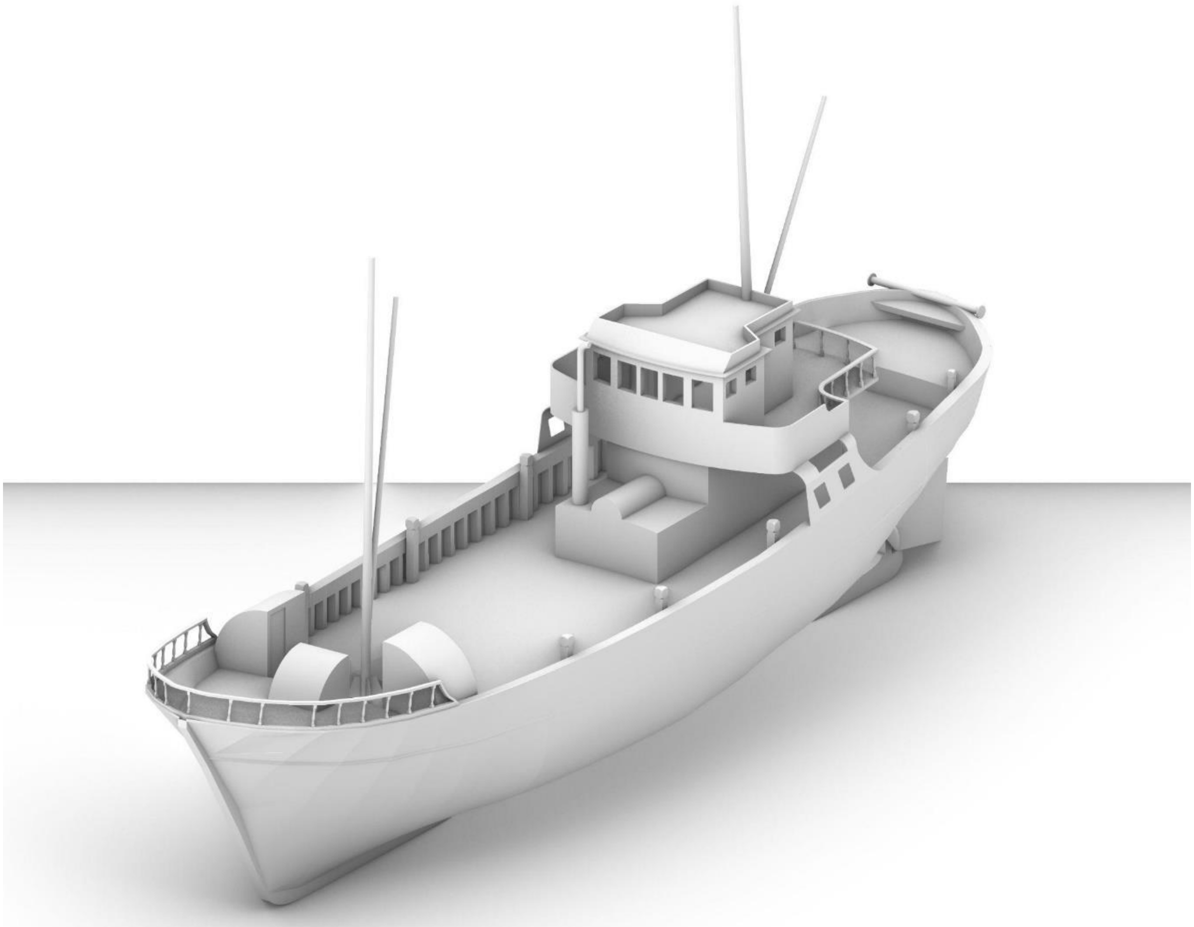


Figure 37: 3D Axonometric of the trawler.

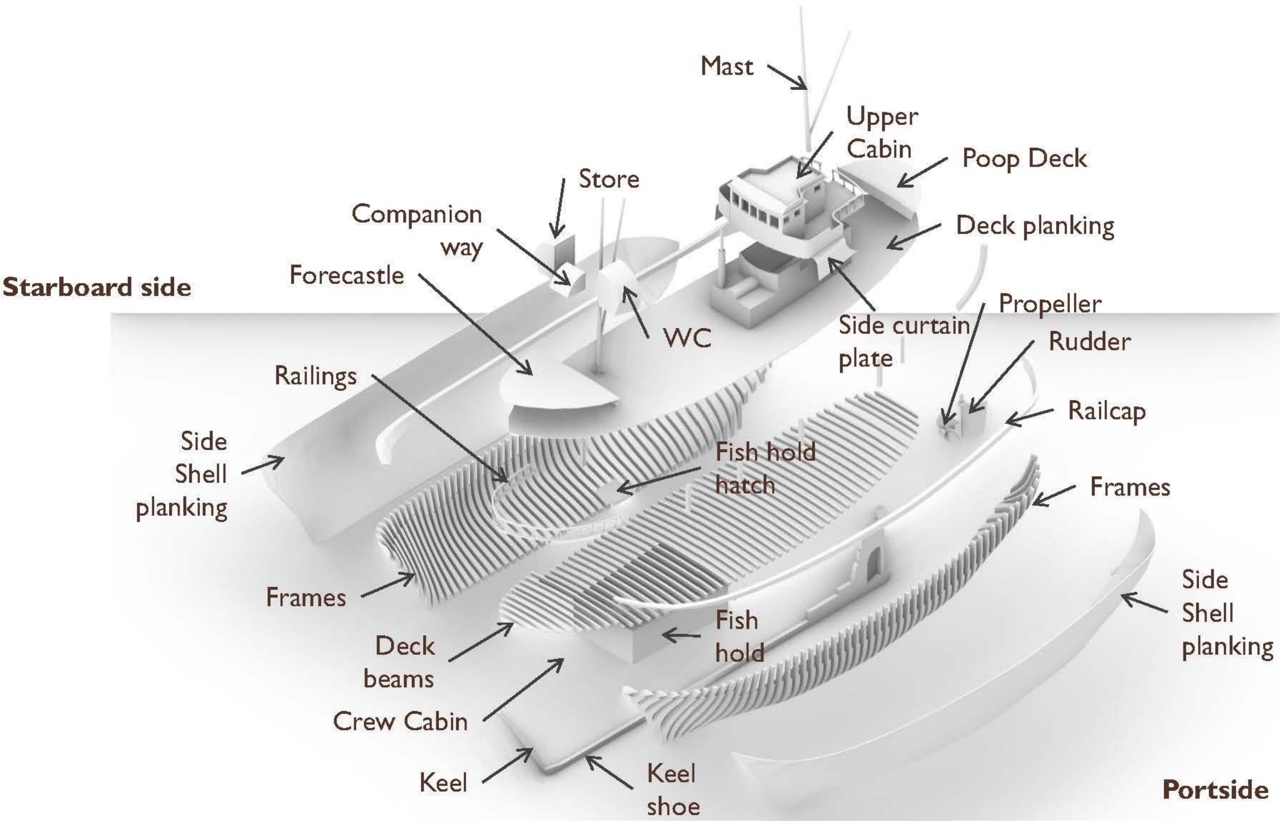


Figure 38: 3D Exploded Axonometric of the trawler.

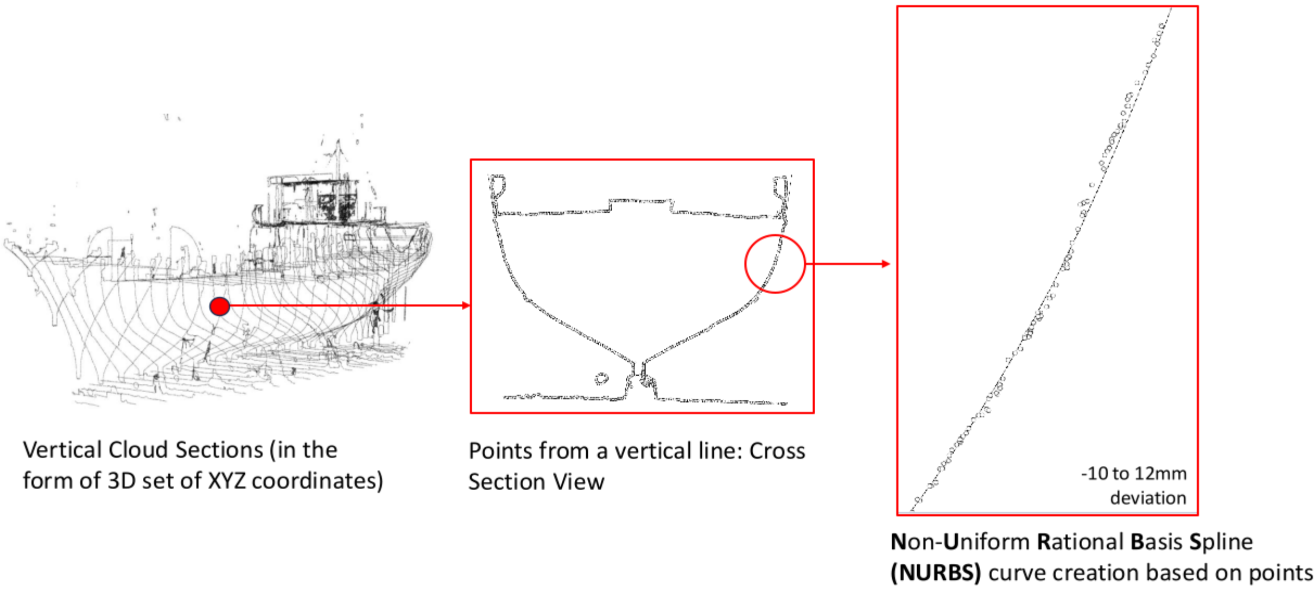


Figure 39: Deviation Analysis.

Bsed on the 3D Model, Naval Architectural drawings were created in CAD software. In particular, the sections, elevations, and plans of the 3D Model are cleaned and annotated. Examples of drawings such as the naval lines, plan view and longitudinal section can be seen from the Figures 40-42.

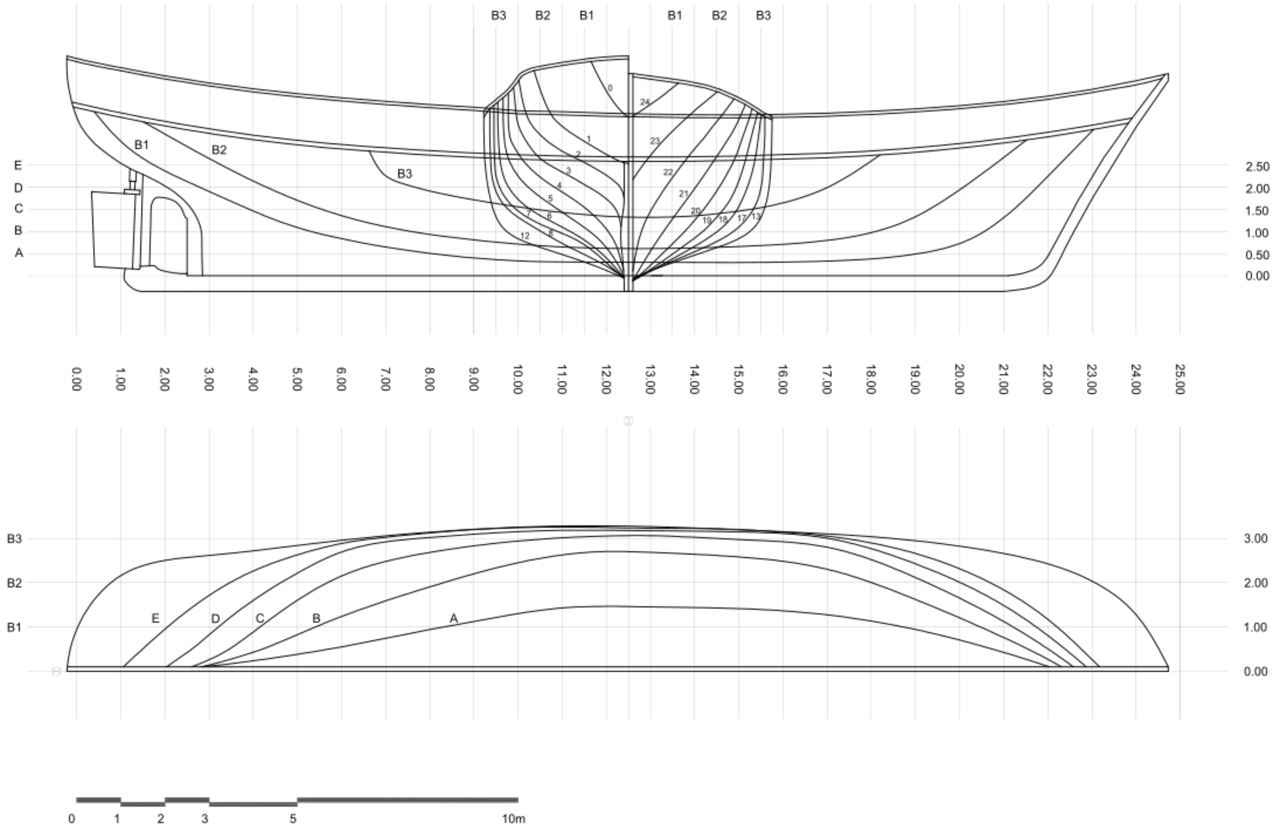


Figure 40: Naval Lines.

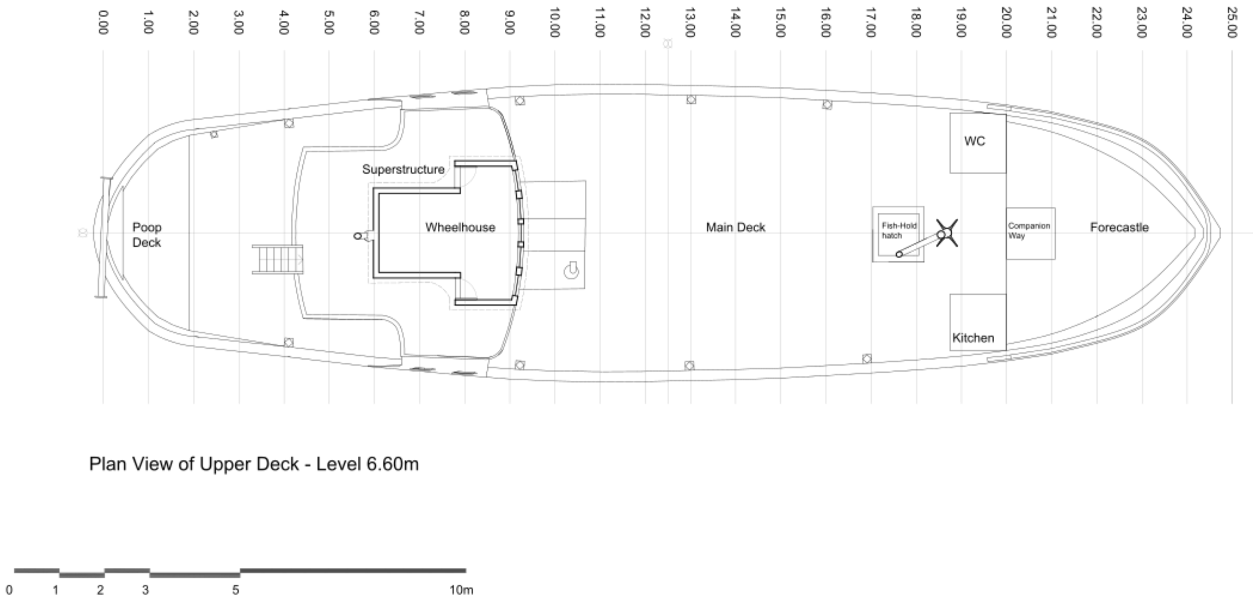


Figure 41: Plan View.

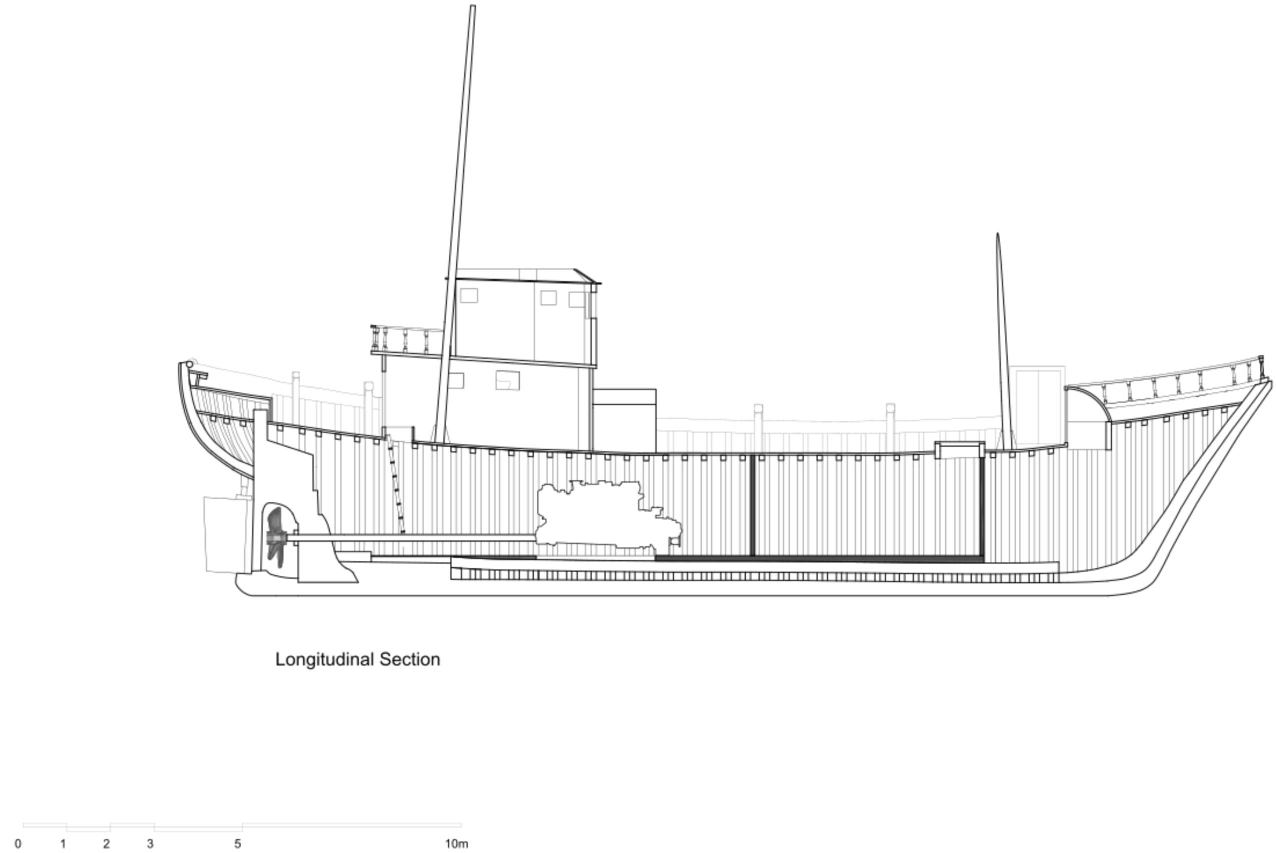


Figure 42: Longitudinal Section.

As mentioned previously, restoration works were undertaken for this trawler, where a physical reconstruction was done. Therefore the deviation of the boat before the restoration and after, had to be found to indicate the precision of the restoration works. This deviation analysis can be seen in Figure 43 in which the point cloud of the restored vessel is compared with the vessel before restoration works.

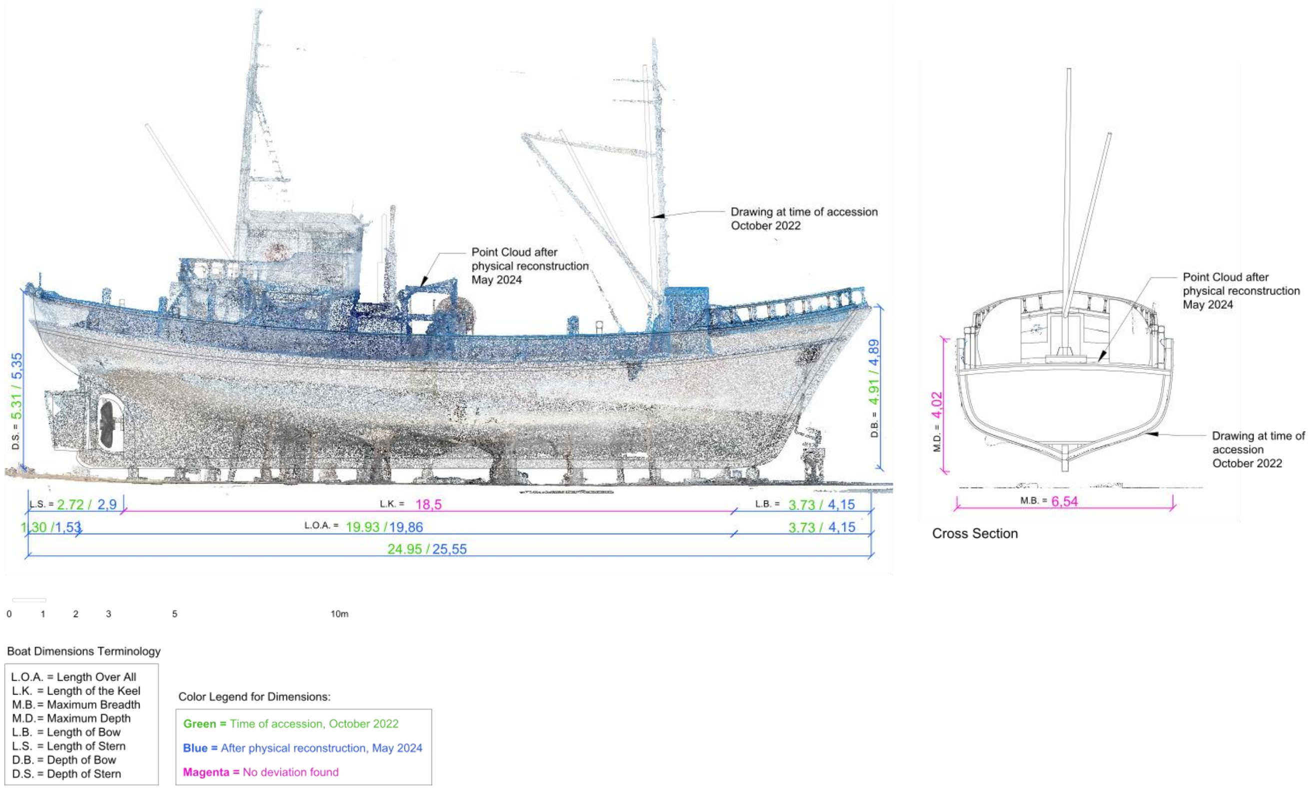


Figure 43: Deviation of physical reconstruction compared to the vessel at time of accession.

3.2 Estimation of Quality of the Digitisation

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 in this deliverable. The following Figures 44 and 45 include further details to the quality documented.

Table 1 includes the list of materials and their corresponding type and component, and Figure 46 shows an example of an image of the frames with the corresponding pathology when the vessel was in a decayed condition.

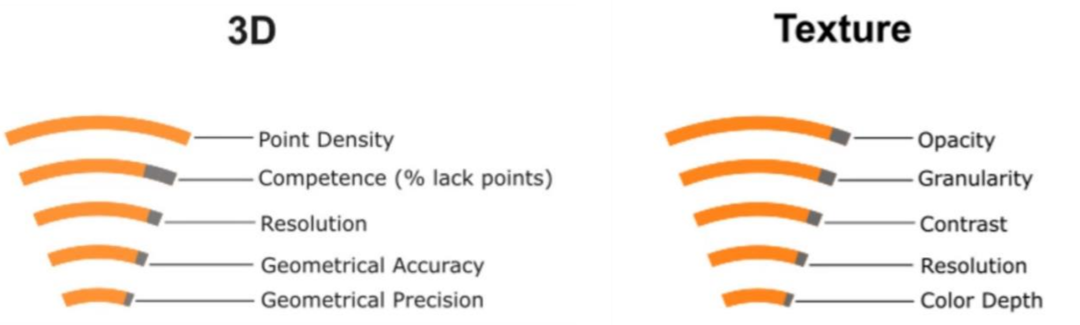


Figure 44: Estimation of quality for 3D and Texture.

Figure 45: 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 46: Timber frames and their corresponding pathology.

3.3 Challenges

During the UAV photogrammetric survey, the boat was in a vacant condition and cleaning had to be done 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 contractor. In addition, the scaffoldings as well as any 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.

3.4 Aggregation of 3D Model results, metadata and paradata through EUrega3D Datahub

The data management platform EGI DataHub which is developed specifically for EUreka3D, 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 EGI 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. These issues, which were related to the workflow of uploading and sharing data, were discussed through weekly meetings and solutions were provided by EGI. 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. Specifically, the 3D viewer couldn't 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 done using the share, open data tool which allowed the model to be published as open data according to B2HANDLE EUreka3D and EDM. Initially, a request is made of a Persistent Identifier (PID), then the metadata is added according to the Europeana Data Model (EDM) format. This data is then shared with Europeana through the harvesting of information via the OAI-PMH protocol which is then visible to 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 EGI Datahub. This URL link is also available from the metadata. This metadata can be consulted via the following link. The EGI Datahub platform with the raw data is shown in Figure 44; the metadata from EGI in Figure 45; the 3D viewer on the Europeana portal in Figure 46 and the metadata in the Europeana portal in Figure 47. The results of this successful aggregation of the Lambousa Vessel were presented on the 14th of May at the high level TwinIt! event.

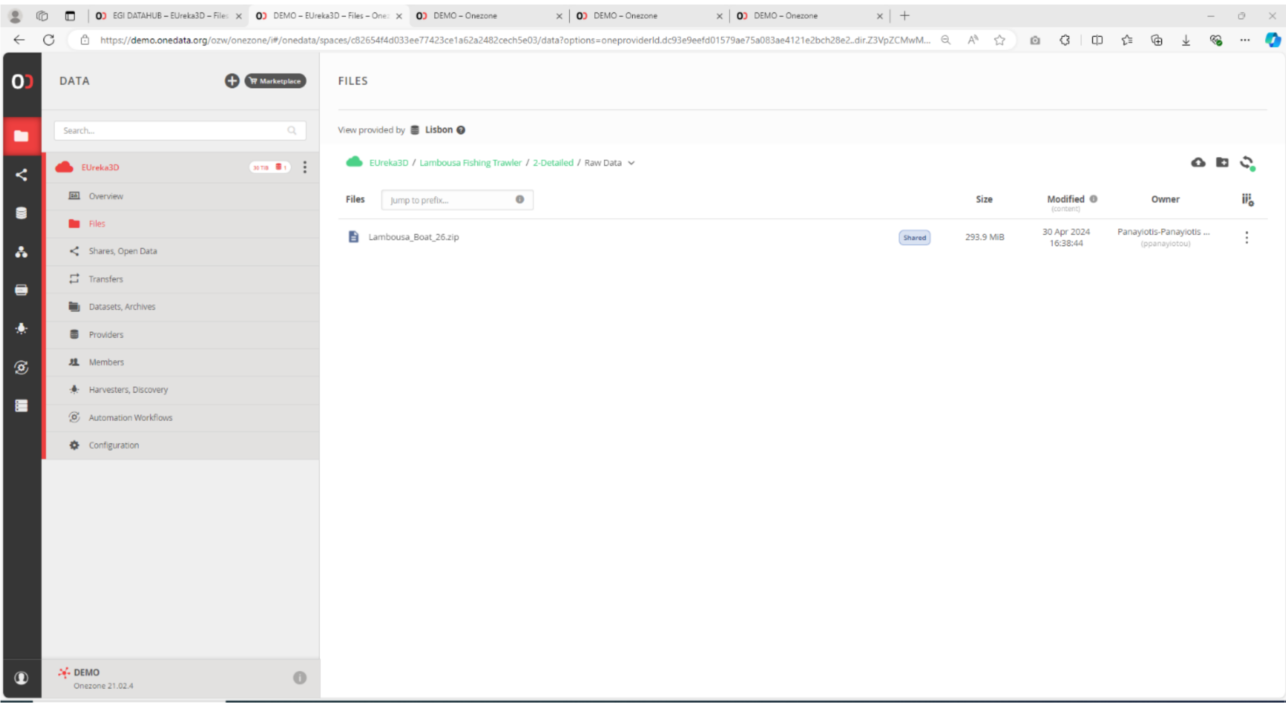


Figure 47: EUreka3D Data Hub platform.

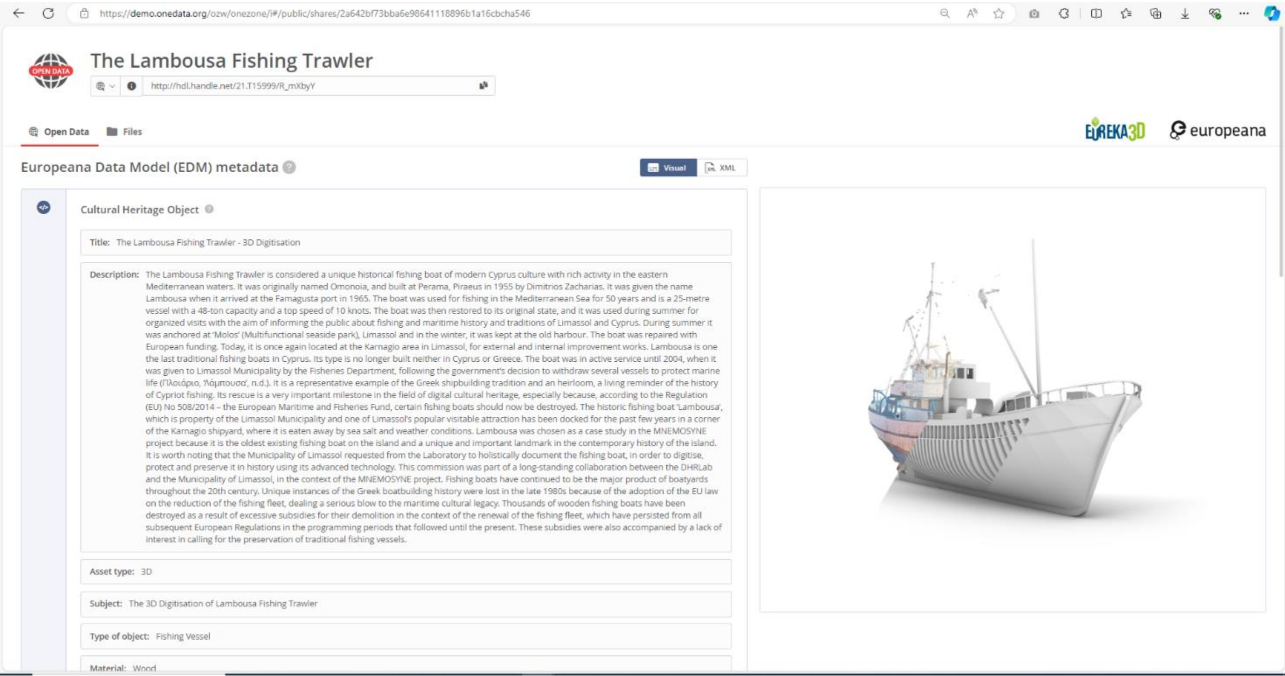


Figure 48: Metadata as displayed in the EUreka3D Data Hub..

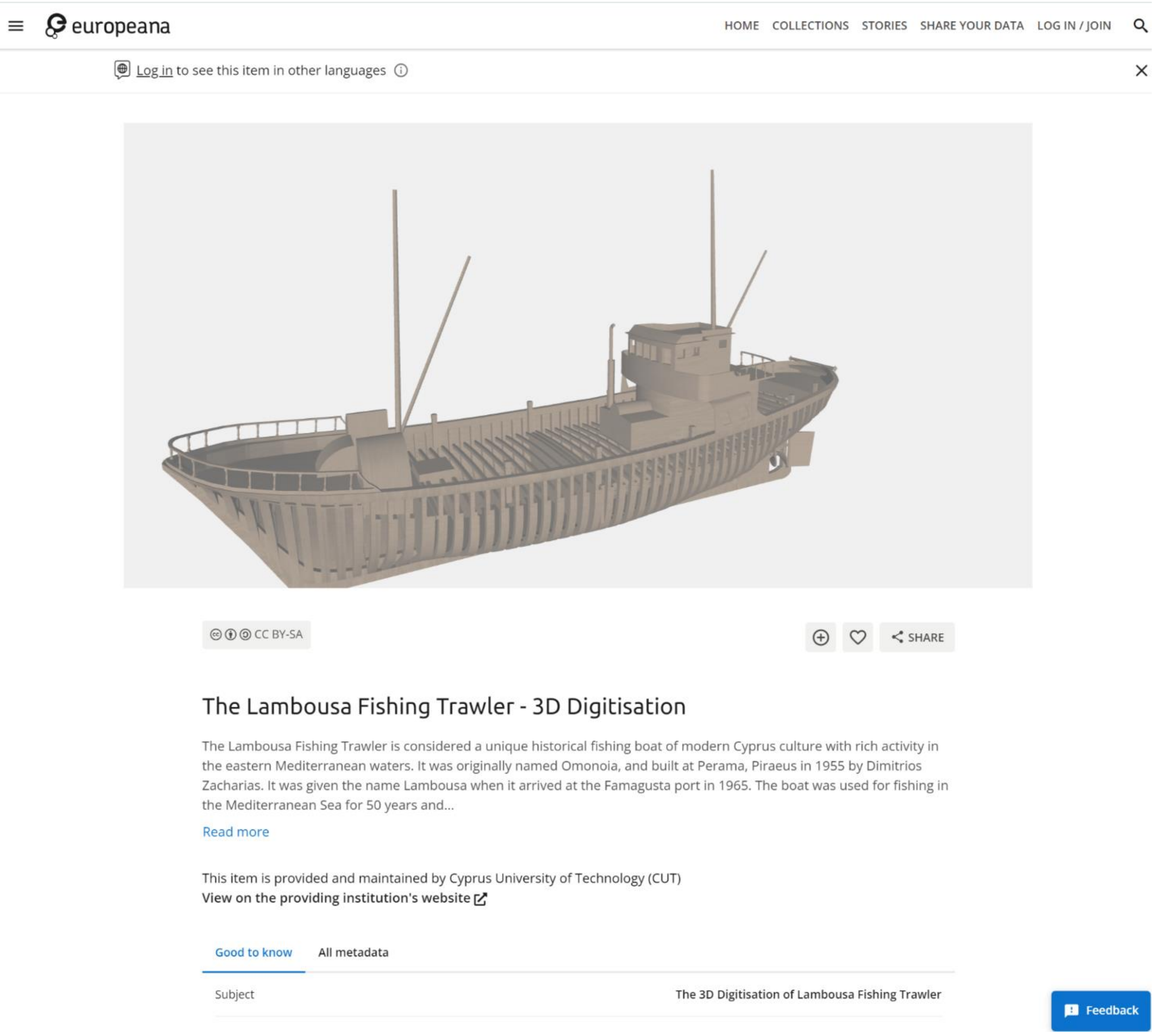
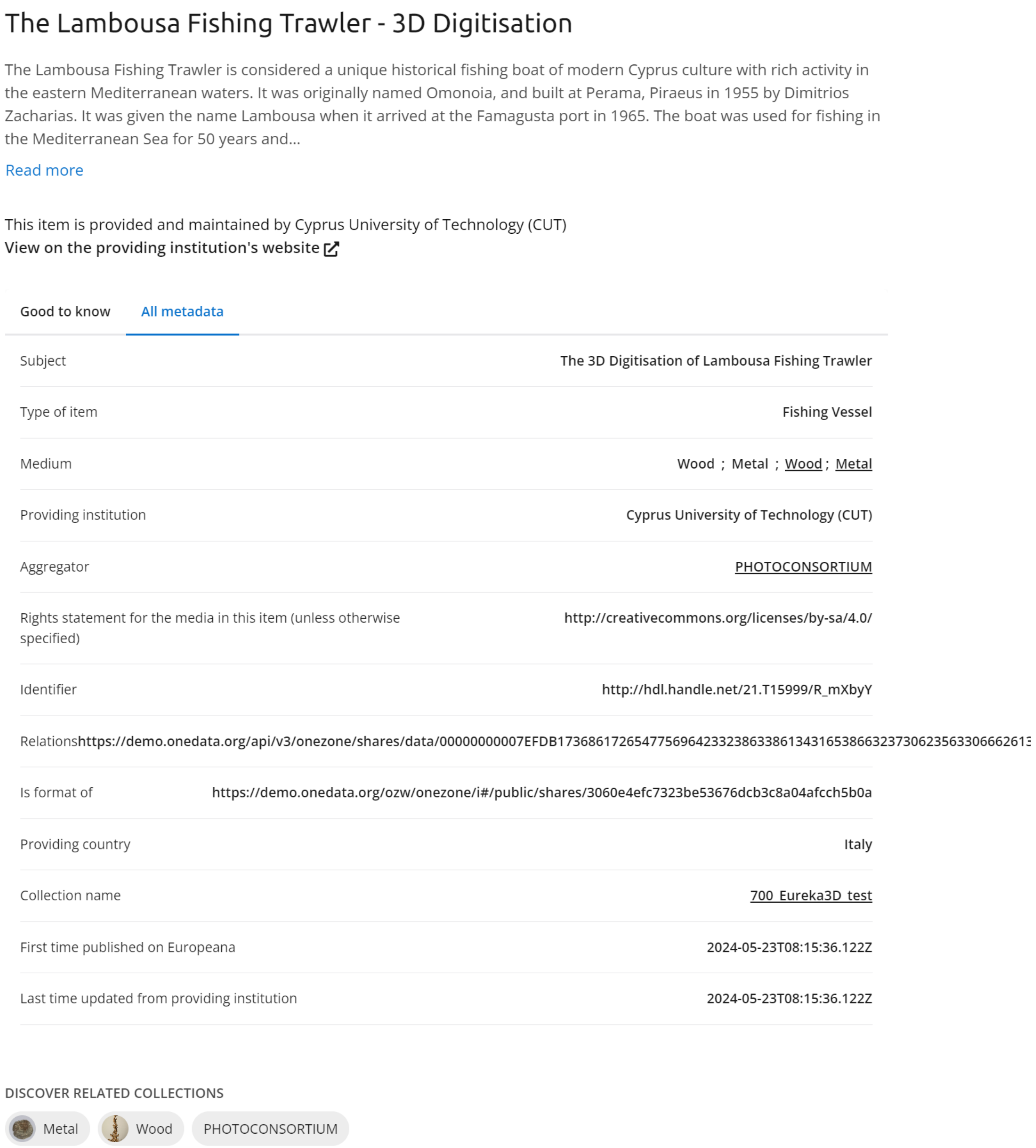


Figure 49: The record as appearing on Europeana, with the object showcasing in the embedded 3D Viewer provided via the EUreka3D Data Hub.



The Lambousa Fishing Trawler - 3D Digitisation

The Lambousa Fishing Trawler is considered a unique historical fishing boat of modern Cyprus culture with rich activity in the eastern Mediterranean waters. It was originally named Omonoia, and built at Perama, Piraeus in 1955 by Dimitrios Zacharias. It was given the name Lambousa when it arrived at the Famagusta port in 1965. The boat was used for fishing in the Mediterranean Sea for 50 years and...

Read more

This item is provided and maintained by Cyprus University of Technology (CUT)
View on the providing institution's website

Good to know | All metadata

Subject	The 3D Digitisation of Lambousa Fishing Trawler
Type of item	Fishing Vessel
Medium	Wood ; Metal ; Wood ; Metal
Providing institution	Cyprus University of Technology (CUT)
Aggregator	PHOTOCONSORTIUM
Rights statement for the media in this item (unless otherwise specified)	http://creativecommons.org/licenses/by-sa/4.0/
Identifier	http://hdl.handle.net/21.T15999/R_mXbyY
Relations	https://demo.onedata.org/api/v3/onezone/shares/data/00000000007EFDB17368617265477569642332386338613431653866323730623563306662613
Is format of	https://demo.onedata.org/ozw/onezone/i#/public/shares/3060e4efc7323be53676dcb3c8a04afcch5b0a
Providing country	Italy
Collection name	700_Eureka3D_test
First time published on Europeana	2024-05-23T08:15:36.122Z
Last time updated from providing institution	2024-05-23T08:15:36.122Z

DISCOVER RELATED COLLECTIONS

Metal | Wood | PHOTOCONSORTIUM

Figure 50: Europeana record, showcasing all metadata.

Figure 51, 52: From the Stakeholder's request up to the finalisation of the record in Europeana, thus offering a 3D model to be used and reused over the cloud: the Lambousa Fishing Trawler digitization project and results presented and handled to Limassol authorities, at Cyprus University of Technology

Figure 53: Presenting the Lambousa Fishing Trawler at the high-level TwinIt! event in Brussels, demonstrating the holistic approach in recovering and digitizing a national monument, that documents its memory from the production up to becoming the first floating museum in Cyprus. In the center of the image, the Deputy Minister of Culture of the Republic of Cyprus Lina Kassianidou together with Marinos Ioannides (CUT) and Antonella Fresa (Photoconsortium).

CONCLUSIONS

This deliverable illustrates the work carried out in the EUreka3D project to enable innovative and high quality digitisation workflows for cultural heritage institutions who approach 3D digitisation projects. This pilot action is based on the VIGIE 2020/654 Study on Quality in 3D Digitisation of Tangible Cultural Heritage and the tools developed in the EUreka3D Data Hub, a platform dedicated to storage, collections management and sharing.

To achieve this, four partners of the project digitised a variety of heritage objects, according to recommendations set out in the VIGIE 2020/654 Study. Two content providers (CUT and Bibracte) did the digitisation using their in-house expertise, resources and equipment. The other two (CRDI and MUSEO DELLA CARTA) outsourced the digitisation to specialised companies, selected according to specific requirements and taking into account the recommendations set in the VIGIE Study as a term of reference, to grant the high quality digitisation result.

The four content providers received support, guidance and training on best practice on high quality digitisation and metadata/paradata collection; on the use of the EUreka3D Data Hub; and on the requirements for Europeana publication.

Estimates of the complexity for the digitisation action and appropriate planning and quality checks were done on various levels by content providers, adapting the digitisation planning to their own specific needs and object peculiarities.

The items digitised in 3D by partners in the project, that are currently being prepared for aggregation to Europeana according to the quality requirements of the EPF Europeana Publishing Framework, are the following:

- Partner CUT: n. 3 high quality models of Cypriot heritage: (a) the Holy Cross / Timios Stavros in Pelendri village, (b) the Chrysorrogiatissa Monastery in Paphos district and (c) the oldest fishing trawler of Cyprus, called “Lambousa”, which has also been contributed as part of the TwinIt! Campaign and acted as a remarkable best practice for inspiration and learning in the project. A dedicated section of this deliverable is provided to illustrate the best practice in detail.
- Partner CRDI: n. 50 objects of pre-cinema and equipment
- Partner BIBRACTE: n. 250 3D records including museal objects and typological 3D models of ceramic tableware, plus 250 photogrammetric terrain models of the archaeological site
- Partner MUSEO DELLA CARTA: n. 2 ancient paper moulds from the museum’s collections

The resulting files and their corresponding metadata and paradata are holistically managed, visualised and shared via the EUreka3D Data Hub, which also allows partners to prepare the collections for upcoming publication in Europeana by the end of the project.

The digitisation journey of the four content providers, with lessons learnt and experience gained for others to be inspired, will be shared publicly as case studies, and also published in the Final Booklet due M24 and presented at the Final conference in Girona on 13 December 2024.