

Factum Foundation's Involvement and Activities in ARCHiVe

May 2020 - May 2021



Factum Foundation has kept working at ARCHiVe during the Covid-19 pandemic except for the short time the whole of the Fondazione Giorgio Cini was closed. The size of the team has varied up to a maximum of 4 when the recording of the island was taking place. The people who have been involved are: Adam Lowe, Carlos Bayod, Guendalina Damone, Ferdinand Saumarez Smith, Dani Trew, Otto Lowe, Pedro Miró, Emanuele Zampieri, Voula Paraskevi Natsi, Gabriel Scarpa, Teresa Casado and Casilda Ybarra.

We have been dependent on both local support and wide-ranging interest in the work we are doing. We are especially grateful to everyone at the Fondazione Giorgio Cini and all those who have provided help and support in different ways.

Factum Foundation is committed to the potential of digital recording and analysis applied to cultural heritage. It is transforming the way diverse forms of heritage can be studied, valued, preserved, monitored and shared. 2021-2022 is a very exciting year for ARCHiVe with a general understanding of the way that a centre like ARCHiVe can move effectively and fast to transform the role of culture within society.

This document presents a summary of the projects carried out by the Factum Foundation in ARCHiVe since May 2020. Some of these projects have been completed. Some are ongoing. All projects have been developed by Factum Foundation and have involved, to greater and lesser degrees, the structure that has been established at ARCHiVe.

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05. Recording Raphael tapestries in Mantua
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RECORDING

01. Recording the Island of San Giorgio Maggiore

June 2020 - processing in progress

From 6th to 17th July 2020, a team from Factum Foundation spent twelve days in Venice recording the Island of San Giorgio Maggiore. The main buildings on the island were recorded but the gardens, swimming pool, residencia and Theatro Verde were left for the next trip.

This ground-breaking ARCHiVe project, linked with EPFL's DHLab/Venice Time Machine, involved the collaboration of Factum Foundation, the Fondazione Giorgio Cini and Ecole Polytechnique Fédérale de Lausanne (EPFL). The French drone recording specialists Iconem were involved but were unable to be present when the recording took place. As a result the drone work still needs to be carried out. The aim was to demonstrate that technologies such as aerial and ground-based photogrammetry and LiDAR recording could eventually be used to record the whole of Venice at millimetric and sub millimetric accuracy.

After the acqua alta in November 2019 reached the highest recorded level in fifty years, ARCHiVe's aim was to efficiently and effectively record the island to aid the preservation of Venice's fragile cultural and natural heritage. Swiftly convened discussions between the partner institutions led to this project being undertaken as soon as the COVID-19 emergency allowed the respective teams to travel.

The first phase of the project involved recording the Basilica of San Giorgio Maggiore. To do this, Factum Foundation's Pedro Mirò, Otto Lowe and Emanuele Zampieri, employed LiDAR scanning (using a Leica RTC360) and ground-based photogrammetry (using a Sony A7Riv camera). The work started with the recording of the interior of the Palladian church, the apse and the inside of the bell tower, while the following days were dedicated to the exterior of the church and the crypt. Factum's team worked alongside three graduates from EPFL sharing information and comparing results. The selected focused areas for recording include:

- Basilica of San Giorgio Maggiore
- Longhena Staircase and Refectory
- Library and Presidential Rooms
- Cloisters, Borges Labyrinth and Gardens

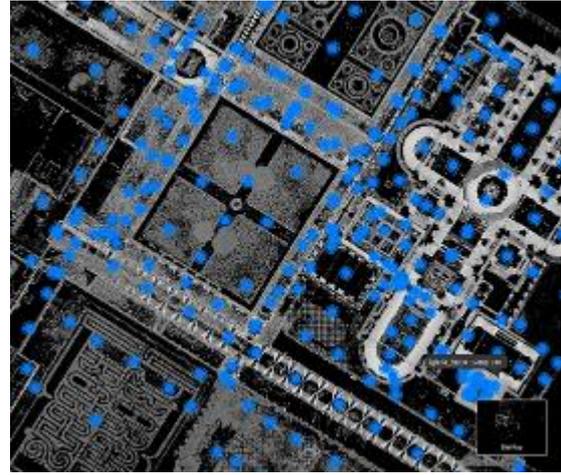
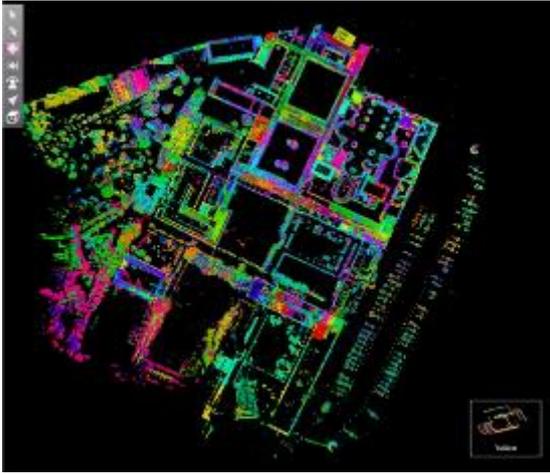
With the Leica the island was recorded from more than 600 different recording spots, from which a massive 60,000 million-point cloud was generated. The LiDAR data was backup up with high-resolution photogrammetry. The two datasets are currently being merged to produce an accurate model that can be used in various ways. It is already being used by Massimo Altieri and the Cini to study the cracks in the presidential area prior to their restoration. Additional information:

Video of the first processing of the (unfinished) 3D model of the Longhena Staircase:

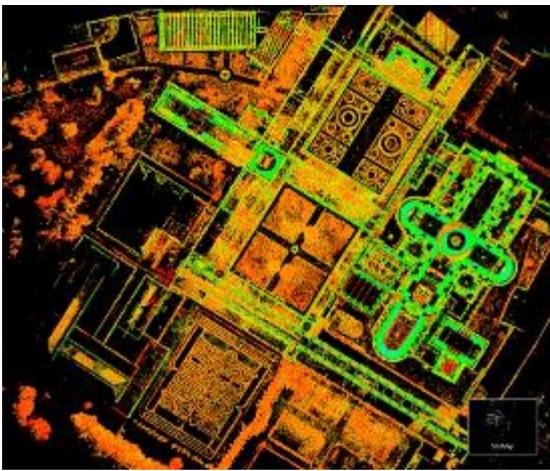
<https://vimeo.com/477490248>

3D model of the bust of Ezra Pound by Henri Gaudier-Brezka (authorized copy by Isamu Noguchi), one of the contemporary sculptures in the Fondazione Cini's courtyards:

<https://vimeo.com/477490278>



Top plan view of the Island of San Giorgio Maggiore; Section of the plan view showing the different recording spots



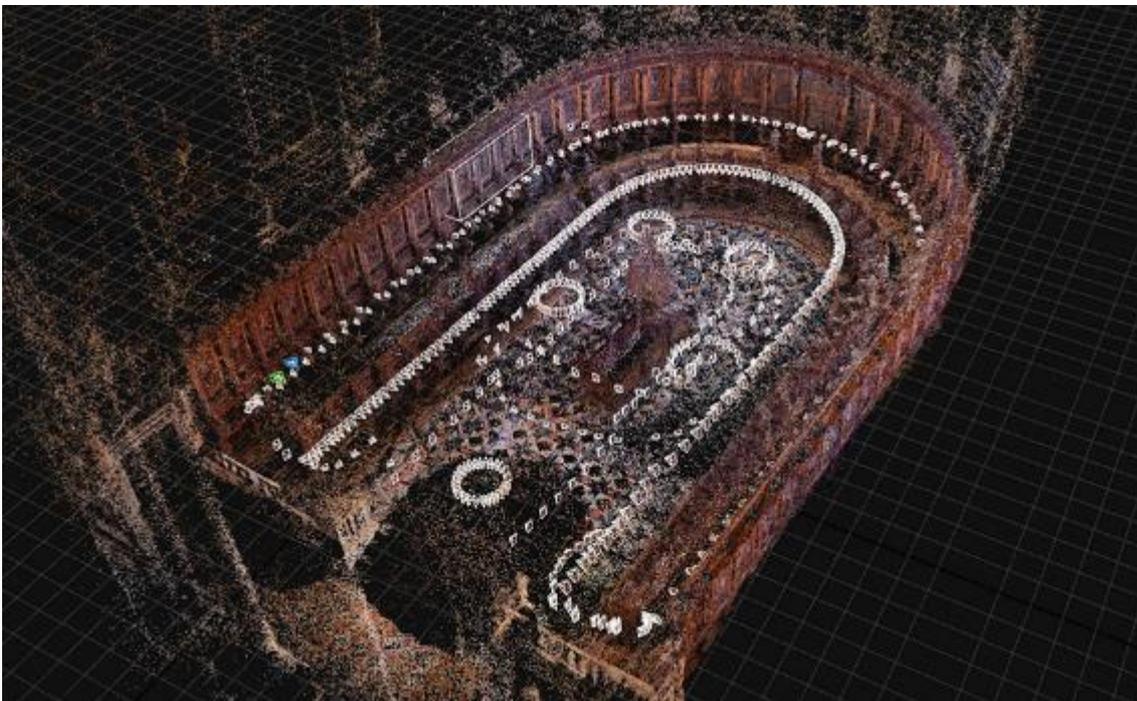
Depth map of the island; Recording the façade of the Basilica of San Giorgio Maggiore



3D model (left) and render (right) of one of the statues on the façade



Recording the altar inside the Basilica of San Giorgio Maggiore; 3D model of the San Giorgio Maggiore altar



Point-cloud of the apse with the camera positions marked in white



Recording the altar and the lectern; 3D model of the lectern



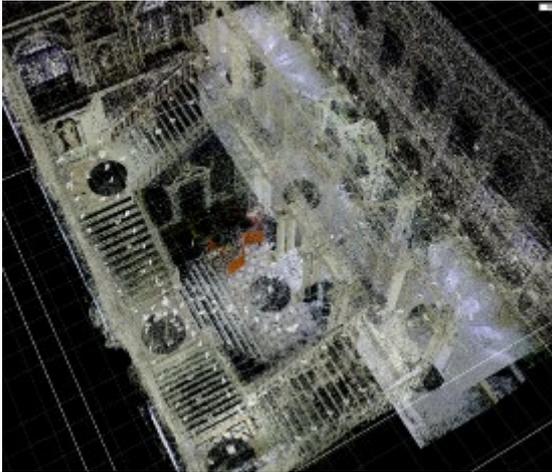
3D model of the choir and lectern



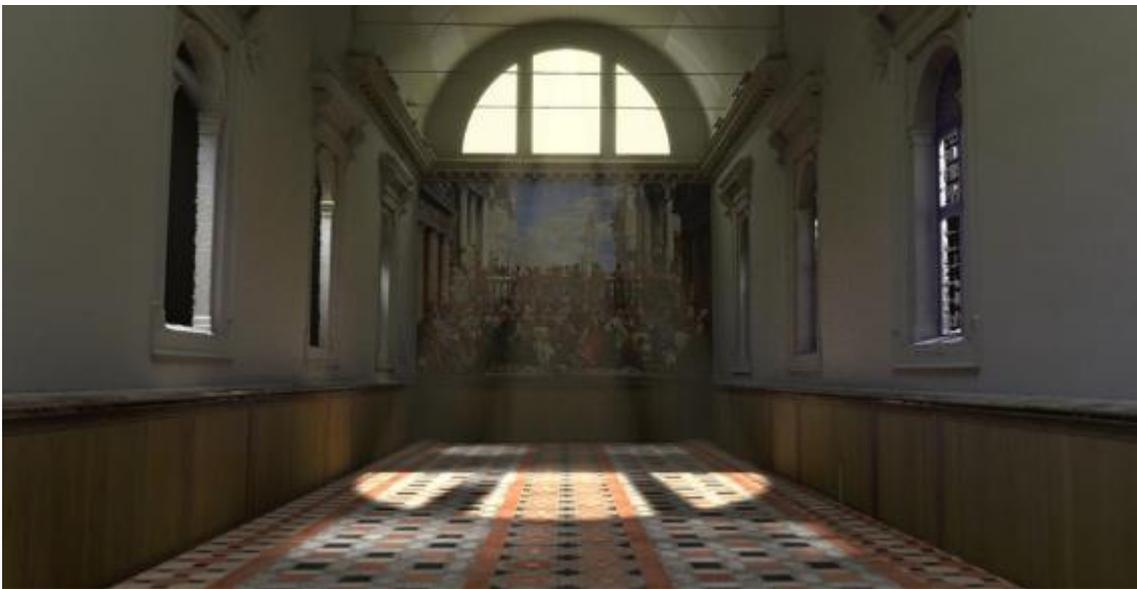
Point cloud of the inside of the flooded crypt; Recording the Longhena Staircase



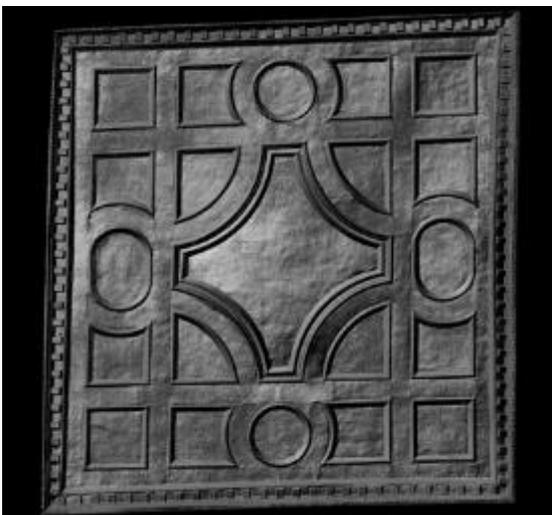
The data acquired with photogrammetry was merged to the LiDAR dataset, creating a 3D model of the Staircase



Point-cloud render of the Longhena Staircase; recording the 'Manica Lunga' library with a LiDAR scanner



3D reconstruction of the palladian refectory of San Giorgio, housing Factum Arte's facsimile of 'The Wedding at Cana' by Veronese made in 2007. The lantern window is speculative and floor extends the floor into the space using data recorded of the tiles on the floor in the Longhena Staircase.



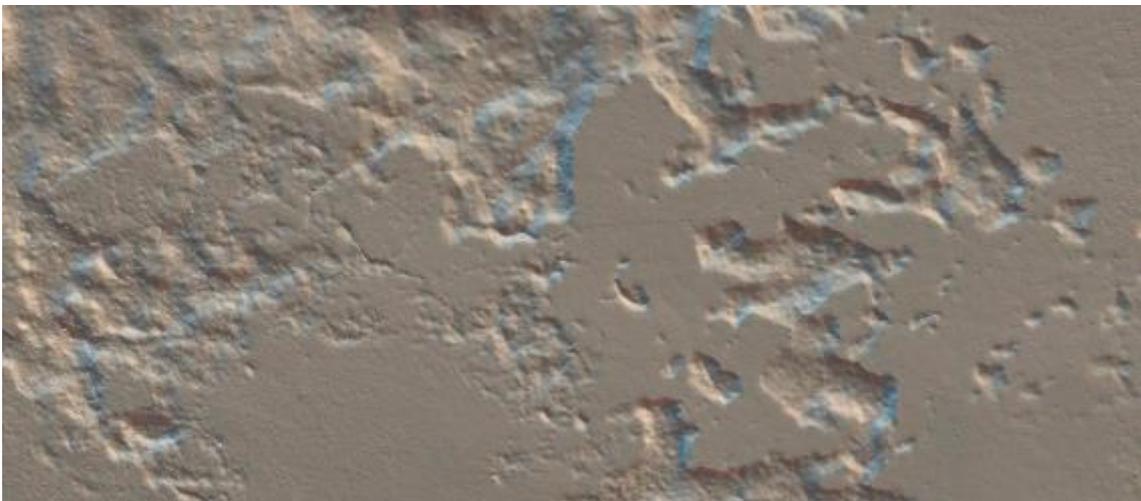
3D model of the Sala del Soffitto's ceiling without colour (left) and with colour (right)



Point cloud of the Borges Labyrinth



Point cloud of the cloister of San Giorgio Maggiore; Point cloud of the damaged walls of the cloister



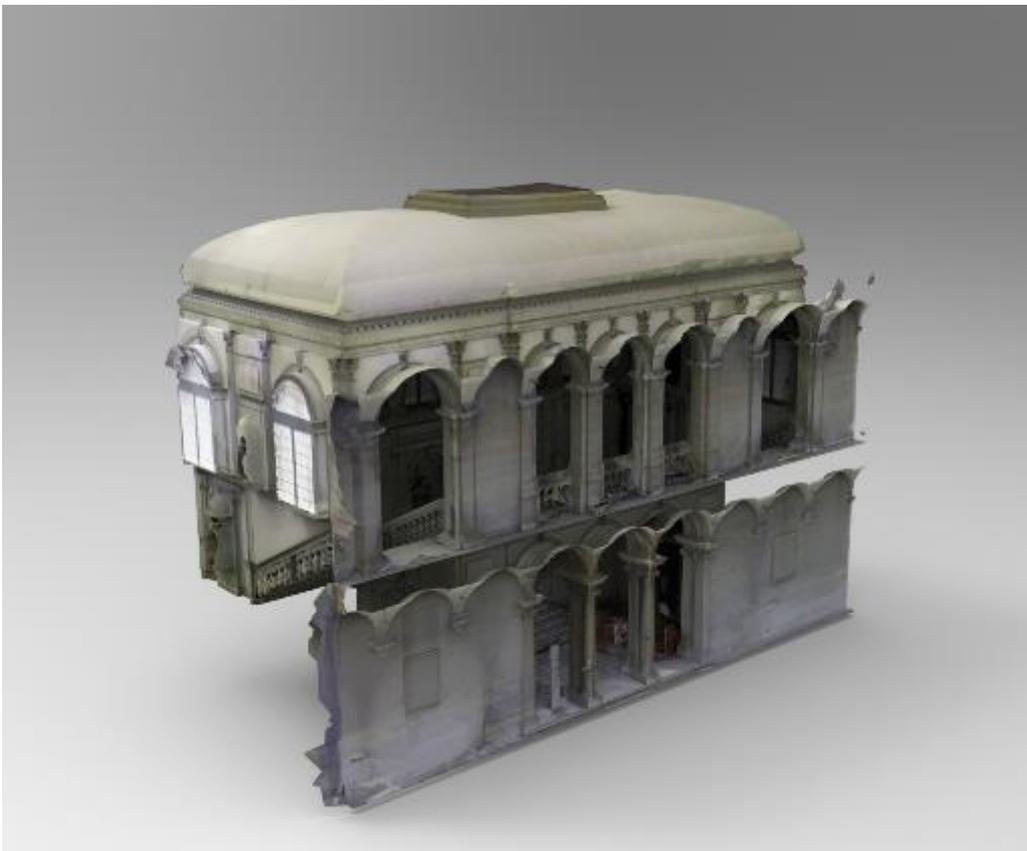
An actual size point cloud of the damaged walls of the cloister showing the resolution of the scan(detail)

The following renders have been generated from the Lidar 3D data:









Press coverage of the project:



[*Sunken Treasures*](#)

(Project Management Institute, March-April 2021)



[*Cutting-Edge Technologies are being used to help save Venice*](#)

(Architectural Digest, October 2020)



[*New technologies might save Venice's cultural heritage from the floods*](#)

(ArchDaily, October 2020)



[*Preserving the floating city of Venice digitally*](#)

(The World, September 2020)



THE ART NEWSPAPER

[*New laser-scanning project will allow Venice to live on forever as a digital avatar*](#)

(The Art Newspaper, September 2020)



IL GIORNALE DELL'ARTE

[*La Magnifica Preda*](#)

(Il Giornale dell'Arte, September 2020)



[*Un visionario sull'isola di Borges*](#)

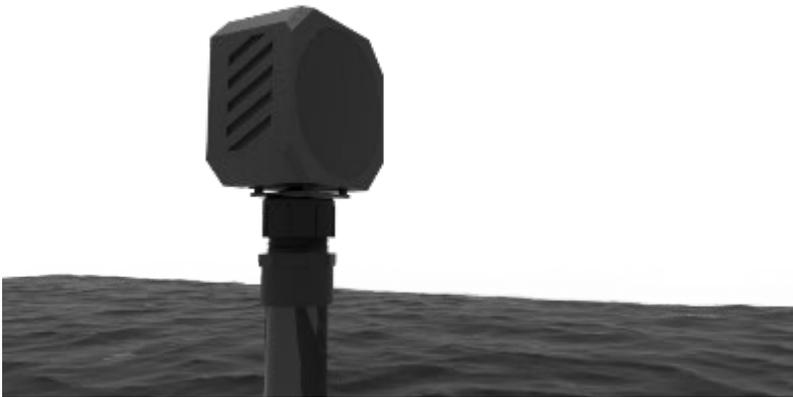
(Il Giornale dell'Arte, Vernissage, July-August 2020)

02. Monitoring the Island with Divirod

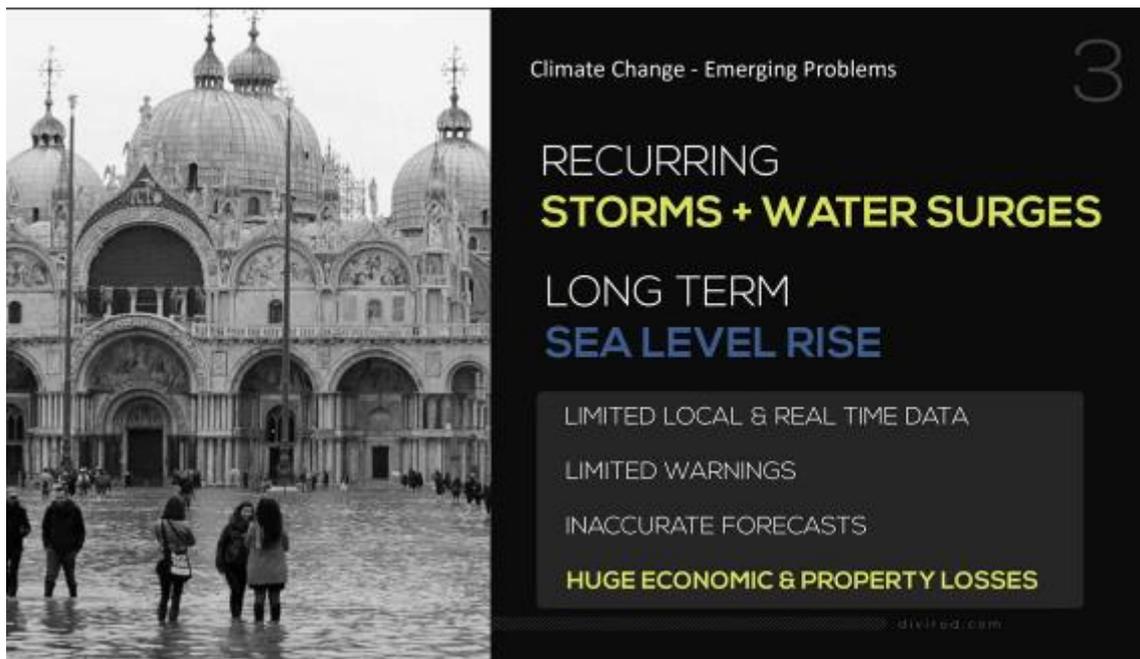
September 2020 - in progress

Following a radio programme on the project of digitizing the Island of San Giorgio (The World, September 2020), Factum Foundation was contacted by a start-up from Boulder, Colorado, called Divirod. They have developed a laser sensor that uses existing satellite data to generate hydrological models that are accurate to about 1 mm, using harmonic recordings to create models of tide, wave activity, erosion, flooding.

Based on the high-profile recording of San Giorgio Maggiore, Divirod have agreed to provide one of their advanced sensors to monitor the relationship between land and water on the island, with the data being accessible in real time on desktop and mobile devices. The sensor is currently being tested in Italy prior to its installation.



Rendered image of one of the Divirod sensors

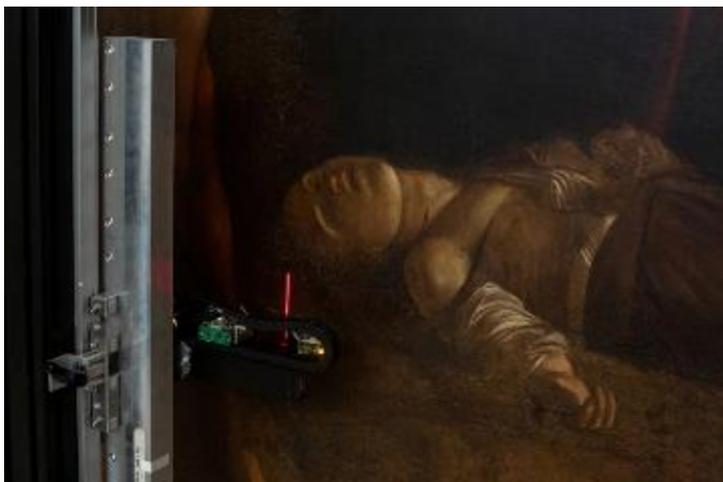


Screen capture of Divirod's website

03. Recording Caravaggio's *Burial of Saint Lucy*

June 2020

Factum Foundation carried out the recording of Caravaggio's *Burial of St. Lucy* in the Chiesa di Santa Lucia alla Badia, Syracuse, between the 24th and the 30th of June 2020. The work was carried out by a team of photographers and 3D scanning operators from Factum and ARCHiVe. The 3D data was processed in ARCHiVe.



This large painting, which originally belonged to the Basilica di Santa Lucia al Sepolcro but was moved to its current location in Ortigia, was commissioned from Caravaggio while he was in Syracuse. The painter fled Malta in 1608 after his expulsion from the Order of the Knights of Malta, arriving in Sicily in October. There, he was offered protection by the local Senate of Syracuse and given the prestigious commission to create an altarpiece dedicated to St. Lucy, the highly revered patron saint of the city. The painting depicts the saint's entombment after her execution, which according to legend happened in Syracuse - where her body was allegedly kept in the city's catacombs. The work was probably unveiled during the celebrations dedicated to St. Lucy on December 13th and represents the start of the final chapter of Caravaggio's work, produced as he moved between Syracuse, Messina and Palermo before his departure from the island and death in 1610.

The painting was recorded with a combination of panoramic and composite photography, close-range photogrammetry and Lucida 3D Scanning. High-resolution information of the surface was obtained with some compromise as a result of the movement of air in the church, the limitations imposed by the authorities and the scale of the painting. As with all paintings movement of the surface is registered as noise in the data. In this case every time the church door was opened the canvas, positioned in the middle of the space, flapped against the stretcher. The resulting colour and 3D information can be inspected in this multi-layered viewer:

http://www.highres.factum-arte.org/Caravaggio_%20Burial_of_St_Lucy/shared/viewer.html

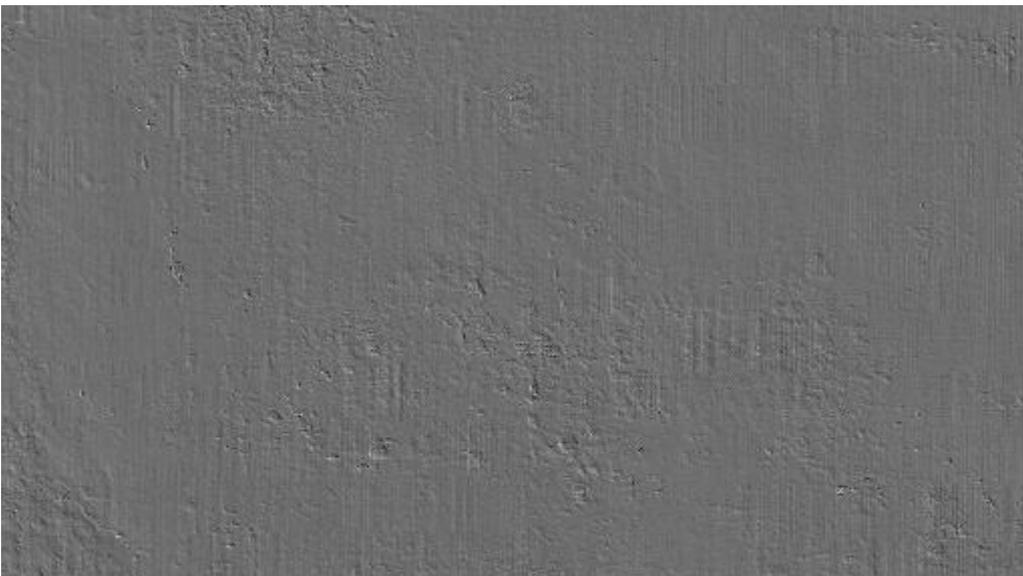
Permissions were granted by the FEC (Fondo Edifici di Culto), to which the digital data now belongs. The recording was conducted at the request Vittorio Sgarbi and Peter Glidewell for MART in Rovereto. (For more information about the creation of a facsimile and the exhibition at MART see the section EXHIBITIONS, from page 71)



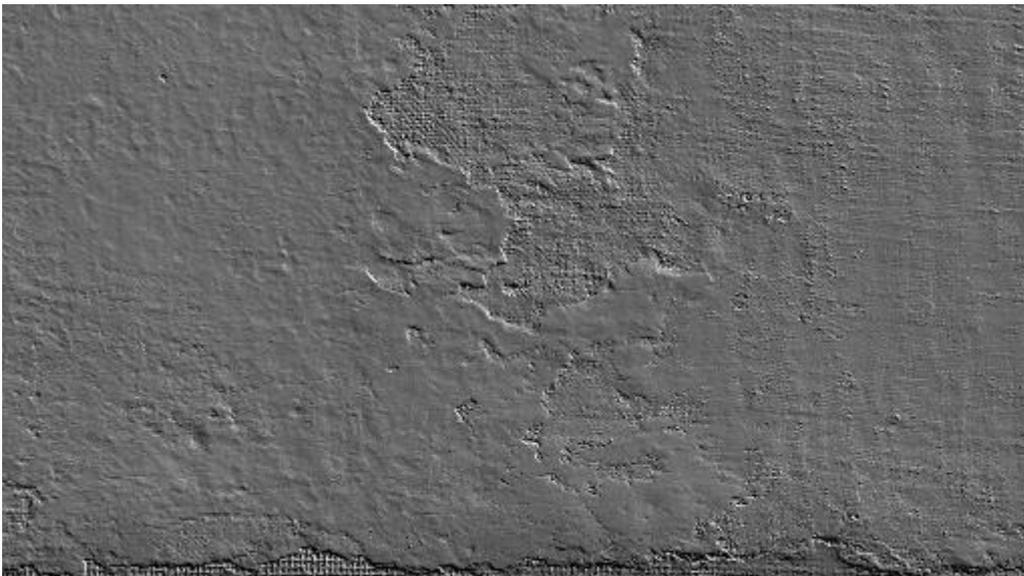
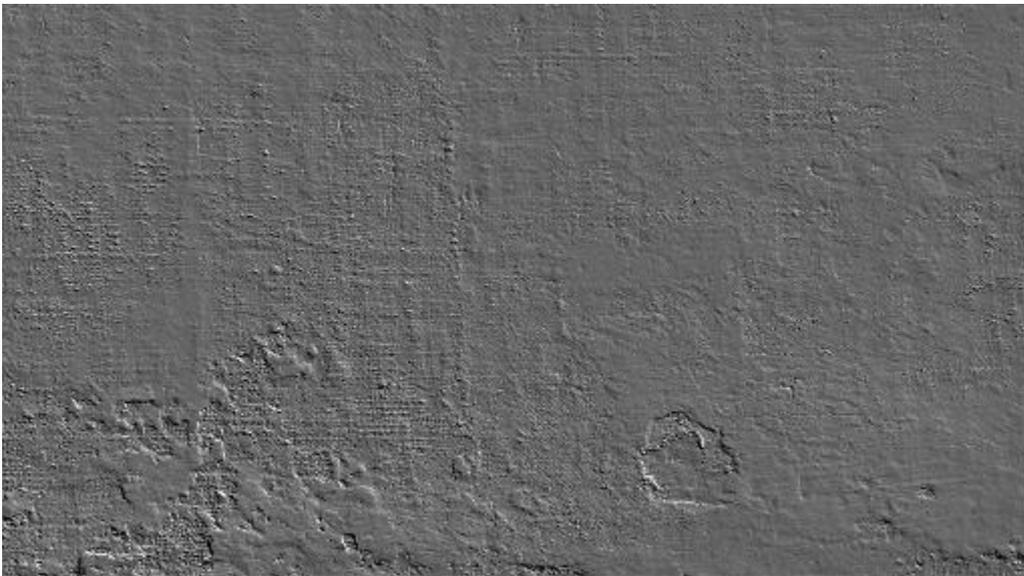
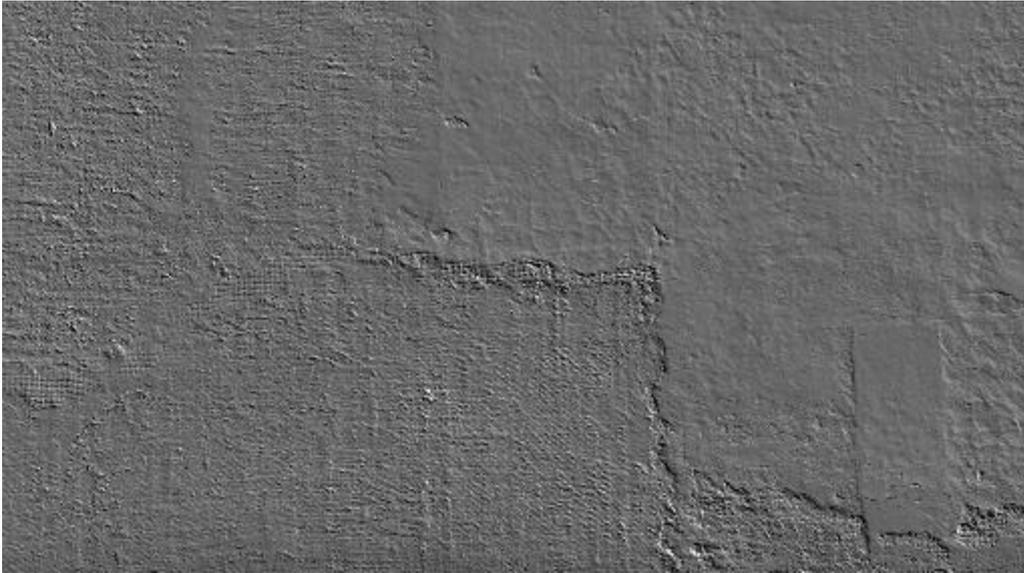
The Lucida 3D Scanner recording the surface relief of the lower section of the painting



Recording the colour and surface relief with close-range photogrammetry



Above: photograph of the painting's lower section; Below: details of Saint Lucy's head in colour and 3D relief



Shaded renders of surface relief details recorded with the Lucida 3D Scanner

04. Recording Tiepolo at Ca' Rezzonico

July 2020

The 18th century Venetian museum known as Ca' Rezzonico is rich in sculptures, paintings, furniture, frescoes and furnishings in the Baroque style. The palazzo is home to some of the great frescoes painted by Giambattista Tiepolo including the *Wedding Allegory*.



In July 2020 a team of Factum Foundation carried out the recording of the *Wedding Allegory* by Tiepolo and a decorative gilt frame, to demonstrate to Fondazione Venezia Musei the important role digital technology can play in the creation of permanent public records and in a new approach to sharing 'Online'. The recording demonstrated what high-resolution panoramic composite photography can achieve in a relatively simple and unobtrusive manner. While the building and its contents have physical impact, digital data can facilitate in-depth study and access to people not physically present in Venice. The global pandemic has had serious impacts on tourism and visitor numbers. Access to this kind of high-resolution data stimulates discussion and interest and will attract new visitors.

The colour information of *Allegoria nuziale* can be seen with this browser in high resolution:
http://www.highres.factum-arte.org/Allegoria_Nuziale_Ludovico_Tiepolo/shared/viewer.html





Details of the colour information of Tiepolo's ceiling, as can be inspected with the online browser. The colour panorama has a resolution of 600 dpi at 1:1 scale and a file size of 77 Gb

05. Recording Raphael tapestries in Mantua

February 2021 - processing in progress

During the last week of February, the Factum Foundation team at ARCHiVe recorded the tapestry of *The Sacrifice at Lystra* at Palazzo Ducale in Mantua. The recording, arranged with Arnold Nesselrath and the curator at Palazzo Ducale, is part of the ongoing research into the production of tapestries and the cartoons from which they were made.



The tapestry, measuring 5 x 7 m, was recorded with close-range photogrammetry in order to obtain high-resolution data of its colour and its surface relief. The recording consists of a mosaic of images made using parallel recording that was carried out from a scaffold at a constant distance, while the tapestry was mounted on the wall. The recording was done before cleaning.

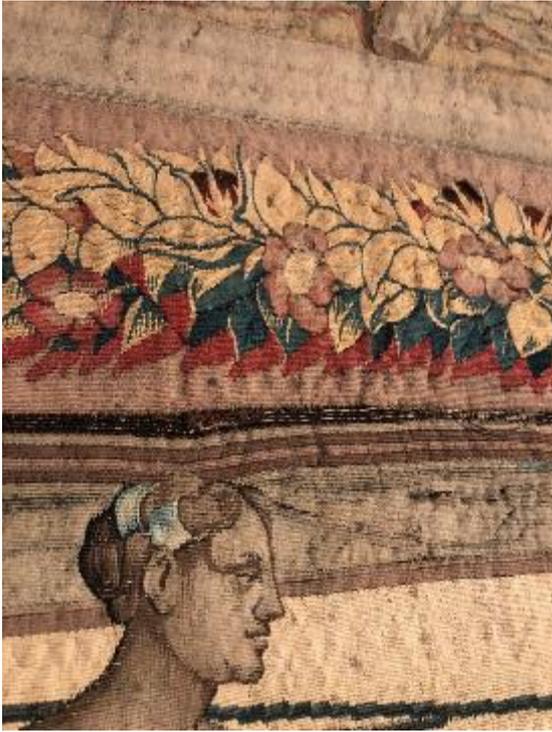
The capture of shape, texture and colour with the same system avoids the need of registering layers in the post-processing phase but sacrifices some detail. With a tapestry this is a pragmatic approach. The goal is to capture as much information as possible with little or no noise. Further recording is expected once the tapestry is removed from the wall and laid horizontally as part of an ongoing cleaning and conservation process. The recording of the tapestry's surface horizontally will be of great use to evaluate the changes in shape and stress on the tapestry while it is hanging.

The data from the high-resolution recording in 3D, colour and infrared of the Raphael Cartoons, carried out by Factum Foundation in 2019 at the V&A (that was partly recorded and processed by the ARCHiVe team), was officially launched on the V&A's website in February 2021: <https://www.vam.ac.uk/collections/raphael-cartoons>

We hope the recording of the tapestry of the *Sacrifice at Lystra* in Mantua will launch a digital humanities research project by ARCHiVe focused on the relationship between the cartoons in the V&A and those held elsewhere and the production of the different tapestries.



Detail of *The Sacrifice at Lystra* by Raphael



Details of the surface texture of the tapestry *The Sacrifice at Lystra*

06. Telamoni of the Biblioteca di San Zanipolo

(Agreement reached: recording dates to be confirmed)

Dr Mario Po' and Dr Frederick Lauritzen at the Scuola Grande di San Marco, Venice, reached out to Factum Foundation for a possible project to 3D scan and produce facsimiles of a series of *telamoni* by the Venetian sculptor Giovanni Battista Piazzetta, that formerly decorated the Biblioteca di San Zanipolo.



Former location of the *telamone* in the library; Present view of the room as a lecture theatre

07. Recording Carpaccio at Museo Correr

November 2020 - ongoing



Factum Foundation has initiated an ambitious project involving the use of digital technologies for recording and re-materialization of a divided panel painting by Carpaccio – the aim is to reunify the panels and analyse the missing area. The painting known as *Two Venetian Ladies* (c. 1490), located at the Museo Correr in Venice, is the lower half of a larger panel that was cut down, possible on each side and in the middle. The upper half being *Hunting on the Lagoon*, is at the J. Paul Getty Museum in Los Angeles, California.



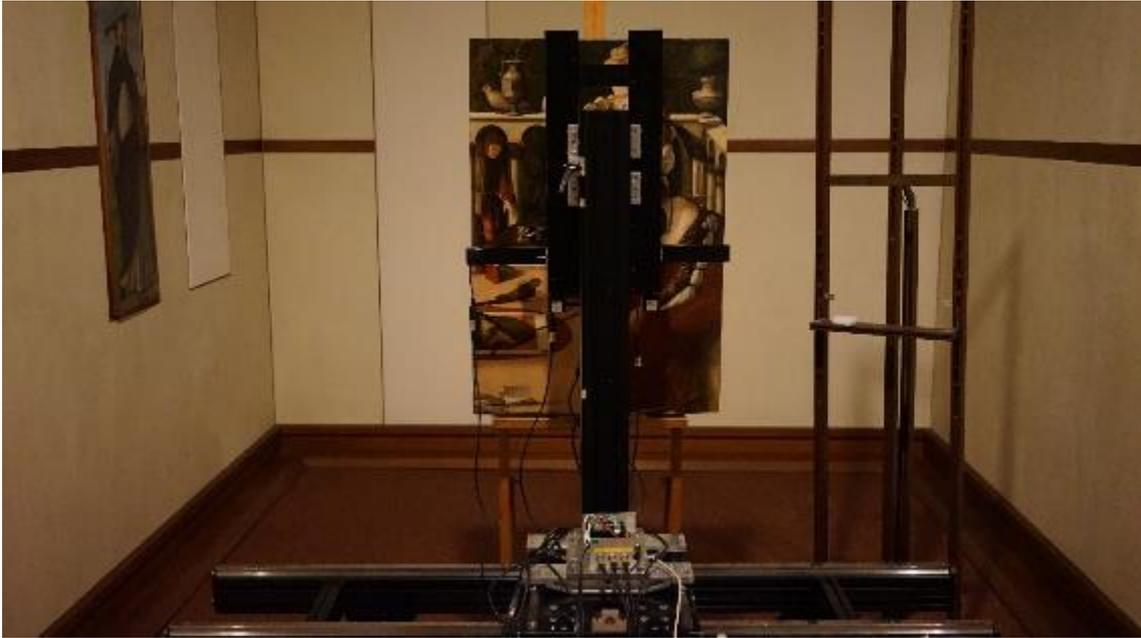
The project that has been discussed with both institutions requires high-resolution 3D and colour recording of each panel. This data will then be used in order to re-unite the complete panel as a facsimile allowing both institutions to contextualise their fragments. The digital data obtained from each panel will be given to each institution, and the facsimile(s) could be part of temporary exhibitions or permanent installations.

The panel at the Getty Museum will be recorded on California soon. Conversations are being held with the Getty curator Davide Gasparotto, who has received the idea with enthusiasm and is willing to participate.

The panel at the Museo Correr was recorded in November 2020 with the assistance of Arteria. The panel was taken out of its protective case and placed on an easel, so that the full surface was exposed. by a team from ARCHiVe, using the Lucida 3D Scanner and composite photography, and the data was processed in ARCHiVe.

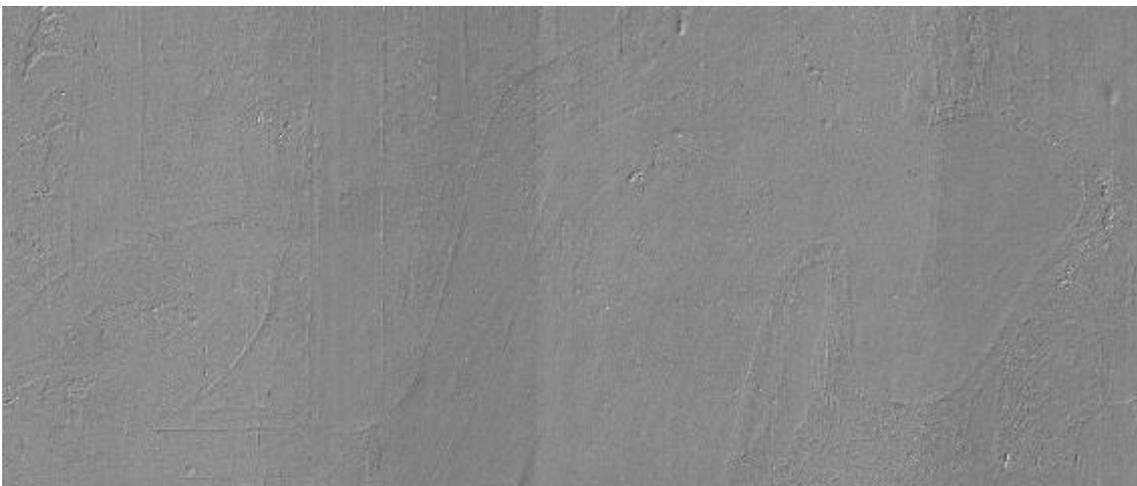
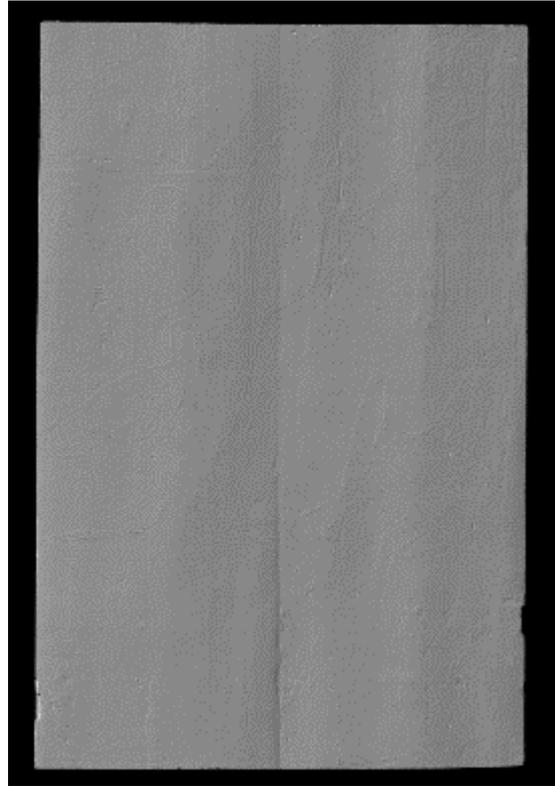


Stages in the preparation of the panel for recording at the Museo Correr



The Lucida 3D Scanner recording the surface relief of the panel painting

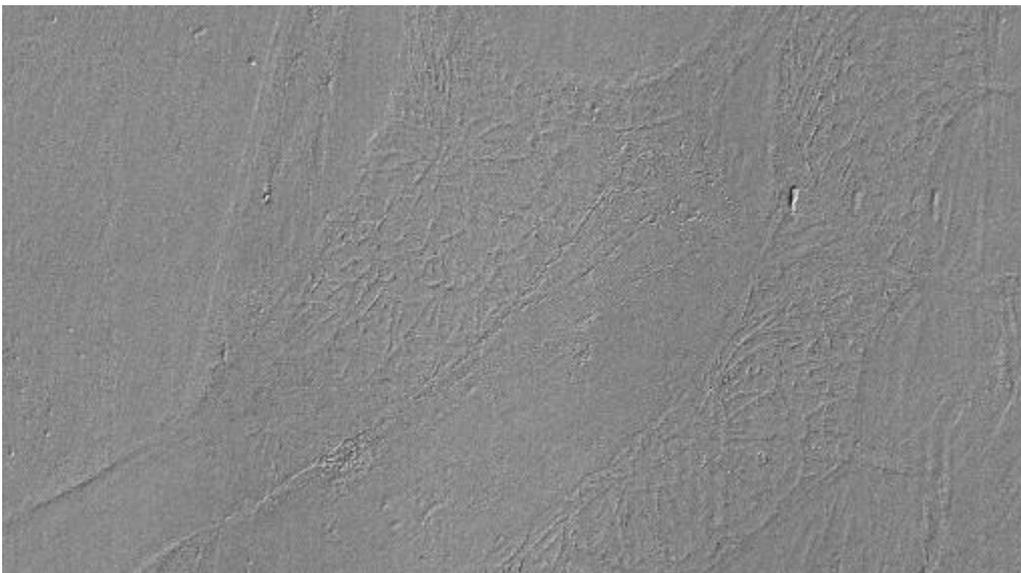
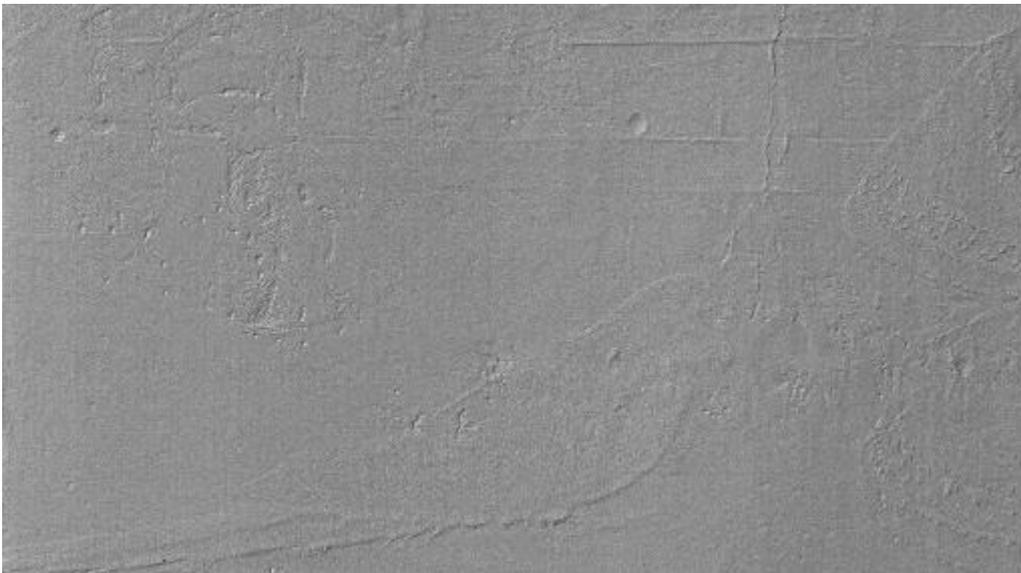
To see the 3D and colour data in registration see the multi-layered browser in this link:
http://www.highres.factum-arte.org/Carpaccio_Two_Venetian_Ladies/shared/viewer.html



The multi-layered browser allows to inspect in detail the colour and relief from any screen-based device



Details of the colour and relief data registered and combined

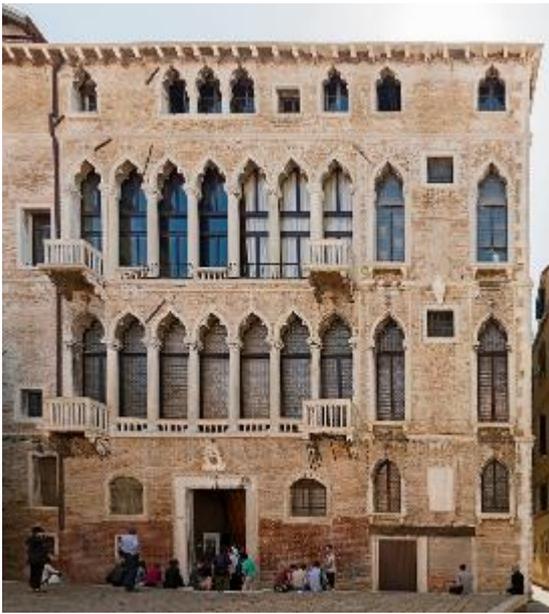


The corresponding details of 3D relief data

8. The photographic archive at Palazzo Fortuny

(A collaboration with Fondazione Musei Civici di Venezia; dates to be confirmed)

This proposal outlines a collaboration between ARCHiVe and Gabriela Belli and Cristina Daroit (conservator) at the Fondazione Musei Civici di Venezia to digitise and create a digital archive of the Fondazione's glass plate negatives held in the Palazzo Fortuny in Venice. The work in the Palazzo Fortuny will be carried out by a trained team in ARCHiVe. The aim is to demonstrate that the full digitization of the archive can be done in cost effective and efficient ways. ARCHiVe will take full responsibility for the running of this innovation initiative.



The aim of the project is to establish a method of recording the Glass plates safely and at high resolution. The work will result in fully working studio in Palazzo Fortuny that can function as an important addition to the digitisation capability of the FMCV. The aim is that EPFL's image-based Machine Learning software will offer additional archiving and search capabilities.

The digitisation of these fragile plates will allow the works to have presence in digital form, with quality for commercial and editorial distribution, academic research and the potential for the production of exhibition quality prints. Over 75,000 delicate plates of different sizes will be digitized using a simple working method developed by Factum Foundation. The conservation team working with FMCV and local apprentices will be trained during the recording process.

The aim is to generate high-resolution digital files of each glass-plate negative with a resolution of 600 DPI at 1:1 (each image will be between 25 and 50 megabytes).

Factum Foundation proposes to record the complete collection of glass-plate negatives at Palazzo Fortuny. It is estimated that the establishment of the recording studio will take one month and that the recording and archiving will take 100-150 working days recording and digitally archiving between 500 and 750 glass plates per day. Two teams will work for 4 hours recording and 3 hours archiving the data.

TRAINING

9. ARCHiVe Online Academy

November 2020 - January 2021

Following the success of the AOA - ARCHiVe Online Academy workshops and seminars held from May to July, the Fondazione Giorgio Cini developed the new training programme for Fall-Winter 2020-2021 organised by ARCHiVe.

Each workshop session lasted about 2 hours and was free of charge but with a limited number of places. The workshops were designed for scholars, researchers, professionals and anyone interested in improving their skills in the field of cultural heritage using both digital and physical methodologies. The sessions were held live on the Zoom platform and were also recorded and made available online on the Cini's YouTube channel through a private link. The aim is to make these public.

Factum Foundation was in charge of teaching the following classes:

15th December 2020

Understanding an artwork through its surface

Teacher: Carlos Bayod Lucini - Factum Foundation



The first class focused on the technologies for recording the surface of paintings and other 2.5D objects. Surface texture is essential for understanding the complex historic trajectories of artworks. In ARCHiVe, systems including the Lucida Scanner and photogrammetry have been used to digitize paintings as well as architectural elements like the trophy wall at St. Mark's Basilica.

18th December 2020

Digital technology for Cultural Heritage preservation

Teacher: Carlos Bayod Lucini - Factum Foundation



The second class discussed other techniques employed by Factum Foundation for recording and reproducing 3D artifacts like sculptures, monuments and architectural spaces. The combination of different systems and approaches makes it possible to obtain an accurate record of key Historical sites, generating invaluable information for assisting in their conservation, and for monitoring their condition over time.

10. Masterclasses for European universities

May 2020 - March 2021

In addition to the ARCHiVe Online Academy, Factum Foundation has kept an active profile in training and dissemination initiatives, connected to leading universities in Italy and Europe especially focused on Cultural Heritage and Digital Humanities graduate programs. These talks have explored the full potential of online teaching, taking advantage of the opportunities of sharing high resolution information on screen even better than during an offline presentation. Additionally, online classes have allowed to reach new audiences, attracting attention to the ARCHiVe projects among Cultural Heritage students, researchers and professionals.

A selection of online/presential classes taught by Factum Foundation in the last months include:

31st March 2021

Alma Mater Studiorum - Università di Bologna

DH.ARC - Digital Humanities Advanced Research Centre

Surface 3D Scanning and Facsimiles for Cultural Heritage Preservation

Teacher: Carlos Bayod Lucini - Factum Foundation

Duration: 2 hours (online)

<https://centri.unibo.it/dharc/en/agenda/carlos-bayod-lucini-project-director-at-factum-foundation-surface-3d-scanning-and-facsimiles-for-cultural-heritage-preservation>

19th March 2021

Una Europa (alliance of eight European universities: Berlin, Bologna, Edinburgh, Helsinki, Krakow, Leuven, Madrid, Paris)

PhD Workshop “Heritage Hybridisation: Concepts, Scales & Spaces”

Displacements

Teacher: Carlos Bayod Lucini - Factum Foundation

Duration: 1 hour (online)

<https://www.una-europa.eu/calendar/online-lecture-on-displacements>

5th February 2021

Universidad de Zaragoza – Masters Degree in Cultural Heritage Management

Seminar on New Technologies for Cultural Heritage Preservation

Facsimiles and other approaches for reproduction

Teachers: Carlos Bayod Lucini, Pedro Miró - Factum Foundation

Duration: 2 hours (online)

<https://fyl.unizar.es/en/masters-degree-cultural-heritage-management>

16th December 2021

Universidad de Castilla-La Mancha, Toledo

Máster Universitario en Patrimonio Histórico

Digital recording and facsimiles in Toledo

Teacher: Carlos Bayod Lucini - Factum Foundation

Duration: 1 hour (In person)

<https://www.uclm.es/estudios/masteres/master-patrimonio-historico>

21st October 2020

ETH Zurich - Department of Architecture

Studio Tom Emerson - Seminar “Faking it / for real - this time”

The Surface of Things

Teacher: Carlos Bayod Lucini - Factum Foundation

Duration: 1 hour (online)

<https://www.emerson.arch.ethz.ch/seminar-weeks>

13th July 2020

Universidad de Alcalá de Henares, Madrid + MASOPA Royal Sites Heritage

Seminario de Virtualización de Patrimonio

Keynote address

Teacher: Carlos Bayod Lucini - Factum Foundation

Duration: 1 hour (online)

<http://royalsitesheritage.eu/event/seminario-online-virtualizacion-del-patrimonio/>

25th May 2020

Universidad Carlos III de Madrid - Máster en Gestión Cultural

Digital technology for Cultural Heritage

Teacher: Carlos Bayod Lucini - Factum Foundation

Duration: 2 hours (online)

<https://www.uc3m.es/master/gestion-cultural>

These masterclasses present the potential of digital technology, in particular close-range 3D scanning, to contribute to the conservation, study and dissemination of art and cultural Heritage. For more than a decade, the Factum Foundation has developed and applied high-resolution recording systems for the documentation of diverse artifacts. The data, apart from being an invaluable source of information for understanding the complex historic trajectories of objects, can be used for the creation of facsimiles. A facsimile is an exact replica made to help the preservation and understanding of the original.

The role of digitisation and facsimiles is explored in the context of the uncertain times we live in. An analysis of the relationship between originality and authenticity, the physical and the virtual, commercial control and open access, human learning and machine learning, online and offline are at the heart of ARCHiVe’s work. A series of case studies are used to help understand the real challenges we face to thrive in today's changing world. Thanks to the diverse initiatives in recording and data analysis at ARCHiVe, we can reach broader and more diverse audiences.

In the last year, most of the ARCHiVe training activities have been carried online. This has affected the practical, onsite fieldwork that characterises Factum’s approach. The transfer of skills and technologies will resume as soon as the travel restrictions are lifted. Remote access and online platforms bring advantages that are being incorporated into our methodology. Broader reach and access, improved image-based content and the creation of a video repository of classes are a few of the positive elements that we will continue to explore in the next months.

The following questions remain urgent and relevant:

- Now that online teaching has become as ubiquitous and functional, which training formats are the most effective at provoking curiosity amongst today's students? What is the appropriate duration of a course? How frequent should they be? what is the ideal balance of practice-theory? Does unsupervised fieldwork produce results? How do you transfer practical skills online?
- What other options exist to enhance scholarship? Virtual workshops and remote access are key concepts, but what is the right balance between online and offline training? How can ARCHiVe help develop a new teaching model?
- As universities face financial and intellectual challenges what role should an independent centre like ARCHiVe fulfil? How can we develop mutually beneficial collaborations with national and international graduate schools? How can ARCHiVe's experts, equipment and facilities reshape the way digital preservation is taught in schools? What kind of apprenticeships and internships work?
- Former students that have benefitted from ARCHiVe are now developing their careers as researchers or professionals and leading their own projects. How can we improve the communication among current and past trainees and researchers in ARCHiVe to create a "community", retaining contact with motivated people after graduation?
- It is Factum Foundation and ARCHiVe's priority to ensure that all the content generated be freely accessible to the widest audience possible, and continuously updated? Should this be available to students with previous connections to ARCHiVe?



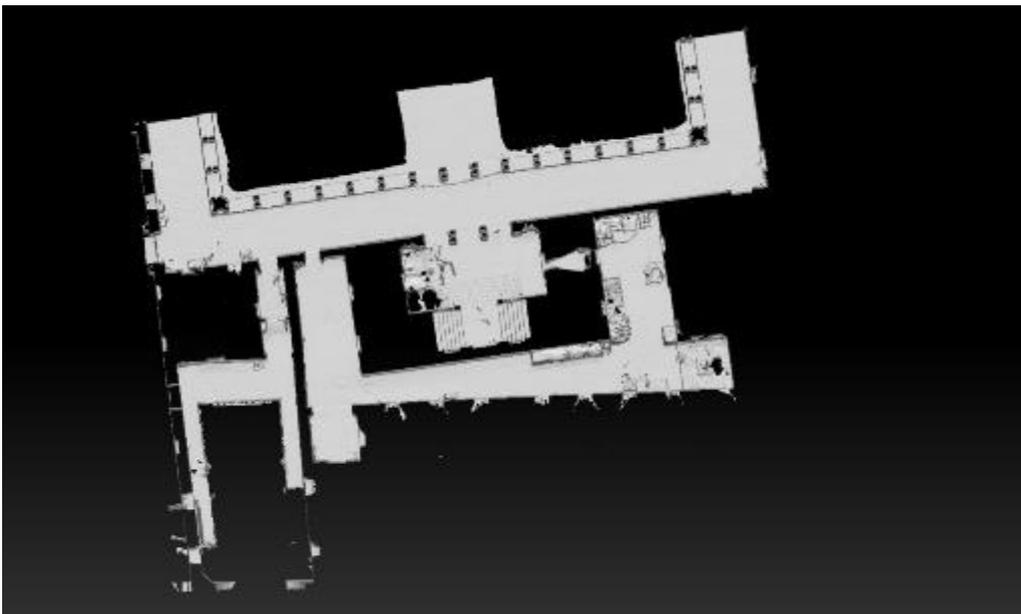
Screen capture of the video of the online seminar on "New technologies generating new knowledge", the third event of a series organized by The Art Newspaper and Factum Foundation with Il Giornale dell'Arte in May 2020, which reached 3,300+ views. Other online events have taken place with The Warburg Institute and the V&A Museum.

RESEARCH and DEVELOPMENT

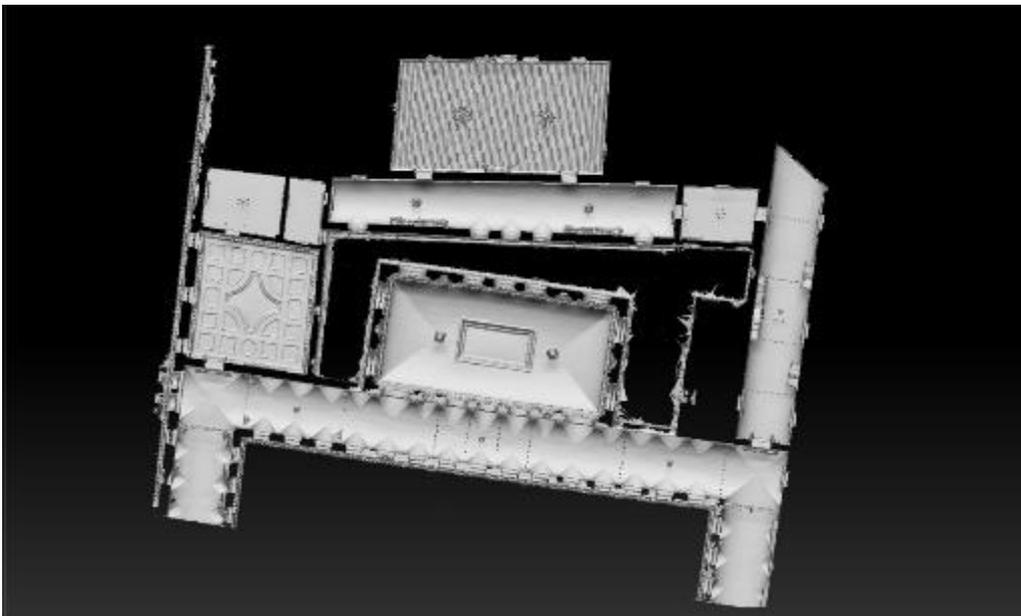
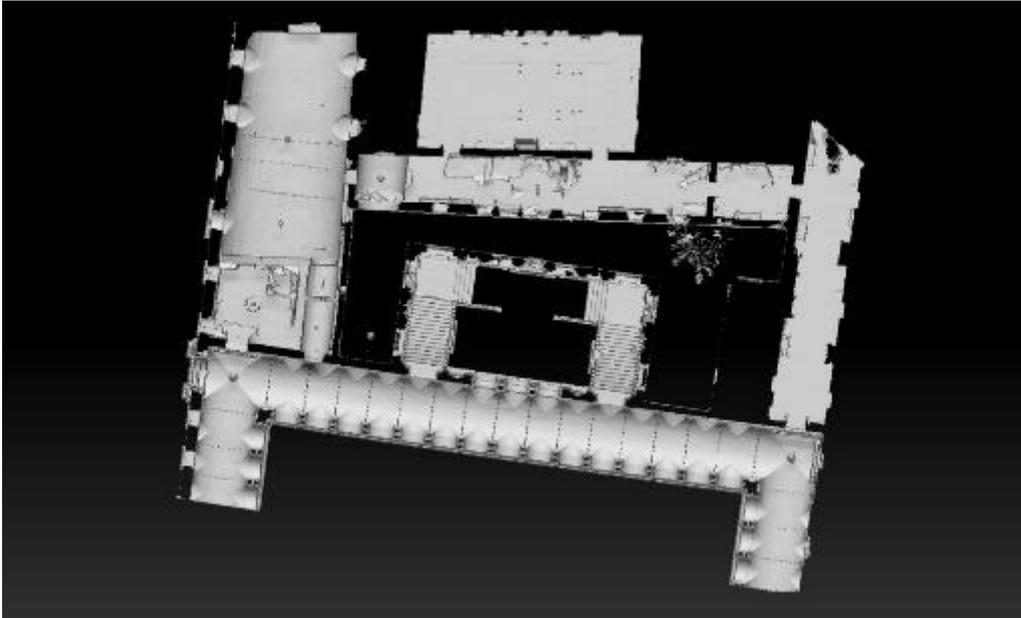
11. Architectural plans and renders of the Island

April 2021 - ongoing

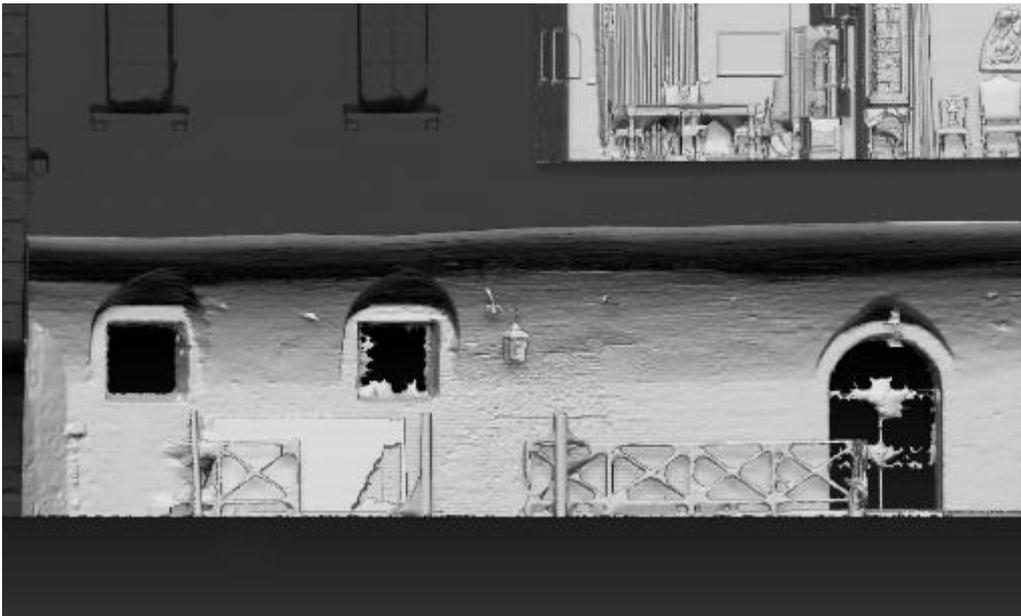
Massimo Altieri from the Fondazione Giorgio Cini asked Factum Foundation for information derived from the model of the island, recorded with the LiDAR and photogrammetry last June. Within Factum we have been generating architectural drawings (accurate plans and sections) for Cini's engineers. The plans will be used to study the specific cracks found in the building's fabric and determine if they might affect the structural condition of the building.



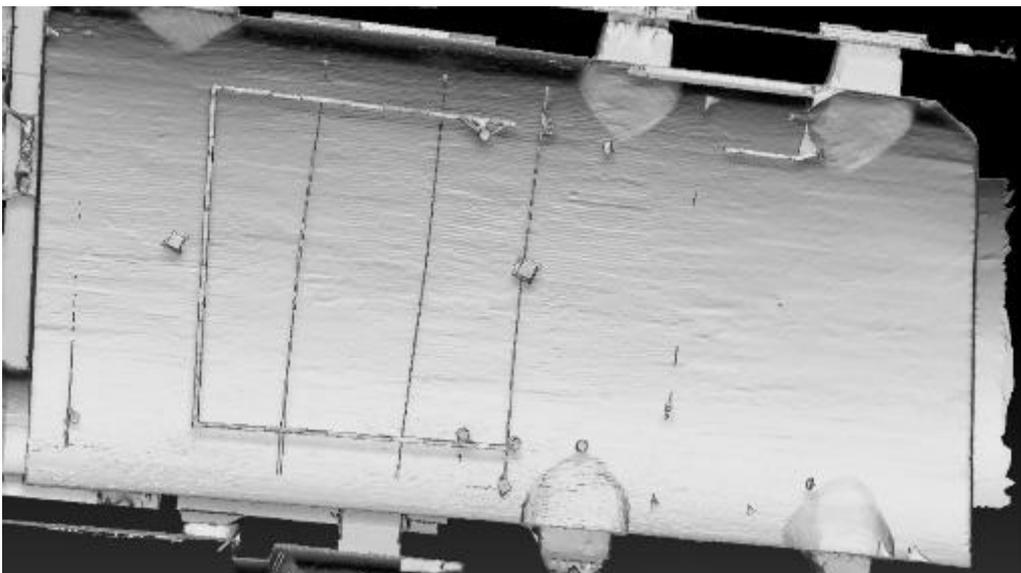
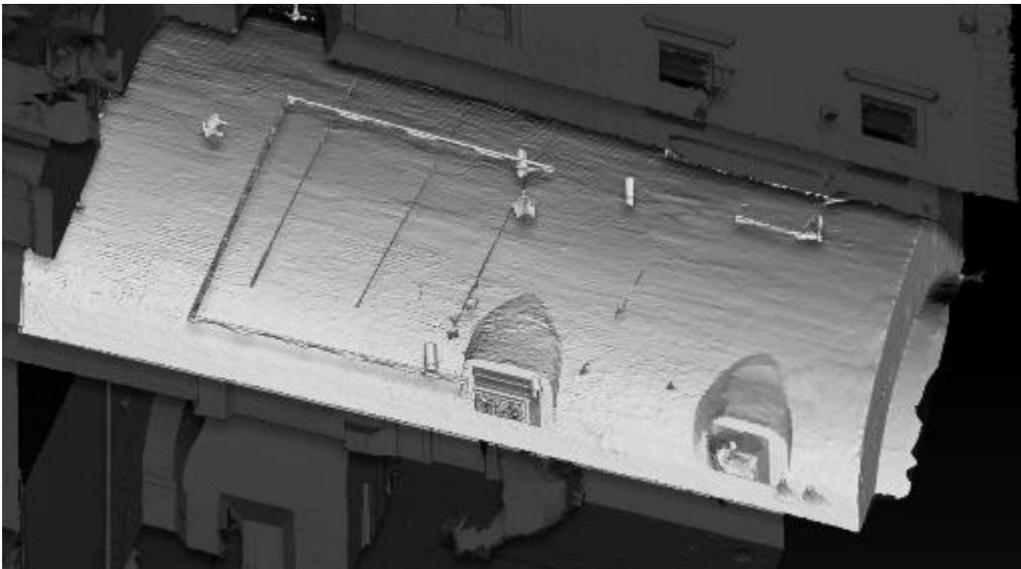
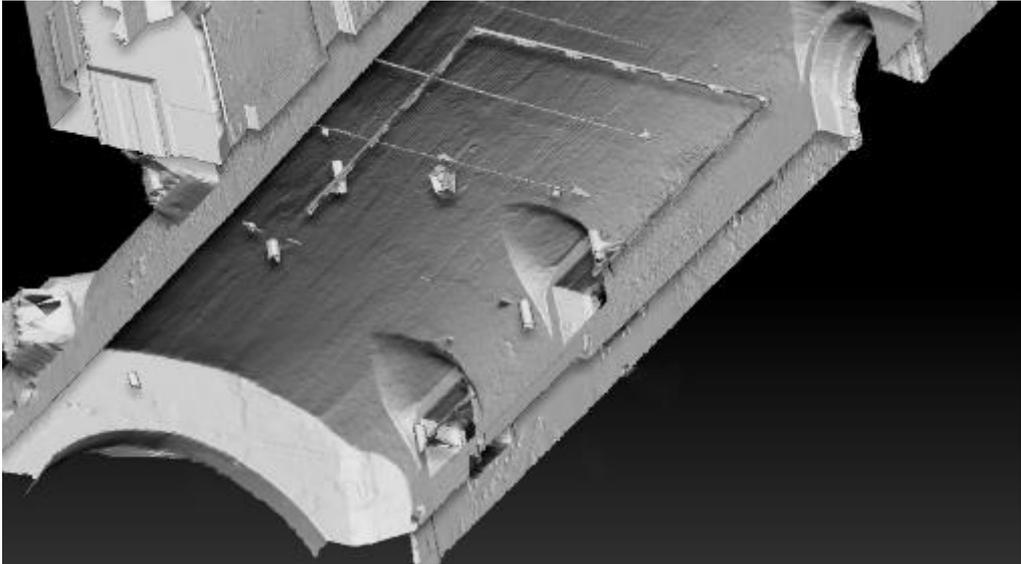
Top image: floorplan, ground floor; Bottom image: floorplan, first floor



Top image: floorplan, ground floor; Middle image: floorplan, first floor; Bottom image: cross section



Different cross sections through the *cavina* (boat house) space



3D spatial views of the *cavina* (boat house) space where the vault cracks have appeared

12. Conservation works at the Knights of Malta

Fall 2020 - ongoing

In October 2019, a class of Graduate students from Columbia University's Graduate School of Architecture, Planning and Preservation (GSAPP) spent one week recording art and architectural elements of the Prioral Palace and Church of the Order of Malta in Venice and processing the resulting data at ARCHiVe on the island of San Giorgio Maggiore.



The results of the work included a full 3D model of the altar (generated by combining the photogrammetric recording of the different sections obtained by the students) as well as high resolution surface 3D data of a series of tombstones suffering from rapid deterioration.

The 3D models can be inspected through the Sketchfab platform, here:

<https://sketchfab.com/advtechstudio>



A series of ortho-photographs obtained from the models were used as a base for a conservation map, highlighting the condition of the different areas in the tombstones. This information was provided to the architect in charge of the complex, Anna Maria Pentimalli, to be used as a source of data during the conservation campaign that has taken place in the last months.



Detail of the surface relief of one of the tombstones recorded with the Lucida 3D Scanner

The tombstones have been restored and a new approach to their long-term preservation has been put in practice: by separating them from the walls, it will be possible to avoid humidity infiltrations that were damaging the stone from the inside. Below images of the work in progress for which the scans carried out by ARCHiVe and Columbia University were essential:



The altar by Sansovino (originally located at the San Gemignano Church in San Mark's Square) has also been cleaned and restored. ARCHiVe's collaboration with the Order of Malta in Venice will continue as other spaces elements will soon be part of the conservation campaign. In Spring 2021 it is expected to begin the restoration of the bas-relief of St. Catherine (moving it from the hall to the Church). And finally the Salone d'onore, containing important frescoes, will also be restored as soon as the Soprintendenza authorize the works.

For previous collaborations between Factum Foundation and Columbia University GSAPP see:
<https://www.factumfoundation.org/pag/1624/columbia-gsapp-and-knights-of-malta>
<https://www.factumfoundation.org/ind/175/columbia-university>

13. Mappa Turchesca's digital restoration

November 2020 - ongoing

The cordiform world map from c.1560, in the Biblioteca Marciana, is attributed to the Tunisian Hajji Ahmed, although recent studies have suggested that there are multi-authors and that the map was made in Venice. The woodblocks were found in 1795 in the Criminal Archive of the Council of Ten within the Palazzo Ducale. 24 prints were made. No further prints are known.

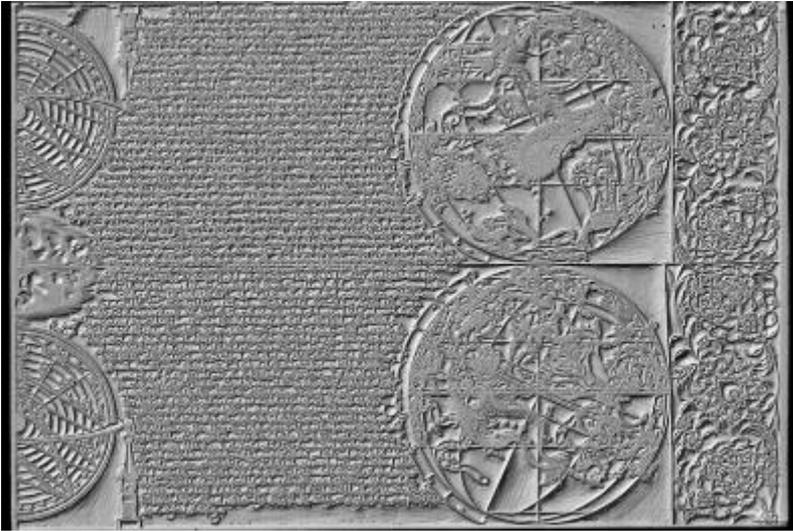
In 2019, the Biblioteca Marciana started a project concerning a new philological edition of the *Heart-shaped map of Hajji Ahmed*, involving the memoranda of understanding between the Venetian institutes of IUAV University and the Academy of Fine Arts. In February 2019, Factum Foundation/ARCHiVe collaborated with the IUAV CIRCE Photogrammetry Lab to record the original cherry-wood printing blocks in high-resolution.

The recording was part of an initiative led by ARCHiVe and was framed as a comparative study designed to assess the merits of three recording techniques: photogrammetry, laser scanning, and the Lucida 3D Scanner.

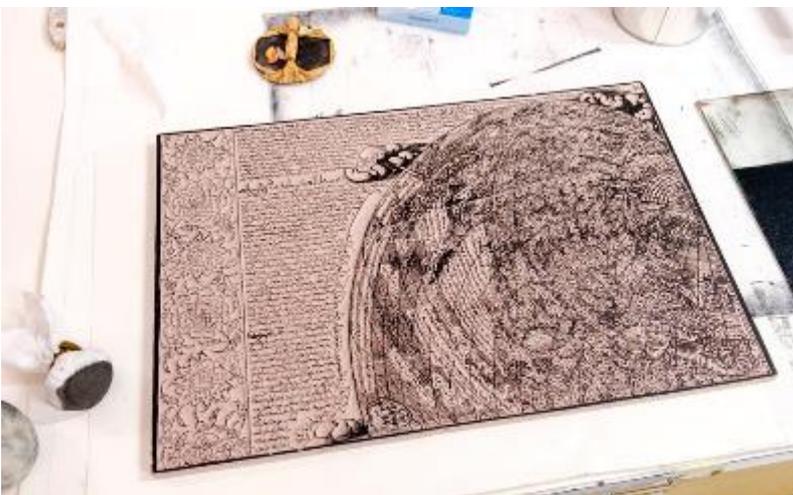


The Lucida 3D Scanner recording the surface of the woodblocks in 2019

The scanned data was CNC milled and new printing blocks have been produced, from which one printed copy of the map has been made. The milled panels and the new print were shown together in the exhibition *The Materiality of the Aura*, in Bologna (May 2020 - February 2021).



Shaded render of one of the six panels, generated with the Lucida 3D Scanner



The woodblocks were recreated through CNC routing on polyurethane resin panels



Detail of the printed edition made by Factum from the milled panels



The copy of the *Mappa Turchesca* printed from the recreated woodblocks



The milled panels and the print on display in Bologna

In November 2020 a team from ARCHiVe completed the recording of the original woodblocks by 3D scanning the back of the panels with the Lucida 3D Scanner. This information will complement the data from the front, to generate a full record of the condition of the object.

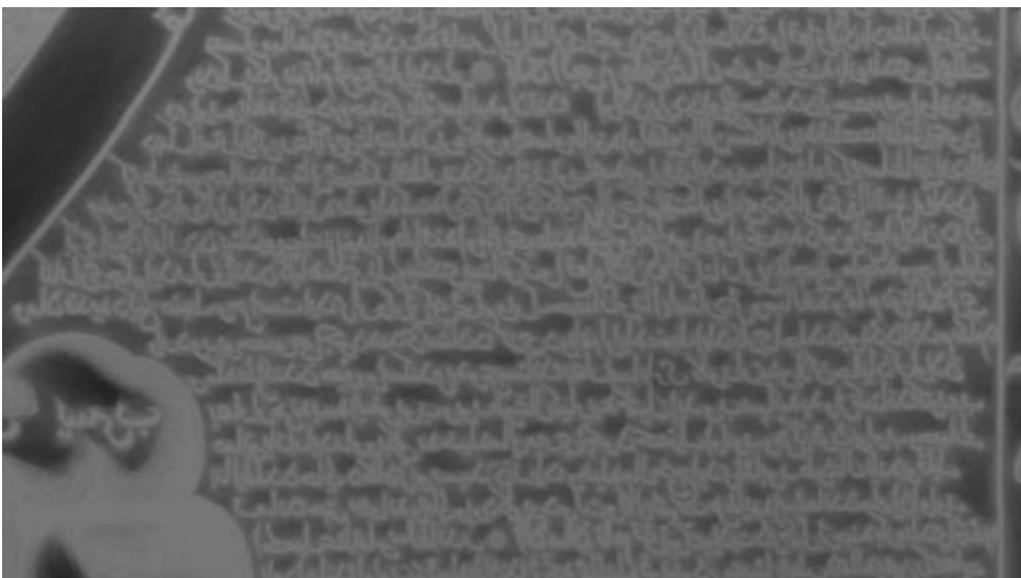
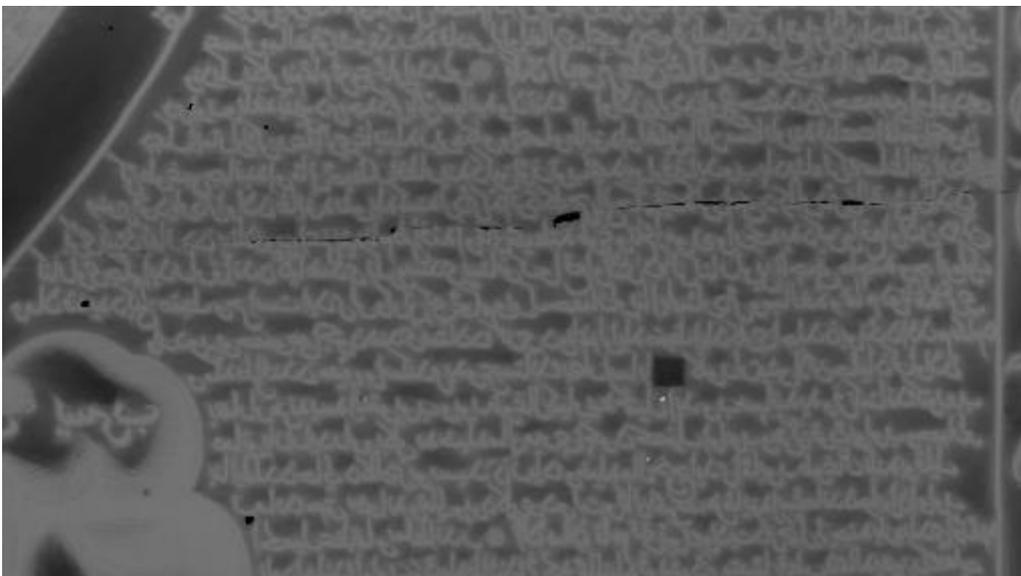
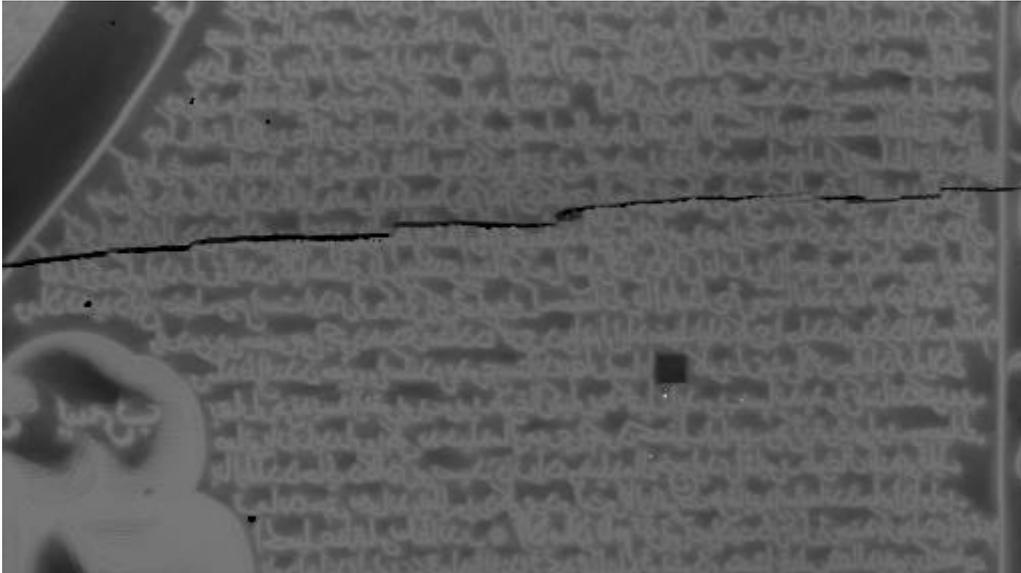


Additionally, the front of the woodblocks was also recorded with high-resolution panoramic composite photography, so that it will be possible to register this data onto the 3D information obtained with Lucida.

Digital restoration

The most recent phase of the project has involved the application of digital restoration techniques to the surface data of the woodblocks obtained in 2019. The aim was to ‘digitally repair’ the cracks and other missing elements present in the original panels. The aim is to create a “restored” set of printing blocks to make a new version of the map that corresponds to the prints made in 1795. The copy of this print at the Biblioteca Marciana has been used as the reference.

The digital restoration process is being done by Factum Foundation’s Teresa Casado working into the greyscale depth-map information from the Lucida. This can be done at high-resolution using image processing software (Photoshop).



Detail of the panel 1. Top: original; Middle: digital restoration at work; Bottom: finished restoration.



One of the panels of the Mappa Turchesca before (above) and after (below) digital restoration

Different tests have been to check the restored version of the surface, made with both CNC milling and with Canon CPP's Elevated Printing. Further printing tests will be carried out to verify, in collaboration with the Biblioteca Marciana, the best prototyping method, before re-materializing the complete set of panels.



Image showing small sections of one of the printing blocks, re-materialized with CNC milling (top of the image) and with CPP's Elevated Printing (bottom left). Initial printing tests have been made out of the CPP surface (bottom right)



Closeup of the Elevated Printed sample showing details of the text and the ornamental details, after digital restoration

14. Machine Learning applied to Surface pattern recognition

2018 - ongoing

Excerpt from “**The Hand of the Artist: Graph Analysis and El Greco**”, a text by Adam Lowe for the book *The Aura in the Age of Digital Materiality* (2020), adapted to latest updates:

The analysis of the painted surface, recorded using high-resolution 3D laser scanning and confocal profilometry, will provide the data for a new graph-analysis software that is being developed at Case Western Reserve University in Cleveland. This research project is an initiative of the Factum Foundation and Case Western Reserve University, in collaboration with the Fundación Casa Ducal de Medinaceli and The Auckland Project.

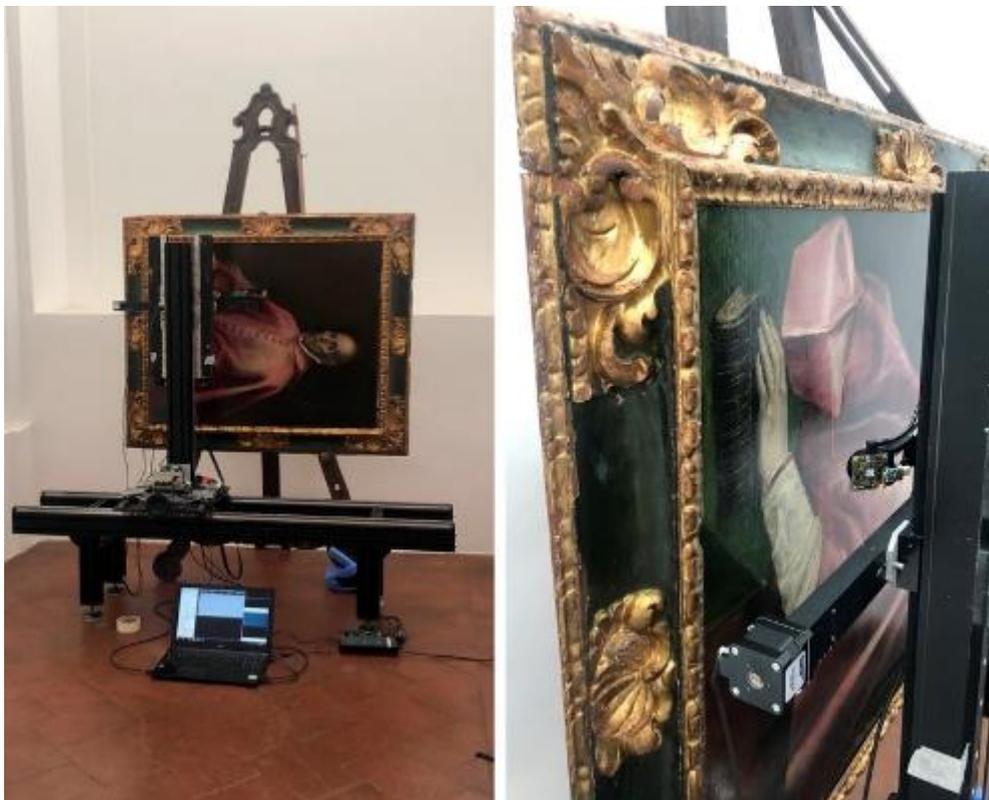


Details of the facsimile of El Greco’s Portrait of Cardinal Tavera, produced by Factum Arte for the new Spanish Gallery at Bishop Auckland, the first museum in the UK dedicated to Spanish art.

(For more information about Factum Foundation’s work for The Auckland Project’s Spanish Gallery see: <https://www.factumfoundation.org/ind/627/the-spanish-gallery-at-bishop-auckland>)

The analysis involves AI machine-learning (ML) techniques using neural-net methods reacting to the three-dimensional characteristics of the surface relief. The aim is to identify different hands at work during the production (and restoration) of El Greco's paintings. The individual technique of each artist leaves its trace on the painted surface. These traces can be clearly read if they are recorded with enough detail. With El Greco, there are often several hands working together to produce a single coherent and recognizable style.

The *Portrait of Cardinal Tavera* and *The Baptism of Christ* were already recorded in 2019 in the chapel of the Hospital of Cardinal Tavera in Toledo (with the participation of ARCHiVe interns during their stay in Madrid). *The Annunciation*, in the collection of Banco Santander, was recorded in 2020. Permission have been requested from the National Gallery of Greece and The Metropolitan Museum to 3D scan the *Concert of Angels* and *The Opening of the Fifth Seal* in their collections. We have recently received permission to record the Crucifixion in MFA Cleveland and we have permission to record an almost identical painting in the UK. We have signed an agreement with Toledo Cathedral and we aim to record the Disrobing of Christ in the near future.



The Lucida 3D Scanner recording the surface of El Greco's *Portrait of Cardinal Tavera*

The aim is to record the other paintings originally made for the Hospital of Cardinal Tavera that are amongst the last produced by El Greco and Jorge Manuel. We are also interested in revealing how El Greco's workshop transferred composition to the canvas with such accuracy that the ML system developed by EPFL at ARCHiVe misattributed two El Greco's, identifying them as the same painting. This collaboration between institutions will hopefully help establish the importance of recording the surface of paintings and reveal new information about the working practice of El Greco's studio.

Multi-layered browsers have been produced by Factum Foundation to inspect in detail the relief and colour of this series of paintings by El Greco. This application makes it possible to isolate the layer of 3D data from the colour, allowing a more direct understanding of the material qualities of the painting.

El Greco, *Portrait of Cardinal Tavera*, 1608-14, oil on canvas, 81 x 102 cm:

http://www.highres.factum-arte.org/Retrato_Cardenal_Tavera_Greco/shared/viewer.html

El Greco, *The Baptism of Christ*, 1608-14, oil on canvas, 329 x 209 cm:

http://www.highres.factum-arte.org/El_Bautismo_de_Cristo_Greco/shared/viewer.html

El Greco, *Annunciation*, 1608, oil on canvas, 294 x 209 cm, (relief only):

http://www.highres.factum-arte.org/Greco_Anunciacion/shared/viewer.html





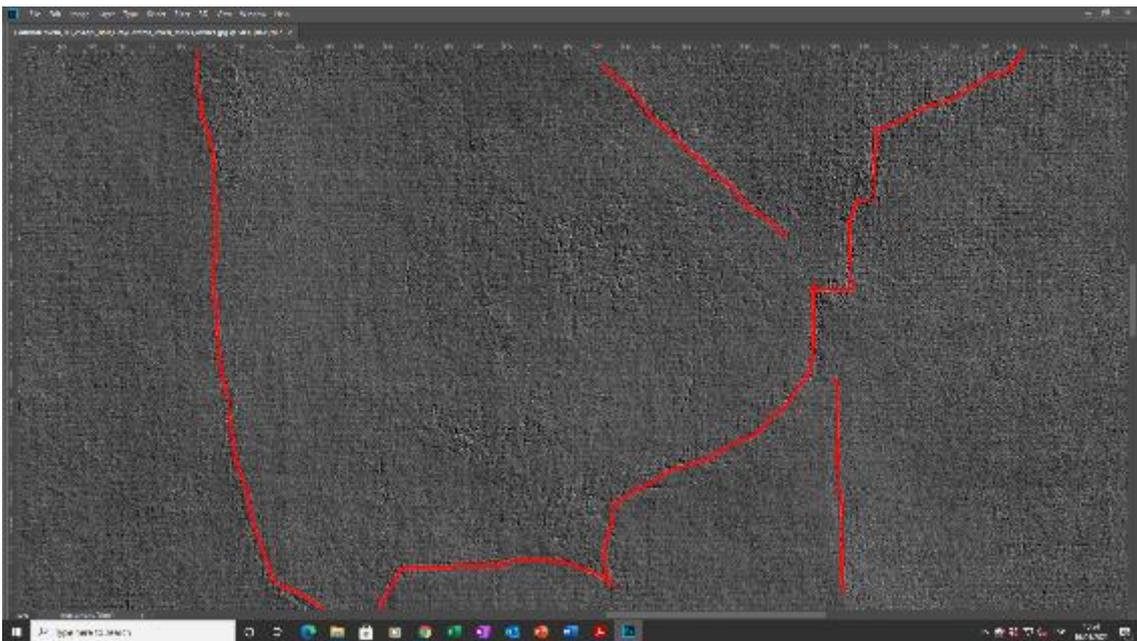
Different details of the colour and 3D data of the *Portrait of Cardinal Tavera* as seen in the multi-layered browser. The top detail shows the “scars” around the head’s edge produced by the vandalization of the painting during Spanish Civil War; the bottom image focuses on the brush strokes creating the highlights on the sleeve.

Artificial intelligence (AI) for image recognition and image analysis has been successful in recent years, with applications ranging from art to ecology, national security to healthcare. The same techniques for clustering and recognising images can be applied to any 2D array of images, such as a render of surface topography. In the case of the El Greco paintings, one experiment will be to train a machine learning (ML) algorithm on regions that a specific connoisseur has attributed to El Greco (Category A) vs. regions attributed to his son (Category B). Then we will apply the trained algorithm to the unknown regions. By applying the algorithm to unknown regions, the AI will suggest with a numerically defined certainty that these regions fit best into one of the trained categories (e.g., Category A with 85% certainty).

A similar approach can be followed to determine the restorer's hand and other interventions. The Portrait of Cardinal Tavera suffered an iconoclastic attack during the Spanish Civil War, but fortunately most ripped fragments were not lost (only the square sections by the left shoulder and the bottom left corner had to be remade) . The subsequent restoration has left visible marks that were recorded in the 3D data.

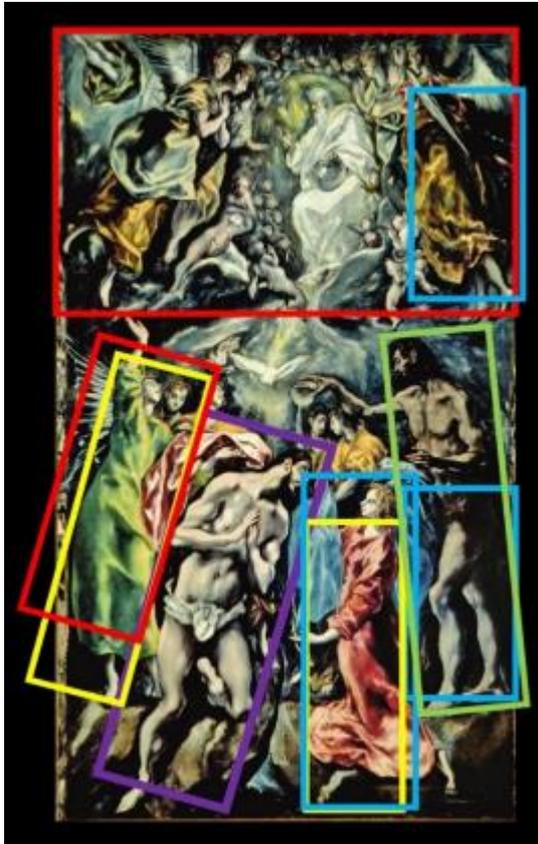


In the period 1936-1938 the painting was ripped in fragments and then rejoined



The red line indicates the visible scar in the 3D relief data, after increasing the contrast of the shaded render to improve visualization. Top: full canvas; Bottom: detail.

Regarding *The Baptism of Christ* the question is mainly about the attribution of the different sections in the painting. The 3D data is still waiting to be analyzed by the Case Western Reserve University. The current view of historians and specialists is that El Greco and his son both worked extensively on this painting. The image below was produced by Lauryn Smith from CWRU, summarizing the hypotheses from available sources:

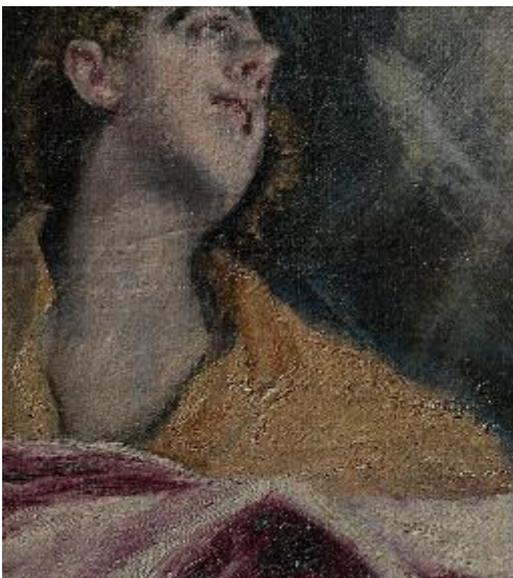


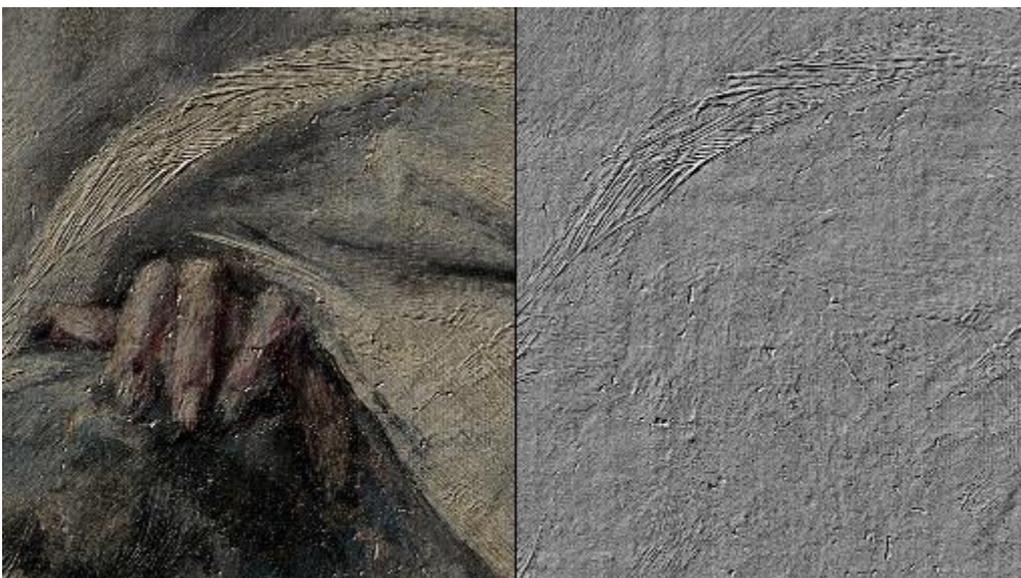
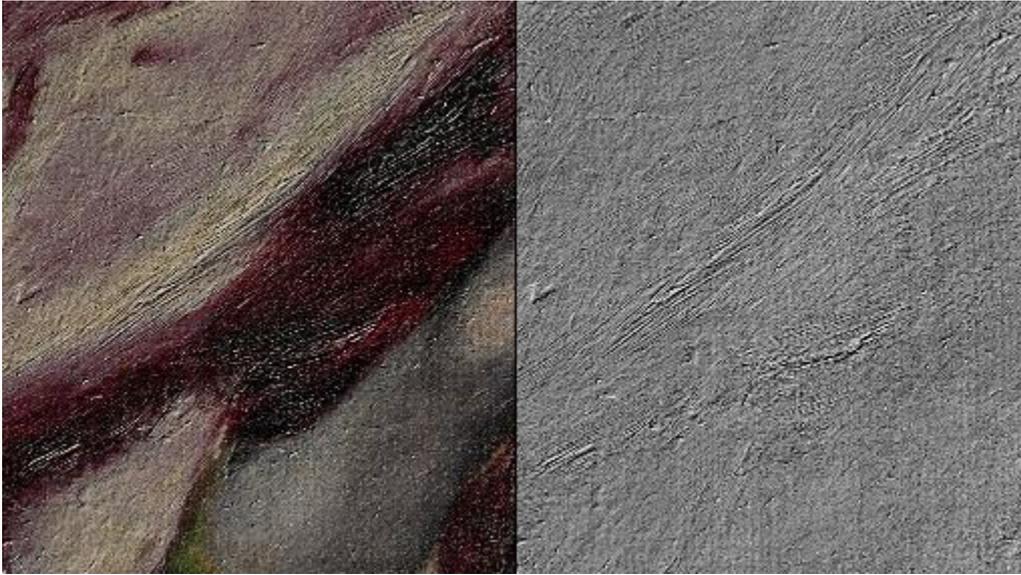
Red: El Greco
Blue: Jorge Manuel (El Greco's son)
Purple: both
Yellow: unfinished
Green: additional hand / workshop

We expect the results of the Machine Learning analysis to reveal the accuracy of the attributions through the analysis of the high-frequency marks on the surface. Further, information encoded at different frequencies within the paintings will contribute to these results. Understanding which 'length scales' the algorithm weighs highly for its determination could result in novel analytical tests for studying paintings. Additionally, we plan to study various imaging modalities, such as panoramic photography, for the ML algorithm, and understand the robustness of the results, so that we can begin to identify the surface information (height, directionality, colour, etc.) contributing to the attribution.

Finally, clustering via AI can be applied to the measurements of the paintings. With clustering, the AI will group similar patches of the paintings with no training. By using various metrics to cluster the data spots or spot sizes, we may see groupings arise within and across the paintings. Then, meaning can be designated to the groupings using knowledge obtained by archival and art-historical research. This method has been known to lend support to existing conclusions while revealing new evidence and interpretations.

See below details of the colour and relief of *The Baptism of Christ* as can be inspected with the multi-layered browser:





15. ARCHiOx: a new chapter in Oxford

Spring 2020 - ongoing

Excerpt from the proposal submitted in February 2021, adapted to latest updates:

Factum Foundation proposes a practical transfer of knowledge and technology to the Bodleian Library with the support of the Helen Hamlyn Trust. It will result in a permanent transfer of equipment and software to the Library while providing access to the ARCHiVe structure established in Venice by Fondazione Giorgio Cini, Factum Foundation and EPFL. The centre for the Analysis and Recording of Cultural Heritage in Venice (ARCHiVe) will establish the same approach to recording, analysing and presenting data in Oxford (ARCHiOx).



The proposal outlines three projects that will be undertaken during a twelve-month collaboration. Six-months will be spent in Oxford and six months in Venice and Madrid.

- The recording of Palm Leaf Manuscripts with a Nanovea ST500 Optical Profiler
- The high-speed recording of loose sheets with the Replica 360 Recto/Verso Scanner
- The recording of relief surfaces and book bindings with the Lucida 3D Scanner

Factum Foundation/ARCHiVe will provide one full time researcher/technician to carry out the work. It will involve high-resolution 3D and colour recording, Machine Learning and Artificial Intelligence, digital restoration, data storage and management, research into the inclusion of 3D data in the IIF framework, sharing of data and online engagement with 3D information, offline study using new elevated printing technology and facsimile production. All work will be carried out in collaboration with the Imaging specialists at the Library and will be compatible with the structure of the Digital Bodleian.

Our proposal outlined the provision of working technologies required for the scanning, preservation, and related studies of palm leaf Manuscripts, loose sheets and objects requiring 3D surface recording in the Bodleian Library collection. There will be opportunities for students and researchers to interact with the work and experience.

Through a practical collaboration, the ARCHiVe approach to digital innovation will be shared with the academic and technical teams at the Bodleian Library. The creation of ARCHiOx will add 3D recording and high-speed high-resolution documentation to the Bodleian's digital capabilities assisting in both online and offline scholarship. There is currently no provision for 3D data within IIF. This will form a significant part of the research work at the Bodleian



Top: Nanovea ST500 “Large Area Ultrafast Profiler”; Middle: Lucida 3D Scanner recording a 10th C. manuscript; Bottom: Replica 360 Recto/Verso Scanner. These are the three main recording system proposed for ARCHiOx

16. Confocal profilometry for palm leaf manuscripts

This was scheduled for Spring 2020 but due to Covid it is now planned for Autumn 2021

Within the ARCHiOx initiative, the 3D and colour digitization of the Bodleian Library's Palm Leaf Manuscripts collection will be prioritized. The Palm Leaf Manuscripts, written in Sanskrit, contain both inked and un-inked writing. This collection was chosen because it is proven to be challenging to digitize with traditional methods. The aspect ratio of the documents is not ideal for photography and their fragility makes the manuscripts hard to handle. The Sanskrit script poses challenges for traditional optical character recognition technologies. The possibility of recording the 3D surface of the palm leaf manuscripts at the required resolution creates an opportunity to study the text using a combination of different software and processing tools.



The Nanovea optical profiler (ST500L) with high-speed sensor (LS3) will be used to document the surface relief of a selection of Palm Leaves, obtaining 3D data as three-column .csv files that can be easily converted to image files that correspond to topographic surface maps or artificially shaded renditions of the 3D surface. The maximum recording area will be 40 x 40 cm, with a variable resolution, with a minimum of 2.5 microns (at X-Y plane) and a 70-nanometer reproducibility (at Z-axis), and a depth of field of 3.4 mm. The measurement is non-contact and uses low intensity light to guarantee the safety of the manuscripts. All equipment will be checked by the library technicians upon its arrival and before use.

The colour of the palm leaf manuscripts will be obtained with macro composite photography. By positioning the camera (Canon 5DSR with 100 mm. macro lens and mounted flash) on a simple linear track at a constant distance from the target (about 40 cm), it will be possible to obtain an image resolution of 5,000 dpi at 1:1 scale. Focus stacking will be used as required. The photographic colour data will be stored as both raw (cr2) and processed (TIFF, JPEG) files, including the necessary metadata, to be determined in collaboration with the library. The colour information will help in understanding and interpreting the relief 3D data and will be prepared to create multi-layered files for access and dissemination.

More information about this and other upcoming projects within the ARCHiOx initiative will be announced soon.

EXHIBITIONS

17. Facsimile of Caravaggio at the MART

June 2020 - April 2021

A facsimile of the *Burial of Saint Lucy* was created by Factum Arte for the exhibition 'Caravaggio. The Contemporary' at MART Rovereto (October 9th 2020 - April 18th 2021), where the original is on display among a selection of contemporary works including paintings by Alberto Burri and photographs of Pasolini's death.

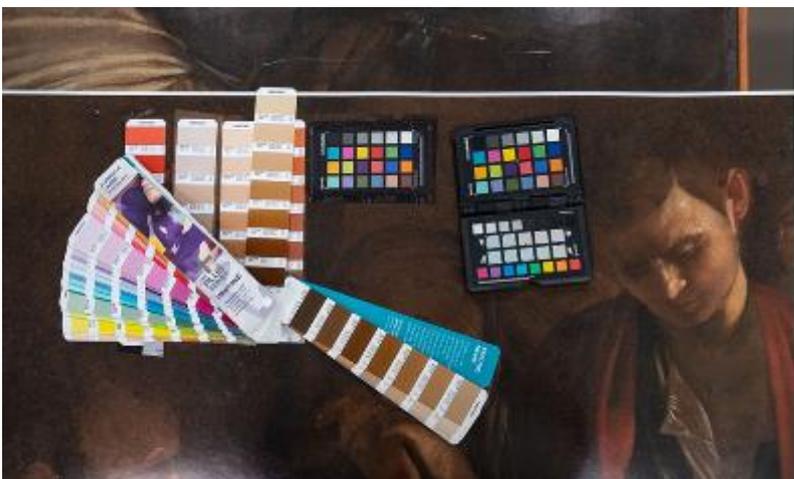


In order to make the facsimile, the surface relief of the painting was first printed in 3D using the elevated printing technology developed by Canon Production Printing, a Canon company with whom Factum has collaborated on many projects. CPP's revolutionary printing method involves building up relief in 5-micron layers to replicate the exact surface of a painting.



In Factum's workshops, liquid silicon was then poured over the relief print to create a mould of its surface. A cast was made from this mould using a specially prepared acrylic gesso mix. This 'skin', which forms the base surface of the final facsimile, was fixed to a backing canvas in a process that is similar to re-lining a painting.

Factum's purpose-built flatbed printer has been designed in-house to print in multiple layers across large surfaces. Using a traditional method of registration, the colour and the relief are perfectly aligned, ensuring that the appearance of the facsimile is entirely faithful to the original. Multiple layers of over-printing ensure that the tone and hue of each colour corresponds precisely to the colour of the original. The final stage is varnishing and hand finishing.



The process involves the exact registration of the colour data onto the relief, first digitally and then during printing

This video describes the process of making the facsimile: <https://vimeo.com/464157354>

A second facsimile of Caravaggio's Burial of St. Lucy was also made. It is now in Syracuse and the plan is to install it in the location for which it was created, the Basilica of Santa Lucia al Sepolcro.



Once the colour has been printed onto the textured skin the finishing is applied with traditional techniques



Vittorio Sgarbi talking to the press in front of the facsimile at the opening of the exhibition in MART Rovereto.

18. The Materiality of the Aura

18th May 2020 - 15th February 2021

The city of Bologna celebrated the return of the *Polittico Griffoni*, one of the greatest altarpieces of the Bolognese renaissance, in two exhibitions at Palazzo Fava commissioned by [Genus Bononiae. Musei nella città](#), its president, Fabio Roversi-Monaco and supported by Fondazione Cassa di Risparmio in Bologna. Originally intended to open from March 12th to June 18th 2020, the exhibition was postponed to May 18th due to the COVID-19 emergency and closed on February 15th 2020.

Il Polittico Griffoni rinasce a Bologna, curated by Mauro Natale in collaboration with Cecilia Cavalca, focused on the importance and meaning of the altarpiece by displaying, together with the individual panels coming from nine museums and collections across Europe and North America, a [facsimile reuniting the Polittico](#). Painted between 1471 and 1472 by Francesco del Cossa and Ercole de' Roberti, the work was commissioned by the original patrons of the Griffoni chapel, but was removed from the Basilica of Saint Petronio in Bologna, dismembered and sold when the chapel assumed the patronage of the Aldrovandi family in 1725.

On the second floor of Palazzo Fava, the exhibition *The Materiality of Aura: New Technologies for Preservation*, curated by Adam Lowe with Guendalina Damone and Carlos Bayod Lucini, explored instead the role of digital technology as a medium between an object's materiality and its 'aura'. Each of the six rooms allowed the visitors to engage with works of art in new ways, showcasing projects carried out by Factum Foundation since it was created in 2009 to guide the visitor through the chosen themes.

In Summer 2020 a new video was created by Factum Foundation with Adam Lowe explaining the exhibition *The Materiality of the Aura. New Technologies for Preservation*:

<https://vimeo.com/451100310>

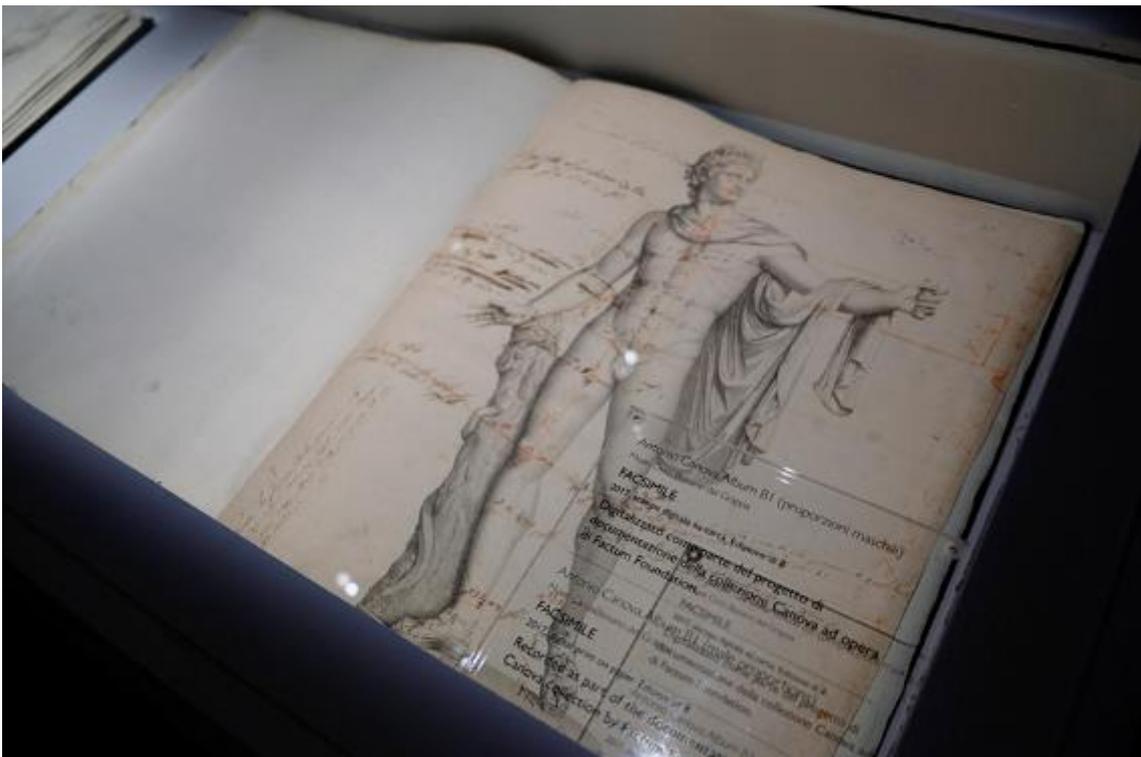












CONCLUSION

May 2020 - April 2021 was a period dominated by the Covid-19 pandemic. It has made the work of ARCHiVe more important than ever...and more urgent. As Museums and Cultural organisations around the world were forced online, they were forced to face the fact that over the last 40 years they have concentrated on visitor numbers, ticket sales and merchandise and the expense of a meaningful digital identity.

The success of the V&A's initiative to record the Raphael Cartoons has both attracted new audiences, assisted scholars, triggered a new digital humanities research programme and assisted in rethinking the ways in which these works can be exhibited. The Facsimile of the *Sacrifice at Lystra* was exhibited in Rome during the 400th anniversary of Raphael's death. It will be exhibited in Vicenza later this year in an exhibition on Raphael as an Architect. Here it will also be used as a screen for a projection mapping where an 3D animation will reveal the complexity of the composition, its narrative, its content and its significance.

Google Arts and Culture are working with Factum Foundation to reveal the tomb of Tutankhamun as a virtual and mobile phone experience. Microsoft is in discussion about ways to integrate Factum's work in ways that will improve their existing Machine learning and processing software. There is a significant need for the work that ARCHiVe is doing in Venice and there is a vast interest in expanding this model for independent research that can move fast and deliver results. The opportunities for ARCHiVe in 2021 and in the years ahead cannot be overstated. It is important that a structure is established that allows this to happen, with the right leadership and the right people involved.

In Spain a new development is taking place. The Spanish Ministry of Foreign Affairs and Factum Foundation are working with the European Commission, the Toledo International Centre for Peace (CITpax), Aliph, the Aga Khan Trust for Culture, UNESCO and other political bodies, cultural foundations, institutes and agencies to organise an international conference in Toledo, in September 2021, to discuss the role of cultural heritage preservation in conflict prevention and resolution. The Toledo Conference will acknowledge the importance of culture as a direct means of communication that can help establish dialogue and understand difference.

The training and the transfer of both skills and technologies to local communities can become a peace-building tool, assisting preservation, creating a local economy and sharing narratives with a global audience. The inclusion of Cultural heritage recording as a tool in conflict resolution represents a significant change in the European Union's approach to the function and value of cultural heritage. It can become a key instrument in the quest for conflict prevention and resolution, as stated in the Council Conclusions, adopted on 6 December 2020. The **Toledo Conference** is being held to discuss and promote the European Union's new policy on heritage documentation as part of conflict resolution.

Factum Foundation is committed to ARCHiVe, its aims and its work. We need to work together to ensure that the centre, at the heart of Venice, can deliver its potential.