



D2.4 Cyprus Pilot Prototype v0.1

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HISTORY OF CHANGES			
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0.2	20/01/2026	Marinos Ioannides, Drew Baker, Petros Siegkas, Maria Paphiti (CUT)	Main content
0.3	30/01/2026	Nadia Magnenat Thalmann, Nedjma Cadi, Thiago Freitas (MiraLab)	Additional content, peer review, refinements
1.0	30/01/2026	Valentina Bachi (PHC)	Final version for submission

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EXECUTIVE SUMMARY

This document accompanies the Deliverable *D2.4 Cyprus Pilot Prototype v0.1* to provide documentation on the first version of the prototype for this scenario, with short description and a preliminary assessment report.

The selection of the subject of the prototype is the *enkleistra* (or hermitage) of St. Neophytos, near Paphos, Cyprus, a series of interconnecting hand carved caves richly adorned with frescoes from the 12th century and the dwelling over some seventy years of the Orthodox saint for which it is named for. St Neophytos works left a vast intellectual, social, theological and cultural imprint on the history of Cyprus which still echoes in modern Cypriot life. The *enkleistra*, its associated structures, the monastery to which it is attached and the landscape in which it is situated form part of a long term holistic digital documentation of the site for monitoring, conservation and protection planning as part of its designation as a “Monument at risk”. The valorisation of this site through the EUreka3D-XR case study forms part of this process, raising awareness of the cultural significance of the site and through the use of the Avatar Builder tool and accompanying scenarios prompting a more personal reflection for the visitor (whether physical or virtual) with the life and times, and message of this iconic religious leader.

This deliverable is deeply linked to other documentation provided in the project, and specifically:

- D2.1 Pilot Specification and planning, which illustrates the specifications of the end product for each pilot, with production schedule and planning (M6, 31/07/2025)
- D3.4 Toolbox Beta version, which illustrates the status (testing phase) of the tools that are used to create and deliver each Pilot scenario, and which compose EUreka3D-XR toolbox (M9, 31/10/2025).

The prototype is an AR/VR experience that can be accessed on site or remotely via visors. A demonstration video is provided in this document to showcase the experience.

The document is composed of the following chapters:

1. Description, with short summary of the Pilot scenario, including access to the prototype
2. Assessment, with indication of challenges encountered and preliminary assessment report
3. Next steps and conclusions

This deliverable and the prototype v0.1 will be followed by a second prototype (internal version), to be showcased in the EUreka3D-XR final event in Cyprus held on 26 May 2026; and a final release of the pilot scenario with extended description and assessment report delivered at the end of the project on 31/07/2026, corresponding to D2.7.

1. DESCRIPTION

The scenario for *A new life for the Enkleistra of St. Neophytos* is shared in common with two implementations, Mixed Reality for onsite use and Virtual Reality for remote engagement. The target audience is twofold, cultural/religious tourism and school children aged 13+.

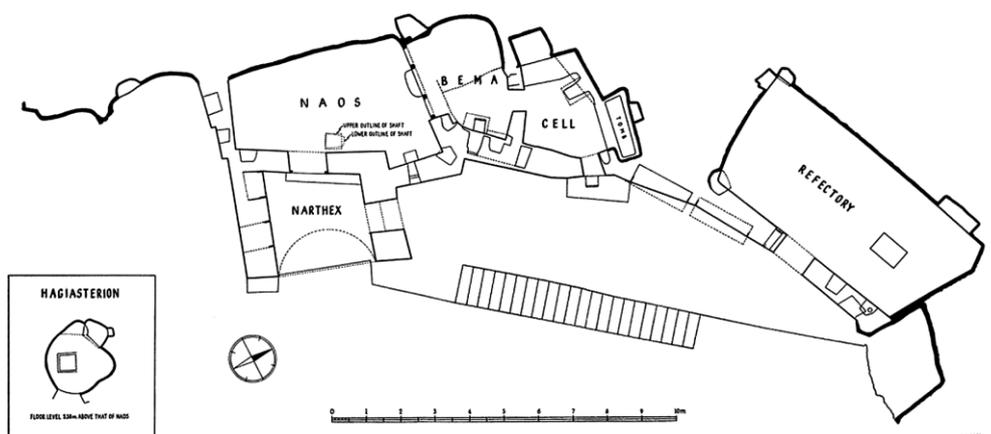
The scenario unfolds inside the 12th century enkleistra (cave hermitage) of St. Neophytos at the Monastery of Saint Neophytos in Pafos, Cyprus, which consists of three spaces, all hand carved in the rock, connected between them via low passages and fully decorated with frescoes. These are (a) to the northeast is the cell of the saint, which includes his bed, desk and tomb, (b) adjacent towards the south is the sanctuary that has the holy altar and (c) to the northeast is the nave. The cell and the nave have doors that open to a balcony.



According to the scenario, the visitors enter the enkleistra from the main entrance of the nave. They are presented with a short narration placing their experience in context, allowing them to familiarise themselves with the virtual environment and select their preferred language for interaction. Once the introductory narrative has concluded, the visitors encounter the digital representation of St. Neophytos (the virtual “avatar”), who takes up the narration from his personal perspective, as documented in his writings (biography) and the historical milieu of the era he lived.

The visitors have the option to explore the virtual reconstruction of the enkleistra, accompanied by the avatar of the saint, who guides them through the three caves, directing their attention to the memory of the frescoes, their specific details, interpretation and symbolism. Beyond the narration, the visitors can extract information through an interactive dialogue with the avatar based on call and response paradigm.

The scenario concludes with the avatar thanking the visitor for their visit and inviting them to discover more about the saint’s life and the monastery’s history at the museum.



ACCESS TO THE PROTOTYPE VERSION 1.1

The prototype is an AR/VR experience that can be accessed on site or via visors. A demonstration video of the prototype is available here: [VIDEO](#).

Also, a QR Code is provided for accessing the same video:



2. ASSESSMENT AND CHALLENGES ENCOUNTERED

Throughout the development process, several challenges were encountered, including balancing feature complexity with ease of use, addressing performance constraints, and ensuring compatibility across devices. To respond to these challenges, iterative evaluation and assessment activities were conducted at multiple stages of development, incorporating user feedback, usability testing, and design reviews, by internal teams and with external stakeholders, such as the experts of Eureka3D-XR Advisory Board and participants in project's events such as the Brussels Capacity Building event on 26/9/2025 where an early version of the VR experience was offered in a booth, and at the Girona demonstration event on 29/1/2026. The software was assessed against key criteria such as usability, accessibility, responsiveness, and overall functionality for the recreation, use and Re-Use of the content. These evaluations informed continuous refinements, resulting in an app that is intuitive, accessible, and aligned with user needs.

This version represents a prototype, and further improvements are planned, including enhancements to the uniform and clothing of the Saint, the addition of background liturgical audio, and refinements to the voices of both the narrator and the Saint.

Technical Challenges – Data Acquisition

Three different methods were utilised to capture the interior of the enkleistra: traditional photography for photogrammetric reconstruction, Terrestrial Laser Scanning (recording both point cloud data and colour imagery) and Simultaneous Localisation and Mapping (SLAM) mobile scanning. Of the three methods, only photography and laser scanning produced results of sufficient quality to attempt reconstruction.

Physically the site is challenging consisting of three organic spaces (the nave, sanctuary and cell) and in total 12m wide by 4m deep with height ranging from 5m to just 1.5m making working conditions cramped (the interior volume being around 49m³ with a surface area of 180m²).



In total 8.52GB of point cloud data (e57 format) and 1.54GB of complementary panorama imagery was acquired from nine scan positions. Photography acquired 14.58GB of data in 2,766 images.

The enkleistra has poor natural lighting and fixed artificial lighting arranged to highlight specific aspects of the frescoes. The latter conditions combined with the irregular nature of the surfaces present problems when

attempting photographic capture even when moderated by portable lighting that aims to minimise shadows and changes in lighting contrast.

While the above had been anticipated to some extent within the digitisation plan, other unexpected challenges arose. Although the data acquisition team had been assured exclusive access to the site from dawn till dusk, the location is an active site of pilgrimage and tourist interest, and thus on several occasions digitisation had to be interrupted by visitors, requiring temporary suspension of work. The initial willingness of the monastery to provide a member of their community to be digitised and represent St. Neophytos within the virtual world wavered, and the fall-back plan to use a character based on the two depictions of the saint within the enkleistra was implemented. Finally, the plan to record the sections of the liturgy (recorded in CUT's anechoic chamber and acoustically rendered in the virtual space) also fell through with the church authorities, citing that the liturgy could not be performed outside of its religious context of space and time. Subsequently the whole of the liturgy, including the arrival and removal of the holy relics to the monastic church was recorded *in situ* in a full video by the data acquisition team, also providing an invaluable intangible cultural heritage record of the event.

Technical Challenges – Asset Development

The development of the virtual environment posed significant challenges and underlines the prevailing fallacy that digitised assets created for one purpose can simply be segued into a different form for “reuse”. Specifically, here we refer to the creation of the digital space in which the scenario is staged (the enkleistra). As a highly complex space, due to the irregular organic nature of the hand carved chambers combined with the intricate frescoes which decorate the cave surfaces, a delicate compromise between presenting the geometry and visual impact of the enkleistra and the limitations of current technology had to be established and maintained to grant a satisfactory visitor experience.

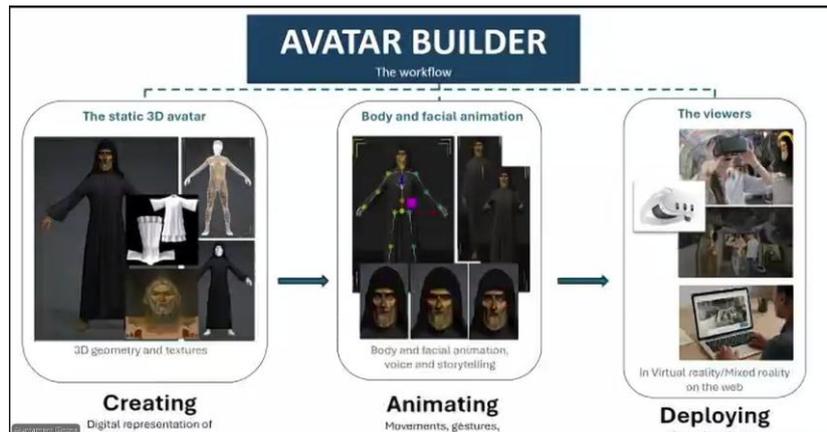
Partner MiraLab undertook this task, focusing on the visitor experience and creating a curated virtual space based on the dramatological needs of the experience, tied to the narrative presented by the avatar of the saint. This prioritisation of visitor experience is, of course, the objective of the case study, and - as with any virtual world - the staging of the virtual experience draws on traditional theatrical/video game tropes, such as hide and reveal, strategic lighting, signposting, prop placement and of course the integration of the narration by the saint's avatar created through the Avatar Builder tool.

The final result facilitates the visitor's suspension of disbelief, by allowing focus to be directed to the narrative provided by the avatar and guiding the user to learn the key knowledge the scenario is intended to impart, rather than allowing users a freeform “sandbox” exploration of the site and/or extraneous details (whether visual, historical or narrative) to be removed, thus keeping the visitor “on track” without distractions.



One early concern for the case study was the mediation between the visual representation of the saint and the environment. It had been agreed that one representative of the monastic community would be digitised to provide the avatars' appearance and movement as part of a closer integration between the monks and

visitor. However, the inclusion of a “real” person, in a stylised environment, raises questions about believability and may trigger the so-called “uncanny valley” (the uncomfortable emotional response humans experience when encountering entities that appear nearly, but not quite, human). As in the end the stakeholder declined to participate, the fall-back plan to create the avatar asset based on the two contemporary depictions of the saint (one in the Bema above the altar, one in the Cell) was enacted: this provided a much more satisfactory outcome, reducing the problem of visual dissonance, and allowed better harmonisation between visual elements supporting the narrative and enhancing the visitor experience.



Technical Challenges – Narrative Construction

While the original vision of the *A new life for the Enkleistra of St. Neophytos* application was to leverage the power of a generative pre-trained transformer (GPT) large language model (LLM) to create a generative AI chatbot embodied in the saint’s avatar taking an “ask me anything” approach to the life and times and religious philosophy of St. Neophytos, it soon became apparent through workshoping different scenarios that this approach presented a number of high risks, and a more curated approach would be required. Among the concern raised during the workshop process were

Extended tarry time: The site is not large, with most visitors spending between five and ten minutes in the space. This was particularly a concern for the mixed reality implementation: if a visitor engaged in a long conversation with the avatar, this may restrict other visitor access to both the technology and the site.

Inconsistent visitor experience: Following from the above, while the desire of the application is to provide a personal connection to the site through interaction with avatar of the saint, there is a concern that the ability to take the narrative “off script” would result in varying degrees of engagement, depending on what the visitor asked. This would not only dilute the purpose of the experience but potentially be counterproductive. It must be remembered that St. Neophytos is still venerated as a saint and forms part of the spiritual landscape of Cyprus, thus raising ethical questions on the authority or trivialisation of results fed back to the visitor through the digital surrogate.

Religious message and mission: the Holy Monastery of St. Neophytos the Recluse has a mission to promote spiritual, religious, and historical education to all, based on the philosophy of their founder. It must be acknowledged that St. Neophytos was a product of his time and some of the opinions expressed are not well aligned to either the church’s mission or current secular norms. For example, St. Neophytos’ views on gender are firmly rooted in the prevailing Orthodox views of the age.¹

¹ For a considered approach to St Neophytos’ view see Galatarriotou, C. S. (1985). Holy Women and Witches: Aspects of Byzantine Conceptions of Gender. *Byzantine and Modern Greek Studies*, 9, 55–94. <https://doi.org/10.1179/030701384806931430>

Research Challenges - Creating the scenario

The scenario, namely the texts that will be recited by the narrator and the avatar of the saint respectively, must provide information that is reliable and interesting for the visitors. Although the information to be shared will be concise, it nonetheless requires a tremendous amount of research. Literature on St. Neophytos and his legacy is limited, as the earliest scientific publications date to the beginning of the 20th century and they are primarily focused on the life and writings of the saint. The first studies on the art of the enkleistra appear in the 1930s and the most thorough scholarly study, still fundamental to the present day, was published in 1966 by Dumbarton Oaks. Since then, there has been an increasing number of papers and references in the discourse about St. Neophytos and his legacy. The Monastery of St. Neophytos undertook the great initiative to organise in 2009 the First International Conference dedicated to the history, theology and culture relevant to the saint, the proceedings of which were published the following year in a big volume. Yet, in terms of the art of the enkleistra there has been no other study as comprehensive as the one carried out by Dumbarton Oaks.

Most of the important publications, see list below, are hard to access, either because they are out of print, hence unavailable in the market, or because they are not stocked in libraries in Cyprus. Archimandrite Neophytos from the Monastery of St. Neophytos has been incredibly supportive in lending us some of the fundamental books from his personal library; this is how, in fact, research has managed to progress.

Furthermore, the Abbot of the Monastery, His Grace Bishop of Chytri, Leontios, allowed us to visit the Monastery and have an extensive tour of the enkleistra accompanied by Archimandrite Neophytos. With the latter we further had a deeply informative discussion about the area surrounding the enkleistra, the 18 further caves in its vicinity where the disciples lived and, the storage spaces, all carved out on the same mount (only a few of them exist presently). This knowledge, extracted *in situ*, has been incredibly useful in placing the information learned from the texts in the natural habitat of St. Neophytos and the broader context of his living.

Essential bibliography:

Galatariotou, C., *The making of a Saint. The life, times and sanctification of Neophytos the Recluse*, Cambridge, 1991

Glaros, A., *Saint Neophytos the Recluse and his Testamentary Rule (in Greek)*, Athens, 2013

Mango, C. and Hawkins, E. J. W., *The Hermitage of St. Neophytos and its wall paintings*, Dumbarton Oaks papers, vol. 20, (1966)

Tsiknopoulou, I., *Saint Neophytos. Elder, Monk and Hermit and His Holy Monastery*, Paphos, 1955

Research Challenges - The appearance of St. Neophytos as an avatar

Given that the outcome of our work will be put to public domain, not only the visitors to the enkleistra, but also the monastic audience and all faithful who will judge us from the theological viewpoint, we deem the conveyance of the saint in the form of an avatar to be extremely important. The quest is: how did the saint look like? We are fortunate to have portraits of the saint on the enkleistra's frescoes, which were painted when the saint was alive. His facial features, as well as his lean, ascetic figure, can be extracted quite safely from his portrayals. As far as his garments are concerned, the saint stated that "I wear my clothes simply, not seeking adornments". Dying the fabrics, for instance in black colour, was thought to be unnecessary, a kind of luxury, therefore, the saint was most probably wearing garments made of humble materials, such as coarse wool in its natural colour, which is in fact compatible with the full length representation of the saint amid the two archangels in the sanctuary of the enkleistra. Therefore, the avatar of the saint should be dressed in garments of earthly colours, more precisely the hue of the sheepskin.

Technical Challenges - Building the VR Scene

One of the first challenges we encountered in developing the VR experience of Saint Neophytos was to find a natural way to recreate the enkleistra. It should look authentic, and the experience in Virtual Reality should be intuitive.

We were provided with rich source material, including a detailed 3D model generated from point cloud data and a series of 360-degree panoramic images of the site. Using these materials, we built an initial prototype that allowed us to test not only the environment itself, but also the narrative structure of the experience. Selected texts from the literature were used to shape the voice of Saint Neophytos, while a narrator was introduced to gently guide users and explain what they were about to experience.

As development progressed, we discovered that the high-resolution 3D model, although visually impressive, was too heavy to run smoothly in VR—particularly when combined with the animated figure of Saint Neophytos. Reducing the model's resolution improved performance, but at the cost of visual continuity, as gaps and missing details appeared in the geometry. To overcome this, we explored a hybrid solution, combining the 360-degree panoramic images with the available 3D model. Even with its imperfections, this approach created a convincing sense of depth and atmosphere, helping users feel present within the space. However, the experience remains demanding in terms of performance, making it clear that a more optimized, VR-ready model of the enkleistra will be necessary.

Development Challenges - The 3D model of Saint Neophytos

Another important challenge emerged around the visual representation of Saint Neophytos himself. Early versions of the 3D character were based on widely available online references, which often present the Saint in different and sometimes interpretative ways. This first prototype was reviewed by experts in Byzantine history and iconography, and their feedback guided us toward more historically reliable sources and provided essential advice on the Saint's appearance and clothing. This collaborative work allows the refinement of the character, ensuring that Saint Neophytos is represented with greater historical accuracy.

3. NEXT STEPS AND CONCLUSIONS

Building on the insights gained from the first prototype, the next phase of the project will focus on targeted improvements to both performance and historical accuracy. A key priority will be to investigate the possibility of replacing the current point cloud-generated 3D environment with a lighter and more optimized 3D model of the enkleistra, specifically adapted for virtual reality. This optimization is expected to significantly improve performance and comfort while preserving the qualities of the VR scene.

In parallel, we will further refine the visual appearance of the virtual Saint Neophytos, drawing on recently published and more authoritative references available through Europeana. These sources provide a more reliable historical and scholarly basis for the Saint's representation and will guide updates to his physical features and clothing, ensuring cultural consistency. The avatars will be published in Europeana as animated 3D models, by using a specialized viewer integrated in the EUreka3D Data Hub.

Finally, we will update the audio components of the experience by replacing both the voice of Saint Neophytos and the narrator with new professional recordings produced by the project partner, CUT. This will allow for improved audio quality and greater narrative coherence.

Dissemination via public demonstration

Two public demonstrations of the final *A new life for the Enkleistra of St. Neophytos* application are planned

1. An onsite demonstration of the mixed reality application for the monastic community and invited guests is planned for the 24th of May 2026
2. A public demonstration of the virtual reality application at the EuroMed 2026 Digital Heritage Summit, Limassol, Cyprus on the 26th of May 2026

Further refinement to ensure the correct balance for engagement with schools is anticipated and will be based on feedback received from educators and curriculum designers arising from the public demonstrations. This will be of particular interest in assessing the need/desire for repurposing of the application for school children under the age of 13 using traditional screen-based interfaces rather than head-mounted displays (in accordance with manufacturers' guidelines and principles of the *European strategy for a better internet for kids - BIK+*).

Dissemination via academic publications and presentations

We aim at publishing at least two papers in academic journals, in which to describe our work and the progress made in the field of implementing technology both for safekeeping the current state of the monument's condition, as well as making it accessible to the specialised and general audience alike.

It will furthermore be proposed to other peer organised events, such for example the Spring Symposium of the Society for the Promotion of Byzantine Studies in the UK and the series of lectures/presentations at the British School at Rome.

Submission to Twin it! 3D for Europe's Culture - Part II

The digital 3D model of the enkleistra has been submitted for consideration as one of the representative 3D entries from Cyprus in the European Commission and the Europeana Initiative, [Twin it! 3D for Europe's Culture - Part II](#), to be held in Brussels, Belgium on the 12th May 2026.