5. EUreka3D case studies

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.

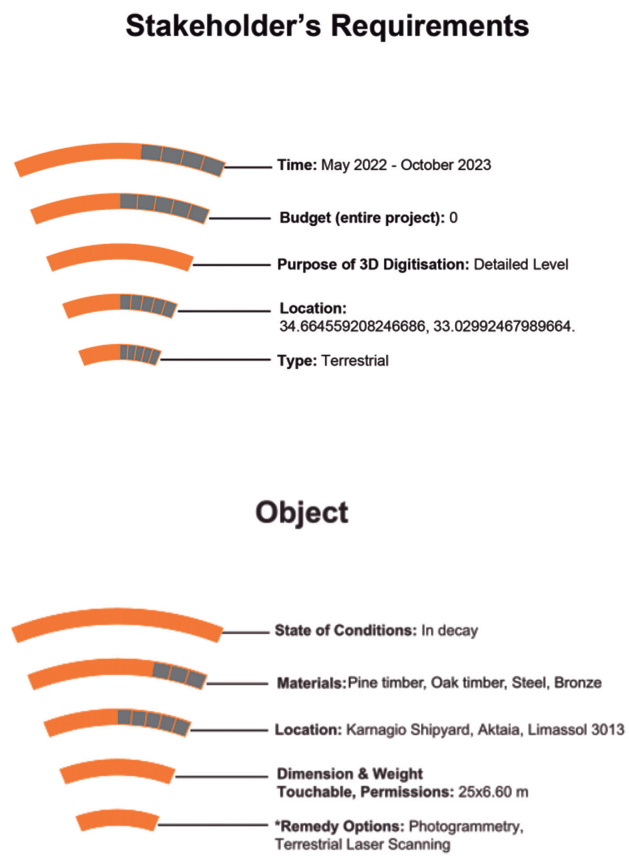


Figure 14. Estimation of complexity for Stakeholder's requirements and Object

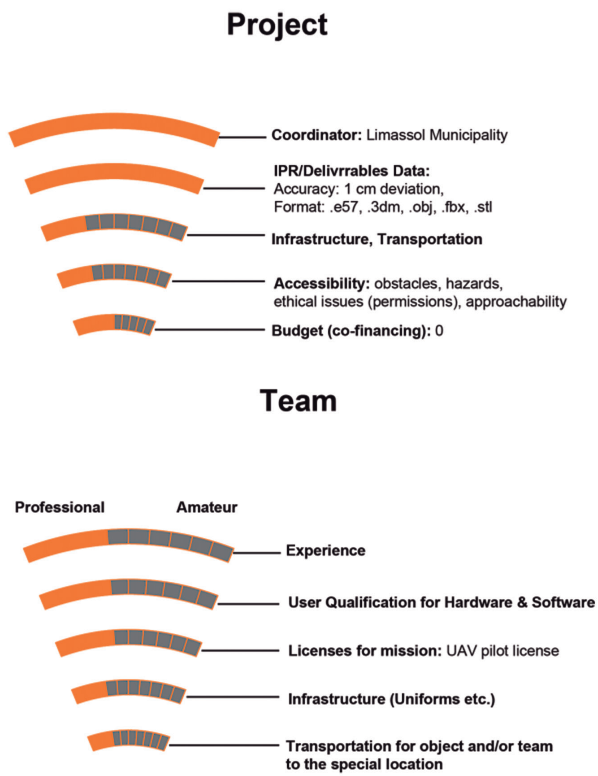
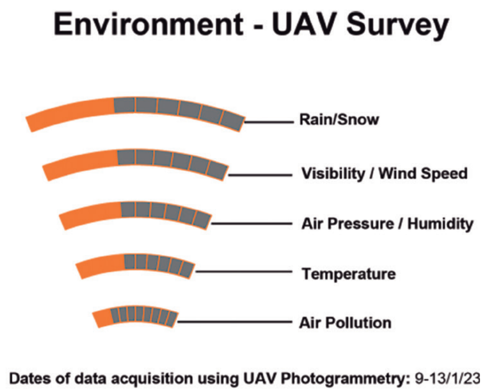


Figure 15. Estimation of complexity for Project and Team



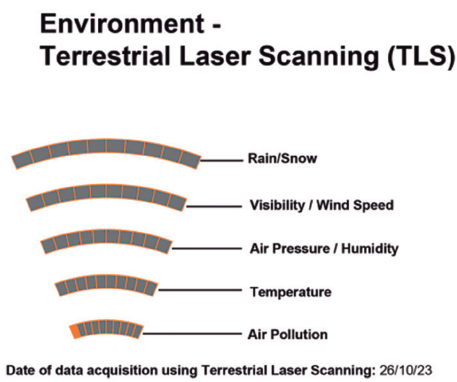


Figure 16. Estimation of complexity for Environmental conditions of UAV and TLS Survey

ENVIRONMENTAL CONDITIONS - UAV

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 17. UAV Environmental data

ENVIRONMENTAL CONDITIONS - TLS

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 18. TLS Environmental data

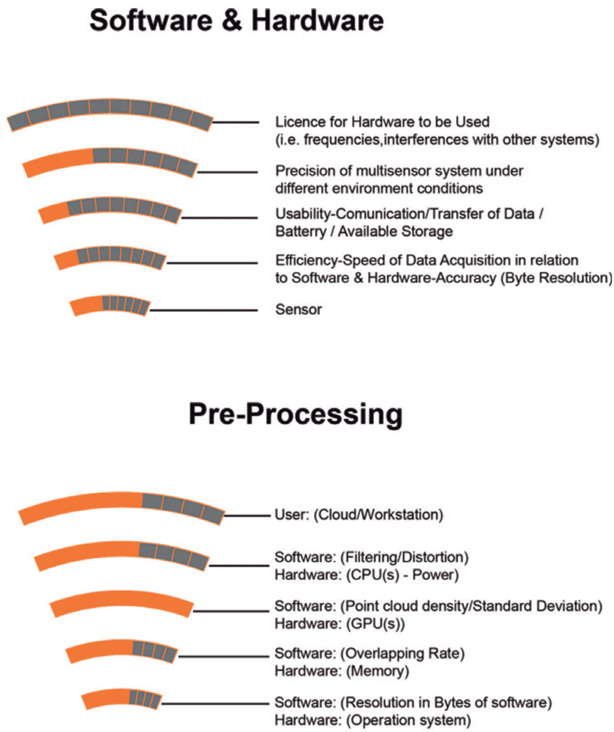


Figure 19. Estimation of complexity for Software, Hardware and pre-processing

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.

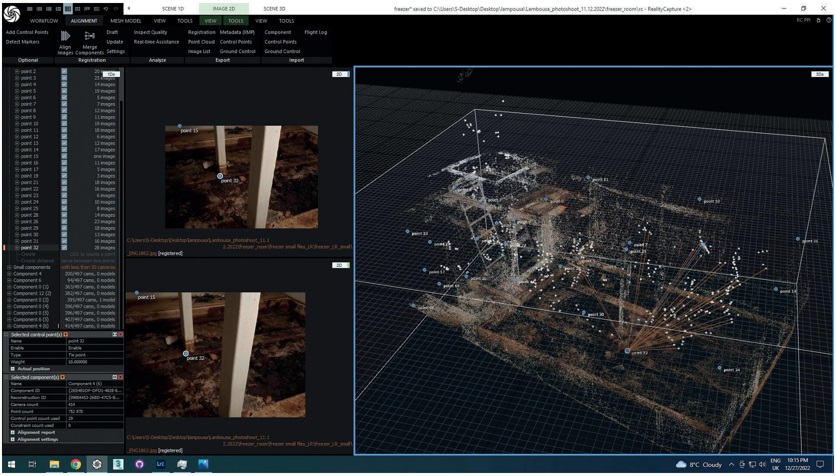


Figure 20. UAV Photogrammetric survey

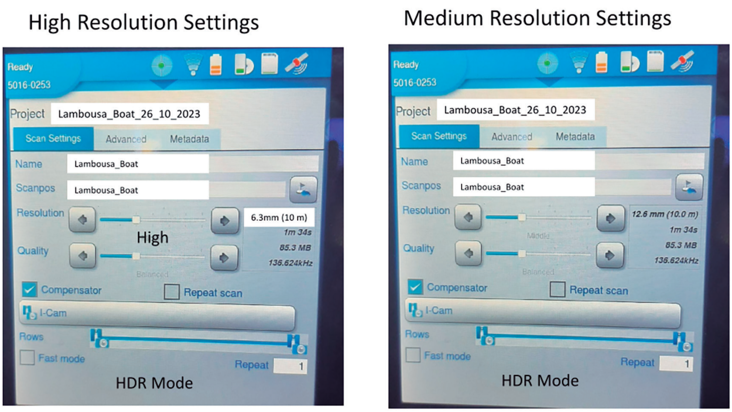


Figure 21. Laser Scanner settings

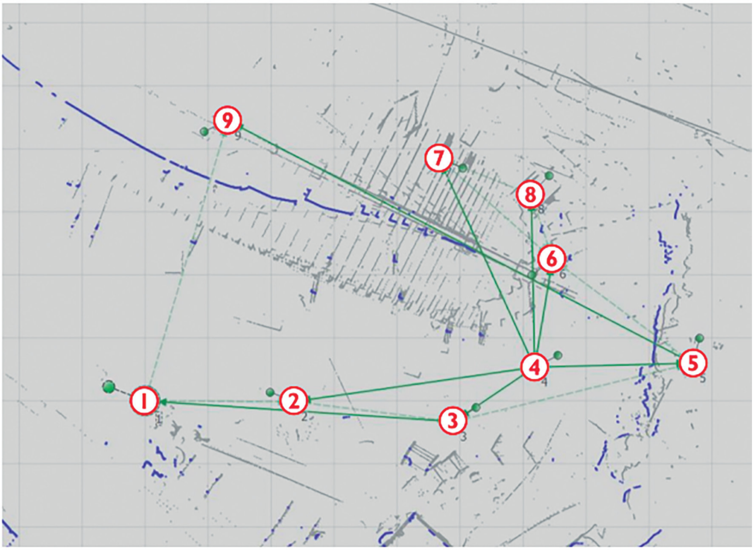


Figure 22. Scanning positions

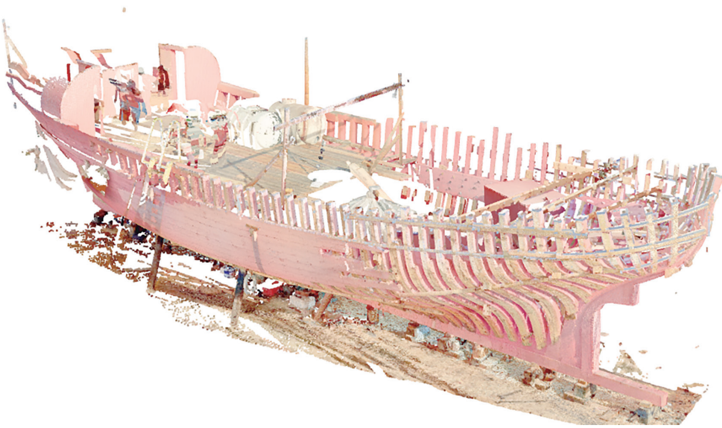


Figure 23. TLS Point Cloud result

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

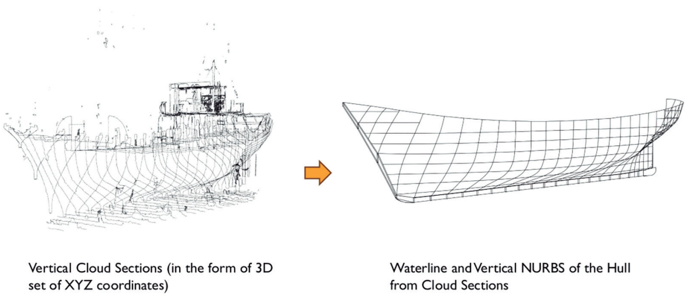


Figure 26. From vertical cloud sections to NURBS curves

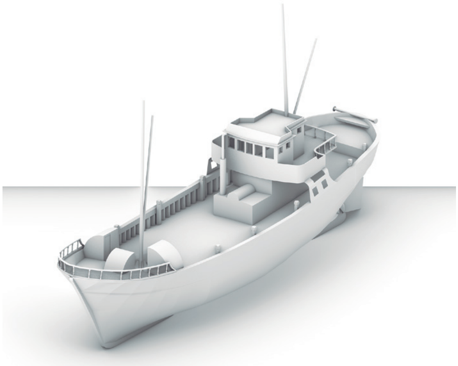


Figure 27. 3D Axonometric of the trawler

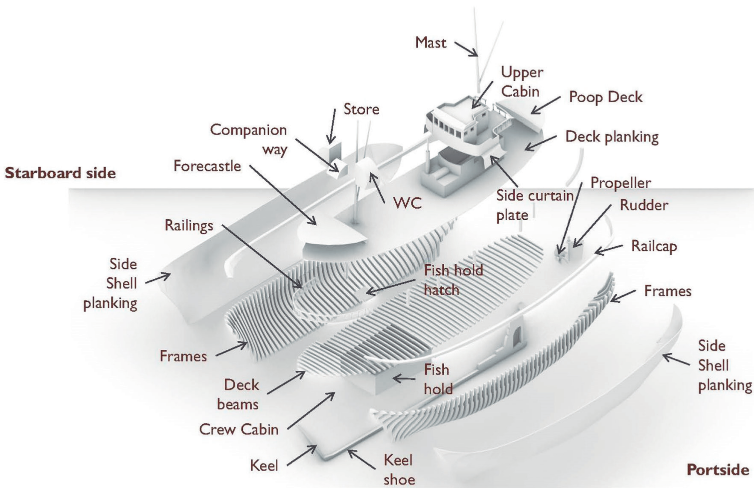


Figure 28. 3D Exploded Axonometric of the trawler

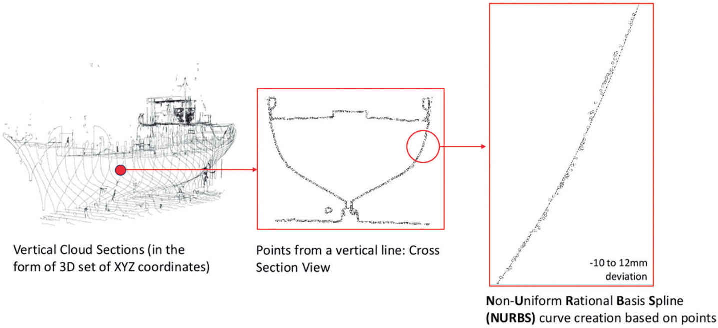


Figure 29. Deviation Analysis

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.

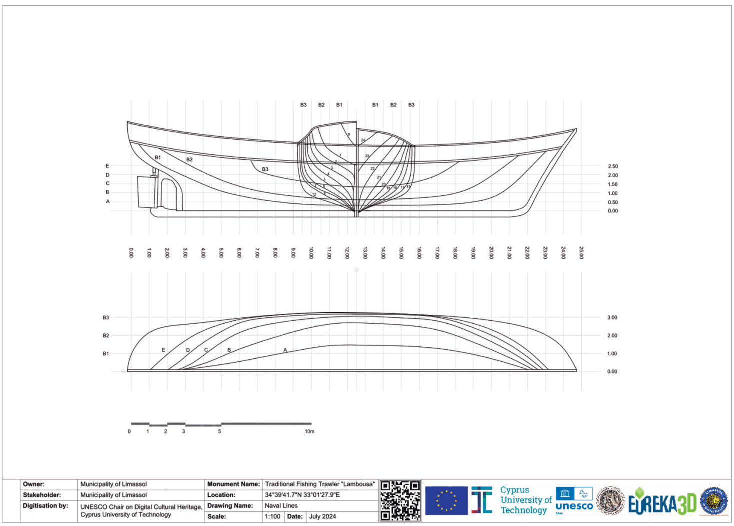


Figure 30. Naval Lines

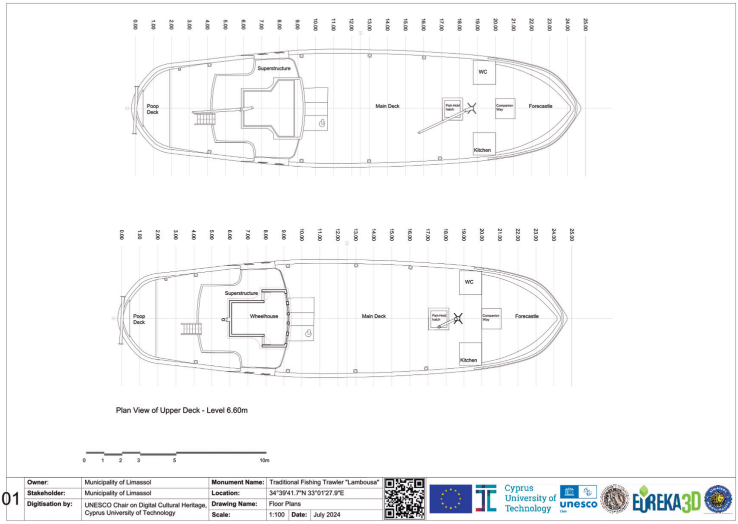


Figure 31. Plan View

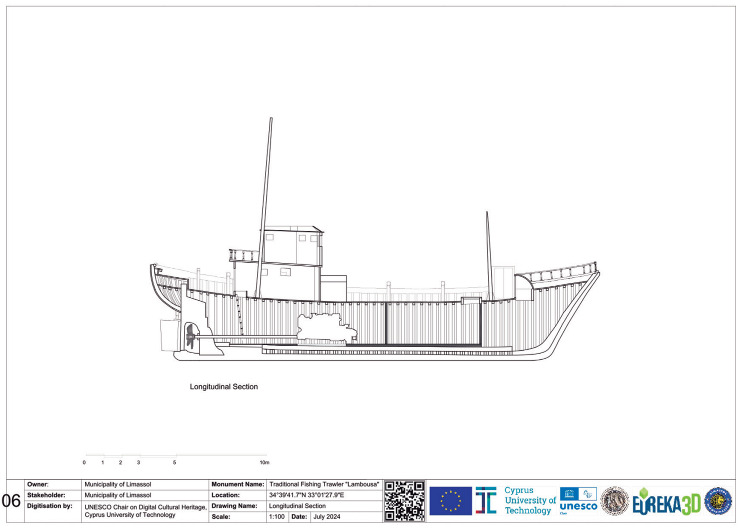


Figure 32. Longitudinal Section

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.

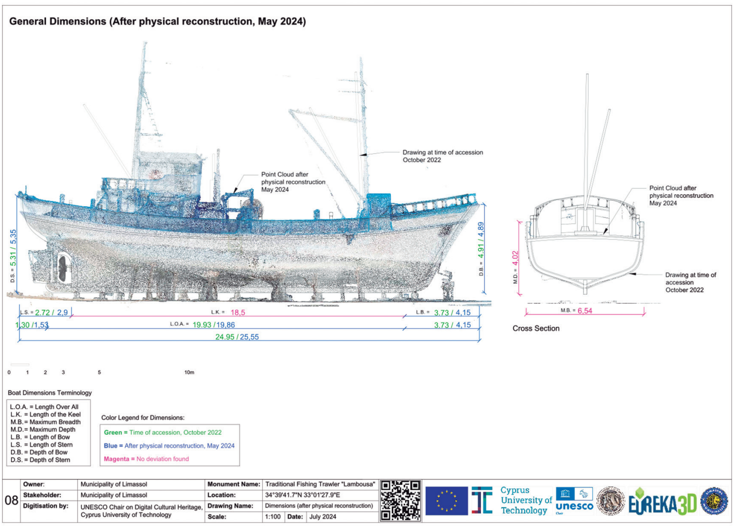


Figure 33. Deviation of physical reconstruction compared to the vessel at time of accession

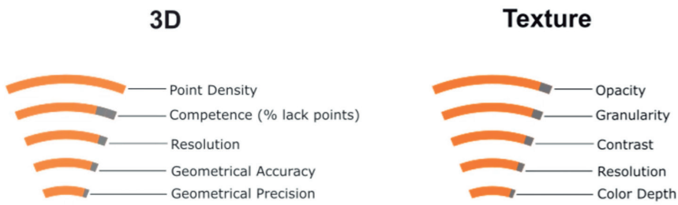


Figure 34. Estimation of quality for 3D and Texture

Figure 35. Estimation of quality for Scale and Materia

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

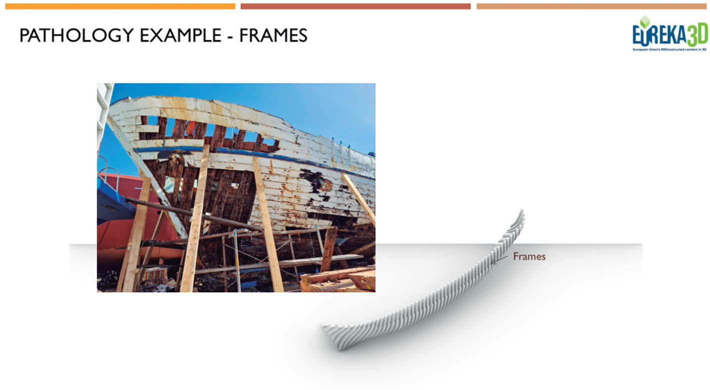


Figure 36. Timber frames and their corresponding pathology

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[1] 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.

1 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.[2] 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.

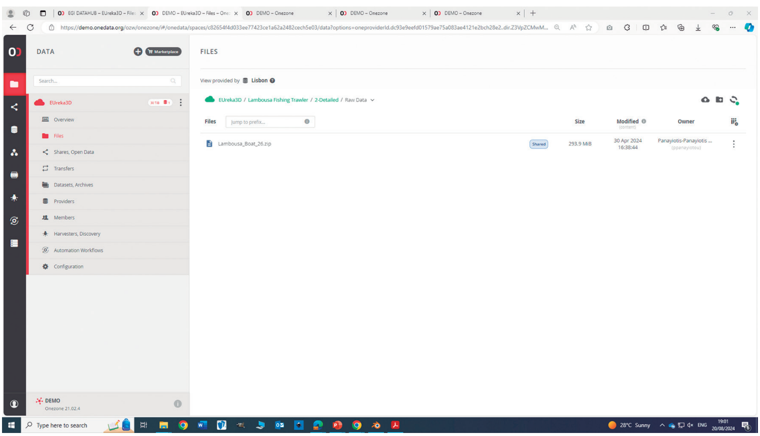


Figure 37. EUreka3D Data Hub platform

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

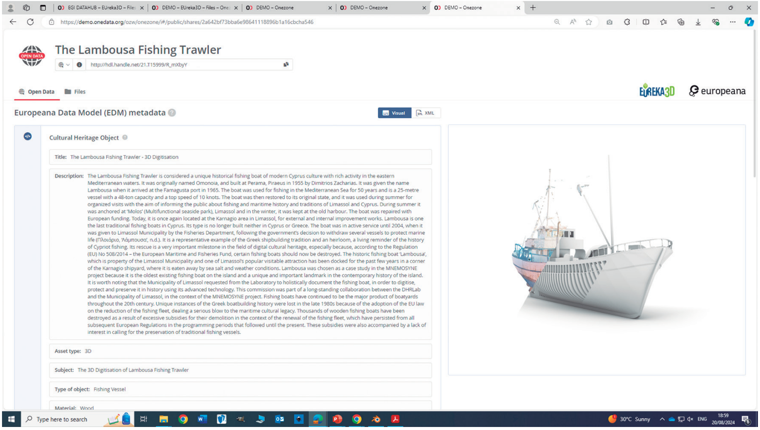


Figure 38. Metadata as displayed in the EUreka3D Data Hub

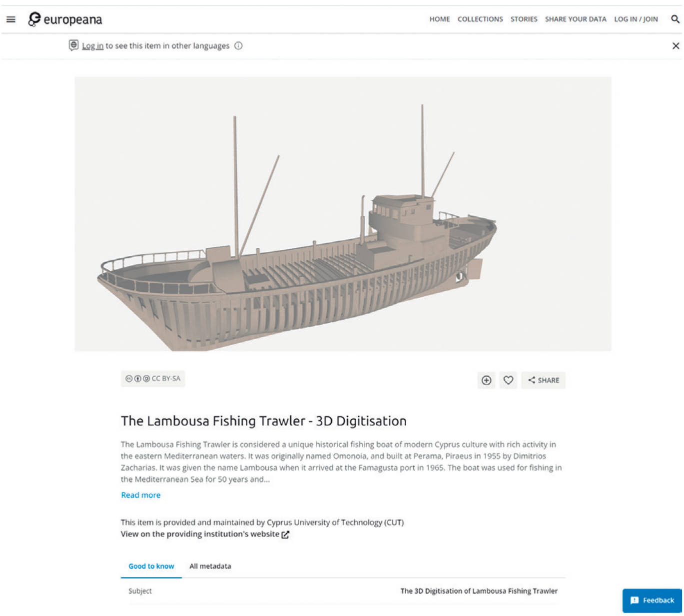
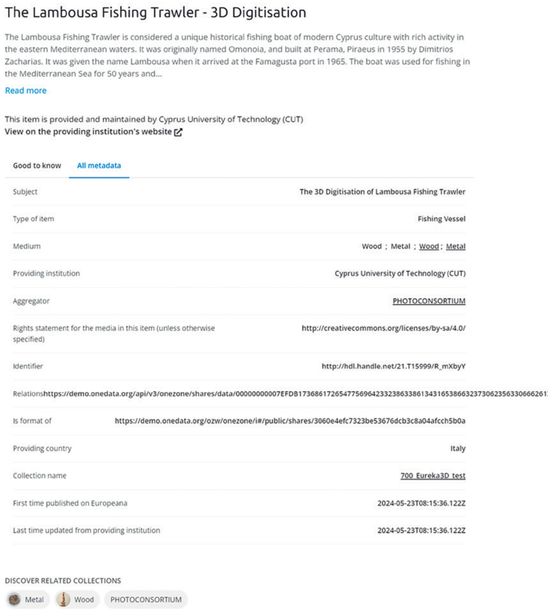


Figure 39. The record as appearing on Europeana, with the object showcasing in the embedded 3D Viewer provided via the EUreka3D Data Hub



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 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.

PARTNERS

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www.digitalmeetsculture.net

Co-funded by
the European Union

EUreka3D project is co-financed by the Digital Europe Programme
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