HERITALISE

CAA2025 – EU HE ECHOES Workshop

Athens, May 2025

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The TEAM

IDP engineering · environment · architecture

University of St Andrews

Tekniker
MEMBER OF BASQUE RESEARCH & TECHNOLOGY ALLIANCE

La Venaria Reale
Residenze Reali Sabaude

Santa María la Real fundación

Politecnico di Torino

comet
Global Innovation

BDTA
BUILDING DIGITAL TWIN ASSOCIATION

Cyprus University of Technology

Open Geospatial Consortium

whm
West Highland Museum

timespan

europeana

CENTRO CONSERVAZIONE RESTAURO LA VENARIA REALE

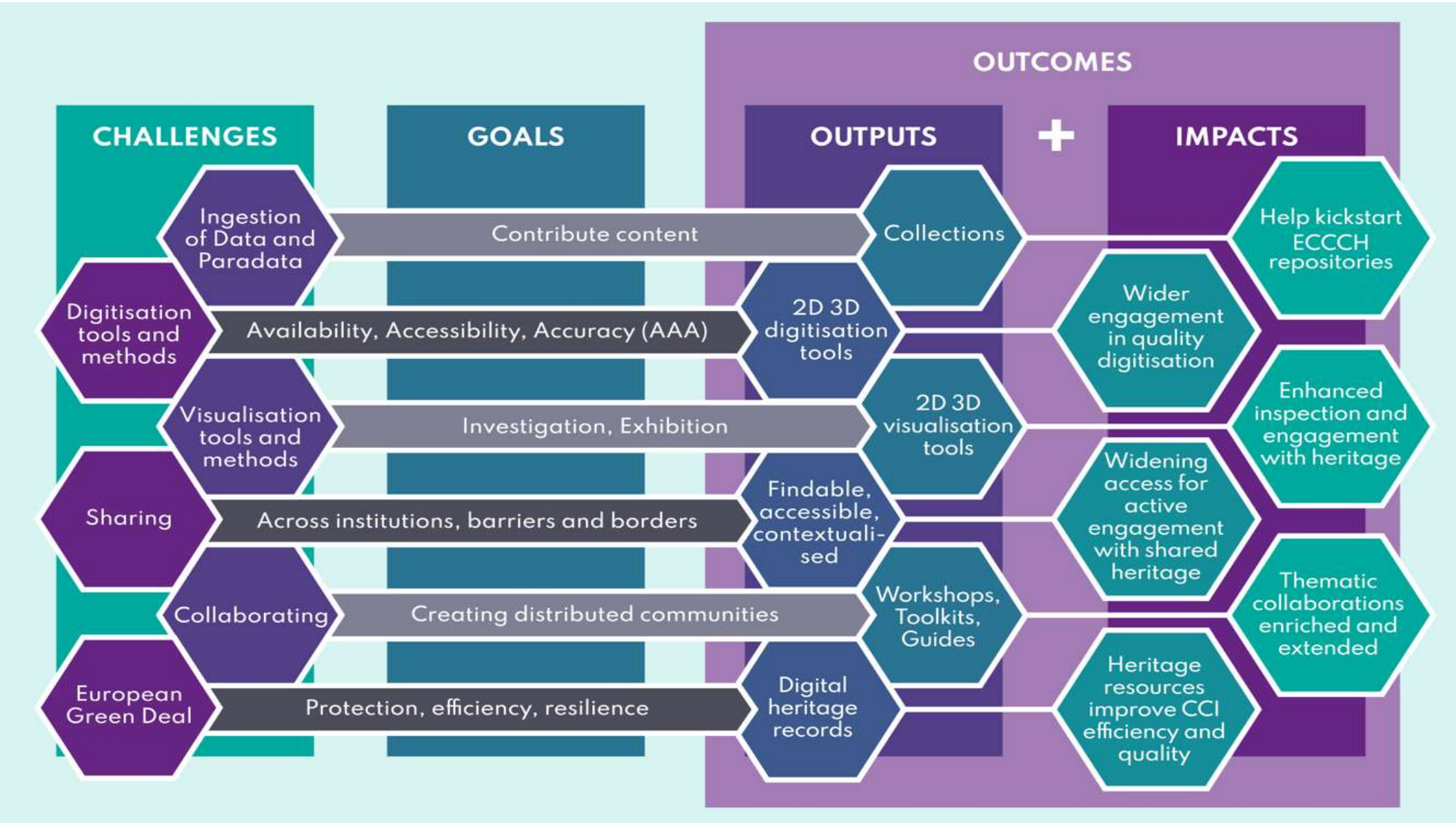
Heritage Malta

eMA
European Museum Academy

EIM
European Innovation Marketplace

Quick Facts

- **Full title**: Heritage buildings and objects‘ digitisation & visualisation within the cloud
- **Coordinator**: IDP Ingenieria y Arquitectura Iberia S.L.
- **Beneficiaries**: 17 (from 7 countries: ES, IT, NL, CY, BE, MT and UK)
- **Topic**: HORIZON-CL2-2023-HERITAGE-ECCCH-01-02
- **Type of Action**: RIA
- **EU Contribution**: 4,2 M €
- **UKRI Contribution**: 0,8 M €
- **Duration**: 1 January 2025 – 31 December 2028 (4 years)


OUTCOMES
CHALLENGES
GOALS
OUTPUTS
+
IMPACTS
Ingestion of Data and Paradata
Contribute content
Collections
Help kickstart ECCCH repositories
Digitisation tools and methods
Availability, Accessibility, Accuracy (AAA)
2D 3D digitisation tools
Wider engagement in quality digitisation
Visualisation tools and methods
Investigation, Exhibition
2D 3D visualisation tools
Enhanced inspection and engagement with heritage
Sharing
Across institutions, barriers and borders
Findable, accessible, contextuali-sed
Widening access for active engagement with shared heritage
Collaborating
Creating distributed communities
Workshops, Toolkits, Guides
Thematic collaborations enriched and extended
European Green Deal
Protection, efficiency, resilience
Digital heritage records
Heritage resources improve CCI efficiency and quality

The OBJECTIVES

- **Review & Protocols:** Assess and define current digitisation standards, methodologies and data requirements for tangible and intangible CH objects. Address gaps, set objectives and assess risks.
- **Advanced Data Acquisition:** Enhance 2D/3D technologies (e.g., LiDAR, photogrammetry) with improved calibration, metrology and multimodal capabilities for scalable, high-quality digitisation.
- **AI-Powered Post-Processing:** Develop AI-driven workflows, data fusion and algorithms to streamline post-processing, integrating tangible and non-tangible data for conservation insights.
- **HW/SW Solutions:** Create tools (e.g. 3D printing, VR/AR platforms, Geo-HBIM) to enhance CH engagement, accessibility and real-time monitoring of digitised assets.
- **Interoperability & Sharing:** Develop open components for seamless data integration across CH databases – ECCCH (ECHOES Infrastructure), leveraging APIs, semantic standards and metadata.
- **Impact & Dissemination:** Adress tech transfer challenges, standardise web platforms and showcase digitisation applications via 4 proof-of-concept use cases.

The IMPACTS

- **Enhanced preservation for cultural heritage**: By leveraging digital heritage data, we will enable **40% faster interventions, optimised maintenance, and precise detection of hidden issues, reducing risks of irreversible damage without dismantling objects**. Advanced methods like HBIM and data fusion will improve geometric accuracy and analysis, ensuring safer evaluations.

- **Impact**: Our initiative aims to support 2,000 heritage professionals, benefit 100 stakeholders, and reach 10 million users. It will **enhance museum engagement, align with Sustainable Development Goals, and foster deeper audience connections**.

- **Efficiency**: Offering **70% greater access to a FAIR-based ecosystem**, it will deliver **50% cost savings in maintenance**, boosting preservation planning and collaboration across Europe and beyond.

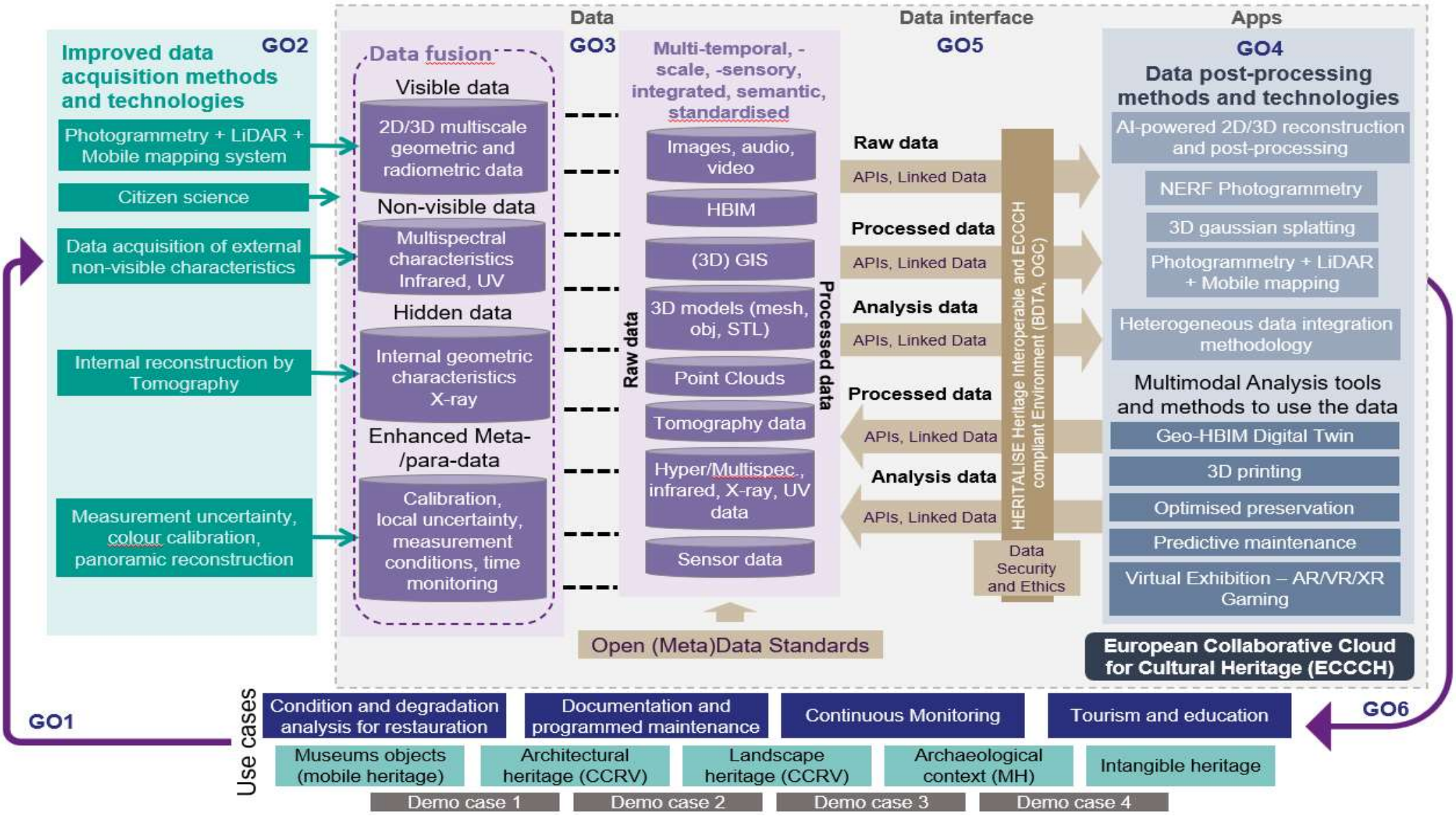
The IMPACTS

- Advancing digitisation accuracy, HERITALISE will enable authentic digital twins of heritage objects, **support tourism, education, and European identity while promoting social cohesion and safeguarding cultural assets**. Integrating cultural heritage into the European Cloud for Cultural Heritage (ECCCH) will **enhance access for museums, enabling diverse thematic exhibits that foster inclusion, unity, and EU values**.

- **Aligned with the UN Agenda 2030 and EU's Green Deal**, it will aid climate efforts by **enabling remote collaboration, reducing travel, and creating impactful exhibits of at-risk heritage. Supporting the New European Bauhaus**, it will enrich lives, promote sustainable development, and **inspire creativity** through detailed metadata and accessible digital heritage.

The PILLARS

1. CH Digitisation requirements and methodology definition
2. Digitisation tools' development and testing at lab scale (photogrammetry, computer tomography scanning, multispectral imaging technologies, reflectance transformation imaging)
3. CH data processing and post-processing supported by AI
4. CH data services development based on CH data (GeoHBIM based DTE, AR/VR visualisation, CH conservation module, CT scan-based 3D printing)
5. Interoperable ICT architecture (CH Digital Twin interoperability suite for ECCCH)
6. Replication and scalability strategies based on HERITALISE demonstration and validation


Improved data acquisition methods and technologies
GO2
Photogrammetry + LiDAR + Mobile mapping system
Citizen science
Data acquisition of external non-visible characteristics
Internal reconstruction by Tomography
Measurement uncertainty, colour calibration, panoramic reconstruction
Data
GO3
Data fusion
Visible data
2D/3D multiscale geometric and radiometric data
Non-visible data
Multispectral characteristics Infrared, UV
Hidden data
Internal geometric characteristics X-ray
Enhanced Meta-/para-data
Calibration, local uncertainty, measurement conditions, time monitoring
Multi-temporal, -scale, -sensory, integrated, semantic, standardised
Raw data
Images, audio, video
HBIM
(3D) GIS
3D models (mesh, obj, STL)
Point Clouds
Tomography data
Hyper/Multispec., infrared, X-ray, UV data
Sensor data
Processed data
Data interface
GO5
Raw data
APIs, Linked Data
Processed data
APIs, Linked Data
Analysis data
APIs, Linked Data
Processed data
APIs, Linked Data
Analysis data
APIs, Linked Data
HERITALISE Heritage Interoperable and ECCCH compliant Environment (BDTA, OGC)
Data Security and Ethics
Apps
GO4
Data post-processing methods and technologies
AI-powered 2D/3D reconstruction and post-processing
NERF Photogrammetry
3D gaussian splatting
Photogrammetry + LiDAR + Mobile mapping
Heterogeneous data integration methodology
Multimodal Analysis tools and methods to use the data
Geo-HBIM Digital Twin
3D printing
Optimised preservation
Predictive maintenance
Virtual Exhibition – AR/VR/XR Gaming
Open (Meta)Data Standards
European Collaborative Cloud for Cultural Heritage (ECCCH)
GO1
GO6
Use cases
Condition and degradation analysis for restauration
Documentation and programmed maintenance
Continuous Monitoring
Tourism and education
Museums objects (mobile heritage)
Architectural heritage (CCRV)
Landscape heritage (CCRV)
Archaeological context (MH)
Intangible heritage
Demo case 1
Demo case 2
Demo case 3
Demo case 4

The DEMONSTRATION SITES

West Highland Museum, Fort William, Scotland

Partners: WHM, USTAN

Building type: Category B listed

Potential outreach: 90,000 in person visitors per year, 200 heritage practitioners

Use case: Transforming Heritage through Digital Innovation

- Digitisation of the Jacobite and Carmichael collections and the building
- New digital exhibits for the museum, website and app to showcase landscapes, buildings, artworks and Gaelic cultural heritage
- Digital exhibits available through VR kiosks offering both touchscreen and immersive headset experiences

Contributing to a larger digital heritage archive

Figure 7: Virtual Time Travel: Past and Future

(a) West Highland Museum in Fort William

(b)

(c) West Highland 100 digitised objects

(d) Fort William Reconstruction 1746, exhibit in West Highland Museum

Figure 8: Digital engagement and with the West Highland Museum, Lochaber

The DEMONSTRATION SITES

Timespan Museum, Highlands, Scotland

Partners: HHAS, USTAN

Building type: Museum and landscape

Potential outreach: Small museum and art gallery with international standing

Use case: Immersive Heritage Experiences

- VR Room: Timespan's new digital venue for hosting HERITALISE partners, developing VR/AR technologies for CH objects and showcasing exhibits using VR, Xbox and touchscreens
- Timespan Object Collection: offers HERITALISE a testbed for visualizing objects and artifacts, even incomplete ones, to study environmental and social changes across Europe
- Kildonan Landscape: a unique open-air museum with archaeological sites spanning 6,000 years, showcasing human occupation through varied historic remnants
- Helmsdale Fishing Village & Jurassic Coastline: A historic 1815 fishing village with VR models depicting its 1890s peak during the herring boom, reflecting Scotland's trade history
- Community & Museum Sector Engagement: Collaborative virtual events held in 2020 featuring digital models, 3D objects, and films, including virtual tours and reconstructions of historical sites like Helmsdale Castle and Iron Age settlements

(a) Timespan Museum, Helmsdale

(b) Female Farmers, in Caen Strath of Kildonan

(c) Male Labourer in Caen

(d) 360 Image of VR Exhibit Green Room

Figure 7: Caen exhibit, located in Timespan Museum, Helmsdale Village adjacent to the Strath of Kildonan

The DEMONSTRATION SITES

Reggia di Venaria Reale, Turin, Italy

Partners: CCRS, CCR, POLITO

Building type: UNESCO site

Potential outreach: strong outreach potential by serving as a testing ground for new digital technologies in CH audience engagement

Use case: Advanced Digital Preservation

- Building Digitisation: Multiscale, multi-sensor scans of the Reggia di Venaria Reale, focusing on St. Uberto Church and the Great Gallery, to support maintenance and enhance visitor experience
- Architectural Analysis: 3D surveys and historical documents will reveal structural and hidden details of the Church and Gallery, monitoring conditions like humidity and microclimate that affect artwork preservation
- Landscape Heritage: Digital tracking of Giuseppe Penone's *Gardens of Fluid Sculptures* to capture the dynamic aging process of this blend of art and nature.
- Object Documentation: 3D imaging and tomography of 18th-century furniture to study cabinet-making techniques and monitor degradation due to environmental factors

The DEMONSTRATION SITES

Villa Portelli, Kalkara, Malta

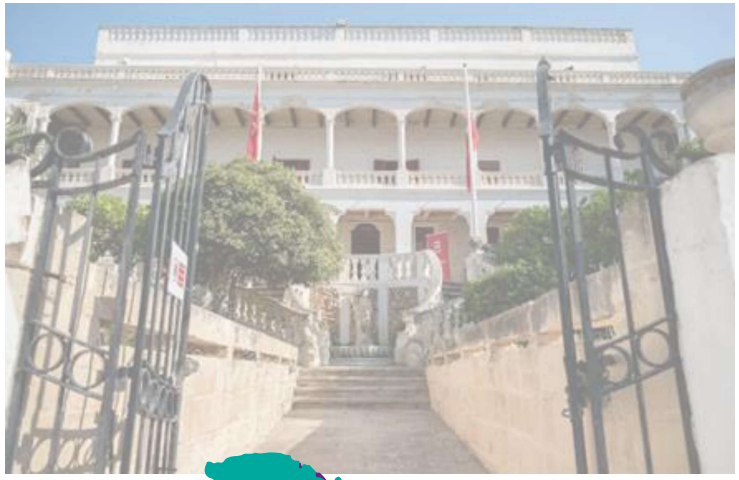
Partners: HM

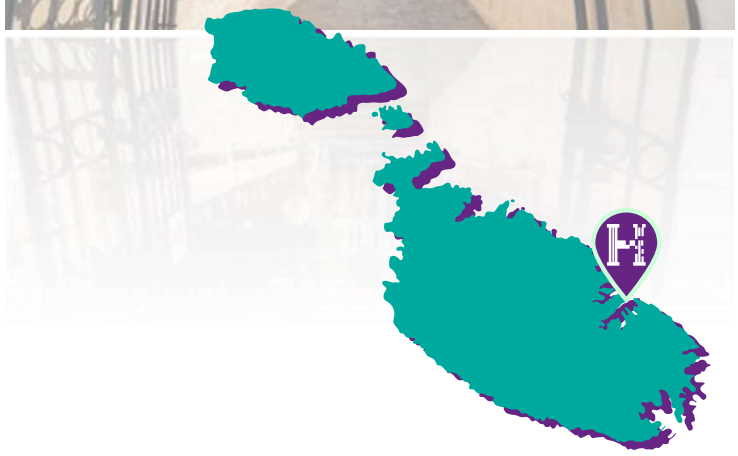
Building type: Historic villa

Potential outreach: 300,000 visitors per year; tens of international stakeholders, restorers, companies

Use case: Innovating Heritage through Digital Storytelling and Preservation

- Oral History Digitisation: Record memories of former VP workers, especially around significant changes in the villa's landscape
- Building Digitisation: Document the entire villa for conservation and as a BIM model and digital twin, usable at other heritage sites
- Methodology Testing: Combine techniques like LIDAR, photogrammetry, laser scanning, and Reflective Transformation Imaging to capture detailed site data
- Public Outreach Tools: Experiment with VR/AR, holograms, and projections to engage Gen Z audiences and study their interactions with digital heritage tools





Moore's Law: The number of transistors on microchips doubles every two years

Our World in Data

Moore's law describes the empirical regularity that the number of transistors on integrated circuits doubles approximately every two years.
This advancement is important for other aspects of technological progress in computing – such as processing speed or the price of computers.

Data source: Wikipedia (wikipedia.org/wiki/Transistor_count)
OurWorldinData.org – Research and data to make progress against the world's largest problems.

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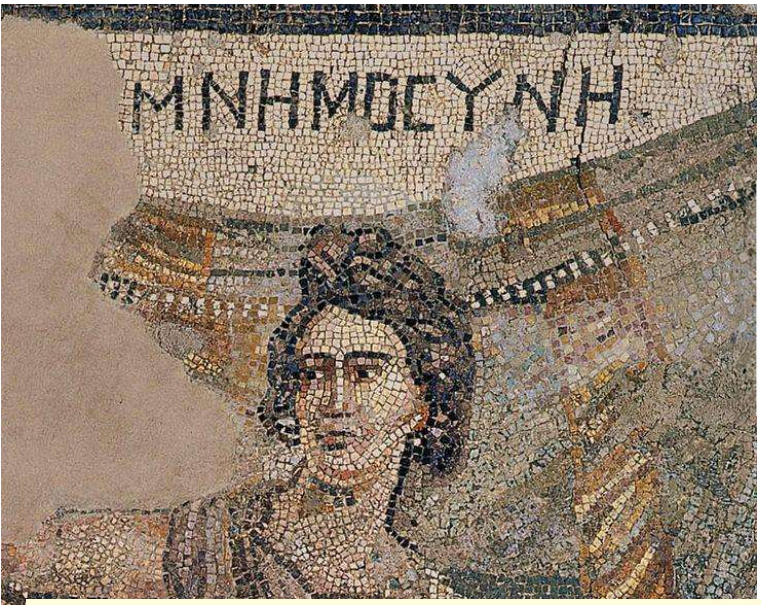
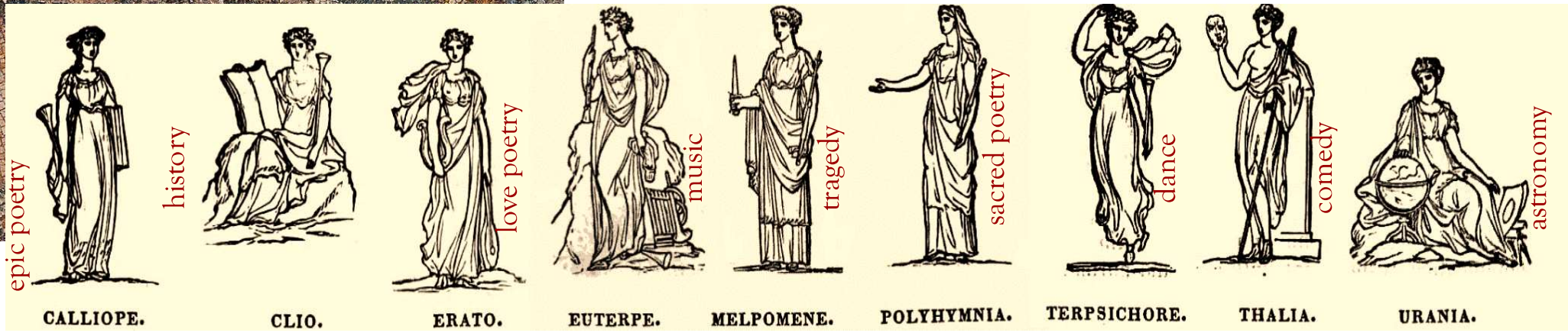


OUR NAME

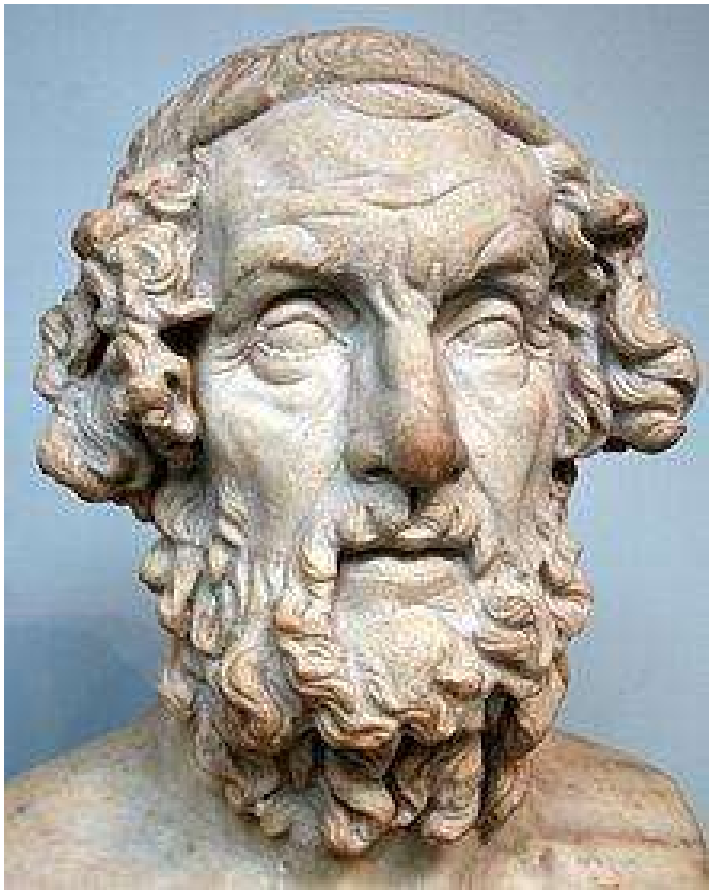
MNEMOSYNE

unesco Chair

The nine Goddesses of ARTS and SCIENCES in Greek Mythology



HERITALISE



ἄνδρα μοι ἔννεπε, **μοῦσα,** πολύτροπον, ὃς μάλα πολλὰ λάγχθη, ἐπεὶ Τροίης ἱερὸν πτολίεθρον ἔπερσεν: πολλῶν δ᾽ ἀνθρώπων ἴδεν ἄστεα καὶ νόον ἔγνω, πολλὰ δ᾽ ὅ γ᾽ ἐν πόντῳ πάθεν ἄλγεα ὃν κατὰ θυμόν, ἀρνύμενος ἥν τε ψυχὴν καὶ νόστον ἑταίρων…

Introducing the Cyprus University of Technology (CUT) Team

Marinos Ioannides
UNESCO Chair on DCH
Holder

Petros Siegkas
Medam-Lab
Mechanical Engineering
Department

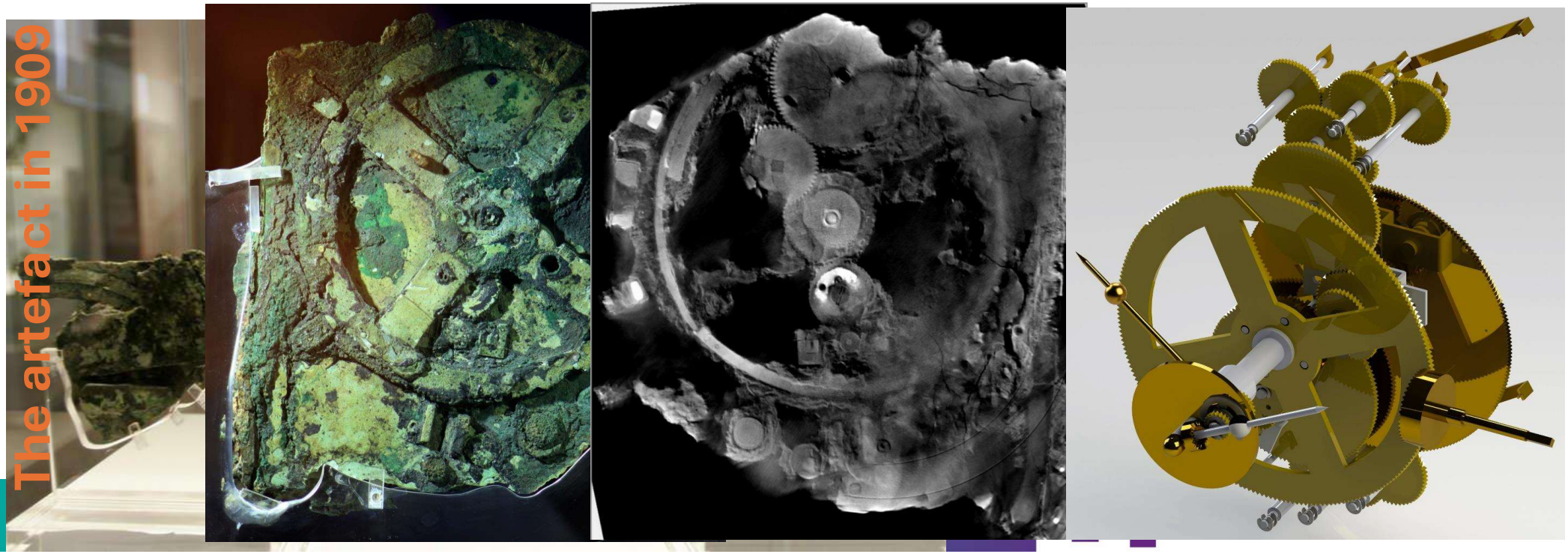
Athos Agapiou
UNESCO Chair Deputy
Earth Observation
Cultural Heritage Lab

Drew Baker
Research Associate

MNEMOSYNE Research Centre

3D Research Challenges in Cultural Heritage

The oldest analog Computer of the World - 2.4K Years



For whom do we digitize ?

- Owner/Stakeholder?
- Multidisciplinary Users

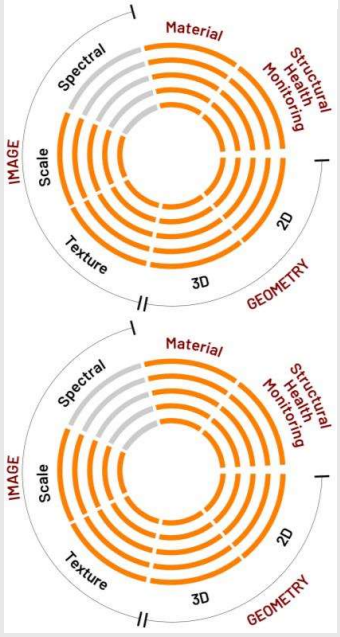
Why do we Digitise?

- Create a Replica / 3D Copy – a Digital Copy ? #DigitalTwin?
- Preservation / Conservation?
- Use / ReUse (for example in the creative Industry / Education)
- Recovery of Knowledge / Story / Memory
- Knowledge based Digitisation?

Analytical complexity and quality parameters for the Antikythera Mechanism.

The Antikythera Mechanism		
COMPLEXITY		
Stakeholder	Object type	Movable
	Dimension	82 Fragments few mm until 150 mm
	Purpose of 3D digitization	Detailed level
	Location	museum
	type	terrestrial
Object		Movable portable Not Permitted to move
Project		
Team		High experience • X-Ray CT scanning • PTM Dom technique • VGStudio Max • CAD system
Environment		Lab Conditions/ Museum
Hardware		X-Ray Tomographer, PDM DOM, CAD system, camera
Software		Commercial (VGStudio Max) (CAD system)
Pre-processing		Geometry, point cloud, texture, material
QUALITY		
Geometry	2D	Ultra-High
	3D, accuracy	Ultra-High (Less than 50 μm)
	3D, precision	Ultra-High
	3D, resolution	50 μm
	Number of CT scans	1500 to 3000 (depends on the fragment)
Image	Texture	Ultra-High
	scale	Ultra-High
	spectral	visible
Material		High/Copper alloy

The Antikythera Mechanism,
82 Fragments
National Archaeological Museum of Athens



What UN

Our planet is hom
tell the story of hu
Acropolis in Ather
of Ancient Kyoto, t
UNESCO for their
Each #WorldHerit
shared history and
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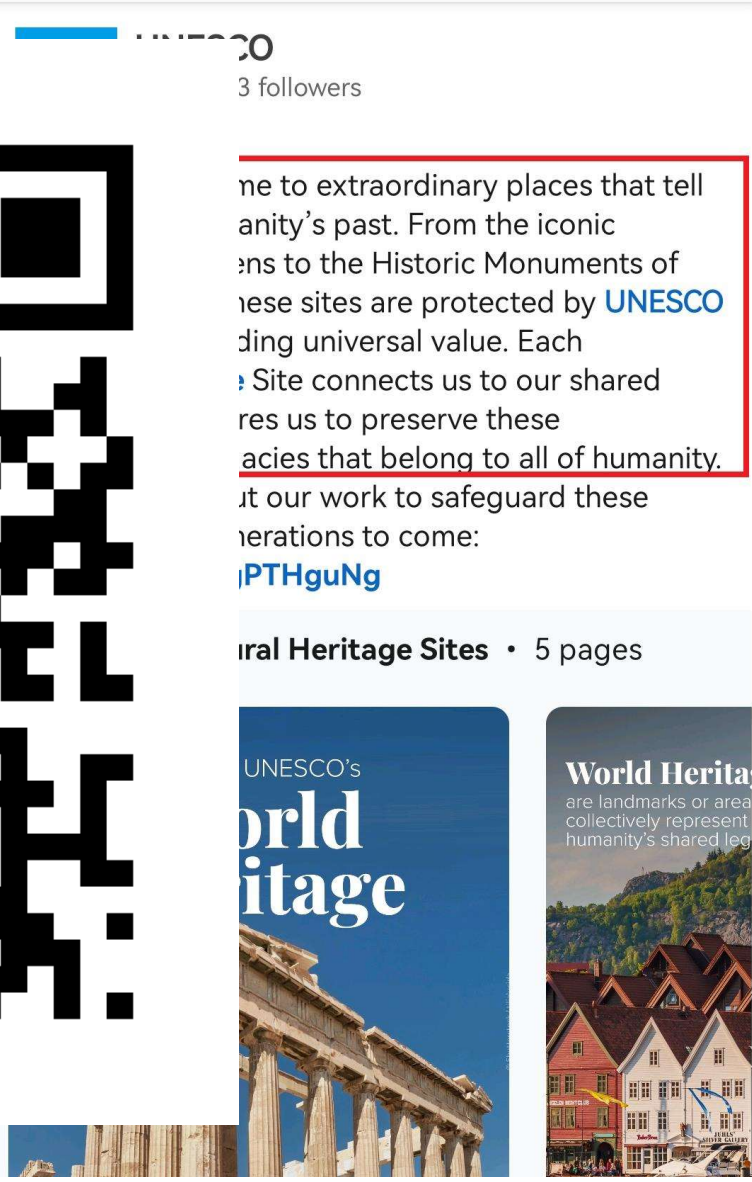
Chair



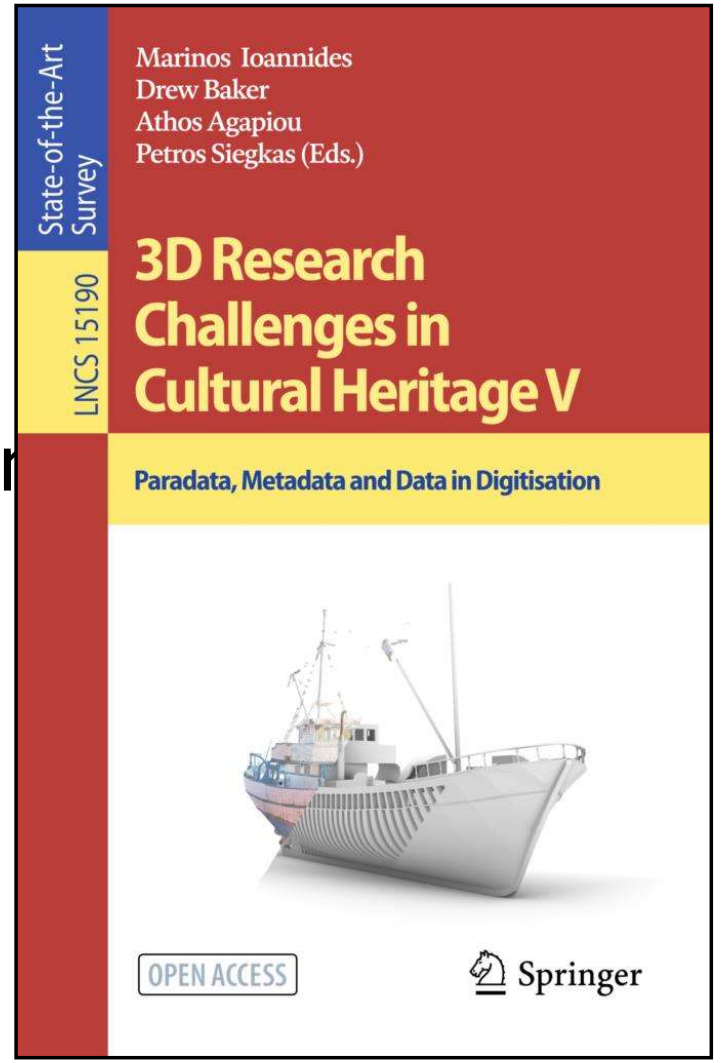
Guidelines for 2D/3D Digitisation

- Owner/Stakeholder Requirements
- Object?
- Team?
- Infrastructure?
- Certification of Digitisation
- Information and Data
- Formats of Info and Data
- Certification of the Methodology (Data Acquisition) and the Results - Quality
- Ethics and IPRs

Any Standards / Guidelines ?

Parada

Info + ion



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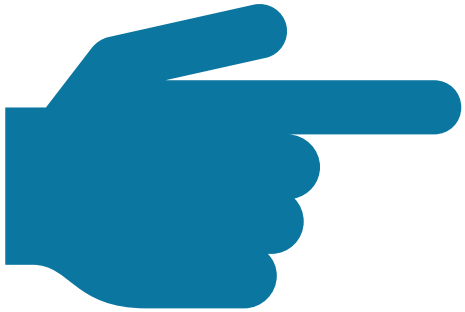
AI driven 3D Documentation

ETHICS

Take your phone and scan this QRC!

VIGIE 2020/654: Study on Quality in 3D Digitisation of Tangible Cultural Heritage

https://unescochair-dch.net/VIGIE-2020-654



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CH object data acquisition services and AI-supported data processing

Two main objectives:

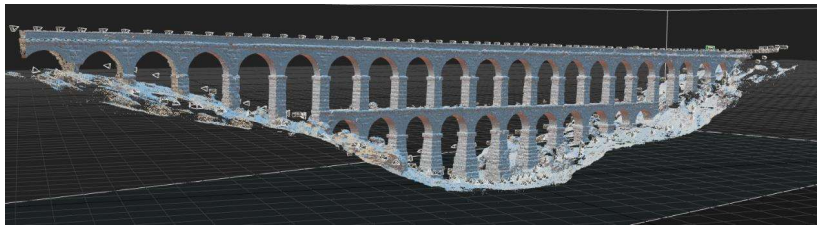
- Improve **2D/3D Data** acquisition technologies – towards new standards & tools to guarantee high data quality
- Improve post-processing adopting **AI-powered techniques**

HERITALISE digitisation tools

Digital Twin

- Data (2D/3D) - digital content quality
- Paradata - acquisition process quality

- **Photogrammetry**
- **CT Scan/Tomography**
- **Multispectral images technology**
- **Reflectance Transformation Imaging**



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CH object data acquisition services and AI-supported data processing

Two main objectives:

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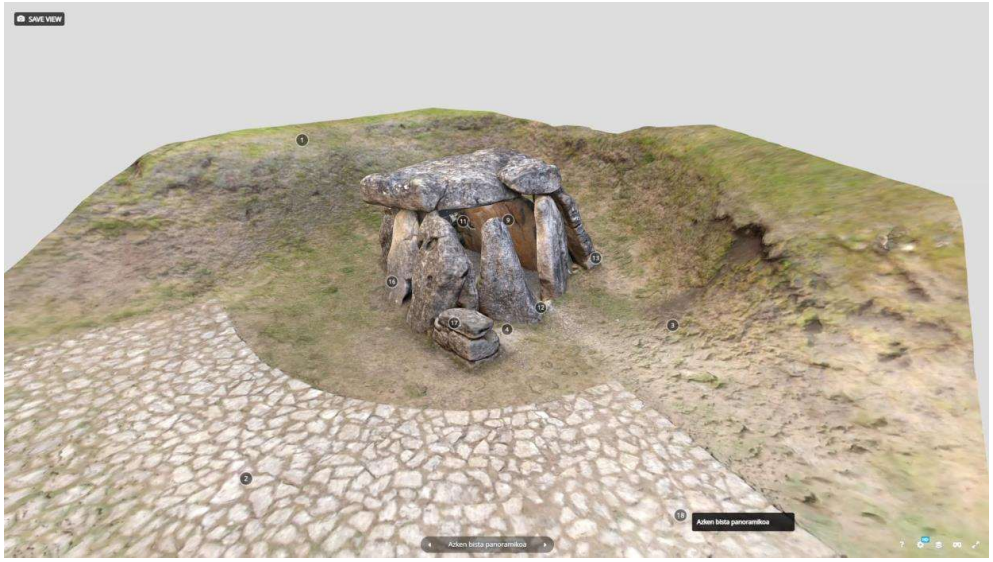


AI powered digitisation

Memory Twin

- Metadata – a story to tell
- Data fusion, “enrich digital twins”
- Advanced 2D/3D data post-processing

- **ML/DL for 2D/3D data classification**
- **NeRF and Gaussian splatting**
- **Damage detection, object recognition, etc.**
- **LLM for CH objects and point clouds**

CH object data acquisition services and AI-supported data processing

HERITALISE digitisation tools

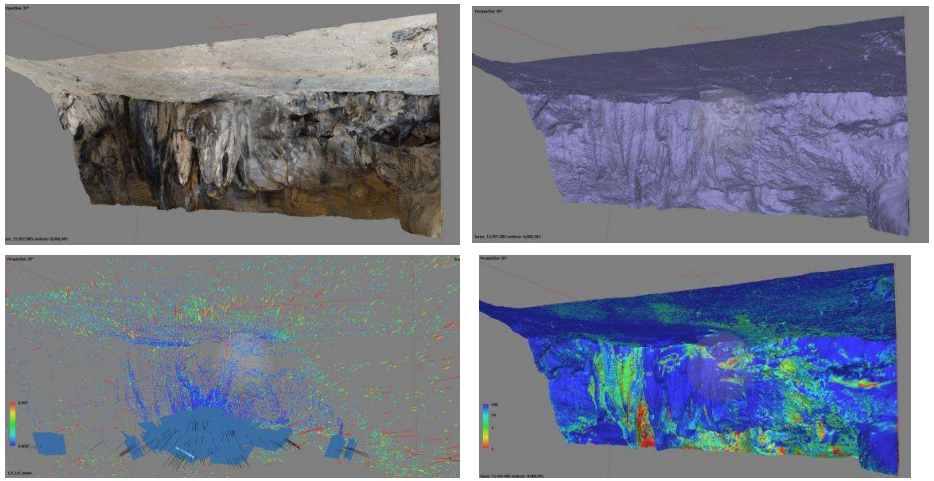
Objective: Improve **3D/2D Data** acquisition methods and technologies, to increase the capability of traditional and well-consolidated one and covering a wide array of data typologies such as visible/non-visible and large/small scale characteristics.

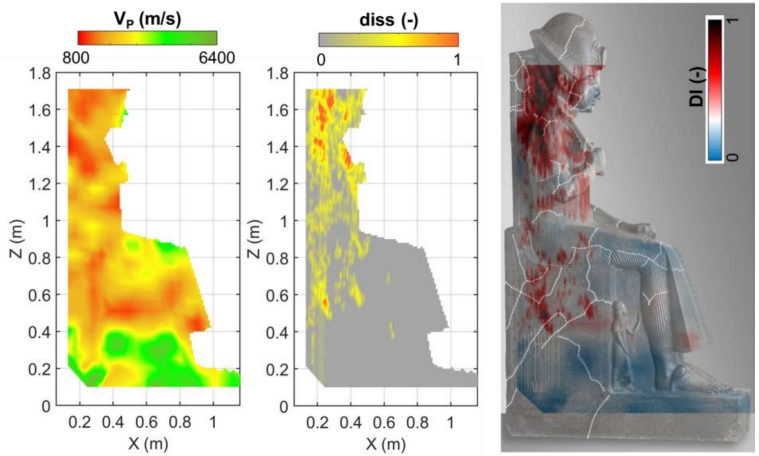
i) development of new innovative methods and tools to improve the digitisation of CH objects, broadening the concept of digitisation from surface 2D/3D geometric data to the whole range of additional information that can enrich the model with information (visible/non visible)
ii) in addition to usual dimensional datum of the surface information will be added regarding the internal constitution of the asset (through Computed tomography - CT), the detection of surface degradation (microscopy),and the study of the constituent materials (through multispectral imaging, surface colour of the artefact will be covered.

- **Photogrammetry**
- **CT Scan/Tomography**
- **Multispectral images technology**
- **Reflectance Transformation Imaging**

CH object data acquisition services and AI-supported data processing

- Data acquisition techniques for both **visible** and **non-visible**, as the input for the **HBIM** for artifacts, sites and monuments.
- An update and comparison of **different methodologies** and evaluation of their suitability, performance, as well as scope and limitations (haw far in terms of range, accuracy, resolution, etc.)
- Find a good balance in the 2D/3D data acquisition process between obtained dimensional and radiometric **data accuracy**, resolution level, data acquisition and processing speed, ease of use, etc.





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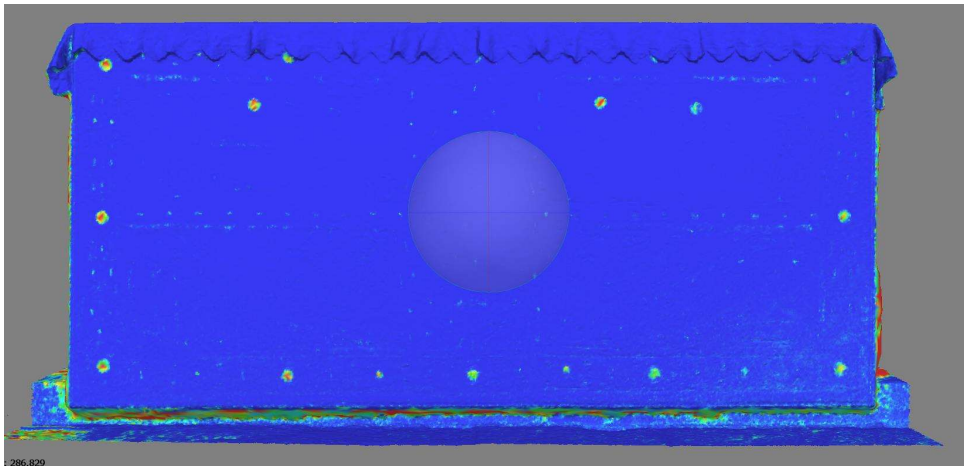
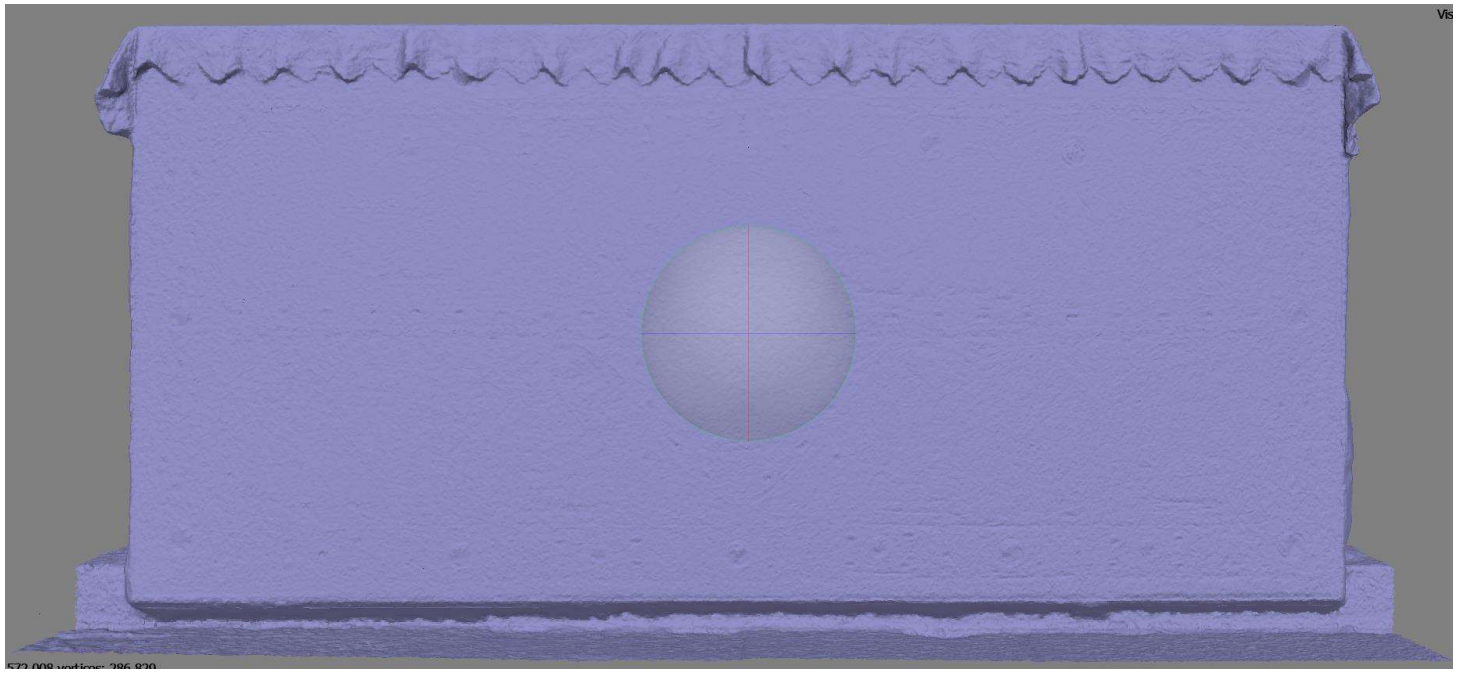
CH object data acquisition services and AI-supported data processing

- Review of **current quality standards. "Quality in, quality out":** we need to take care of **data quality**.
- Need to adopt standards on **instrument calibration**.
- Need for create new standards for **controlling and assessing data quality from acquisition processes**.
- Procedures and software tools available, but still **strong limitations**. An example on **photogrammetry**.



CH object data acquisition services and AI-supported data processing

- Available quality control parameters telling “well done!” … but the model is incorrect!!!
- Almost flat mesh, the gothic relief is totally missing … data quality still not under control.
- Need for new software tools and procedures for controlling **data quality** in the ECCCH.



CH object data acquisition services and AI-supported data processing

Data Post Processing supported by AI

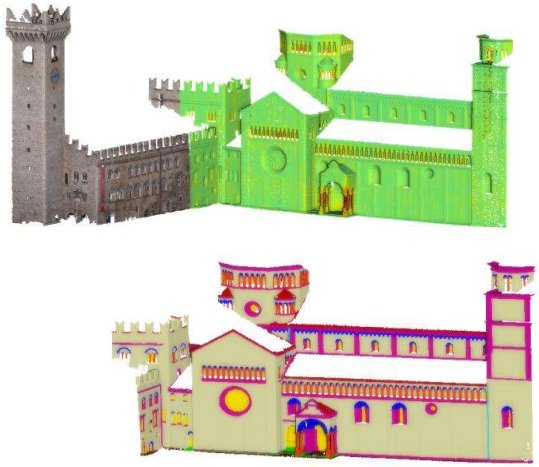
Objective: Data post-processing methods and technologies will be adopted, including new **AI-powered digitisation** methods and the development of data fusion

i) Combination of NeRFs, semantic segmentation, decay identification and recognition for complete and semantically enriched 3D models;
ii) Data fusion with the integration of the internal parts of CH (such as statues) with the external one, thanks to tomography;
iii) Creation of standards and guidelines on data acquisition and expected accuracy based on the different types of instruments and sensors used;
iv) The introduction of new indicators on the quality of the data acquired and processed thanks to the characteristics of the sensor and statistical methods. This will allow you to have a new awareness of the quality of the data; and
v) Automatic interpretation, starting from multi-sensor techniques, of 3D models for the identification and recognition of the types of degradation.

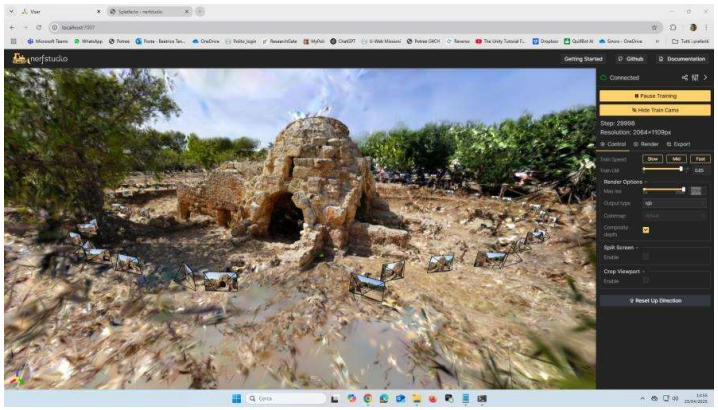
CH object data acquisition services and AI-supported data processing

AI algorithms application data acquisition, data preprocessing and modelling (geometry integration and reconstruction, pathology, materials and their conditions, automatic decay mapping etc.)

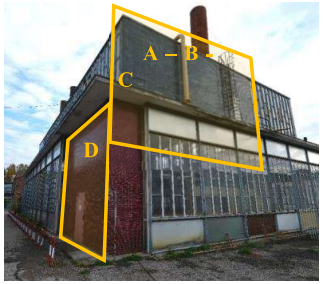
- ✓ *ML/DL for 2D/3D data classification (images/point clouds)*
- ✓ *NeRF and Gaussian splatting for 3D modeling and reconstruction*
- ✓ *AI for damage detection, object recognition, virtual restoration,*
- ✓ *LLM for CH objects and point clouds*

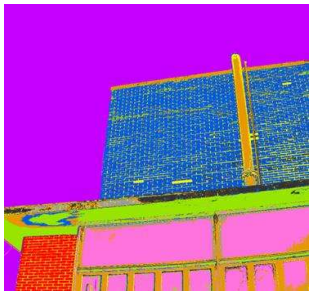


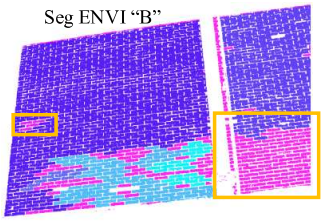
Automatic classification of point clouds using AI



NeRF and GS for 3D modeling







Automatic decay mapping from HS images

HERITALISE

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Cultural Heritage Services Based on Digitised Data

HERITALISE aims to provide CH stakeholders and end-users with a SW and HW solutions/services toolkit. Objective is to provide end-users with a **web-based and HHBIM-based Digital Twin Environment (DTE)** where the **integration of CH data and tools is seamless and supported by back-end webAPI services**. This toolkit will include the following services:

- **HHBIM-based Digital Twin and path towards Memory Twin**
- **CH Conservation Module**
- **AR/VR/XR Game Engine service for Virtual Museum Concepts**
- **CH object CT-scanned based 3D printing**

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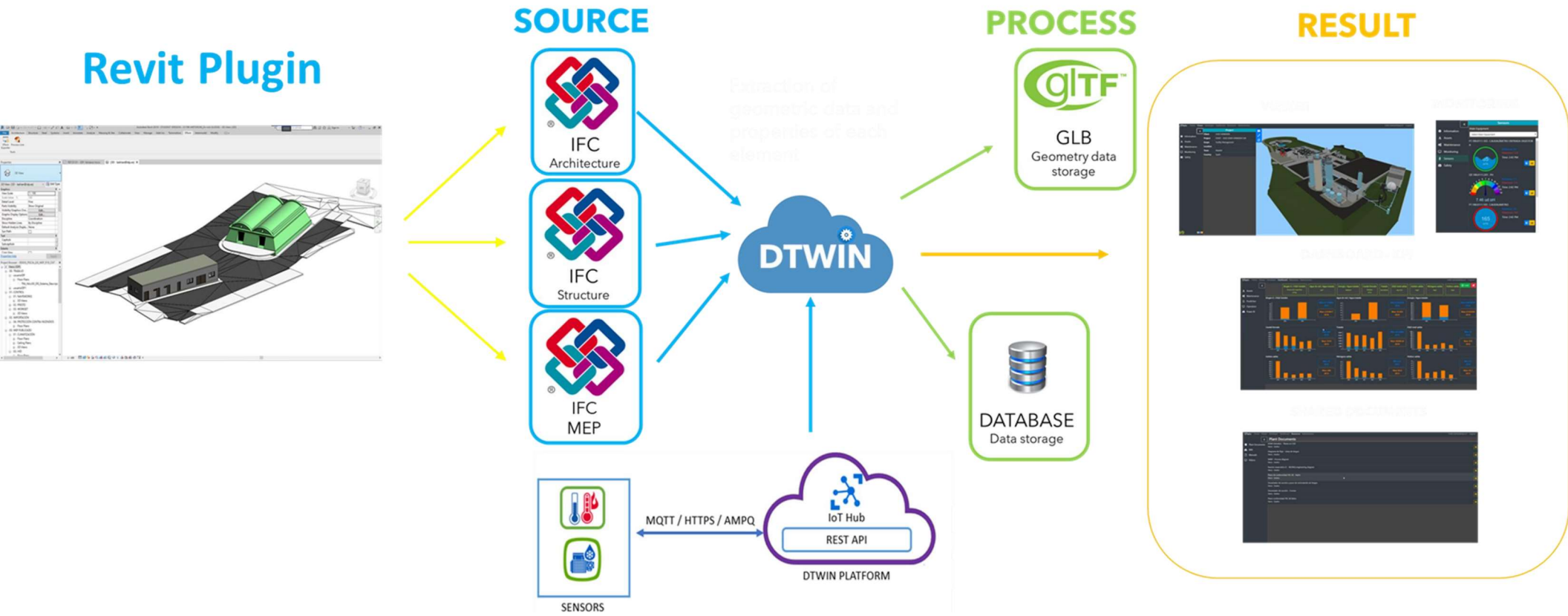
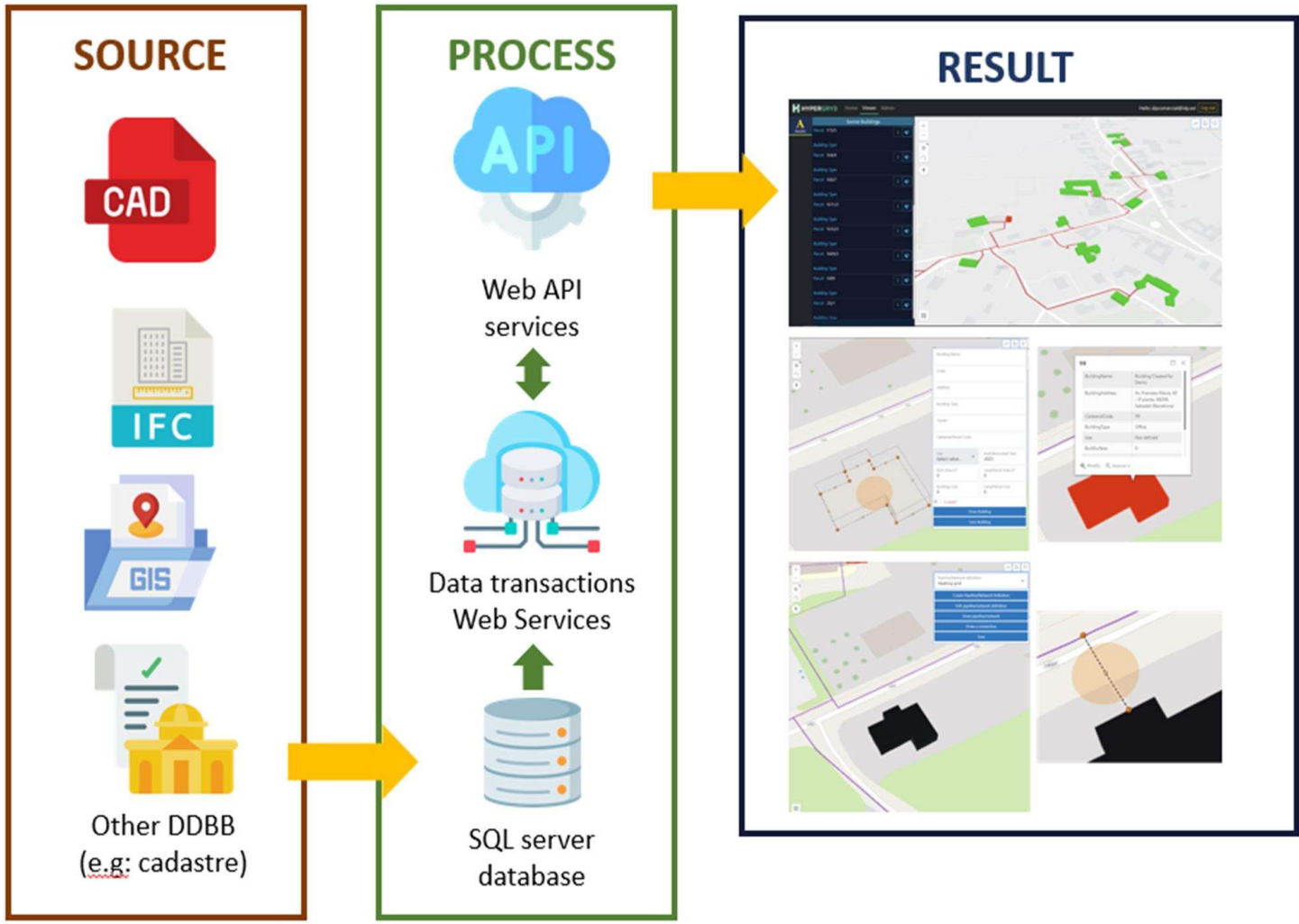
HHBIM-based Digital Twin and path towards Memory Twin

IDP Twin Information Source from HBIM Model



HHBIM-based Digital Twin and path towards Memory Twin

IDP Twin GIS-HBIM Network Modelling toolkit information source



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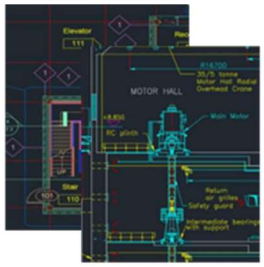
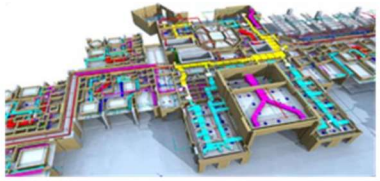
IFS Number 10147707, 10135283, 10147532

HHBIM-based Digital Twin and path towards Memory Twin



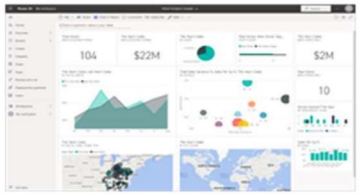
2D Model

PDF



BIM Model

Excel Templates



Power BI

Digital Twin Execution Plan (DTEP)

Other IDP Twin information sources

Microsoft SQL Server

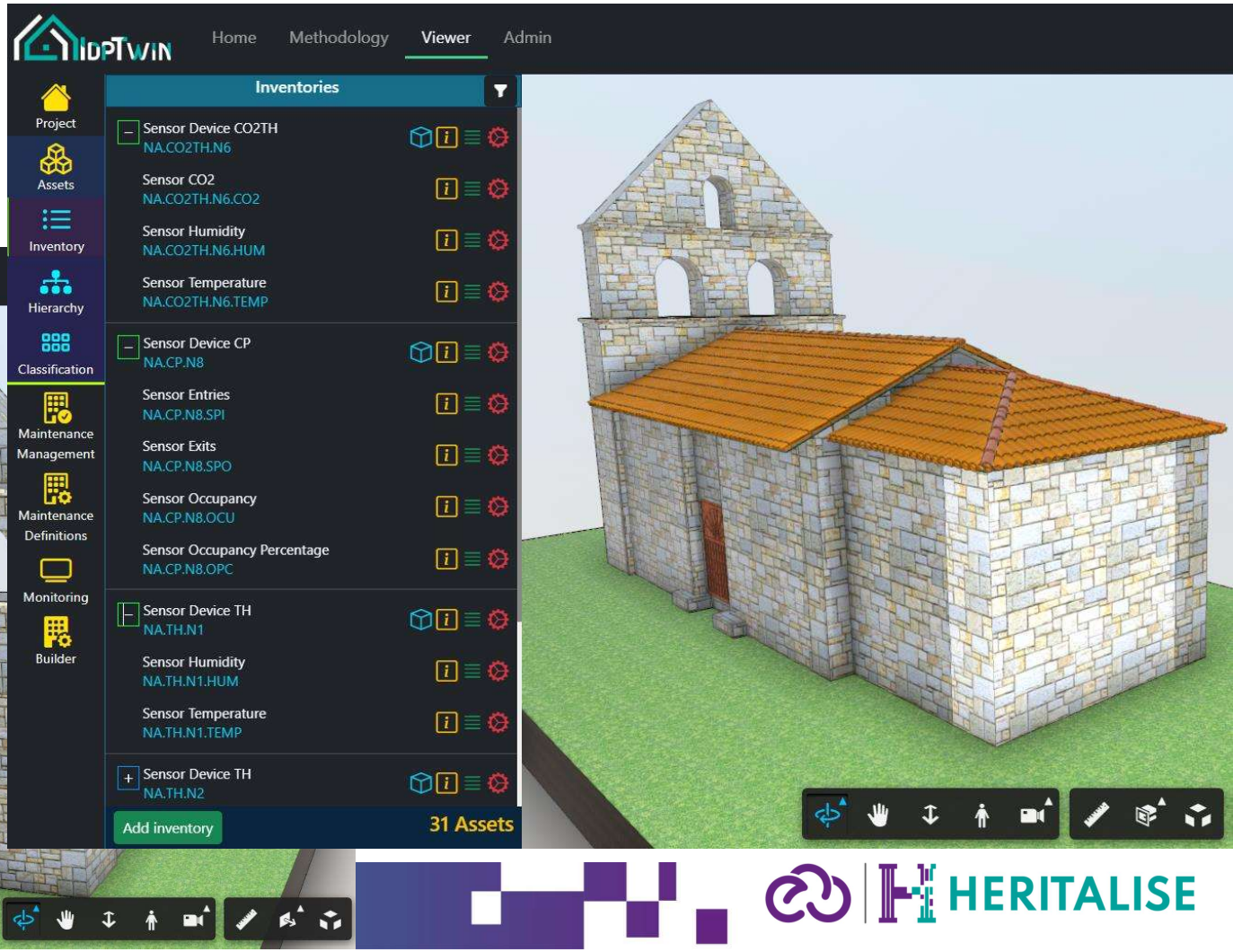
mongoDB.

PostgreSQL

HHBIM-based Digital Twin and path towards Memory Twin

IDP DTE default modules:

- Asset structuring
- Preventive & Predictive maintenance
- Monitoring data (IoT)



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The CH Conservation Module

Preventive conservation in Heritalise

Protecting Heritage Before Damage Occurs

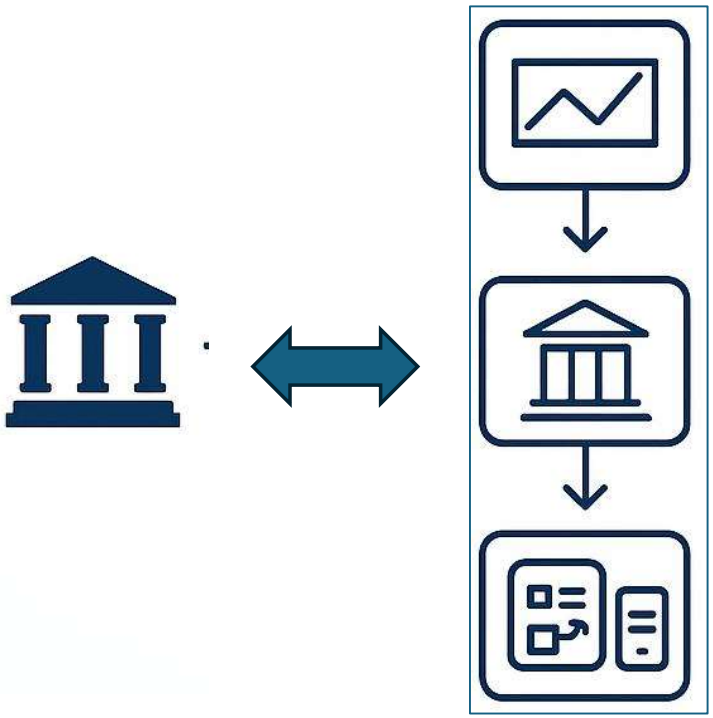
Preventive conservation: actions to control deterioration factors before they cause damage.

Objective: minimize the need for costly and invasive interventions.

System implemented: MHS Monitoring Heritage System by the FSMLR

Strategy: Monitor environmental and structural conditions. Interpret data to anticipate risks and define conservation actions

In HERITALISE: The collected information enriches digital models, supporting better management, conservation planning and decision-making



The CH Module

Enriching Models with Data in HERITALISE

Supporting Better Heritage Management

Temperature, moisture, luminosity

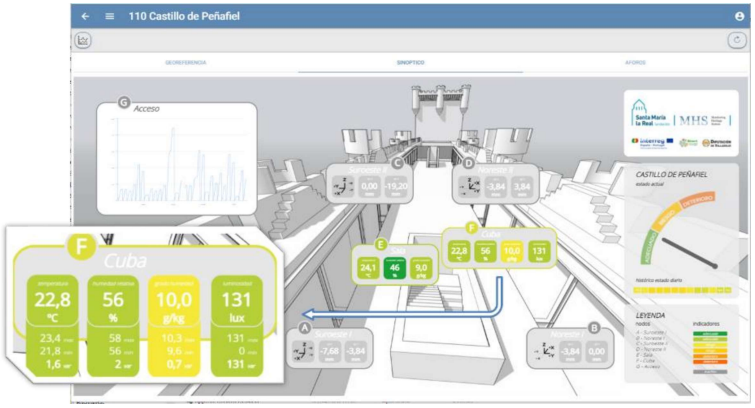
CO2

Particles, VOC

Plagues

Users, access control

Structural measurements



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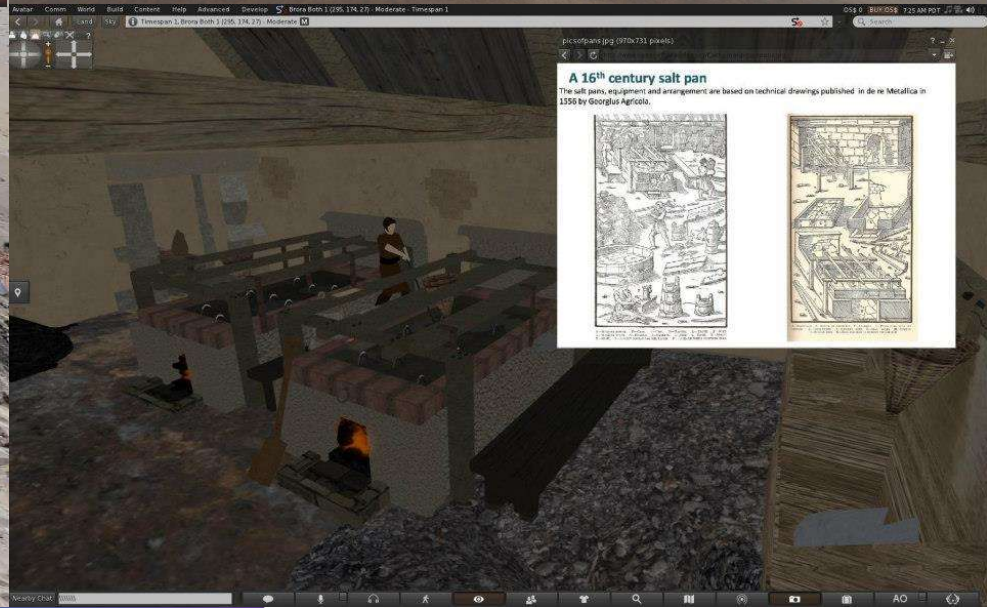
Moore's Law: The number of transistors on microchips doubles every two years

Our World in Data

Moore's law describes the empirical regularity that the number of transistors on integrated circuits doubles approximately every two years.
This advancement is important for other aspects of technological progress in computing – such as processing speed or the price of computers.

Data source: Wikipedia (wikipedia.org/wiki/Transistor_count)
OurWorldinData.org – Research and data to make progress against the world's largest problems.

Historic Scenes
Brora Saltpans



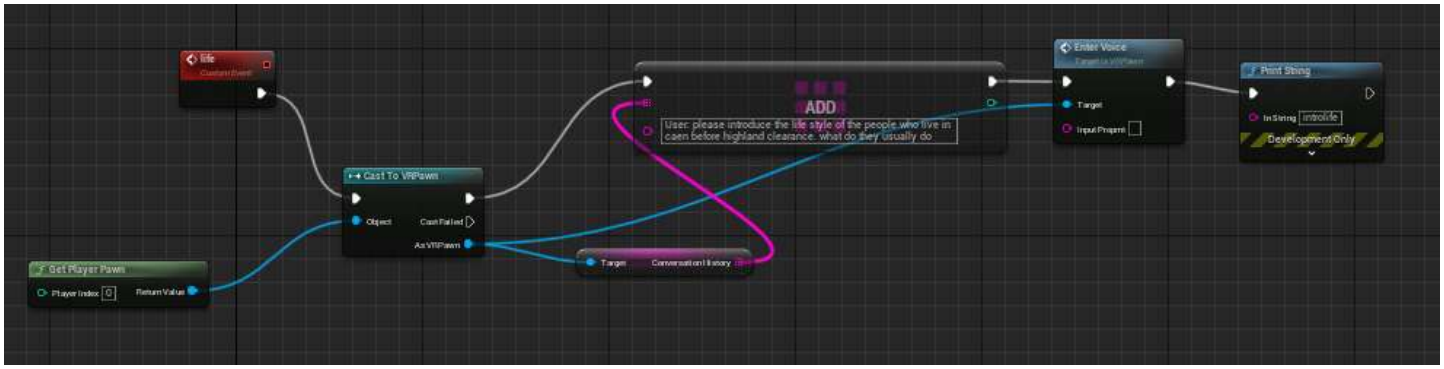
Remote Historic Scene – St Kilda

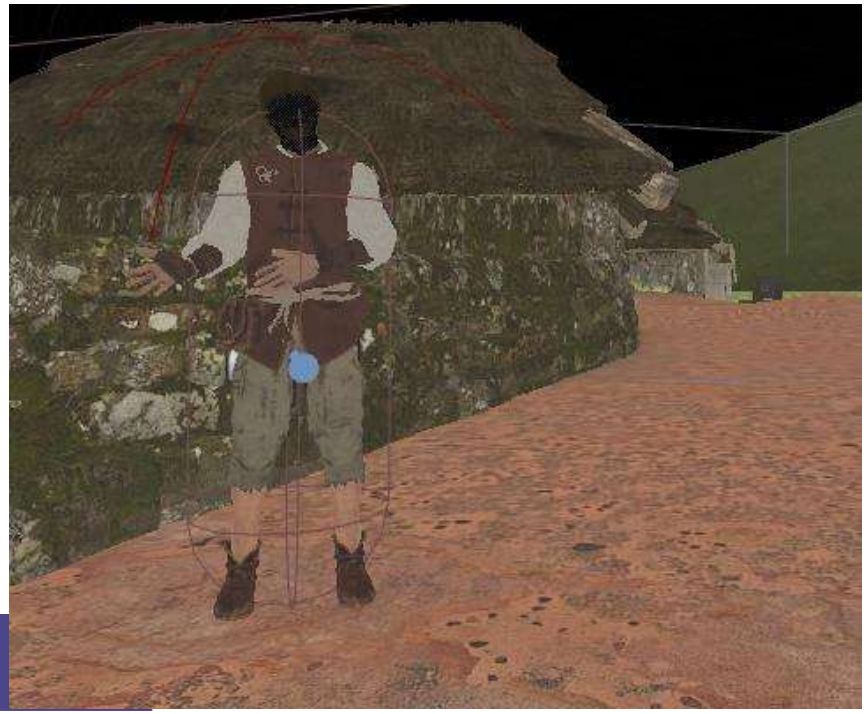
Antarctic time travel

Present

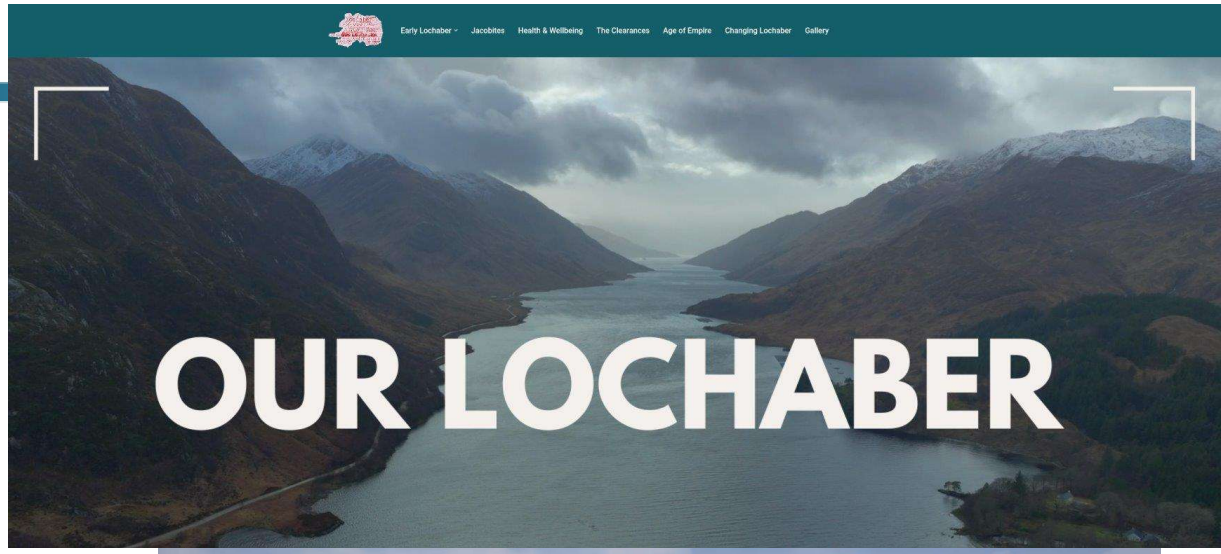
RCP 6.0

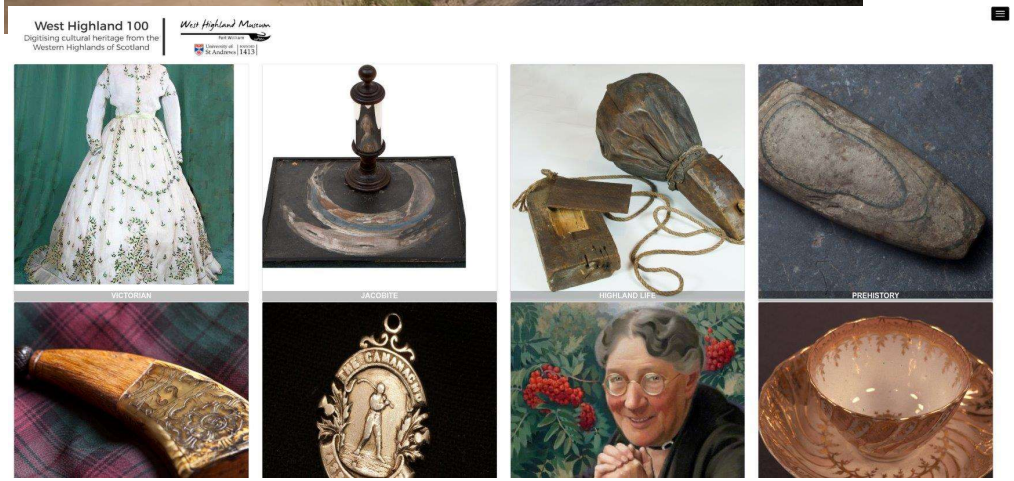

LAGAVULIN


life
Cast To VRPawn
Object
Cast Failed
As VRPawn
Get Player Pawn
Player Index 0
Return Value
ADD
User: please introduce the life style of the people who live in caen before highland clearance. what do they usually do
Target
Conversation History
Enter Voice
Target
Input Prompt
Print String
In String introlife
Development Only



WHM Virtual Reality





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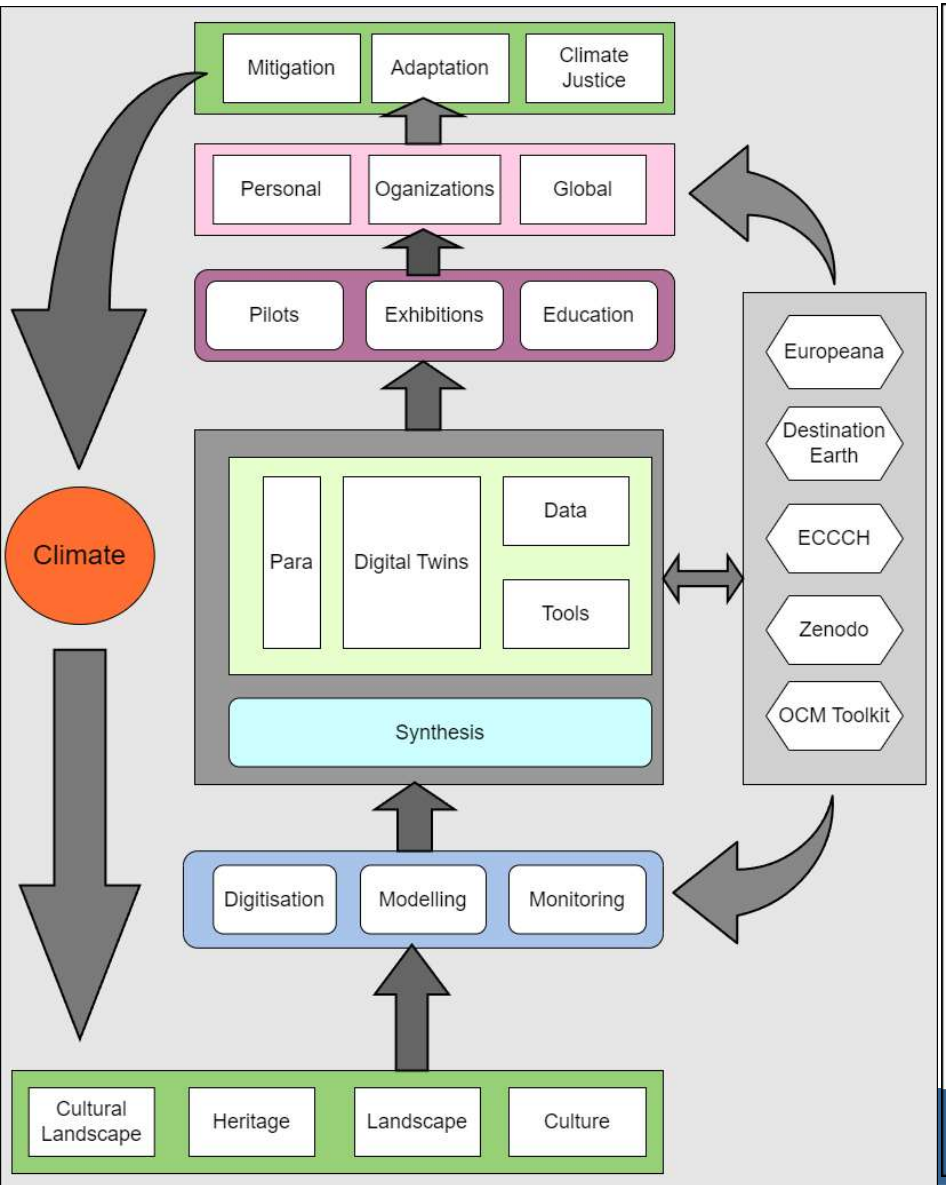
Mitigation
Adaptation
Climate Justice
Personal
Oganizations
Global
Pilots
Exhibitions
Education
Europeana
Destination Earth
ECCCH
Zenodo
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Climate
Para
Digital Twins
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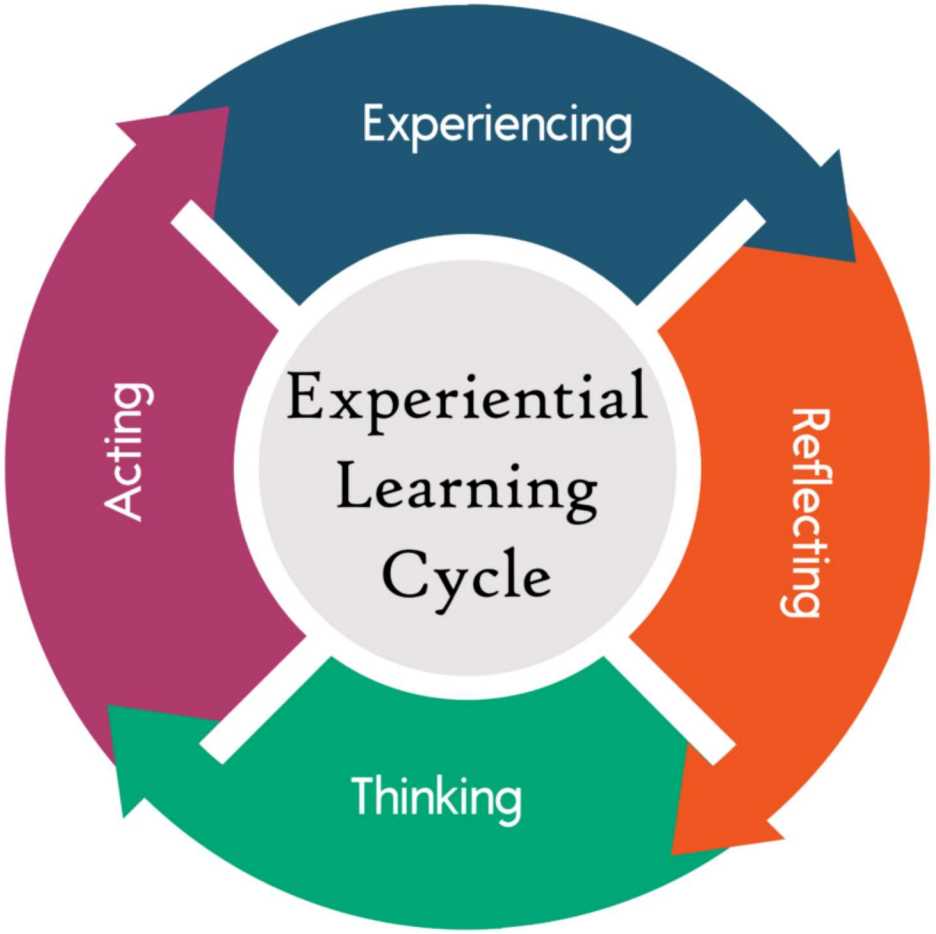
Synthesis
Digitisation
Modelling
Monitoring
Cultural Landscape
Heritage
Landscape
Culture


Experiencing
Reflecting
Thinking
Acting
Experiential Learning Cycle

HERITALISE

Installation

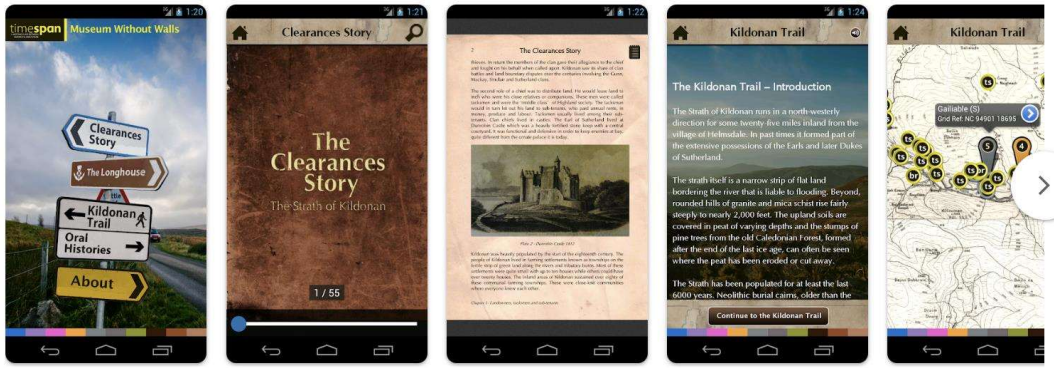
Timespan Museum Without Walls

Open Virtual Worlds

500+
Downloads

PEGI 3

Install Share Add to wishlist



About this app

Museum Without Walls: Scotland's Clearances Trail App brings alive one of the most notorious episodes in Scottish history – The Highland Clearances.

The aim of the App is to give virtual and actual visitors an interactive trip around one of the country's most beautiful and historic areas,

App support

More by Open Virtual Worlds

- Timespan 360
  Open Virtual Worlds
- Whithorn Eras
  Open Virtual Worlds
- Glasgow Green
  Open Virtual Worlds
- Downpatrick Head Tour
  Open Virtual Worlds


CaLLM
Climate Action Large Language Model

Virtual Orkney North Isles

The ICOM AVICOM awarded Virtual Orkney North Isles is one of the mediums created to build a shared exhibit virtual platform.

MORE ABOUT →

Virtual St Kilda

Discover the wild beauty of St. Kilda, an island once inhabited by a charming people. St. Kilda is renowned for its wildlife, now home to millions of birds and the endemic St Kilda mouse.

MORE ABOUT →

Seinn Spioradail

Seinn Spioradail is an exploration of the incredible wealth of sights, sounds and memories of spiritual singing and song writing in everyday life in Highland and Island communities, something which has been part of Highland culture for millenia.

MORE ABOUT →

Church 360° tour

Home 360° tour

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Non-Invasive Tomographic Imaging in Archaeology: Tools for Seeing the Invisible

Overview: Tomography enables researchers to explore the **internal structure of artifacts** and remains without damaging them.

Some Types of Tomographic Imaging:

•**X-ray Computed Tomography (CT)**
– Used for bones, ceramics, mummies, scrolls

–**Micro-CT (µCT) 15µm**
– High-resolution imaging of small objects (e.g., coins, animal mummies)

–**Synchrotron Radiation CT**
– Extremely high resolution; used for fragile organic materials and ink detection

–**Key Advantages:**
•Fully non-invasive
•High spatial resolution
•Enables study of fragile or sealed objects
•Produces digital 3D data suitable for reconstruction or printing

From Scan to Print: Combining Tomography with 3D Printing

How the Process Works:

1.Scan: Object is imaged using tomography (e.g., CT, µCT)

2.Model: Data is processed into a digital 3D model

3.Print: 3D replica is printed for analysis, restoration, or public use

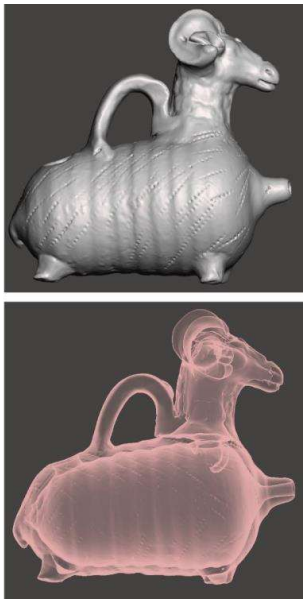
Examples Applications:

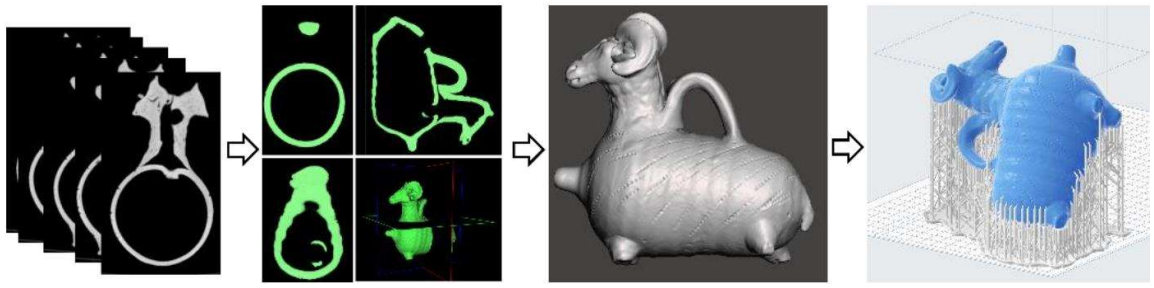
- *En-Gedi Scroll* – digitally unrolled via micro-CT
- *British Museum's animal mummy scans → 3D prints for exhibits*
- *CT scan of the mummy head of Djehutymose → 3D print used in facial reconstruction*
- *CT of sealed Roman vessels → 3D printing of internal contents for analysis*

Workflow

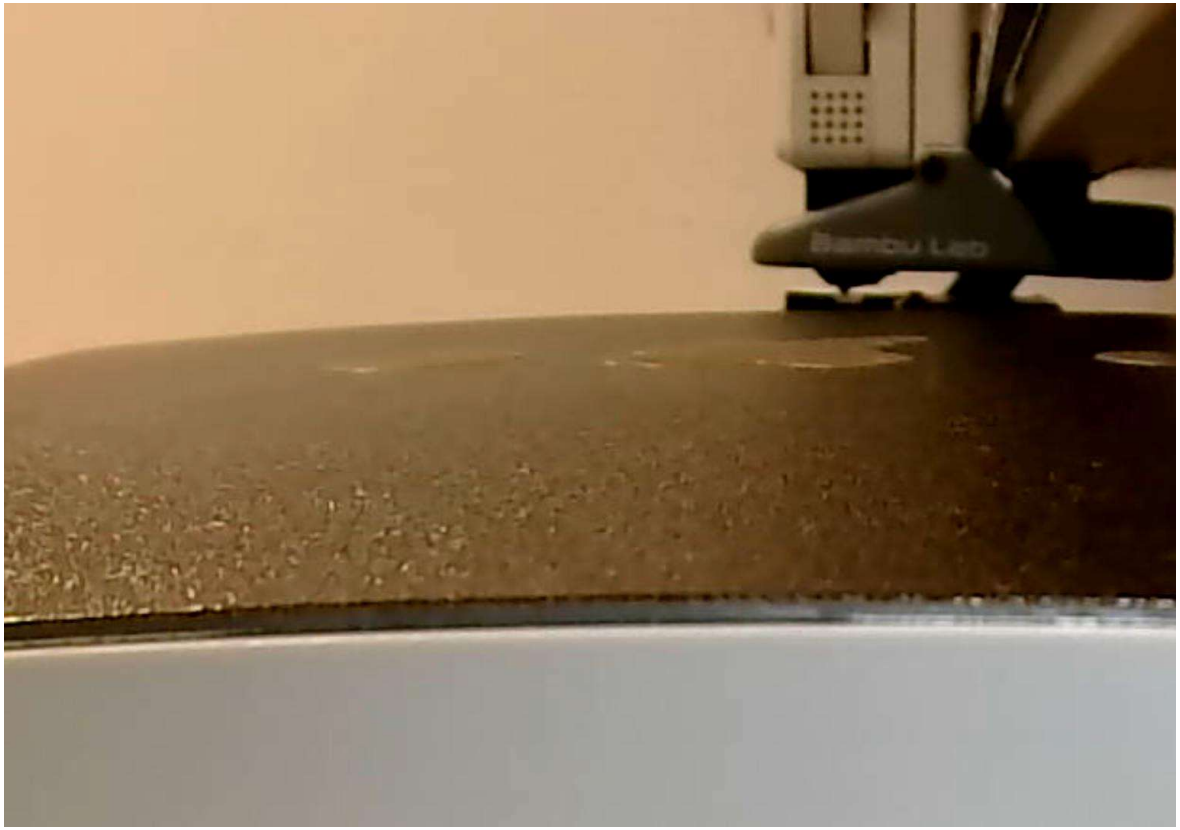
1.Data Acquisition
→ Scan the object using CT, micro-CT, MRI, or neutron tomography
→ Output: 2D image slices (e.g., DICOM)
2.Image Reconstruction
→ Use imaging software to build a 3D volume from slices
→ Clean and align data
3.Segmentation
→ Isolate the region of interest (e.g., bone, artifact, soft tissue)
→ Separate it from surrounding material
4.Mesh Generation
→ Convert the volume to a 3D mesh (STL/OBJ format)
→ Repair holes, simplify geometry if needed
5.3D Print Preparation
→ Load model into slicing software
→ Choose material, resolution, supports, and printer settings
6.Printing and Post-Processing
→ Print the model (FDM/SLA)
→ Clean, remove supports, optionally paint or finish
Applications:
•Museum displays and education
•Artifact restoration and study
•Accessibility (e.g., tactile replicas for the visually impaired)

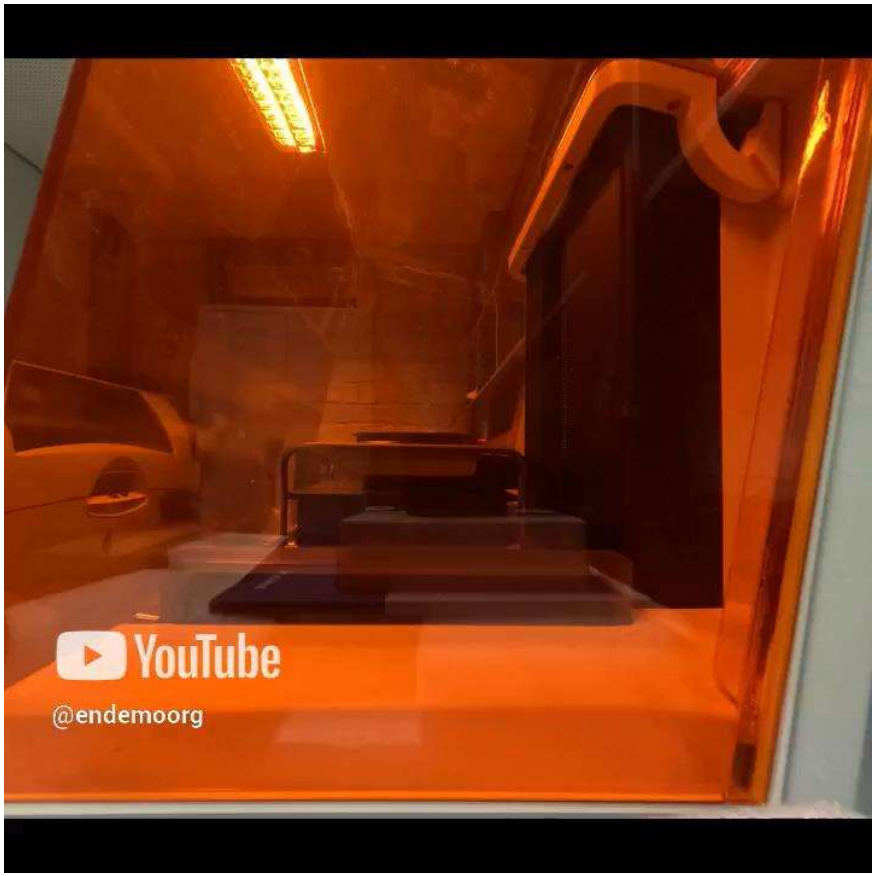
Hellenistic period (310-30 B.C) Found in Cyprus





Additive manufacturing (FDM, SLA)



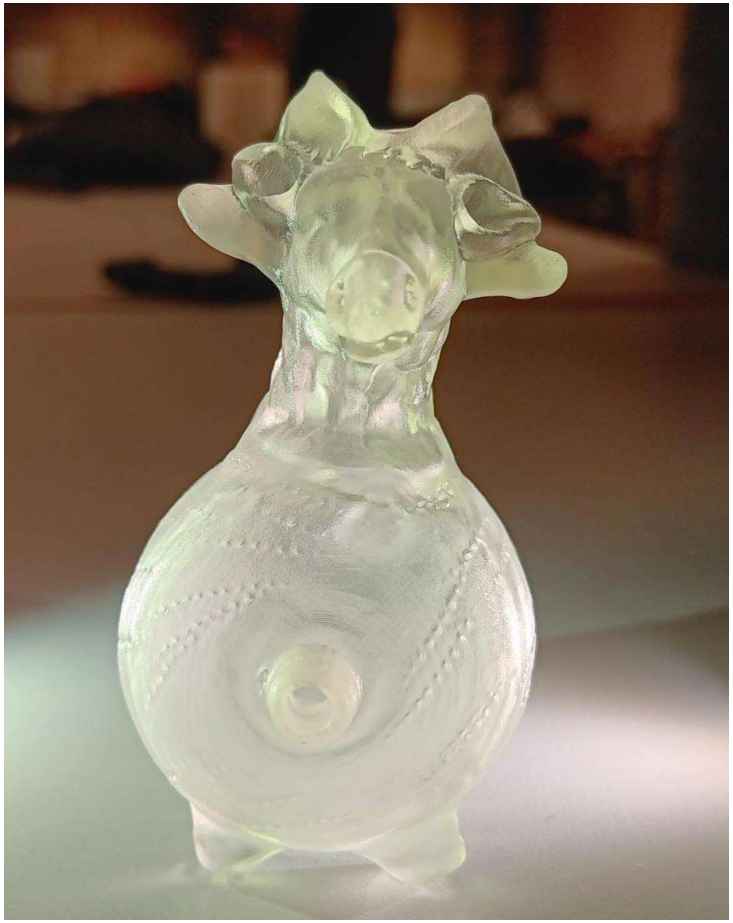


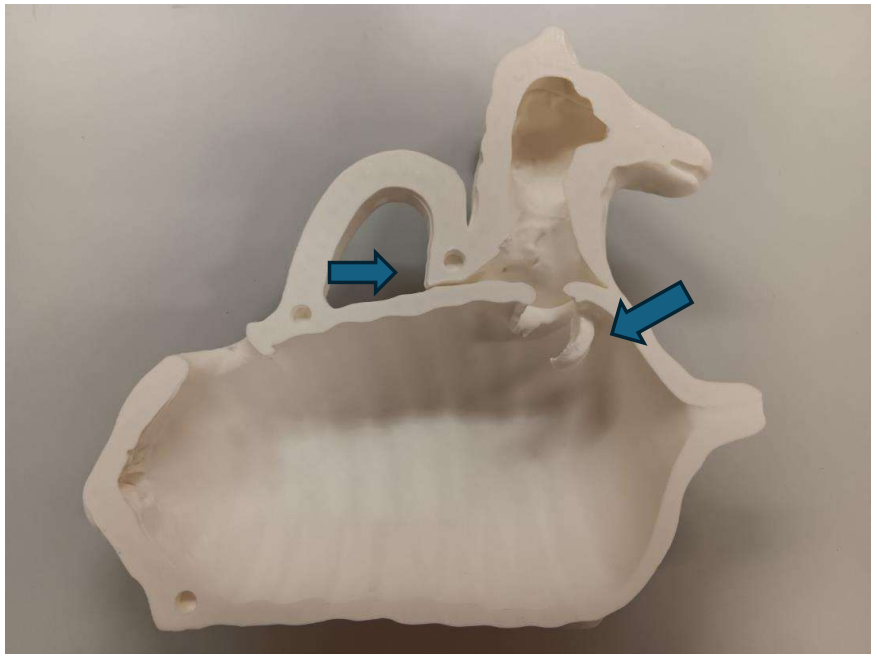
Restoration
Replication
Research

- **Museum Exhibitions**
- Display fragile or inaccessible artifacts without risking damage
- Tactile replicas for interactive exhibits
- **Education & Outreach**
- Hands-on learning tools for schools, universities, and public programs
- Tactile teaching aids for visually impaired audiences
- **Digital Conservation & Restoration**
- Reconstruct and print missing or damaged parts of artifacts
- Assist in planning physical restorations (e.g., testing fit of components)
- **Research and Analysis**
- Enable physical manipulation and study without touching originals
- Test hypotheses about use, function, or assembly
- **Forensic Reconstruction**
- Facial reconstruction from skull scans (e.g., mummies, human remains)
- Crime scene or burial reconstructions

- **Virtual Repatriation and Cultural Sharing**
- Share high-quality printed replicas with source communities or museums abroad
- Facilitate international collaboration without moving original artifacts
- **Preservation Planning**
- Create physical models for evaluating conservation treatments or transport strategies
- **Replica Production for Reenactments or Film**
- Accurate reproductions of tools, weapons, or clothing accessories
- **Public Accessibility and Digital Archiving**
- Expand access to rare objects via distributed 3D prints or online downloadable files
- Contribute to global heritage databases

50% scale, semi-transaparent material,





Scaled up, section

Manufacturing-technique, use, information
(e.g. two parts assembly, anti colic opening, reduced recirculation flap?)

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THANK YOU

https://heritalise-eccch.eu/

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