

# 3D Modeling and Virtual Access of Omega House in the Athenian Agora

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This paper presents a project conducted in the Athenian Agora, Greece which was realized through the cooperation of participants from Canada, Greece, Slovakia and the United States. It documents and presents results from surveying, photographing and 3D modeling of Omega House as well as comparative retrospective 3D modeling of the site using archival photographs.

Omega House is a 30 room structure in the Athenian Agora dating from the fourth to sixth centuries A.D. It is considered to be one of the last philosophical schools of the ancient world. It was originally excavated between 1969 and 1971 by John Camp and is currently inaccessible to the public and in need of preservation and restoration. The project's purpose is to provide accurate three dimensional (3D) modeling of Omega House as it was when first excavated and as it is now in order to achieve two goals. Firstly, to provide the Hellenic Ministry of Culture and Sports with data which can be used for the conservation of the site. Secondly, to create a virtual environment which will allow the public to experience the site in its current form, its post-excavation form and in a recreation of its original ancient form. The virtual environment will accommodate visitors on site while the monument is closed to the public.

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Photogrammetry, Athens, 3D modeling, virtual reality.

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## INTRODUCTION

In the Athenian Agora, situated below the Acropolis of Athens, Greece, is an archaeological residential complex referred to as Omega House. In 2016, in cooperation with the Ephorate of Athens, we commenced a photogrammetric project to record the condition of Omega House in order to facilitate evaluation of its current state and commence with conservation and restoration measures as well as using the data gathered to present the site to the public in a virtual environment. In addition to conducting high resolution contemporary photogrammetry it was envisioned that 3D modeling of the site as it was when first excavated could help in the understanding of not only what could be restored, but also in assessing the kind of deterioration that takes place over 47 years. This provided an opportunity to assess how, without the wear and tear of tourist access, an archaeological site is affected by natural processes.

In this paper we present Omega House as A) a contemporary photogrammetric model, B) a model using archival photographs, and C) a virtual reality model for public presentation.

In order to achieve optimal results in all facets of the project, an accurate site survey of features that have remained intact since the time of excavation was performed allowing coordinates to be applied to both the contemporary and retrospective models. Additionally, elements of the contemporary modeling were employed in the construction of the archival model with only archival photographs used as texture.

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## OMEGA HOUSE

Omega House (also referred to in archives as House C and School C) is a rich Late Roman Villa situated on the north slope of the Areopagus hill in the Athenian Agora. It is an extensive residence, believed to have been one of the private Athenian philosophical schools of late antiquity [Camp 1989]. The house was built during the 4th century A.D. and went through significant remodeling during the 5th and 6th centuries. According to excavation data, the house was forcibly vacated in the early 6th century, and was re-inhabited by new Christian owners until the invasion of the Slavs in 582 A.D. [indicatively Camp 2010].

The house has a spacious plan measuring 60 by 30 meters (approximately 1800 m<sup>2</sup>), encompassing 30 rooms developed in three flanks (western, central and eastern) grouped around peristyle courtyards. The rooms hosted all of the activities of the private, professional and social life of its owners [Franz 1988].

The most impressive feature of the house is the central peristyle courtyard and a suite of rooms situated at the lower level on the southeast corner. By descending a flight of steps flanked by two Ionic columns, one enters in a spacious suite. The suite encompasses a rectangular area (probably a triclinium) decorated with a colourful mosaic floor and marble-revetted walls, a semicircular pool and an apsidal space (Nymphaeum), towards the east, covered with a barrel vault ceiling. The triclinium is believed to have served as a private teaching area [Travlos 1993]. Above the low (1.30m high) western wall of the triclinium there was a terrace with a railing that was supported by sculpted figures; herms of Silens [Franz 1988; Tsogka 2014]. Water was supplied by a natural spring, "which has been exploited by the property owners in various ways for centuries" [Camp 2010].

Among the rooms of the western flank, a spacious rectangular room with five niches in the walls is notable. The room was probably used for lectures and/or as a library [Tsogka 2014].

The eastern part of the house is not as well preserved and encompasses smaller rooms grouped around a smaller peristyle court. This part of the house is thought to have hosted the private apartments of the owners [Tsogka 2014]. A bathing area with hot and cold rooms was built after remodeling in the 5th century. [Camp 2010].

A rich collection of Greek and Roman sculptures adorned the house; among them a statue of Athena, a head of Nike, a statue of Heracles, a bust of Helios, and a bust of the emperor Antoninus Pius. Most of the sculptures were carefully deposited in two wells, which were then closed, while the ones which remained above ground were deliberately decapitated [Franz 1988; Roccas 1991; Camp 2010].

## CONTEMPORARY MODEL

Omega House has remained untouched and off limits to visitors for decades. As such, it is an excellent example of how natural processes act upon an exposed archaeological site. In the summer of 2016, C. Wallace and D. Moullou photographed and 3D modelled the site initially in its natural condition and subsequently, after a moderate cleanup of vegetation in order to capture accurate "before" pictures and models. This was done using a 16,2 megapixel Sony A-35 DSLR with an 18-35 mm lens set at 18 mm. Pre-cleaning photography of the site consisted of 1.120 photographs of 4912 x 3264 pixels. Post cleanup involved 1.140 photographs at the same resolution.

The first modeling of the site was arranged having not seen it in its contemporary condition. Photography was done despite it being immediately apparent that the amount of vegetation was prohibitive to producing an accurate model featuring every detail of the site. Arrangements were made to have a cleanup done by the managing authorities. The subsequent modeling, while being more comprehensive and cohesive still involved areas that needed further clearing and better lines of site. After consultation with the Ephorate of Athens it was decided that the following spring a complete cleanup including preservation efforts in key areas would enhance the quality of the modeling and the ability to discern the features of the site.

In the summer of 2017 a high intensity 3D modeling study of Omega House was done with the assistance of Studio 727 from Bratislava, Slovakia, ASCSA architect James Herbst and the Ephorate of Athens. Months of preparation by the Ephorate involved removing all vegetation, trimming lower tree branches to provide better lines of sight for photography and surveying, and most importantly uncovering and preserving the mosaic in the pool area (triclinium) (Fig. 1. Omega House pool and mosaic: a) 2016; b) 2017). The mosaic has been under layers of soil for almost five decades and conservation efforts included removal of an approximately 3 meter marble column lying on top of it. That column was originally mounted at the entrance to the triclinium and can be seen in the original excavation

photographs. After the mosaic was cleaned and preserved for photography, it was sprayed with a fine mist in order to bring out the vibrancy of the tesserae's (tile's) colours (Fig. 2).



*Fig. 1. Omega House pool and mosaic: a) 2016; b) 2017.*



*Fig. 2. Mosaic in Nymphaeum - 3D model orthophoto during conservation.*

In the 1950's the Athenian Agora was planted with trees [Thompson and Griswold 1982], which have grown quite dense and tall. This presents difficulties in using known georeferencing markers for surveying due to blocked lines of sight. Despite these impediments, a survey of 12 points was completed using locations known to be unchanged since the site was first excavated. These coordinates were then applied to both the contemporary and retrospective models.

Surveying was done using a total station. GPS measurements were not available and there are no permanent survey markers within Omega house so permanent georeferencing points from the greater Agora area were referenced in relation to the 12 stable points within. During surveying, we did not use visual targets so that they would not show up in the photographs and modeling. Instead, we took numerous photographs, up close and at a distance, of the position of each surveyed point (example circled in Fig. 3). 526 photographs were taken for the sole purpose of recording the exact position of the survey points.



*Fig. 3. An example of one of the 526 survey positioning photographs taken.*

A total of 43,571 photographs were taken over a period of three days using a Nikon D800E and a Nikon D810; each with 36,3 megapixels and varying between Nikon 20 mm f/1,8, 24 mm f/1,4 and 14-24 mm f/2,8 lenses. It was decided to use 8 meter monopods for the photography rather than a drone due to some of the more complex aspects of the site as well as overhanging trees. This not only proved to be a more flexible method but also maintained a consistently high resolution to the photographs.

Due to intense sunlight with only sporadic cloud cover, a flash was used when photographing areas of intense light and shade in order to reduce contrast. This was further compensated for during processing using CapturingReality software which blended all of the exposures of varying light conditions. The resulting images with their lack of intense shadows produced superior results when compared to those produced in the 2016 modeling (using Agisoft Photoscan, which required disabling photographs that were taken in direct sunlight with high contrast shadows during the texturing process in order to produce a more homogenous result).

Despite the efforts of the Greek archaeological service in cleaning and clearing the site of vegetation, in the weeks preceding photography, unusually heavy rains caused an unseasonable resurgence of plant growth as well as filling all of the site's wells and low lying areas with water. The complex water systems of Omega House include four wells ranging from 3 meters to 11 meters deep. The wells are not all interconnected and needed to be pumped out separately using an electric pump in order to photograph and model them. The well in the peristyle was not emptied as it is covered with a marble column base. Photographing the deepest well (Fig. 4), adjacent to the bath area, required connecting two monopods and remotely activating the shutter as the camera was lowered and rotated. The well in the triclinium was photographed from above and through a side access (Fig. 5), capturing detail of what was once a fresco.



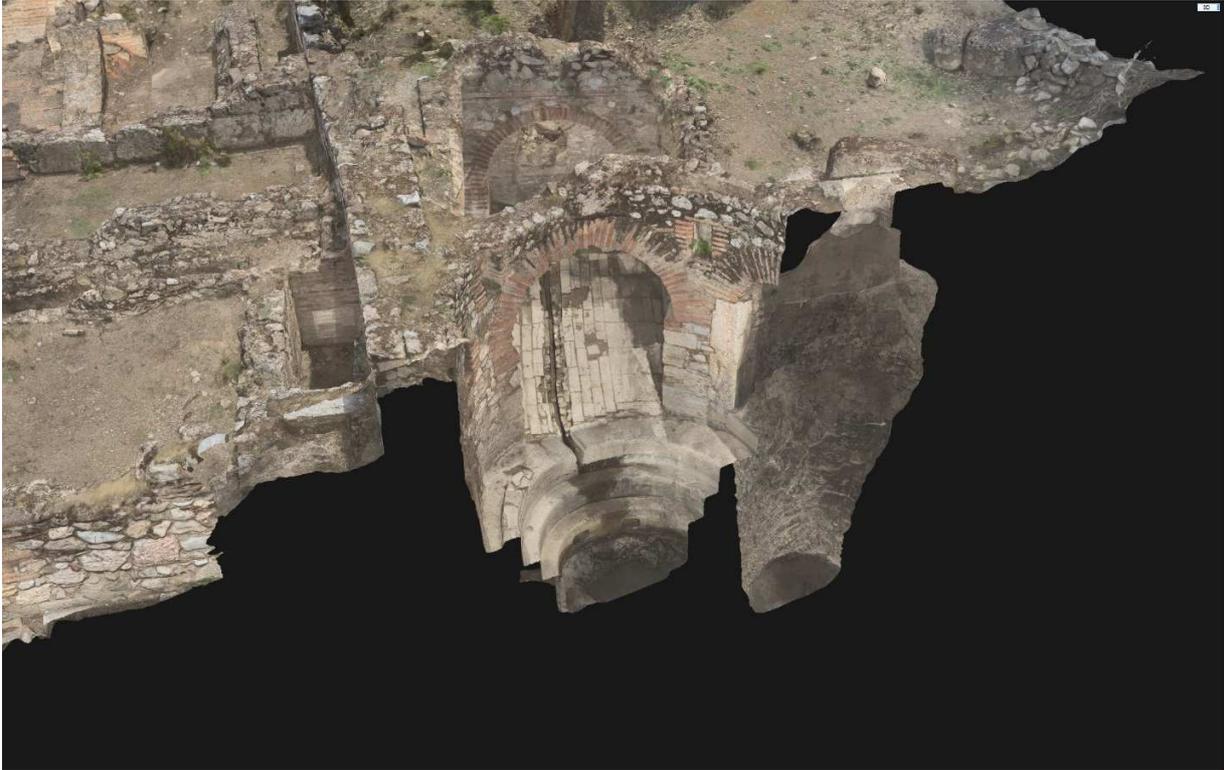
*Fig. 4. Central area of Omega House with cutaway showing the 11 meter deep well.*

37.150 of the 43.571 photographs taken were used in the modeling, which produced a finished model consisting of 3,9 million of polygons. The model processing time was five days using CapturingReality software on a Titan2 computer: Intel i7-5820K, 64GB RAM, 4x1TB RAID0 SSD, 2x4TB RAID0 HDD, 2x NVidia GTX 980.

During fieldwork, the base photographic distance was from 0,5 m to 2 m while the elevated photographic distance was from 2 m to 7 m. Our median GSD (Ground Sample Distance) (centimetres/pixel) was 0,04 cm/pixel or 0,4 mm/pixel. The final model was processed in normal mode downscale 2 to a GSD of 0,8 mm/pixel.

The accuracy of the model was calculated from the source images GSD. Camera registration was calculated on 66.667.549 tie points. The median reprojection had an error of 0,476593 pixels while the mean reprojection error was 0,418071 pixels. The resulting model error is below 1cm.

Every aspect of the site is now able to be examined and measured from within the model allowing highly accurate reconstruction of any features that might subsequently erode or otherwise deteriorate. While the 2017 modeling was more accurate due to better software, more photographs and the inclusion of surveying, comparison of the two models with just one year difference, documented areas that had deteriorated in the interim. With the contemporary modeling now completed we were now in a position to produce a retrospective model for comparison.



*Fig. 5. 3D model of fountain area with cutaway of well.*

## RETROSPECTIVE MODEL

Developing empirically accurate digital 3D models using archival photographs has been achieved successfully in an increasing number of projects. [Gruen et al. 2002; Falkingham et al. 2014; Discamps 2016; Peppas et al. 2018] “Photographs taken at the time of excavation are static and while informative, hold little quantifiable data. When multiple overlapping images were taken, this provides an opportunity for the photogrammetrist to produce three-dimensional models.” [Wallace 2017]. Photogrammetry has been used in architectural documentation for well over a century. With regard to conservation and restoration, as early as 1962, E. H. Thompson documented the efforts of a research team using archival photographs to calculate geometries to assist in the restoration of Castle Howard in Yorkshire, England. Their methods incorporated the use of architectural drawing prints but the scale was not of a level that could enhance the accuracy of their measurements. However, by incorporating plans and drawings retrospective 3D modeling as though they are all photographs, geometries within a digital model can be “pulled together”, leading to greater accuracy. This technique compensates for a lack of comprehensive photographic documentation on many archaeological sites. Fortunately some excavations were extensively documented and can provide opportunities for photogrammetric modeling.

Omega House is an excellent candidate for retrospective photogrammetry in that it was thoroughly documented during excavations, upon completion, and after partial backfilling. C. Wallace has been conducting retrospective photogrammetry for several years and the surveying and contemporary modeling of the Omega House site in the present day presented the opportunity to apply that data to the retrospective models in order to increase their accuracy.

A number of limitations became apparent when producing the model from archival photos. Primarily, the lack of camera calibration limits the number of software products that can be used to produce the model. Many of the current photogrammetric software programs will not run unless they are given calibration parameters so Agisoft Photoscan was chosen as it is capable of estimating calibration.

When using only archival photographs to create a 3D model, the overall error level increases proportionally with increases in the number of included photographs, because the software has difficulty in assimilating the diversity of the data and its sources.

Applying the survey points to the model significantly decreased the error in pixels (metric comparison is unavailable when no survey data is present). The next experimental step was to create a model combining archival and contemporary photographs along with the survey and then removing the contemporary photographs after the sparse cloud was achieved (Fig. 6). Producing a model with both archival and contemporary photographs using the same common survey points reduced the error from 0,548528 meters to 0,107097 meters (Table 1) with optimization for the contemporary camera. The above noted technique resulted in visibly straightened walls and enhanced clarity.

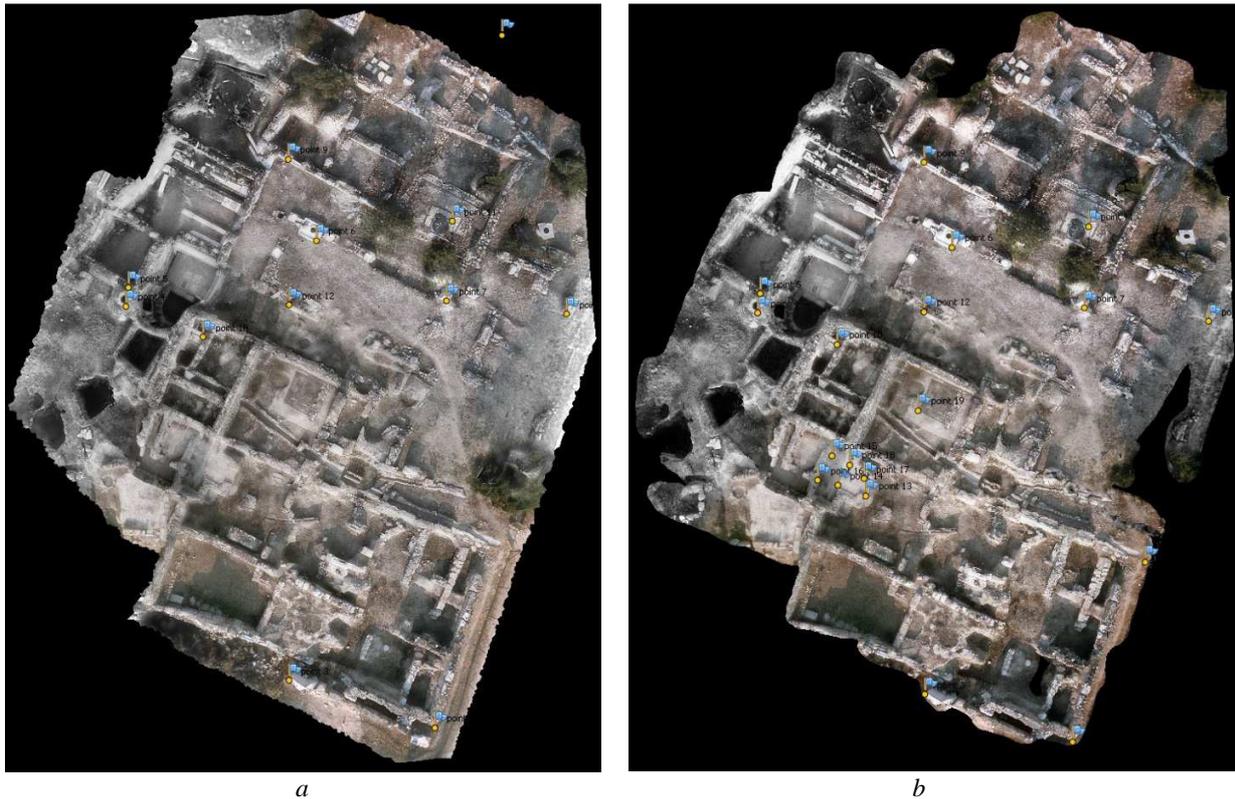


Fig. 6. Omega House: a) using survey coordinates; b) using survey coordinates and contemporary model.

This technique cannot be applied in all instances; for example when the site has been significantly damaged or even destroyed, but when possible, it can enhance the accuracy of the retrospective model.

While the retrospective modeling has not yet reached a level to be suitable for a VR environment, it is producing measurable results and some areas of the site which have better photo documentation, can produce models of higher accuracy.

Table 1 - Empirical effect of adding survey data and contemporary photographs to retrospective model

	Error (m)	Error (pixels)	Photos	Included photos	Points
Only control points	NA	12.122	221	15	4,796
With survey	0.548528	.85	242	12	7,526
With survey and contemporary model	0.107097	.642	553	11	9,243

In producing small scale archival 3D models, Discamps et al. [2016] found that “While the resolution and quality of archive 3D models is far from perfect, their coherent geometry makes them extremely useful field and lab documents, particularly in cases of sites with limited archival material.” The photographs used for the archival modeling of Omega House were made available through the ASCSA internet database and at the time of modeling it was unknown if the scans were done from original negatives or from paper prints. While accessing negatives would be highly preferable, a bigger problem was the variety of cropping, resolution and scanners involved in producing the photographs. It is our intention to take the quality in retrospective 3D modeling to a higher, more accurate and useable level. This includes gaining access to original negatives in order to control the detail and consistency of scans as well as removing further error inducing steps. As Thompson stated in the nineteen sixties “Having regard to all possible sources of error, it is very doubtful if we could have come anywhere near this accuracy had we been without the glass negatives and forced to use old paper prints.” [Thompson 1962]. The retrospective modeling, when compared to contemporary models showed how much loss of marble revetments, pitting of brickwork and overall deterioration of the site has occurred in ways that simply looking at two dimensional photographs does not achieve. The ability to view the site at the time of excavation from previously unphotographed angles significantly enhances the ability of conservators to assess deterioration and restoration.

### VIRTUAL REALITY MODEL

The 3D modeling of Omega House also allowed for the construction of a virtual reality (VR) model (Fig. 7) produced using Unity gaming software. The VR environment has two purposes. The first is to allow archaeologists, researchers, conservators and engineers to access the details of the site at any time from any place while studying or working on restoration planning.



*Fig. 7. Omega House aerial view in virtual environment.*

The second purpose of the VR model addresses the inaccessibility of the site. In its current condition, allowing visitors to enter the grounds of Omega House poses a danger to both them and the site itself. Within the virtual environment, every detail of the site can be accessed without jeopardizing either.

The model with textures for Unity VR constituted 72 million polygons and 16 textures with a resolution of 16,000 x 16,000 pixels each. Processing the model took one week. The computer used was a Kraken2: Intel i7-5820K, 64GB RAM, 4x1TB RAID0 SSD, 2x4TB RAID0 HDD, NVidia GTX 980Ti.

The Virtual environment, currently made for Windows PCs, runs at resolutions ranging from 640 x 480 to 1920 x 1080 with a choice of six levels of graphics quality, allowing it to be displayed on virtually any computer. Of course the realism of the experience is enhanced dramatically both when using a more powerful computer and when wearing immersive VR goggles.

While in the VR environment, users have an experience very similar to a first-person video game in which obstacles prevent movement, causing the user to move about in the environment just as they would have to in real life. Stairs can be climbed and precipices fallen off of. A bird's eye mode is also available in order to facilitate moving more easily through the site and to allow a greater range of viewing angles as well as for the users to extricate themselves after falling into wells or pools (Fig. 8); hazards which attest to the reasons for the site being unavailable for actual visitation.



Fig. 8. *Nymphaeum in virtual environment.*

Modeling the wells allows visitors who tour the site to access the wells virtually, when in reality such access would be dangerous or impossible. While it might be expected that the wells would be of little interest, in fact, they allow close viewing of features such as the transition from masonry to bedrock and hand cut foot holds in the bedrock to allow ingress and egress for building and maintenance.

Another feature of the VR environment is the ability to view statues *in situ*. The statues currently reside in the Stoa of Attalos and the model can be further enhanced by placing them in their proper context.

The Hellenic Ministry of Culture and Sports is currently working to facilitate presentation of the Omega House VR to the public. Not only will this allow people to visit the site while it is closed, but it will also allow access to the site during its restoration and further provides access to persons with physical disabilities.

## DISCUSSION

The models of Omega House that have been created, both contemporary and retrospective, will be used by the conservators to assess restoration and monitor erosion and also be made available to researchers who now can have unprecedented remote access to the site.

There are a number of current projects that monitor the ongoing deterioration of archaeological sites using photogrammetry [Fujii et al. 2009; Güimil-Fariña et al. 2016]. However most are specifically monitoring geological erosion and have only begun 3D documentation in recent years. We believe that 3D modeling those sites using archival photographs creates a broader temporal picture of their deterioration over time.

A secondary benefit of contemporary modeling of an exposed site like Omega House is the photographic archive it produces. In general, insisting on the photogrammetric documentation of any site ensures that it is properly photo documented with an infinite number of viewing angles available from the modeling. When an archaeological site is photographed without the intention of 3D modeling, features of greatest interest tend to be favoured. Later when the site has deteriorated or has been backfilled or destroyed, overlooked features can no longer be examined or used to create a retrospective model and knowledge can be lost forever.

In the near future a virtual reality exhibition will be installed in the Stoa of Attalos in the Athenian Agora showcasing Omega House as it is, giving virtual access while it is not accessible and during its restoration. After restoration is completed it will allow those who are physically unable to access it the opportunity to explore this historic landmark. Touring archaeological destinations in Greece is physically demanding due to the terrain and heat. With VR environments augmenting archaeological site visits, visitors with limited mobility can have a more fulfilling interaction, leaving them with a broader appreciation of what they have experienced and, as found by Bruno et al. [2010], inspiring them to visit other archaeological sites.

Work is continuing on a virtual reconstruction which will incorporate, where possible, the construction techniques, styles and textures of the original building (Fig. 9). We intend to add this to the contemporary VR and add a time shifting option for users to move from 2017 to 600 A. D. Similarly, we hope to add the post excavation modeling to the VR allowing users the option of walking through the site in 1972.

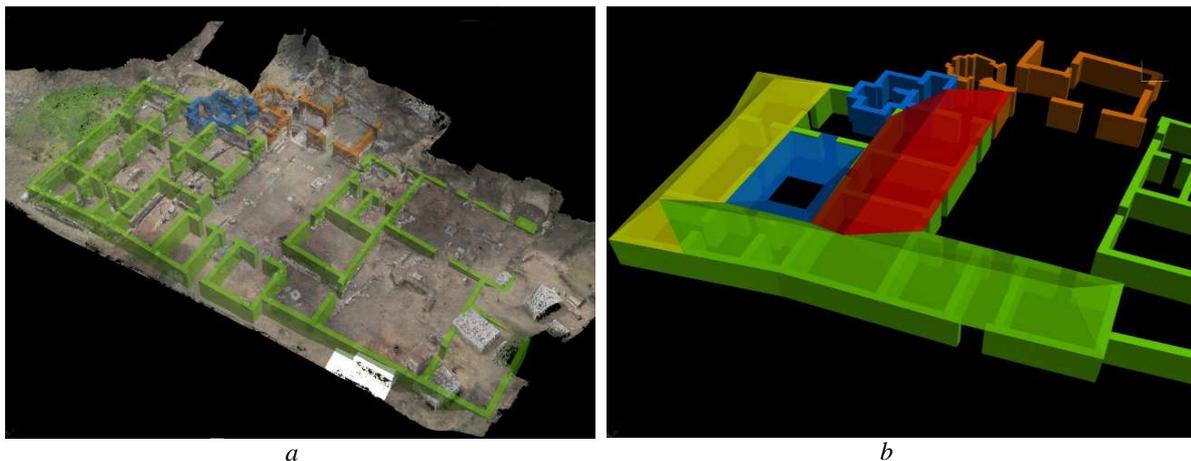


Fig. 9. Planned reconstruction of Omega House with a) wall reconstructions and b) possible roof configurations.

## CONCLUSIONS

Physically revisiting a previously excavated and documented archaeological site such as the Omega House not only provides accurate contemporary documentation but also makes a significant impact on the accuracy of retrospective photogrammetric modeling. Introducing accurate coordinates for known stable features makes the archival photographs more cohesive and in many cases allows previously rejected photographs to be accepted into the model. Additionally, being able to model portions of the site that have not changed allows for disparate archival photographs to be linked and modeled.

With regard to the retrospective 3D modeling; while it has reached a level at which it is attaining accuracy, there is much more that can be done. What has become apparent in approaching a number of retrospective projects is that during the process between the initial photography and the final modeling, each step introduces new levels of error. Our next actions will be to introduce measures that remove or reduce each of those errors.

Finally, the current VR model serves to create unprecedented access to this site, where both visitors and scholars can view the site from any location, defying financial or physical limitations. This creates greater exposure and public outreach.

It is our view that the successful use of these methods will not only benefit the preservation and restoration of Omega House, but will also be applicable to other sites for their conservation and in allowing the public to have a broader experience of monuments and sites that are not accessible. Furthermore, it provides an opportunity for scholars to remotely study historical sites.

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## REFERENCES

- Fabio Bruno, Stefano Bruno, Giovanna DeSensi, Maria-Laura Luchia and Maurizio Muzzupappa. 2010. From 3D reconstruction to virtual reality: A complete methodology for digital archaeological exhibition. *Journal of Cultural Heritage*, Volume 11, Issue 1, January–March 2010, 42-49.
- John Mck. Camp II. 1989. The philosophical Schools of Roman Athens. *Bulletin Supplement* (University of London. Institute of Classical Studies), no. 55 (1989): 50-55. <http://www.jstor.org/stable/43768502>.
- John Mck. Camp II. 2010. *The Athenian Agora Site Guide*, The American School of Classical Studies, Princeton, New Jersey.
- Emmanuel Discamps, Xavier Muth, Brad Gravina, François Lacrampe-Cuyaubère, Jean-Pierre Chadelle, Jean-Philippe Faivre and Bruno Maureille. 2016. Photogrammetry as a tool for integrating archival data in archaeological fieldwork: examples from the Middle palaeolithic sites of Combe-Grenal, Le Moustier, and Regourdou. *Journal of Archaeological Science: Reports*. 8, 268-276.
- Peter L. Falkingham, Karl T. Bates and James O. Farlow. 2014. Historical Photogrammetry: Bird's Paluxy River Dinosaur Chase Sequence Digitally Reconstructed as It Was prior to Excavation 70 Years Ago. *PLOS ONE* 9(4): e93247. DOI: 10.1371/journal.pone.0093247
- Alison Franz. 1988. Late Antiquity: A.D. 267-700, *The Athenian Agora*, vol. XXIV, The American School of Classical Studies, Princeton, New Jersey.
- Yukiyasu Fujii, Enrico Fodde, Kunio Watanabe and Kazuya Murakami. 2009. Digital photogrammetry for the documentation of structural damage in earthen archaeological sites: The case of Ajina Tapa, Tajikistan, *Engineering Geology*, Volume 105 ( 1–2), 124-133.
- Armin Gruen, Fabio Remondino and Li Zhang, 2002, Reconstruction of the Great Buddha of Bamiyan, Afghanistan, *International Archives of Photogrammetry and Remote Sensing*, 34(5), 363-368.
- Alejandro Güimil-Fariña, Patricia Mañana-Borrazás, Elias Lopez-Romero, Marie-Yvane Daire. eds Hans Kamermans, Wieke de Neef, Chiara Piccoli, Axel G. Posluschny and Roberto Scopigno. 2016. Archaeology and coastal erosion: monitoring change through 3D digital techniques. Proceedings of the XVII UISPP World Congress (1–7 September 2014, Burgos, Spain). Oxford: Archaeopress. 89-97.
- M. V. Peppas, J. P. Mills, K. D. Fieber, I. Haynes, S. Turner, A. Turner, M. Douglas and P. G. Bryan. 2018. Archaeological Feature Detection from Archive Aerial Photography with a SfM-MVS Image Enhancement Pipeline, *The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, 42(2), 869-875, ISPRS Technical Commission II Symposium 2018 “Toward Photogrammetry 2020”, 3-7 June 2018, Riva del Garda (Italy), 869-875.
- Linda Jones Roccas. 1991. Athena from a House on the Areopagus. *Hesperia: The Journal of the American School of Classical Studies at Athens* 60, no. 3, 397-410. <http://www.jstor.org/stable/148073>.
- Helena Rua and Pedro Alvito. 2011. Living The Past: 3D Models, Virtual Reality And Game Engines As Tools For

- Supporting Archaeology And The Reconstruction Of Cultural Heritage – The Case-Study Of The Roman Villa Of Casal De Freiria, *Journal of Archaeological Science*, Volume 38, Issue 12, December 2011, Pages 3296-3308.
- Dorothy Burr Thompson and Ralph E. Griswold. 1982. *Excavations of the Athenian Agora Picture Book No. 8*, American School of Classical Studies at Athens.
- E.H. Thompson. 1962. Photogrammetry in the Restoration of Castle Howard. *The Photogrammetric Record*, 4,94-119. DOI:10.1111/j.1477-9730.1962.tb00334.x
- Ioannis Travlos. 1993. *Poleodomiki Ekseliksisis ton Athinon*, Kapon Publications, Athens.
- Kleio Tsogka. 2014. *I Oikia Omega sti boreia kliti tou Areiou Pagou. Protasi apokatastasis, sintirisis kai anadeiksisis*, MA Thesis, School of Architecture NTUA, Athens.
- Colin Wallace. 2017. Retrospective Photogrammetry in Greek Archaeology. *Studies in Digital Heritage*, 1(2), 607-626, DOI: <https://doi.org/10.14434/sdh.v1i2.23251>.

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