JOINT INTERNATIONAL CONGRESS

ARQUEOLÓGICA 2.0 9TH

&

GEORES 3RD

PROCEEDINGS

Digital Twins for
Advanced Cultural Heritage
Semantic Digitization

Online - Valencia
26-28 April 2021

UNIVERSITAT POLITÈCNICA DE VALÈNCIA

Congress UPV

Proceedings of the ARQUEOLÓGICA 2.0 - 9th International Congress & 3rd GEORES - GEOmatics and pREServation
Lemma: *Digital Twins for Advanced Cultural Heritage Semantic Digitization.*

ARQUEOLÓGICA 2.0 – 9th International Congress on Archaeology, Computer Graphics, Cultural Heritage and Innovation.
GEORES – 3rd GEOmatics and pREServation.

The contents of this publication have been evaluated by the Scientific Committee which it relates and the procedure set out http://ocs.editorial.upv.es/index.php/arqueologica20/arqueologica9/about/organizingTeam

Scientific Editors

J. L. Lerma
M. Cabrelles

www.lalibreria.upv.es / Ref.: 6589_01_01_01

ISBN: 978-84-9048-872-0 (print version)
Print on-demand

DOI: https://doi.org/10.4995/arqueologica9.2021.13259

Proceedings of the joint international event 9th ARQUEOLÓGICA 2.0 & 3rd GEORES, Valencia (Spain). 26–28 April 2021

Conference Committee

Congress Co-Chairs:

- ✓ José Luis Lerma (UPV)
- ✓ Raffaella Brumana (POLIMI)
- ✓ Grazia Tucci (UNIFI)
- ✓ Víctor M. López-Menchero (Global Digital Heritage)

Organising Committee:

- ✓ Ana Belén Anquela (Dir. ETSIGCT/UPV)
- ✓ Matilde Balaguer (DICGF/UPV)
- ✓ Fabrizio Banfi (POLIMI)
- ✓ Inés Barbero (GIFLE/UPV)
- ✓ Miriam Cabrelles (GIFLE/UPV)
- ✓ Lourdes García (SEAV)
- ✓ José Luis Lerma (UPV)
- ✓ Ángel Marqués (DICGF/UPV)
- ✓ Jordi Padín (Dir. DICGF/UPV)
- ✓ Erica Parisi (UNIFI)

Scientific committee:

✓ Athos Agapiou	*Cyprus*	✓ Minna Lonnqvist	*Finland*
✓ Ana Almagro	*Spain*	✓ Eva Malinverni	*Italy*
✓ Julia Armesto	*Spain*	✓ Andrea Masiero	*Italy*
✓ Juan Antonio Barceló	*Spain*	✓ Camilla Mileto	*Spain*
✓ Gabriele Bitelli	*Italy*	✓ Gaspar Mora-Navarro	*Spain*
✓ Valentina Bonora	*Italy*	✓ Maurice Murphy	*Ireland*
✓ Rosario Cebrián	*Spain*	✓ Mª Amparo Núñez	*Spain*
✓ Filiberto Chiabrando	*Italy*	✓ Roberto Pierdicca	*Italy*
✓ Arivaldo Leao de Amorim	*Brazil*	✓ Mattia Previtali	*Italy*
✓ Donatella Dominici	*Italy*	✓ Fulvio Rinaudo	*Italy*
✓ Salim A. Elwazani	*USA*	✓ José Ignacio Rojas-Sola	*Spain*
✓ Steven Fai	*Canada*	✓ Riccardo Roncella	*Italy*
✓ Francesco Fassi	*Italy*	✓ Mario Santana	*Canada*
✓ Oreto García	*Spain*	✓ Jin Shang	*China*
✓ Andreas Georgopoulos	*Greece*	✓ Nannina Spanò	*Italy*
✓ Pierre Grussenmeyer	*France*	✓ Grazia Tucci	*Italy*
✓ Luis Hernández	*Spain*	✓ Fernando Vegas	*Spain*
✓ David Hernández-López	*Spain*	✓ Geert Verhoeven	*Austria*
✓ José Luis Jiménez	*Spain*	✓ Ona Vileikis	*UK*
✓ José Luis Lerma	*Spain*	✓ Alex Yen	*China*

Supporters:

- ✓ Universitat Politècnica de València

Collaborators:

- ✓ CIPA Heritage Documentation
- ✓ Spanish Society of Virtual Archaeology (SEAV)
- ✓ Virtual Archaeology International Network (INNOVA)
- ✓ Virtual Archaeology Review (VAR)
- ✓ School of Engineering in Geodesy, Cartography and Surveying
- ✓ Dept. of Cartographic Engineering, Geodesy and Photogrammetry
- ✓ Photogrammetry & Laser Scanning Research Group (GIFLE)

EDITORIAL UNIVERSITAT POLITÈCNICA DE VALÈNCIA

Proceedings of the joint international event 9th ARQUEOLÓGICA 2.0 & 3rd GEORES, Valencia (Spain). 26–28 April 2021

Preface

More than 10 years have passed since the first edition of ARQUEOLÓGICA 2.0 (International Congress on Archaeology, Computer Graphics, Cultural Heritage and Innovation) was held, in 2009. At that time, its promoter, Dr. Alfredo Grande, dreamed of creating a meeting place for all researchers and professionals who were experimenting with the application of new technologies in the field of archaeology. They were years of change and resistance, since part of the academic community considered these new lines of research as something secondary and residual, without connection to true scientific knowledge. People who worked in the field of virtual archaeology did so as isolated units, scattered across different regions and countries and with very little connection to each other. Although in the first decade of the 21st century the number of researchers working in this field had grown exponentially, there was a lack of spaces that would make it possible to make visible what was being done. Thus ARQUEOLÓGICA 2.0 was born, to fill those spaces for the Spanish case but with an international vocation. An open and inclusive congress where it was possible to know what other researchers from different countries were doing but also to forge new contacts and relationships to foster not only the virtual archaeology field but also the widening field of cultural heritage with collateral resources. A congress that favoured the emergence of new collaborations and projects. A congress to know that we were not working alone, encouraging new researchers to join the field of virtual archaeology.

In these years, this congress has evolved at the same time as the scientific discipline that today we call virtual archaeology. During this time, ARQUEOLÓGICA 2.0 has established itself as a meeting forum for professionals from different branches of knowledge. The congress has served to build in Spain and the rest of the world, a link between the latest technological developments and archaeological science. It has promoted the creation of the *International Principles of Virtual Archeology* (*Seville Principles*) that were ratified by ICOMOS in 2017. It has served as the basis for creating a scientific journal, *Virtual Archaeology Review* (VAR), which in 10 years has been positioned as one of the most important archaeology journals in the world, and which has allowed, and continues to allow, researchers from around the world to share their progress with the international scientific community in an open and free format.

ARQUEOLÓGICA 2.0 has also demonstrated its commitment internationally and in some editions, Marseille 2013 and Granada 2015, it has joined other similar congresses. This year, ARQUEOLÓGICA 2.0 once again demonstrates its ability to join forces, in this case with the close friendship of the GEORES (GEOmatics and pREServation) community. The previous two editions of GEORES in Italy capture the innovative spirit of the cultural heritage community. In the present edition of the virtual joint international event, the 9th ARQUEOLÓGICA 2.0 & 3rd GEORES 2021, deal with topics related to data acquisition, virtual archaeology, virtual architecture, conservation, cultural heritage, high-end digitization, advanced geomatics, preservation and restoration, through the event lemma, **Digital Twins for Advanced Cultural Heritage Semantic Digitization**. The power of technology, combined with deep understanding of heritage will definitely contribute to increase the scientific level of state-of-the-art technologies applied to safeguarding our heritage, trying to be useful to our society.

EDITORIAL UNIVERSITAT POLITÈCNICA DE VALÈNCIA

The proceedings report about 87 contributions that have been peer-reviewed by an international scientific committee fully compromised with the advancement of technology. We would like to express our gratitude to the PhD Forum co-chairs, Nannina Spanò (POLITO), Giulia Sammartano (POLITO), Valentina Bonora (UNIFI), Mattia Previtali (POLIMI) & Roberto Pierdicca (UNIVPM), for their active compromise and excellent undertakings in this congress.

We want to express our gratitude to both the Organising Committee and the Scientific Committee for their compromise in the success of this virtual event during the COVID-19 pandemic era. Hopefully, the next editions will be in a face-to-face format. Last but not least, our gratitude to all the researchers and participants for their positive input that have allowed us to gather this excellent manuscript.

Prof. José Luis Lerma (UPV), Prof. Grazia Tucci (UNIFI), Prof. Raffaella Brumana (POLIMI) & Dr. Víctor M. López-Menchero (Global Digital Heritage)
Congress Co-Chairs

EDITORIAL UNIVERSITAT POLITÈCNICA DE VALÈNCIA

Proceedings of the joint international event 9th ARQUEOLÓGICA 2.0 & 3rd GEORES, Valencia (Spain). 26–28 April 2021

Contents

Long scientific papers

EDITORIAL UNIVERSITAT POLITÈCNICA DE VALÈNCIA

ARQUEOLÓGICA 2.0
CONGRESO INTERNACIONAL DE ARQUEOLOGÍA E INFORMÁTICA GRÁFICA, PATRIMONIO CULTURAL E INNOVACIÓN
INTERNATIONAL CONGRESS ON ARCHAEOLOGY, COMPUTER GRAPHICS, CULTURAL HERITAGE AND INNOVATION
GEORES 2021
UNIVERSITAT POLITÈCNICA DE VALÈNCIA

Proceedings of the joint international event 9th ARQUEOLÓGICA 2.0 & 3rd GEORES, Valencia (Spain). 26–28 April 2021

EDITORIAL UNIVERSITAT POLITÈCNICA DE VALÈNCIA

ARQUEOLÓGICA 2.0
CONGRESO INTERNACIONAL DE ARQUEOLOGÍA E INFORMÁTICA GRÁFICA, PATRIMONIO CULTURAL E INNOVACIÓN
INTERNATIONAL CONGRESS ON ARCHAEOLOGY, COMPUTER GRAPHICS, CULTURAL HERITAGE AND INNOVATION
GEORES 2021
UNIVERSITAT POLITÈCNICA DE VALÈNCIA

Proceedings of the joint international event 9th ARQUEOLÓGICA 2.0 & 3rd GEORES, Valencia (Spain). 26–28 April 2021

EDITORIAL UNIVERSITAT POLITÈCNICA DE VALÈNCIA

ARQUEOLÓGICA 2.0
CONGRESO INTERNACIONAL DE ARQUEOLOGÍA E INFORMÁTICA GRÁFICA, PATRIMONIO CULTURAL E INNOVACIÓN
INTERNATIONAL CONGRESS ON ARCHAEOLOGY, COMPUTER GRAPHICS, CULTURAL HERITAGE AND INNOVATION
GEORES 2021
UNIVERSITAT POLITÈCNICA DE VALÈNCIA

Proceedings of the joint international event 9th ARQUEOLÓGICA 2.0 & 3rd GEORES, Valencia (Spain). 26–28 April 2021

Works in progress

Extended Abstracts

EDITORIAL UNIVERSITAT POLITÈCNICA DE VALÈNCIA

Proceedings of the joint international event 9th ARQUEOLÓGICA 2.0 & 3rd GEORES, Valencia (Spain). 26–28 April 2021

Received: 14/12/2020
Accepted: 05/03/2021

DIGITAL SURVEY AND RECEPTION STRUCTURES FOR A VIRTUAL FRUITION: THE CASE STUDY OF THE HYPOGEUM OF CALAFORNO (RAGUSA)

Graziana D'Agostino[a,*], Marianna Figuera[b], Gianluca Rodonò[a]

[a] Department of Civil Engineering and Architecture, University of Catania, Via Santa Sofia 64, 95125 Catania, Italy. graziana.dagostino@unict.it; gianluca.rodono@unict.it

[b] Department of Human Sciences, University of Catania, Via Biblioteca 4, 95124 Catania, Italy. marianna.figuera@unict.it

Abstract:

This contribution offers the initial results of an on-going multidisciplinary project aimed at exploring digital approaches to overcoming the complexities associated with certain archaeological monuments, such as the Hypogeum of Calaforno, one of the most interesting prehistoric monuments in Sicily. It is a unique sample of rock-cut architecture in terms of size and architectural features, in comparison with the Sicilian territory and the entire Mediterranean context. In addition to the usually rock-cut architecture characteristics, as the narrow spaces and the lack of light, the hypogeum also presents some practical problems due to the serpentine route of the rooms and the presence of water in some spaces. This case study highlights the need to pursue the development of digital products which have a clearly scientific value and can also improve the dissemination aspects. The paper also shows the development and experimentation of workflows to obtain viable 3D digital twin models through the use of low-cost techniques for the photogrammetric surveying of archaeological sites characterized by the presence of narrow and complex spaces. Thanks to the comparison with the laser scanner point cloud of a previous survey, it was possible to verify the accuracy of the photogrammetric model. This has been obtained through the use of the action cam GoPro Black Hero 6. This cam proved to be a highly useful instrument, with lenses offering fields of view somewhere between those of fisheye lenses and of traditional lenses. The aim of this work is the communication of cultural content to the public through immersive virtual experiences that can enhance real visits to stimulate public interest and improve understanding of the monument with the help of unique reception and observation structures based on innovative enabling technologies. The construction system is designed to integrate analogue and digital apparatus and allow the creation of privileged observation points to experience 3D reconstructions of the site.

Keywords: archaeology, virtual fruition, narrow spaces, digital survey, photogrammetry, GoPro

1. Introduction

The work presented here is part of an on-going project focused on improving public appreciation of sites that are not readily accessible, through the development of digital twin environments that offer virtual access as an effective instrument of cultural transmission. The work is part of the wider eWAS project aimed at the precautionary conservation of Cultural Heritage assets before they are lost or compromised due to unforeseen calamities.

The test site is the Hypogeum of Calaforno (province of Ragusa, Sicily), chosen by the eWAS project for its high historical, archaeological and cultural significance, as well as for its intrinsic fragility and criticality associated with hydrogeological and seismic factors. The site is also characterized by access difficulties and resides in a remote location away from tourist circuits, generating communication issues and a general lack of sufficient support to allow visitors to fully appreciate the structural and functional significance of the hypogeum.

The project includes plans to render 3D tours possible on location through structures in the vicinity using specific technologies that will ensure flexibility, reversibility, and low environmental impact. The ultimate goal of the project is to therefore improve and heighten public awareness of the hypogeum through virtual experiences made possible by integrated digital survey methodologies such as Laser Scanner (LS) and Structure from Motion (SfM).

2. The Hypogeum of Calaforno

The Hypogeum of Calaforno is one of the most interesting prehistoric monuments in Sicily in terms of size and its unique representation of rock-cut architecture (Figuera, 2018).

The hypogeum was identified in the 1970s by Lorenzo Guzzardi (1980) but, notwithstanding its peculiarity, did not undergo systematic investigation until 2013, when archaeological research under the direction of Pietro Militello (University of Catania) allowed a more profound

* Corresponding Author: Graziana D'Agostino, graziana.dagostino@unict.it

understanding of its chronology, architecture and function (Militello & Di Stefano, 2015; Militello, 2021). Since 2016, the Superintendence BB.CC.AA. of Ragusa has been leading excavations around the main entrance of the monument (Militello, Sammito, & Scerra, 2018).

The hypogeum (Fig. 1) is carved into a layer of soft marl lying beneath a harder limestone layer. It includes a wide entrance room (ca. 12 x 4 m), and 35 circular rooms forming an irregular route (ca. 100 m long). The rooms have a diameter ranging from 1.5 to 3 m, and range in height between 1.6 and 1.8 m; concave floors and walls curve slightly up to the ceiling, which is perfectly flat. A second entrance was added in the vicinity of room 17.

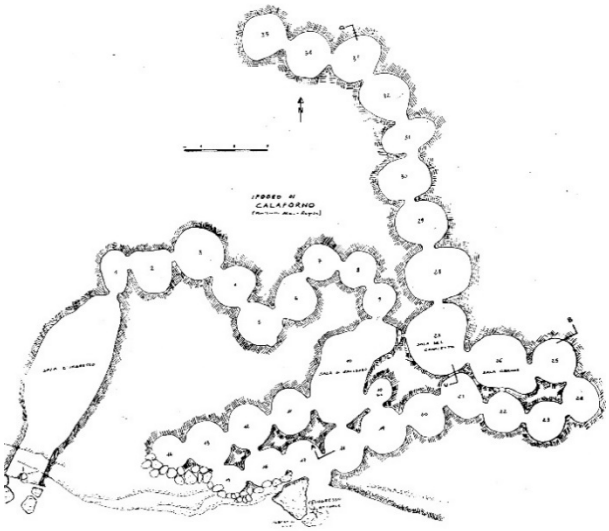

Figure 1: Calaforno Hypogeum (Guzzardi, 1980).

Construction spanned a long period, from the Late Copper Age (ca. 2700-2200 BC) to the Early and Middle Bronze Age (ca. 2200-1250 BC). It was initially used as a burial site until it became a ritual area in honour of the ancestors between 1000 and 700 BC. After a period of abandonment (excluding the immediate external area, which continued to be frequented), it was partially reoccupied as a cemetery (ca. 300-500 AD), and as an industrial and stockage area or an animal shelter (ca. 800-1050 AD), until the final collapse of the entrance.

The features of the Calaforno Hypogeum do not lend themselves to straightforward survey: in addition to the lack of relevant points of discontinuity and the difficult identification of section planes necessary for identifying the layout, there are practical problems due to the narrow spaces, the serpentine route of the rooms, the lack of light and the presence of water in some spaces (Figuera, in press).

An initial solution to these problems came in the form of a laser scanning survey performed in 2017-19, culminating in a final 3D model consisting of approximately 25 million points and additional data, such as a coloured view based on the reflectivity of the materials detected by the instrument (Fig. 2). The technique proved fundamental for the resolution of many scientific problems caused by various technical issues that riddled the first survey (Guzzardi, 1980), as well as for identifying previously undiscovered architectural elements and recording the current state of preservation in enough detail to be able to adequately monitor any future degradation.

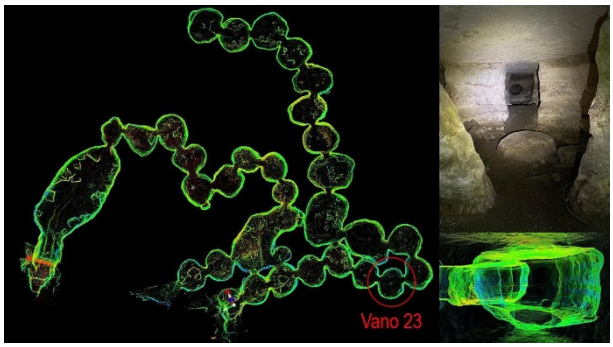

Figure 2: The laser scanner point cloud.

This case study highlights the need to pursue the development of digital products which, besides having a clearly scientific value, can also vastly improve communication aspects associated with sharing and disseminating information regarding heritage sites from local to supralocal scales (Salerno, 2017).

3. The Structure from Motion survey: from point cloud to 3D model

In recent years, several studies have been conducted on photogrammetric survey using fisheye or wide-angle lenses, together with necessary comparisons with other methods of digital acquisition (e.g., laser scanning), to verify the accuracy of acquired data and the reliability of derived models (Mandelli, Fassi, Perfetti, & Polari, 2017). Our interdisciplinary research group addressed the matter by successfully deploying a GoPro action cam to survey tall and narrow environments in poor lighting conditions (Aiello et al., 2019), in addition to the laser scanning survey technique. The GoPro proved to be a highly useful instrument, with lenses offering fields of view somewhere between those of fisheye lenses and of traditional lenses. The experimentation carried out on the Calaforno Hypogeum, however, presented new challenges in terms of morphological and environmental complexity, with no lighting and very narrow rooms connected by small passageways.

Current research is aimed at developing and experimenting workflows to obtain viable 3D digital twin models featuring high quality and highly realistic chromatic data through low cost survey techniques. The first step of the SfM survey involved the acquisition of a single room (Room 23) to determine the most appropriate instrumentation and processes, before proceeding to acquire the entire site. The selected room is one of the smallest in the hypogeum and is part of a group of four rooms arranged in a ring shape around Room 26. The room was subject to renovation work during its history, so its original shape remains undetermined. A serendipitous outcome of this detailed 3D survey is the identification of previously unseen geological features like traces due to water infiltration, especially in the ceiling, while realistic colour rendering on the slightly curved walls also revealed numerous geological stratifications.

The advantages of using the GoPro action cam instrumentation for capturing very tight environments include its small size (L: 62.3 mm., H: 44.9 mm., D: 32.0 mm.; Weight: 118 g.), high manoeuvrability and wide field of view (FoV), which allow greater area to be captured. The 130° FoV implemented produces a fisheye aspect,

especially at the scene edges, which simplifies the entire surveying phase by reducing the number of images needed to acquire the whole site and reducing the processing time with more manageable data.

Lighting was introduced with a LED lamp (24 LEDs, 0.5 W, 220 Lm; L: 73 mm., H: 250 mm., D: 165 mm.; Weight: 640 g.), configured to deliver neutral white light (4000-5000 K) in order to derive realistic 3D model chromaticism. In addition, a portable lamp was employed to follow the shooting path of the dataset and to facilitate movement in narrow spaces.

The photographic dataset collected (35 images at 4000 x 3000 resolution) was processed using the Agisoft Metashape photogrammetric software to generate a point cloud of about 23 million points and a polygonal model of about 5 million faces.

CloudCompare was used to compare the accuracy of the photogrammetric data with the more accurate laser scanning metric information. The GoPro point cloud was georeferenced in Metashape by assigning the coordinates of 7 recognizable markers from the laser scanner point cloud to corresponding points in the photogrammetric model (Fig. 3).

The deviation between the two models is shown in a Blue/Red scalar field. The calculation range was set between 0.00-0.01 m (Fig. 4).

With the reliability of the model to some extent verified, we believe that this research can contribute to the formulation of new protocols governing the archaeological survey of sites characterized by irregular surfaces, narrow spaces, specific chromatic features, scarce or total absence of illumination, and physical obstacles.

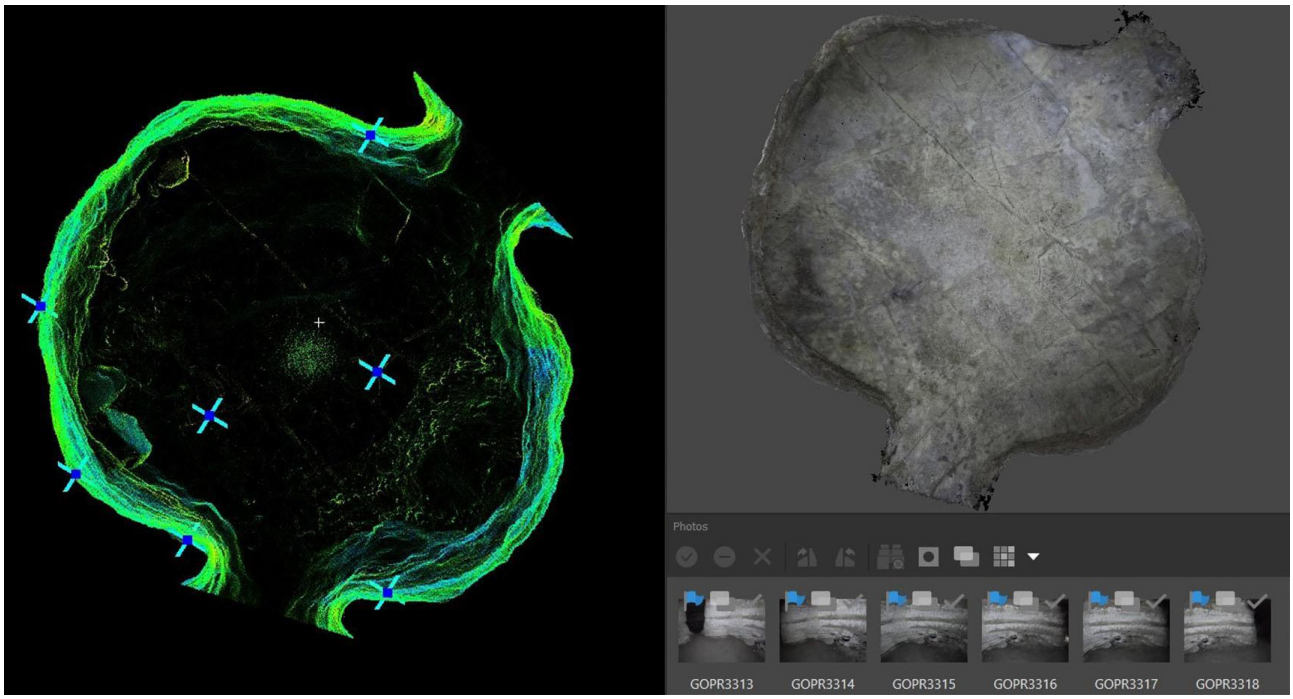

Figure 3: On left, top view of laser scanner point cloud with control points; on right, top view of GoPro polygonal model.

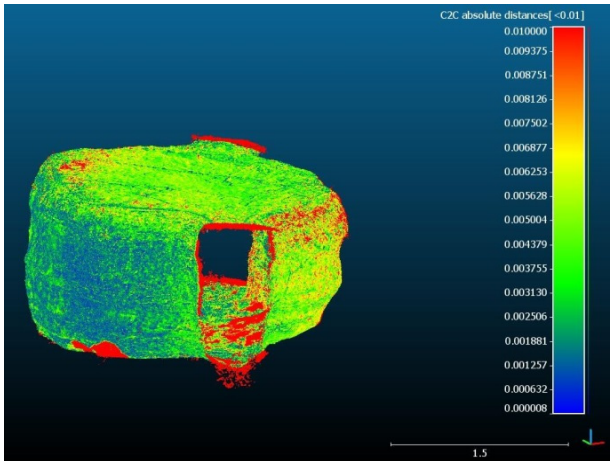

Figure 4: Comparison between the laser scanner and GoPro point clouds.

4. The reception structures

The intrinsic complexity of the Calaforno site renders the need to implement small pavilions and other micro service infrastructure particularly relevant in order to adequately communicate the knowledge acquired from past, current and subsequent research.

The construction of architectural volumes in sensitive areas demanding minimal and non-invasive interventions has inspired, within the scope of the eWAS project, experimentation with innovative technologies that, beyond the aforementioned requirements, also account for difficulties associated with access and supply of energy that often characterize sensitive areas. Any viable architectural objects must therefore be characteristically lightweight, easy to assemble and disassemble, and have minimal impact on the underlying terrain. A modular system was therefore conceived, involving a prefabricated timber frame with corrugated cardboard boxes inside.

These materials offer low cost, rapid assembly and installation due to their low specific weight and complete recyclability (Distefano, Rodonò & Sapienza, 2016).

The construction system is designed to integrate analogue and digital apparatus (periscopes and camera equipment), and allow the creation of privileged observation points to experience 3D reconstructions of the site in its original configuration. Flexible and envelope integrated photovoltaic cells shall complete the design to ensure off-grid energy independence.

5. Conclusions and future developments

3D digital technologies can be instrumental research and documentation tools, as well as providing innovative communication channels. They should not, however, represent substitutes for real visits, but rather encourage them by stimulating public interest. For this reason, the on-location fruition of acquired digital information through flexible reception structures is integral to this project. The structures are intended to allow virtual consumption of immersive and realistic digital twins in order to enhance the overall experience of interested visitors and academics alike. The former, by overcoming any inconveniences associated with less accessible areas, and the latter, by providing realistic morphologic and chromatic data, with levels of resolution and detail that will allow focus and investigation of particular aspects of the monument. To this end, the 3D model shall be enriched with semantic content providing detailed information surrounding the hypogeum, including architectural features, chronological and functional aspects, and so on.

Acknowledgements

The research was partly funded by the project PON ARS01_00926 eWAS - An Early Warning System for Cultural Heritage - PNR 2015-2020. The scientific director is prof. Vincenzo Sapienza (Department of Civil Engineering and Architecture, University of Catania), responsible for on-site research activities is prof. Pietro Militello (Department of Human Sciences, University of Catania).

Excavation activities were conducted under Project Mneme, Costruzione del passato e pratiche della memoria nel Mediterraneo, Bando Prometeo Linea 3, University of Catania.

The laser scanning activities were performed in trying conditions with the technical contribution of Antonio and Salvatore Garro (3D Dimension Company, Catania, Italy).

References

Aiello, D., Buscemi, F., D'Agostino, G., Galizia, M., Militello, P., & Santagati, C. (2019). Low cost techniques for the digital survey of a Minoan architecture in the archeological site of Phaistos (Crete). *Int. Arch. Photogramm. Remote Sens. Spatial Inf. Sci., XLII-2/*W17, 31–38. https://doi.org/10.5194/isprs-archives-XLII-2-W17-31-2019

Distefano, D.L, Rodonò, G, & Sapienza, V. (2016). Le nuove frontiere dell'architettura di cartone. *Il progetto sostenibile, 38*, 112–119.

Figuera, M. (2018). Patrimonio diffuso, comunità locali. La "riscoperta": per una ipotesi di valorizzazione innovativa dell'ipogeo di Calaforno. *Archivio Storico per la Sicilia Orientale, 2018*(1), 5–23. https://doi.org/10.3280/ASSO2018-001001

Figuera, M. (in press*). Sicilian Landscape and A-structural Architecture from Survey to Virtual Reconstruction: the case of the Calaforno Hypogeum*. In D. Panagiotopoulos & P.M. Militello (Eds.), Modelling Archaeological Landscapes.

Guzzardi, L. (1980). Un ipogeo preistorico a Calaforno e il suo contesto topografico. *Sicilia Archeologica, 42*, 67–94.

Mandelli, A., Fassi, F., Perfetti, L., & Polari, C. (2017). Testing different survey techniques to model architectonic narrow spaces. *Int. Arch. Photogramm. Remote Sens. Spatial Inf. Sci., XLII-2*/W5, 505–511. https://doi.org/10.5194/isprs-archives-XLII-2-W5-505-2017

Militello, P.M. (2021). *Calaforno I. Le indagini 2013-2017*. Oxford.

Militello, P.M., & Di Stefano, G. (2015). Calaforno (Giarratana, Prov. di Ragusa). Indagini 2013-2014. *Notiziario di Preistoria e Protostoria, 2*(II), 63–65.

Militello, P.M., Sammito A.M., & Scerra, S. (2018). Calaforno (Giarratana, RG). *Notiziario di Preistoria e Protostoria, 5*(II), 90–93.

Salerno, R. (2017). Digital Technologies for "Minor" Cultural Landscapes Knowledge: Sharing Values in Heritage and Tourism Perspective. In A. Ippolito & M. Cigola (Eds.), *Handbook of Research on Emerging Technologies for Digital Preservation and Information Modeling* (pp. 510–535). https://doi.org/10.4018/978-1-5225-0680-5.ch019