



fRamework for safE, opEn, collaboratiVe And inclUsive digitisAtion and management of cultural heritagE

Grant Agreement No 101132389

DELIVERABLE 2.4:

Cultural Items Identification & Digitisation

Work Package: 2

LEAD BENEFICIARY:

3D Research (3DR)

Delivery Date: 30.04.2026

Document Sheet

Project acronym	REEVALUATE
Project full title	Framework for safe, open, collaborative and inclusive digitization and management of cultural heritage
Programme	Horizon Europe
Topic	HORIZON-CL2-2023-HERITAGE-01-03
Type of Action	HORIZON-Research and Innovation Actions
Grant Agreement	101132389
Start day	1 January 2024
Duration	36 months

LEGAL NOTICE

This project has received funding from the European Union Horizon Research and Innovation programme under grant agreement No 101132389. Neither the European Commission nor any person acting on behalf of the Commission is responsible for the use, which might be made, of the following information. The views expressed in this report are those of the authors and do not necessarily reflect those of the European Commission.

©REEVALUATE Consortium, 2025

Reproduction is authorised provided the source is acknowledged.

Deliverable number	D2.1
Deliverable name	Identification and digitisation of CH artefacts for the use during pilot phase
Lead beneficiary	3D RESEARCH
WP	2
Related task(s)	2.1
Type	Deliverable
Reviewers (Organisation)	MoMu, SPK
Delivery date	30.04.2026
Main author(s)	Fabrizio Fuoco (3DR)
Contributor(s)	Dieter Suls (MOMU), Chiara Gransinigh (AQUILEIA), Andrea Donda (AQUILEIA), Maria Oulouki (OLY), Deniza Popova (SPK), Maurice Mengel (SPK), Marco Cozza (3DR)

Dissemination level

PU	Public	X
SEN	Sensitive, limited under the conditions of the Grant Agreement	
Classified UE/EU-R	R-	EU RESTRICTED under the Commission Decision No2015/444
Classified UE/EU-C	C-	EU CONFIDENTIAL under the Commission Decision No2015/444
Classified UE/EU-S	S-	EU SECRET under the Commission Decision No2015/444

Document history

Version	Date	Changes	Reviewer/Contributor
0.1	27.02.2026	Table of contents	3DR
0.2	06.03.2026	Creation of First draft and general sections	3DR
0.3	11.03.2026	Contribution to chapters 2 and 4	3DR
0.4	16.03.2026	Invite partners to contribute	Task Partners, 3DR
0.5	26.03.2026	Contribution to chapters 2, 3, 4, 5	AQUILEIA, OLY, MOMU
0.6	07.04.2026	Integration of partner contribution	3DR
0.7	16.04.2026	Contribution to chapters 2, 3, 4, 5	SPK
0.8	17.04.2026	Integration of partner contribution	3DR
0.9	20.04.2026	Deliverable shared for internal review	3DR
1.0	27/04/2026	Internal review completed, in-text comments and reviews	MOMU
1.1	27/04/2026	Fixing suggestions and comments	3DR
1.2	27/04/2026	Internal review completed, in-text comments and reviews	SPK
1.3	28/04/2026	Fixing suggestions and comments	3DR

Table of contents

Publishable summary	10
1 Introduction.....	11
1.1 Purpose of the deliverable.....	11
1.2 Relation with other deliverables	12
2 Cultural Heritage Institutes and typology of artefacts	14
2.1 Cultural Heritage Institutes and artefact collections	15
2.1.1 Pilot 1 – Fashion Time Machine – MoMu	15
2.1.2 Pilot 2 – From Museums to Screens – Olympic Museum of Thessaloniki, Ethnologisches Museum of Berlin.....	16
2.1.3 Pilot 3 – From Public Sensing to Virtual Tours – Aquileia archaeological area.....	17
2.2 Results of the preliminary survey on the CHI's collections	19
2.2.1 Pilot 1 – Fashion Time Machine	22
2.2.2 Pilot 2 – From Museums to Screens.....	23
2.2.3 Pilot 3 – From Public Sensing to Virtual Tours	23
3 Selection of CH artefacts for the Piloting phase	25
3.1 Pilot 1	25
3.2 Pilot 2	27
3.2.1 SPK	27
3.2.2 OLY.....	28
3.3 Pilot 3	28
3.3.1 Selection of CH Assets	28
3.3.2 Participatory prioritisation phase	29
4 Digitalisation of the selected CH artefacts	30
4.1 Overview of techniques and technologies for digitising Cultural Heritage artefacts	31
4.1.1 Pilot 1	38
4.1.2 Pilot 2	41
4.1.3 Pilot 3.....	47
5 Results	55
5.1 Pilot 1	55
5.2 Pilot 2	56
5.2.1 SPK	56



5.2.2	OLY	57
5.3	Pilot 3	59
6	Conclusion	61
	References.....	62
	Annex 1	63

List of Figures

Figure 1. Context of Task 2.1 in the REEVALUATE framework.....	12
Figure 2. Workflow followed during T2.1 activities.....	14
Figure 3. Example of MoMu digital collection. Source: https://heron.libis.be/momu/s/studiecollectie/page/welcome	16
Figure 4. Exhibit room of the Olympic Museum of Thessaloniki.	17
Figure 5. Part of Aquileia archaeological area.....	18
Figure 6. Result of preliminary mapping of needs across Pilot partners.	21
Figure 7. Example of a published pattern of an object from the study collection. https://data.momu.be/ark:34546/mm3843	22
Figure 8. Example of informative header of a published pattern from the Reevaluate-longlist (Trousers of Cycling ensemble: https://data.momu.be/ark:34546/mrjdw4)	26
Figure 9. Example of a digital camera with an interchangeable lens (on left); example of a photographic setup using a homogenous background, multiple light sources and light diffusers (on right).	31
Figure 10. Commercial palette for colour correction. Source: www.calibrite.com	32
Figure 11. Example of SLS in digitising Cultural artefacts.	33
Figure 12. 3D digitising of a vase by photogrammetry.....	34
Figure 13. Drone survey with planned path and overlapping images (on top); example of 3D model (on bottom).....	35
Figure 14. Example of choosing different values of GSD and the impact on final results.....	35
Figure 15. Example of metadata schema for a Digital Object. Source: Pilot 3 collection.	37
Figure 16. Image Pattern-a-thon – Matthias De Boeck	38
Figure 17. On left: Example of a raster image (jpg) of a paper cutting pattern (Object ST572 – Study collection). On right: Example of vectorised pattern (published as PDF), of object ST572 – Study Collection).....	39
Figure 18. Example of creating a 3D asset from a digital pattern in CLO3D.	40
Figure 19. Left: Waza trumpet in the Berlin collections today, right: fieldwork photo by Artur Simon of similar instruments in Sudan in 1983. Staatliche Museen zu Berlin, Ethnologisches Museum.	42
Figure 20. Images from the dataset.	43
Figure 21. Images during the digitisation process.	44
Figure 22. Process of mesh optimisation of Tokyo 2020 shoes.	45
Figure 23. Post-processing operation on the fencing mask and final 3D object.....	45
Figure 24. Example of final digital objects in 3D.....	46

Figure 25. Process for creating 3D models of medals, starting from high-resolution images and the preliminary 3D model to the final objects..... 46

Figure 26. A set of codified markers in the dataset (on top) and measures in the cloud point (on bottom)..... 50

Figure 27. Dense cloud of the area (on top) and segmentation of the same cloud point in three classes (on bottom)..... 50

Figure 28. Screenshot from the 3D model of the archaeological area. From the top: mosaic, oven, stone well..... 51

Figure 29. Screenshot from the 3D modelling environment while reconstructing the modern coverage on the ancient area..... 52

Figure 30. Digitisation of an immovable object..... 54

Figure 31. Digitisation of movable objects. 54

Figure 32. Colour correction, white balance and measure recording while digitising an oil lamp. 54

Figure 33. Some 3D objects obtained from the digitisation campaign..... 60

List of Tables

Table 1. General classification of the three Pilots. 21

Table 2. Technical data of Pilot 3 digitising in the Domus of Titus Macrus..... 49

Table 3. Technical data of Pilot 3 digitising in the National Archaeological Museum of Aquileia.. 53

Table 4. MoMU digital objects collected..... 55

Table 5. The Berlin Phonogramm-Archiv 1900–2011 56

Table 6. Digital Objects produced and delivered for Pilot 2 – OLY. 58

Table 7. Digital Objects produced and delivered for Pilot 3 – AQUILEIA. 59

Abbreviations

Abbreviations	Full name
CH	Cultural Heritage
WP	Work Package
D	Deliverable
T	Task
M	Month
3D	Three dimensional
VR	Virtual Reality
CHIs	Cultural Heritage Institutes
MB	Megabytes
SfM	Structure from Motion
GSD	Ground Sampling Distance
DAMS	Digital Asset Management Systems
SLS	Structured Light Scanner
DSLR	Digital Single-Lens Reflex
GLB	Graphics Library Binary
OBJ	Wavefront Object
JPEG	Joint Photographic Experts Group
PNG	Portable Network Graphics
GPS	Ground Positioning System
GCP	Ground Controlled Point

Publishable summary

The deliverable D2.4 is the second part of D2.1 and outlines the results of Task 2.1 "Cultural Items Identification & Digitisation" within the REEVALUATE project. The task aimed to identify and prepare a curated selection of cultural heritage artefacts—both existing digital resources and newly digitised content—for use in three pilot actions. Through collaboration with Cultural Heritage Institutions (CHIs) across Europe, the project mapped the availability, quality, and metadata standards of digital collections and supports small-scale digitisation where gaps were identified. This specific section highlights the artefacts digitisation and digital restitution for Task 4.4 use.

The preparatory work has permitted the development of a common methodology, a harmonised documentation and representation of artefacts across the three identified domains: fashion heritage (Pilot 1), Olympic and ethnographic culture (Pilot 2), and Roman archaeology (Pilot 3).

1 Introduction

This deliverable reports on the second phase of Task 2.1, *Cultural Items Identification and Digitisation*, within the REEVALUATE project. It builds on the initial survey of Cultural Heritage Institutions (CHIs). It consolidates the activities undertaken to identify, select, describe, and digitise Cultural assets for use in the project's three Pilot actions. By combining already digitised resources with newly produced digital surrogates, the task established the content base required to support pilot development and validation.

It is clearly known that producing high-fidelity digital representations of physical artefacts [1] brings to multiple advantages:

- It allows for seamless sharing and collaboration between researchers, museums, and institutions across the globe [2];
- It enhances the understanding of cultural items by integrating and aggregating heterogeneous data, including historical, artistic, material, and conservation-related information;
- It contributes to digital preservation strategies that safeguard artefacts against physical degradation or loss [3];
- It supports the creation of interactive tools, educational products, and immersive experiences for museums, galleries, and cultural organisations [4];
- It enables the reuse of digital objects in diverse contexts, such as virtual exhibitions, gaming environments, and creative industries [5].

The work in the REEVALUATE Project was carried out through a shared methodology designed to harmonise the documentation of artefacts across the three pilot domains: fashion heritage, Olympic and ethnographic culture, and Roman archaeology. In each case, the selection of assets was guided by thematic relevance, metadata quality, technical suitability, legal considerations, and the specific needs of the pilot use cases, resulting in curated collections tailored to the REEVALUATE framework.

In addition, the deliverable outlines the main digitisation technologies and workflows applied to cultural heritage materials, as well as the metadata approach adopted to support interoperability, reuse, and future integration of the selected assets within the project infrastructure.

The document is structured as follows:

- First section recalls the composition of Pilot partners (CHIs) and their collections, showing preliminary results from D2.1;
- Second section highlights the decisional process in the selection of artefacts, from used enablers to description and digitization availability;
- The third section explores the digitisation process and preparation of Digital Objects for pilot development.

1.1 Purpose of the deliverable

D2.4 consolidates the activities of Task 2.1 "*Cultural Items Identification & Digitisation*", building a process aimed at finalising the selection, enrichment, and preparation of cultural heritage assets for the REEVALUATE Pilots. It details the refined artefact selections across the three pilots following preliminary surveys, participatory prioritisation, and tailored digitisation workflows, resulting in curated digital collections ready for framework integration and testing. D2.4 provides comprehensive documentation of

the iterative selection processes, digitisation technologies (including 2D/3D scanning and photogrammetry), metadata harmonisation (aligned with CIDOC-CRM and CACAO ontologies), and the production of interoperable assets such as high-resolution images, 3D models, and patterns. As the final deliverable of T2.1, it ensures these resources support pilot execution, validation of REEVALUATE enablers, and long-term reuse within the project's Knowledge Graph and Marketplace.

The key outcomes of this deliverable explain and highlight the process, from identification to selection and/or digitisation (where needed):

- Pilot-Specific Collections: finalised datasets with enriched metadata, legal clearances, and technical specifications for immediate use in demonstrations;
- Digitisation Advancements: extended coverage of 3D reconstruction techniques and public-sensing campaigns to address initial gaps identified in D2.1;
- Interoperability Focus: standardised documentation enabling seamless integration into REEVALUATE's technical ecosystem.

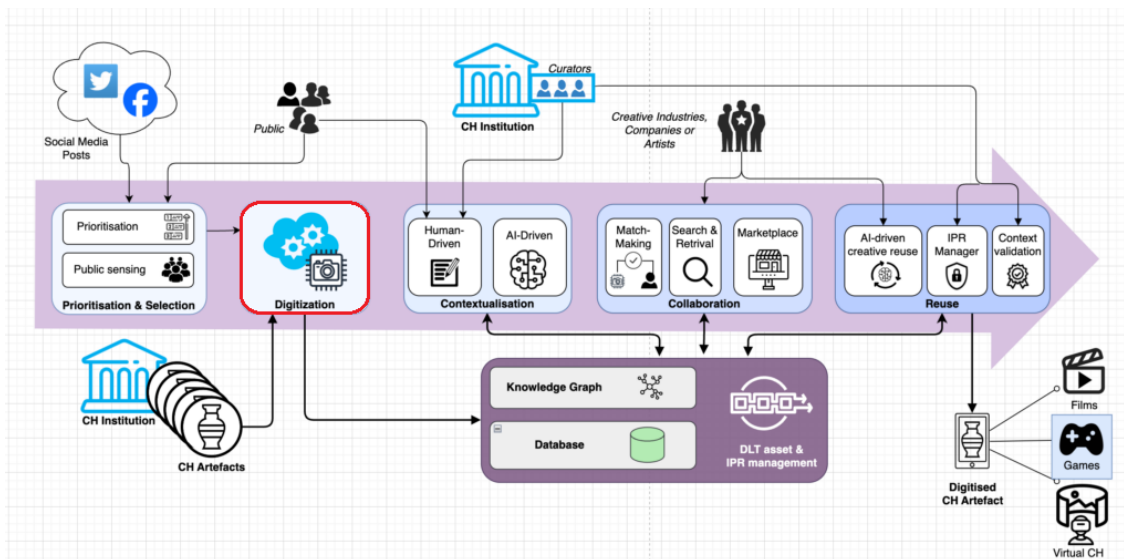


Figure 1. Context of Task 2.1 in the REEVALUATE framework.

1.2 Relation with other deliverables

This deliverable is positioned inside the workflow of the REEVALUATE Project, benefiting from the contribution of the first part of this deliverable, named **D2.1**. D2.1 aimed to initiate Task 2.1 by identifying Cultural Heritage Institutions (CHIs) and mapping available digital collections across the three REEVALUATE pilots, establishing initial test cases for framework validation. The deliverable focused on verifying artefact availability, formats, metadata quality, and reuse conditions, while proposing small-scale digitisation to address gaps in pilot requirements

D1.3 “User needs & User scenarios”, which aims to integrate the outcomes of the previous two tasks to define a comprehensive set of user needs and usage scenarios, also helped CHIs in the identification and selection of needs for the REEVALUATE framework and its tools, and was useful for conducting T2.1 preliminary activities and releasing D2.1.

Most important contribution to the development of Task 2.1 comes from **D2.2** “Public Sensing Prioritisation Enabler”, considering that the Task focuses on the development of a digital enabler to support the **democratised prioritisation of cultural artefacts for digitisation**, ensuring that people’s preferred objects are correctly used inside the digital experiences. In fact, the loop of the process for Pilot 2 and Pilot 3 was driven by the use of the developed tool, which allowed the general public to choose and prioritise artefacts via the public sensing enabler, driving the decision-making process of pilot development.

Relevant contributions also come from **Task 4.1** (and so, **D4.1**) “Pilot planning and validation methodology definition”, in which the Institutes better clarify the road to follow during the development, explaining the starting point and the result to achieve.

2 Cultural Heritage Institutes and typology of artefacts

Understanding Cultural Heritage Institutions (CHIs) involved in the REEVALUATE project, along with the typology of collections, is a critical step in establishing robust test cases for validating the REEVALUATE framework and its enablers. While large-scale digitisation remains outside the project's scope, accessing a sufficient number of already digitised artefacts and conducting targeted small-scale digitisation ensures the pilots' operational viability and technical relevance.

Building on the preliminary mapping from D2.1, the methodology for D2.4 involved iterative consultations with each CHI to assess existing digital collections against pilot-specific needs, including formats (e.g., high-resolution images, 3D models, SVG patterns, audio tracks), metadata richness, and reuse conditions. Special emphasis was placed on quality, interoperability (via CIDOC-CRM and CACAO alignment), privacy and legal clearance, with participatory public-sensing campaigns and expert curation used to prioritise assets where initial resources fell short.

The results of D2.1 highlighted some important aspects of CHI's collections:

- Preliminary mapping and survey of digitised collections highlighted the already existing digital collections and their digital representation (images, 3D models, texts, audio) for fashion heritage (Pilot 1), Olympic culture and ethnographic (Pilot 2), and Roman archaeology (Pilot 3);
- Metadata strengths and weaknesses were identified, and helped to understand and develop interoperability needs (pre-CIDOC-CRM/CACAO alignment).

These results pointed clearly to a **baseline assessment of institutional digitisation readiness**, producing curated longlists of representative artefacts ready for D2.4 refinement and pilot execution. The process provided curated and enriched collections for each pilot project, specifically designed to demonstrate the potential of REEVALUATE, whilst also offering insights into the maturity of institutional digitisation and the potential for reuse within the cultural sector.

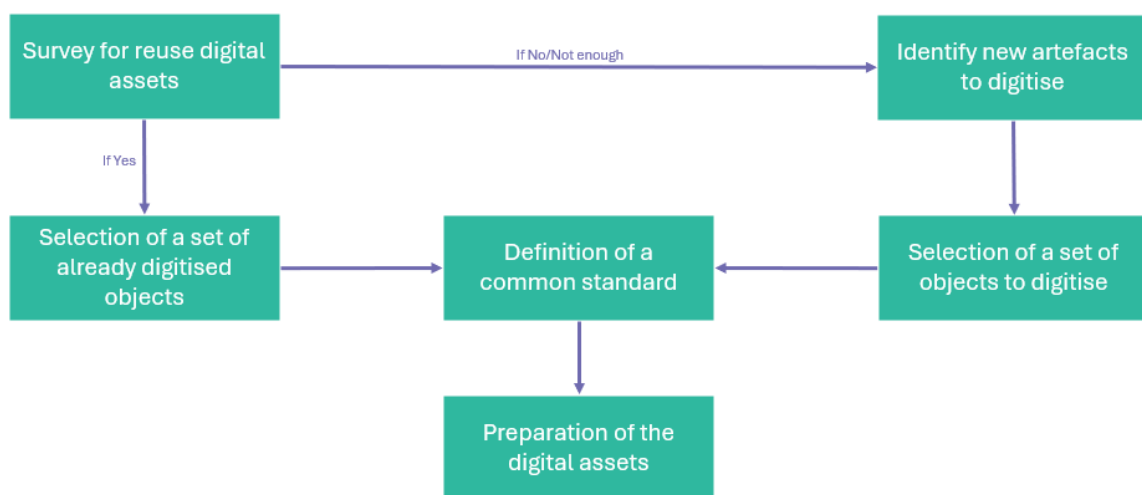


Figure 2. Workflow followed during T2.1 activities.

2.1 Cultural Heritage Institutes and artefact collections

2.1.1 Pilot 1 – Fashion Time Machine – MoMu

The First Pilot involves the collaboration of EFHA, the MoMu – Fashion Museum Antwerp, and the company FibreMood. Following the bankruptcy of partner NURO, their tasks were taken over by CERTH and FFP. The goal is to validate REEVALUATE’s comprehensive framework for managing digitised cultural heritage (CH) artefacts in the **Fashion and Gaming sectors**. The starting point of Pilot 1 is the museum collection of MoMu, and its expertise as a heritage institution. MoMu contributes both the physical artefacts to be digitised and the knowledge necessary to contextualise their cultural and historical significance. In addition, MoMu provides guidance on the appropriate use and interpretation of the artefacts. Pilot 1 will develop two components:

- A functional **Fashion Game** (Game Pilot);
- A published, personalised **sewing pattern** (Pattern Pilot).

Both pilots are based on digital assets provided by MoMu, the pilot lead. The pilot began with a preliminary survey of the collection of fashion heritage artefacts from MoMu, including garments, accessories, and sketches, to identify needs and both digital and physical artefacts that Pilot 1 will work on. The ModeMuseum in Antwerp stands as Belgium's premier institution dedicated to fashion, renowned for its immersive exhibitions and a vast collection that emphasises both historical garments and contemporary design. This Cultural Heritage Institute houses a substantial collection of Western European costumes, textiles, garments, accessories and tools, including over 40.000 objects from the 18th Century until now. It also houses a Study Collection of ca. 2.000 objects, which is, because of its accessibility, open licenses and level of digitisation, very suitable for the REEVALUATE project. All these objects from the Study Collection are **already digitised and described** (with images and metadata) and are accessible through a built-in house online catalogue (using the open-source CMS Omeka-S) that allows users to search and filter historical and contemporary dresses and accessories using filters and classes by period, by materials, techniques, images and by full text.

MoMu will share a selection of the artefacts, including metadata, images and cutting patterns, with FibreMood, a company that publishes a DIY magazine for creatives who love to sew their own garments and helps sewers select fabrics and customise patterns. FibreMood will create the necessary assets for its community (patterns, work descriptions, instructive videos, etc.) to enable its users to recreate garments from MoMu’s Study, enabling them to recreate garments while understanding their historical and cultural context.

The same artefacts and related digital assets will also be provided to CERTH and FFP to develop Fashion Time Machine, a mobile game that lets players design and customise virtual outfits using elements from the digitised collections, allowing users to mix and match clothing and accessories. As will be explained further in this document, MoMu will also create a 3D model of a selection of artefacts, which will be used in the Piloting phase via the integration in the Fashion Game to develop.



Figure 3. Example of MoMu digital collection. Source: <https://heron.libis.be/momu/s/studiecollectie/page/welcome>

2.1.2 Pilot 2 – From Museums to Screens – Olympic Museum of Thessaloniki, Ethnologisches Museum of Berlin

Pilot 2 involves two institutions whose collections effectively represent culture and the integration of different cultures through a shared theme: sport.

The **Ethnologisches Museum**, which belongs to the Prussian Cultural Heritage Foundation (SPK) in Berlin, is one of the world's most significant institutions dedicated to non-European cultural heritage. Founded in 1873, it now resides in the Humboldt Forum, housing a vast collection of artefacts and documents that reflect the diversity and richness of global cultures. The museum's extensive holdings include ethnographic, archaeological, and cultural-historical objects from Africa, Asia, the Americas, Australia, and the Pacific Islands. These are complemented by substantial archives of photographs, films, sound recordings, and written documents, making it one of the most comprehensive collections of its kind. The Museum houses the Berlin Phonogramm-Archiv, one of the world's most significant ethnomusicological sound archives, listed in the UNESCO Memory of the World register. These recordings capture music and speech from various cultures from all continents. Since 2021, the museum has new exhibitions in the Humboldt Forum in the centre of Berlin.

The **Thessaloniki Olympic Museum**, the 1st Olympic Museum in Greece (2004), recognised by the International Olympic Committee (Lausanne 2006), the International Council of Museums (ICOM) and the International Sports Heritage Association (ISHA), narrates, through an Olympic collection of great historical value with more than 10,000 items, the fascinating history of the world's greatest sports event.

As a cultural and educational landmark not only for the city of Thessaloniki but for the whole of Greece, the founding member of the World Network of Olympic Museums has, for over two decades, been a dynamic hub of sports heritage, education, and cultural innovation — a living testament to the enduring ideals of Olympism. In a 4,500 m² museological space with modern architecture, past and present are connected to the global Olympic heritage and the cultural side of sports. The Olympic collection is of enormous historical and emotional value and includes personal items of significant athletes in Olympic history, such as the 1st

Greek Gold Olympians. The collections include remarkable objects with historical value from 1896 till today, which bring to life the significant and special moments of the Olympic Games from antiquity until today. The collections also communicate the ideals of the Olympic Movement. The museum accomplishes the dissemination of knowledge in a unique cultural-educational exhibition space (the Summer and Winter Olympic Games Permanent Exhibition, the Paralympics and Youth Games Permanent Exhibition, and numerous temporary exhibitions).

The Olympic Museum of Thessaloniki stands today not only as a guardian of athletic history but as an active, future-oriented institution that educates, inspires, and connects. Hosted in the birthplace of the Olympic Games, the Museum serves as both a custodian of national heritage and a modern cultural ambassador. It affirms Greece’s enduring legacy in shaping the ideals of athletic excellence, fair play, and peaceful competition—values that continue to resonate across borders and generations.

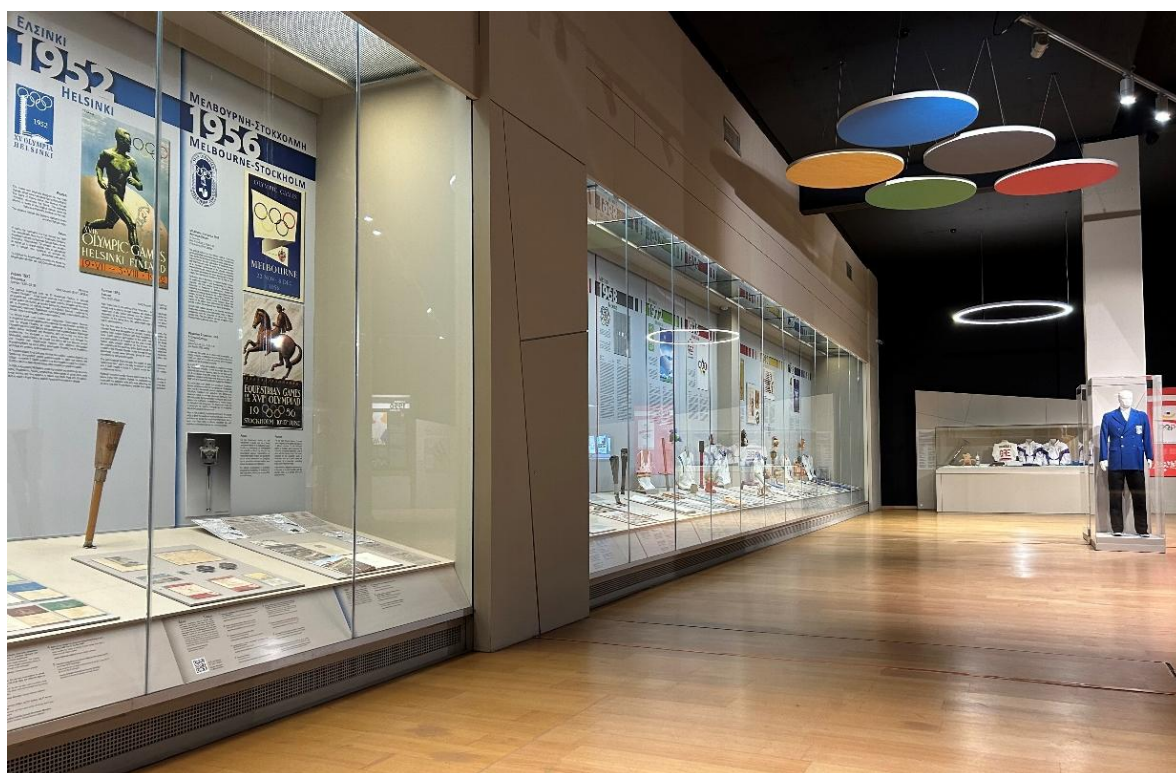


Figure 4. Exhibit room of the Olympic Museum of Thessaloniki.

2.1.3 Pilot 3 – From Public Sensing to Virtual Tours – Aquileia archaeological area

The Aquileia Foundation is a public-private foundation responsible for the management and promotion of state-owned archaeological sites, entrusted to it by the Ministry in accordance with the Code of Cultural Heritage and Landscape and the State-Region Agreement (2008; renewed in 2018 and 2026).

The statutory objectives are:

- Planning, promoting and supporting the **enhancement of the archaeological sites** entrusted to the organisation, through periodically updated strategic action plans and in coordination with other bodies operating in the area;

- Creating a **living archaeological park integrated** into the urban and social fabric of Aquileia;
- Promoting awareness of the site and developing **cultural tourism**, including by expanding the services offered to the public;
- **Research, excavation and restoration** activities, including through agreements with other bodies;
- Drafting and updating the **Management Plan** for the UNESCO site.

The **National Archaeological Museum of Aquileia** and the **Early Christian Museum of Aquileia** are institutions affiliated with *MU MIRA-DRMN FVG*, which defines common strategies and objectives for the promotion of cultural heritage to ensure its wider enjoyment and the creation of integrated museum services; it ensures high standards of quality in management and communication, in educational and technological innovation within the museums under its remit, and collaborates with state and local authorities to define programmes and strategic plans. Furthermore, it works with local bodies and institutions to integrate visitor experiences and services into cultural and tourist itineraries. The National Archaeological Museum of Aquileia and the Early Christian Museum of Aquileia provide in their respective Statutes for activities aimed at scientific research, the promotion and enhancement of their collections, encouraging the active participation of visitors and ensuring meaningful experiences of learning and public enjoyment, with a commitment to making the museum a vibrant, inclusive and accessible place. They hold in their storerooms artefacts from archaeological excavations carried out over the decades in the Aquileia area.



Figure 5. Part of Aquileia archaeological area.

2.2 Results of the preliminary survey on the CHI's collections

The preliminary survey on the CHI's collections was conducted using a structured, two-page questionnaire designed for consistent data collection across all three pilots, enabling systematic assessment of digital readiness and digitisation needs.

- Section 1 catalogued already-digitised assets, capturing details on artefact counts, formats (e.g., 2D images, 3D models, audio), metadata standards, copyright status, and access platforms;
- Section 2 identified objects requiring new digitisation, including their thematic relevance, conservation constraints, and preferred technical outputs. A detailed third page text documented five representative artefacts per pilot, specifying titles, classifications, digitisation specs, and rights clearance to facilitate REEVALUATE integration.

This methodology yielded comprehensive insights into collection maturity, revealing:

- Strong 2D assets in Pilot 1 - Fashion Heritage: standardised methodology in producing 2D digital objects starting from design patterns and high-quality images, and the possibility to create new 3D models from garments;
- Diverse media in Pilot 2 - Olympic culture: the collection of the Olympic Museum and Ethnologisches Museum can tell a story about cultures using diverse digital objects, from audio tracks to 3D models;
- Digitisation gaps in Pilot 3 – Roman archaeology: museum collections and archaeological areas represent a typical condition of CHI across Europe, or a digital lack and non-standardised workflow in representing collections to visitors.

The questionnaire was developed to support a systematic data collection process, ensuring consistency across all pilot sites. It was designed to be user-friendly, allowing pilot leaders to complete it independently or in collaboration with technical partners, particularly the tool developers, where technical clarification or support was needed. The document is divided into two main sections, spread across two pages, each aimed at gathering specific categories of information.

Page 1: Section 1 – Already Digitised Objects

This section focuses on identifying digital objects already in the possession of the CHIs, which are available and potentially usable within the pilot use case. Respondents are asked to provide general information about the scope and content of their digitised collections, including:

- The estimated number of digitised artefacts available in the collections;
- The types of objects already digitised;
- The formats used for storing and related size (e.g., 2D images, 3D models, video/audio recordings, metadata standards, textual documents);
- Details on copyright and usage rights associated with the digital objects;
- Platforms or repositories where these collections are currently accessible;

This section is critical to understand the state of readiness of the partner CHIs and to determine whether the existing assets can satisfy the technical and thematic needs.

Page 1: Section 2 – Objects to Be Digitised

This section investigates the potential need for new digitisation efforts during the project. Partners are asked to briefly identify artefacts that are not yet digitised but could be relevant for the pilot use case and aligned with the overall project goals. For each identified object or group of objects, respondents are invited to describe:

- The type and estimated number of artefacts;
- The significance or relevance of the objects for the pilot theme;
- Conservation or handling constraints;
- Existence of documentation, such as descriptions, metadata, information related to objects;
- Preferred or recommended digitisation methods and representation for the pilot development;
- Any legal, ethical, or logistical considerations that may affect access or reuse;

This section allows the REEVALUATE consortium to anticipate digitisation needs, plan the necessary resources, and align technical workflows accordingly.

Page 2: Digital Objects – Detailed Examples

The second page of the questionnaire is dedicated to collecting detailed data on 5 specific and representative objects, digitised or to be digitised, that the CHIs intend to include in their respective pilot use cases. This granular level of documentation is crucial for facilitating the integration of these assets into the REEVALUATE framework, ensuring metadata alignment, verifying legal clearance for reuse, and estimating resources to produce. For each of the selected objects, CHIs are asked to provide information on the following items:

- Object name and unique identifier;
- Brief description of the artefact;
- Type and classification (called domain in the sequent tablet);
- Digitisation format(s), resolution/quality, file size;
- Type of metadata available;
- Rights statement or usage license;
- Existing access link (if the item is already published online);

The objective of this data collection step was to establish a representative sample of high-quality digital assets per pilot, enabling rigorous testing, technical integration, and demonstration of the REEVALUATE tools and enablers across framework iterations. Following analysis of questionnaire responses from participating CHIs (as documented in D2.1), this classification delineates pilot-specific needs, object typologies, and target digital formats, maintaining methodological consistency across diverse institutional contexts to support REEVALUATE's interoperability goals.

Five digital/physical objects were preliminarily identified from each Pilot and used as a case study for helping the development of the REEVALUATE framework.

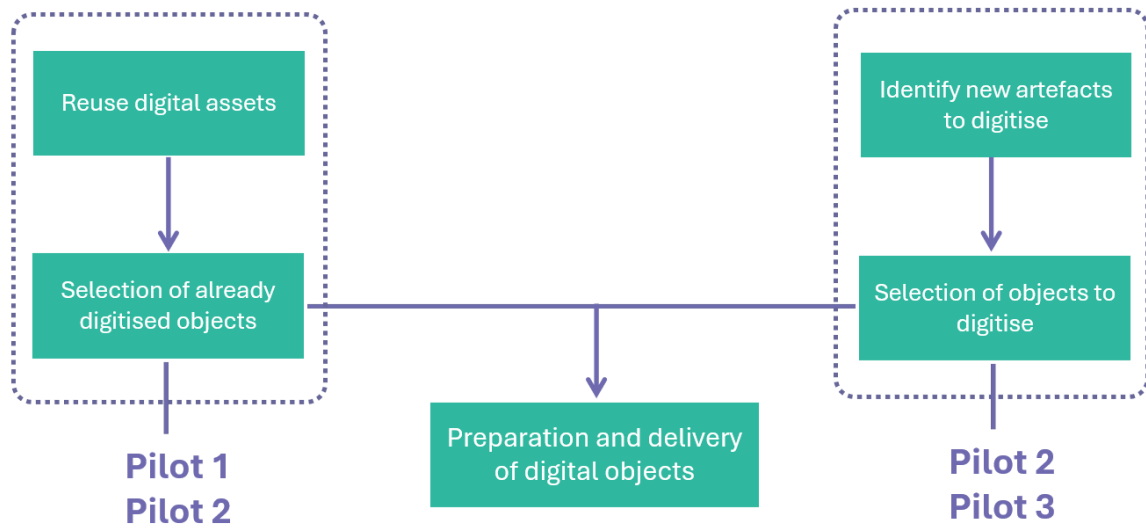


Figure 6. Result of preliminary mapping of needs across Pilot partners.

Table 1. General classification of the three Pilots.

	Pilot 1	Pilot 2	Pilot 3
Type of objects	<i>Garments and digital patterns</i>	<i>Museum objects and cultural contents</i>	<i>Archaeological finds</i>
Domain	<i>Historical Fashion Heritage</i>	<i>Cultures and music in Olympic Games</i>	<i>Archaeology</i>
Collection	<i>Already digitised and to be digitised</i>	<i>Already digitised and to be digitised</i>	<i>To be digitised</i>
Expected Final Format File	<i>Images, patterns and 3D models</i>	<i>Images, 3D models, audio tracks</i>	<i>3D models, images</i>
Metadata associated	<i>Creator, object name, ID, location, description, date, contextual information, technical spec (material and techniques).</i>	<i>Description, material, category, technical spec., condition, date</i>	<i>Material, historical context, provenance, comparison with similar objects, aim</i>

2.2.1 Pilot 1 – Fashion Time Machine

The Study Collection is managed by MoMu as a CHI partner and comprises approximately **2.000 total objects**. The collection is stored in the museum’s library and is accessible for visitors (by appointment).

From this collection, a smaller subset has been selected for the Pilot development. Selected objects are **already digitised (digital photos) and accompanied by relevant descriptive content and metadata**. The digital files primarily consist of high-resolution images (JPG) and for about 25 objects 2D (cutting) patterns in scalable vector formats (SVG) or PDF were created for REEVALUATE. These patterns have been published on the Study Collection website, ensuring both visual documentation and potential for reuse in creative and educational contexts. The 25 objects document “a woman’s wardrobe in different periods/contexts” and could all potentially feature in pilot 1 (game or pattern). These 25 patterns will be uploaded as a collection in the Marketplace before the start of the 2nd pilot iteration, when they can be used to test the different integrated enablers.

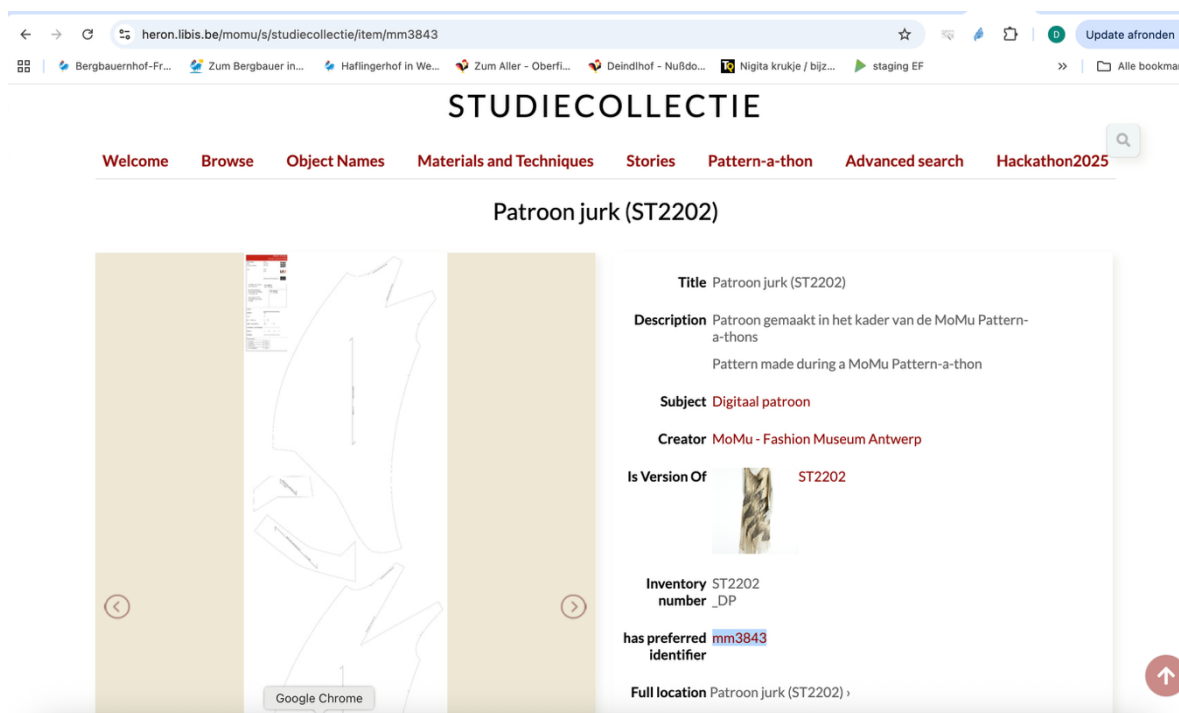


Figure 7. Example of a published pattern of an object from the study collection.
<https://data.momu.be/ark:34546/mm3843>

Each of the 25 artefacts is accompanied by essential metadata, including but not limited to object name, creator (if known), date of creation, materials and techniques, descriptive and contextual content. Some metadata elements come from a thesaurus (e.g. object name, material, technique), linked to 2 multilingual Linked Open Data sources (Europeana Fashion Thesaurus and Art & Architecture Thesaurus). This level of documentation ensures that the objects can be effectively integrated within the REEVALUATE framework and reused for the Pilot execution. Also, a set of representative objects has been shared by MoMu and

stored on the NextCloud shared project folder. From those 25 objects, 5 will be selected to feature in the fashion game and pattern pilot.

In addition to serving as a dataset for pilot development, the Study Collection dataset will be almost fully integrated into the Knowledge Graph, where it will provide relevant, domain-specific training data. Prior to its release, the dataset underwent a thorough revision process, during which it was screened for privacy-sensitive and personal data, as well as for copyrighted materials. As a result of this review, the dataset was reduced to 1.796 records, which were subsequently made available to the REEVALUATE partner LINKS for integration into the Knowledge Graph.

2.2.2 Pilot 2 – From Museums to Screens

The **already digitised collection** available for the pilot includes a diverse range of materials such as images, historical letters, and audio recordings. These digital assets are provided in various standard file formats, including JPEG, PNG, TIFF, PDF, DOCX, and MP3, supporting both visual and auditory engagement. Each object is accompanied by associated metadata, ensuring contextualisation. The metadata structure (LIDO) covers a broad set of descriptors, including the object's category, theme, creator, provenance, physical and technical characteristics, date and place of creation. The estimated total size of this collection is between 300 and 500 MB. These items are currently accessible via the institution's official website and through wider dissemination platforms such as Europeana and SearchCulture.

The **existing collection from SPK** can be expanded on for curatorial reasons related to the theme of "Music and Sport" and for the purposes of dissemination and promotion of the REEVALUATE project if the need arises within Pilot 2. As a CHI partner, SPK opened its collection for the REEVALUATE project.

The **existing collection of OLY does not fully meet the needs** of the REEVALUATE pilot scenario, so the CHI partner is prepared to digitise a new set of physical objects. This includes at least 15 artefacts suitable for 3D modelling, such as medals and sporting equipment. The expected output includes both 3D models and high-quality 2D images. This level of documentation enables the effective integration of the objects into the REEVALUATE framework, allowing their reuse during the pilot phase. By combining storytelling with 3D content creation, Pilot 2 not only supports the technical validation of the REEVALUATE framework but also aims to engage audiences with the fascinating history of the Olympic Games and music.

2.2.3 Pilot 3 – From Public Sensing to Virtual Tours

For this pilot, a collection of **high-resolution videos** has been made available to contextualise the requirements. These videos focus on the 3D reconstruction of archaeological areas within the UNESCO World Heritage Site of Aquileia. While only the final video outputs are available (not the original 3D model source files), these assets provide valuable audiovisual material that can support the communication and dissemination components of the pilot. Considering that no digital materials are available for the Pilot execution, **the CHI foresees the digitisation of a set of artefacts associated with the "Domus di Tito Macro"** (Titus Macer's House), one of the largest Roman domestic complexes discovered in northern Italy. The

selected objects for digitisation include archaeological finds with provenance from the Domus, currently exposed inside the same area and in the National Archaeological Museum. The items will also be selected from public sensing for their representativeness, their connection to the archaeological context, and their relevance for the development of a virtual experience of the Domus. **The expected output format is 3D models**, suitable for immersive digital presentation. For each object, a descriptive text will be compiled, including provenance, historical context, physical materials, intended function, and comparisons with similar artefacts (when available). Photographs and extracted images from the existing video material may also be provided to support interpretation. Through the combination of storytelling and 3D content creation, the Aquileia pilot contributes not only to the technical testing of the REEVALUATE framework but also to the broader goal of engaging the public with the hidden richness of Roman heritage preserved within and beneath this historic site.

3 Selection of CH artefacts for the Piloting phase

This chapter outlines the selection and decision-making process applied across all three REEVALUATE pilots to identify and finalise cultural heritage artefacts, whether already digitised or targeted for new digitisation, for pilot execution and framework validation.

This structured, iterative methodology combines curatorial expertise, public-sensing prioritisation campaigns (leveraging social media engagement via likes/comments on social campaigns), and technical assessment against pilot-specific requirements, including metadata quality, legal clearance/licensing, format compatibility, and narrative coherence.

The process follows a consistent two-phase structure adapted to each pilot's thematic context:

1. Longlist curation from CHI collections and survey results (D2.1), systematically reducing candidate pools based on storytelling potential, physical condition, and technical suitability;
2. Shortlist finalisation through participatory validation and expert review, ensuring the selected assets align with REEVALUATE enablers like Knowledge Graph integration, Marketplace dissemination, and immersive demonstration scenarios.

3.1 Pilot 1

Selecting suitable cultural heritage (CH) artefacts for Pilot 1 is a key activity and is carried out through a staged, iterative process. Drawing on the Study Collection, MoMu identifies artefacts best suited for reuse and provides expert guidance on their contextualisation and presentation. A unifying theme, *“The wardrobe of a woman in five different periods/settings”*, guides both the Game and Pattern pilots. This theme enables coherent storytelling and aligns closely with Fibre Mood’s focus on women’s patterns. It allows the exploration of diverse historical periods, techniques, garments, materials, and fabrics, fully leveraging the richness of MoMu’s Study Collection. As described in Deliverable D4.1, multiple criteria are considered during the selection process, including:

- Physical condition and accessibility of the object
- Quality and completeness of metadata
- Complexity of the garment’s pattern
- Materials and techniques used
- Year of creation
- Licensing and intellectual property considerations
- Storytelling potential
- Relevance and appeal for both the Game and Pattern pilots

The selection process is iterative and consists of two distinct phases: a longlist and a shortlist.

Longlist: Pattern Collection dataset

This phase produces a curated subset of the Study Collection featuring CH artefacts with:

- Object descriptions (metadata);
- JPG images;
- Cutting patterns in SVG and PDF formats.

All cutting patterns are validated for accuracy, follow a standardised layout, and include complete technical metadata (e.g. measurements, symbols, and explanatory elements) to support pattern makers. The patterns are published with a persistent identifier on MoMu’s Study Collection’s website and released under an open **CC BY licence** and branded with the REEVALUATE and European Commission logos. The dataset will be made available on a dedicated webpage on MoMu’s website¹ and through the Marketplace Enabler and functions as a pre-selected longlist for both the Game and Pattern pilots. It includes women’s garments spanning different periods, cultures, and contexts.



Figure 8. Example of informative header of a published pattern from the Reevaluate-longlist (Trousers of Cycling ensemble: <https://data.momu.be/ark:34546/mrjdw4>)

Shortlist: Pilot 1 dataset

From the Pattern Collection, five artefacts are selected to form the Pilot 1 dataset. These enriched Digital objects include:

- Artefact metadata;
- Extended “contextual” information;
- JPG images;
- SVG/PDF cutting patterns”
- 3D models (e.g. GLB format), based on the SVG patterns and digitally stitched together in 3D design software;
- Texture maps, either derived from material texture scans or inferred from a standard texture library.

¹ <https://heron.libis.be/momu/s/studiecollectie/page/reevaluate> - webpage still under development, will be released at start of the 2nd pilot iteration phase.

The Pattern Pilot is created based on the SVG files, artefact metadata and contextual information and documentation by external partner Fibre Mood. The 3D models/texture maps are made available to partners CERTH and FFP, to be included in the Fashion Game Pilot.

Pilot development is executed iteratively. The second iteration builds on the outcomes of the first, scaling up workflows and technical integrations and informing further refinement of artefact selection and digitisation activities.

- **Iteration 1** took place between **Month 23 and Month 26** (November 2025 – February 2026), with 1 object from the Pilot 1 dataset;
- **Iteration 2** is scheduled for **Month 30 to Month 34** (June 2026 – October 2026). With 4 objects from the Pilot 1 dataset.

3.2 Pilot 2

Pilot 2 focuses on cultural content in the context of music, sport, and the Olympic Games and comprises a range of media.

3.2.1 SPK

The decision-making process at SPK went through several stages, with each stage producing a more refined selection of objects and assets. SPK uses already digitised objects (audio tracks, images of instruments, and others).

Firstly, this level focused on the theme of ancient Olympia. Musical instruments that belonged to the Ancient Olympics were classified according to the Hornbostel–Sachs classification system to identify similar instruments in the Berlin collections (cf. Hornbostel & Sachs, 1914). Assets related to these instruments were identified and assembled in multiple formats (photos of instruments, sound recordings, etc.).

Secondly, since the partners in Thessaloniki found the results of the first selection not satisfactory for the envisaged project, in a second step, the search criteria were modified. This time, sound recordings were identified that relate to sport, movement and competition and might better suit film productions. The aim was to identify as many different atmospheres as possible and to develop a musical mood board as a basis for the later collaboration.

Thirdly, drawing from the two earlier selections in the third phase, assets were specifically selected to be used in Pilot 2, taking into account legal and ethical limitations. The targeted KPI of 20 assets was achieved. This phase coincided with the completion of the prioritisation enabler and the start of the associated campaign. In terms of content, it focuses on the competition of trumpeters—particularly the ancient salpinx—during the opening of the Olympic Games. The “Trumpets” collection can be used as a film made as part of Pilot 2. An example was provided to the project partners.

Fourthly, this phase coincides with the completion of the marketplace. At this stage, the selected assets were uploaded and made accessible for testing of the enablers.

3.2.2 OLY

The selection of CH artefacts for the piloting phase at the Olympic Museum is carried out through the testing of the **Public Sensing Prioritisation Enabler (T2.2)**, with the ultimate aim of engaging audiences in identifying the most recognisable and relevant artefacts to the general public. Initially, OLY curated a representative subset of artefacts from its extensive collection of over 10.000 items, covering different categories and time periods from 1896 to the present, in order to ensure diversity and breadth.

To achieve the prioritisation, the Museum implemented gamified campaigns on social media, allowing diverse groups to explore the history behind key items from the collection while actively participating in the selection process. Public engagement was encouraged through interactions such as likes and comments on Facebook, which were subsequently analysed to inform decision-making. The campaign was shared via both the Reevaluate Project Facebook page and the Olympic Museum's official Facebook page.

Through this approach, the artefacts to be digitised are selected using the Public Sensing Prioritisation Enabler, which is employed by both participating museums to foster audience-driven identification of culturally significant assets from multiple backgrounds, ensuring that the final selection reflects items of high public recognition and interest. Results of the campaign are available in D2.2.

3.3 Pilot 3

The selection of artefacts from the Domus of Titus Macro was made by the Aquileia Foundation, taking into account what is visible within the building itself, while the objects from the National Archaeological Museum were chosen on the basis of what would best suit the various rooms. Consequently, the intended use of these artefacts was taken into account in a practical sense, namely, in view of the creation of the virtual tour, and in a structured way, combining curatorial expertise, coherence, and a participatory approach of a selected target (young community).

3.3.1 Selection of CH Assets

Selection of the Domus

As one of the largest Roman dwellings in Northern Italy, covering approximately 1.500 square metres, the Domus represents a unique case study within the broader context of Aquileia, a major Roman emporium and UNESCO archaeological site. Thus, the Domus of Titus Macro was chosen for its great historical and archaeological significance, as well as for its suitability for the creation of an immersive virtual tour.

First preliminary selection of the artefacts

In a first phase, Aquileia Foundation conducted a preliminary selection of the artefacts discovered within the domus, based on their relevance to understanding domestic life in Roman times. Some finds are located directly within the archaeological site and include elements such as the oven, the wellhead and the polychrome mosaic. Furthermore, a sestertius and a stone weight engraved with the name T. Macr., the owner of the domus, were discovered within the area. These last two artefacts were chosen because of their functionality, helping to understand Roman life at the time and to create a comprehensive virtual tour.

Second selection of artefacts

At the same time, a second phase of selection involved the National Archaeological Museum of Aquileia, which provided additional artefacts from its own collections. These items have been chosen based on their storytelling with the setting of the Domus, to ensure that they could add meaning and sense to the spatial narrative of the virtual tour. Moreover, the Museum artefacts were linked to specific rooms or functions within the Domus, thereby reinforcing the coherence between the physical space and the idea of the digital narrative. In total, 20 artefacts were scanned for inclusion in the pilot project, in addition to the Domus site.

3.3.2 Participatory prioritisation phase

The site is visited by large numbers of tourists every year, with school trips accounting for a significant proportion of visitors. It is for this reason that the aim is to actively involve **young people and local students**. They were invited to engage with the selected archaeological artefacts by liking and commenting on them, contributing to their prioritisation through the **Public Sensing Prioritisation Campaign**. This Campaign made it possible to tailor the selection of content for the virtual tour to the public's interests, making the final product more targeted and engaging. Participants were invited to express their preferences on Facebook through likes, comments, and reactions, providing both quantitative and qualitative feedback. These online contributions helped to prioritise artefacts for the pilot phase, ensuring that the selection of these items reflected not only curatorial criteria but also the interests and perceptions of future visitors. Results of the campaign is available in D2.2.

4 Digitalisation of the selected CH artefacts

Although large-scale digitisation remains beyond the main project scopes, accessing a sufficient number of high-quality, pre-existing digital artefacts or executing targeted digitisation activities where gaps exist ensures operational relevance across diverse demonstration scenarios. Starting from this assumption, in this chapter, the process that brings physical artefacts to their digital representation is highlighted, exploring different technologies and techniques in digitising Cultural Heritage related to Pilot collections. The methodology employed involves systematic mapping of participating CHIs according to thematic objectives, with each institution consulted via structured questionnaires to verify the availability of existing digitised assets, their storage formats, metadata, and accessibility conditions. Particular attention is paid to technical quality metrics (e.g., resolution for images and 3D meshes), current standards in digitising Cultural Heritage across Europe, interoperability potential through standard metadata representation, and legal clearance, with iterative refinement incorporating public engagement campaigns and expert curation to address insufficiencies in quantity, relevance, or specifications.

Where existing collections prove insufficient, small-scale digitisation workflows are implemented, encompassing structured light scanning, photogrammetry, 2D pattern extraction, and UAV-based aerial capture, producing enriched, multi-format assets suitable for Knowledge Graph integration and to be used in WP4 development, such as immersive applications, Marketplace upload, and creative reuse.

This chapter introduces the digitisation technologies and workflows implemented in T2.1 to produce high-quality digital assets required for REEVALUATE pilot execution, building directly on the artefact selection and gap analysis from D2.1.

The digitalisation of cultural heritage encompasses advanced, multidisciplinary techniques for accurate documentation, preservation, and virtual dissemination of diverse artefacts, specifically in the REEVALUATE framework, which spans from fashion garments (Pilot 1) to Olympic memorabilia (Pilot 2) and Roman archaeological finds (Pilot 3). For fashion heritage, and more in general for documentation and 2D features extraction, workflows usually combine a solution of **digital photography** and advanced techniques in 2D **technical drawing**. This solution combines high-resolution DSLR photography (RAW capture, calibrated lighting) with SVG/PDF 2D pattern extraction, enabling precise capture of textile geometries, material textures, and construction techniques for pattern-making. On the other hand, for Museum objects, a combination of metrological-grade **3D scanning and photogrammetric workflows** is employed to generate accurate 2D and 3D representations of three-dimensional objects. Considering Pilot 2 and Pilot 3 collections, these objects can be identified in archaeological finds, fragments, vases, medals, sports equipment, sculptures, and memorabilia. For archaeological and natural sites, **LiDAR scanning and photogrammetry using unmanned aerial vehicles (UAVs)** are also suitable for full-scale 3D reconstruction of the site, generating GPS-integrated resources and providing high-resolution topographical data. These geospatial datasets can be integrated into geographic information systems (GIS) to support spatial analysis, stratigraphic interpretation and site management, as well as providing a clear overview of the site's dimensions.

So, in most cases, digitising is a process that involves both 2D and 3D representations of objects, being the process of transformation of data from analogue to digital form. Across all pilots, these workflows can transform physical collections into interoperable digital objects such as 2D images, 3D meshes, and metadata files.

While the techniques above refer to tangible Cultural Heritage, audio digitisation captures and preserves intangible elements, transforming analogue media into reusable digital formats for analysis, archiving, and fruition. The process begins with signal acquisition from source media (vinyl records, magnetic tapes, wax cylinders, or live field recordings) using specialised **playback hardware connected to high-fidelity audio interfaces**. Several techniques are used to compensate for medium-specific degradation and frequency response integrity, preserving dynamic range and spectral detail.

4.1 Overview of techniques and technologies for digitising Cultural Heritage artefacts

2D digitising is a scientific technique that involves several aspects to ensure proper representation of the object without distortions and colour aberrations. Setting up a **photographic digitisation** station requires careful consideration of lighting, camera equipment, positioning, and environmental control to ensure high-quality, consistent, and reproducible digital captures. The process begins with selecting a suitable camera system, typically a high-resolution DSLR or mirrorless camera equipped with a lens for sharp detail reproduction. The camera should be mounted on a sturdy tripod or a copy stand to maintain stability and consistent framing throughout the digitisation session. Lighting plays a crucial role: a controlled, diffuse lighting setup is essential to minimise reflections, shadows, and hotspots on the object's surface. This is commonly achieved using multiple continuous LED light panels or studio strobes fitted with softboxes or diffusers positioned at 45-degree angles relative to the subject. Colour temperature should be standardised (usually daylight balanced at ~5500K) to ensure accurate colour rendition, often calibrated with a colour target or grey card before each session. The **digitisation workspace must be designed** to reduce environmental variables such as ambient light fluctuations, dust, and vibrations. A neutral, non-reflective background and surface are used to prevent colour contamination and unwanted reflections. The object should be positioned securely, sometimes on custom mounts or supports, to avoid movement and to clearly display key features. Camera settings are optimised for maximum image quality—using low ISO to reduce noise, an appropriate aperture for depth of field, and manual focus to ensure critical sharpness. Images are captured in RAW format to preserve maximum detail and allow for precise post-processing adjustments.



Figure 9. Example of a digital camera with an interchangeable lens (on left); example of a photographic setup using a homogenous background, multiple light sources and light diffusers (on right).

A colour calibration workflow involving colour charts and software profiles ensures consistent colour management from capture to final output. **Colour calibration** is essential in the digitisation of cultural artefacts because it ensures that the digital image reflects the object's true appearance as faithfully as possible. Accurate colour reproduction is especially important for items such as textiles, paintings, ceramics, manuscripts, and painted surfaces, where subtle differences in hue, tone, and saturation can convey information about materials, techniques, age, and conservation condition [6] [7]. Without proper calibration, lighting conditions, camera settings, and post-processing can introduce distortions that weaken both scholarly value and visual reliability. A calibrated workflow, therefore, supports the documentation. Common methodologies include codified colour palette profiling with multiple patch targets that can be shot by a camera for generating a DCP/ICM camera profile. Closed-loop verification employs concurrent grey card (usually 12%-18% reflectance) metering and Macbeth Chart validation post-processing.

Finally, metadata documentation, including object identification, capture settings, and date/time, is recorded alongside the image files to maintain traceability and facilitate asset management. Regular quality control checks are implemented to verify image sharpness, exposure, and colour fidelity throughout the digitisation project [8].



Figure 10. Commercial palette for colour correction. Source: www.calibrite.com.

On the other hand, **3D scanning** allows the reproduction of objects in their complete state of both manipulable geometry and texture [9]. The main techniques for the digitisation of cultural heritage or physical objects, from small to medium-sized objects, are structured light scanning and photogrammetry. Setting up a 3D scanning station involves configuring hardware and software components to achieve precise, high-resolution digital models. For **structured light scanning** [10], the core equipment includes a structured light projector and one or more high-resolution cameras. The system projects a sequence of coded light patterns onto the object's surface, and the cameras capture the deformation of these patterns to calculate accurate 3D geometry via triangulation. The scanner can be securely mounted on adjustable stands or a robotic arm to maintain stable positioning and control scanning angles, or driven by a human operator. Most of the time, human operators are preferred due to the precise control of the process, being capable of looking at the preview and correcting for missing parts, but most importantly, to avoid impacts and damages to important artefacts. Calibration of the scanner is essential before each session, involving

the use of calibration panels or reference targets to ensure spatial accuracy and correct lens distortion. Lighting conditions are controlled to minimise ambient light interference, as structured light scanners rely on projected patterns that can be affected by external lighting. The scanning environment should be shielded from direct sunlight or strong artificial lights, using blackout curtains or controlled lighting chambers where possible. The object to be scanned is positioned on a turntable or a stable platform to allow for multi-angle capture and complete surface coverage. For larger or complex objects, multiple scans are acquired from different viewpoints and later registered and merged in post-processing software to create a unified 3D model [11].



Figure 11. Example of SLS in digitising Cultural artefacts.

For **photogrammetry**, the setup involves a calibrated digital camera system, often the same high-resolution DSLR or mirrorless cameras used in photographic digitisation, and a controlled environment with diffuse lighting to avoid harsh shadows and reflections. The object is captured from multiple overlapping angles, typically ensuring 60-80% overlap between images, to enable accurate feature matching during 3D reconstruction. A turntable or tripod-mounted camera rig can facilitate systematic image capture for smaller objects, while larger objects or archaeological areas may require handheld photography. Both methods require robust data processing pipelines: structured light scanning software reconstructs 3D meshes from captured pattern deformation, while photogrammetry software (e.g., Agisoft Metashape, Reality Capture) uses Structure-from-Motion (SfM) and Multi-View Stereo (MVS) algorithms to generate dense point clouds and textured meshes. Post-processing includes mesh cleaning, hole filling, texture mapping, and model optimisation to produce accurate, usable digital assets. Metadata documentation and quality assurance procedures are integral, recording scan parameters, calibration data, and environmental conditions to ensure reproducibility and long-term usability of the 3D digital surrogates [12].

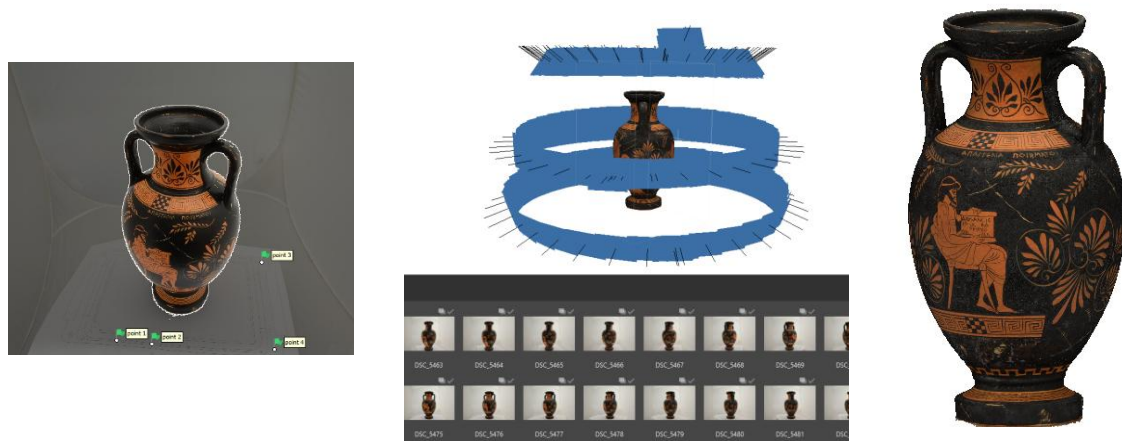


Figure 12. 3D digitising of a vase by photogrammetry.

Photogrammetry can also be extended to larger areas and buildings, such as archaeological areas, and it is named **aerial photogrammetry** [13]. The workflow for the digitisation of cultural landscapes, archaeological sites, or large-scale heritage contexts involves a series of technical and procedural steps to ensure accurate spatial data acquisition and high-quality 3D reconstruction. The core of the setup is the use of Unmanned Aerial Vehicles (UAVs) (drones) equipped with high-resolution cameras, preferably with fixed focal lengths and global shutters to reduce image distortion, usually directly mounted on the UAV but also as an external payload. Multi-rotor drones are ideal for detailed site documentation with vertical take-off and landing capabilities, while fixed-wing drones are used for larger areas requiring greater flight endurance. Mission planning is critical and is typically performed using dedicated flight planning software (e.g. DJI GS Pro, Pix4Dcapture, or DroneDeploy), even if precise monitoring of distances between the drone and the site is preferred by manual controls. The flight plan is an important technique because it ensures adequate image overlap (generally not less than 70%) to allow photogrammetric algorithms to perform reliable feature matching, and requires the choice of parameters, flight altitude, camera angle (usually nadir for mapping, oblique for facades or volumetric data), and Ground Sampling Distance (GSD). The GSD, being a direct measure of the number of millimetres represented by a single pixel in an image, is one of the most important parameters, and directly impacts the final results in terms of quality and level of detail. Environmental conditions (e.g. light levels, wind speed) must be carefully monitored according to the site's characteristics and desired model resolution. The registration of undercuts must be executed manually in accordance with the complexity of the site. Before the flight, Ground Control Points (GCPs) should be strategically placed and surveyed to ensure spatial accuracy during the georeferencing stage. Image acquisition is carried out during flight, with camera triggering managed by the UAV's onboard system. It is essential to maintain consistent lighting conditions, ideally shooting during overcast days or at solar noon to minimise shadows and exposure variation. Images are captured in RAW format, when possible, to retain full dynamic range and maximise detail in post-processing. Once collected, the dataset is processed using photogrammetric software (e.g. Agisoft Metashape, Pix4Dmapper, Reality Capture), which employs Structure-from-Motion (SfM) and Multi-View Stereo (MVS) techniques to generate dense point clouds, digital surface models (DSMs), digital terrain models (DTM), orthophotos, and textured 3D meshes. The integration of the GCPs ensures the final outputs are properly scaled and georeferenced. Post-processing includes editing the mesh, removing artefacts, refining textures, and exporting results in standard formats (e.g. OBJ, LAS, GeoTIFF) for integration into GIS platforms or 3D visualisation tools.

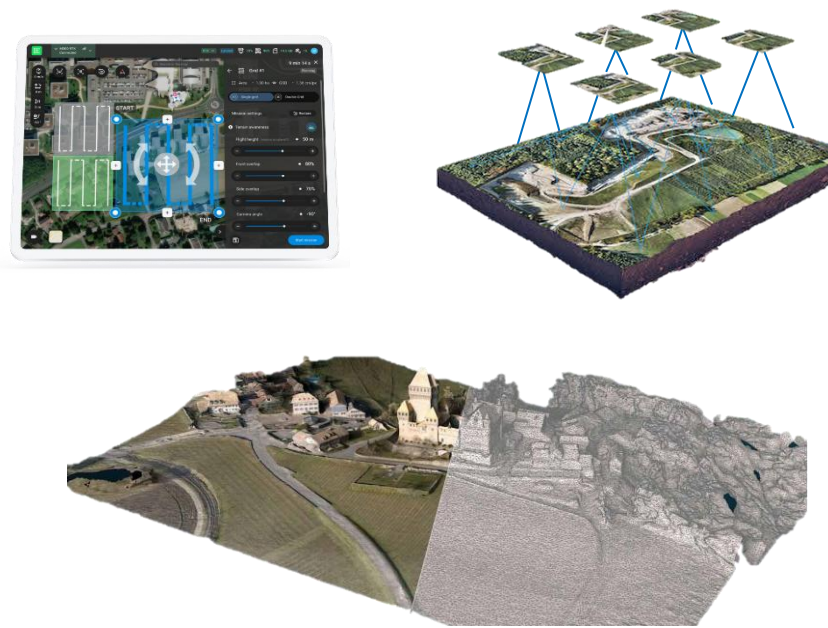


Figure 13. Drone survey with planned path and overlapping images (on top); example of 3D model (on bottom).



Figure 14. Example of choosing different values of GSD and the impact on final results.

Metadata documentation is essential and includes flight logs, camera calibration data, environmental parameters, and coordinate systems used. All assets should be managed in compliance with FAIR data principles (Findable, Accessible, Interoperable, Reusable), ensuring long-term usability and accessibility for both research and public engagement [14].

The digital workflows culminate in the creation of a dataset and derived 3D models from master ones, adequately scaled, decimated and optimised concerning the final delivery, like online 3D visualisation or implemented in immersive multimedia products, that help and facilitate multidisciplinary collaboration, remote research, and public dissemination, ensuring that archaeological heritage is preserved digitally for future generations. Furthermore, digital asset management systems (DAMS) and standardised metadata protocols ensure interoperability and long-term preservation of digital surrogates within institutional repositories.

In terms of **file formats**, DSLR and mirrorless cameras typically record images in proprietary RAW formats such as Canon CR3/CR2, Nikon NEF, Sony ARW, or Fujifilm RAF. These files function as the digital master record, storing the original Bayer Color Filter Array (CFA) sensor data in an unprocessed state. Because they preserve the full photometric dynamic range and maintain a linear sensor response, RAW files are ideal for high-quality post-production workflows, including demosaicing, exposure correction, radiometric calibration, and ColorChecker-based colour profiling. From these masters, derivative outputs can then be generated in widely used formats such as 16-bit TIFF for archival and editing purposes, PNG for lossless distribution, or JPEG for lightweight access and publication. In the field of 3D scanning and photogrammetry, data acquisition software generally creates an internal project-based 3D representation that can later be exported into multiple standard formats depending on the intended use. OBJ, together with its companion material file (MTL) remains one of the most common polygonal interchange formats for meshes and textures. PLY is frequently adopted for coloured point clouds and dense geometry datasets, while E57 is widely recognised as a robust standard for storing terrestrial laser scanning data with embedded spatial and sensor information. For real-time visualisation, web deployment, and immersive applications, GLB/gITF has become increasingly important, as it can package geometry, Draco-compressed meshes, physically based rendering (PBR) textures, animations, and scene metadata into a single efficient asset ready for platforms such as WebGL, WebXR, or ARCore. CAD systems and modelling environments typically export geometry in formats designed to preserve structural hierarchy, UV mapping coordinates, and material definitions. This ensures that assets can move reliably between design, visualisation, simulation, and heritage documentation workflows while maintaining both geometric integrity and appearance data. Considering the cited aspects, it was chosen to adopt the GLB format file for 3D digital objects, while images are shared in JPEG and PNG.

Metadata is also an important key for correlating digital representation with technical, administrative and descriptive information. Given that many datasets derived from the pilot studies have their own data representation schemes, which differ from one another, it was decided during the preliminary phase of WP2 development to adopt a common metadata representation scheme. For the purposes of this activity, the CACAO ontology was used as the reference model to associate each object with a semantic type and a coherent set of properties. In particular, the model makes it possible to distinguish between the physical artefact, the production event, the chronological interval, the object's digital representation, and the rights associated with the image, thereby enabling a structured and interoperable description of the available cataloguing information.

During the phase of selecting and collecting information related to the objects, the following were recorded in summary form:

- Title of the artefact;
- Description of the object;
- Provenance of the digitised object;
- Inventory number;
- Approximate date/period, expressed at the century level;
- Material from which it is made;
- Purpose/use of the artefact;
- Photograph of the artefact.

In order to insert this information into the database correctly, the data had to be adapted to a structure that was both compatible with the storage system and compliant with the reference ontologies (primarily

CACAO and CIDOC-CRM). The mapping between the collected information and the representable data was carried out as follows:

1. A type was assigned to each object. The following classes were used:
 - a. Physical Artefact (CACAO_0000023);
 - b. Artwork (CACAO_0000024);
 - c. Human-Made Feature (crm:E25_Human-Made_Feature);
2. The title is treated as a simple label using the corresponding property provided by the RDF Schema vocabulary;
3. Description is expressed through the *description property* in *Schema.org*;
4. The inventory number, used as a unique and persistent identifier, is assigned to a separate entity and linked to the object through the property *crm:P1_is_identified_by*;
5. All information relating to dating is encapsulated in an *event*, a standalone entity of type *crm:E12_Production* and linked to the object through the property *crm:P92i_was_brought_into_existence_by*. More precisely, the dating is reported with the property *crm:P4_has_time-span* and by considering an external entity of type *crm:E52_Time-Span*, indicating with the property *crm:P82_at_some_time_within* the string containing the temporal value;
6. Composing material is expressed through the property *crm:P45_consists_of* and by linking the object to the corresponding Wikidata entry;
7. To report information such as the provenance of the object, its purpose/use, and any comments on similar objects, multiple occurrences of the property *crm:P3_has_note* are used;
8. The digital object, or digital representation of the artefact, is represented as a separate entity and is linked to the object through the property *crm:P138i_has_representation*;
9. The information relating to the rights holder of the image is assigned directly to the image entity through the property *crm:P105_right_held_by*.

```
# =====
#          Oggetto 1
# =====

<http://w3id.org/cacao/vocab/part/46ff9309-0701-43c6-afc3-981b33186261> # OGGETTO
a cacao:CACAO_0000023 ;
schema:description "Mould-made three-nozzle oil lamp with a closed channel, missing handle, and three rounded pointed nozzles. The shoulder is decorated with two small knobs; it has a smooth recessed disc with a central filling hole, a small air hole in the central part of each of the three channels, and a chipped handle attachment. On the exterior base appears the stamp EVCARPI in raised letters within three concentric circles. Traces of blackening are visible on the nozzles."@en ;
crm:P3_has_note "Provenance: Historical collection"@en ;
crm:P1_is_identified_by <http://w3id.org/cacao/vocab/identifier/ee5e5c84-df1f-4f0f-bf0c-95e3e334fccd> ; # Da inserire direttamente agli oggetti
rdfs:label "Three-nozzle oil lamp (trilychnis) + K5D11C2:K6"@en ;
crm:P45_consists_of <https://www.wikidata.org/wiki/Q42302> ;
crm:P138i_has_representation <http://w3id.org/cacao/vocab/dart/42f49e90-aab4-43a5-9267-c064cea089ea>.

<http://w3id.org/cacao/vocab/identifier/ee5e5c84-df1f-4f0f-bf0c-95e3e334fccd> # N. INVENTARIO
a crm:E42_Identifier ;
crm:P190_has_symbolic_content "7042" .

<http://w3id.org/cacao/vocab/dart/42f49e90-aab4-43a5-9267-c064cea089ea> # IMMAGINE Per indicare la licenza si va di p104 tra e30 cacao:000086
a cacao:CACAO_0000086 ;
crm:P1_is_identified_by <http://w3id.org/cacao/vocab/identifier/42f49e90-aab4-43a5-9267-c064cea089ea> ;
crm:P138_represents <http://w3id.org/cacao/vocab/part/46ff9309-0701-43c6-afc3-981b33186261> ;
crm:P105_right_held_by <http://w3id.org/cacao/vocab/actor/5f5a0c1c-a7a1-41c0-ab28-62ebaeaed6d4> .

<http://w3id.org/cacao/vocab/actor/5f5a0c1c-a7a1-41c0-ab28-62ebaeaed6d4>
a crm:E39_Actor ;
rdfs:label "MAN Aquileia" .
```

Figure 15. Example of metadata schema for a Digital Object. Source: Pilot 3 collection.

4.1.1 Pilot 1

The following section focuses on the preparatory activities carried out by the Cultural Heritage Institution (CHI) and content provider MoMu. It primarily addresses the upstream processes required to prepare cultural heritage assets for digital reuse, rather than their downstream implementation by developers within the Game and Pattern pilots. The digitisation workflow for Pilot 1 is quite different from the aforementioned 2D and 3D digitisation techniques; it is more designed to support a **reverse-engineering workflow**, whereby physical garment artefacts are digitally reconstructed in a manner analogous to traditional tailoring practices. This approach enables the systematic transformation of historical garments into reusable digital assets while preserving material, structural, and contextual accuracy. The final outputs of this workflow are physical cutting patterns and corresponding digital garments, derived from selected artefacts within MoMu’s Study Collection. While the object selection process is described in the preceding section, the digitisation workflow begins with the creation of cutting patterns.

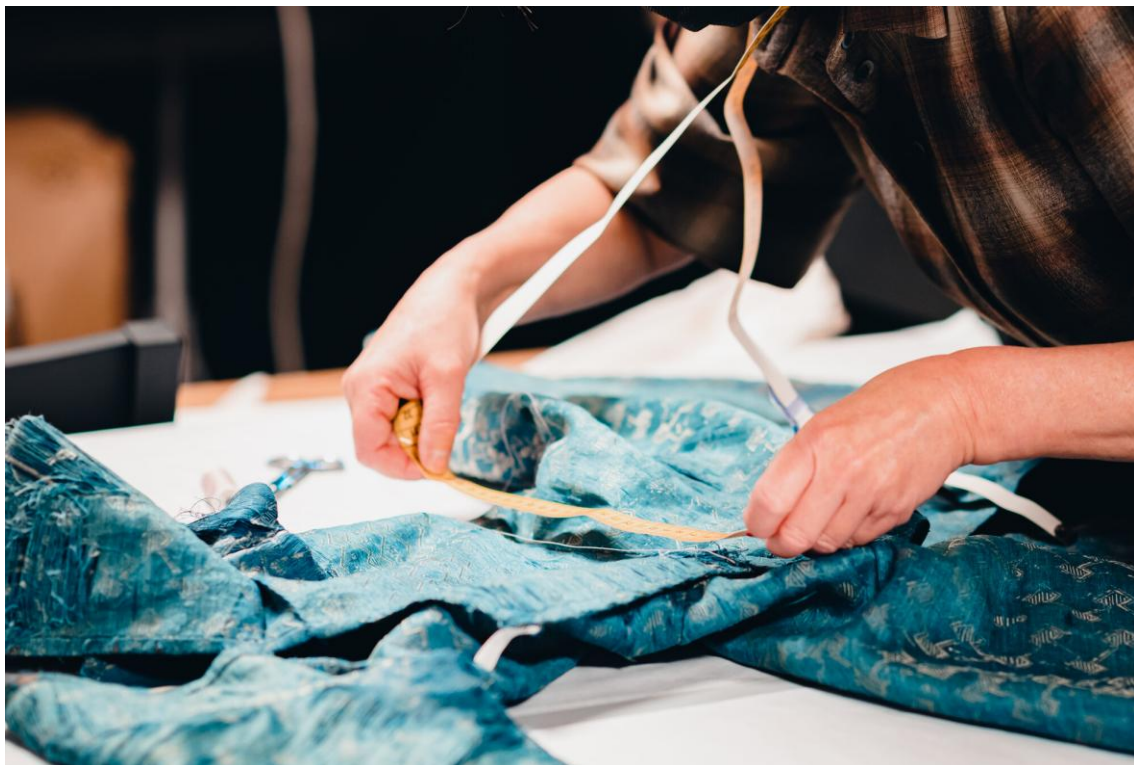


Figure 16. Image Pattern-a-thon – Matthias De Boeck

The creation of cutting patterns begins with a physical activity: the systematic measurement of each garment panel and the transfer of these measurements onto pattern paper. The precise procedure is outlined in a set of guidelines developed by MoMu, published within the margins of the REEVALUATE project². Initially, the patterns are produced on paper and represent the individual components that constitute a garment. The digitisation of these paper patterns involves two sequential steps:

² <http://data.momu.be/doc/studycollection/patternathon/guidelines>

1. **Scanning** the paper patterns to produce a raster image (e.g. JPEG).
2. **Vectorisation** of the scanned image, resulting in a scalable vector format (e.g. SVG) suitable for use in digital design software.

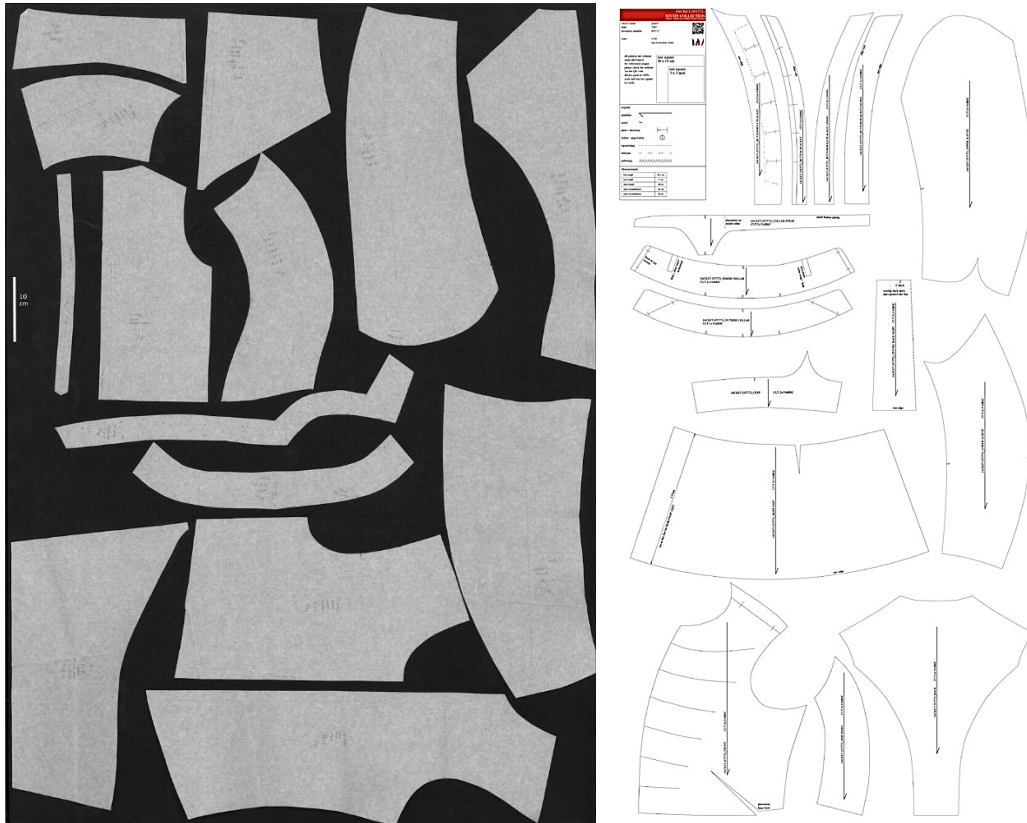


Figure 17. On left: Example of a raster image (jpg) of a paper cutting pattern (Object ST572 – Study collection). On right: Example of vectorised pattern (published as PDF), of object ST572 – Study Collection)

The resulting vector-based 2D patterns can then be used as input for 3D garment modelling workflows. Using specialised software such as **CLO3D**, designers can create, visualise, and simulate garments in a virtual environment. CLO3D supports realistic fabric behaviour, garment draping, and fitting on configurable avatars, and is widely used within the fashion and apparel industries. Its use reduces the need for physical sampling, contributing to efficiency gains in terms of time and material consumption. Through this process, 2D patterns are transformed into fully textured, three-dimensional models suitable for deployment as virtual products.



Figure 18. Example of creating a 3D asset from a digital pattern in CLO3D.

The general digitisation workflow implemented for the fashion pilot comprises the following steps:

- Selection of garments to be digitised, in collaboration with the other pilot partners;
- Creation of 2D cutting patterns on paper;
- Digitisation and vectorisation of the paper patterns;
- Conversion of 2D patterns into textured 3D models;
- Standardisation and export of assets in neutral formats (e.g. FBX, GLB, OBJ).

These standardised digital assets constitute the technical basis upon which the Game and Pattern developers further build to realise Pilot 1.

In parallel with the technical digitisation activities, a comprehensive review of the metadata associated with the selected artefacts was conducted. For Pilot 1, a museum curator and registrar systematically reviewed all existing documentation and metadata records to ensure accuracy, consistency, and completeness. Beyond validation, the metadata was further enriched through the addition of a **storytelling component**, aimed at improving accessibility and engagement for non-specialist audiences. This narrative content was integrated into the *context* property of MoMu's internal database, ensuring that the digitised assets are supported by both reliable technical metadata and interpretative information.

4.1.2 Pilot 2

The Pilot consists of already digitised objects (audio tracks, pictures of instruments, pictures of historical telegrams and letters) and requires some digitisation of physical objects such as cups, medals, sports equipment, documents and other objects coming from the Olympic Museum of Thessaloniki. The plan was to digitise these objects via a **structured light scanner** for the restitution of 3D objects and **digital photography** for image production.

4.1.2.1 SPK

SPK uses predominantly assets digitised outside the Reevaluate project (sound recordings, video) using conventional means of digitisation and participating in the workflow that new digitisations are not needed if already existing and can be exposed to the general public. SPK typically follows the guidelines developed by the International Association of Sound and Audiovisual Archives (IASA) for digitising audio and video. One particularity of the SPK is its collection of Edison phonograms on wax and copper cylinders. Copper negatives first have to be cast as new wax positives before they can be digitised. Digitisation happens typically using a mechanical procedure, not optical means. A needle is used to read the information in the groove and then transferred to the digital domain using high quality AD converters. For long-term storage, the audio and video information is encoded in formats approved for archive use according to the IASA guidelines, such as WAV and AV1. Metadata is processed using the museum documentation system, MuseumPlus, by the Swiss company Zetcom.

2D photography of 3D objects, such as musical instruments, is typically created by professional photographers using a medium-format Phase 1 camera employed by the museum. Typically, each instrument is represented by a single photograph. For Pilot 2, a few key audio recordings were made in Thessaloniki and Berlin during sports events, which may be used as part of the soundtrack in the films produced by Pilot 2.



Figure 19. Left: Waza trumpet in the Berlin collections today, right: fieldwork photo by Artur Simon of similar instruments in Sudan in 1983. Staatliche Museen zu Berlin, Ethnologisches Museum.

4.1.2.2 OLY

OLY physical objects to be digitised were selected based on the first decisional iteration, which also led to the use of Prioritisation enabler. All the physical objects were digitised, creating a digitising setup inside a Museum room. After a preliminary survey of the room, the light scheme and instrumentation were placed following a structured workflow:

1. Two setups were created by digitisation technique, differentiating high-definition digital photography and structured light scanning;
2. Each artefact was captured with a metric bar and a colour checker, or a palette with a codified colour scheme for calibrated colour correction in post-processing;
3. Firstly, medals were captured with at least three images (front side – rear side – thickness) and one-sided 3D scanning to record the right metric scale;
4. Non-reflective objects were scanned by SLS;
5. Reflective objects were scanned at the end, changing light conditions;
6. On-site pre-elaboration was carried out, ensuring the completion of the dataset and the absence of missing parts.

Here the instrumentation used during the digitisation process:

- DSLR Nikon D800e camera CMOS sensor 36MP;
- Fixed lens AF-S NIKKOR 50mm 1:4G;
- Fixed lens AF-S Micro NIKKOR 105mm 1:2.8G ED;
- 2x Flash Godox AD600Pro;
- 3D Scanner Artec Eva;
- 3D Scanner Artec Spider;
- X-Rite ColorChecker Passport Photo 2 – 24 patches + 2-level grey;
- 5x codified marker 12 bit
- Multiple metric bar – from 50 mm to 250 mm;

- Light diffuser;
- Gloves, tablecloth, museum-plexiglass pieces for supporting objects.

A total of 33 digitisations were carried out, considering some objects were captured in multiple configurations or were composed of two objects (e.g. shoes count as a single artefact, but two physical objects represent the artefact, books were captured in open-middle-closed configuration).



Figure 20. Images from the dataset.

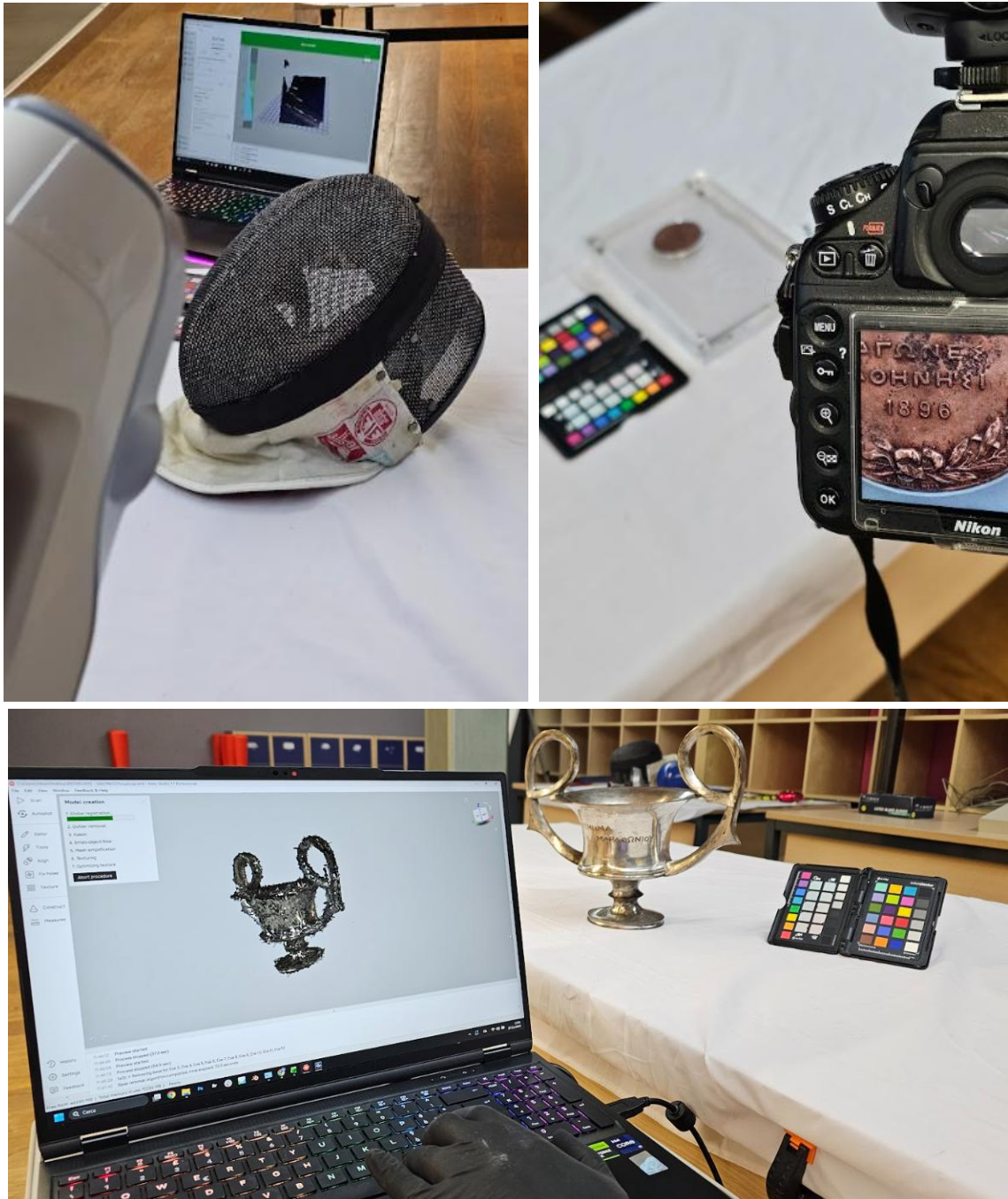


Figure 21. Images during the digitisation process.

After digitisation and on-field activities, the dataset was subjected to several activities aimed at improving quality ensure consistency between the metrological and colourimetric scales. All images passed through a process of colour calibration and enhancement by applying white balance and contrast masks. The dataset acquired via SLS was processed using filtering, hole closing, mesh optimisation and texturing. Some generated models were used as a blueprint for re-modelling final objects, using retopology and optimisation methods.

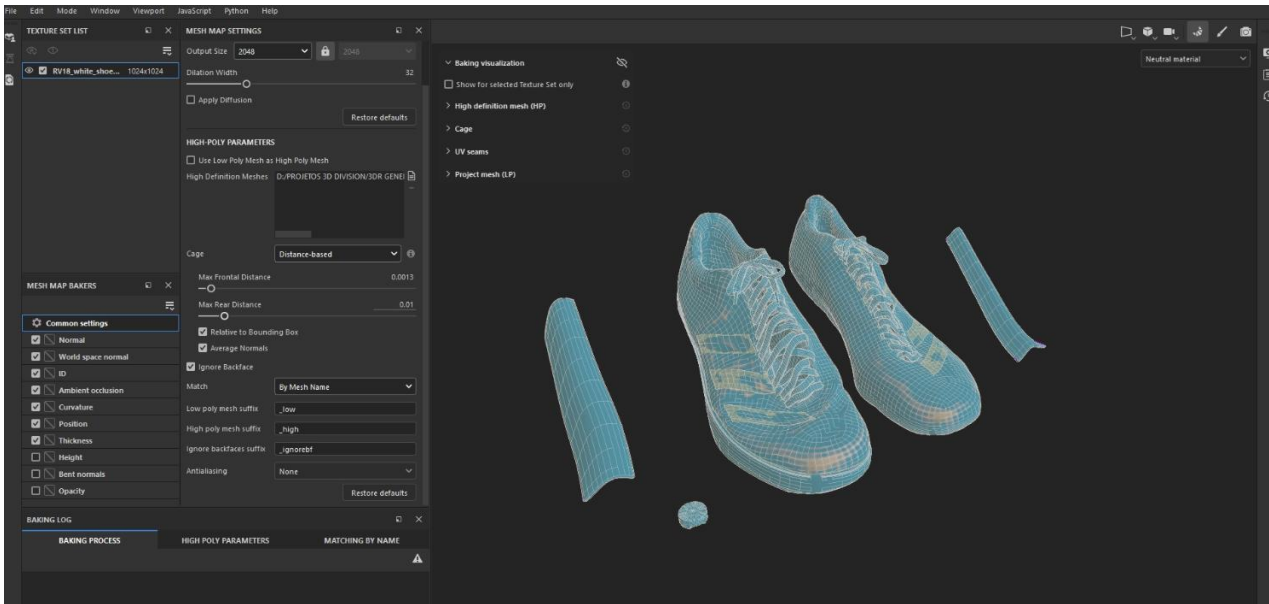


Figure 22. Process of mesh optimisation of Tokyo 2020 shoes.

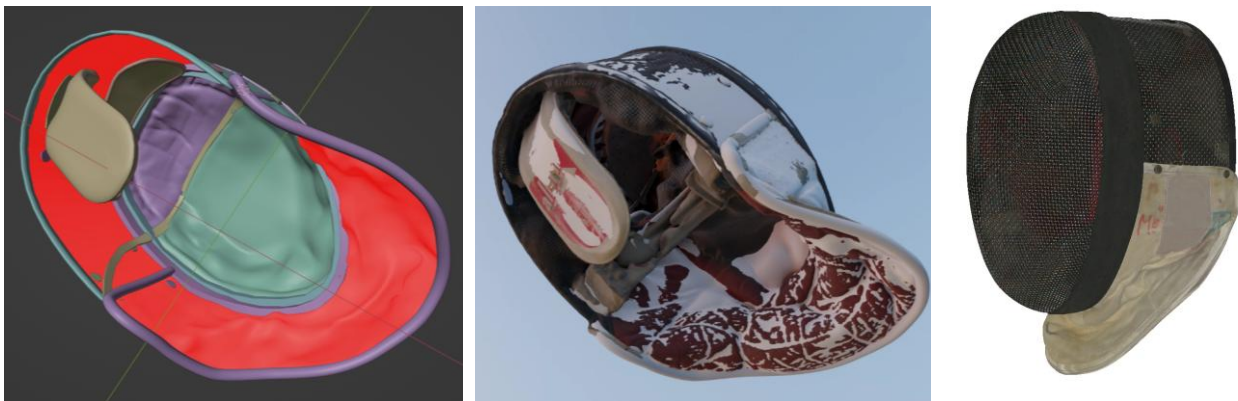


Figure 23. Post-processing operation on the fencing mask and final 3D object.

At the end, all models were simplified, textured and exported in OBJ+JPEG and GLB embedded, with a target of 200.000 polygons as average meshing and one 4K-sized texture.



Figure 24. Example of final digital objects in 3D.



Figure 25. Process for creating 3D models of medals, starting from high-resolution images and the preliminary 3D model to the final objects.

4.1.3 Pilot 3

The AQUILEIA archaeological site was selected for its importance and meaning in documenting Historical and Archaeological Cultural Heritage. In contrast, as shown in section 3.3, relevant and “single” objects were selected through a structured process that followed the Task 2.2 “Public Sensing Prioritisation Enabler” activities. Physical objects and the archaeological area were digitised in two separate sessions. The first one inside the National Archaeological Museum of Aquileia, and the second one inside the archaeological area itself. The preliminary on-field survey, executed in February 2025, was helpful to define the strategy to be followed during the digitisation activities:

- Site’s specific characteristics and logistical conditions were documented, such as overall dimensions, ambient light, wind conditions, and height of the internal coverage;
- It was decided that one full working day was required to perform the activity, splitting it in two sub-sessions:
 - Manual drone mapping, inside and outside the modern coverage;
 - Manual photogrammetry, inside the coverage;
- Physical objects from the Museum collection require a separate and dedicated session, preparing two different setups:
 - Setup for handled 3D scanner;
 - Setup for photogrammetry and high-quality digital photography.

A total of 24 digitisations were carried out. Although the Domus of Titus Macrus was initially released as a single digital object, as it represents one archaeological site, it is in fact composed of several distinct components. These elements can be separated from the overall area and delivered as independent digital objects, as they constitute individual artefacts. The general area was therefore divided into the following digital objects:

1. General archaeological area;
2. Mosaic;
3. Oven;
4. Stone Well;

achieving the number of 27 digital objects.

For completing the digitisation and final release process, after on-field activities, the dataset was subjected to specific activities for improving texture and metric quality and correspondence between physical objects and digital ones. So, images were subjected to colour calibration and white balance, while 3D scanned objects were processed using filtering, hole closing, mesh optimisation and texturing.

4.1.3.1 Domus of Titus Macrus

The Domus of Titus Macrus required a digitisation procedure structured as a site-specific workflow combining high-resolution photographic documentation, photogrammetric capture, and targeted 3D modelling of the most representative architectural and archaeological elements. The acquisition of overlapping calibrated images under controlled lighting conditions ensured geometric accuracy and colour fidelity by integrating drone-based aerial imaging to document the relationship between the domus and its surrounding archaeological setting and close-range captures for interior details, structural features, and

artefacts linked to specific rooms or functions. The collected images were then processed into dense point clouds, textured meshes, and orthophotos, which can be refined and exported in interoperable formats for adding specific details such as modern coverage and boundary regions.

The process followed these stages:

1. Session I: Indoor preliminary mapping by drone and camera, ensuring overall coverage of the whole area: following a manual-driven double-grid path, a lot of images were captured using an average altitude of 2.5 m;
2. Session II: Indoor detailed mapping by drone and camera to cover the most important rooms, such as the main mosaic, the oven and the well, but also the pattern of other mosaiced floors;
3. Session III: Indoor mapping managed by a handheld camera, to cover undercuts;
4. Session IV: Indoor mapping managed by a handheld camera to document modern coverage and attaching points on the archaeological area;
5. Session V: Outdoor mapping by drone to capture boundary region and modern coverage.

On-site pre-elaboration was carried out, ensuring the completion of the dataset and the absence of missing parts. Here is listed the instrumentation used during the digitisation process:

- DSLR Nikon D800e camera CMOS sensor 36MP;
- Fixed lens AF-S NIKKOR 50mm 1:4G;
- Fixed lens AF-S Micro NIKKOR 105mm 1:2.8G ED;
- 2x Flash Godox TT685 with Light diffuser;
- X-Rite ColorChecker Passport Photo 2 – 24 patches + 2-level grey;
- 8x codified marker 12 bit;
- Multiple metric bar – from 10 cm to 5 m.

Considering the drone internally contains a GPS sensor, the metric scale was recorded in two different procedures:

- By using EXIF information saved in the drone scan;
- By using codified markers, in a closed loop calculation (n. 2 sets of n. 4 markers in square configuration, measuring both perimeter and diagonals) and drone position in a Ground Control Point (GCP), or the take-off position.




These two measures were introduced in a specific photogrammetry software for error calculation and alignment improvement. The resulting error was reduced by optimising camera position during the generation of the sparse cloud. After that, a dense cloud was generated and used for the **segmentation of the cloud point**: this process helped to identify three main classes of geometries: archaeological buildings, terrain, and man-made/modern objects. Thanks to this workflow, it was possible to generate separate meshes instead of a unique merged one. In fact, 3D digitisation of modern coverage was not a point of interest, and it was deleted from the 3D scene. Preserving attaching points on the floor, it was later modelled in a 3D environment using orthophotography and the 3D model as a blueprint. In this way, it was possible to:

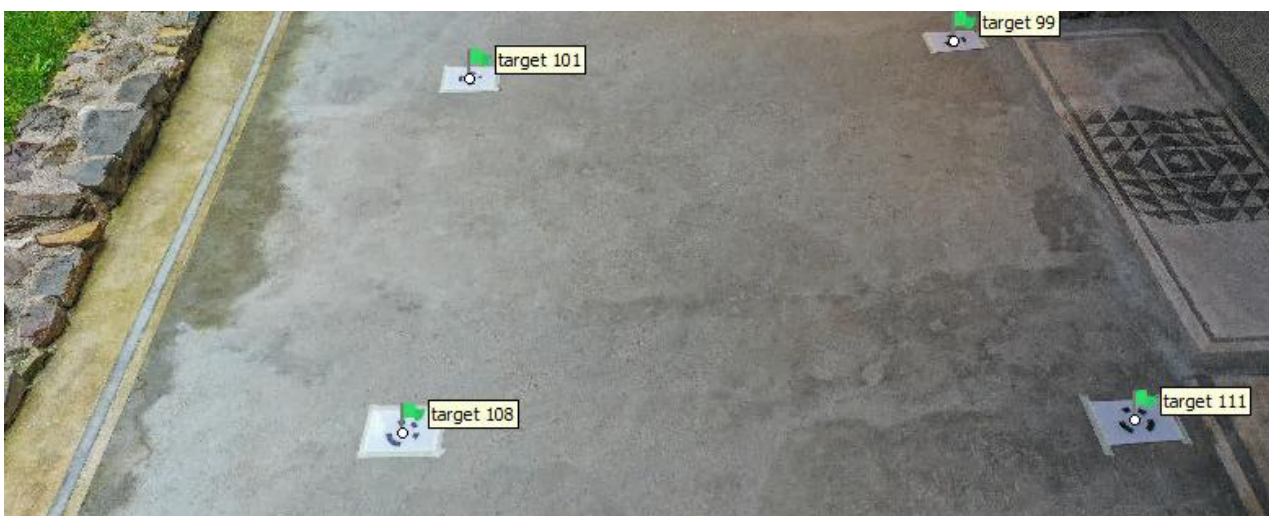
- Preserve a high level of detail in ancient geometries;
- Reduce the weight of the project and its computational cost during elaboration;
- Simplify the dataset;

- Produce a lightweight 3D model preserving the structure's special position.

At the end, all models were simplified, textured and exported in OBJ+JPEG and GLB embedded, with a target of 1.000.000 polygons and n. 4 8K-sized textures.

Table 2. Technical data of Pilot 3 digitising in the Domus of Titus Macrus.

	Light Structured	Camera	Objects info
Instrumentation	<i>DJI Mavic 2 Pro 1" CMOS Sensor Hasselblad 20MP</i>	<i>Nikon D800e Reflex Fullframe 36x24mm 36MP</i>	<i>Aquileia, Italy</i>
N. cameras	<i>Session I - 826 Session II - 499 Session V - 280</i>	<i>Session I - 805 Session II - 253 Session III-IV - 1272</i>	<i>Area approx. L 70 x W 25 m (inside)</i>
Process	<i>Manual Flight Outdoor + Indoor</i>	<i>Manual photography Indoor</i>	<i>Partially covered</i>
Format File (raw)	<i>DNG+JPEG</i>	<i>NEF+JPEG low res</i>	
Ref.			
N cameras	<i>3924 to be processed</i>		
N markers	<i>8 – codified 12 bit</i>		
N scale bars	<i>12 total measures (2 squares and 8 diagonals) – closed loop x2</i>		
Measure Errors	<i>Initial error: 2,793 mm Final error: 0.759 mm</i>		



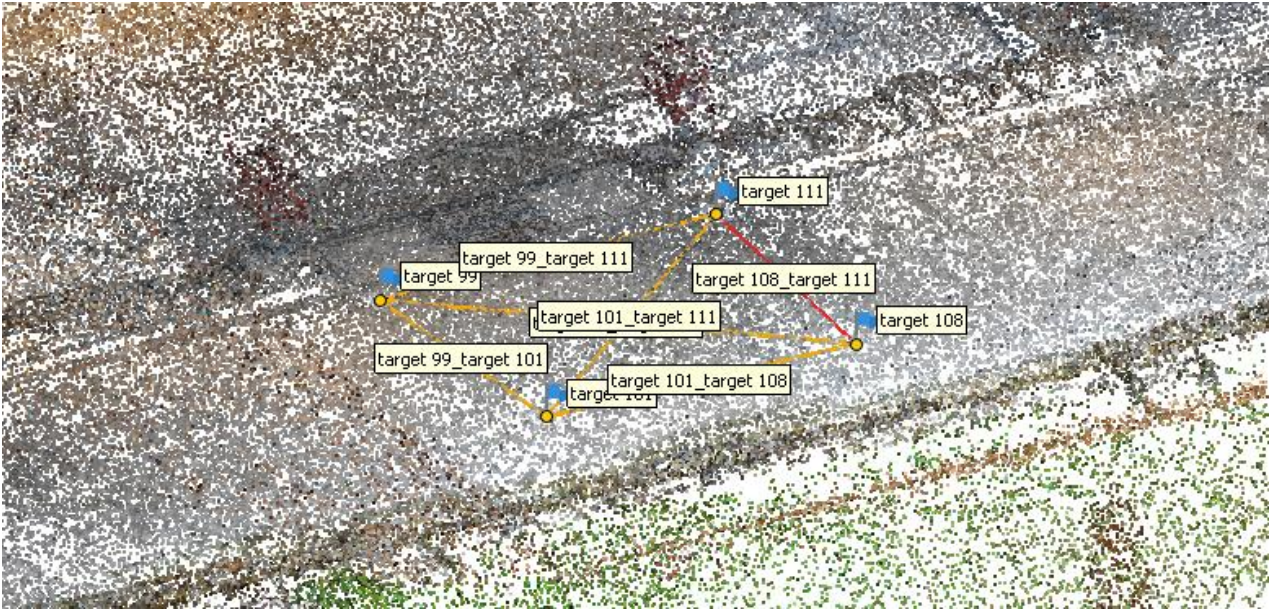


Figure 26. A set of codified markers in the dataset (on top) and measures in the cloud point (on bottom).

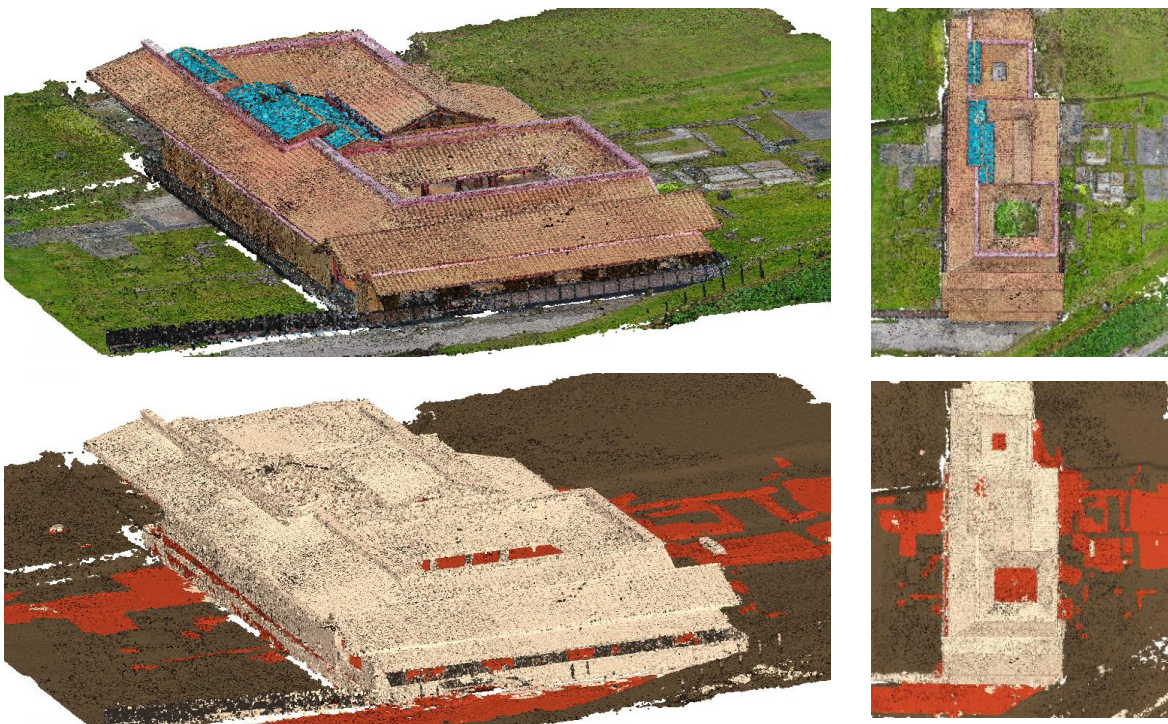


Figure 27. Dense cloud of the area (on top) and segmentation of the same cloud point in three classes (on bottom).

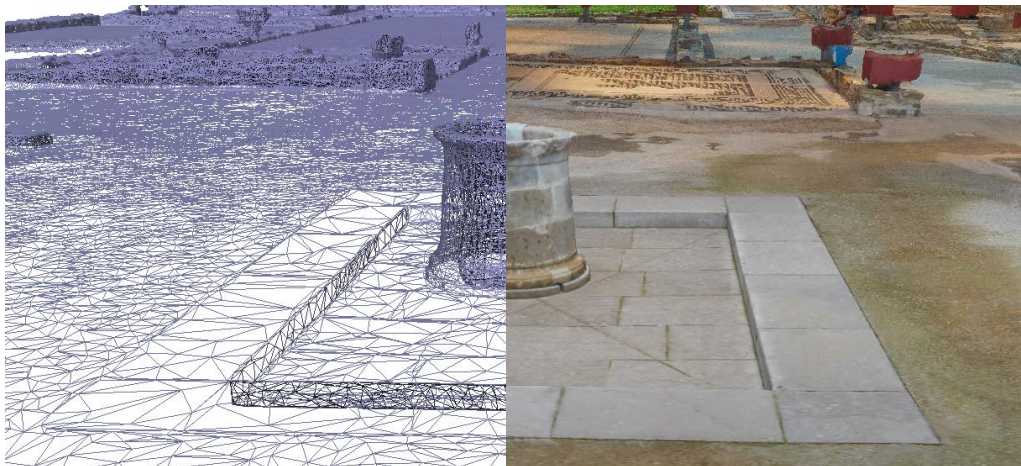


Figure 28. Screenshot from the 3D model of the archaeological area. From the top: mosaic, oven, stone well.

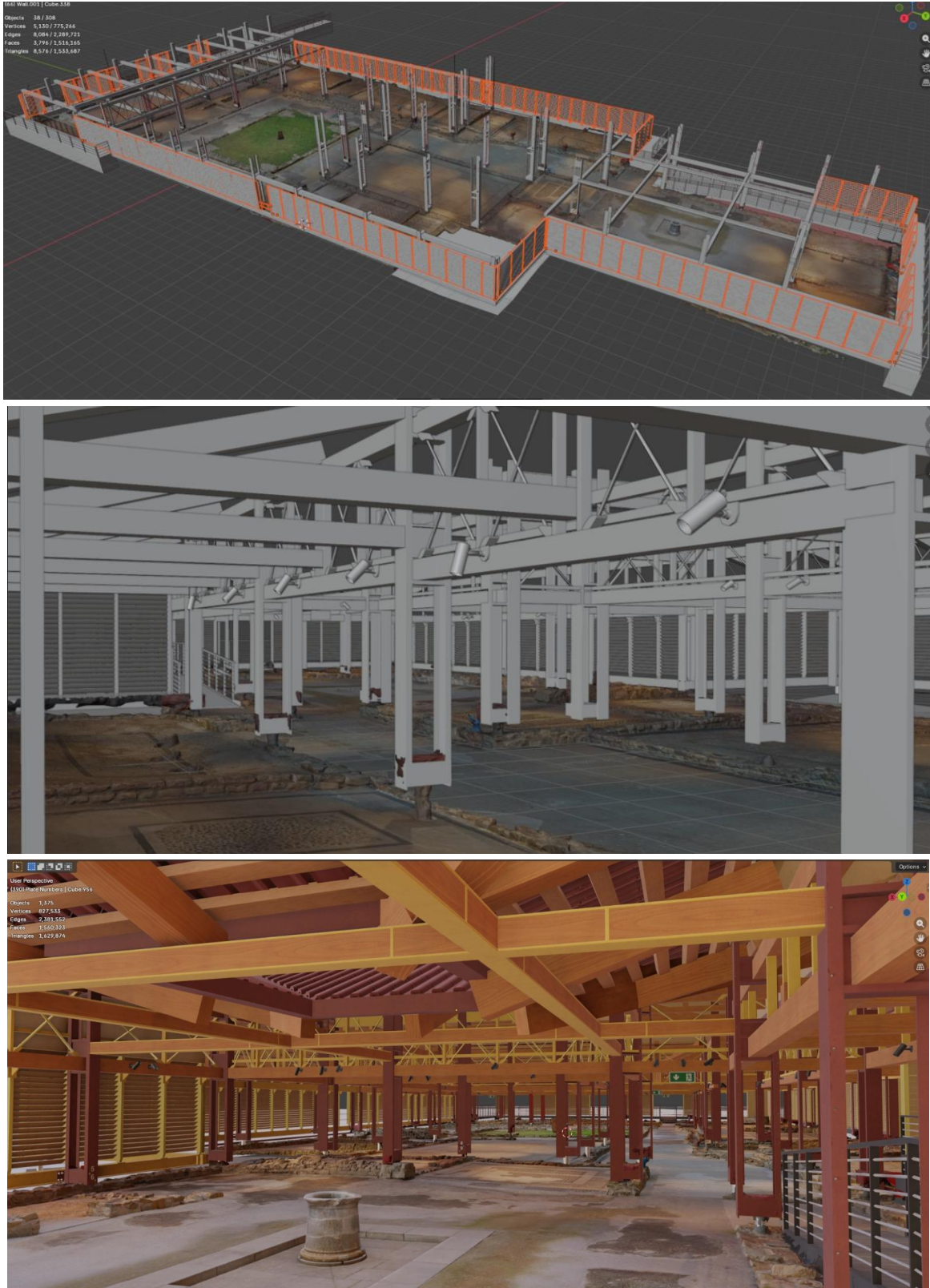


Figure 29. Screenshot from the 3D modelling environment while reconstructing the modern coverage on the ancient area.

4.1.3.2 National Archaeological Museum

Four stations were created inside the museum rooms: three of them for “unmovable” artefacts, one for movable artefacts inside the storage and laboratory room. For Unmovable setups, direct 3D scanning to record geometry and texture, and digital photography to record colour correction, were executed. Movable artefacts followed the same operations, plus some shots in photogrammetry. In every case:

- Each artefact was captured with a metric bar and a colour checker;
- Coin was captured with at least three images (front side – rear side – thickness) and one-sided 3D scanning to record the right metric scale;
- Amphora, vases, oil lamps and bronze sculptures were scanned by SLS;
- Two semi-transparent objects were subjected to a mixed technique (SLS, photogrammetry, digital photography);
- On-site pre-elaboration was carried out, ensuring the completion of the dataset and the absence of missing parts.

Here is listed the instrumentation used during the digitisation process:

- DSLR Nikon D800e camera CMOS sensor 36MP;
- Fixed lens AF-S NIKKOR 50mm 1:4G;
- Fixed lens AF-S Micro NIKKOR 105mm 1:2.8G ED;
- 2x Flash Godox AD600Pro;
- 3D Scanner Artec Eva;
- 3D Scanner Artec Spider;
- X-Rite ColorChecker Passport Photo 2 – 24 patches + 2-level grey;
- 5x codified marker 12 bit;
- Multiple metric bar – from 50 mm to 250 mm;
- Light diffuser;
- Gloves, tablecloth, museum-plexiglass pieces for supporting objects.

At the end, all models were simplified, textured and exported in OBJ+JPEG and GLB embedded, with a target of 200.000 polygons as average meshing and one 4K-sized texture.

Table 3. Technical data of Pilot 3 digitising in the National Archaeological Museum of Aquileia.



	Light Structured	Camera	Objects info
Instrumentation	Scanner Artec 3D Eva Scanner Artec 3D Spider	Nikon D800e Reflex Fullframe 36x24mm 36MP	Ceramic oil lamps
N. objects	20	3	Ceramic jugs
Process	Recording of deformed light pattern	Feature recognition between multiple cameras (MVS+SfM)	Stone weight
Format File (raw)	A3D	NEF+JPEG low res	Coin
Ref.			Bronze and marble statues



Figure 30. Digitisation of an immovable object.



Figure 31. Digitisation of movable objects.

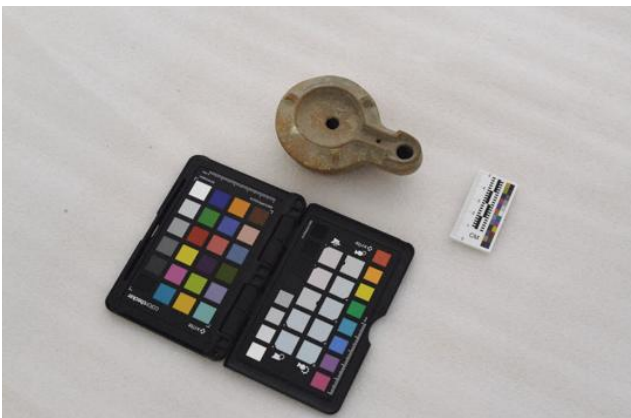


Figure 32. Colour correction, white balance and measure recording while digitising an oil lamp.

5 Results

5.1 Pilot 1

MoMu has selected, updated, and digitised three datasets that are being used to validate the REEVALUATE framework. These datasets differ in scope, level of enrichment, and intended use, and together form a progressive pipeline from large-scale collection data to highly enriched pilot-ready assets. A significantly larger dataset than originally anticipated was delivered.

Table 4. MoMU digital objects collected.

Collection/dataset	Quantity of digital objects	Remarks / function
Study Collection dataset: Cultural heritage (CH) artefacts consisting of metadata records describing the objects and associated JPG images, most of which are available under an open CC.BY licence. The full Study Collection contains over 2,000 objects; for this project, a smaller subset was provided, with records containing personal data, unclear intellectual property rights (IPR) status, or in copyright content filtered out.	<i>1.796 objects</i>	Made available via the Omeka S API to LINKS for large-scale integration into the Knowledge Graph. Serves as a foundational dataset for semantic linking and validation.
Pattern Collection dataset: A curated subset of the Study Collection dataset featuring cultural heritage (CH) artefacts with object descriptions (metadata), JPG images, and cutting patterns (SVG/PDF). The cutting patterns have been validated for accuracy, use a standardised layout, and include all necessary technical metadata (measurements, symbols, and descriptive elements) to support pattern makers. All patterns are made available under an open CC.BY licence and are branded with the REEVALUATE and European Commission logos.	<i>>25 objects</i>	Collection will be published before 2nd iteration of 'REEVALUATE page' of Study Collection website. To be made available through the Marketplace Enabler. Acts as a pre-selected longlist for the Game and Pattern pilots, featuring women's garments across different periods, cultures, and contexts.
Pilot 1 dataset: A subset of the Pattern Collection featuring enriched digital objects that include artefact metadata, additional contextual information, JPG images, SVG/PDF cutting patterns, 3D models (e.g. GLB), and texture maps (either derived from material texture scans or inferred from a standard library). All assets are made available under a CC.BY licence.	<i>5 objects have been selected:</i> - <i>ST2202: Evening Dress</i> (http://data.momu.be/ark:34546/mn0318) <i>Object from 1st Iteration</i> - <i>ST503 Corsage (TBD)</i> (http://data.momu.be/ark:34546/mcc2mf) - <i>ST81114AB (Cycling Blouse)</i>	Used directly in the Pattern and Game pilots, developed by partners FFP and CERTH in collaboration with the external company Fibre Mood.

	<p>(http://data.momu.be/ark:34546/m2rbtz) - ST81116 (Cycling trousers) (http://data.momu.be/ark:34546/mt76pz) - ST80998 (Palestinian bridal gown – TBD) (http://data.momu.be/ark:34546/mp5hw9)</p>	
--	---	--

5.2 Pilot 2

5.2.1 SPK

The following table lists the digital assets selected for Pilot 2 according to the methodology described. Music digital assets are already uploaded in the collection “Music and Sports” in the REEVALUATE Marketplace platform.

Table 5. The Berlin Phonogramm-Archiv 1900–2011

Assets N°	How	When	Where	Nr.	What
<i>SPK: Music! 111_VII_CD_1325-8</i>					
1	Phonograph	1912	China	1/8	Rowing song of a boat's crew on the Yangzi
2	Phonograph	1935	Ivory Coast	1/21	Kuadinkro bessueba (flute ensemble & singer)
3	Phonograph	1908	Cameroon	1/23	Music for the 'Iela' celebration
4	Phonograph	1928	Sudan	1/27-28	Two songs of the Zande
5	Phonograph	1903	Tanga	1/29	Xylophone piece of the Bondei
6	Phonograph	1897	Columbia	1/30	Dance song of the Thompson River Indians
7	Phonograph	1909	Lithuania	1/38-39	Instrumental pieces (skuduciai ensemble)
8	Phonograph	1909	Lithuania	1/38-39	Skuduciai players (photo)
9	Tape	1956	Turkey	2/1	Instrumental narration (diidiik flute)
10	Tape	1955	Turkey	2/5-6	Uigur musicians (zihizga & dombra)
11	Tape	1955	Turkey	2/5-6	Uigur musicians (zihizga & dombra)

12	Tape	1955	Cairo	2/11-12	Mawwal and Nubian song
13	Tape	1962	N'guya	2/13	Song of harp player Kali (Buduma)
14	Tape	1958	Bolivia	2/22	Music for 'ayarichi' dance
15	DAT	2000	Myanmar/Burma	3/4	Praise song 'Pat pyo'
16	Tape	1958	Bolivia	3/8	Oceania, New Guinea, Dance Festival
17	Concert	1977	Berlin	4/7	Music of 'mizmar baladi' ensemble
18	Composition	2013	Berlin	5/3	52°46' North 13°29' East - Music For Wax-Cylinders (Ex-cerpt)
<i>Trumpets VII_CD_1675: Waza, Bal Naggaro, Abangaran Music of the Berta from the Blue Nile, Sudan</i>					
19	CD	1983	Sudan	8	Akharo (2:43)
20	CD	1983	Sudan	14	Bartha waiyo (6:07)
<i>Südinische Tempelinstrumente VII_LP_5566, Josef Kuckertz Editor: Dieter Christensen 1969</i>					
21	LP	1969	South India	B 17	Langstuba pānkà
22	LP	1969	South India	B 18	Längstuben napuri und pānkà
23	LP	1969	South India	B 22	Schneckentrompete sankha
24	LP	1969	South India	B 23	Schneckentrompete sankha
25	LP	1969	South India	B 24	Schneckentrompete sankha

5.2.2 OLY

OLY selected the needs according to the Pilot requirements and deployed the public sensing enabler for participatory prioritisation. Thanks to this procedure, XX artefacts were subject to new digitisation, expanding the dataset collected from Pilot 2. These digital assets validate the REEVALUATE framework through Marketplace uploads, Knowledge Graph integration, cross-enabler workflows, and WP4 development.

Table 6. Digital Objects produced and delivered for Pilot 2 – OLY.

N°	Title	Olympic Game edition
1	Competition Ball of Hellenic National Water Polo Team	Rio 2016
2	Competition Shoes Stelios Mygiakis (red)	Moscow 1980
3	Competition Shoes Miltiadis Tentoglou	Tokyo 2020
4	Competition Baseball Ball Ioanna Bouziou	Athens 2004
5	Competition Baseball Glove Ioanna Bouziou	Athens 2004
6	Olympic Torch	Berlin 1936
7	Cup Intercalated Olympic Games	Athens 1906
8	Rhythmic Gymnastics ball - Hellenic National Team Ensemble	Sydney 2000
9	Participating Medal	Athens 1896
10	Gold Medal Stelios Mygiakis	Moscow 1980
11	Silver Medal Alexandros Nikolaidis	Beijing 2008
12	Bronze Medal Ioanna Hadziioannou	Sydney 2000
13	Participating Medal	Athens 1906
14	Medal "B' ZAPPYA OLYMPIA 1870"	Zappia Olympia 1870
15	Competition Racket Of Panagiotis Gionis	Rio 2016
16	Swimming glasses - Competition Equipment Spyridon Gianniotis	Rio 2016
17	Rhythmic gymnastics club - Hellenic National Team Ensemble	Sydney 2000
18	Rhythmic gymnastics hoop - Hellenic National Team Ensemble	Sydney 2000
19	Competition Fencing Mask Dimitra Maganoudaki	Athens 2004
20	Competition Fencing Sword Dimitra Maganoudaki	Athens 2004
21	Competition Weightlifting Belt Nikolaos Iliadis	Montreal 1976
22	Olive crown- Kotinos	Athens 2004
23	Competition Arrow Evangelia Psarra	London 2012
24	Book – Gymnastics – Ioannis Fokianos	1883
25	Photography Album	Berlin 1936

5.3 Pilot 3

AQUILEIA has selected the destination site, used the enabler for public sensing and digitised a number of artefacts higher than the required KPI. All these digital objects are being used to validate the REEVALUATE framework, uploading them to the Marketplace, to the Knowledge Graph, to the use of other enablers and for the development of the virtual tour in WP4.

Table 7. Digital Objects produced and delivered for Pilot 3 – AQUILEIA.

N°	Title	Description	Invento ry Nr.
1	Three-nozzle oil lamp (trilychnis)	Three-nozzle oil lamp: mould-made, closed channel, rounded nozzles, knobs, chipped handle.	7042
2	Open-channel oil lamp	Three-knob clay oil lamp: mould-made, open channel, air hole, iron encrustation, use traces.	6437
3	Oil Lamp	Oil lamp (mould-made clay) with an open channel, featuring three small knobs on the shoulder and an air hole positioned halfway along the channel.	6603
4	Jug	Jug in refined common ware with a rounded rim and a thick strap handle.	2018
5	Jug	Jug in refined common ware	8390
6	Jug	Jug in refined common ware	
7	Inkwell	Globular terracotta inkwell with a lid perforated at the centre.	
8	Casserole	Knossos 2–type casserole in Eastern common ware. It features an everted rim slanting upward and a carinated body.	320079
9	Small bronze statuette (offerer)	Bronze statuette depicting an offerer holding a patera in the right hand and a garment.	17722
10	Statuette	Small bronze statuette	17724
11	Statuette	Small bronze statuette (Minerva)	
12	Statuette	Small bronze statuette (Mercury)	
13	Glass bottle	Bottle with a tall funnel-shaped neck, globular body, and slightly concave base, made of blown glass shaped while hot.	595076
14	Glass cup	Blown glass cup with a wide mouth and a truncated-conical body narrowing towards the base.	12906
15	Amphora	Cylindrical amphora of Tunisian origin intended for the transport of wine or olive oil.	R51061

16	Slab	Slab decorated in low relief (Priapus) on the front face.	1517
17	Slab	Priapus low-relief slab: elderly god with sickle, fruits, cloak, phallus, apotropaic eye. Late Imperial, reused marble.	
18	Bust	Mature bearded man bust: taenia-crowned, curly hair/beard, muscular neck, himation fold.	476
19	Mortar	Marble mortar (patera?): decorated rim, four handles, flower foot, spiral motifs, Roman period.	51835
20	Stone weight	Stone weight with iron handle, with inscription "T. MACR."	544755
21	Sestertius	Sestertius of Maximinus Thrax, the emperor who died in Aquileia.	54174
22	Unguentarium	Unguentarium made by free-blowing, with a vertically cut rim, slightly flared outward.	12702
23	Unguentarium	Small glass amphora	2007/31
24	Stone wellhead	Atrium wellhead: impluvium-located, partially excavated, 3D-printed reconstruction, shallow aquifer.	
25	Oven	Bakery oven places in the Domus: southern shop, circular base, millstone, bread counter, cardo-facing sales.	
26	Polychrome mosaic with fawn and dog	The mosaic rich in details and colours, located in the small room overlooking the garden, represents a deer and dog with their jaws wide open. In general, the mosaics kept in the Domus offer a sampling of the tastes in vogue for mosaic decoration.	
27	Domus Titus Macrus	One of the largest Roman-era residences discovered in northern Italy and part of the Aquileia UNESCO site, covers an area of 1,700 square metres and is unique in Europe. The house is situated between two of the city's paved streets (cardines) within one of the southern blocks of the colony, founded in 181 BC.	



Figure 33. Some 3D objects obtained from the digitisation campaign.

6 Conclusion

This deliverable has presented the outcomes of the second phase of Task 2.1, Cultural Items Identification & Digitisation, within the REEVALUATE project. Building on the preliminary mapping carried out in D2.1, the activities described in D2.4 enabled the transition from an initial assessment of available collections to the effective preparation of curated and interoperable digital assets for the three pilots.

Across the project, a common methodological framework was applied to very different cultural heritage domains: fashion heritage, Olympic and ethnographic culture, and Roman archaeology. Despite the diversity of collections, institutional contexts, and technical requirements, the task demonstrated that a harmonised workflow based on selection criteria, metadata enrichment, and fit-for-purpose digitisation can successfully support the reuse of Cultural Heritage assets in innovative digital environments.

A key result of the work was the production and consolidation of pilot-specific datasets ready for integration into the REEVALUATE ecosystem. Existing digital collections were reviewed and enhanced where possible, while targeted digitisation campaigns addressed gaps in quality, formats, or availability. This included:

- 2D pattern extraction and garment reconstruction for Pilot 1;
- 3D digital objects for Olympic games equipment and culture-related audio tracks for Pilot 2;
- 3D digital objects of archaeological artefacts and site-based assets for Pilot 3.

These outputs confirm the value of combining pre-existing resources with selective new digitisation actions rather than relying exclusively on large-scale digitisation programmes.

The deliverable also highlighted the strategic importance of interoperability. By aligning information structures with file format archiving and use, the project strengthened the long-term usability of the generated assets and their future integration into several services inside and outside project scopes, such as the Knowledge Graph, Marketplace, and immersive/mobile applications. In this sense, digitisation was treated not only as image or model production, but as the creation of reusable digital knowledge objects. This approach demonstrates how digital transformation can also support more inclusive and community-oriented heritage practices.

In conclusion, D2.4 confirms that the identification, preparation, and digitisation of cultural heritage assets are fundamental enabling steps for the wider REEVALUATE framework. The activities carried out under Task 2.1 have provided technically validated resources for pilot implementation and future experimentation.

References

- [1] H. Yilmaz, M. Yakar, S. Gulec and O. Dulgerler, "Importance of digital close-range photogrammetry in documentation of cultural heritage," *Journal of Cultural Heritage*, pp. Pages 428-433, 2007.
- [2] E. Commission, "Commission recommendation on the digitisation and online accessibility of cultural material and digital preservation," *Official Journal of the European Union*, 2011.
- [3] M. Mudge, M. Ashley and C. Schroer, "A digital future for cultural heritage. In *Visual Resources*," 2007.
- [4] A. C. Addison, "Emerging trends in virtual heritage," *IEEE Multimedia*, 2000.
- [5] F. Bruno, S. Bruno, G. D. Sensi, M. Luchi, S. Mancuso and M. Muzzupappa, "From 3D reconstruction to virtual reality: A complete methodology for digital archaeological exhibition," *Journal of Cultural Heritage*, vol. 11, pp. Pages 42-49, 2010.
- [6] K. A. P. H. B. T. B. R. F. S. M. P. B. a. M. B. –. L. o. C. D. W. a. R. T. –. I. S. A. M. H. –. U. N. A. Thomas Rieger, "FADGI - Technical Guidelines for Digitizing Cultural Heritage Materials," Don Williams and Michael Stelmach, 2023.
- [7] R. S. S. T. Alain Trémeau, *Computational Color Imaging, Second International Workshop, CCIW*, Springer, 2009.
- [8] L. MacDonald, "Digital heritage: Applying digital imaging to cultural heritage," *Elsevier*, 2006.
- [9] N. Yastikli, "Documentation of cultural heritage using digital photogrammetry and laser scanning," *Journal of Cultural Heritage*, 2007.
- [10] G. Guidi, M. Russo and J. Beraldin, "Acquisition of 3D models for cultural heritage: Surveying and modeling. In *Virtual Archaeology Review*," 2014.
- [11] F. Remondino and S. Campana, "3D recording and modelling in archaeology and cultural heritage: Theory and best practices," *Archaeopress*, 2014.
- [12] I. Aicardi, F. Chiabrando, A. Lingua and F. Noardo, "Recent trends in cultural heritage 3D survey: The photogrammetric computer vision approach," *Journal of Cultural Heritage*, 2018.
- [13] I. Colomina and P. Molijna, "Unmanned aerial systems for photogrammetry and remote sensing: A review," *ISPRS Journal of Photogrammetry and Remote Sensing*, 2014.
- [14] I. Bajena and P. Kuroczyński, "Metadata for 3D Digital Heritage Models. In the Search of a Common Ground," *Research and Education in Urban History in the Age of Digital Libraries*, 2023.

Annex 1

PARTNER		SHORT NAME
 CERTH CENTRE FOR RESEARCH & TECHNOLOGY HELLAS	CENTRE FOR RESEARCH & TECHNOLOGY HELLAS	CERTH
	FRAUNHOFER INSTITUTE FOR OPEN COMMUNICATION SYSTEMS FOKUS	FOKUS
	FROMSCRATCH DESIGN STUDIO BV	FS
	FONDAZIONE LINKS - LEADING INNOVATION & KNOWLEDGE FOR SOCIETY	LINKS
	FFP FILM- & FERNSEHPRODUKTION GMBH	FFP
	NUROGAMES GMBH	NURO
	GVAM GUIAS INTERACTIVAS SL	GVAM
	STIFTUNG PREUSSISCHER KULTURBESITZ	SPK
	HYPERTECH	HYP
	OLYMPIAKO MOUSEIO	OLYMPIC
	ARTHUR'S LEGAL BV	ARTHUR

	KATHOLIEKE UNIVERSITEIT LEUVEN	KU Leuven
	AG CULTURELE INSTELLINGEN ANTWERPEN/ ERFGOED	MoMU
	EUROPEAN FASHION HERITAGE ASSOCIATION	EFHA
	3D RESEARCH SRL	3DR
	FONDAZIONE AQUILEIA	AQUILEIA