Research Article

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Melite Civitas Romana in 3D: Virtualization Project of the Archaeological Park and Museum of the Domus Romana of Rabat, Malta

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Abstract: The archaeological site of the Domus Romana in Rabat, Malta was excavated almost 100 years ago yielding artefacts from the various phases of the site. The Melite Civitas Romana project was designed to investigate the *domus*, which may have been the home of a Roman Senator, and its many phases of use. Pending planned archaeological excavations designed to investigate the various phases of the site, a team from the Institute for Digital Exploration from the University of South Florida carried out a digitization campaign in the summer of 2019 using terrestrial laser scanning and aerial digital photogrammetry to document the current state of the site to provide a baseline of documentation and plan the coming excavations. In parallel, structured light scanning and photogrammetry were used to digitize 128 artefacts in the museum of the Domus Romana to aid in off-site research and create a virtual museum platform for global dissemination.

Keywords: Malta, Roman archaeology, 3D digitization, 3D visualization, virtual museums

1 Introduction

The virtualization project of the archaeological park and museum of the Domus Romana of Rabat, Malta is an integral part of the international interdisciplinary and collaborative research project *Melite Civitas Romana*, which is sponsored by Heritage Malta, the University of South Florida, the University of North Alabama, and the Intercontinental Archaeology Consortium. The project entails excavations at the site between 2020 and 2022 and the creation of a web platform for the global dissemination of digital content related to the Domus Romana, its museum, the new excavations, and Roman material culture in the Maltese Archipelago more generally. Although the first excavation campaign scheduled for summer 2020 was postponed due to the Covid-19 pandemic, the previous year's preliminary work such as the geophysical

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prospection of the site, the overall terrestrial and aerial three-dimensional (3D) digitization of the Domus, and the close range 3D capturing of the highlights of the museum collection provide a foundation for later planned fieldwork. This article discusses the results of these virtualization activities conducted by the University of South Florida's Institute for Digital Exploration (IDEx) (Tanasi, 2020) by presenting its capturing methodologies, solutions to technical challenges, data curation and dissemination strategies, and the archaeological documentation on the Domus Romana yielded by the 3D portion of the *Melite Civitas Romana* project and its significance to address open research questions.

1.1 The Domus of Rabat and the Islamic Cemetery

The Domus Romana is located at the southwestern periphery of Rabat overlooking Mtarfa to the west. It was first excavated in 1881. The site's remains, which comprise a large peristyle containing rooms adorned with very fine mosaic floors, were uncovered during the planting of trees along the esplanade in front of the fortifications of medieval Mdina (Bugeja, 2004). The exploration subsequently conducted by A. A. Caruana led to the discovery of a luxurious Roman suburban mansion, comprising at least six rooms, which was documented with a very schematic plan (Caruana, 1881, 1882).

Decades later, the importance of the remains convinced authorities to build a small museum to protect part of the ancient structures. This building, originally known as the Museum of Roman Antiquities, was opened in February 1882 and was the first edifice in Malta that was constructed specifically to house a

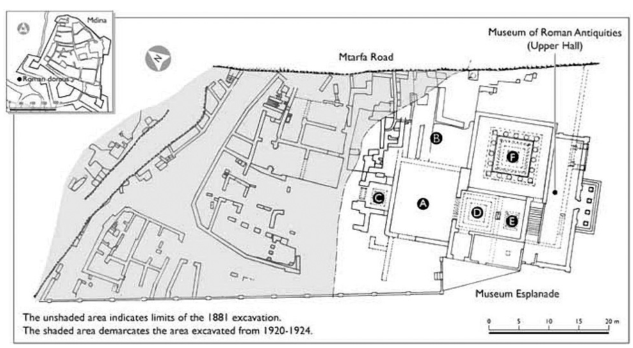

Figure 1: Aerial view of archaeological site of the Domus Romana and of the museum building.

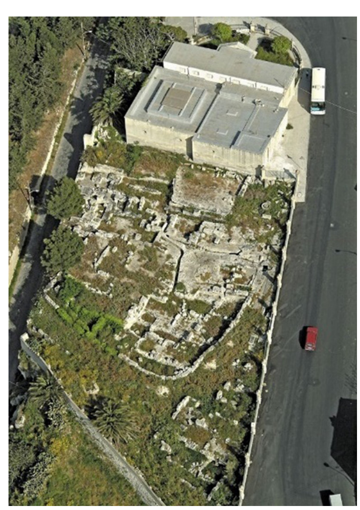

Figure 2: Archaeological site of the Domus Romana with indication of the areas excavated, elaborated merging the schematic plans produced after Caruana's 1881 and Zammit's 1920–1924 excavations (Caselli, 2013).

museum of a particular archaeological site. The expansion of the museum building in 1922 (Figure 1) – with a new design by the architect L. E. Galizia, a neoclassical façade, and a larger display room – led to further excavations by Sir Themistocles Zammit between 1920 and 1925 that concentrated on the area to the northwest of the Domus Romana. Through these excavations, Zammit uncovered remains of other structures, provisionally interpreted as "humble houses" whose relationship with the mansion is still unclear, and a section of a Roman road, bordered on the western side by residential blocks (Zammit, 1922). In this case too the new uncovered archaeological features were hastily documented in a general plan (Figure 2). Zammit also excavated along the façade of the museum and in the fields across the road from the train station where he found several Muslim burials (Zammit, 1923).

However, both Caruana and Zammit were unable to shed light on three critical points, which to date represent significant open questions: the eventual presence of a second story of the Domus; the spatial and chronological relationship between the villa and the other structures uncovered in the area adjacent to it to the west; and the presence of multiple architectural phases marking the development of the Domus complex. The floors of the peristyle corridors, the open courtyard, and the surrounding rooms of the Rabat Domus were decorated with mosaics of the finest quality (Rooms A–F) (Figures 3 and 4). The Domus also shows finely painted wall plaster imitating coloured marbles and showing parts of stylized architectural elements which would place them somewhere between the first and second Pompeian Styles (Caselli, 2013). On the basis of the style of the mosaics, the original construction of the building was roughly dated to the beginning of the first century BCE – during the conflict between Marius and Sulla (Bonanno, 2018).

The Domus survived in the same form for about a century and a half. Towards the mid-first century CE, it must have been occupied by a person of some high political standing who undertook the expense of adorning it with a cycle of fine portrait statues representing the emperor Claudius (Figure 5) and members of his family (Bonanno, 2007).

Some years later the Domus fell into disuse and after a long chronological gap, its area was reoccupied and reconfigured by the new inhabitants who lived nearby in the late antique and medieval periods. Details about the cultures and societies of these peoples are unfortunately slim. Archaeological data, particularly pot sherds, indicate that coastal settlements in Malta gradually fell into disuse and were supplanted by inland settlements (Molinari & Cutajar, 1999; Cutajar, 2004; Wettinger, 2011; Bruno & Cutajar, 2013). This narrative, however, remains contested and has been enveloped in larger arguments about continuous Christian inhabitation on the island. Godfrey Wettinger, for example, argues that Malta was nearly

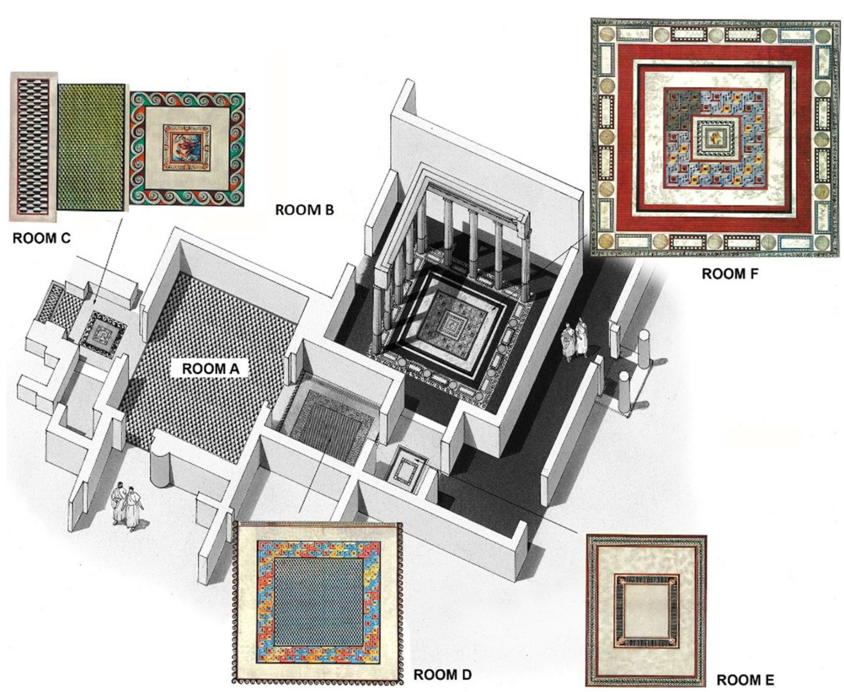

Figure 3: Reconstruction of the central part of the Domus and its mosaic floors (after Bonanno, 2018).

Figure 4: Mosaic floor of Room F.

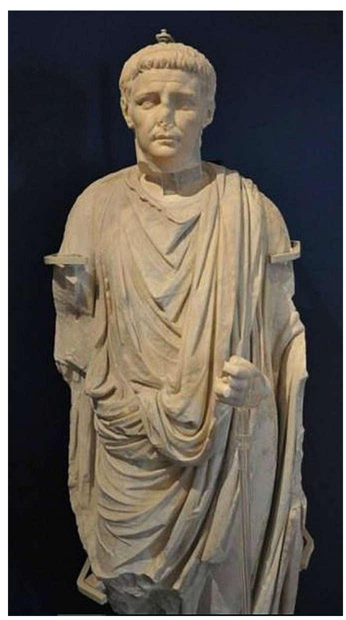

Figure 5: Marble statue of emperor Claudius.

completely depopulated during the early Middle Ages and that it was only around the end of the tenth century that Muslim populations from Sicily and North Africa began to repopulate the island (Wettinger, 1986). Stanley Fiorini conversely advocates for a theory of unbroken Christian inhabitation on Malta and nearby Gozo throughout the Late Antique and Medieval periods (Buhagiar, 2007; Busuttil, Fiorini, & Vella, 2010; Fiorini, 2010; Fiorini & Vella, 2016; Fiorini & Zammit, 2016). Scholars tend to agree with the argument of Wettinger on the basis of flawed translations within the work of Fiorini (Wettinger, 1987; Buhagiar, 2007; Lauxtermann, 2014; Cooperson, 2015).

However, while many Christians may have been on Malta during the early Medieval period, it is clear that there was a substantial Muslim population on the island by the eleventh century. The most substantial

Figure 6: Plan of the site showing the excavated Muslim tombs (green: graves oriented east to west; red: graves oriented north-east to south-west).

Figure 7: Excavations of the Muslim cemetery in the early 1920s (courtesy of Heritage Malta).

Figure 8: Reconstruction of a Muslim tomb and selection of gravestones at the museum of the Domus Romana.

body of archaeological evidence in the proximity of the *domus* comes from a cemetery built atop the site. The excavations of 1881, and even more so the exploration carried out by Zammit, brought to light 254 burials within the area of the Domus Romana, some of which were buried into the earth around the Domus and others of which were placed directly on the floor of the Roman site (Figures 6–8). He presumed the presence of long-decayed wooden coffins at the site as well, based on the presence of heavy iron clamps that could have held them together. Although Zammit noted stylistic differences between the Kufic headstones, he provided little details about the provenance of these burials relative to each other. As a result, it is difficult to draw concrete conclusions about this community of Muslims beyond the chronological dates found on the stones, which indicate burials from roughly 1085 to 1188 – a span that bridges the period of Muslim rule on the island and into the period of Norman dominion (Luttrell, 1975, 1977, 1992; Dalli, 2005, 2006).

2 Virtualization of the Domus Romana and its Museum

2.1 Rationale

The decision to undertake the 3D digitization of the site and museum of the Domus Romana was driven by several factors. Considering that the excavation and the technical documentation of the site were carried out nearly a century ago, there remains a lack of reliable data about the site; no modern technical plan or any requisite section views exist to serve as a necessary reference for the new structures that will be uncovered. The 3D digitization of the site and all the 3D technical documentation that can be extrapolated from the 3D models will thus facilitate scholars to address the abovementioned research question about the volumetric and spatial organization of the Domus complex and its environs. Furthermore, the overall 3D model of the Domus will become the essential starting point for further 3D scanning as the site is explored through excavation. The site itself likewise needs to be contextualized in the changing urban landscape of the city of Melite during the Roman period. Furthermore, although some of the mosaic floors of Rooms A–F have been represented with reconstructive drawings and analogic pictures (Gouder, 1983), none of them have been properly documented with a technique capable of allowing modern pattern studies, degradation monitoring, or restoration planning. For this reason, it was decided to employ terrestrial laser scanning (TLS) to capture the entire archaeological site of the Domus and of the museum. The 3D model obtained with TLS likewise serves to facilitate the overall reappraisal of all built stratigraphic units related to the numerous occupation phases of the complex from the Early Imperial period to the Middle Ages. Additionally, aerial digital photogrammetry (ADP) of the entire complex was carried out alongside close range digital photogrammetry to create high-quality 3D models of the better-preserved mosaic floors in Rooms C–F. The 3D capturing methodology and protocols adopted have been successfully tested in a previous IDEx virtualization project at the Roman Villa del Casale at Piazza Armerina in Sicily, a site larger in scale but with similar architectural and decorative features (Gabellone, Chiffi, Tanasi, & Decker, 2020). The creation of detailed 3D models of the Domus will allow for the online dissemination of the layout of the site to increase public access and engagement with it.

Shortly after the initial field season of 2019, the outbreak of Covid-19 hampered the planned excavations on site. The global reach of the pandemic also caused issues in the day-to-day functioning of the museum of the Roman Domus. The pandemic caused by the Covid-19 virus created an exogenous shock in tourism around the world (Keller, 2020) that created a crisis for many cultural institutions (e.g. Christiansen, 2020; Potts, 2020), and Malta was no exception. The benefits of 3D technologies as applied to cultural heritage thus became more poignant (Iguman, 2020). As a result, in conversation with Heritage Malta, it was deemed necessary to rapidly deploy the 3D data captured during the initial stages of the project for public outreach purposes so that the museum could maintain connection with its audience.

2.2 3D Capturing

IDEx members, in partnership with USF Access 3D Lab (https://www.usf.edu/arts-sciences/labs/access3d), used two Faro Focus x330 laser scanners over the course of 6 days to capture the site. The settings enabled the capturing of colour and scanned with an accuracy of up to 6 mm. Scans were processed using Faro Scene (version 2019.1) with settings that allowed for the application of colour to the point cloud and minimal filtering of stray points. An automatic registration, i.e. the placement of the scans, took place immediately after the processing step. If scans could not be placed automatically, they were registered manually by finding planes and points in common between the scans. These steps were taken every day on-site in order to ensure that no sections or areas were missed in the final point cloud. After the placement of the scans, the 3D project was examined and manually cleaned of extraneous data, stray points, and artefacts from scanning – such as other scanners and people. Once the cleaning of the data was completed, a project point cloud was created in order to provide better access to the point cloud in Faro Scene's onboard virtual reality (VR) function. Additionally, scanned areas were exported in the PTS file formats for use in other programs for analysis and creation of point cloud animations. A total of 168 scans were taken to capture the entire site of the Domus and the areas to be excavated in upcoming excavations. Of the 168 scans, 41 were of the museum interior (Figures 9–13).

Due to the museum being open to the public during the scanning process, a great deal of artefacts had to be cleaned from the scans. Additionally, the scanning team had to remain nearby the scanners to ensure that the scanners were not accidentally bumped during the scans and that the presence of the visitors did not interfere with scan overlap. In taking more scans of the area from many different angles, it was possible to ensure that the model covered the entire area after processing and cleaning.

Figure 9: 3D capturing with Focus ×330 laser scanners of the external area of the Domus.

Figure 10: 3D capturing with Focus ×330 laser scanners of the interior of the Domus.

Figure 11: Coloured dense point cloud with indication of the scanning stations of the area of the museum courtyard.

Figure 12: Coloured dense point cloud of the area of Room D.

A total of 12 scans were taken of the areas to the north and northeast of the site designated for excavation (Figure 13). The area to the northwest was a flat open area, so only four scans were required to cover it. Eight scans of the area to the north were required to capture the area that would be excavated in the coming field season. As the northern area still contained trees and brush at the time of scanning, it will be scanned again prior to the upcoming field season to ensure that the area is captured as it is immediately prior to opening excavation units.

The digitization project included the use of a DJI Phantom FC330 drone to capture the site using digital photogrammetry (Figure 14). The 3D capturing activity was outsourced to the local company Micallef Surveying (http://www.micallefsurveying.com). Over the course of 3 days, 1,741 images were captured using the drone onboard camera at the resolution of 4,000 × 3,000 in a TIFF format at a zenith and 45° angle. The digital photogrammetry processing software, Agisoft Metashape (version 1.6.1), was used to process the images for its proven reliability in cultural heritage (Kingsland, 2019). High quality settings for alignment and creation of the dense cloud were used to create the point cloud (Figure 15).

Handheld digital photogrammetry was employed to capture the mosaic floors still *in situ* in Rooms F and D. A Nikon D3400 DSLR with a stock AF-P Nikon 18–55 mm 1:3.5–5.6 G lens was used to take 1,696 pictures of Room F (Figure 16) and 1,154 pictures of Room D at a resolution of 6,000 × 4,000 pixels. Four mosaic panels and two *emblemata* (Figure 17), removed from their original location and placed in the museums, were also photographed as discussed in Section 2.3.

Figure 13: Plan of the Domus Romana with indication of the 3D scanning stations.

Figure 14: Drone photogrammetry with a DJI Phantom FC330.

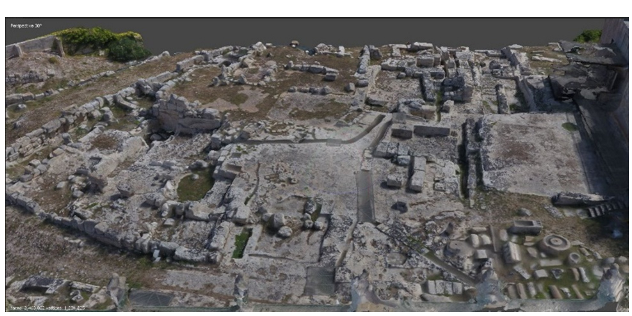

Figure 15: Preliminary drone photogrammetry of the external area of the Domus Romana.

Figure 16: 3D digitization with digital photogrammetry of mosaic floors of Room F.

Figure 17: 3D digitization with digital photogrammetry of mosaic panels and *emblemata*.

2.3 Processing and Production of the Outcomes

The processing of the point cloud data was entirely carried out using the proprietary software Faro Scene. Thanks to updates to the software, an automatic moving object filter facilitated the removal of points related to people or other moving objects, reduced processing time, and removed some of the issues that may arise from human error. Once processing was completed, a raster of the overall top view of the point cloud model of the entire area (Figure 18) was vectorialized in order to create a multilayered CAD plan of the Domus Romana and its museum (Figure 19). The 3D model of the site was used to produce section views of the entirety of the site to evaluate differences in height between the various floor levels and infer hypotheses about different building phases (Figure 20) using data that were not available prior to this analysis. The overall point cloud model was subsequently segmented in order to create individual 3D models for clusters of rooms (Figure 21) or for a single room (Figure 22).

The processing of the 1,741 pictures taken by the drone in Agisoft Metashape produced a high resolution aerial 3D model (Figure 23) of the archaeological site of the Domus and of large plots of land to the north and north west of the Domus, which will be examined by future excavations (Areas 3 and 4 of Figure 24). An OBJ model was exported with 4k texture for dissemination and analysis in other software. The final model was uploaded to the IDEx Sketchfab, though the OBJ had to be reduced in order to meet the 500 MB upload

Figure 18: Top view of the point cloud model of the Domus Romana and its museum.

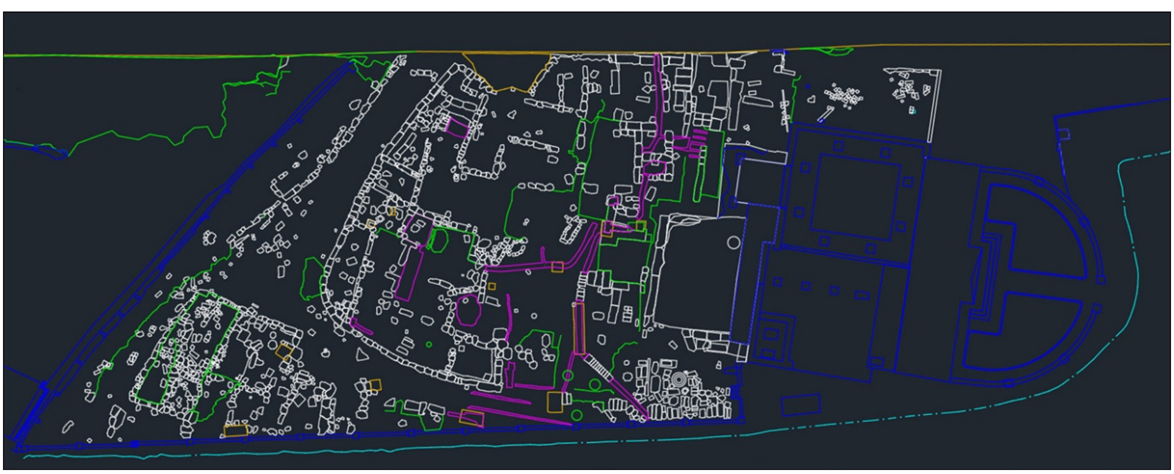

Figure 19: Multilayered CAD plan of the archaeological site of the Domus Romana, with indication of structures belonging to different architectural phases indicated with blue, green, purple, and white colours.

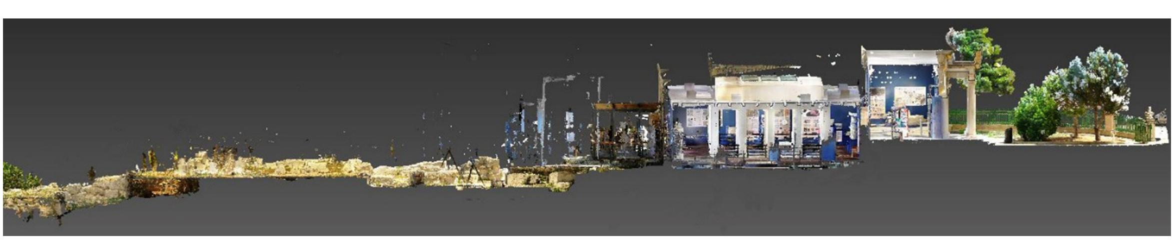

Figure 20: Preliminary study of the section view east-west of the Domus Romana and its museum.

Figure 21: Point cloud models of the rooms incorporated into the museum building.

Figure 22: Point cloud model of the peristyle (Room F).

Figure 23: 3D model from ADP of the Domus Romana and the surrounding areas.

Figure 24: Aerial photograph of the Domus Romana with indication of the designated excavation areas.

limit and has lost a lot in terms of quality (https://sketchfab.com/3d-models/domvs-romana-drone-photogrammetry-992a8326cc1444aa8c0d840fedd35819). The utility for this low-resolution digital model for public outreach initiatives is described in Section 4.

3 Virtualization of the Museum Collection

3.1 Rationale

Apart from the documentation of the site as a whole, the other objective of the scanning campaign, under the umbrella project of *Melite Civitas Romana* project, consisted of close-ranged scanning of the Roman and Muslim material culture relevant to the site. Ultimately, the close-range scanning aimed to capture a representative sample of the museum's collection and the finds from the site for two inter-related purposes: to create a collection of digital surrogates for documentation and research purposes and to use these surrogates for community outreach and dissemination.

The creation of a collection of digital surrogates achieves the same goals as traditional archaeological documentation methods such as photography and technical drawings that would be the basis for research on the objects of any museum collection or archaeological assemblage. Just as the technical drawings and photographs are representations of the objects themselves, acting as surrogates for the objects themselves, so are 3D models (Rabinowitz, 2015). The 3D models thus serve as a substitute for photographs and further allow for traditional technical drawings to be extracted from them. This utility provides curators, archaeologists, and researchers a globally accessible collection of objects to observe and use for formal study off-site. These 3D models have the added benefits of being able to serve as a more engaging form of documentation by providing points of access for non-specialists.

The Domus Romana museum contains 332 objects ranging primarily from the Punic to Roman period (Figures 25 and 26), with a small selection of medieval materials related to the Muslim period of Malta. In conversation with the curator, a prioritized list of artefacts to be digitized was made, consisting of Roman Imperial statuary, Roman mosaics, and architectural features, the Muslim tombstones found at the Domus (some of which were housed in the National Museum of Archaeology in Valletta, Malta), and various representative examples of Roman period ceramics, and some of daily life, for a total of 128 artefacts.

Figure 25: Punic-Roman pottery in display at the Domus Romana museum.

Figure 26: Roman amphorae in display at the Domus Romana museum.

The 128 selected artefacts were split into different material classes. They include 33 gravestones, 7 bone objects, 2 ceramic moulds, 6 mosaics/*emblemata*, 3 metal items, 3 coroplastics, 6 elements of fresco, 9 stone items, 11 elements of statuary, and 48 ceramic objects.

3.2 3D Capturing

Based on the wide variety of material culture that was to be scanned, it was decided to use two forms of 3D scanning: structured light 3D scanning and image-based structure from motion – also known as digital photogrammetry. Digital photogrammetry has long been a popular method of digitization in cultural heritage application due to its relatively low costs and potentially very high-quality results (Olson, 2016; Olson & Placchetti, 2015).

During the virtualization process, there were a handful of common technical challenges. As both the structured light scanning and photogrammetry collect texture data, lighting is of utmost importance. Diffuse natural light is optimal, but various techniques of lighting management can be used to improve lighting conditions and is one of the most important factors to consider in the planning states of scanning (Guery, Hess, & Mathys, 2018). While structured light 3D scanning generates its own light, digital photogrammetry depends entirely on the quality of the photographs taken. The other challenge to confront is the physical organization of space. Both virtualization methods require considerable space to carry out effectively, something that can be hard to find in museum storage rooms. Finally, once the space available is assessed, scanning must be organized to ensure safety for the operators, the technology, and the museum objects. Ample care and forethought must be given to the storage, movement, and stability of the objects being scanned.

An example of the aforementioned challenges can be found in the case of glass objects. These artefacts are extremely fragile and characterized by transparent or iridescent surfaces, a reality that makes capturing them with structured light and photogrammetry difficult. The combination of these challenges led to their omission at this stage of the project, unfortunately leaving out an entire class of materials. In other cases, it was best to scan the objects *in situ* in the museum rather than attempting to move them. These can present further challenges to data acquisition, which may result in data that need post-processing to make it whole (see Section 3.5).

3.2.1 Structured Light 3D Scanning

Some of the benefits of the Artec Space Spider are its portability, ease of use, and the visibility of results in real time. It requires a moderate amount of space to scan and a computer with the proprietary software Artec Studio 13 (Figure 27). Coupled with a turntable, this scanning technique can also be quite fast, even for objects with complex geometry (Figure 28). The structured light scanner was particularly useful for medium sized objects, such as elements of statuary or tombstones. The scanner has much more difficulty capturing very small objects, which are best left for photogrammetry.

3.2.2 Digital Photogrammetry

Photogrammetry is even more portable than structured light 3D scanning in that the only hardware required is a digital camera of any type, though a DSLR camera with a high pixel count, reliable sensors, and a good amount of settings (compared to the cameras found on most Smartphones) will allow the operator to better adapt to lighting conditions. The quality of the finished model is directly linked to the quality of the photos taken, and thus, a good camera is recommended, as well as familiarity with principles of photography.

Figure 27: Impromptu Artec Space Spider structured light 3D scanning station at the National Museum of Archaeology in Valletta, Malta.

Figure 28: Artec Space Spider structured light 3D scanning station at the Domus Romana museum in Rabat, Malta.

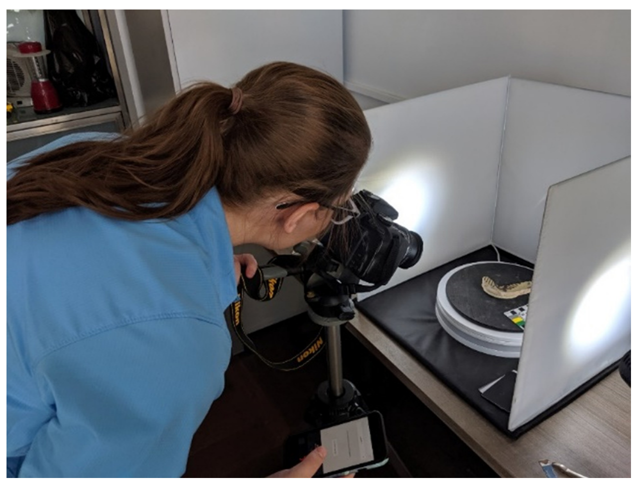

Figure 29: Photogrammetry station at the Domus Romana Museum in Rabat. Note the use of the Foldio 360 app on the operator's mobile phone.

Figure 30: Photogrammetry station at the Domus Romana Museum in Rabat.

The IDEx team used a D3400 Nikon camera with a stock AF-P Nikon 18–55 mm 1:3.5–5.6 G lens, a Canon EOS Rebel T3i with a Canon EF-S 24 mm f/2.8 STM fixed lens, a Foldio 360 turntable, a tripod, and a mobile phone with the Foldio 360 app that enables control of the device from a Bluetooth enabled mobile device and a small lightbox (Figures 29 and 30).

Images were captured at a resolution of 6,000 × 4,000 in the case of the Nikon and 5,184 × 3,456 in the case of the Canon. Objects were placed on the turntable, the camera placed at a 90° angle horizontally, and a set of 36 pictures were taken. Another set of photographs were then taken at a roughly 45° angle from above. For smaller objects, these two sets were sufficient for that object position. These sets were then repeated based on the size and geometry of the object. The object was then moved to cover different sides of it with sufficient overlap that the photographs could be aligned during the processing phase. Once the photographic data set was acquired, it was sent to the production phase. At this stage, the focus shifts to having adequate hardware and appropriate software.

3.3 Close-range Processing and Outcomes

3.3.1 Structured Light Scanning

The Artec Space Spider processes 3D models in the same software that is used to scan them: Artec Studio 13. Several raw scans were carried out until the object was sufficiently covered on one side (Figure 31). Then,

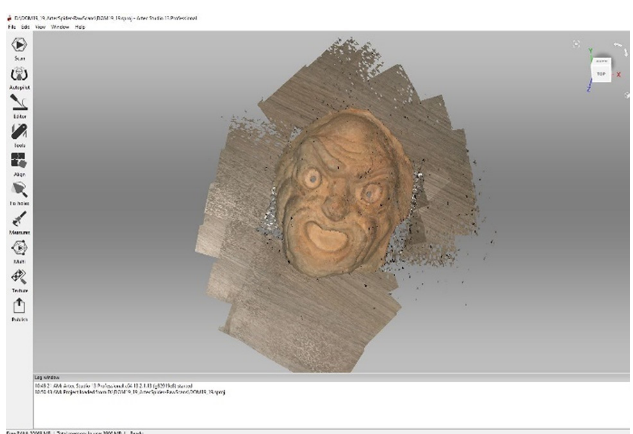

Figure 31: Raw scans of theatrical mask.

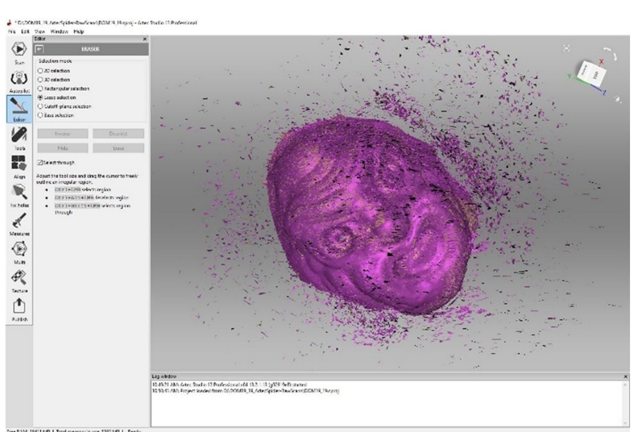

Figure 32: Editing of extraneous data.

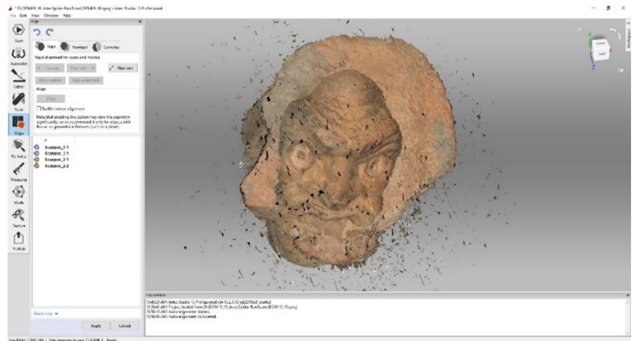

Figure 33: Aligning the two different object positions in Artec Studio 13.

the object was moved and scanned again with the aim of creating sufficient overlap for the object to align itself. A series of "registrations" were made in the software to clean the data and any additional extraneous data were then manually removed (Figure 32). The already textured scans were further aligned automatically or manually as needed (Figure 33). Finally, when the object was aligned, the software performed a sharp fusion of the scans to create the final version of the model (Figure 34). Light hole coverage was done in Artec Studio 13, but if major issues occurred, the model was then taken into other software for post-processing.

3.3.2 Processing of Digital Photogrammetry

Unlike the Artec Space Spider, photogrammetry can be processed in a number of different software programs. In the field of cultural heritage, however, Agisoft Metashape has become standard due to its relatively low cost, ease of use, and high-quality results (Kingsland, 2019). The photographic data set was imported into Agisoft Metashape in chunks, based on the various object positions needed to capture it in its entirety. From there, the images were processed through a series of steps: from alignment to creation of the sparse point cloud, from production of the dense point cloud to removal of extraneous data, and from production of the mesh to generation of the photographic texture (Figure 35). The visualization of every object from the Domus Romana required alterations to processing after the workflow had been completed in order to ensure an accurate digital representation. If major issues within the data presented themselves, the models were exported into 3D modelling software for manual corrections.

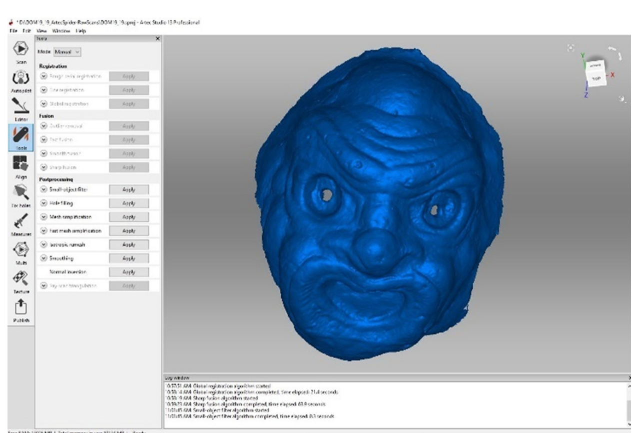

Figure 34: Sharp fusion and mesh of the aligned model in Artec Studio 13.

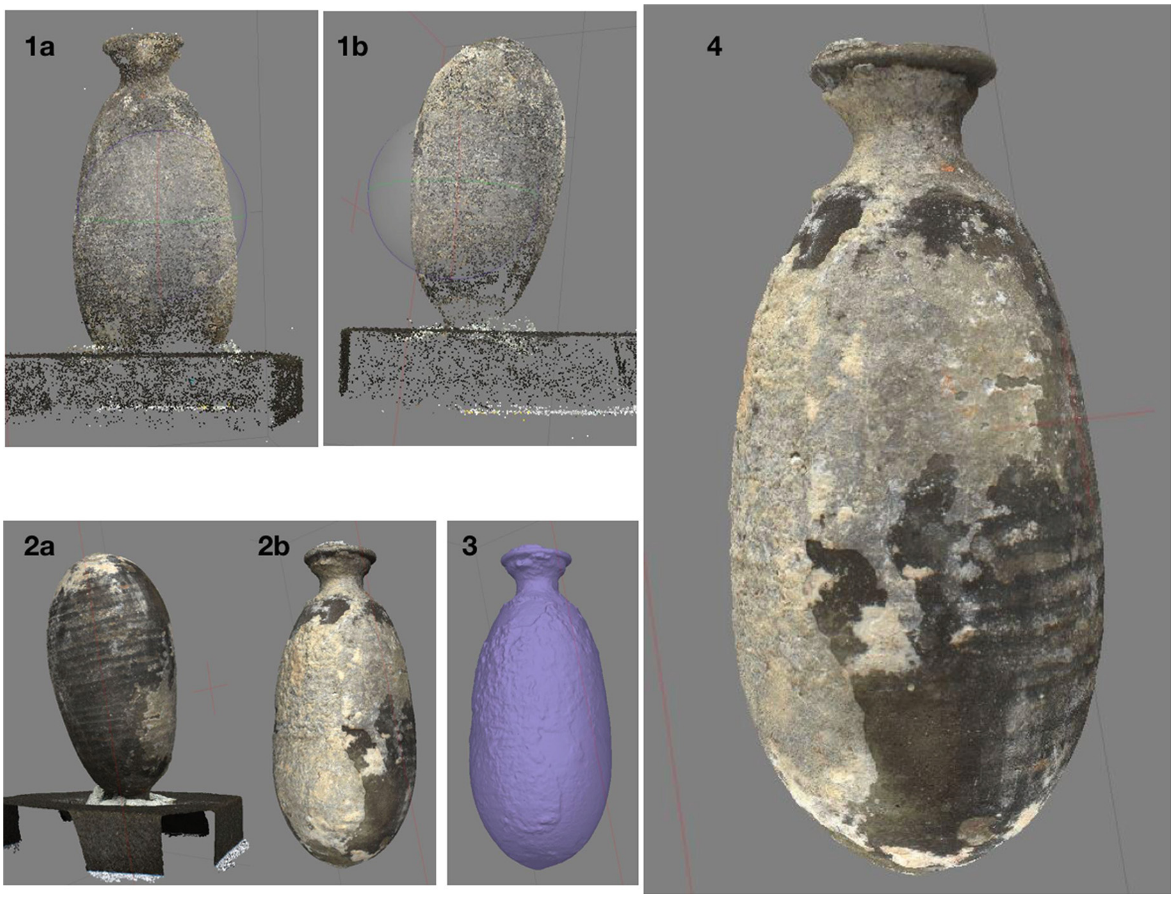

Figure 35: Digital photogrammetry processing steps in Agisoft Metashape: (1a and 1b) sparse cloud resulting from the align images function, with two different chunks processed for the two artefact positions; (2a) dense cloud of the chunk featured in 1b; (2b) aligned dense clouds from the two chunks with support material manually removed; (3) untextured mesh from the build mesh process; and (4) final textured mesh (Kingsland, 2019).

3.4 Results

3.4.1 Structured Light Scanning

Out of the 128 total models created, 52 were scanned and processed using the Artec Space Spider and Artec Studio 13. A wide variety of objects in various materials were scanned, including stone (Figure 36), terracotta (Figure 37), and pottery (Figure 38).

3.4.2 Results of the Photogrammetry

Of the 128 total models scanned, 74 were done with photogrammetry, and an additional 2 were created out of uniting disparate objects into a single model. These models were created with as little as 82 images to as many as 398. Photogrammetry was particularly useful for the mosaic *emblemata* (Figure 39), smaller ceramic objects such as lamps (Figure 40), and statues that were too large to be scanned with the Artec Space Spider (Figure 41). Due to the size, weight, placement, and mounting methods, it was impossible to capture the entire geometry of some of the objects including the marble statue of Emperor Claudius, the replica of a Muslim tomb, the mosaic panels, and some architectural elements. As the publication of the

Figure 36: Results of structured light 3D scanning of Head of Maenad.

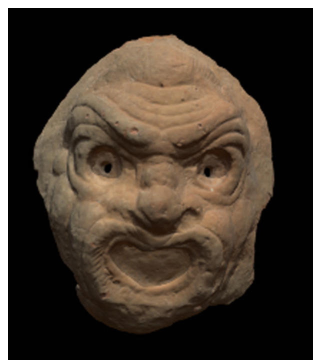

Figure 37: Results of structured light 3D scanning of ceramic theatrical mask.

Figure 38: Results of structured light 3D scanning of black-slipped bowl.

photogrammetry of the objects is currently narrowed in scope to public outreach, rather than academic publication, it was deemed appropriate to lightly alter the digital surrogates of the objects for public consumption. Thus, issues related to incomplete capture were handled by filling missing geometry and elaborating the objects with bases and walls that reflect their positioning within the museum in the post-processing phase. The blue background added to the 3D models reflect the colour of the museum walls.

Figure 39: Mosaic in *opus vermiculatum*.

Figure 40: African Red Slip lamp featuring a gladiator, captured with digital photogrammetry.

Figure 41: Marble statue of Emperor Claudius, captured with digital photogrammetry.

3.5 Post-Processing Methods and Results

Of the 128 models produced, 26 models required light touches in the post-processing phase and 12 required more intensive repairs. The replica of a Muslim tomb is an example of the most drastic intervention and serves as a good example (Figure 8). The reproduction was placed in a gallery of the museum illuminated by soft diffuse light coming only from the ceiling of the room. The position of the object in the corner of the room made it difficult to capture the photographic data set for the entirety of the tomb. A third difficulty for this object was the presence of a perimeter glass enclosure and a glass plate placed on the tomb where part of its cover had been omitted to show the reproduction of a skeleton.

To overcome these difficulties, the photographic data set was elaborated in Adobe Lightroom in order to make the lighting in each photo more homogenous and to reduce noise caused by using too high of an ISO in the DLSR camera. The resulting model to be processed within Agisoft Metashape was also flawed due to the reflectivity of the glass surface on the tomb, which led to distortions of its shape and the loss of the reproduction of the skeleton within it (Figure 42a). The object developed in Agisoft Metashape was subsequently treated with 3D Systems Geomagic Wrap in order to clean up alignment and meshing errors. At the end of this process, there was also a quick remeshing of the model before saving the file. The model was

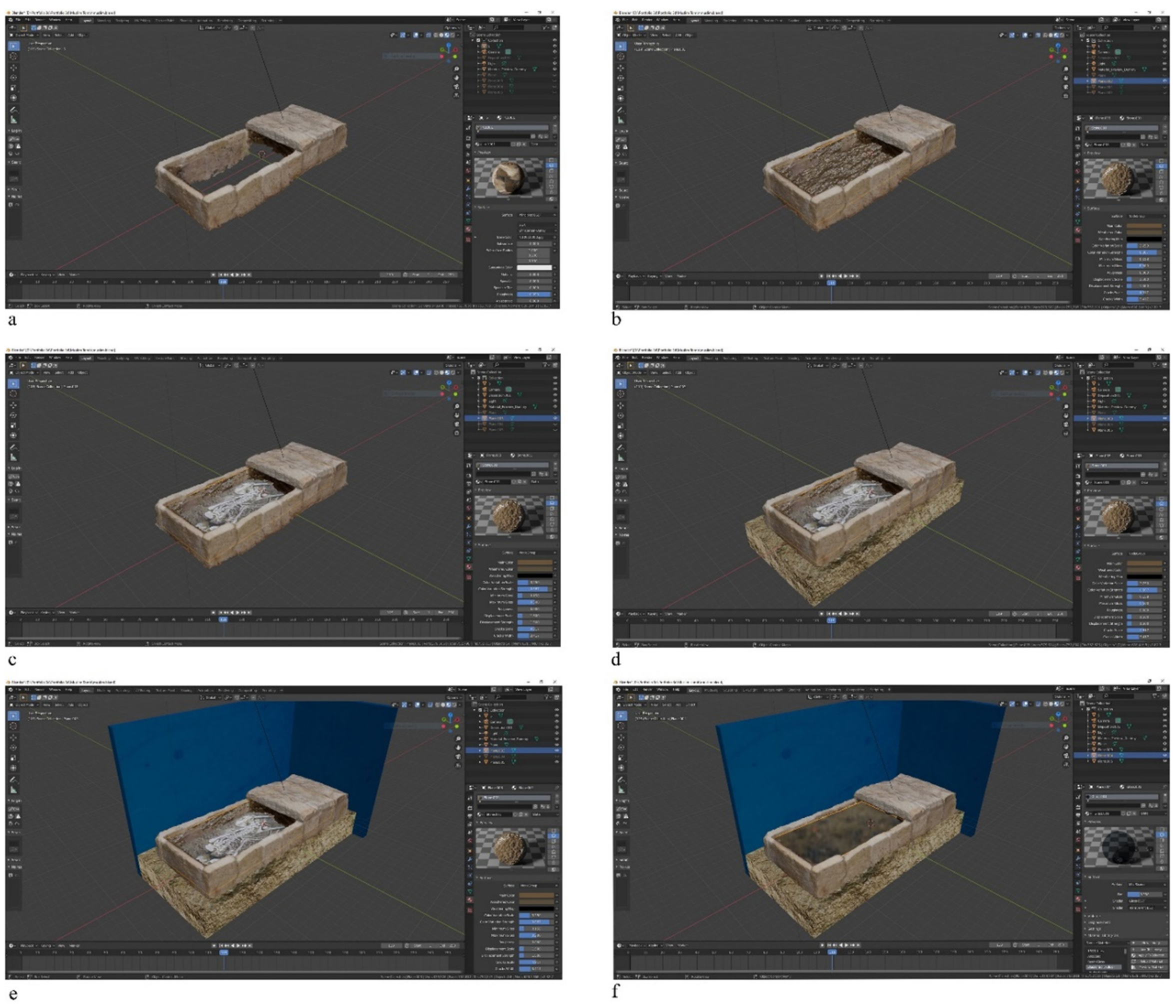

Figure 42: Import of the model into Blender and phases of elaboration of the added elements: (a) addition of the base; (b) creation of the interior of the tomb and shading through PBR materials; (c) insertion of an image of the inhumation; (d) creation of the base of the tomb and shading with PBR materials; recreation of the angled wall with PBR materials; and (f) creation of the glass pane above the inhumation and shading with PBR materials.

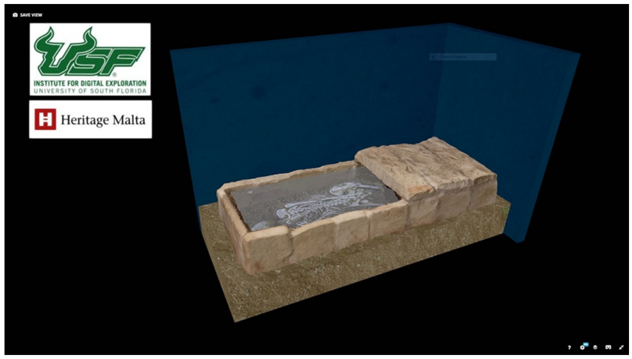

Figure 43: Finished 3D model of the replica of a Muslim tomb.

then moved to Blender, which was used to repair the model. A copy/paste and mirroring operation was done of the facades to create a basic shape similar to the original (Figure 42b). The base of the tomb was closed in order to create a sort of containment block that reproduced the interior of the tomb, and a larger external block was made to reproduce the soil and external crushed stone on which the tomb rested. Physically based rendering (PBR) materials similar to the originals were applied to these reproduced fictitious elements through Blender's shading operations (Figure 42d).

The same procedure was adopted to recreate the glass sheet covering the tomb using PBR materials. To replace the 3D model of the inhumed skeleton, which was impossible to process with the original data set, an image of it was inserted into the model. To complete the operation, two tracts of wall were created and placed at the corner of the reconstructed sides of the tomb and coloured to match the original museum walls (Figure 42e). The resulting blend file from Blender was imported directly to Sketchfab and the individual textures and materials used were loaded accordingly, as the website makes this multi-level process possible. The result was the digital reproduction of a physical reproduction as it can be viewed in the museum (Figure 43). The process by which this model was formed shows that insufficient data can still be salvaged to be used for dissemination and education purposes. However, it is important to note that this model would not fit the definition of a digital surrogate that could serve as a form of documentation like any other. As has been noted (Beacham, 2011), the responsible publication of paradata concerning the alterations made to 3D models mitigates "falsifying" archaeological and historical data through manipulation in 3D modelling software. All paradata are published on the collection's website at www.usfidex.com so that any user will be made aware of interventions made on any given object.

4 Dissemination Plan

4.1 Issues Related to Dissemination of TLS Data

In terms of the dissemination of point clouds, there are several issues related to current technological limitations. Point clouds generated with high accuracy are typically dense and heavy. They can contain billions of individual points, which may not cause a problem when run on a higher-end computer, but may be difficult for computers used by the general consumer. The most common and accessible way to present the 3D data to a global community is via the web. Unfortunately, service providers limit the size of data that can be uploaded to their sites, which means that in order to successfully present the point clouds on these viewing platforms the data must be significantly reduced. This means that the accuracy of the point cloud must also be reduced, and the resulting quality of visualization will be less than ideal. Instead, presenting videos and images of the point cloud itself and the photogrammetric model ensure accuracy for the majority of the public while also allowing researchers to request the data to be sent to them to view on their local devices.

As the project continues and further 3D data are added to the model as it is revealed by excavation, the project requires a method to share the final version of the point cloud in unreduced form. One of the earliest and most reliable tools for sharing point cloud data is Potree, a popular open-source web-based application (github.com/potree/potree). Potree is based on a multi-resolution octree data structure that allows users to render and visualize point-cloud data in a web browser that uses a variety of measuring tools for the analysis and validation of raw data without the need for a time-consuming and costly meshing process. Although its usability is limited to a few billions points due to the amount of computation required to create the multi-resolution octree data structure, applications have been tested to overcome such limits (Martinez-Rubi et al., 2015), making it an excellent candidate for final publication of the 3D model post-excavation. There is likewise ongoing research that seeks to integrate data from Potree into a VR web viewer that would allow for integration into a game engine like Unity such that objects could be accessible within browsers via either point-and-click style rotation or in the first person (Kharroubi, Hajji, Billen, & Poux, 2019). This makes it an excellent candidate for final publication of the point cloud.

Pending the completion of the project, however, for the purposes of the project thus far, the IDEx team has simply shared point-cloud data captured at the Domus Romana with its Maltese governmental partner (Heritage Malta), allowing them to collaborate with other institutional authorities, such as the Maltese Superintendence of Cultural Heritage. The project has been shared via the web as a file which can be downloaded by researchers without the need to pay for a license, as the free version, Faro Scene LT, allows for viewing and analysis of the point cloud and allows the user to make point-to-point measurements, take screenshots, and explore in VR.

4.2 Issues Related to Dissemination of Digital Photogrammetry and Structured Light 3D Scanning Data

The dissemination of 3D models generated is still at the centre of a debate regarding how to most effectively share them online without a loss in quality and what tools are required for an archaeology-minded 3D web viewer with respect to tools and annotation features (Scopigno, Callieri, Dellepiane, Ponchio, & Potenziani, 2017). In a previous project (Gradante & Tanasi, 2016), these issues were tested by using a 3D web viewer embedded in the USF Libraries Digital Collections platform based on 3DHOP, an open-source software package for the creation of interactive web presentations of high-resolution 3D models, oriented towards the Cultural Heritage field (Galeazzi et al., 2016). 3DHOP allows the creation of interactive visualizations of 3D models directly inside a standard web page by adding HTML and JavaScript components to the website's underlying code. The 3D scene and user interaction can be easily configured using a simple "declarative programming" approach and by a series of provided JavaScript functions. By using multi-resolution 3D model management, which supports efficient streaming, 3DHOP is able to handle high-resolution models with ease – even on low bandwidth (http://vcg.isti.cnr.it/3dhop). However, 3DHOP is not contextualized within a larger visualization infrastructure, as has only recently been attempted (Boutsi, Ioannidis, & Soile, 2019).

The greatest obstacle to the effective display of 3D models online is often related to file size, which is subject to constraints set by various web platforms and impacted by the user's bandwidth. For public outreach purposes, the simplest solution consists of using the popular digital showcase for the collection of 3D models Sketchfab (www.sketchfab.com). This platform is currently the main hub for dissemination of 3D models produced by IDEx (https://sketchfab.com/cvast/collections). While the use of a commercial software is not ideal, the Premium account expands the upload size limit to files of up to 500 MB, which is of sufficient quality for dissemination at the early stages of the project, though it does come with a monthly limit to the number of files that can be uploaded. The 500 MB limit of the model size negatively impacted only the drone photogrammetry model of the Domus, the quality of which had to be reduced by one third in order to meet the size limit, though this was considered permissible considering it is not being published for research purposes yet.

4.3 The IDEx Dissemination Framework

A Sketchfab collection entitled “Melite Civitas Romana in 3D” was created to host the 128 3D models of the artefacts in the museum collection and is accessible at https://sketchfab.com/cvast/collections/melite-civitas-romana-in-3d (Figure 44).

This collection of 3D models amounts to almost half of the materials exhibited in the Domus Romana’s Museum and fully covers the highlights of the museum’s collection with artefacts comprising pottery, statues, bone, stone and metal items, coroplastics, mosaic panels, and fragments of frescoed wall plaster and moulds. Prominent among this collection are 33 3D models of gravestones from the Muslim cemetery atop the Domus Romana, which have been virtually reunited for the first time, as only 7 of them are housed in Domus’ Museum and the other 26 are at the National Museum of Archaeology. Here, one of the most serious limitations of the Sketchfab interface presents itself, especially when it comes to large collections. Sketchfab does not allow for the creation of sub-collections in order to sort the items per class, chronology, or typology. Tables 1 and 2 thus list the 3D models accessible in this collection.

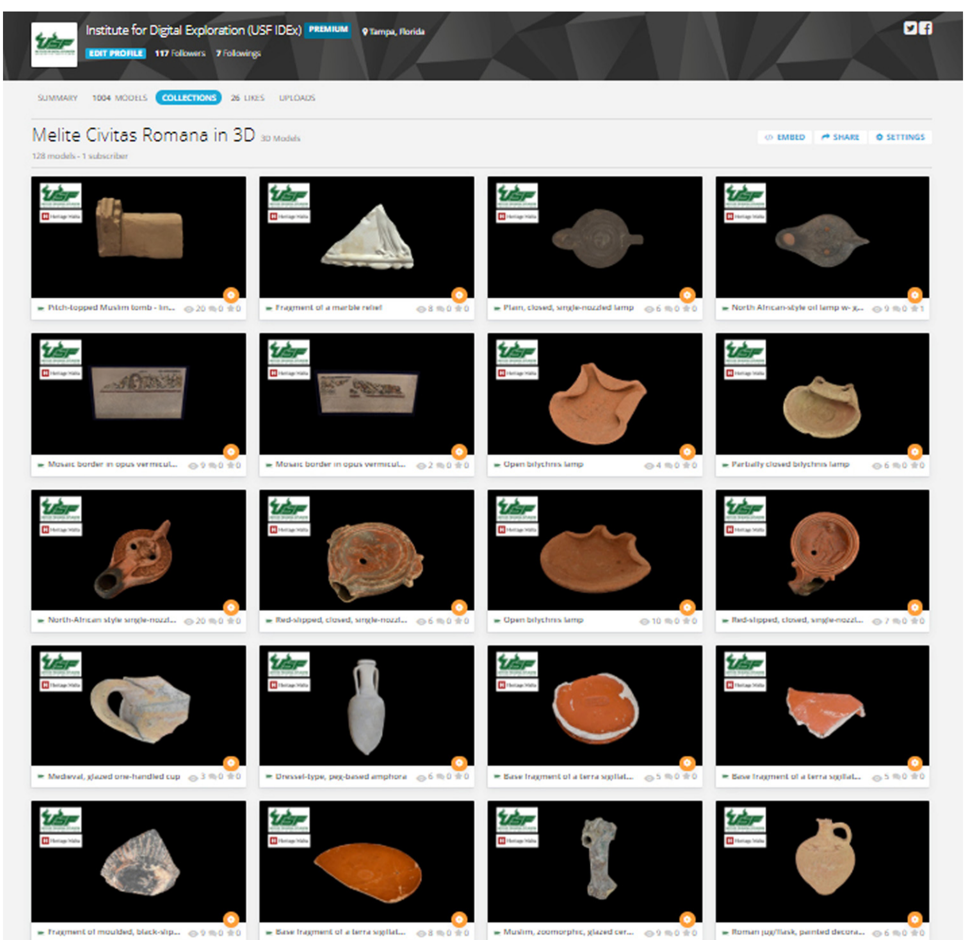

Figure 44: Landing page of the IDEx Sketchfab collection “Melite Civitas Romana in 3D.”

Table 1: 3D models of Muslim gravestones, pottery, bone items, and moulds with related discreet Sktechfab URLs

	Muslim gravestones	
RDR19.001	Gravestone	https://skfb.ly/6TZIZ
RDR19.002	Gravestone	https://skfb.ly/6TZIH
RDR19.003	Gravestone	https://skfb.ly/6TZIG
RDR19.004	Gravestone	https://skfb.ly/6TZIE
RDR19.005	Gravestone	https://skfb.ly/6TZIS
RDR19.006	Gravestone	https://skfb.ly/6TZIN
RDR19.007	Gravestone	https://skfb.ly/6TZHo
NMV19.001	Gravestone	https://skfb.ly/6TZJT
NMV19.002	Gravestone	https://skfb.ly/6TZJS
NMV19.003	Gravestone	https://skfb.ly/6TZJO
NMV19.004	Gravestone	https://skfb.ly/6TZJQ
NMV19.005	Gravestone	https://skfb.ly/6TZJM
NMV19.006	Gravestone	https://skfb.ly/6TZJL
NMV19.007	Gravestone	https://skfb.ly/6TZJK
NMV19.008	Gravestone	https://skfb.ly/6TZJV
NMV19.009	Gravestone	https://skfb.ly/6TZJF
NMV19.010	Gravestone	https://skfb.ly/6TZJD
NMV19.011	Gravestone	https://skfb.ly/6TZJC
NMV19.012	Gravestone	https://skfb.ly/6TZJA
NMV19.013	Gravestone	https://skfb.ly/6TZJB
NMV19.014	Gravestone	https://skfb.ly/6TZJy
NMV19.015	Gravestone	https://skfb.ly/6TZJ8
NMV19.016	Gravestone	https://skfb.ly/6TZJw
NMV19.017	Gravestone	https://skfb.ly/6TZJv
NMV19.018	Gravestone	https://skfb.ly/6TZJt
NMV19.019	Gravestone	https://skfb.ly/6TZJq
NMV19.020	Gravestone	https://skfb.ly/6TZIK
NMV19.021	Gravestone	https://skfb.ly/6TZIL
NMV19.022	Gravestone	https://skfb.ly/6TZIM
NMV19.023	Gravestone	https://skfb.ly/6TZJ6
NMV19.024	Gravestone	https://skfb.ly/6TZJp
NMV19.025	Gravestone	https://skfb.ly/6TZFN
NMV19.028	Gravestone	https://skfb.ly/6TZJ7
	Bone items	
RDR19.043	Flute frag.	https://skfb.ly/6TZGn
RDR19.045	Flute frag.	https://skfb.ly/6TZFU
RDR19.046	Flute frag.	https://skfb.ly/6TZFZ
RDR19.047	Flute frag.	https://skfb.ly/6TZFX
RDR19.048	Flute frag.	https://skfb.ly/6TZFY
RDR19.049	Flute frag.	https://skfb.ly/6TZFV
RDR19.123	Spoon	https://skfb.ly/6TZHF
	Mould parts	
RDR19.014	Mould part	https://skfb.ly/6TZHs
RDR19.015	Mould part	https://skfb.ly/6TZH9
	Pottery	
RDR19.108	Bilychnis lamp	https://skfb.ly/6TZGs
RDR19.109	Bilychnis lamp	https://skfb.ly/6TZG8
RDR19.111	Bilychnis lamp	https://skfb.ly/6TZGx
RDR19.030	Lamp	https://skfb.ly/6TZGz
RDR19.031	Lamp	https://skfb.ly/6TZFQ
RDR19.032	Lamp	https://skfb.ly/6Swqp
RDR19.033	Lamp	https://skfb.ly/6TZHZ

Table 1: continued

	Pottery	
RDR19.034	Lamp	https://skfb.ly/6TZIp
RDR19.035	Lamp	https://skfb.ly/6TZIn
RDR19.052	Lamp	https://skfb.ly/6TZHU
RDR19.105	Lamp	https://skfb.ly/6TZFR
RDR19.106	Lamp	https://skfb.ly/6TZG9
RDR19.107	Lamp	https://skfb.ly/6TZGt
RDR19.110	Lamp	https://skfb.ly/6TZKq
RDR19.101	Amphora	https://skfb.ly/6SxWT
RDR19.102	Amphora	https://skfb.ly/6TZKz
RDR19.103	Amphora	https://skfb.ly/6TZKy
RDR19.104	Amphora lid	https://skfb.ly/6TZIC
RDR19.118	Amphora lid	https://skfb.ly/6TZGQ
RDR19.119	Amphora lid	https://skfb.ly/6TZGT
RDR19.120	Amphora lid	https://skfb.ly/6TZGV
RDR19.121	Amphora lid	https://skfb.ly/6TZGW
RDR19.095	Plate	https://skfb.ly/6TZGE
RDR19.096	Plate	https://skfb.ly/6TZGG
RDR19.097	Plate	https://skfb.ly/6TZGI
RDR19.018	Bowl	https://skfb.ly/6TZIq
RDR19.073	Bowl	https://skfb.ly/6TZIz
RDR19.088	Bowl	https://skfb.ly/6TZKn
RDR19.090	Bowl	https://skfb.ly/6TZJZ
RDR19.092	Bowl	https://skfb.ly/6TZGH
RDR19.100	Bowl	https://skfb.ly/6TZKx
RDR19.125	Bowl	https://skfb.ly/6TZGY
RDR19.126	Bowl	https://skfb.ly/6TZFT
RDR19.068	Cup	https://skfb.ly/6TZHn
RDR19.069	Cup	https://skfb.ly/6TZGD
RDR19.013	Jug	https://skfb.ly/6TZHp
RDR19.040	Jug	https://skfb.ly/6TZI7
RDR19.080	Jug	https://skfb.ly/6TZGM
RDR19.084	Jug	https://skfb.ly/6TZHN
RDR19.068	Sieve vessel	https://skfb.ly/6TZIw
RDR19.076	Cooking pot	https://skfb.ly/6TZIy
RDR19.099	Rython	https://skfb.ly/6TZK6
RDR19.098	Pilgrim flask	https://skfb.ly/6TZK8
RDR19.079	Jar	https://skfb.ly/6TZK9
RDR19.059	Glazed spout	https://skfb.ly/6TZGL
RDR19.065	Glazed wall fragment	https://skfb.ly/6TZIu
RDR19.066	Glazed wall fragment	https://skfb.ly/6TZIv
RDR19.067	Glazed wall fragment	https://skfb.ly/6TZKw

Each individual 3D model is accompanied by a set of metadata comprising an inventory number, names of the contributors who captured the object and processed the 3D model, data collection date and 3D model creation date, 3D digitization method, equipment used, image resolution in the case of digital photogrammetry, and paradata (Figure 45). Unfortunately, descriptive historical and archaeological metadata are presently missing at this stage because the objects exhibited in the Domus' Museum have never been the subject of a systematic academic study. A preliminary review of the evidence has at least produced detailed object names and (at times) precise stylistic, typological, and chronological information.

The accessibility of Sketchfab is advantageous for the online storage of this collection as its contents can be easily disseminated via social networking sites to interact with posts and share with other stakeholders (Hagmann, 2018). On the other hand, the proliferation of collections highlighting works of

Table 2: 3D models of statuary, mosaic panels, frescoes fragments, coroplastics, and stone and metal items with related discreet Sktechfab URLs

	Statuary	
RDR19.017	Female head	https://skfb.ly/6TZHr
RDR19.036	Foot	https://skfb.ly/6TZHJ
RDR19.037	Hand	https://skfb.ly/6TZHO
RDR19.038	Relief	https://skfb.ly/6TZFO
RDR19.039	Finger	https://skfb.ly/6TZHK
RDR19.055	Statue of C. Antonia	https://skfb.ly/6TZHV
RDR19.057	Statue of Claudius	https://skfb.ly/6TZHS
RDR19.077	Female statue	https://skfb.ly/6TZKC
RDR19.086	Theatrical mask	https://skfb.ly/6TZHR
RDR19.093	Female statuette	https://skfb.ly/6TZKp
RDR19.122	Foot	https://skfb.ly/6TZGX
	Stone items	
RDR19.020	Stone loom weight	https://skfb.ly/6TZHH
RDR19.021	Stone loom weight	https://skfb.ly/6TZIo
RDR19.022	Stone loom weight	https://skfb.ly/6TZIr
RDR19.053	Stone loom weight	https://skfb.ly/6TZKr
RDR19.091	Stone loom weight	https://skfb.ly/6TZGN
RDR19.070	Marble column	https://skfb.ly/6TZKv
RDR19.072	Vat	https://skfb.ly/6TZK7
RDR19.081	Millstone	https://skfb.ly/6TZID
RDR19.082	Muslim tomb	https://skfb.ly/6SDSF
	Mosaics	
RDR19.114	Mosaic panel	https://skfb.ly/6TZHM
RDR19.115	Mosaic panel	https://skfb.ly/6TZHL
RDR19.063	Mosaic *emblemata*	https://skfb.ly/6TZHD
RDR19.064	Mosaic *emblemata*	https://skfb.ly/6TZHE
RDR19.112	Mosaic border	https://skfb.ly/6TZGq
RDR19.113	Mosaic border	https://skfb.ly/6TZGp
	Metal items	
RDR19.025	Wall plaster	https://skfb.ly/6TZHA
RDR19.024	Wall plaster	https://skfb.ly/6TZHu
RDR19.026	Wall plaster	https://skfb.ly/6TZHv
RDR19.027	Wall plaster	https://skfb.ly/6TZHw
RDR19.028	Wall plaster	https://skfb.ly/6TZHy
RDR19.029	Wall plaster	https://skfb.ly/6TZHz
	Coroplastics	
RDR19.019	Theatrical mask	https://skfb.ly/6SwWO
RDR19.085	Male head	https://skfb.ly/6TZIB
RDR19.086	Theatrical mask	https://skfb.ly/6TZKs

professional artists as well as the recent addition of an online store has gradually transformed Sketchfab into more of a commercial 3D repository that deprives the platform of its initial academic use. Furthermore, the lack of implementation in recent updates to the platform of descriptive fields for metadata makes it unsuitable for adding structured metadata or database data. Thus, while Sketchfab is presently an acceptable medium for hosting artefacts from the Domus Romana, its role as the primary tool for dissemination is likely not a sustainable strategy for the long term. However, Sketchfab can be used as a host for 3D models that can be linked to a dedicated website with descriptive fields for metadata.

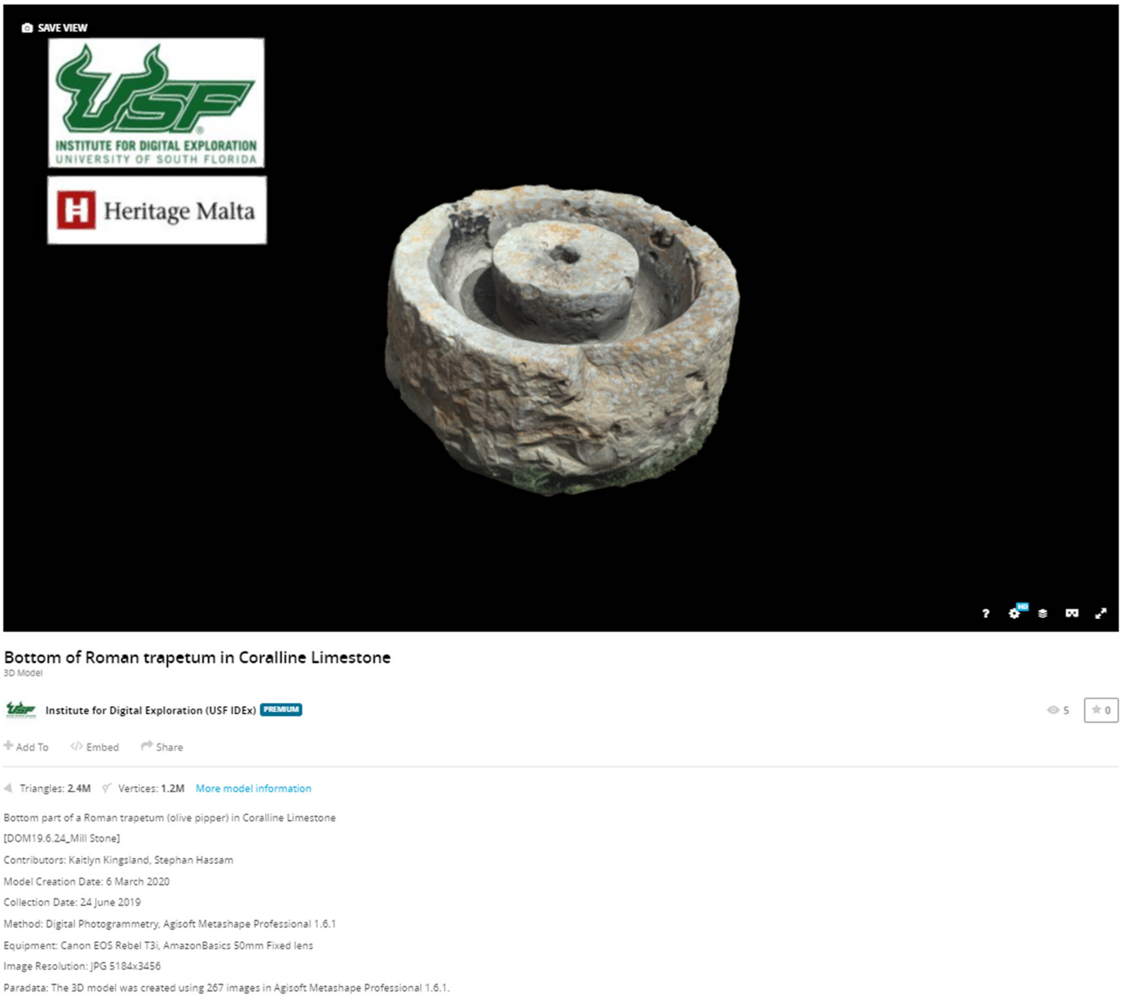

Figure 45: Example of metadata description associated with the 3D models on the IDEx Sketchfab collection.

Figure 46: Virtual Karam Collection on IDEx's website.

The alternative to Sketchfab is a dedicated website with a customized interface and database functionalities linked to data stored on Sketchfab, which in this case works as a cloud drive for the storage of large 3D models. The next stage of the 3D scanning portion of the project entails building such a website for the collection of artefacts from the Domus Romana's museum, complete with annotations of relevant features

Figure 47: An example of an object in the IDEx online virtual collection with its metadata and paradata displayed next to the embedded Sketchfab model.

of the artefacts, metadata, paradata, and historical and archaeological contextualization. An example of such a concept is represented by IDEx's Virtual Karam Collection project that has resulted in the web platform www.virtualkaram.com (Figures 46 and 47). The first fully completed IDEx digital collection (Tanasi, Hassam, & Kingsland, 2018); this project entailed the 3D digitization of 149 archaeological artefacts from the University of South Florida Libraries' "Farid Karam M.D. Lebanon Antiquities Collection." This project entailed the processing of 3D models, the historical and archaeological study of individual objects, the production of metadata according to Dublin Core schema, the design and production of a web repository integrated with a database platform, and the design of a digital data curation plan according to Data Curation Center's "Curation Lifecycle Model." The organization of this collection into thematic sub-collections and the combination of structured metadata mapped with the IDEx master database offers a more user-friendly experience. The positive feedback received by users of the "Farid Karam M.D. Lebanon Antiquities Collection" have further encouraged the adoption of a similar dissemination model for "Melite Civitas Romana in 3D." At the time of writing, the dedicated website or "Melite Civitas Romana in 3D" is under construction.

5 Conclusions

The virtualization project of the archaeological park and museum of the Domus Romana at Rabat is the necessary starting point for the larger Melite Civitas Roman excavation and research project. The production of the overall 3D model of the site and its surrounding urban context via TLS and ADP resulted in the production of an updated and accurate set of technical drawings that will be the basis for any future documentation of newly excavated structures. The 3D model itself is a powerful research tool for scholars invested in the reconstruction of the complex architectural story of the Domus across several chronological phases and of the spatial organization of its surrounding areas. The production of the first multilayered CAD plan of the archaeological site of the Domus Romana, substantiated by an onsite study of built stratigraphic units conducted at the time of the 3D scanning, has distinguished multiple progressive phases characterized by different archaeological features (Figure 19). The availability of a new metrologically accurate ensemble of overall section views and close-up plans of the area west of the Domus will offer a new powerful interpretative tool for those scholars tasked to address those research questions still open about the site.

The high-resolution 3D models of the mosaic floors, available both as dense coloured point cloud and photogrammetric models, will likewise be valuable tools to monitor their current condition via the creation of digital elevation models to assess the presence of swollen or sinking areas, as was successfully done at the Villa del Casale of Piazza Armerina (Gabellone et al., 2020). If the 3D capturing of the mosaics is routinely repeated, the comparison between 3D models produced in different times will allow curators to evaluate whether the artefacts are decaying and how their conservation strategies are working. The availability of the 3D model of the museum building itself will also prove useful to curators whenever they must plan an exhibition or an update of the current exhibition.

The virtualization of 128 artefacts on display in the Domus's Museum represents to date the largest 3D digitization effort that has ever occurred for Maltese archaeological heritage and represents, in embryo, the first Maltese virtual museum. In addition, an unanticipated result of the creation of the virtual collection is the provision of an alternative for visiting the Domus' museum when it is closed, which has become all the more pressing considering the Covid-19 pandemic. With the outbreak of the pandemic and the resultant closure of the Domus' Museum, the IDEx team has worked to complete and deploy the collection "Melite Civitas Romana in 3D" on Sketchfab to give the curators a tool to maintain engagement with their public in such a difficult time. Since May 7, the 3D models of "Melite Civitas Romana in 3D" have been disseminated by the official Facebook pages of the Domus Romana (https://www.facebook.com/domvsromana/), the Melita Civitas Romana project (https://www.facebook.com/melitecivitasromana), and IDEx (https://www.facebook.com/IDEXUSF) in an attempt to maintain the interest of the museum's stakeholders and to trigger interest in prospective visitors.

Although the results achieved from this initial stage of research are significant, there remains substantial work to be done at the Domus Romana. Future research at this site should include the combination of the various layers of 3D data generated into a fully formed virtual museum experience with augmented reality (AR), VR, and mixed reality components. These 3D objects can be integrated into AR applications for Heritage Malta to be used in the museum setting or elsewhere, as in an archaeological park (Watrall, 2018). This form of engagement will allow for museum visitors to engage with archaeological metadata and manipulate the digital surrogate in real time within the museum itself – acts that break down some of the traditional barriers between object and viewer. Interested parties can see the full object, zoom, and manipulate them as they please without danger to harming the original. Objects could also be linked into an application (e.g. a virtual tour) or into an original context (e.g. an archaeological park). The 3D models of the Domus and its environs, when coupled with the digital surrogates resulting from close-range 3D scans, can also serve as the basis for future projects that can model potential reconstructions of the Domus and integrate them into VR applications, allowing the viewer to better understand antiquity through a phenomenological experience (Eve, 2012) and deepen the "authenticity" of a museum experience (Guttentag, 2010). These possibilities must not be attempted uncritically, but the creation of both a 3D model of the Domus Romana museum and much of its collection has, in any case, generated all the necessary components for a fully virtual and interactable museum experience.

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