

Tuesday July 11th 2023

Educational Digital Innovative **CULTURAL** heritage related Learning Activities

EDICULA

**EDICULA
SYNTHESIS
EVENT**



TECHNICAL CHAMBER OF GREECE

Executive Committee Hall, 4 Nikis Str, Athens

14:00 - 16:30 EEST

Co-funded by the
Erasmus+ Programme
of the European Union



Project Code: 2020-1-EL01-KA203-079108



NATIONAL TECHNICAL
UNIVERSITY OF ATHENS
[GREECE]



SAPIENZA
UNIVERSITÀ DI ROMA
[ITALY]



BEZALEL ACADEMY
OF ARTS AND DESIGN
[ISRAEL]



PerpetielSI
SRL
PERPETIELSI SRL
[ROMANIA]



ISRAEL ANTIQUITIES
AUTHORITY
[ISRAEL]



HELLENIC RESEARCH INSTITUTE OF
THE ALEXANDRIAN CIVILIZATION
[GREECE]

***Advanced knowhow, interdisciplinarity and professional profiles
responding to the challenges of sustainable preservation of
Cultural Heritage***

**Professor Emeritus – NTUA Antonia Moropoulou
Member of the Executive Committee - Technical Chamber of Greece
Scientific Responsible of EDICULA project**

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Educational activities for the transfer of the knowhow that we developed in the project, with the National Technical University of Athens – NTUA as the coordinator of the European **Erasmus + Program EDICULA** and participating institutions: University of Sapienza in Rome (Italy), the Bezalel Academy of Arts and Design, Jerusalem (Israel), Israel Antiquities Authority – IAA (Israel), the Hellenic Research Institute of the Alexandrian Civilization -HRIAC (Greece), Perpetiel SI Srl (Romania) so as to continue offering and exchanging knowhow and experiences augmenting the continuation of the works in the Church of the Holy Sepulchre, on this occasion with the responsibility of the Sapienza University of Rome, as well as to other World Cultural Heritage rehabilitation and protection projects.



OBJECTIVES

The objectives of the EDICULA project are:

- to **disseminate through education the interdisciplinary and innovative research and know-how** developed in the **rehabilitation of the Holy Aedicule** under NTUA leadership
- cultivate **cooperation between NTUA and UNIROMA1** in the **projects of rehabilitation of the Holy Aedicule and the underground interventions in the Church of the Holy Sepulchre** in Jerusalem,
- to utilize the **interdisciplinary and innovative research** in the rehabilitation of the **Holy Aedicule**, its context and setting, **to trans-cut with the history of architecture in Jerusalem**, through **cooperation with BEZ and IAA**, and promote **transdisciplinarity as an educational lever** in the protection of CH, through **cooperation with HRIAC**, as well
- to create **advanced educational material and dissemination by using AR**, through **cooperation with PerpetielSI**, to create (i) an educational toolkit and (ii) digital games, in **order to promote social responsibility and awareness**



OBJECTIVES

The objectives of the EDICULA project are:

- to **reform the curricula of the three postgraduate programs** of the EDICULA partners, in order to exchange good practices and create new courses that in a complimentary approach will lead to the **promotion of a Joint Master Degree in the field of protection of monuments**
- to **develop the EDICULA Teachers' Course**, in order to train higher education teachers to promote the transdisciplinary scientific synthesis as a key element for innovative education
- to proceed with the **organization of multiplier events**, such as (i) **hands-on events in Jerusalem and Alexandria**, (ii) **special conference sessions** in Athens
- to **promote students to a professional and entrepreneurship mentality**, by advancing education in collaboration with enterprises concerning technical works and digital applications, and thus enhance learning outcomes to ensure professional qualifications



EDICULA PROJECT STRUCTURE

EDICULA project Management and Implementation

Transnational Project Meetings

Kick-off Meeting
21.10.2020

Review Meeting 1
12.2021

Review Meeting 2
03.2022

Final Project Meeting
02.2023

**O1: EDICULA
EDUCATIONAL
TOOLKIT**

**O2: EDICULA
CURRICULA
REFORMATION**

**O3: EDICULA
HANDS-ON
FRAMEWORK**

**O4: EDICULA
DIGITAL
GAMES**

**O5: EDICULA
SYNTHESIS**

**MULTIPLIER
EVENTS**

*E1: The Holy
Sepulchre Hands-on
Experience*
03.2022

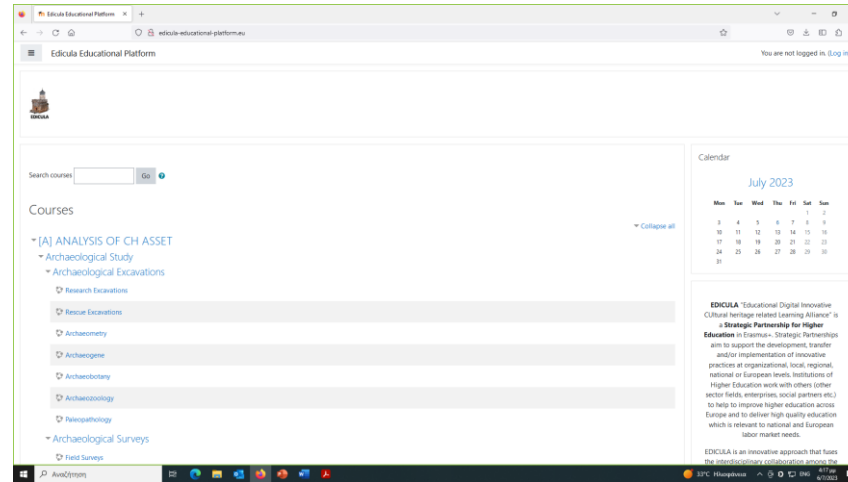
*E2: The Alexandria
Immersive Experience*
06.2022 & 12.2022

*E3: EDICULA
Innovation Session
TMM_CH Conf.*
12.2021

*E3: EDICULA
Educational Session
TMM_CH Conf.*
12.2021

**EDICULA
Teachers' Course**
03.2023

O1: EDICULA EDUCATIONAL TOOLKIT



O2: EDICULA CURRICULA REFORMATION

**EDICULA CURRICULA REFORMATION
NTUA SEMINAR SERIES**

Towards a curricula reformation of the National Technical University of Athens MSc
"Protection of Monuments – Direction: Materials and Conservation Interventions"

Course 3.8
'INTERDISCIPLINARY DOCUMENTATION, DIAGNOSIS, REVEALING AND PROTECTION OF CULTURAL HERITAGE TOWARDS SUSTAINABLE DEVELOPMENT'

SEMINAR 1
THE REHABILITATION OF THE HOLY AEDICULE OF THE HOLY SEPULCHRE IN JERUSALEM

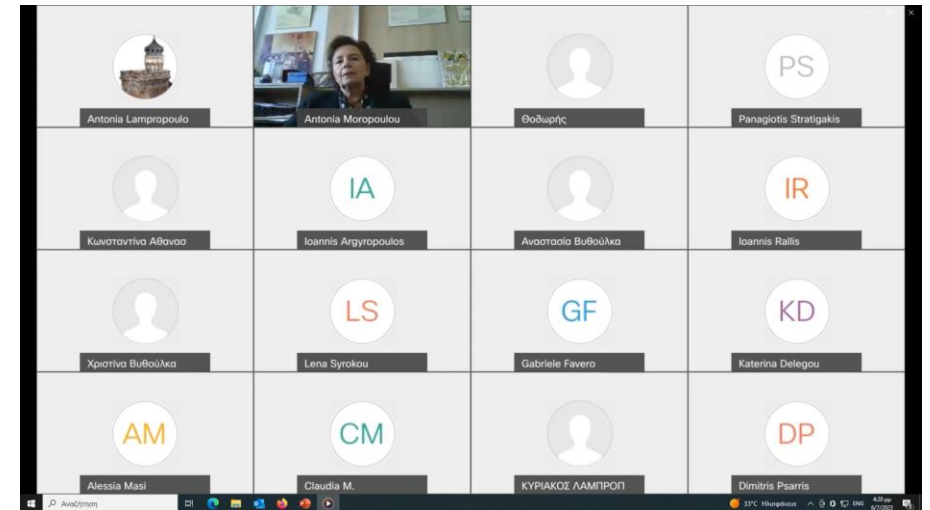
1-7 December 2021 - online seminar

WEDNESDAY 1 DECEMBER 2021
15:00-16:00 Prof. A. Moropoulou

EDICULA
Educational Digital Innovative Cultural heritage related Learning Activities

edricula.eu
facebook.com/ediculaproject

Co-funded by the Erasmus+ Programme of the European Union



Postgraduate curricula reformation

- The **UNIROMA1 postgraduate curricula reformation** has been proceeded with the design and organization of 2 new compulsory core courses [*“Applied geosciences and bioconservation laboratory” - “Plant biology and conservation for cultural heritage”*] and 1 new optional course [*“Climate risk assessment of cultural heritage”*] within Post Graduate Program in “Science and Technology for the Conservation of Cultural Heritage”. 2021-2022 implementation has been evaluated to be taken under consideration within 2022-2023 implementation.
- The **NTUA postgraduate curricula reformation** has been proceeded with the design and reformation of 3 optional courses [*The rehabilitation of the Holy Aedicule of the Holy Sepulchre in Jerusalem – Interdisciplinary documentation and guidelines for the exploiting and revealing of cultural assets augmenting their resilience*] within Post Graduate Program in “Protection of Monuments” – Direction “Materials and Conservation Interventions”. The reformation of the 1st course took place in fall 2021-2022 and the implementation of the reformation of the 2nd and 3rd courses took place in spring 2023.
- The **BEZ Master postgraduate curricula reformation** has been proceeded with the design of co-teaching and studio activities forwarding hands-on approaches [*new track in Conservation and Heritage – Jerusalem lab 2022 Growing Jerusalem*] within Post Graduate Program in “Urban Design”

Upscaling EDICULA curricula reformation with the perspective of a future joint Master Degree

- The curricula reformation can act as the first step towards a **post-EDICULA future creation of a Joint Master Degree** that will contribute in European level to provide new skills to the professionals requested in the field of the conservation of Cultural Heritage, in accordance with the European Skills Agenda.
- **UNIROMA1 has developed a “Tuning matrix”** that is still being completed by all EDICULA academic partners, in order to identify the needs and objectives of such a Joint Master Degree and serve as a basis for its design, as a post-EDICULA proposal. The tuning matrix will serve as the guide to design the joint syllabus of the proposed Joint Master degree.
- The EDICULA reformed courses will be part of the **future joint curricula**. Contents developed in the EDICULA hands-on and the EDICULA immersive experience will also be included.

PhD thesis assignment and elaboration

- The **UNIROMA1 Department of Earth Sciences** has assigned a **PhD thesis** to Adi Sela Wiener, which is already under elaboration, with the title *“Redefining urban heritage materiality: a conceptual study of Jerusalem”* under the co-supervision of Prof. Gabriele Favero (Department of Environmental Biology, Sapienza University of Rome) and Dr. Laura Medeghini (Department of Earth Sciences, Sapienza University of Rome).
- **NTUA** has opened a **new PhD position** within EDICULA concept at the NTUA School of Rural, Surveying and Geoinformatics Engineering within the subject *“Decision making in the analysis of technologies of image analysis / computer vision in the structural condition of materials of cultural heritage monuments”*. In parallel, a PhD thesis within the scientific topics of EDICULA, with the title *“Standard information system for the management, processing and analysis of large multidimensional data for the diagnosis of historical monuments”* is under elaboration at the NTUA Section of Materials Science and Engineering under the supervision of Emer. Prof. A. Moropoulou.
- **BEZ** has been inquiring for a **practice-based PhD assignment in cooperation and co-supervision with the Hebrew University**, which will be helpful in order to achieve the assignment, since the Israel academic framework for PhD elaboration is different than the European.

O3: EDICULA HANDS-ON FRAMEWORK

D3.1 | Survey of Hands-on methodologies

12. Is the course supported by external providers (such as: other faculties and departments, outsourcing instructors and contributors, collaborat...n with other institutions/ industry partners, etc.)?
11 responses

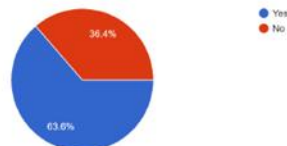


Fig. 3.6 | External providers

3.3 | ASSESSMENT AND EVALUATION

Two open questions dealing with evaluation of the state of the art of hands-on methodologies in the field of Cultural Heritage were presented, with an additional space to add open remarks. These final questions were answered by closed to three-quarters (73%) of the contributors. Their insights provide a thorough and important input for the summary and conclusions of Task 3.1 presented in the following chapter. Below are the questions with the full responses. Significant components are highlighted.

1. Please describe your opinion regarding the constructive alignment between the learning outcomes, course's objectives, or pedagogic tools (with special attention to the hands-on feature) and the evaluation process:

a) How do the pedagogic methods applied in the course contribute to the achievement of the declared learning outcomes?

Very important for the two first semesters of the program to achieve interdisciplinary and intercultural collaborative methodologies.

- The timing of the course; interdisciplinary and intercultural collaborative methodologies.

Exercises under the reflected light microscope will allow the student to be able to recognize the main opaque minerals in reflected light and their alteration products.

- Strengthening of problems identification and analysis.

The intensive workshop is resulting in good design projects, the mixed groups (Israelis and foreign students) help. Tours of relevant sites add good reference points.

- The intensity of the course;
- Supporting pedagogical methodologies in the sites;

General Information

General remarks:

- In the questions to follow please indicate only one course
- For any additional course in the same program, or for any additional program please open a new form.
- Filling the form may take approximately up to an hour and a half.
- Information gathered in the form will be used for the EDICULA project.

Please indicate the name of the contact person from the EDICULA project and the name of the institution: *

Your answer _____

Contributor:

Please indicate the following details that are related to the contributor (the person filling the form)

Name of contributor: *

Your answer _____

Email address: *

Your answer _____

Name of the academic institution and the faculty: *

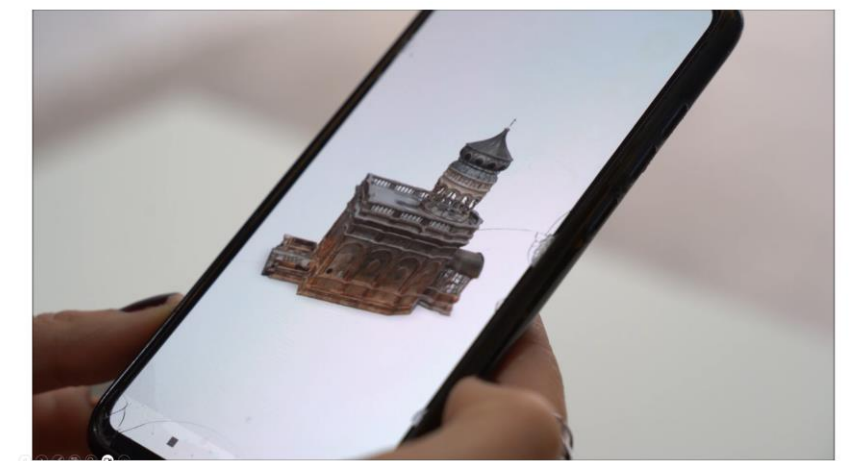
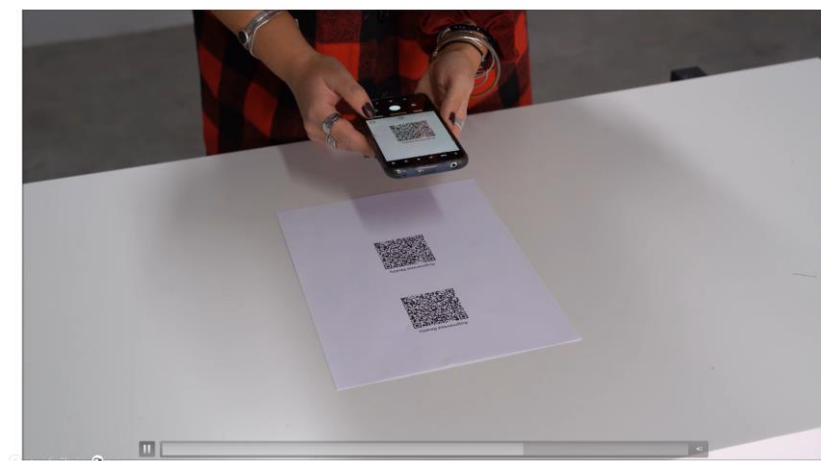
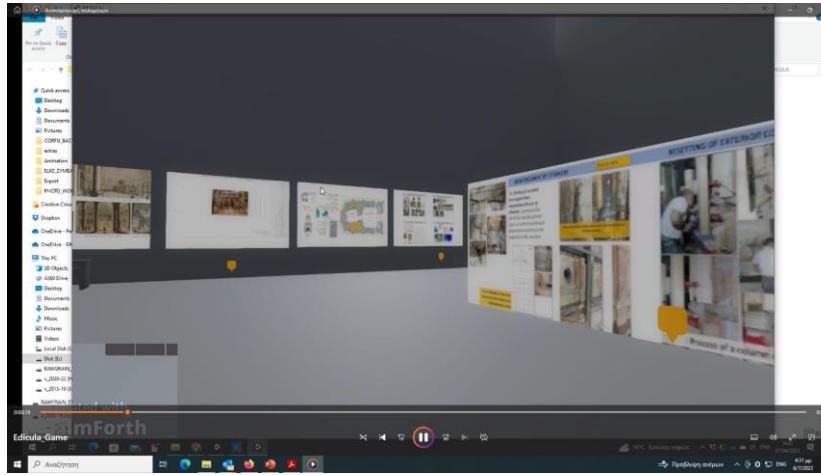
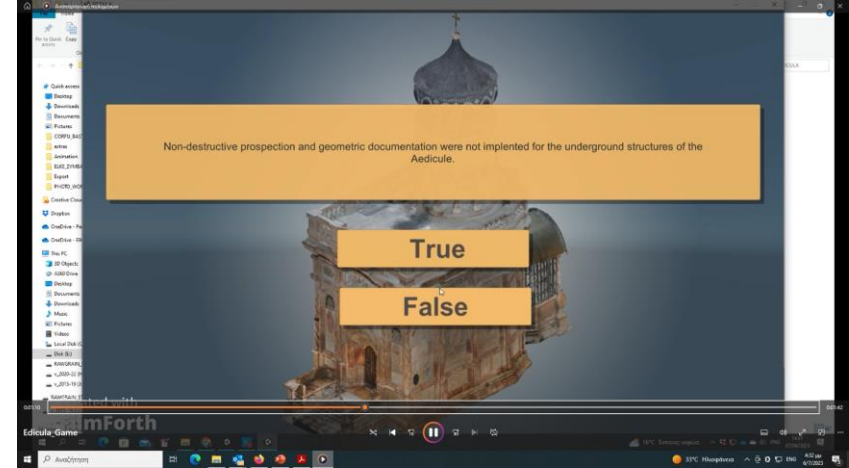
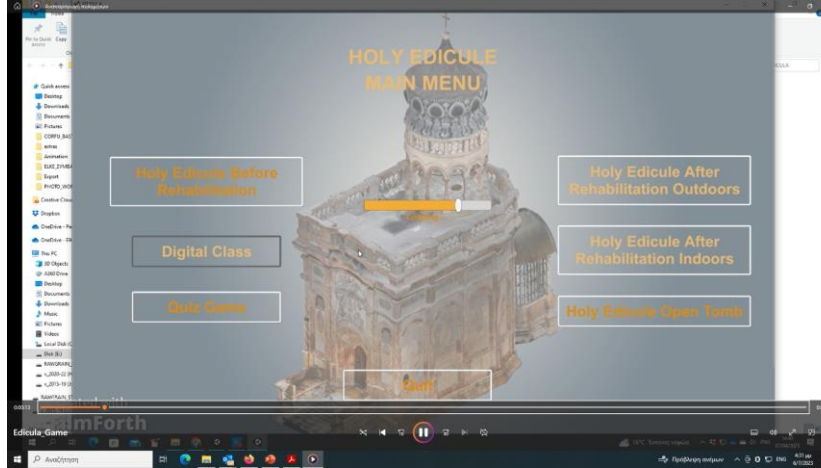
Your answer _____

Back

Next

Clear form

O4: EDICULA DIGITAL GAMES



MULTIPLIER EVENTS

*E1: The Holy
Sepulchre Hands-on
Experience
03.2022*



MULTIPLIER EVENTS

E2: The Alexandria Immersive Experience

06.2022 & 12.2022

3D scanning in Alexandria

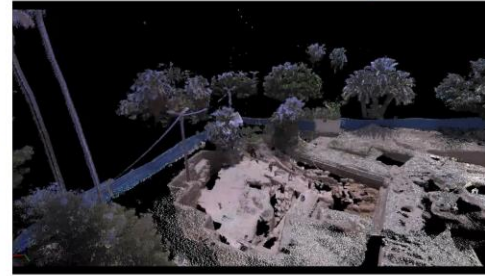
- Shallalat Park – Excavation of the HRIAC
Director and Coordinator Dr K. Papakosta



THE EDICULA IMMERSIVE EVENT 19 December 2022



Terrestrial laser scanning



Data acquired with the kind permission of Dr K. Papakosta



Terrestrial laser scanning



THE EDICULA IMMERSIVE EVENT 19 December 2022

3D scanning in Alexandria

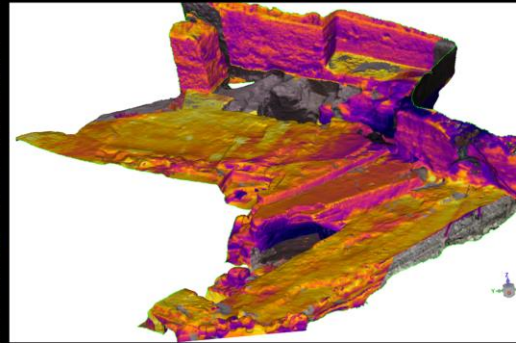


Museum of the Greek Orthodox Patriarchate of Alexandria and All Africa

Data acquired after invitation and with the kind permission of the Patriarch of Alexandria and All Africa



Developing an IRT textured 3D point cloud

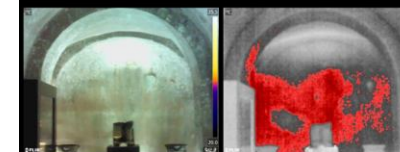
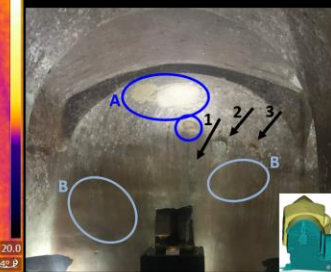
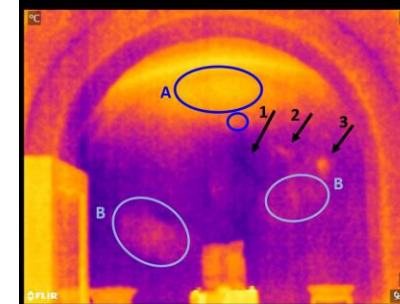


- ✓ Integration of thermal variations into the 3D point cloud
- ✓ Geo-location of the thermal variations of the Royal Road (R1)
- ✓ Classification of building materials texture
- ✓ Improved assessment of preservation state

A. Georgopoulos, S. Tapinaki, E.T. Delegou, A. Moropoulou

with the permission of chief archaeologist K. Papakosta

IRT monitoring in the Museum of the Greek Orthodox Patriarchate of Alexandria and all Africa



- masonry below the arch:
- ✓ The masonry's part designated by the red color can reach temperatures below the dew point
 - ✓ In this case, condensation occurs and liquid water is withheld inside the masonry

- ✓ Low Temperature distribution width (1°C)
- ✓ Area A: higher T, due to spot light stimulation, special geometry (apse), patches of newer restoration plasters & salt efflorescence
- ✓ Higher T of Area B indicates the presence of a defect area, non observable visually
- ✓ The lower T of Spot 1 can be attributed to a geometrical thermal bridge (niche). However, the thermal bridge is deviating from the vertical, due to salt efflorescence
- ✓ The higher T of Spot 2 is attributed to geometrical effects (shallow cavity), and to salt efflorescence
- ✓ The higher T of Spot 3 is attributed to salt efflorescence and surface exfoliation

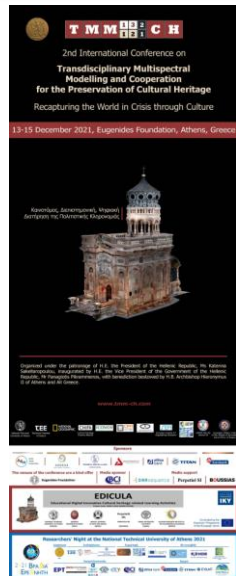
The exact area of the thermogram

After invitation and with the permission of the Greek Orthodox Patriarchate of Alexandria and all Africa

MULTIPLIER EVENTS

**E3: EDICULA
Innovation Session
TMM_CH Conf.
12.2021**

**E3: EDICULA
Educational Session
TMM_CH Conf.
12.2021**



EDICULA Teachers' Course 03.2023

EDICULA Teacher's Course | 19-23.03.2023

19-23.03.2023 EDICULA
EDICULA TEACHERS' COURSE
Project Code: 9323-4-GI-0-0-2023-071018

TIMETABLE

DAY 1 | 19.03.2023

National Technical University of Athens - School of Chemical Engineering

EDICULA Teachers' Course Introduction
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DAY 2 | 20.03.2023

European Foundation for Education
European Foundation for Education
European Foundation for Education

DAY 3 | 21.03.2023

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DAY 4 | 22.03.2023

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DAY 5 | 23.03.2023

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SCIENTIFIC FIELD VISIT
By the Academy of Education Athens



O5: EDICULA
SYNTHESIS



EDICULA Synthesis Event

Advanced knowhow, interdisciplinarity and professional profiles responding to the challenges of sustainable preservation of Cultural Heritage



NATIONAL TECHNICAL UNIVERSITY OF ATHENS

Interdisciplinary Team for the Protection of Monuments

Emblematic application of
[1] Interdisciplinarity & innovative approach
[2] Dynamic digital documentation as a core space of integration

The rehabilitation of the Holy Aedicule of the Holy Sepulchre

NATIONAL TECHNICAL UNIVERSITY OF ATHENS

Chief Scientific Supervisor

Emer. Prof. Antonia Moropoulou

NTUA Interdisciplinary Team

Prof. E. Korres, Prof. A. Georgopoulos, Prof. A. Moropoulou, Prof. C. Spyrakos,

Assist. Prof. Ch. Mouzakis, Deputy Construction Site Manager

Innovations of the Holy Aedicule rehabilitation

Dynamic digital documentation as a core space of integration

This interdisciplinary project, within a holistic approach, merges capabilities and know-how from the scientific fields of architecture, civil engineering, surveying engineering, materials science and engineering, information technology, archaeometry and archaeology.

Throughout the project, innovative and high-measuring technologies were applied - with emphasis on non-destructive techniques - to fully document the Holy Aedicule, assess its state of preservation, identify the causes of the observed damages, and monitor all rehabilitation interventions



Innovations of the Holy Aedicule rehabilitation

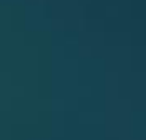
Dynamic digital documentation as a core space of integration

The three-dimensional reconstruction of the monument provides an integrated core space, enables and optimizes:

- ✓ Accurate and detailed (3D) design of rehabilitation interventions
- ✓ Estimation of required quantities of restoration materials
- ✓ Dynamic environment for the optimization and redesign processes throughout all stages of the rehabilitation project
- ✓ Assessment of the rehabilitation, with reference to the main goals

Merging of all necessary information through the 3D data is achieved, by a **fragmented approach**

This provides the basis for TRANSDISCIPLINARITY



Aim and interdisciplinary methodology of Research

DOCUMENTATION

Integrated documentation of the problem

Geometric, Structural, Architectural documentation

Documentation and characterization of building materials

DIAGNOSIS

Prospection of building phases and decay diagnosis and pathology



Assessment of current state against static and seismic loads

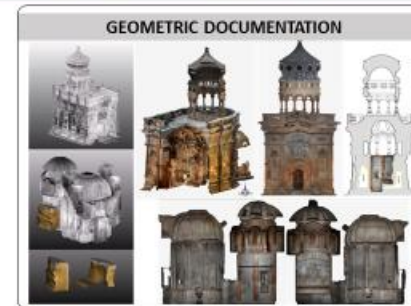
PROPOSAL

Principles, ethics, requirements and instructions for conservation reinforcement and rehabilitation materials and interventions

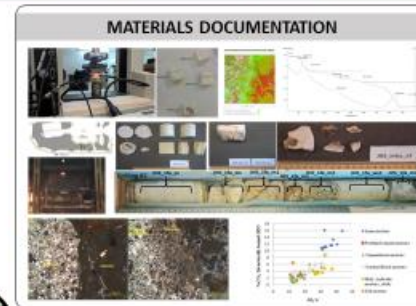
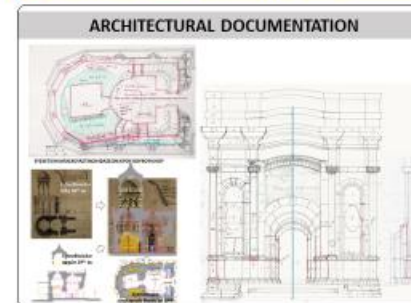
Continual update of the three religious communities of the Holy Church of the Resurrection in Jerusalem and organization of scientific and institutional debate for decision making regarding the most appropriate solution.

INTERRELATED GEOMETRIC, ARCHITECTURAL, MATERIALS AND STRUCTURAL DOCUMENTATION

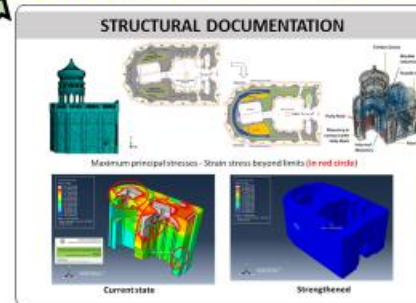
How architectural, historical and materials characterization geometrical documentation and structural assessment act as knowledge based digital infrastructure to support the design of the rehabilitation



NATIONAL TECHNICAL UNIVERSITY OF ATHENS



DIAGNOSTIC INTERDISCIPLINARY STUDY

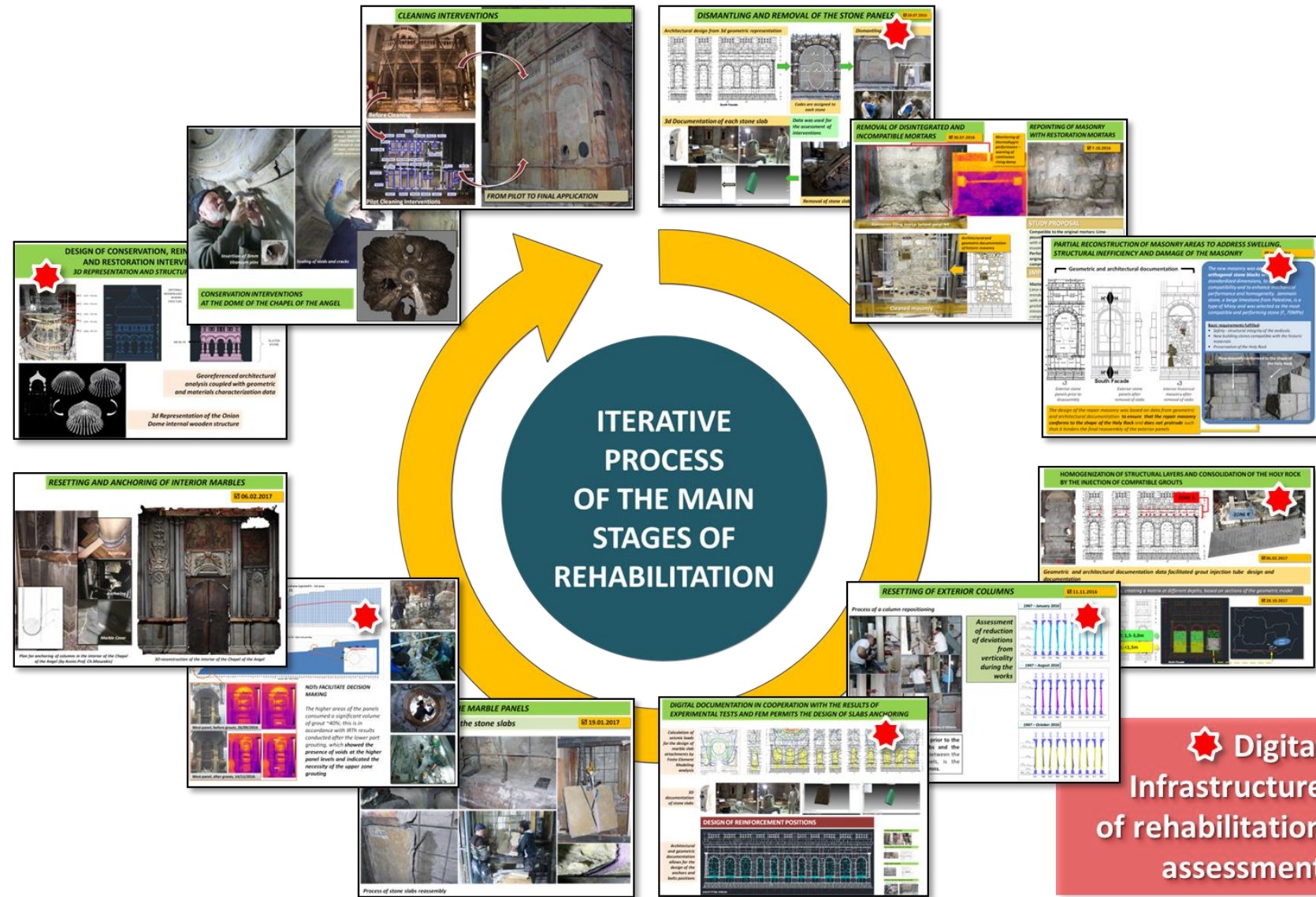


Optimization of planning of all stages of the rehabilitation works while addressing case-specific limitations



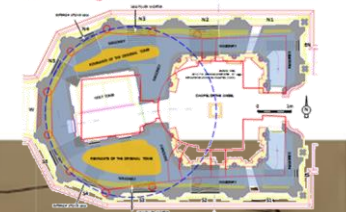
All stages of the **works and logistics** of human resources, instrumentation and materials were **carefully planned and controlled**, so that necessary works could be performed in parallel at adjacent areas of the Aedicule

The actual **works were performed during the night**, when the Church was closed to the public, with the exception of the sixty hours when the Tomb of Christ was opened, during the grouting process, when the monument was inaccessible to the public

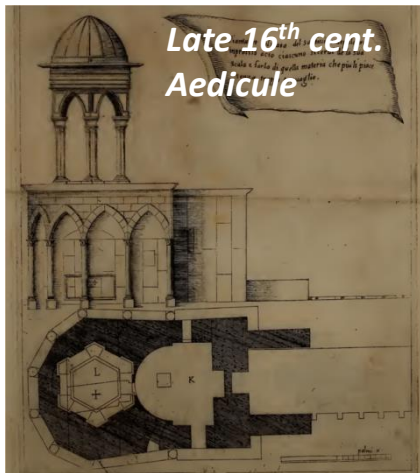


Digital Infrastructure of rehabilitation assessment

INNOVATIVE METHODOLOGY TO REVEAL AND INTERPRET FINDINGS TO PRESERVE AND HIGHLIGHT THE VALUES OF THE MONUMENT



HISTORIC REPRESENTATION OF THE HOLY AEDICULE EVOLUTION BY DIGITAL CORRELATIONS: LATE 16th & EARLY 19th CENT. AEDICULE



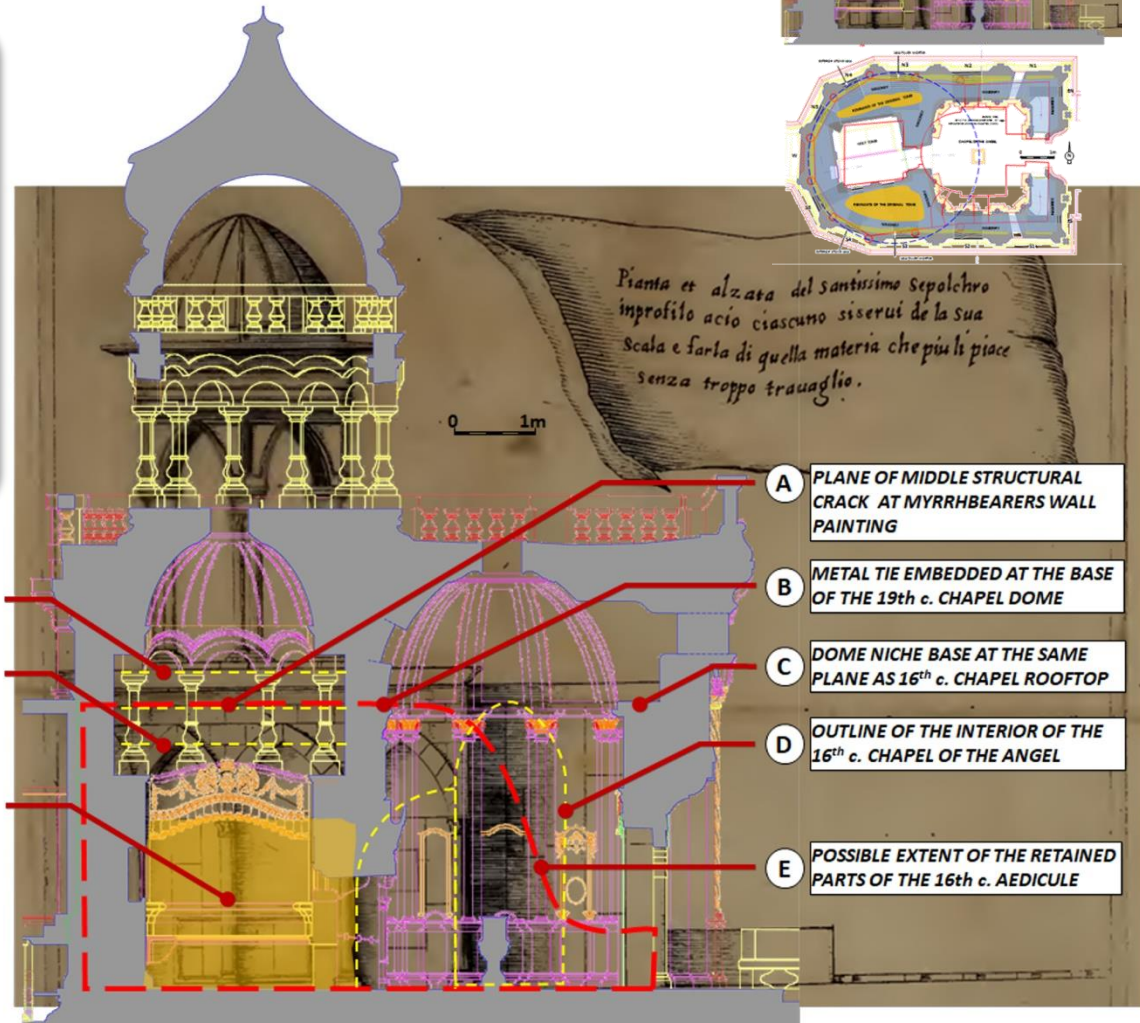
The digital correlation, (NDT prospection, and architectural, geometric and historic documentations) of the late 16th and the early 19th c. Aedicule indicates the probability of embedded parts of the earlier structure:

- At the western part, up to the Myrrhbearers area
- At the eastern part, up to 1.5m of the northern masonry of the Chapel of the Angel



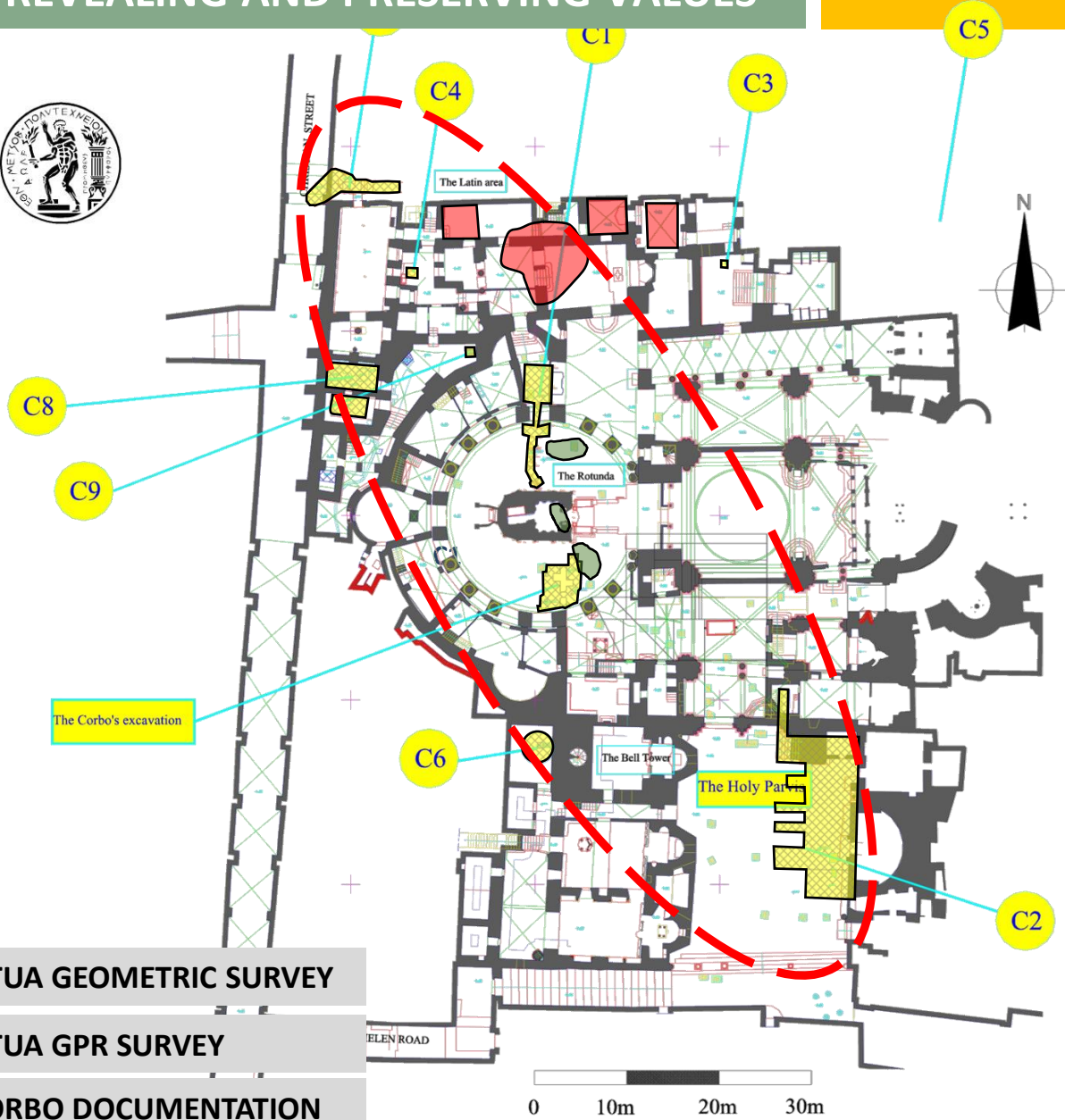
Lampropoulos, K.C., Korres, M., Moropoulou, A. "A transdisciplinary approach to reveal the structural evolution of the Holy Aedicule in the Church of the Holy Sepulchre", in *Nondestructive Evaluation and Monitoring Technologies, Documentation, Diagnosis and Preservation of Cultural Heritage*, Eds. A. Osman and A. Moropoulou. Springer, SPM (2019) 107-120. [DOI: https://doi.org/10.1007/978-3-030-25763-7_8]

- PLANE OF UPPER STRUCTURAL CRACK AT MYRRHBEARERS WALL PAINTING (F)
- PLANE OF LOWER STRUCTURAL CRACK AT MYRRHBEARERS WALL PAINTING (G)
- REMNANTS OF ORIGINAL AEDICULE (HOLY ROCK) (H)



ACHIEVING THE PROJECT'S GOALS: 2. REVEALING AND PRESERVING VALUES

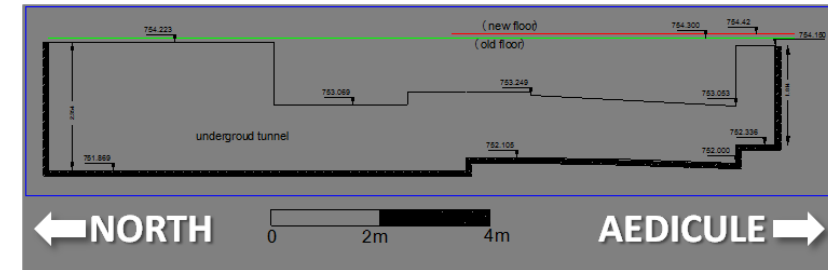
ARCHAEOLOGICAL SEMANTICS OF THE UNDERGROUND AREA OF THE CHURCH OF THE HOLY SEPULCHRE



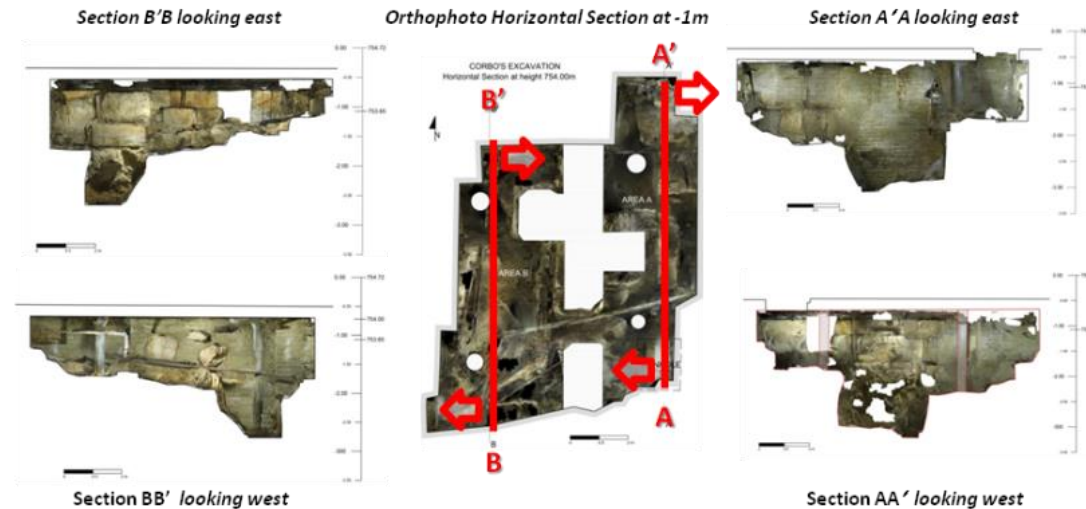
The Holy Aedicule is located at the center and above a cluster of underground cisterns, and natural and manmade underground voids and spaces

NTUA Laboratory of Photogrammetry

Geometric documentation (vertical section) of cistern C1



Geometric documentation of Corbo's Excavation

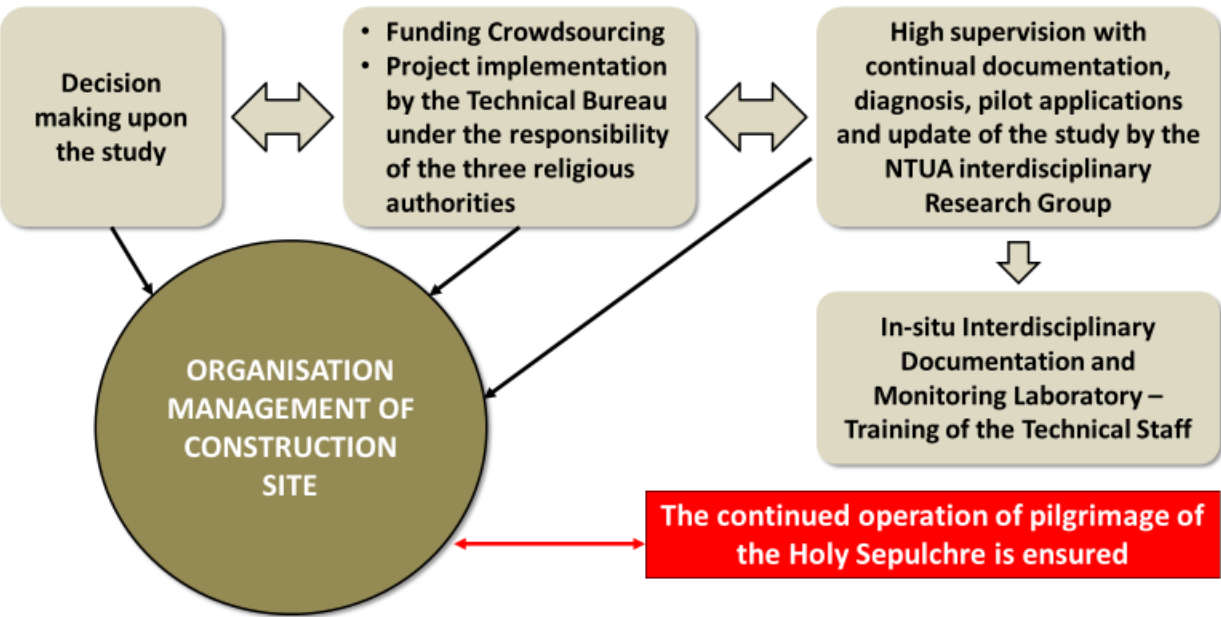


NTUA GEOMETRIC SURVEY

NTUA GPR SURVEY

CORBO DOCUMENTATION

Effective implementation methodology



INNOVATIVE MULTILAYERED DATA MANAGEMENT

The Integrated Information System Platform:

- ✓ establishes and develops transdisciplinarity among:
 - *relevant scientific and engineering fields*
 - *digital and non-digital layers of information*
 - *non-destructive and analytical information creation technologies*
- ✓ utilizes the information created through the rehabilitation project:
 - *sets interrelationships*
 - *creates a digital infrastructure where information can be assigned spatially for further correlation with others*
- ✓ offers modular functionalities
- ✓ is extendable
- ✓ is applicable to other cases
- ✓ is transferable



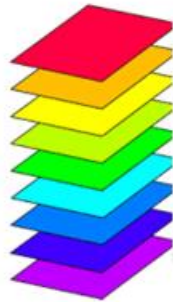
This integration establishes transdisciplinarity

Innovative Multilayer Data Management – Platform Architecture

Content-Based Management through Semantic Data Integration

Multilayer Management of Information Big Data Integration

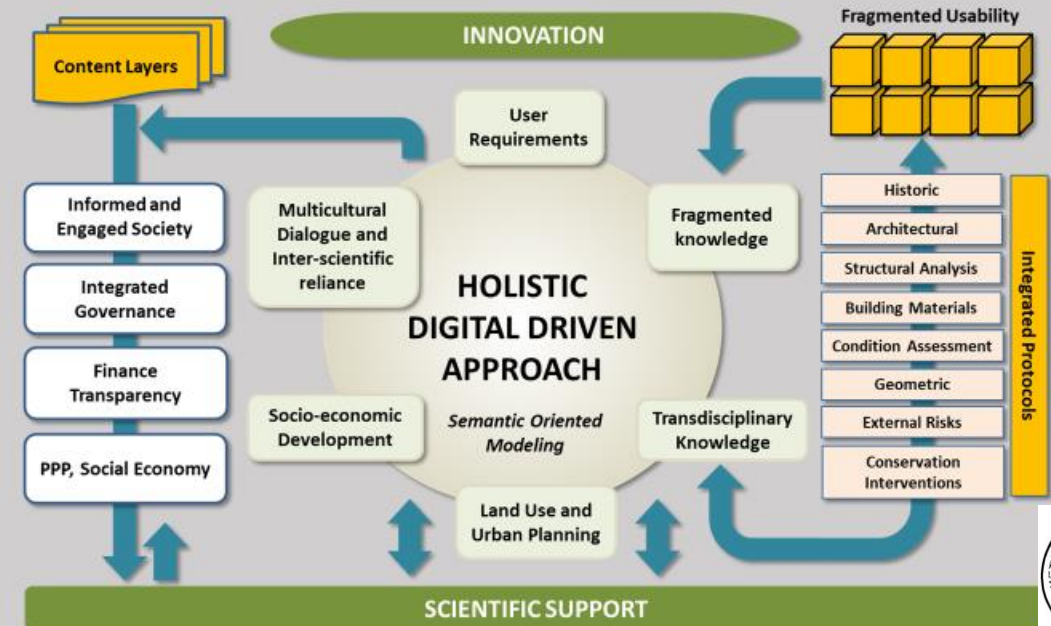
- Non destructive Testing
- Analytical Techniques
- Spatial
- Historic
- Time, etc.



Multilayer Data Fusion

Platform as the **cornerstone** for data management, knowledge acquisition & information sharing

Usability of Digital Driven Preservation of CH



From multi - disciplinarity
to trans - disciplinarity

From research &
work to training

Holistic approach
for the sustainable
preservation of CH



Holy Sepulchre
project

Diffusion of
Innovation

Social Accessibility /
Narration

Transfer of Know-How
→ contributes to the future
trends of Cultural Heritage
preservation at large



The TCG and the technical world have contributed to **the modernization of the institutional framework of studies and projects in general and in particular to the protection of monuments in collaboration with the Ministry of Culture:**

- In the final formulation of **Law 3028/2002** (Government Gazette A-153/28-6-2002) "For the protection of Antiquities and Cultural Heritage in general" in collaboration with the Minister of Culture Mr. Evangelos Venizelos
- In the discussion and joint agreement on the specifications of studies (architectural, structural and diagnostic studies, studies of maintenance, protection, restoration, promotion, management and integrated use of the monuments) and implementation of quality control systems in the maintenance and restoration projects, in March 2007 (***Scientific Conferences of the TCG for the Protection of Cultural Heritage***)

Although we have successively submitted these proposals to all governments since then, they have not yet been enacted.

Only in 2019 the Ministry of Culture M. Zorba instituted certain standards, without however taking into account the proposals of the TCG.

Today we discuss in the TCG the establishment of interdisciplinary cooperation in the studies and projects of the protection of the cultural heritage, maintaining the specifications of the individual studies by establishing the ones that are missing as above.

There exists, of course, the institutional framework for the formation of a Working Group in the Presidential Decree 99/2018 (Article 1, § 6) *"The study and implementation of projects at the level of a qualified engineer may, depending on the needs of the project, **be carried out by an interdisciplinary team, under the coordination of a qualified engineer.** The central responsibility regarding the organization, division of tasks, management and coordination of work of interdisciplinary team of qualified engineers and others, is assumed by the coordinator qualified engineer"* and the **specifications for the coordinator of the interdisciplinary team** are determined by article 2

This effort is linked to **Capacity Building** at the European level.

Europe has prepared through the **4CH program**, where I participate in the coordination group of the **Advisory Board**, the **Competence Center** as a Competence and Action Center that aims to strengthen national networks which will lead to corresponding national centers if necessary.

Therefore, we can immediately create a **national network** of the technical world in cooperation with the **Ministry of Culture**, in order to give content to the general direction today which is **digital cultural heritage**.

Although the 4CH gives this emphasis and additionally identifies the deficiencies in the diagnostic studies and recommends the inclusion of studies (material characterization, diagnostic study, etc.) and the introduction of on-site non-destructive testing studies, it does not link them to the current studies that are necessary condition for the licensing of the project (architectural, structural, topographical, E/M studies, environmental).

My intervention at the **Competence Center** during the meeting "**4CH General Assembly - Advisory Board Session**" in **Bilbao**, on **June 27, 2023**, had the same character as what I propose by completing the Erasmus+ EDICULA program, that is to **investigate and propose the institutionalization of interdisciplinary cooperation in the studies and projects of cultural heritage protection**



Grant Agreement No:
101004468



**The role of the Advisory Board towards
the AB Competence Centre Statute**

Antonia Moropoulou
Prof. Emer. - National Technical University of Athens
Member of the Executive Committee - Technical Chamber of Greece

*4CH General Assembly - Advisory Board Session
Bilbao, June 27, 2023*

The restoration project of the **Holy Aedicule of the Holy Sepulcher in Jerusalem** and the restoration of the **Katholicon of the Monastery of Varnakova** are *prime examples of the synthesis of the different disciplines in the 3D models of documentation of monuments and historical buildings.*

The risk lies in not carrying out 3D visualizations with high-precision photogrammetric methods that will allow the data to be posted and merged with the precision required by architectural and structural design, redesign and studies.

Case Study: The rehabilitation of the Holy Aedicule of the Holy Sepulchre

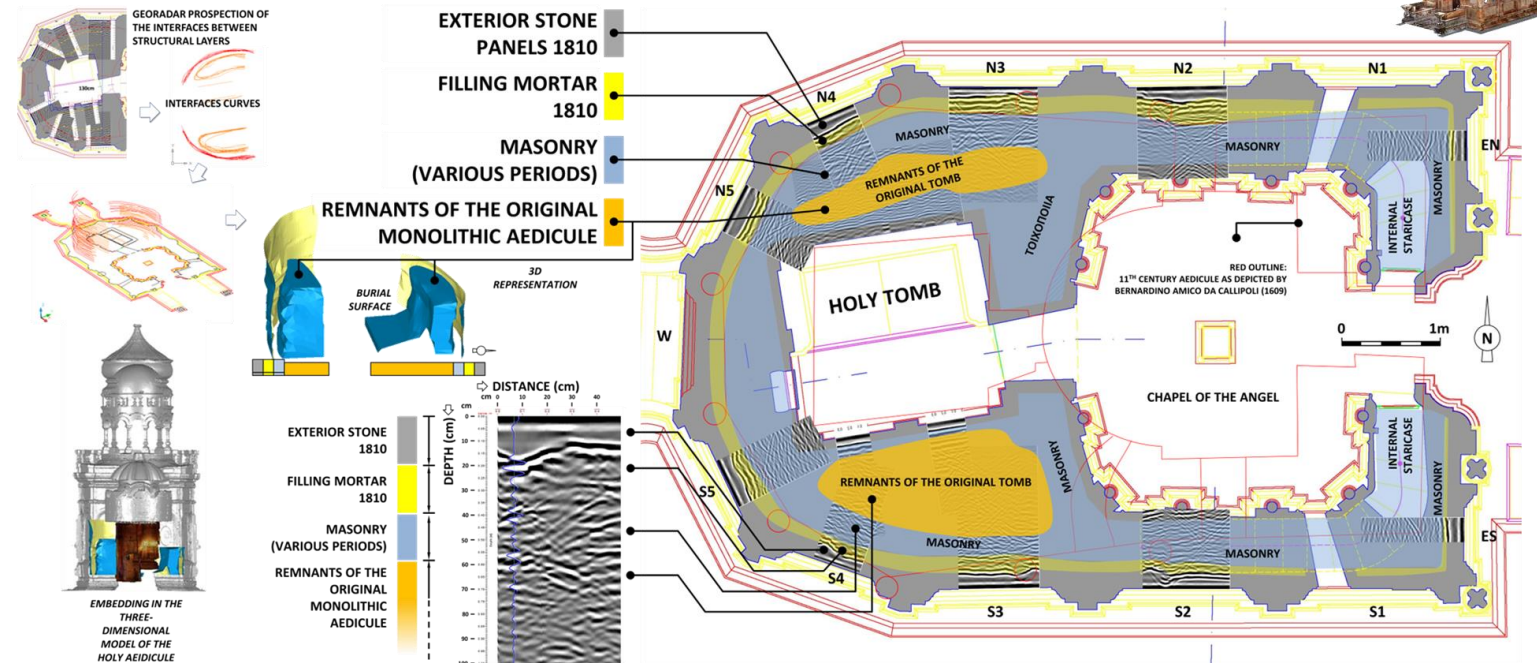
The photogrammetric documentation of the works allowed us to present, based on the results of the **non-destructive testing**, the **3D morphology of the Holy Rock** and the **interior of the panels**, which includes the **historical masonry** of various periods and the phases of the mortars.

This allowed us to plan the works with high accuracy

INNOVATIVE PROSPECTION OF THE NON-VISIBLE LAYERS OF THE AEDICULE AS A MAJOR TOOL FOR ITS REHABILITATION

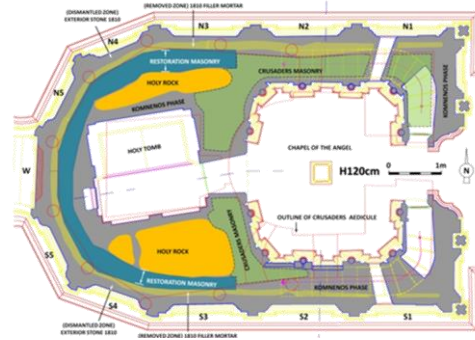
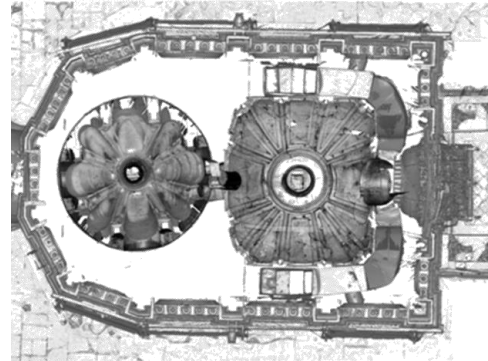
3D SUPPORT TO THE DESIGN AND QUANTIFICATION OF MATERIALS AND REHABILITATION INTERVENTIONS

Integrated Non-destructive Prospection, Architectural and Geometric Documentation Digitally Render the Internal Structure of the Holy Aedicule and Reveal its Construction Phases



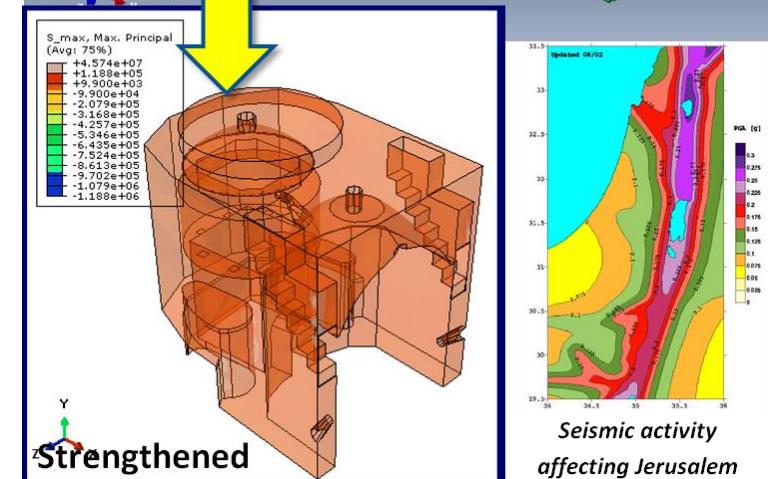
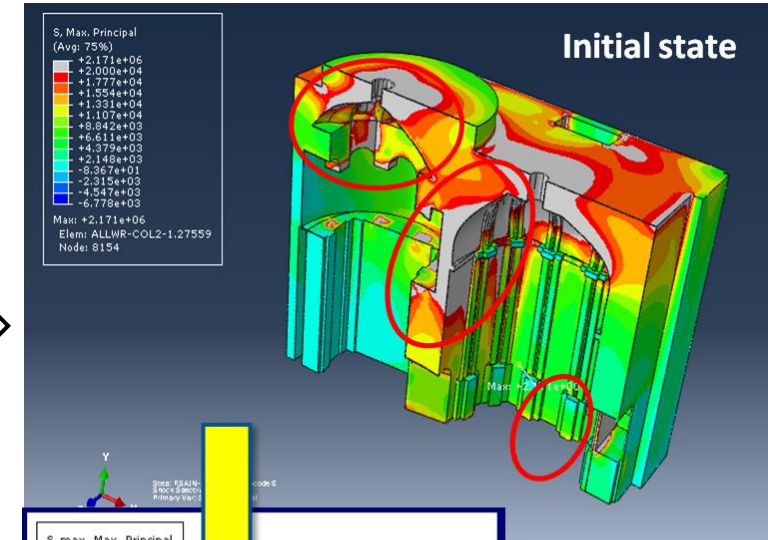
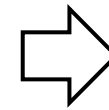
Case Study: The rehabilitation of the Holy Aedicule of the Holy Sepulchre

It also allowed us during the project, by accurately photogrammetrically capturing all the surfaces of the restoration phases, to modify the original finite element model (FEM) to innovatively and accurately assess the restoration of the structural integrity of the monument



DIGITAL
GEOMETRIC
DATA

DIGITALIZED
MATERIAL DATA



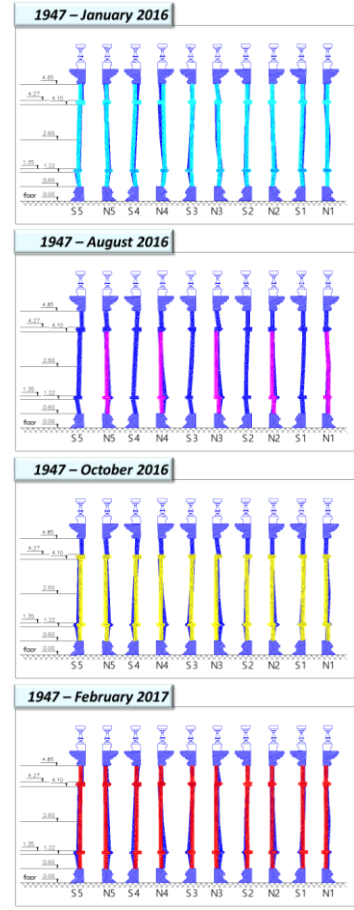
**THE RESPONSE OF THE RETROFITTED
STRUCTURE IS VALIDATED**

The retrofitted structure fulfills the damage limitation performance level for the design seismic action.

Case Study: The rehabilitation of the Holy Aedicule of the Holy Sepulchre

At the same time, the resetting of the columns after precise monitoring with a general geodetic station and the delivery of the monument without deviations to the vertical, allowed us to remove the iron cage that relieved the distortions

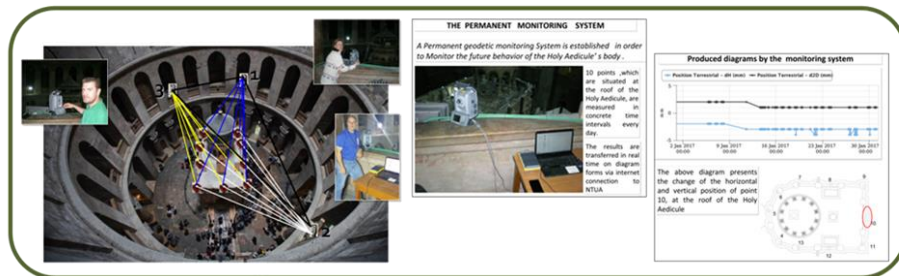
Time Evolution of the columns' Deviations from verticality



Diminution of the deformations

Diminution of the deformations – significant reduction of deviations from verticality

As a result, the iron frame installed by the British Mandate in 1947 (Freeman), in order to negate the deformation of the Aedicule and ensure safety, was removed



Case Study: The rehabilitation of the Holy Aedicule of the Holy Sepulchre

If we compare the photogrammetric model of NTUA with the 3D model of National Geographic we will realise that the latter is good for AR and VR applications or to introduce the world to the monument, but not for the precision required to design, redesign a complex project

3D model of the Holy Aedicule after the restoration (National Technical University of Athens)

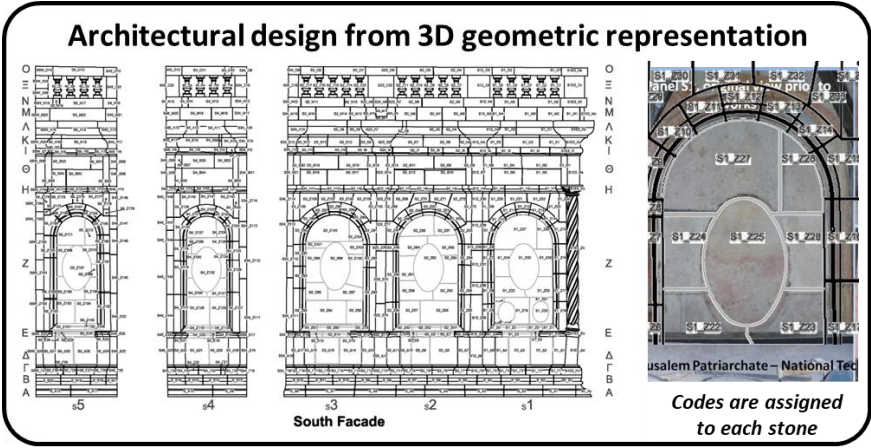


3D model of the Holy Aedicule by National Geographic



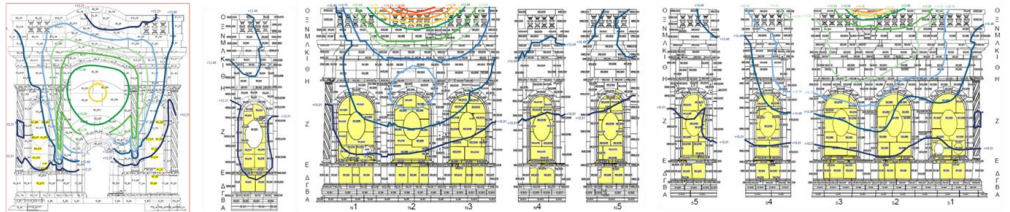
Case Study: The rehabilitation of the Holy Aedicule of the Holy Sepulchre

The specialized work of surveyor engineers is necessary, with the use of high measuring technology instruments, as the NTUA photogrammetric model provides the accuracy (1cm) required for the planning, redesign of a complex project, compared to the accuracy (>10cm) provided by the models resulting from scans for typical AR & VR applications.

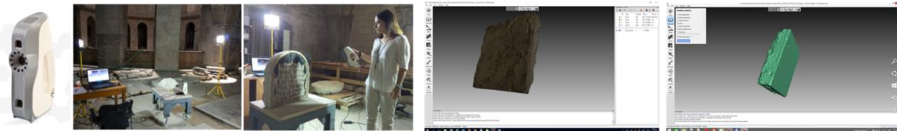


DIGITAL DOCUMENTATION IN COOPERATION WITH THE RESULTS OF EXPERIMENTAL TESTS AND FEM PERMITS THE DESIGN OF SLABS ANCHORING

Calculation of seismic loads for the design of marble slab attachments by Finite Element Modeling analysis

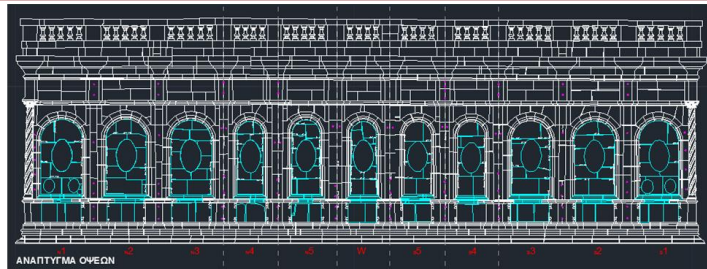


3D documentation of stone slabs



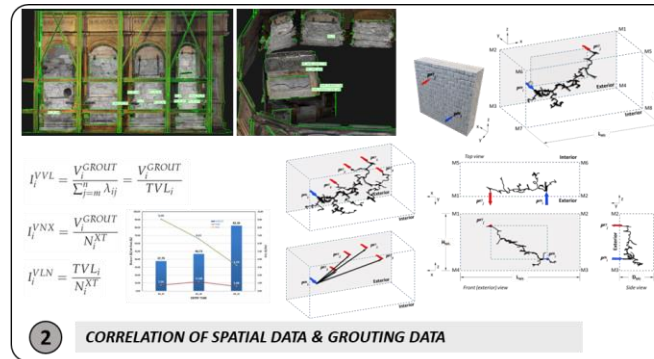
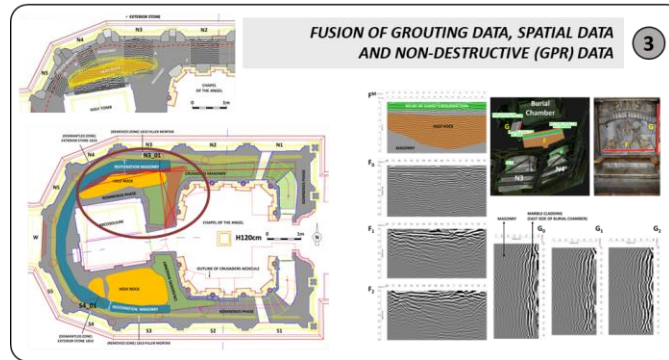
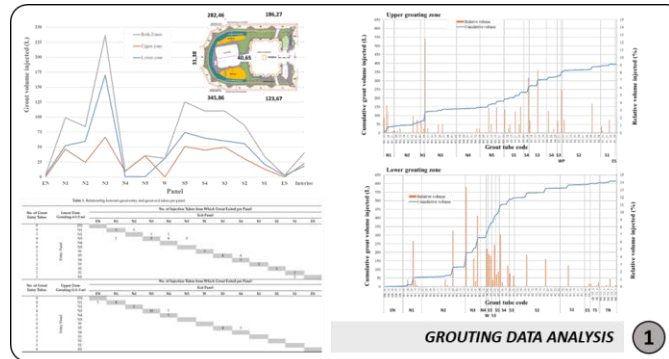
DESIGN OF REINFORCEMENT POSITIONS

Architectural and geometric documentation allows for the design of the anchors and bolts positions



Case Study: The rehabilitation of the Holy Aedicule of the Holy Sepulchre

Similarly, during the in-situ assessment of materials and restoration works, that was carried out in real time, the uploading of the data of the non-destructive testing to the 3D photogrammetric models allowed valuation and additions – corrections accurately and in real time

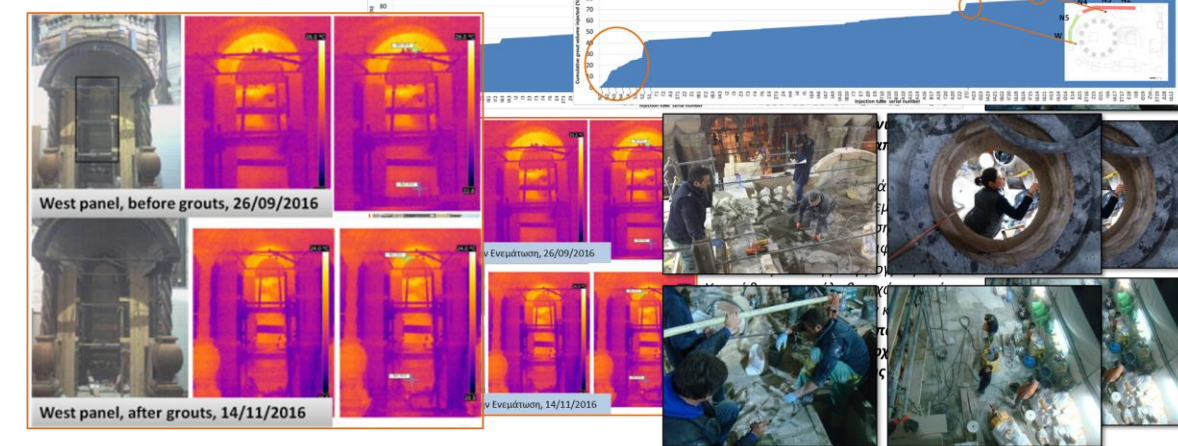
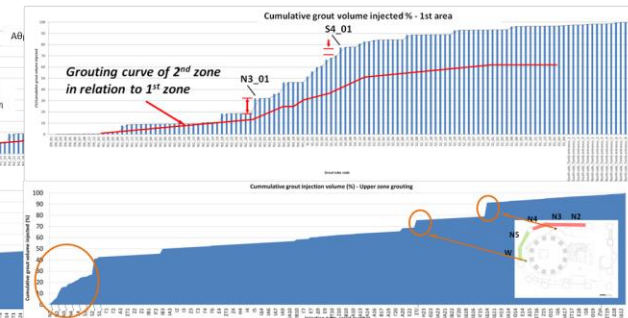


K.C. Lampropoulos, M. Apostolopoulou, E. Tsilimantou, A. Moropoulou. The Grouting Process as an Innovative Tool for the Assessment of the State of Preservation and Internal Features of the Holy Aedicule of the Holy Sepulchre. *Heritage*, 5, 61–87, 2022

ASSESSMENT OF EFFECTIVENESS OF THE GROUTING MATERIALS AND PROCEDURE THROUGH CO-ANALYSIS OF SPATIAL DATA & ADVANCED NDT

NDTs FACILITATE DECISION MAKING

The higher areas of the panels consumed a significant volume of grout ~40%; this is in accordance with IRTh results conducted after the lower part grouting, which showed the presence of voids at the higher panel levels and indicated the necessity of the upper zone grouting



For these reasons, EDICULA proposed the creation of a **special academic faculty position at NTUA** entitled "***Scientific support on decision making for the interdisciplinary documentation and monitoring of monuments, through characterization of building materials, decay diagnosis, and assessment of rehabilitation interventions***" for the interdisciplinary synthesis of data within the photogrammetric models

The pilot application in Greece of the restoration project of the Katholikon of the Monastery of Varnakova by the NTUA interdisciplinary team (Interdisciplinary diagnostic research and proposals for the restoration of the Katholikon and the cells of the Varnakova Monastery in Fokida - ELKE NTUA 91002200) and the evaluation of materials and restoration interventions during the project (High scientific supervision of the restoration project of the Katholikon of the Varnakova Monastery with interdisciplinarity ELKE NTUA 91009500) enabled the connection of the required architectural, structural, topographical, E/M studies and the diagnostic study, material study, NDT study accurately to the monument



Overall supervision: Emer. Prof. **A. Moropoulou**

Principal Investigator: Assoc. Prof. **Ch. Mouzakis**

Supervising architects.: **G. Andriotakis, I. Vobiri**

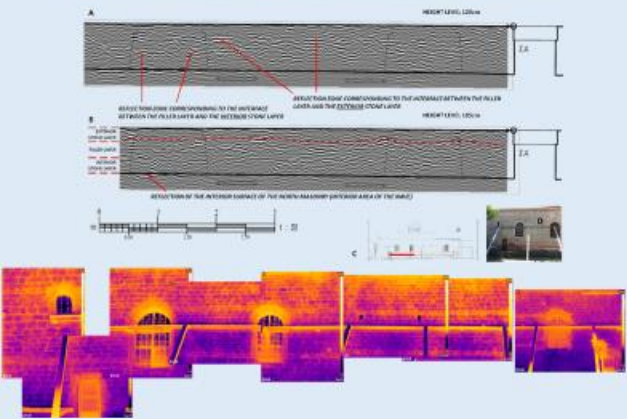
3D models: **T. Kouimtoglou, E. Tsilimantou**

Under the supervision of the Director of the Ephorate of Antiquities of Phocis, Dr. **A. Psalti**, with the approval of the studies by the **Central Archaeological Council**, under the supervision of the Director of Restoration of Byzantine and Post-Byzantine Monuments of the Ministry of Culture, Dr. **Th. Vlahoulis**, in collaboration with the Directorate of Conservation of Ancient and Modern Monuments, Dr. **M. Mertzani**

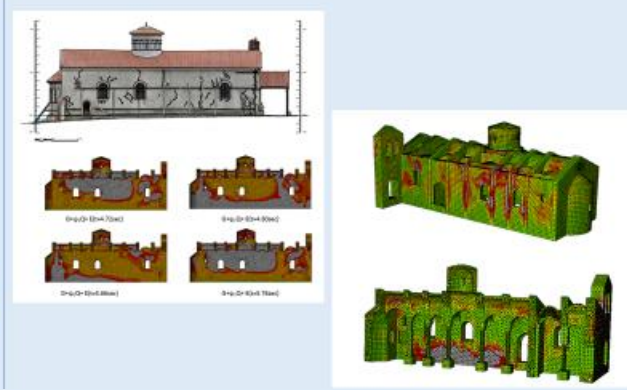
Interdisciplinary study and rehabilitation proposals

The stages include multispectral & interdisciplinary analysis:

3. On site non-destructive testing OBTAIN INFORMATION REGARDING "UNSEEN" FEATURES AND PATHOLOGY



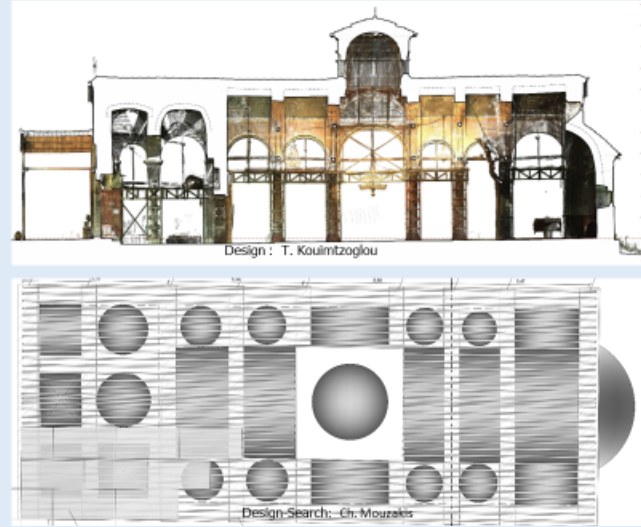
4. Structural analysis ASSESS VULNERABILITY AND EXAMINE MEASURES FOR STRUCTURAL INTEGRITY



New findings during the project – Restoration of the roof

During the study, a specific plan was proposed and accepted regarding the restoration of the roof

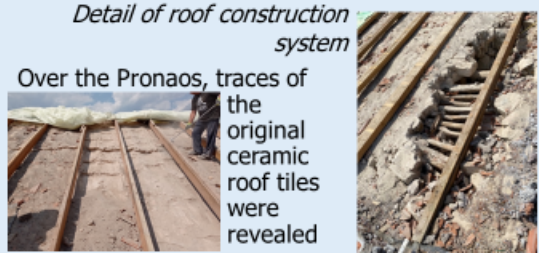
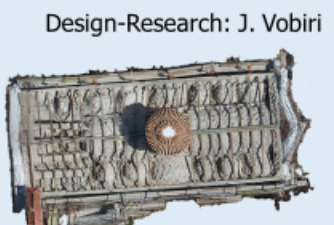
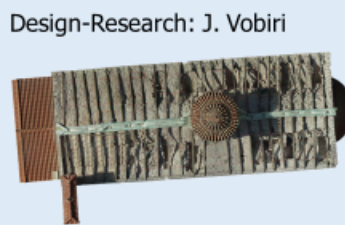
The roof of the Temple consists of a vaulting system that is composed of domes, semi-domes and groin vaults, which rest on columns and pillars.



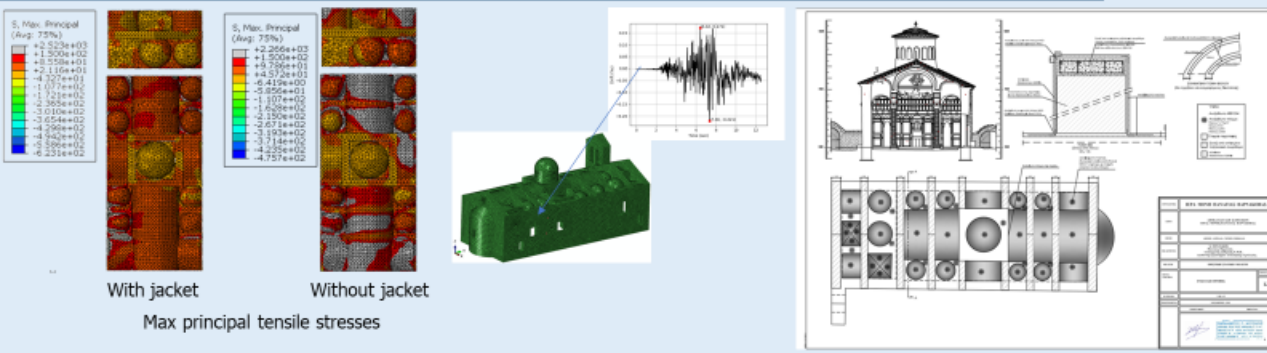
New findings during the project – Restoration of the roof

However, when the roof was opened during the project, a complex building system was found

The slope of the roof is formed by stone gables, the gaps between which are bridged with wooden logs. The gaps are filled with stones and mortar. Stone slabs, wooden logs, slats and tiles were placed on top.



New findings during the project – Restoration of the roof



Structural analysis through numerical modelling was undertaken, taking into account the new findings

Different solutions were investigated in order to select the optimum measures
THE ROOF RESTORATION PLAN WAS MODIFIED and new detailed designs were drawn regarding the reinforcement measures

New findings during the project – Removal of plasters

Already from the study, the characterization of the historical mortars indicated that the Pronaos (at least in certain areas) belonged to an earlier building phase of the Church and has survived the 1826 explosion

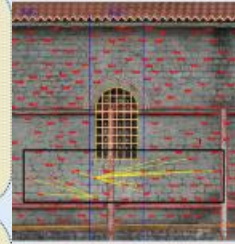


During the works, when the plasters were removed from the east masonry of the Pronaos, a byzantine masonry system (**cloisonné style**) was revealed

This masonry corresponds to the west **façade of the church** before the construction of the Pronaos
READJUSTMENT: it will be conserved and remain **visible** and **unplastered**

Monitoring and control - Grouting

During the grouting process, the **volume of grout** entering each tube was documented, as well as the **interconnection of tubes** (grout injection tubes and grout flow tubes)



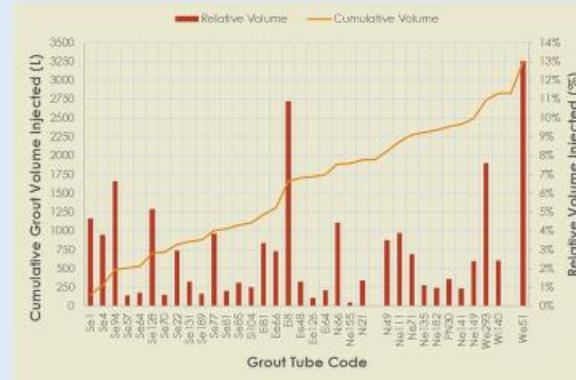
No interconnection with interior, indicating absence of transparent cracks



Grout flow from tubes in interior of Catholicon



Grout injection was successful in lower areas – analysis highlights areas with larger voids



Reinforcement materials used for restoration

The materials used for the restoration works were **defined in the study**, continually **assessed** throughout the project and, if needed, **readjusted**. The aim is to achieve **compatibility, performance and durability**

Stainless steel 304 elements: for greater strength and resilience



Lime-metakaolin mortars and grouts
Koufoyiannis quarry stone

High quality byzantine type ceramic tiles



Installation of supports and scaffoldings

30/07/2021 ✓

Readjustment and reinforcement of interior scaffoldings and supports



Masonry restoration – Grouting

30/09/2022



Grouting was conducted, from lower areas to higher areas to reinforce the structure (6.500 injection grout tubes were installed)



Resetting of arches

25/11/2022



Reinforcement of arches

30/09/2022



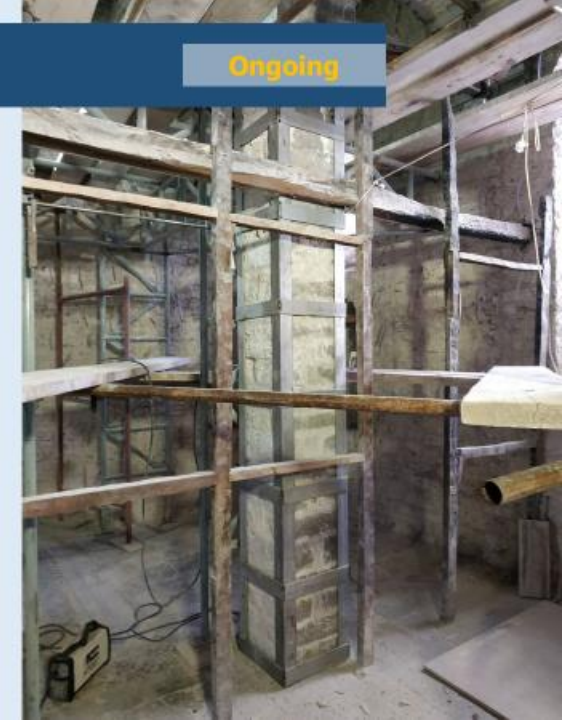
- 150 holes were drilled to enable the placement of metal round rods
- 75 metal round rods were placed in the arches to suspend the supporting metal structures



Reinforcement of columns

Ongoing

Columns are being reinforced with **stainless steel** elements





Therefore, today we start with interventions and views to define:

- Networking procedures with Competence Centers
- Proposals for a procedural framework for the establishment of interdisciplinary cooperation in the studies and works for the protection of cultural heritage

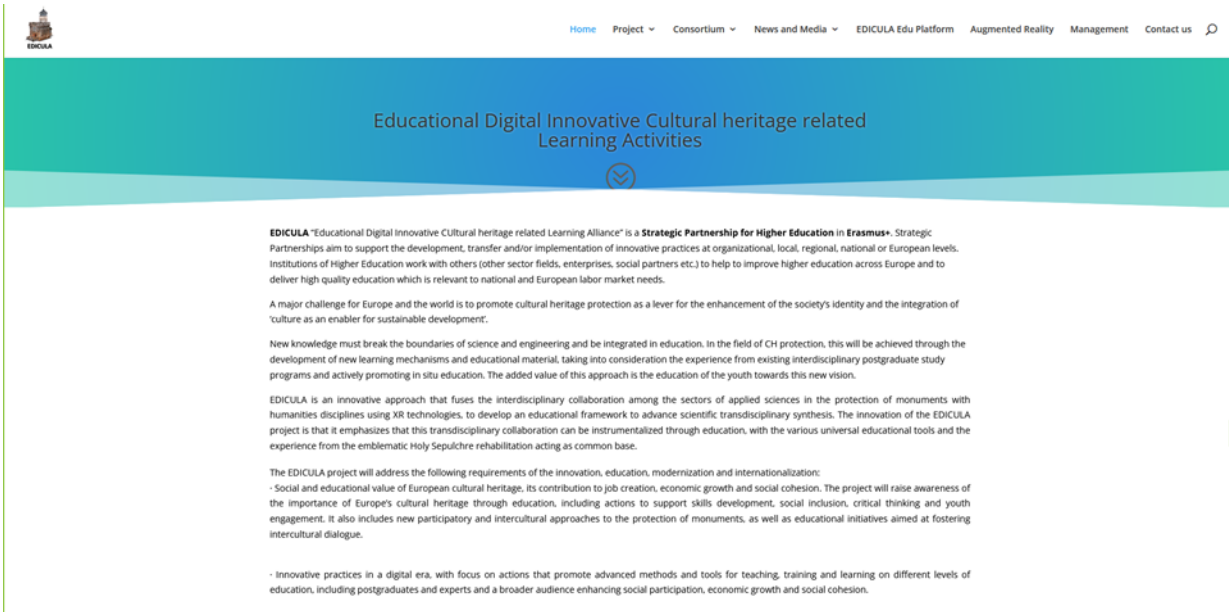
EDICULA

Educational Digital Innovative Cultural heritage related Learning Activities

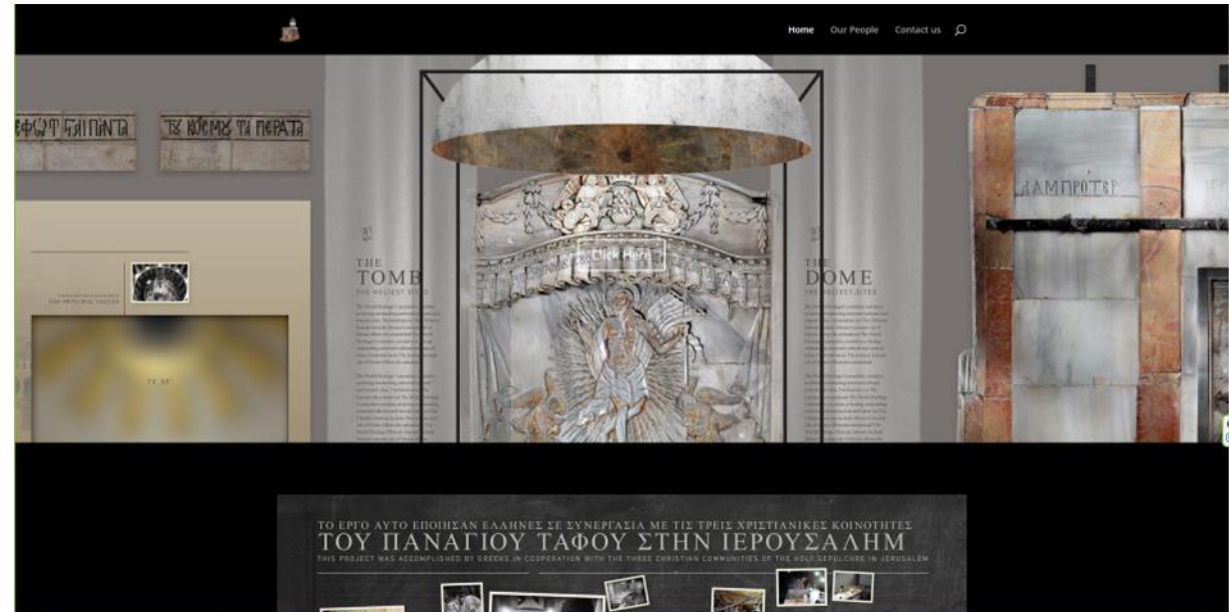
I consider very important the contribution of the Erasmus+ EDICULA Educational Digital Innovative Cultural heritage related Learning Activities program which, in synergy with foreign partners, allowed us to document the relevant know-how through moodle



<http://edicula.eu>



<http://holysepulchreproject.ntua.gr/>



NATIONAL TECHNICAL
UNIVERSITY OF ATHENS
[GREECE]



SAPIENZA
UNIVERSITA DI ROMA
[ITALY]



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OF ARTS AND DESIGN
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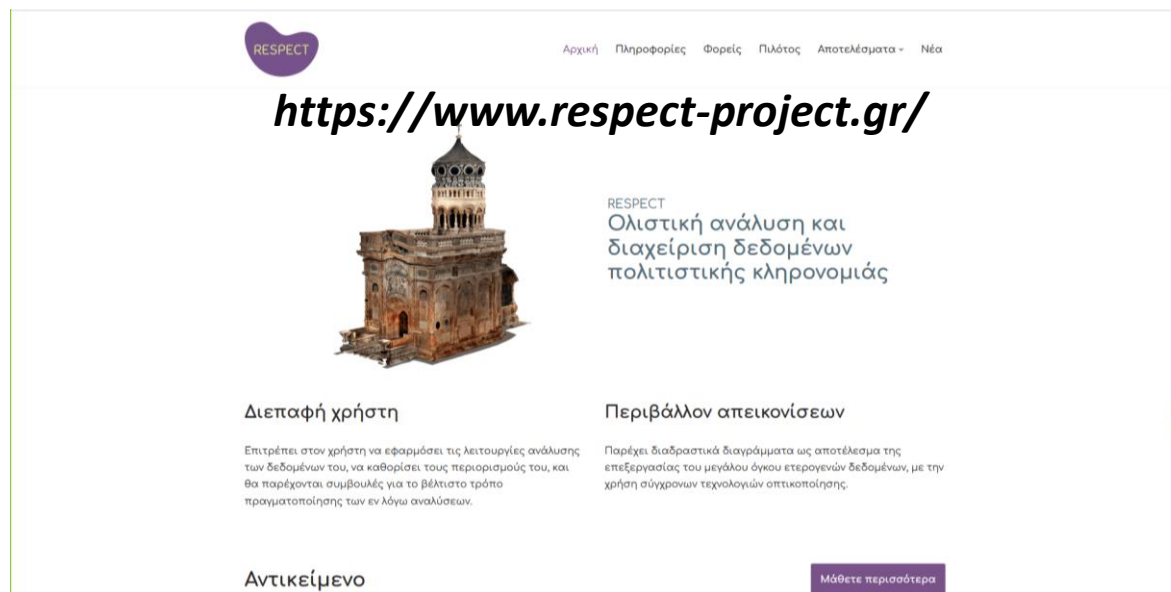
HELLENIC RESEARCH INSTITUTE OF
THE ALEXANDRIAN CIVILIZATION
[GREECE]

Co-funded by the
Erasmus+ Programme
of the European Union



Project Code: 2020-1-EL01-KA203-079108

Soon, we will inform you about the website of the **RESPECT** program *“An exemplary Information System and Methodology for the Integrated Management, Analysis and Dissemination of Digital Cultural Heritage Data coming from the rehabilitation of the Holy Aedicule of the Holy Sepulchre in Jerusalem”* where at the level of research we will process - with interdisciplinary synergy - all the data of the restoration project of Holy Aedicule of the Holy Sepulchre



An Exemplary Information System and Methodology for the Integrated Management, Analysis and Dissemination of Digital Cultural Heritage Data coming from the rehabilitation of the Holy Aedicule of the Holy Sepulchre (Project T2EDK-03741)



European Union
European Structural and Investment Funds

HELLENIC REPUBLIC
MINISTRY OF INVESTMENTS
SPECIAL SECRETARIAT FOR
ERDF & CF PROGRAMMES
MANAGING AUTHORITY OF "COMPETITIVENESS PROGRAMME"

ΕΡΑΝΕΚ 2014-2020
OPERATIONAL PROGRAMME
COMPETITIVENESS
ENTREPRENEURSHIP
INNOVATION

ΕΣΠΑ
2014-2020
ανάπτυξη - εργασία - αλληλεγγύη
Partnership Agreement
2014 - 2020

Co-financed by Greece and the European Union