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# The Project iMARECULTURE: Advanced VR, iMmersive serious games and Augmented REality as tools to raise awareness and access to European underwater CULTURal heritage

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**Abstract.** The project iMARECULTURE is focusing in raising European identity awareness using maritime and underwater cultural interaction and exchange in Mediterranean Sea. Commercial ship routes joining Europe with other cultures are vivid examples of cultural interaction, while shipwrecks and submerged sites, unreachable to wide public are excellent samples that can benefit from immersive technologies, augmented and virtual reality. iMARECULTURE will bring inherently unreachable underwater cultural heritage within digital reach of the wide public using virtual visits and immersive technologies. Apart from reusing existing 3D data of underwater shipwrecks and sites, with respect to ethics, rights and licensing, to provide a personalized dry visit to a museum visitor or augmented reality to the diver, it also emphasizes on developing pre- and after- encounter of the digital visitor. The former one is implemented exploiting geospatial enabled technologies for developing a serious game of sailing over ancient Mediterranean and the latter for an underwater shipwreck excavation game. Both games are realized through social media, in order to facilitate information exchange among users. iMARECULTURE supports dry visits by providing immersive experience through VR Cave and 3D info kiosks on museums or through the web. Additionally, aims to significantly enhance the experience of the diver, visitor or scholar, using underwater augmented reality in a tablet and an underwater housing. iMARECULTURE is composed by universities and SMEs with experience in diverse

underwater projects, existing digital libraries, and people many of which are divers themselves.

**Keywords:** Underwater, archaeological sites, shipwrecks, maritime, virtual museums, serious games, immersive, holography, European identity

## 1 Introduction

The area of Virtual Museums, Virtual Guides and Virtual Reconstruction of Cultural Heritage, has a number of past and currently important active projects of this scope (e.g. V-MUST, F-MU.S.EU.M., VENUS, MINERVA, MINERVA PLUS, MINERVA EC, THE MICHAEL PLUS, ATHENA, ATHENA PLUS, ARCHEOGUIDE, 3DMURALE etc.). However, these projects do not address the real challenge of an Underwater Virtual Museum. In addition, projects related to underwater cultural heritage and environments are not engaged with the challenge of Virtual Museums and Immersive Technologies. These projects (e.g. SASMAP, WRECKPROTECT, ARROWS, STACHEM, 3D-UNDERWORLD, NOPTILUS, CURE are focusing on the development of tools and techniques to survey, assess, stabilize, monitor and preserve Underwater Archaeological Sites like robot systems and scanners. It is important to note that the majority of these projects are not dealing with underwater cultural heritage in the Mediterranean Sea where the underwater assets are older and most at risk due to the marine environment, trawlers, looting and wood degrading marine borers.

### 1.1 Objectives

Project's i-MareCulture scope is to raise public awareness of European identity by focusing in maritime cultural heritage, which by default bridges different civilizations. In particular, i-MareCulture aims in bringing inherently unreachable underwater cultural heritage within digital reach of the wide public by implementing virtual visits, serious games with immersive technologies and underwater augmented reality. Scope of the project is to design, analyze, develop and validate pioneer applications and systems in the context of Virtual Museums through collaborative and innovative research from a diverse group of scientists, researchers, archaeologists, experts and museums.



**Fig. 1.** Schematic representation of the ambition to combine the two major research areas into the project i-MareCulture

The project i-MareCulture combines the two aforementioned groups of research projects into one by merging advancements in VR with the underwater environment. It will accomplish that by using existing technology to create breakthrough applications and digital experiences in the area of Virtual Museums in order to empower different types of users to engage with European underwater cultural heritage digital resources by exploiting re-use and re-purposing of existing data.

## 2 iMARECULTURE Approach and Methodology

### 2.1 Approach

Being an interdisciplinary project, the first step is the clear definition of targets, goals, test sites and wrecks to be used. Several decisions about the serious games, the age, the era and data to be gathered, will be taken. Discussions about existing VR and AR technologies [1] and implementation will clarify the roadmap towards milestones and goals.

**Data gathering & pre-processing phase:** Is the fundamental pillar for the project. Both 3D as well as supporting data will be accumulated by partners, from open sites, published journals and books and partner's archives to support storytelling, narratives, 3D models of sites [2,3,4], ships [5], cargos, probabilistic geospatial analysis about ship routes, wreck site formation processes, etc. Having all the necessary information, iMARECULTURE will create and re-use a plethora of 3D models for both the ship wrecks and the amphorae, allowing people to examine the 3D underwater environment and objects on it. Similarly, a site of Baiae underwater archaeological park where a complete 3D model exists [6,7], will be used for the implementation of the AR supported dives.

**Virtual reality phase:** This phase offers the users more than underwater tour, at a safe environment. Additionally, this phase offers the enhanced experience of the diver, visitor or scholar, using underwater augmented reality in a tablet and an underwater housing. In VR people around the world can access any environments using immersive technologies and internet access. Supportive narrative and multimedia tools [8] will provide interactive information about the site and objects allowing for a personalized experience, both in terms of navigation as well as in objects' queries. At the same time, emphasis will be given towards the creation of a universal standard for storytelling presentation [9]. End-users will be in position to interfere/adjust the excavation discovery story, according to their liking.

**Serious games in platforms:** All the knowledge acquired through iMARECULTURE project will lead to the creation of serious games in platforms [10]; actual and high detailed environments will be presented, allowing the gamers to fully explore and interact with them. The main focus will be on the two imperative aspects of the serious games: storytelling and interaction; both of which are essential in engaging the users and inspiring further intrinsic learning.

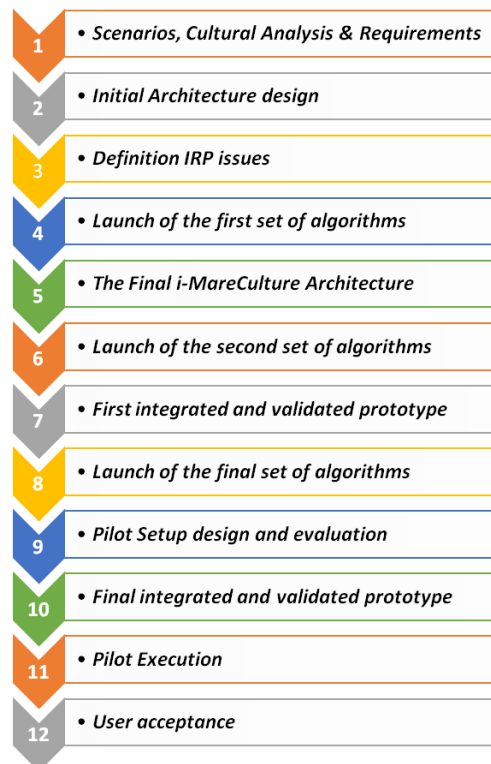
Additionally, the knowledge base will cover, under a unified framework, a variety of underwater CH sites of different properties and characteristics. Holistic records enable rich and generic characterization of the aforementioned cultural heritage elements into well-defined and structured components and machine-readable formats that allow

the utilization of multi-domain information in an automated way. This holistic knowledge is built upon the CIDOC/CRM protocol and it extends the standard to include historic documentation, geometric survey, material survey, as well as critical environmental parameters. Furthermore, iMARECULTURE project will extent BIM protocol, which is a process involving the generation and management of digital representations of physical and functional characteristics of places and objects, in order to describe and manage knowledge about underwater sites and CH assets.

Finally, diagnostic schemes for site formation analysis will be bullied by incorporating (i) underwater changes profiling, (ii) non-invasive/non-destructive analysis methods while (iii) documenting the sensor acquired spatio-temporal data and (iv) supporting data aggregation strategies. Protocols developed in past EU projects will form the basis for the iMARECULTURE protocols and will be adapted according to specifications.

### 3 Methodology

#### 3.1 i-MareCulture Methodology Steps



**Fig. 2.** The i-MareCulture methodology steps

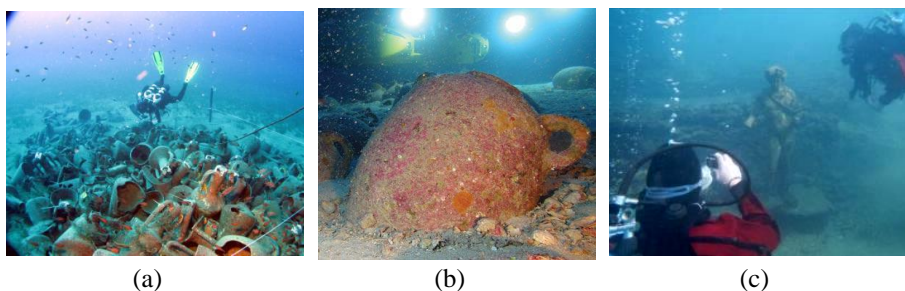
The project starts with the project scenario and use case definition. The cultural heritage items of the three involved underwater cultural sites will be selected in a way that covers all i-MareCulture challenges. Then, an iterative process is adopted to specify a concrete architecture that can fulfil all user requirements and pilot sites demands. The design is performed at two cycles. The first gives the first form of the algorithms needed to be applied.

Additionally, are specified and defined the IPR issues involved in the project. Then the first set of algorithms is launched and the updated architecture takes into account results from the previews step. Subsequently the second set of algorithms is launched. At the next step the first integrated and validated is created: All the aforementioned research components are integrated to launch the first initial prototype.

Then we launch the final set of algorithms and we design the pilots and the evaluation frameworks used for objectively assess the performance and acceptance of the architecture. Additionally, the final i-MareCulture platform is created and tested over the Baiae archaeological park and Thalassa Museum. Finally, the final i-MareCulture platform will be assessed by different types of users.

### 3.2 Description of “Virtual Sites”.

The project iMARECULTURE exploits 3 different “Virtual Sites” (existing sites for virtual and augmented reality applications) in order to implement its multidisciplinary approach and accomplish the described objectives. The proposed sites are representative of different kind of Underwater Cultural Heritage, of different states of environmental and geomorphologic conditions (i.e. water depth) and of different periods, in order to present the users a wide range of the common European maritime culture. Consequently, our selection of 3 virtual sites includes: 1) Mazotos shipwreck site, Cyprus; 2) Xlendi shipwreck site, Malta and 3) Baiae underwater archaeological park, Italy. These cover the Mediterranean basin from center to east. We have also taken care that these sites cover a wide chronological span from 700BC to 400AD.



**Fig. 3.** (a) The main concentration of Mazotos shipwreck site (photo: MARELab, University of Cyprus), (b) Amphorae laying on the seabed at the Xlendi wreck (Photo: The University of Malta/ COMEX/ CNRS), (c) The Nymphaeum of Punta Epitaffio

**Mazotos shipwreck site:** The site was virtually undisturbed, so its archaeological importance, as well as the immediate need for its protection, triggered the organization of

the first Cypriot underwater archaeological project. The wreck lies at a depth of -44 m, some 14 nautical miles south-west of Larnaca, 1.5 nm from the shore, near Mazotos village. The main visible feature of the site is a concentration of amphorae on a sandy, almost flat sea-bed. Its maximum vertical relief measures 1 m and its maximum dimensions are 17.5 x 8 m. The oblong concentration, almost in the form of a ship, has a north-south orientation and consists of 500-800 Chian amphorae partly or totally visible, which date to the middle of fourth century BC [11, 12].

**Xlendi shipwreck site:** The Phoenician shipwreck off Gozo Xlendi. Resting at a depth of 110 m, it is probably the oldest ancient shipwreck in the central Mediterranean (700BC). Xlendi Bay is a narrow inlet on the south-west coast of Gozo, close to the island's south-western point Rasil-Wardija and to the capital Rabat, which is 2.5 km away. Rabat is a hilltop town that is thought to have been the main settlement area throughout Gozo's history. Xlendi lies at the mouth of a valley which runs from the Rabat hill to the coast. The valley is bounded by high rock walls but opens into a floodplain, which is the site of the modern village, before meeting the sea. There is a good, fresh water source in the village of Fontana, on the road between Rabat and Xlendi [13].

**Baiae underwater archaeological park:** The Baiae site is of particular interest, it was created in 2002 and it is together a Marine Protected Area and an Underwater Archaeological Park. Environmental aspects of this area are related to a peculiar volcanic and deformational history. The submerged area includes part of the territory of the ancient city of Baiae and Portus Iulius, comprising the roman harbour and numerous constructions used as warehouses. The archaeological remains include luxurious maritime villas and imperial buildings, more modest houses, private thermae, tabernae and all those structures that characterize the cities of the Roman age. The itineraries of "Villa con ingresso a protiro" (selected for iMARECULTURE Project) with black and white and white mosaic floors, and thermae; the Villa of Pisoni, the Nymphaeum of Punta Epitaffio (with copies of statues of the Imperial families and of Roman gods); the Portus Iulius with the remains of mosaics floor of a republican Villa and a building with a porticos (all for iMARECULTURE Project). The Baiae underwater archaeological park will serve also as a demonstration site for the developed Augmented Reality systems.

### 3.3 Description of Demonstration Sites

**Thalassa Museum:** Thalassa Municipal Museum was opened in August 2005, and it is directed by the Pierides Foundation, in association with the Hellenic Institute for the Preservation of Nautical Tradition and the Tornaritis-Pierides Marine Life Foundation. The Museum is located at the centre of Agia Napa in Cyprus and it has the sea as a subject-matter. It is the first museum of its kind across the Mediterranean region with main principle to present to the audiences, the local and foreign visitors, the impact and the significance of the sea upon the history of the island.



**Fig. 4.** The life size exact replica of the ancient ship of Kyrenia, The reconstruction of the old shipwreck

The main exhibit at the fourth level and of the museum itself is the ‘Kyrenia II’ vessel. A life size exact replica of the ancient ship of Kyrenia of the Classical period (400 B.C.), which was built in 1985 for scientific experimental purposes by the Hellenic Institute for the Preservation of Nautical Tradition of Athens. At the same level the visitor walks on a glass floor where a reconstruction of the old shipwreck is displayed.

#### **4 Specific Innovations**

As already mentioned, main aim of the project iMARECULTURE is to design, analyze, develop and validate pioneer applications and systems in the context of Virtual Museums through collaborative and innovative research from a diverse group of scientists, researchers, archaeologists, experts and museums. iMARECULTURE connects the Education, Research and Industry by supporting and boosting innovative enterprise to develop their technological breakthroughs into viable products in the area of Virtual Museums and Digital Heritage, with real commercial potential:

- 3D Library tools for Maritime Archaeology
- Naval engineering models and shipbuilding content
- Maritime archaeology geospatial database and ontological schemes
- Multimedia storytelling
- Underwater Augmented Reality Interfaces
- Hybrid tracking solution based on acoustic sensors and computer vision
- Virtual Reality Interfaces
- The serious games platform

The tools will be validated and tested across real-world application scenarios and cases and under a number of different participants. This way, we will prove the innovation potential of our platform over diverse and challenging environments. The serious games platform, the AR/VR interfaces will be assessed in real cases and will include scenarios coming from maritime archaeology research so as to achieve a great mixture between entertainment, informal educational, and underwater/maritime CH understanding. The project supports concrete plans and exploitation activities at certain times to further improve innovation potential.



## 5 Impact in the Society

iMARECULTURE will promote Cultural Heritage as a means to reinforce social cohesion. Throughout the iMARECULTURE project, enhanced participation and involvement of a large and diverse variety of people is ensured. This includes public authorities and stakeholders to set the requirements for analysis and improvement of the resilience of underwater cultural heritage items and to provide valuable knowledge regarding effective, compatible and sustainable solutions that take into account social needs and interests. The rich Cultural Heritage of Europe is not only significant due to its direct measurable economic impact, but more importantly, due to the improvement of the quality of life for European citizens and the contribution to their well-being, sense of history, identity and belonging. iMARECULTURE ensures that this non-renewable resource maintains its social impact. iMARECULTURE realizes and highlights the fact that the social benefits of cultural heritage are important in the face of globalization and digital media, which can break down traditional cultural ties and relationships and challenge people's identity and sense of belonging. In fact, iMARECULTURE is uniquely placed to exploit these phenomena for positive outcomes in the interests of cohesion and wellbeing, as demonstrated by the multi-level involvement of social groups (scientists, citizens, stakeholders, businesses, social carriers), from a large variety of European countries and social backgrounds.

iMARECULTURE, through its multi-national research and innovation team, and through the diversity of Use Cases will offer a better understanding of Europe's cultures and especially of the underwater one which is the less examined and surveyed. iMARECULTURE will enable the realization of a new autonomous scientific area for the resilience management of the underwater CH assets, leading to the creation of relevant employment posts in Europe, and in the development of a rich knowledge base supporting decision making through new regulations and directives at European level. Moreover, iMARECULTURE will demonstrate that Cultural Heritage, and in particular the protection and sustainable development of Cultural Heritage, is a source of creativity and innovation, exploited by many sectors, such as Governance, Research, Education, Tourist services, crafts. Community cultural heritage innovation will be supported through an open innovation process, whereby the local authorities and cultural heritage institutions support the citizens to participate in the development of solutions, products and processes that not only protect and mitigate the effects of the environment on CH assets, but also ensure that their contribution to economy, cultural identity, quality of life and sense of belonging is further enhance.

Much of our cultural heritage is under attack-from environmental degradation and climate change, from socio-economic pressures and the accelerating pace of urbanization, and from the strains of global tourism. iMARECULTURE addresses these challenges by stimulating, encouraging and exploiting collaboration among the heritage managers the tourism and construction sectors, policy-makers and above all, cooperation among researchers, conservators, industry and academia, thereby, demonstrating, in practice the reinforcement of social cohesion.

## 6 Conclusions

The project iMARECULTURE combines different research disciplines, namely experts in 3D acquisition, Virtual and Augmented reality, serious games developers, geostatistics and GIS, archaeologists, story tellers, along with technology of underwater tablets, holographic screens, in underwater sites and museums into one group. This way it will accomplish existing technology to create breakthrough applications and digital experiences in the area of Virtual Museums in order to empower different types of users to engage with European underwater cultural heritage digital resources by exploiting re-use and re-purposing of existing data.

## 7 References

1. Liarokapis, F., An Augmented Reality Interface for Visualizing and Interacting with Virtual Content, *Virtual Reality*, Springer, 11(1): 23-43, (2007)
2. Poullis, C., A Framework for Automatic Modeling from Pointcloud Data, *IEEE Transactions on Pattern Analysis and Machine Intelligence*, (2013)
3. Skarlatos, D., S. Demesticha, S. Kiparissi. An 'Open' Method for 3D Modelling and Mapping in Underwater Archaeological Sites. *International Journal of Heritage in the Digital Era*. Vol. 1, No 1. (2010)
4. Georgopoulos, A. and Agraftiotis, P., Documentation of a submerged monument using improved two media techniques. In *Virtual Systems and Multimedia (VSMM)*, 2012 18th International Conference on (pp. 173-180). IEEE, (2012)
5. Castro, F. and Gomes-Dias, D., Moulds, Graminhos and Ribbands: a pilot study of the construction of saveiros in Valença and the Baía de Todos os Santos area, Brazil. *International Journal of Nautical Archaeology*, 44.2: 410-422, (2015)
6. Bruno, F., Lagudi, A., Gallo, A., Muzzupappa, M., Petriaggi Davide, B., Passaro, S., 3D documentation of archaeological remains in the underwater Park of Baiae. In *International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences - ISPRS Archives*, 40 (5W5), pp. 41-46, (2015)
7. Davide Petriaggi, B., Gomez de Ayala, G., Laser Scanner Reliefs of selected archaeological structures in the submerged Baiae (Naples), *Int. Arch. Photogramm. Remote Sens. Spatial Inf. Sci.*, XL-5/W5, 79-83, doi:10.5194/isprsarchives-XL-5-W5-79-2015, (2015)
8. Balogh, T., Forgacs, T., Agocs, T., Bouvier, E., Bettio, F., Gobbetti, E. and Zanetti, G., A Large Scale Interactive Holographic Display, *IEEE VR2006 Conference*, Virginia, USA (2006)
9. Rizvic, S., Skalonjic, I., Reconstructing Cultural Heritage Objects from Storytelling - Virtual Presentation of Sultan Murat's Fortress in Sjenica, *Proceedings of 2nd International Congress on Digital Heritage 2015*, Vol. 2, ISBN: 978-1-5090-0047-0, (2015)
10. Anderson, E.F., McLoughlin, L., Liarokapis, F., Peters, C., Petridis, P., de Freitas, S. Developing serious games for cultural heritage: a state-of-the-art review, *Virtual Reality*, Springer, 14(4): 255-275, (2010)
11. Demesticha, S., "The 4th-Century-BC Mazotos Shipwreck, Cyprus: a preliminary report." *International Journal of Nautical Archaeology* 40.1: 39-59, (2011)

12. Demesticha, S., Skarlatos, D. and Neophytou, A., "The 4th-century BC shipwreck at Mazotos, Cyprus: New techniques and methodologies in the 3D mapping of shipwreck excavations." *Journal of Field Archaeology* 39.2: 134-150, (2014)
13. Drap, P., Merad, D., Hijazi, B., Gaoua, L., Nawaf, M.M., Saccone, M., Chemisky, B., Seinturier, J., Sourisseau, J.-C., Gambin, T., 2015. Underwater Photogrammetry and Object Modeling: A Case Study of Xlendi Wreck in Malta. *Sensors-Basel* 15, 30351-30384, (2015)