HERITALISE. Project Insights and Initial Developments

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Abstract
Cultural Heritage (CH) encompasses a broad spectrum of tangible and intangible assets, from artifacts and architecture to landscapes and traditions. These require diverse and complex data for documentation, study, and preservation. Technological advancements have significantly improved how CH is digitised, enhancing understanding and access. Digital records preserve historical, aesthetic, and scientific values while supporting public engagement. However, there remains no universal standard for CH digitisation, with approaches often tailored to each project based on various technical and contextual factors.
Digitisation methods depend on object-specific complexity criteria such as size, material and their condition, and location, requiring multidisciplinary collaboration. Common techniques are usually employed like laser scanning, photogrammetry and structured light, while AI and emerging technologies are expanding the capabilities of advancing digitization and visualization. In the present paper the EU HERITALISE project is presented, which addresses current limitations by developing advanced methods for capturing holistically both visible and non-visible CH features. It extends frameworks like H (Holistic)-HBIM to a Memory twin, integrating multimodal and complex data types in four (4) selected demo sites presented in this paper.

1. Introduction

Cultural Heritage (CH) represents a complex and dynamic ecosystem involving institutions and stakeholders who continuously generate and utilise diverse data and knowledge related to various CH objects. These objects span a wide range, from movable artefacts and architectural heritage to archaeological sites and natural landscapes. Whether tangible or intangible, CH assets can be digitally represented, requiring extensive and varied data to effectively document, study, and support their preservation.

Recent technological advancements have unlocked new possibilities for data acquisition, analysis, and sharing, enhancing the understanding and protection of CH. Additionally, contextual and environmental data play a crucial role in ensuring a comprehensive perspective on these assets. Digital recording is fundamental in preserving and transmitting the historical, artistic, scientific, aesthetic, social, and economic values embedded in CH. It creates a precise digital record for the future while facilitating knowledge dissemination to society. Despite various efforts, currently there is no universally accepted framework, methodology, or standardised procedure for defining the level of detail, completeness, and accuracy in CH digitisation. Documentation projects are often determined on a case-by-case basis, utilising various available methods and requiring extensive interdisciplinary collaboration.

A CH object must be thoroughly observed to determine the most suitable digitisation approach for 2D/3D data acquisition, processing, visualisation, and usage. This involves considering stakeholder requirements, technical specifications, environmental conditions, intended applications of the digital model, and its metrical accuracy and fidelity to the physical object. Selecting the appropriate human expertise and digitisation technology depends on multiple factors, including the CH artefact's size, complexity, material, texture, location, accessibility, and intellectual property rights. Established technologies, such as laser scanning, structured light systems, and photogrammetry (Aicardi et al., 2018), are widely used for capturing visible characteristics (Ioannides & Patias , 2023). However, artificial intelligence and emerging technologies present new opportunities for enhanced digitisation (Gîrbacia, 2024).

The heritage sector increasingly demands the integration of advanced data types, including hyperspectral and multispectral imaging (Alicandro et al., 2024), panoramic detection, local assessments of data uncertainty, and tomography for capturing non-visible surfaces. Despite these advancements, further research is needed to refine these techniques for CH applications. Moreover, integrating diverse complex datasets require the development of new pre- and post-processing software tools that leverage the latest innovations in Information and Communication Technologies (ICT) (Pisani et al., 2022).

Therefore, HERITALISE will explore -for the first time- how the data acquisition of cultural heritage for digital twins can be expanded to include historical and intangible heritage elements, advancing towards the concepts of H-HBIM to memory twins (Cassar, 2024).

Moreover, HERITALISE aims to address these challenges by advancing the state-of-the-art in CH digitisation, fostering a more comprehensive and interoperable approach to digital heritage preservation. Its mission is to research and develop

cutting-edge digitisation techniques and solutions for documenting and representing diverse Cultural Heritage assets, ensuring a comprehensive understanding of both visible and non-visible features.

The project will contribute to the European Collaborative Cloud for Cultural Heritage (ECCCH) by providing an interoperable web-based ecosystem, advanced input data from improved digitisation methodologies, and preservation-supporting tools, aligning with the project's overarching objectives in the framework of the Echoes Project.

The implementation has been structured into 16 work packages, to be executed in 48 months as it is illustrated in Figure 1: WP 1 and WP10 serve as the project's central hub for management and coordination, WPs 3-9 focus on HERTALISE CH data acquisition, data processing, services, ICT Ecosystem design in accordance with HERITALISE Demo Site owners and CH stakeholders in general. In turn, WPs 12 to 16 tackle all the developments necessary as well as implementation within demo sites: Reggia di Venaria Reale in Italy, Villa Portelli in Malta, Time Span and Highlands Museum in Scotland that give way to exploitation, communication and dissemination strategies aiming at a broad replicability and scalability at a European scale.

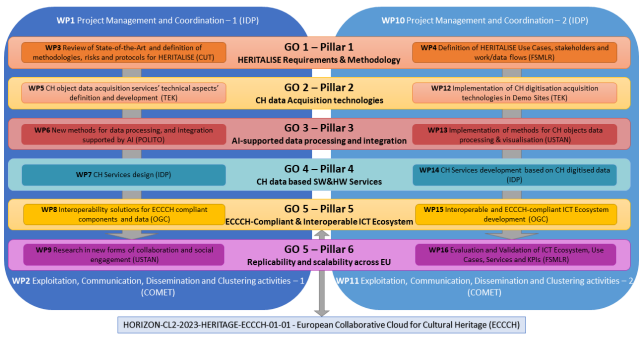

Figure 1. Work Package structure of the HERITALISE Project

2. Tangible and intangible objects' digitisation approach

The digitisation of Cultural Heritage has become a pivotal tool in preserving, studying, and disseminating both tangible and intangible assets. With rapid technological advances, the ability to capture, document, and model CH in digital formats has transformed heritage practices across institutions, research, and communities. However, to fully harness these capabilities, the role of metadata and paradata information that contextualizes and explains the digital data has become increasingly significant in ensuring transparency, reusability, and long-term sustainability.

The digitisation of tangible CH includes tangible movable and immovable (such as artefacts, monuments, and sites is carried out with a range of technologies such as active (laser scanning) and passive (photogrammetry) systems, which allow for high-resolution 3D reconstruction. These technologies are employed to document an object's geometry, texture, and surface detail, preserving a digital twin of the object for future generations. Multispectral and hyperspectral imaging, as well as thermal, CT -Scan, Ground Penetrating Radar and ultrasonic tomography (Sambuelli et al., 2015) further enrich these digital models by revealing underlying materials and hidden features, contributing to conservation science and historical research (Del Pozo et al., 2017). Moreover, recent trends include the use of Building Information Modelling (BIM) adapted for heritage, known as H-BIM (Historic Building Information Modelling), where supports the semantic structuring of CH data and facilitates the integration of architectural, material, and historical information into a unified model (Murphy et al., 2013). In this context, recent works have been driving the development of such models through a holistic approach based on the concept of the memory twin (Brumana et al. 2025).

On the other hand, intangible CH includes non-physical elements such as oral traditions, rituals, performing arts, and knowledge systems. Digitisation efforts focus on capturing these practices through multimedia formats audio, video, VR/AR experiences and involving communities in co-creation to ensure authenticity and representation (Kalay et al., 2008). On this specific topic innovative approaches include motion capture for dance and performance, 3D animation for re-enactment of rituals, and interactive platforms for storytelling. These tools offer immersive and participatory experiences, bridging traditional knowledge with modern audiences.

Digitisation is not just about producing visual or spatial replicas; it requires robust metadata descriptive information about the digital objects. Metadata ensures the discoverability, accessibility, and interoperability of CH datasets. ISO Standards such as Dublin Core, CIDOC CRM, and de facto standard like Europeana Data Model (EDM) are widely used to manage metadata in heritage documentation (Doerr, 2003).

Beyond metadata, Paradata plays a crucial role in CH digitisation. Paradata refers to the methodology and the documentation of the processes, decisions, and assumptions made during the digitisation workflow. It includes details on modeling choices, scanning conditions, interpretation of incomplete data, and any restoration or reconstruction interventions (Bentkowska-Kafel et al., 2012). It gives a detail overview of who, where, when, why, under which conditions and which equipment has been used, etc. This transparency is vital for scholarly integrity, reproducibility, and user trust especially when digital models are used for educational or heritage management purposes. Paradata is increasingly included in digital repositories and 3D heritage platforms to provide users with insight into the reliability, completeness, and limitations of the models they are viewing. Despite notable progress, digitisation of CH faces several challenges, including the lack of harmonised standards, the high cost of 3D technologies, and difficulties in capturing contextual and ephemeral aspects of intangible practices.

Ensuring high data quality is not only critical for archival and visualization purposes but also becomes important when considering the reuse of 3D data for advanced applications e.g. 3D printing. Additive manufacturing relies on high quality and precise, watertight geometry, accurate scaling, and complete metadata to produce physically faithful and functionally meaningful replicas. Inaccuracies, incomplete datasets, or extensive postprocessing and geometrical interventions may result in unusable prints or misleading representations of cultural heritage objects. Significant features may be lost, rendering the process invalid or of limited value. Therefore, the definition of quality must also cover intentions or potential of reuse. Establishing such standards is essential not only for preservation but also for enabling inclusive access, educational use, and the tangible experience of cultural heritage through physical reproductions.

Within this panorama, the HERITALISE project aims to address the methodological and technical gaps while holistically addressing the CH assets by joining the tangible dimension with the historical and intangible ones, enriching the CH assets with the digital recording of its sociocultural value that differentiates it from any other asset.

Initiatives like the European Collaborative Cloud for Cultural Heritage (ECCCH) and HERITALISE are working toward creating interoperable platforms that support advanced metadata standards and integrate AI for data enrichment and multimodal analysis. These projects aim to unify tangible and intangible CH data within sustainable, open-access ecosystems that promote reuse and interdisciplinary research.

3. HERITALISE digitisation approaches and quality standards

Digital acquisition techniques play a key role both for documenting tangible and intangible heritage. The EU Study on quality in 3D digitisation of tangible cultural heritage (EU Study VIGIE 2020/654) offers a detailed overview on the active and passive digitization techniques available for building up digital twins for tangible heritage (Figure 2). The HERITALISE project will adopt a broad set of complementary acquisition techniques, covering an extent scale range of scenarios and applications, form entire sites and monuments down to individual artefacts, aiming at the digitisation of both visible (e.g.: external geometry, cracks) and non-visible (e.g.: subsurface damage, internal geometry) tangible properties. Table 1 presents the set of the main techniques considered that will be used in the framework of the project.

Active sensors	*Topographic methods*	Global Navigation Satellite System (GNSS) Total station Laser tracker
	Range-based sensors	Terrestrial Laser Scanning (TLS) Mobile Laser Scanners (MLS) Structured Light Scanning (SLS) Confocal microscopes
	Beyond visible	Ground Penetrating Radar (GPR) Computed tomography (CT) Reflectance Transformation Imaging (RTI)
Passive sensors	*Image based sensors*	Close-range photogrammetry (terrestrial, drones) Hyperspectral cameras Multispectral cameras Thermal cameras
Health monitoring	*Environmental characteristics*	Hygrometer Thermometer Photometer Accelerometer

Table 1. Acquisition techniques for enriched digital twins at HERITALISE.

The aim will be related to the data-fusion of the information acquired by complementary sensors into unique digital twins, enabling a more integral analysis and documentation of tangible heritage. As an example, in (Gómez-Gil, et al., 2024) the benefits of fusing 3D scanning techniques to thermal imaging are shown for the structural health monitoring of buildings.

Following this trend, the HERITALISE project will aim at new HBIM (Heritage BIM) based data infrastructures where the information gathered by all different acquisition techniques will be integrated and fused into enriched Digital Twins. This, in turn, will also allow for the extension of these HBIM-based Digital Twins into HHBIM (Holistic HBIM) Memory Twins once the integration of ICH is successfully achieved.

On the other hand, as a key upgrade of the VIGIE 2020/654, the HERITALISE project will face a step forward in terms of quality standards for tangible heritage digitisation, further bridging industrial metrology accuracy concepts and traditional standards related to the CH sector. Indeed, due its extended use and impact, special attention will be paid in the project to the development of novel tools and methodologies for the quality control and certification of the accuracy of 3D scans, such as those obtained by relatively low-cost approaches as photogrammetry.

Beyond widely known concepts in BIM and architecture as LOD (Level Of Detail), less adopted ones such as LOA (Level Of Accuracy) (LOA, 2016) will be further developed in the project, towards the adoption of the measuring uncertainty as the fundamental concept upon which the quality of a point cloud or mesh resulting from a 3D scan should be standardized, specified and assessed.

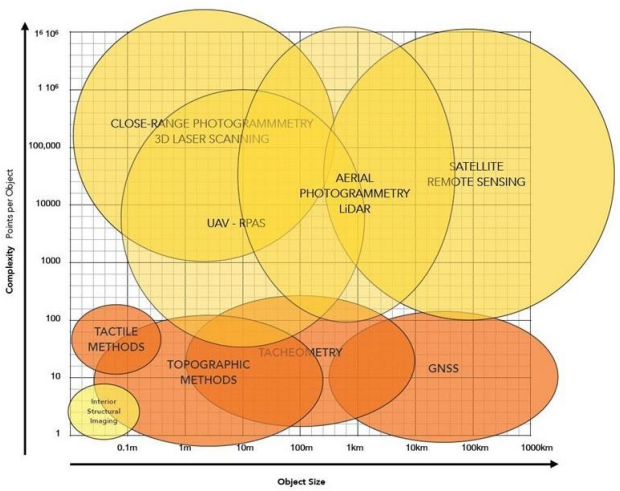

Figure 2. Overview of 3D digitisation techniques by (EU VIGIE 2020/654).

Nowadays, the use of GCPs (ground control points) is anextended concept by which spatial errors can be assessed onsite, so that the quality of a 3D scan is estimated as stated in industrial metrology guidelines such as the VDI2634 – part 1 (Jaganmohan et al., 2024). In a similar way, the evaluation of LME (length measuring errors) between GCPs at calibrated scale bars enables evaluation of errors at a 3D measurement scenario (Mendikute et.al., 2018; Puerto et.al., 2022)..

However, the accuracy assessment based on GCPs is focused on a limited set of specific points, and as a result, lacks for the capability of observing scanning errors over complete surfaces, without a practical onsite mean of quantifying and controlling the quality of a 3D point cloud or mesh.

Due to this limitation, the HERITILISE project will further extent the GCPs error observation procedure to a novel standard for 3D scan quality control, based on the latest ongoing updates at VDI2634 – part 2 and 3 and ISO 10.360-13:2021 for novel methodologies and calibrated surface artifacts for assessing the quality of 3D scanning systems in industrial metrology.

On the other hand, the practical use of such novel surface reference artifacts will depend on the size and accessibility of the measuring scenario, and might result unfeasible for large scale monuments and sites. As an alternative, different photogrammetric software (i.e.: Metashape by Agisoft, Reality Scan by Epic Games) offer dedicated post-processing tools where different quality metrics can be obtained throughout the camera alignment and meshing workflows, such as the uncertainty estimation of the tie point clouds, image coverage and mesh confidence heatmaps. However, these metrics still lack of using a common standard for expressing a 3D mesh quality in terms of the delivered measuring uncertainty as stated at the VDI 2634 and ISO 10.360-13:2021.

To overcome this limitation, following industrial metrology standards, the HERITALISE project will develop specific post-processing software tools for photogrammetry so that a complete 3D mesh measurement uncertainty can be estimated and documented as key accuracy paradata linked to the delivered digital twin. In the following sections a first overview of the HERITLISE demo sites is shown with some first information about the followed approach for the digitisation process.

3.1 Reggia di Venaria Reale demo site

La Venaria Reale, located near Turin (Italy), constitutes a significant example of integrated architectural and landscape heritage (Figure 3). The complex encompasses approximately 80,000 square meters of built area within the Royal Palace, alongside 60 hectares of Gardens, adjacent to the 17th-century historic village of Venaria and the 3,000-hectare enclosed area of the La Mandria Park. This ensemble of Baroque architecture and anthropized landscape was inscribed on the UNESCO World Heritage List in 1997. Following the completion of the largest cultural restoration project co-financed by the European Union to date, the site was reopened to the public in 2007.

Figure 3. Reggia di Venaria Reale in Italy

Through a multiscale digitisation strategy, the project will acquire high-resolution 2D, 3D data and materials of both the exterior and interior architectural elements of selected areas within the Reggia di Venaria Reale. This initiative aims to support predictive maintenance, conservation planning, and the development of enhanced digital experiences for visitors.

The main areas of intervention include the Great Gallery and the Church of St. Uberto. The Church, characterized by complex decorative features such as sculptural elements and mural paintings, is affected by persistent humidity-related degradation phenomena. As such, it is subject to continuous microclimatic monitoring and environmental data acquisition. The Great Gallery, an architecturally significant 80-meter-long space, is distinguished by its black-and-white diamond-patterned marble flooring, which interacts dynamically with natural light, creating a high-contrast luminous environment that presents both aesthetic and photogrammetric challenges. (Figure 4). Beyond the building itself, Venaria Reale hosts a diverse landscape heritage. The Gardens of Fluid Sculptures offer a unique experience of contemporary art by renowned Italian artist Giuseppe Penone, alongside the century-old vegetation and design of the Reggia. Given the gardens' expansion and the dynamic nature of the natural artworks influenced by time, specialized methods are required to digitize their changing properties and track deterioration.

Figure 4. Great Hall in the Reggia di Venaria Reale in Italy

The initial surveying campaign was conducted between January and March 2025. A range of geomatics technologies including Terrestrial Laser Scanning (TLS), Mobile Mapping Systems (MMS), and Uncrewed Aerial Vehicle (UAV) photogrammetry were employed to acquire, process, and integrate preliminary spatial and geometric data of the Reggia di Venaria site. (Figure 5).

The extensive and heterogeneous dataset collected during the survey campaign requires robust validation and data management protocols to guarantee its accuracy and reliability.

The initial phase focuses on the quality assessment of the acquired point clouds through both statistical and qualitative methodologies. This includes the analysis of section views, cross-comparison of overlapping datasets, and the computation of Root Mean Square Error (RMSe) over selected control areas to evaluate both local and global registration accuracy.

Particular emphasis has been placed on the integration of datasets acquired from multiple platforms MMS, UAV, and TLS ensuring consistency in both geometric and radiometric properties across varying spatial scales and sensor modalities.

Figure 5. A portion of the registered MMS point clouds (above), 3D model of Reggia di Venaria generated via UAS (below)

The survey campaign is still in progress and the next step will be connected to the semantic classification using traditional and AI approach for the 3D modelling in an H-BIM environment following a holistic approach aimed at deepening the knowledge and understanding of cultural heritage assets.

3.2 Villa Portelli demo sites

Villa Portelli (Figure 6), a historic residence overlooking Kalkara Creek and the Grand Harbour, was entrusted to Heritage Malta in 2023. This transfer marked the beginning of an ambitious restoration project aimed at reactivating the site as a cultural and community hub. The villa’s architectural synthesis of Maltese baroque and British colonial styles, along with its layered socio-political history, positions it as a site of national significance.

Figure 6. Villa Portelli in Kalkara, Malta

As part of the HERITALISE initiative, Villa Portelli was selected to pilot the Memory Twin framework a digitally enriched, participatory approach to heritage documentation that extends beyond the physical to include narratives, traditions, and contextual knowledge (Ioannides et al., 2024). This approach builds on and expands the concept of the digital twin, adapting it to the complexities of cultural heritage (D’Andrea & Di Mascio, 2023).

Central to this effort is the development of a Holistic Heritage Building Information Model (H-HBIM), integrating 3D scanning, archival research, oral histories, and stakeholder input. The H-HBIM model will be linked to Malta’s national GIS, enabling spatially aware, interoperable heritage data that serves internal teams, researchers, and the public (Jouan & Hallot, 2019). The Villa will also be submitted as Malta’s entry within Twin IT II. The Memory Twin not only documents physical attributes but also embeds evolving narratives and community perspectives. While the integration of diverse data types presents technical and institutional challenges, particularly in standardizing Paradata and narrative content - the project exemplifies a shift toward inclusive, sustainable heritage management.

Villa Portelli thus serves as a model for how digital acquisition can support the co-creation and reinterpretation of heritage through a multidisciplinary approach.

3.3 Time Span and West Highlands Museums demo sites

The West Highland Museum and Timespan Museum working with University of St Andrews bring to HERITALISE experience in digitization of tangible and intangible heritage, and the development of Virtual Reality exhibits which enrich visitor interaction in the museum, the surrounding landscape and at home. Museums play a special role in society, they are institutions of life long learning, enable communities to shape the definition of their heritage and to communicate it more widely (Cassidy et al.,2018). In so doing museums can articulate the connection between heritage, community and sustainable development. Through these use cases we will explore the way emergent technologies such as Virtual Reality, Mobile Devices and Large Language Models transform where, when and how communities can engage with their heritage. The use cases also explore the reuse of digital heritage in Memory Twins, as part of HBIM applications as well as in Virtual Museums.

The West Highland Museum (WHM) is one of the oldest museums in the Scottish Highlands (Figure 7), situated in Fort William and founded in 1922. The museum’s collections span a wide range of subjects, from archaeology to modern industry, with a special emphasis on the Jacobite risings of the 18th century and Highland Life. The Alexander Carmichael collection is an important collection of objects of Gaelic material culture collected in the C19 and C20th.

Since 2020 the WHM has been working with the University of St Andrews we have created an online whm100.org gallery, including 3D models. A virtual reality experience was installed in the gallery in December 2022 which recreates the fort at Fort William in 1746 when the fort was under siege by the Jacobites. This immersive experience has proven popular with families and has brought younger audiences in touch with CH.

The objective is to develop digital content about Highland Life and the Jacobites, that will enable us to develop digital story telling and narratives that will engage community and visitors. The museum is about to embark on an ambitious project to treble its size. This will be a good opportunity to digitise the rest of the building to create a museum of a museum so that the museum as it is now can be preserved in digitised form and

explored by members of the public. We plan exhibits for the museum, web and app, platforms. Through this activity the WHM will become an exemplar for the digitisation of landscapes, buildings, art works and CH objects together with intangible heritage relating to the lost Gaelic culture of the Highlands and Islands of Scotland.

Figure 7. West Highlands Museum in Scotland

Visual and non-visual data for the collections will be ingested into our virtual museum and in this way made available for reuse for museums to work with in their collections. Digital exhibits will be created to demonstrate VR kiosks in two modes. In mode one interactions via touch screen/game controller will be used. In mode two a headset will be combined with screen to give individual immersion and group view.

The second demo site in Scotland is represented by the Helmsdale Heritage and Arts Society, commonly known as Timespan (Figure 8), was founded in 1986 with the main aim of providing the community and visitors with an insight into the rich heritage of Helmsdale and its surrounding area.

Timespan is in the historic fishing village of Helmsdale on the 58°latitude, on the east coast of Sutherland, in the North Highlands of Scotland. In 2009 an R+D report established a new direction for the art programming, aiming to bridge arts, heritage, and community. Timespan has an international profile for its contemporary art programme, digital heritage, and local history research. It provides a rich cultural programme of events and activities for the 17,000+ people from near and far who visit and engage with us every year.

Timespan’s “Green Room” is a crucial asset for developing and testing new technologies and tools for digitising Cultural Heritage objects from diverse collections and making them accessible through VR and AR immersive experiences. The space accommodates multiple exhibits and has been custom designed for VR, Xbox, and touchscreen interactivity. The collections the museum offers the opportunity to develop resilient object and artefact visualisation techniques for entire objects and incomplete artefacts, and a range of natural material types. These themes can be found in most European contexts and are useful indicators of environmental and social change. Through the HERITALISE project Timespan will explore the application of emergent technologies to Decolonialisation and promoting Climate Action. This will include developing exhibits focussed on the Flow Country world heritage site as well as the Strath of Kildonan from the Jurassic to Climate Futures . We will do this building on our current exhibits which include installations, apps, maps and online galleries.

Underpinning the work of both use cases will be the HERITALISE Virtual Museum which provides authoring and deployment frameworks for community museums and networks of museums. Support for developing and deploying high quality heritage exhibits will make AI and XR technologies available across the heritage value chain and support the reuse of materials.

The Virtual Museum Ecosystem supports multidisciplinary by enabling domain experts to engage with digital content, it supports complementarity by connecting physical and the virtual, and through the association of meta and para data supports documentation of digital assets contributing to historic rigor and authenticity. Embedding toolkits contributes to empowerment.

These solutions are beneficial beyond physical museums since the methods could be adapted for virtual reality setups, museum at home visits, and museum without walls, ensuring democratic and immersive opportunities to explore a wide range of cultural expressions independent of your geographical location.

Figure 8. Helmsdale Heritage and Arts Society - Time Span Museum in Scotland

4. HERITALISE first activities and project implementation

During the first 6 months of the project focus has been put on the one hand, on the definition and development of HERITALISE communication materials (WP2) in accordance with the ECHOES-ECCCH dissemination/communication guidelines and ono the definition/planning of communication activities and publications throughout the project.

In addition to this, first deliverables have been developed and submitted regarding the Project Management, Risk Management and Data Management (WP1), the latter being a critical one given the vast amounts of different data that we are planning to bring in and manage throughout the project.

On the other hand, and from a technical perspective, different technical WPs have kicked off too, addressing different aspects of the CH digitisation process which have been managed jointly in the Project Management Team and Technical Group meetings scheduled on a monthly basis.

4.1 WP3 Review of State-of-the-Art and definition of methodologies, risks, and protocols for HERITALISE

This WP, led by Cyprus University of Technology (CUT), is currently putting heavy efforts in the CH tangible and intangible objects' digitisation SoA review, following-up on the "Study on quality in 3D digitisation of tangible cultural heritage", and also in the evaluation of existing relevant methodologies for data acquisition. These activities are seeing to the CH sector from a holistic perspective but giving some focus to the techniques, solutions, services, etc. brought into HERITALISE project by respective partners. This WP and respective activities will give way to four deliverables to be submitted by December 2025.

4.2 WP4 Definition of HERITALISE Use Cases, stakeholders, and work/data flows

This WP, led by Fundación Santa Maria la Real (FSMLR), has dedicated plenty of efforts in the analysis of HERITALISE Demo Sites framework, needs and requirements, and in the analysis of potential Use Cases and operational models. It has (and is being) really critical to understand the nature of the different Demo Sites' respective cultural heritage and the status of digitisation therein. All of this aims at defining what is to be digitised, how, and to what end and/or services that make use of the digitised data, models, etc.

This is a slow and really critical work as it will affect all other technical WPs and respective works/activities to be undertaken throughout the project and, more importantly, in the Demo Sites and respective Use Cases.

To this end, Demo Site owners have presented in several meetings their respective Demo Sites and state of the art in terms of their respective CH's digitisation; moreover, multiple partners have presented their respective solutions/services so that everyone, above all Demo Site owners, understand the different capabilities within the consortium and the objectives HERITALISE Project/partners want to achieve with the project.

4.3 WP5 CH object data acquisition services' technical aspects' definition and development

This WP, led by Fundación TEKNIKER (TEK), has focused on the survey of advanced digitisation technologies not only within HERITALISE partners but across the world. Thus, this WP is working hand by hand with WP4 to define this data acquisition solutions that are to be brought into the project and Demo Sites to fulfil the respective Use Cases defined. This is led by TEK and also has a very important participation of Politecnico di Torino (POLITO).

5. Conclusion and future works

These are exciting times for digital innovation and initiatives in the Heritage sector. The relevance of digital to development and social agendas such as the United Nations Agenda 2030 and sustainable development goals is demonstrated by several initiatives. At the same time the Common European Data Space for Cultural Heritage and digital competency initiatives such as the 4CH 3D offer the opportunity for sharing of heritage content more widely than ever before.

The European Collaborative Cloud for Cultural Heritage (ECCCH) Echoes and associated sister projects offer the prospect of sharing tools on a pan European basis and building the capacity of heritage organisations and practitioners. Within this context the HERITALISE project aims to create digital tools that connect with heritage and address Sustainable Development.

The HERITALISE project summary states: HERITALISE mission is to research and develop advanced digitisation techniques and solutions for documenting and representing diverse CH assets, giving a full comprehension of the diverse CH features, visible and non-visible. In addition, AI-powered tools including Machine Learning (ML) will be developed for improved and optimised data post-processing and integration based on standard and expanded methodologies. All this will be connected through a knowledge graph environment that allows the individual aspects known about the CH object to be related and retrievable.

By following this aims it will be possible to learn more about a particular object, what research has been done, and what results have been derived from it. HERITALISE will provide the upcoming ECCCH with an interoperable web-based Ecosystem, advanced input data from improved digitalisation methodologies and preservation supporting tools, which will be achieved by meeting the following General Objectives (GO) and setting the conditions for a wide-scale replicability and scalability across European CH institutions/organisations across European CH institutions/organisations:

- State-of-the-art review of current digitisation standards and methodologies defining the data requirements for Cultural Heritage tangible and intangible objects
- Improve 3D/2D Data acquisition methods and technologies, with novel standards and tools for 3D accuracy assessment.
- Data post-processing methods and technologies will be adopted, including new AI-powered digitisation methods and the development of data fusion techniques to mix various multimodal digitisation approaches (multisensory, multiscale, multispectral, external and internal)
- Development of methodologies and solutions as Hardware (HW) and/or Software (SW) services, including Virtual Reality and Augmented Reality supported by Virtual Museum ecosystems.
- Development of ECCCH-compliant open interoperability components enabling connecting and sharing data and modular services in a distributed web-based architecture
- Increasing the Impact of current and developing digitisation technologies

The project is just started and in the present paper the first initiative are reported in connection with the demo sites selected within the project.

You can find out more of the HERITALISE project here: https://heritalise-eccch.eu/

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References

Aicardi, I., Chiabrando, F., Lingua, A. M., Noardo, F., 2018. Recent trends in cultural heritage 3D survey: The photogrammetric computer vision approach. *Journal of Cultural Heritage,* 32, 257-266.

Alicandro, M., Mileto, C., Lerma, J. L.,2024. Material Inspection of Historical Built Heritage with Multi-Band Images: A Case Study of the Serranos Towers in Valencia. *Remote Sensing*, 16(17), 3167.

Bentkowska-Kafel, A., Denard, H., Baker, D., 2012. *Paradata and transparency in virtual heritage*. Ashgate Publishing, Ltd..

Brumana, R., Roascio, S., Attico, D., Gerganova, M.R., Genzano, N., 2025. Paradata to Reuse Holistic HBIM Quality Models in the SCAN-to-HBIM-to-VR Process. The Mausoleum of Cecilia Metella and the Castrum Caetani. In: Ioannides, M., Baker, D., Agapiou, A., Siegkas, P. (eds) *3D Research Challenges in Cultural Heritage V. Lecture Notes in Computer Science*, vol 15190. Springer, Cham. https://doi.org/10.1007/978-3-031-78590-0_13

Cassar, A., 2025. Digitising the National Collection. In: Ioannides, M., Baker, D., Agapiou, A., Siegkas, P. (eds) *3D Research Challenges in Cultural Heritage V. Lecture Notes in Computer Science*, vol 15190. Springer, Cham. https://doi.org/10.1007/978-3-031-78590-0_16

Cassidy, C. A., Fabola, A., Miller, A., Weil, K., Urbina, S., Antas, M., Cummins, A., 2018. Digital Pathways in Community Museums. *Museum International*, 70(1–2), 126–139. https://doi.org/10.1111/muse.12198

D'Andrea, A., Di Mascio, D., 2023. The Heritage Digital Twin: A bicycle made for two. The integration of digital twin and CIDOC CRM for cultural heritage documentation. arXiv. https://arxiv.org/abs/2302.07138

Doerr, M., 2003. The CIDOC Conceptual Reference Model: An Ontological Approach to Semantic Interoperability of Metadata. *AI Magazine*, 24(3), 75–92.

Gîrbacia, F., 2024. An Analysis of Research Trends for Using Artificial Intelligence in Cultural Heritage. *Electronics,*13(18).

Gómez-Gil, A., Patrucco, G., Lerma, J. L., 2024. Traditional and New Sensing Techniques Combination for the Identification of the Forgotten" New Flour-Weighing House" in Valencia, Spain. *Applied Sciences* (2076-3417), 14(24).

Del Pozo, S., Rodríguez-Gonzálvez, P., Sánchez-Aparicio, L. J., Muñoz-Nieto, A., Hernández-López, D., Felipe-García, B., González-Aguilera, D., 2017. Multispectral imaging in cultural heritage conservation. *The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, *42*, 155-162.

Ioannides, M., Patias, P., 2023. The Complexity and Quality in 3D Digitisation of the Past: Challenges and Risks. In: Ioannides, M., Patias, P. (eds) *3D Research Challenges in Cultural Heritage III. Lecture Notes in Computer Science, vol 13125*. Springer, Cham. https://doi.org/10.1007/978-3-031-35593-6_1

Ioannides, M., Karittevli, E., Panayiotou, P., Baker, D., 2024. Integrating paradata, metadata, and data for an effective Memory Twin in the field of digital cultural heritage. In *3D Research Challenges in Cultural Heritage V* (Vol. 15190). Springer. https://doi.org/10.1007/978-3-031-78590-0_3

Jaganmohan, P. , Muralikrishnan, B. , Lee, V. , Ren, W. , Icasio Hernandez, O. and Morse, E., 2023., VDI/VDE 2634-1 Performance Evaluation Tests and Systematic Errors in Passive Stereo Vision Systems, *Precision Engineering-Journal of the International Societies for Precision Engineering and Nanotechnology*.

Jouan, P., Hallot, P., 2019. Digital Twin: A HBIM-based methodology to support preventive conservation of historic assets through heritage significance awareness. *ISPRS Archives, XLII-2/W15,* 609–616. https://doi.org/10.5194/isprs-archives-XLII-2-W15-609-2019

LOA, 2016. Document C120 [Guide] Version 2.0 - Guide for USIBD Document C220TM: Level of Accuracy (LOA) Specification for Building Documentation, U.S. Institute of Building Documentation .

Mendikute, A., Yagüe-Fabra, J. A., Zatarain, M., Bertelsen, Á., & Leizea, I., 2017. Self-Calibrated In-Process Photogrammetry for Large Raw Part Measurement and Alignment before Machining. *Sensors*, 17(9). https://doi.org/10.3390/s17092066

Murphy, M., McGovern, E., Pavia, S., 2013. Historic Building Information Modelling – Adding intelligence to laser and image-based surveys of European classical architecture. *ISPRS Journal of Photogrammetry and Remote Sensing*, 76, 89–102.

Pisani, S., Miller, A., Hall, M., 2022. Digitally restoring artefacts using 3D modelling techniques for immersive learning opportunities. *In 2022 8th IEEE International Conference of the Immersive Learning Research Network (iLRN),* pp. 1-8.

Puerto, P., Heißelmann, D., Müller, S., & Mendikute, A., 2022. Methodology to Evaluate the Performance of Portable Photogrammetry for Large-Volume Metrology. *Metrology*, 2(3), 320-334. https://doi.org/10.3390/metrology2030020

Sambuelli, L., Böhm, G., Colombero, C., & Filipello, A., 2015. Photogrammetry and 3-D ultrasonic tomography to estimate the integrity of two sculptures of the Egyptian Museum of Turin. In *Near Surface Geoscience 2015-21st European Meeting of Environmental and Engineering Geophysics* (Vol. 2015, No. 1, pp. 1-5). European Association of Geoscientists & Engineers.

EU Study VIGIE 2020/654: European Commission: Directorate-General for Communications Networks, Content and Technology, Study on quality in 3D digitisation of tangible cultural heritage – Mapping parameters, formats, standards, benchmarks, methodologies, and guidelines – Executive summary, Publications Office of the European Union, 2022, https://data.europa.eu/doi/10.2759/581678

ECCCH: https://www.echoes-eccch.eu/ accessed on 26/06/2025