



FACTVM FOVNDATION



FACTVM
FOVNDATION
FOR DIGITAL TECHNOLOGY
IN PRESERVATION

2023

The first portrait of the most noble



The lively portraicture of the most noble



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IN PRESERVATION

Walter Benjamin begins his essay *The Work of Art in the Age of Mechanical Reproduction* (1935) with a quote from Paul Valéry's *The Conquest of Ubiquity*:

For the last twenty years neither matter nor space nor time has been what it was from time immemorial. We must expect great innovations to transform the entire technique of the arts, thereby affecting artistic invention itself and perhaps even bringing about an amazing change in our very notion of art (Aesthetics, 1928).

Digital technology is bringing about that 'amazing change'.

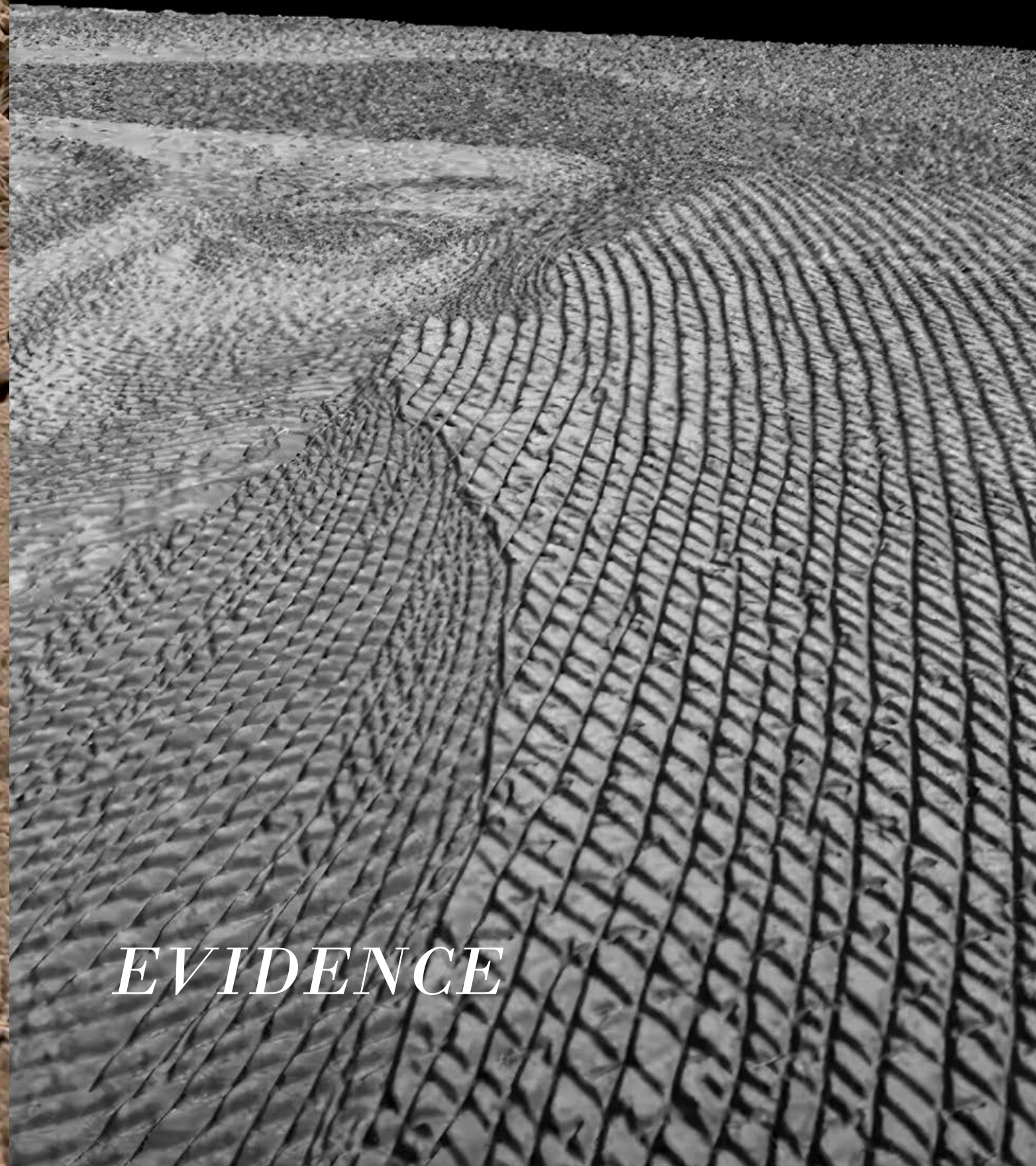
Valéry's prediction seems almost prophetic with what follows in the original text:

At first, no doubt, only the reproduction and transmission of works of art will be affected. It will be possible to send anywhere or to re-create anywhere a system of sensations, or more precisely a system of stimuli, provoked by some object or event in any given place. Works of art will acquire a kind of ubiquity. We shall only have to summon them and there they will be, either in their living actuality or restored from the past. They will not merely exist in themselves but will exist wherever someone with a certain apparatus happens to be. A work of art will cease to be anything more than a kind of source or point of origin whose benefit will be available and quite fully so, wherever we wish.

2019 - 2023
www.factumfoundation.org



SURFACE

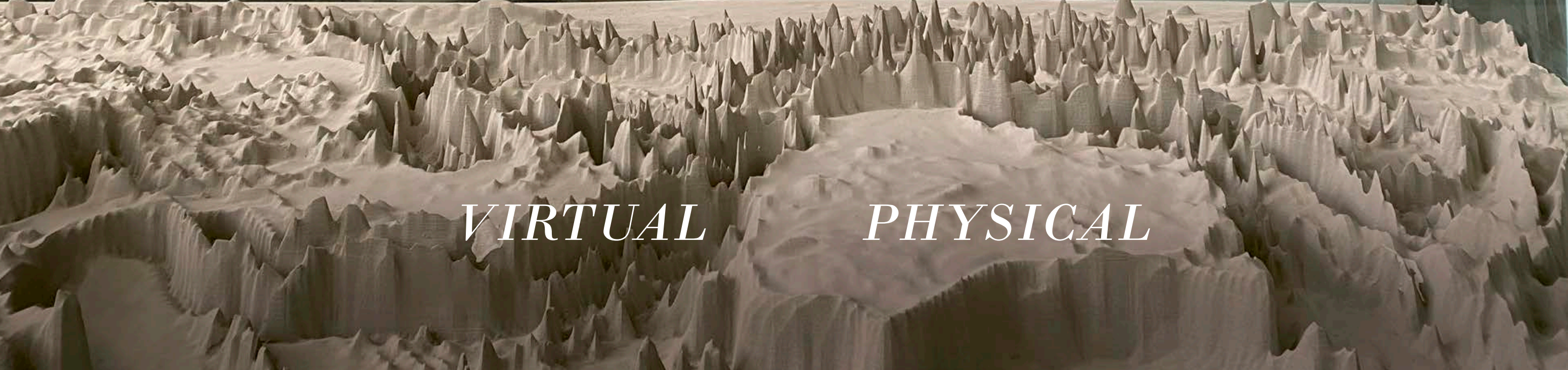


EVIDENCE



SCALE

DETAIL



VIRTUAL

PHYSICAL

This book is dedicated to the memory of six people who have shaped Factum:

James Crown died in an accident in June 2023.

Jim and Paula Crown have been two of the significant supporters of Factum Foundation and valued friends.

Bruno Latour died in October 2022.

Without Bruno (and others who know who they are) Factum would not exist.

Andrew Edmunds died in September 2022.

He played an important part of the development of Factum Foundation in many ways.

Philip Hewat-Jaboor died in March 2022.

His insight and kindness benefitted Factum Foundation in many ways.

Padre Justo died in October 2021.

His single-handed task to build a Cathedral in Mejordada del Campo remains a source of inspiration.

Colin Franklin died in May 2020.

He understood how books come alive when handled, discussed and shared.

There are so many other people that Factum Foundation needs to thank in so many different ways.

Special thanks to: Lady Helen Hamlyn (The Helen Hamlyn Trust), Jonathan and Jane Ruffer, Paula Crown, José Luis Colomer, Charles Saumarez Smith, Paul and Jill Ruddock, Richard Ovenden, Suneil Setiya, Jeffrey and Veronica Berman, Nicolás Berlanga, Ana Botín and Guillermo Morenés, Adrian Cussins, James and Sarah Sassoon, Ariane Braillard, Paul August, Jean August, TARA, Terry Little, Abba Tijani, Richard Tscharnier and the Carène Foundation, Candace Allen, Josué Tanaka, Jerry Brotton, Pauliina Ståhlberg, Mauricio Torres Leclerc, Matthew Zucker, Simon Schaffer, Bruce Mau and Bisi Williams.

Factum Foundation owes a great deal to James Macmillan Scott

who has been an integral part of its growth since the start of the foundation in 2009.

*Charlotte Skene Catling has been living with the production of this book
and the development of the projects that Factum Foundation has carried out.*

At times it's a joy and at others it can feel overwhelming.

*This book has been designed by Blanca Nieto as a work in progress. It has been in a state of flux
requiring constant amendments and modifications, demanding extraordinary patience and tolerance.*

And, of course, everyone at Factum Arte

who works tirelessly to support the Factum Foundation and turn ideas into realities.

Selected Factum Foundation projects carried out between 2019 and 2023

**By Adam Lowe,
with Nicolas Béliard, Giulia Fornaciari,
Ferdinand Saumarez Smith,
Otto Lowe, Jorge Cano and Carlos Bayod,
and contributions from
Charlotte Skene Catling, Nicholas Reeves,
Rashmi Gajare and John Barrett
with Paul Valéry's essay *The Conquest of Ubiquity***

*‘Factum Arte’ can be translated from Latin as ‘made with skill’.
At the heart of both Factum’s work and name is an attention and
dedication to the mediation and transformation of materials. History
is made manifest in the spectrum of visual information around
us. Archaeologists are trained to read this evidence, so are forensic
detectives at a crime scene. Indeed, experimental physicist Patrick
Blackett said of his work, the aim was to ‘cultivate an intimacy with
the behaviour of the physical world’, an aim that characterises our own
work at Factum. Using cutting-edge technology, our practice allows us
to record and respond to subtle details and obvious shapes, minuscule
variations on a surface and monumental rock cut forms, external
impositions and intentional decisions embedded in material objects.
By cultivating an increasing intimacy with the physical evidence,
Factum gives voice to the stories and histories encoded into the material
evidence of the world around us.*

Previous pages: 3D model of one of the Aršāma seals (left) and 3D model of the surface of a printing copper plate, without colour (right). Recording the Qaṣr al-Farid with aerial photogrammetry. A view of Factum's workshop with test prints of Caravaggio's *Martyrdom of St Matthew* and Banksy's *Migrant Child*. In the foreground, Adam Lowe's projection of the world without water from the exhibition 'Terra Forming: Engineering the Sublime'.

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FOREWORD

ORIGINALITY AS A PROCESS

This book begins with the opening of Walter Benjamin's essay, a text that has dominated the subject of 'mechanical reproduction' since it was written in 1935. In it, he quotes Paul Valéry's *The Conquest of Ubiquity*, where Valéry reflects on the creative fusion of art, science and technology that was bringing about 'amazing change' in 1928. Revisiting the source essay (reproduced in full on page 334) reveals that the quote Benjamin chose is sandwiched between two intriguing statements:

'In all the arts there is a physical component which cannot be considered or treated as it used to be, which cannot remain unaffected by our modern knowledge and power.'

and

'Works of art... will not merely exist in themselves, but will exist wherever someone with a certain apparatus happens to be.'

Valéry called it, *'the home delivery of Sensory Reality'*.

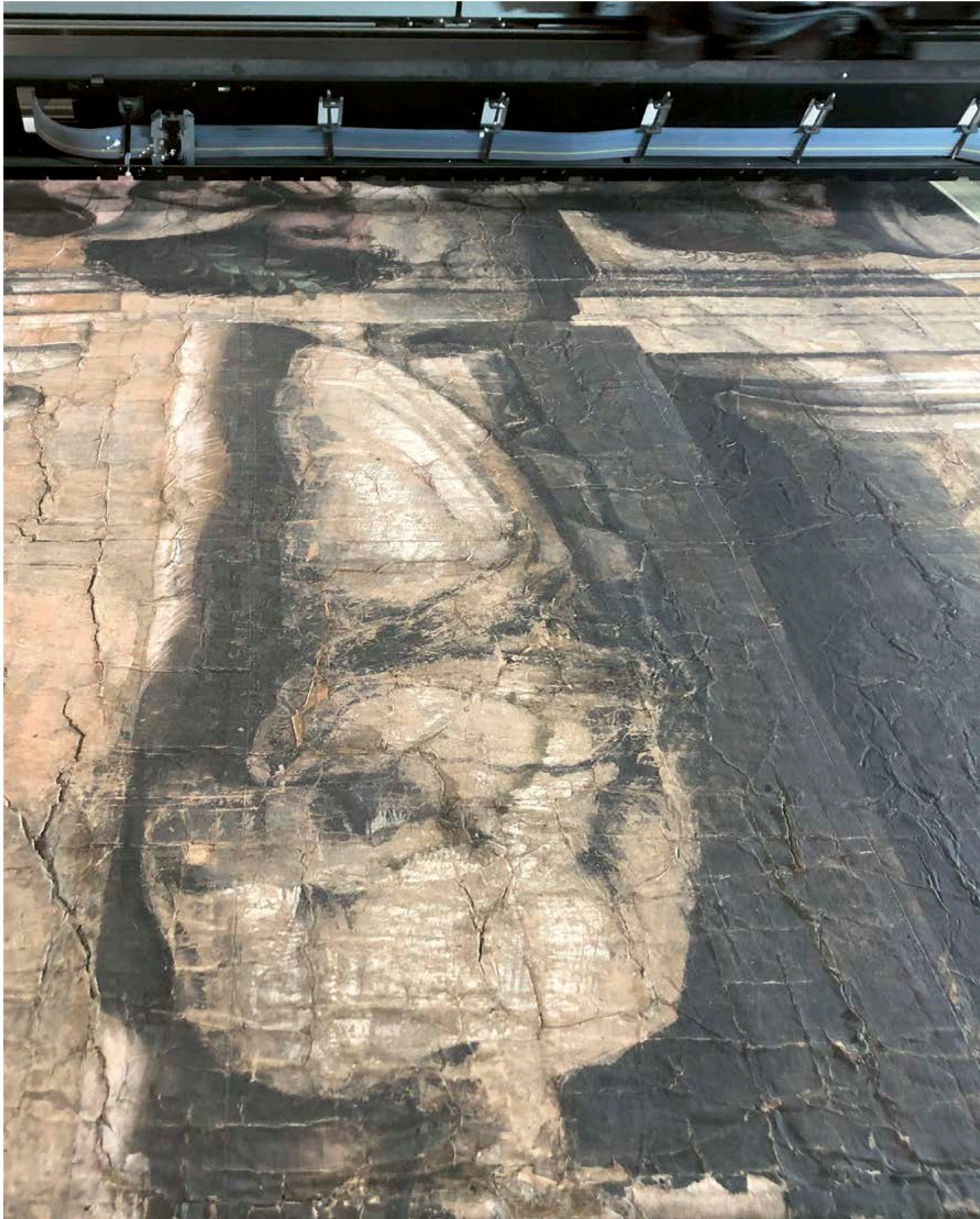
Factum Foundation operates in the space between shifting attitudes to the 'physical component' and the diverse technologies that are now available to record, experience, share and rematerialise the work of art in many forms, both in private and public spaces. Valéry's reflections were perceptive but also reflect how he loved the idea of music without a live performance, *'for it permits creatures to live again in a vibrant milieu not very different from that in which they were created'*. In his imagination, the electrical world could offer ubiquitous sensory stimulus simply through the blink of an eye or a movement of the head.

William Blake died 101 years before Paul Valéry wrote *The Conquest of Ubiquity*. Blake's London was polluted and dominated by the dark satanic mills that dominated the south bank of the Thames where the Tate Modern now occupies a re-purposed electricity generating station. Unlike Valéry, he didn't have electricity at the flick of a switch, and space and time were not yet relative. Blake was both a poet and an innovative printer who understood how the medium could embed colour images into the creative imagination of an age on the cusp of technological change. For Blake, printing was both enriching and mind-expanding, opening a world of wonder that offered the potential of deep communication fueled by curiosity. For Walter Benjamin printing was accessible but impoverishing. Benjamin essentially identifies that photomechanical reproduction captures some aspects of the image but lacks both scale and topography. What follows in this book is a demonstration that Benjamin's 'aura' is embedded in the materiality, especially in the surface, of a painting or work of art.

95 years after Valéry wrote his essay, we are still struggling with the relationship between aesthetics and technology, concepts of originality and authenticity and the nature of the physical and the virtual. Words can't keep up with ideas located in different sensory forms. In 1964, Marshall McLuhan famously said, *'the medium is the message'*. Recently, in conversation with another Canadian, Bruce Mau, I discovered that in 1967 this quote was modified (corrected?) to read; *'the medium is the massage'*. The medium of communication, whatever form it takes, is like a massage that changes our physical state and alters our mental space. The medium shapes the message and embodies some of its meaning. It transforms the idea and then lies in wait as evidence.

Factum Foundation records this evidence and studies the way materials have been transformed. The evidence is often contained in the surface characteristics of an object, the critical zone between the

Opposite: The creative chaos of Factum: several tests belonging to different projects often crowd corners and tables.



The colour of Raphael's Cartoons being printed over the heavily textured paper surface of Factum's flatbed printer.

object itself and the outside world that acts upon it. In 2013 Bruno Latour, who was both a close friend and one of the intellectual forces behind the creation of Factum, wrote:

'Because it connects the most advanced technology with the deepest care for the materiality, history and intricacies of works of art, Factum occupies now a central place at the cross-roads of all the issues concerning the restoration, conservation and politics of treasures spread in many different countries... it has given the words 'reproduce' and 'fac simile' a completely new sense of direction that has become synonymous with creation and innovation.'

In 2023, a decade later, this book shows that the technologies we have developed in the workshops in Madrid are having a growing impact. The software that supports each technology has its own poetics that massage the medium while the medium massages us. Redefining the words 'reproduce' and 'facsimile' in a positive way is still not easy. Prejudices about access to the original, even at the risk of causing it damage, still prevail. We need to clarify what differentiates a reproduction from a facsimile. What qualities does something need to have to 'look like', 'be like' and 'feel like' the original. The answer is becoming clearer: if the surface exactly matches the original, and the colour and reflectivity are produced with the same care, then it will function in the same way as the original for most levels of research and exhibition use, and the act of recording and display will reveal new insights into the original object. We refer to this as 'digital connoisseurship'.

Factum Foundation was formed in 2009, having grown out of the work of Factum Arte that Manuel Franquelo and I founded eight years earlier. We were both painters focused on the qualities that make things what they are and on issues that condition our understanding of realism. In the 22 years since Factum was formed, both input (digital recording systems) and output (systems for rematerialisation) have been developed and used for the creation of new works of art by Factum Arte, and the preservation of existing ones by Factum Foundation. In this time, the qualities of the display systems have started to engage with the high-resolution of the data we have recorded and processed. Some of these systems are developed in house, others are not.

'High-resolution' is a term in urgent need of definition, but the difference between 'good' recordings and 'average' ones is instantly visible on the right apparatuses. The new Varjo VR headset developed in Finland, with eye tracking and variable focus that mimics peripheral vision, can facilitate an intuitive access to the Tomb of Seti I. Factum began recording this tomb in 2001 and finished in 2022, funding the entire process. The tomb can be experienced as an embodied 'first person' view with our feet on the ground, or as a gravity-defying fly-through. It can be accessed by anyone, anywhere, as long as they have the right equipment. Global access is now possible and virtual reality is starting to look and feel real. The illusion gives access to the original object in an immaterial form. After spending time in this headset looking at the tomb, the immateriality becomes the norm – you enter into its realm. When removing the headset, the physical world seems strange for a brief period. You have to adjust when you put the headset on, and you have to readjust when you take it off. The human brain rewires fast. Neither objectivity nor our subjective response are fixed. Reality, as Maurice Merleau-Ponty demonstrated, can be inverted.

Perception is subjective but artefacts, the evidence of both natural and human action, facilitate objective and shared communication. Our goal is to present the qualities of the objects we engage with, without touching them or altering them in any way. The dimensionally accurate superficial qualities of a vast array of cultural artefacts must be preserved, fast and accurately, without imposing our perception upon them.

In Basel in 2017, Charlotte Skene Catling and I curated and designed an exhibition focused on the life of the tomb of Seti I during the 200 years since its discovery. In that period, approaches to preservation have changed dramatically. The exhibition contained various forms of access to the tomb in different media. It brought together facsimiles of fragments removed in the 19th-century, revealed the damage caused by Belzoni when he cast or 'squeezed' the walls, and demonstrated the processes he used. The



A bronze Dodo made in collaboration with Errol Fuller in 2021. This is one of a series of casts of creatures that have become extinct over the past 500 years.

sarcophagus was recreated in 3D printed facsimile form, identical to the original in Sir John Soane's Museum, London. The exhibition began with a physical reconstruction of the *Hall of Beauties* based on our recordings and research but using Belzoni's and Ricci's watercolours to replace the colour and reconstruct the missing parts of the room. It ended with a physical facsimile of the same room in its current state. It is now planned to establish a permanent version of this exhibition in the Grand Egyptian Museum in Cairo, which will hopefully open next year. The narrative is focused on revealing how things are changed, how they age with time and how they reflect the values of their age.

This book, the fourth in a series of publications produced by Factum Foundation, records the diverse projects that have been carried out since the beginning of the Covid pandemic in March 2020. Some of the central themes that have been reinforced over the past three years are the following:

Access

Archives are a great source of stories waiting to be discovered and revealed. Access is a central issue, both online and in the physical world. The work of ARCHiOx at the Bodleian Libraries has produced some remarkable results (see page 57): the discovery of marginal indentations on an insular manuscript revealed the name of 'Eadburg', a mother superior from Kent; the history of the Gough Map is being rethought and it is now seen as a copy of a previous map; un-inked palm-leaf manuscripts can now be read; the working process of Ukiyo-e printmakers is being re-evaluated and the recording of Raphael's drawings in the Ashmolean has generated a vast archive of information that needs to be studied and discussed. These are all examples that reveal the importance of the materiality of objects. Access to libraries, museums, and their content in virtual form, is a critical extension of their physical presence. But it is equally important that the virtual form contains the information needed by both the public and scholars. Online access is reinforcing the materiality of the book; one does not replace the other, but working in tandem, they can attract new visitors and help with issues of long-term preservation.

Education

The application of technology is rapidly changing education. The eurocentric approach to art history is being replaced by a much more global sense of how different societies represent themselves. There's an explosion of new information requiring new forms of scholarship. Previously inaccessible places, which range from geographically remote archaeological sites to libraries and collections closed to the general public, can now be visited online. Different technologies can be targeted towards a wide variety of audiences, from children to university-level researchers, and from those who never had the opportunity to study, to others returning to it in later life.

In England, education used to be free, and students were provided with means-tested grants to live on. Universities need to adapt and rethink their responsibilities. Their students are not clients, they are individuals who need to be inspired, motivated and empowered. The ARCHiVe Online Academy (AOA) (see page 32) is one of the main initiatives of Factum Foundation for the next three years. The recent 'learning by doing' course on San Giorgio Maggiore will be followed by others. The AOA presentations will be freely available, and we hope that students taking advantage of this facility will create new economies focused on the preservation of natural and cultural heritage.

Exhibitions

Technological access and innovation is transforming exhibition design and content while prioritising the preservation of works of art. Facsimiles allow the presentation and juxtaposition of objects and artefacts that were impossible to move and impractical to display. Now they can be in dialogue with each other in previously unimaginable configurations. André Malraux called for *Museums Without Walls* to facilitate new groupings, readings, and insights. This approach bypasses orthodox classifications, encourages debate, and offers solutions to issues of restitution, repatriation, and ownership. Facsimiles also play a significant part in helping to preserve fragile works of art that are most vulnerable when being loaned, handled, and shipped. It is transforming museum practice and informing a new approach to sharing.

Tourism

In a painful irony, mass tourism causes damage to the heritage sites that are its core focus, but many of these sites urgently need the revenue tourists provide in order to survive. Factum has been working to develop forms of immersive and sustainable tourism, which can either be remote and online or can help manage much needed visitors in places where the revenue they generate will help preserve the heritage.

Factum has been working in the Valley of the Kings, Luxor, since 2001. In 2015, Factum formed the *Theban Necropolis Preservation Initiative* (TNPI) to ensure the ongoing study and monitoring of tombs in the Valley of the Kings, and to establish an autonomous Egyptian team with the technologies, skills and infrastructure to provide 3D recording services to the Ministry of Antiquities and the many foreign archaeological missions working in Luxor. Factum's digital data can be displayed and rendered

at different levels of definition for a wide variety of contexts. This can involve the creation of exciting, scalable immersive tourist experiences designed to engage, delight and enlighten.

Factum created a facsimile of the tomb of Tutankhamun, which was given to the Egyptian people, and in 2014 installed in an underground building designed by Tarek Waly at the entrance to the Valley of the Kings. In 2016, Factum commissioned Tarek Waly to carry out the restoration of Hassan Fathy's Stoppelaëre House. It was repurposed as a 3D Scanning, Archiving, and Training Centre run by a fully Egyptian staff and with an Egyptian manager. The scanning of the whole of the tomb of Seti I, facsimiles of the Pillared Hall J, the Hall of Beauties and Seti's sarcophagus led to a major exhibition held at the Antikenmuseum Basel: *Scanning Seti: The Regeneration of a Pharaonic Tomb* in 2017. Many fragments removed from the tomb by early excavators and tourists, now in museums around the world, have been recorded. In 2019, the TNPI received the official patronage of the Egyptian National Commission for UNESCO, and in 2022, the programme established at the Centre saw ten students complete training in a range of recording technologies, providing them with skills which can be transferred to other projects within the Valley of the Kings and beyond. All these initiatives have been entirely funded by Factum Foundation to demonstrate how technology can create a new approach to tourism based on preservation and benefitting local communities.

Gaming and Entertainment

From historical reconstructions to scripted storytelling, the aim is to use technology to bring cultural communication to life and let it take seed in the popular imagination. Technological applications are often dismissed as being impoverished, but there is no reason why they cannot be enriching. The *Assassin's Creed* game saga managed to create a virtual world that educated a generation into the wonders of archaeology. The task is to merge entertainment with the richness of history, stimulate curiosity and allow ideas to flow.

First person experiences can engage visitors in new ways with many sites. In a virtual environment, users can interact with natural and architectural spaces and discover narratives in ways that are not possible or allowed in the real world. The different technologies are finding their form and discovering their strengths.

A New Approach to Sharing and Ownership

Objects have always migrated and moved. They will continue to do so, reflecting the values of dominant social forces. The collaboration between Factum Foundation and the individuals or organisations it partners with, is an unprecedented, independent cultural initiative. It is one where all involved mutually benefit. Through this new model, the binary issue of ownership, where something is 'either yours or mine', is overturned.

In the case of the Spanish Gallery (see page 285), the artworks recorded by Factum remain in their original locations displayed as they were designed to be seen. It is both revealing and moving to see artworks as originally intended when they are well cared for. But often they can be hard to see, to focus on or get close to. They can be unapproachable for several different reasons. Access might be restricted because of conditions placed by, or on, their guardians, through fear of damage to the original, or they could simply be physically 'out of reach'. Low light levels required for conservation can alienate artworks behind glass and, in some cases, will make a meaningful understanding of the work's material qualities, and all this reveals, almost impossible. When hung in an elaborate or historical context, the detail of individual artworks is sometimes overwhelmed or lost as they become elements of larger compositions. Guided tours, crowds of visitors and the way objects are displayed can prevent contemplation. There is a multiplicity of ways to experience artworks; all fulfil a function.

Facsimiles can contribute through the return of artworks to their places of origin, either as originals or in facsimile form. The installation of Veronese's *Wedding at Cana* in the Palladian refectory for which it was commissioned is a good example of how a facsimile can give a richer experience than the original, had its return been possible. The conditions needed to preserve the original painting (a sealed

atmosphere, protective glass, no natural light) would have altered both experience of the room and the experience of the painting, destroying the subtle dialogue between the architecture and artwork.

Facsimiles allow objects that cannot move to exist in alternate sites, facilitating a new approach to exhibition and display (as at Bishop Auckland), by reuniting artworks or collections that have been broken up and scattered, as well as by providing the means for preservation, close proximity and study. The copies being made now are an addition to supplement the originals, not replace them.

Collaborations

Collaborative work to preserve and re-think ownership was clearly demonstrated by the return of a Bakor monolith from the collection of the Chrysler Museum in Norfolk, Virginia. In February 2023, during the exhibition *The Bakor Monoliths: Endangered Heritage* at the British Museum, Factum put a call out to all institutions with monoliths acquired since 1970, asking for their return in exchange for an exact copy produced and funded by Factum Foundation.

The Chrysler Museum replied, agreeing to return a monolith from the village of Njemetop that had been bequeathed to them in 2012. It was removed in the 1970's in the aftermath of the Nigerian Civil War and is thought to date from the 15th to the 17th-century. The monolith was either sold or stolen, probably travelling over the nearby border with Cameroon before entering the international antiquities market via Brussels or Paris. Factum made an exact facsimile, and in June 2023 there was an exchange between the museum and the Nigerian ambassador in the United States. The facsimile is now part of a display about looting and restitution (see page 143). The original is currently in Calabar but will soon be returned to its original location. At a time when the debate on restitution and repatriation is centre stage in cultural conversations, digital technologies are presenting new ways of thinking about – and perhaps even resolving – some of the issues.

Natural, Cultural and Environmental Heritage

Originality is a process that needs tending. As nature and culture come closer together the relationship between the human and the non-human, the animate and the inanimate is changing fast. One of the projects that seems to come closest to the poetry of Valéry is the collaboration that has begun with Divirod, a company from Boulder Colorado started by Javier Marti, who previously worked in the European Space Agency (see page 31).

Divirod have developed a way to harness the 'noise' generated by mobile phone signals to 'read' the movement of water in real time. As it uses what is essentially the 'waste product' of another process, it is very cheap. Together, Factum and Divirod have installed several advanced sensors on the island of San Giorgio Maggiore in Venice, which can detect the unique signature of satellite signals bouncing off the surface of the water of the Lagoon. This provides a local, accurate and dynamic image of the relationship between a fixed point on the land and the water. The data is uploaded to the cloud in real-time, where a machine learning software developed by Divirod aggregates and processes it. The more sensors installed, the greater our understanding of the relationship between the land and the water.

Water is a dynamic fluid that is animated by many forces, from gravity and the wind to the energy released by earthquakes or the passing of boats. The accurate hydrological models generated from these harmonic recordings are used to create constantly updating representations of the tide, wave activity and wind speed. They can be used to predict erosion and flooding. Over the next two years this collaboration will also link to the work with the AaltoSiilo project in Oulu, Finland (see page 159), which focuses on recording changing natural and industrial heritage on the edge of the Arctic Circle. Venice is sinking about half a centimetre a year, while Oulu is rising at the same speed due to post-glacial rebound as the ice melts; the brackish water of the Gulf of Bothnia now supports fish of both fresh water and marine origins. Both Oulu and Venice are dependent on bodies of water that are vulnerable to change. The next phase of the collaboration will be to extract information about temperature and salinity from how satellite signals penetrate, and reflect off, the surface of water.



CONCLUSION

Paul Valéry observes that, 'colour and relief are still rather resistant. A sunset on the Pacific, a Titian in Madrid cannot yet be enjoyed in our living room with the same force of illusion as a symphony'. But today, a Pacific sunset can be mediated through an LED screen, a VR headset, or a variety of other display systems. The Titian can exist 'wherever you are' both physically, and as an ultra-thin, ultra-rapid illusion.

In times of uncertainty the future needs more than ever to learn from past. The many different narratives contained in this book show that we are not talking theoretically; our work is the practical demonstration of our philosophy that also enables us to transfer skills and technologies while creating new local economies based on preservation.

The recent events around the sacred cave of Kamakuwaká ultimately give reason for optimism (see page 157). The cave is on a tributary of the Amazon River in North Brazil, in a contested zone just outside the protected area of the Upper Xingu that the Villas Boas brothers set up in 1961 to safeguard indigenous communities and preserve their way of life. In 2017, Akari Wauja, a local leader and protector of oral traditions, asked Factum Foundation to send a team to record the sacred cave. But when Ferdinand Saumarez Smith and Arthur Prior arrived at the site, it had been urgently and systematically vandalised. Someone had hacked off each of the ancient petroglyphs with a hammer and chisel, leaving them as rubble at the base of the walls of the cave. Akari picked up the shards of symbols in disbelief, but also in fear that they might fall into the wrong hands. These objects, and what they represent, are considered to hold potent magic powers. The Wauja people have few possessions. But the cave was the compendium of their origin myths. It was where and how they handed on their stories and identity from one generation to the next.

The site was recorded in colour and 3D in its vandalised state. From historical photographs, and the reconnaissance reference pictures taken by the Factum team, it became clear that the cave could be digitally restored by creating 'depth maps' created from photographic evidence and with the memories and help of the local communities. From 2017 until the end of 2019 every petroglyph was analysed, researched, cross-checked and objectively recreated as part of a 1:1 scale reconstruction of the cave.

In late October 2019, the communities of the Upper Xingu made the collective decision to declare that the reconstruction would now act as the 'original' cave, communicating the knowledge of ancestors to those who follow. The vandalised site, now surrounded by the monoculture of soy production in a de-forested area outside the reserve, should stand as articulate evidence, a ruin of itself. A team from People's Palace Projects and Àterra Bioarquitetura is currently building a centre to house the facsimile of the cave of Kamakuwaká. The building will also house a research centre for monitoring the nearby river Batovi. The cave will begin its odyssey into the Upper Xingu as soon as the building is complete.

The task to protect and preserve both cultural and natural heritage is more critical than ever. The decision of the Wauja, Kuikuro and Krenak communities shows that originality is a process that needs to be understood and respected. This enlightened way of engaging with our environment will hopefully help shape cultural management and offer clues for a way forward for all of us. Artefacts enable us to perceive the world from the perspective of others and access a vast shared archive of memories embedded in the world around us.

Opposite: Checking the colour on a facsimile of 'aTitian in Madrid'. Titian's *Danae* from the collection of the Duke of Wellington, was in Madrid for the exhibition 'Titian: Love, Desire, Death' (20 October - 10 January 2021). The painting has been identified as the original version of *Danae* after detailed research and scholarship by Miguel Falomir and Paul Joannides. It was 3D scanned and recorded in colour while it was in Madrid.



1. COLLABORATIONS

*‘When one has had a good argument about spirit and matter,
one always finishes by not understanding each other.
No philosopher has been able with his own strength to lift
this veil stretched by nature over all the first principles of things.
Men argue, nature acts.’*

*Voltaire
Philosophical Dictionary, 1764*

Opposite: Burial across time and space: behind the facsimile of Seti I's sarcophagus, a 3D print of Cardinal Tavera's marble sepulchre rests on top of Tutankhamun's outer sarcophagus.

ARCHiVe

In June 2018, the Fondazione Giorgio Cini, Factum Foundation for Digital Technology in Preservation, and the Digital Humanities Laboratory of the École Polytechnique Fédérale de Lausanne (EPFL-DHLAB) created ARCHiVe – Analysis and Recording of Cultural Heritage in Venice – with the Helen Hamlyn Trust as supporting founder. ARCHiVe's 1000 sq metre facility, located above the Stanze del Vetro on the Island of San Giorgio Maggiore, is dedicated to the development and use of technology to preserve cultural heritage. Since its launch, ARCHiVe has become a hub devoted to high-resolution scanning and the creation of digital archives with institutions from around the world.

All the tools developed in ARCHiVe are made available to institutions pursuing the study, protection, and conservation of cultural heritage. The founding partners work constantly to develop this technology, improving its efficiency and effectiveness to keep up with the ever-evolving world of big-data analysis.

Among the technologies developed and employed by ARCHiVe are the Replica Recto/Verso Scanner and the Portable Manuscript Scanner. Both use open-source software created especially for handling data gathered from manuscript scanning. These non-contact technologies are integrated with Factum Foundation's most used recording methods and technologies: the Lucida 3D Scanner, photogrammetry, panoramic composite

photography, LiDAR scanning and structured white-light scanning. Furthermore, the non-contact high-resolution recording techniques employed by ARCHiVe enhance the field of digital restoration, a fast-growing application of digital technologies.

In its first year, ARCHiVe was shortlisted by Apollo Magazine for its Digital Innovation of the Year Award and has since been regularly cited in national and international media outlets.

Additionally, from 2018, interns and collaborators were hired and trained by ARCHiVe, and several workshops and training programmes have been carried out with national and international universities and cultural institutions. Every year, ARCHiVe offers fellowships to young researchers, as well as student internship opportunities aimed at developing or enhancing the skillsets related to digital technologies and digital humanities within a dynamic and professional context, aligning with Factum's aim to make technology widely accessible.

Recently ARCHiVe launched its own social media profile on Instagram and launched a dedicated website:

archive-venice.org

Images of Venice's *acqua alta* in November 2019, the highest recorded level in fifty years.

From this mix of technology, recording, analysis and archiving new areas of study are emerging. The list of themes is being expanded through ongoing work but some can be identified as the main topics in the field of digital humanities: condition monitoring; repatriation; in-depth analysis and research; multi-layered archives; access to inaccessible sites and objects; reuniting objects with their intended location or as they were intended to be seen; assisting in museum loans and ownership issues; providing new opportunities for exhibitions, theatrical interventions and diverse forms of display; digital restoration; re-creating lost objects; transferring skills and technologies; providing long-term stable archiving, generating raw data for machine learning and AI... The list is growing.

Adam Lowe in 'Fondazione Cini. 70 anni di storia', Marsilio Arte, 2022



San Giorgio Maggiore: Recording an Island

In November 2019, Venice experienced one of the worst episodes of *acqua alta* (high water) since the dreadful record set in 1966. The extensive damage to the buildings and cultural heritage highlighted the fragility of our material past, and the urgency of recording and preserving the history of Venice. This event kickstarted one of ARCHiVe's most ambitious projects: the recording of the entire island of San Giorgio Maggiore.

Over a period of twelve days during the summer of 2020, Factum Foundation and the Fondazione Giorgio Cini recorded the island of San Giorgio Maggiore.

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. The island was recorded by a team of five people from more than 600 different stations, generating a massive 60,000-million point-cloud. Point-clouds of large areas, which are generated by LiDAR laser scanners, can be merged with higher resolution photogrammetry data of more localised areas to create a 3D model of the whole island – it is hoped that further financial support for the project will enable this to happen.

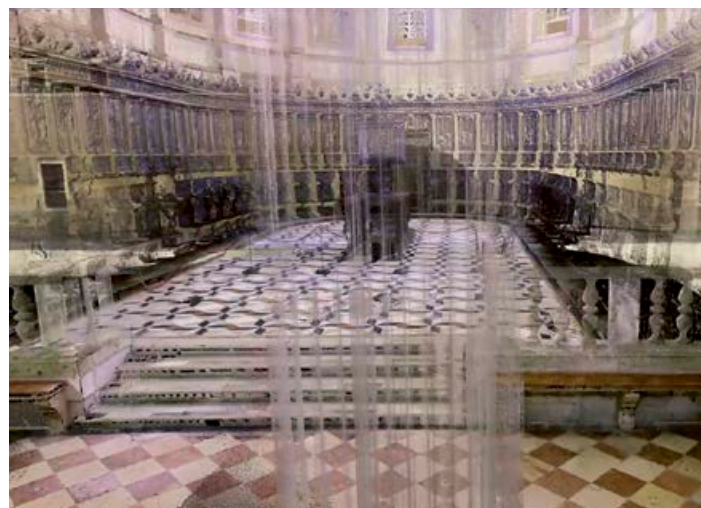
Since 2020, the work carried out on the island has found direct applications for the study and monitoring of the speed of the salt damage to the stucco walls of the cloisters of San Giorgio Maggiore. The data has been used to generate a restoration program for the external surfaces of the building and the presidential rooms, as well as facilitating a detailed study of the furniture in the Cini's collection.

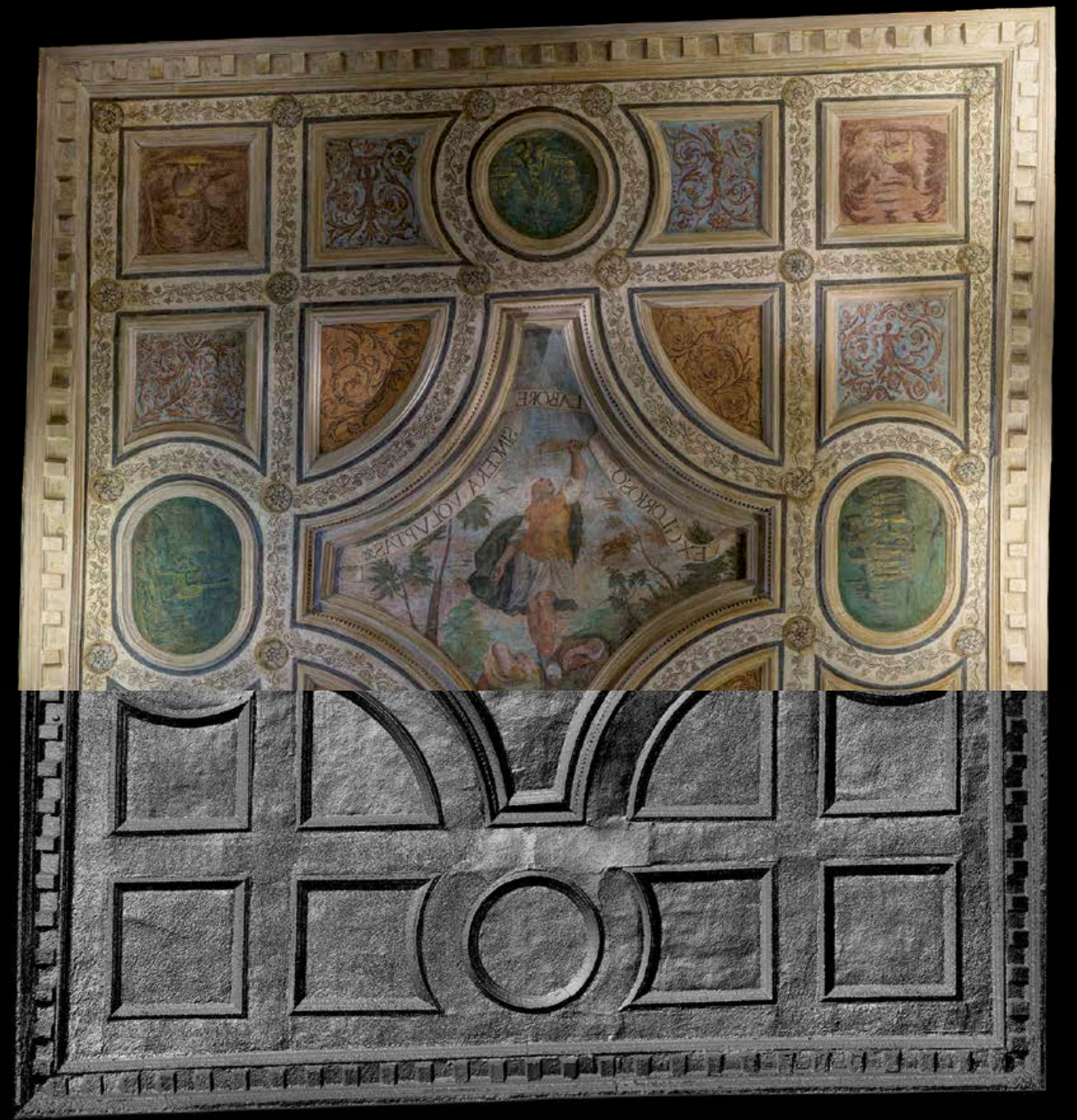
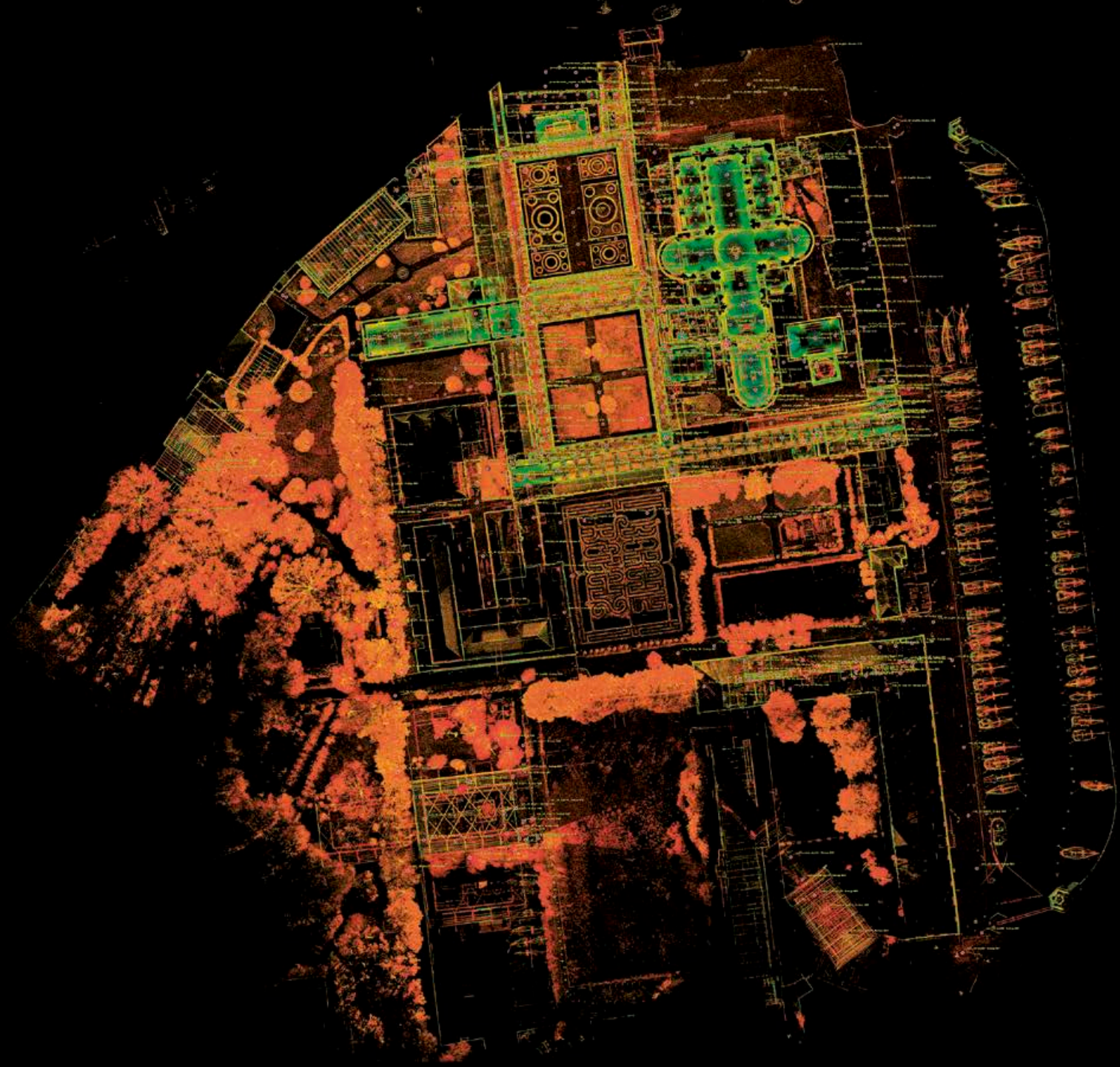
As the recording of both the island and its contents continues, it will make the remarkable collections of the Fondazione Giorgio Cini increasingly open and accessible. As new technologies are developed and refined, we will be able to gather increasingly detailed data which will enhance the entire field of study and research.

3D render of the cloister of San Giorgio Maggiore, near ARCHiVe's headquarters.

Opposite: 3D renders of the island and the façade of San Giorgio Maggiore, of the apse and the altar inside the Basilica.

Overleaf: Tonal map of the island (left). 3D model of the Sala del Soffitto's ceiling with and without colour (top right). Recording the altar inside the Basilica of San Giorgio Maggiore. 3D model of the altar (bottom right).







Divirod: Monitoring San Giorgio Maggiore's water levels

Following a radio programme on the digitisation of the Island of San Giorgio Maggiore (*TheWorld*, September 2020), Factum Foundation was contacted by Divirod, a tech start-up from Boulder, Colorado.

Divirod has developed a passive radar sensor that uses satellites and locally recorded data to generate accurate hydrological models. The software transforms harmonic resonances into dynamic representations of tide, wave activity and wind speed to predict erosion and flooding. Divirod has provided various examples of advanced sensors to monitor the relationship between land and water on the island, with the data accessible in real-time on desktop and mobile devices. In late August 2021, ARCHiVe installed the first Divirod sensor to enable the study and documentation of the natural changes on and around the island.

The advanced sensor installed in Venice detects the unique signature of satellite signals bouncing off the water of the Lagoon. This provides a local, accurate and dynamic image of the relationship between a fixed point on the land and the water. The data is uploaded to the cloud in real-time, where machine learning software developed by Divirod compiles and processes it. The accurate hydrological models generated from the harmonic recordings are used to create constantly updating representations of the tide, wave activity and wind speed, to predict erosion and flooding. As more sensors are installed, our understanding of the relationship between land and water will continue to deepen. Indeed, though the latin 'terra firma' defines the land by its solidity and firmness, it is in slow but perpetual motion, while water is a truly dynamic fluid, animated by everything from gravity to speedboats. As ARCHiVe's study progresses, we hope to further investigate

the interplay between land and water, so characteristic of the cultural heritage of Venice.

A second sensor was installed in February 2022 on the north-eastern point of the island. As the sensors start to log vast quantities of dynamic information, Factum Foundation and Divirod will be working with the Cini Foundation to find new applications and develop tools that will help provide answers to practical needs, such as the extraction of information about salinity and temperature.

Top: The second sensor installed on the north-eastern point of the island, February 2022. Bottom: Dashboard on the Divirod platform where the results can be monitored.

Opposite: Salt damage recorded on one of the cloister walls over three years (top). Point cloud of the inside of the flooded crypt (bottom).



AOA — ARCHiVe Online Academy

In 2021, ARCHiVe started hosting AOA – the ARCHiVe Online Academy. AOA is an online training program initiative aimed at a broader audience of students, scholars, researchers and those who want to improve their skills in the field of digital technologies applied to cultural heritage. Each two-hour-long classes is free and broadcast live, before being uploaded on the Giorgio Cini Foundation's YouTube channel for subsequent access.

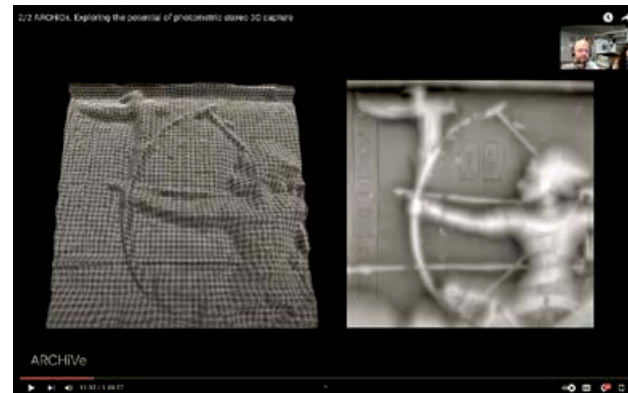
AOA has also organised workshops to complement the online programme wherever possible, covering topics as diverse as the recording of the relief of paintings in 3D, the use and application of close-range photogrammetry, as well as digital restoration and photometric recording. Together, these courses and workshops have been instrumental in sharing Factum's work and offering instruction in their technological innovations.



In September 2021, a special presentation was dedicated to the recording of the island of San Giorgio Maggiore and celebrated the 70th anniversary of the Fondazione Giorgio Cini, presided over by Renata Codello, Secretary-General of the Foundation. Factum's founder Adam Lowe also contributed to *Fondazione Giorgio Cini. 70 anni di storia*, a volume edited by Pasquale Gagliardi and Egidio Ivetic, published by Marsilio Arte in 2022.

For more information on AOA's programmes, please write to: info.aoa@cini.it.

You can also visit the website (archive-venice.org) or follow the centre's Instagram account (@centroarchive).



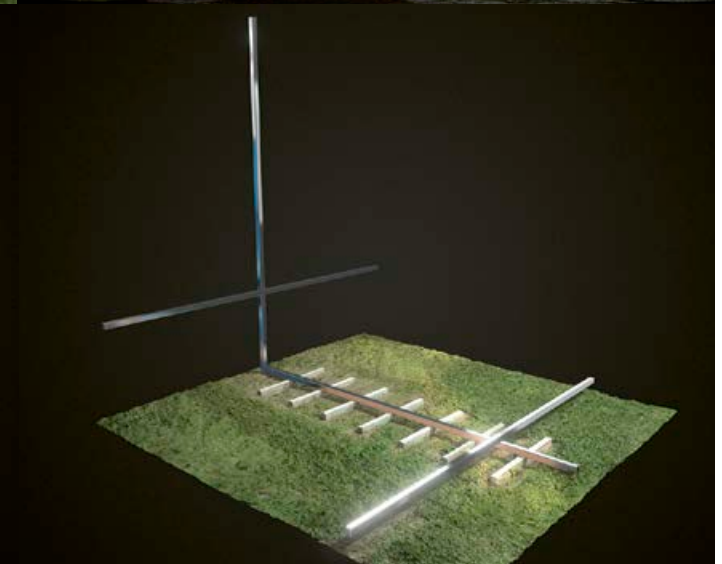
Teatro Verde and the Vatican Chapels

The Teatro Verde was not initially included in Factum's first digitisation campaign in July 2020. It was recorded later, in July 2022, as part of the project to restore and reopen the theatre to the public. Preliminary results of the recording were provided to artist Mattia Casalegno, to be included in an experimental AI-generated film *La Maschera del Tempo*, produced by the Giorgio Cini Foundation.

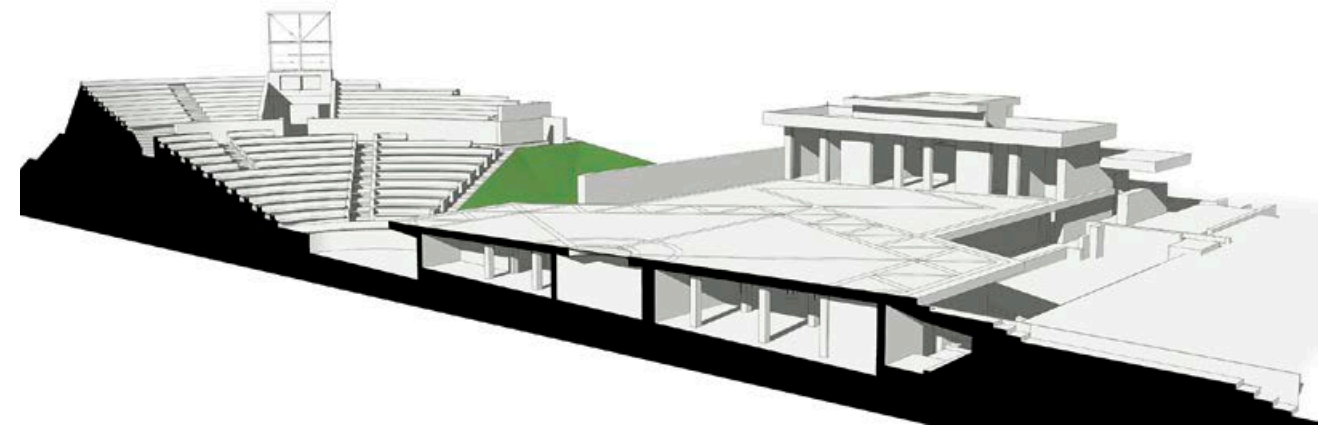
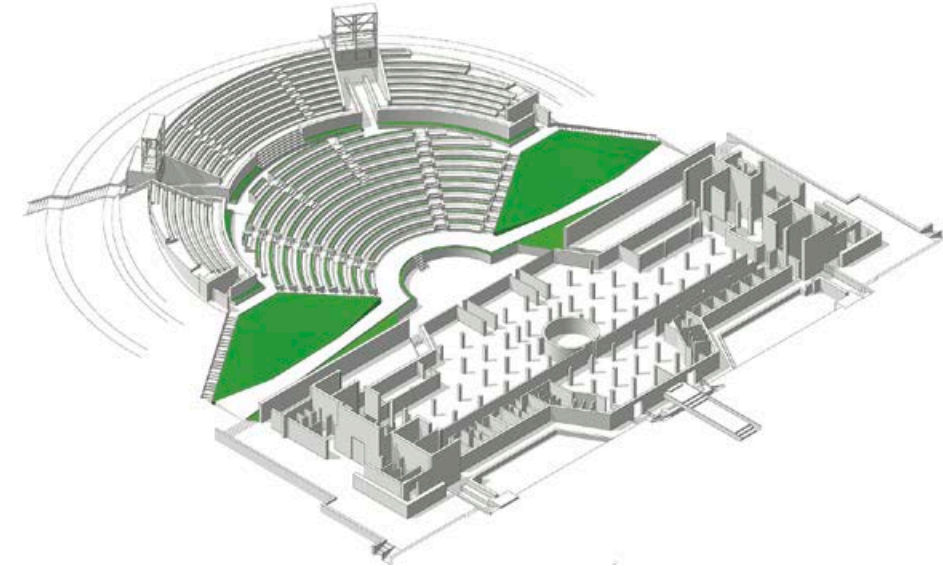
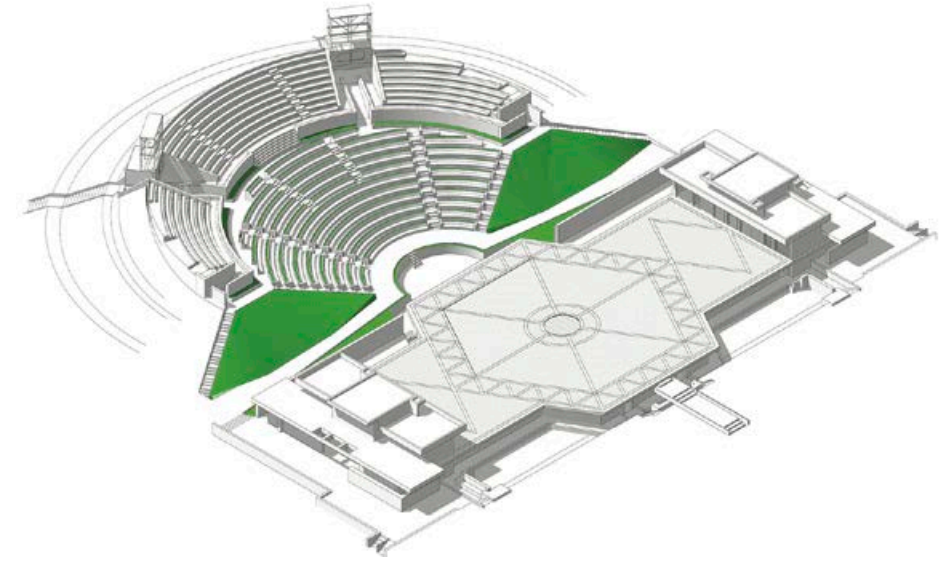
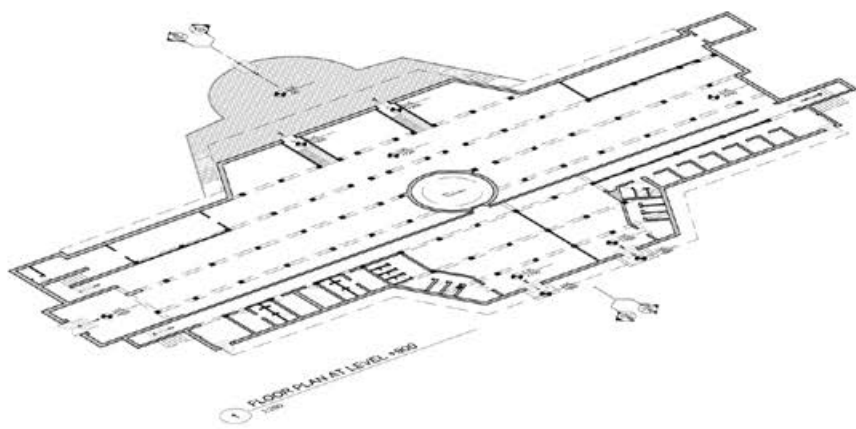
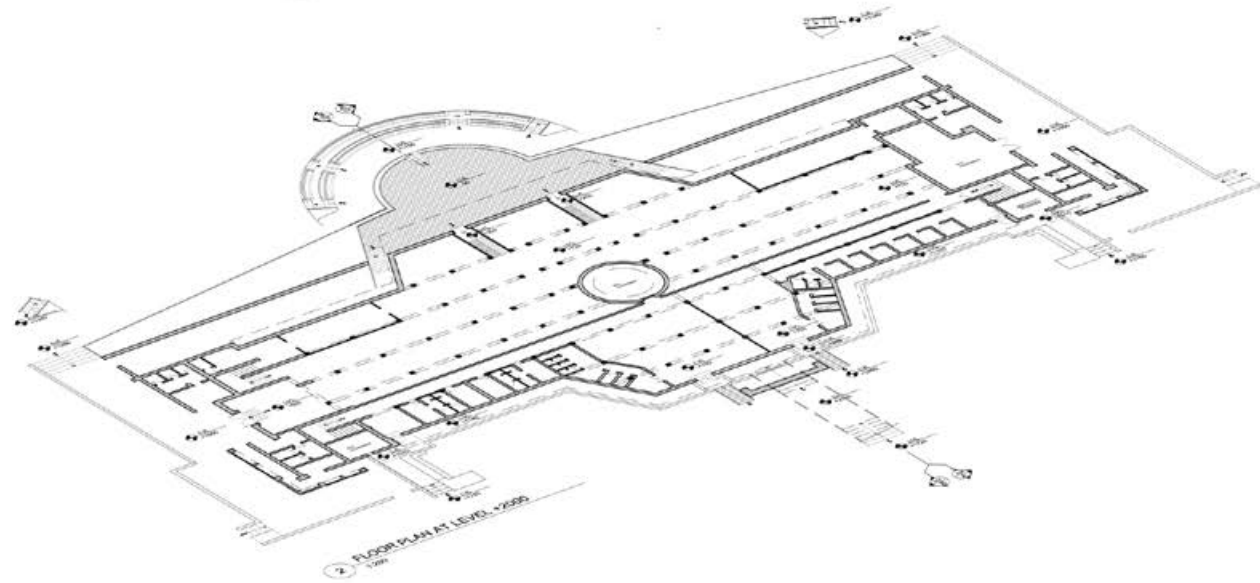
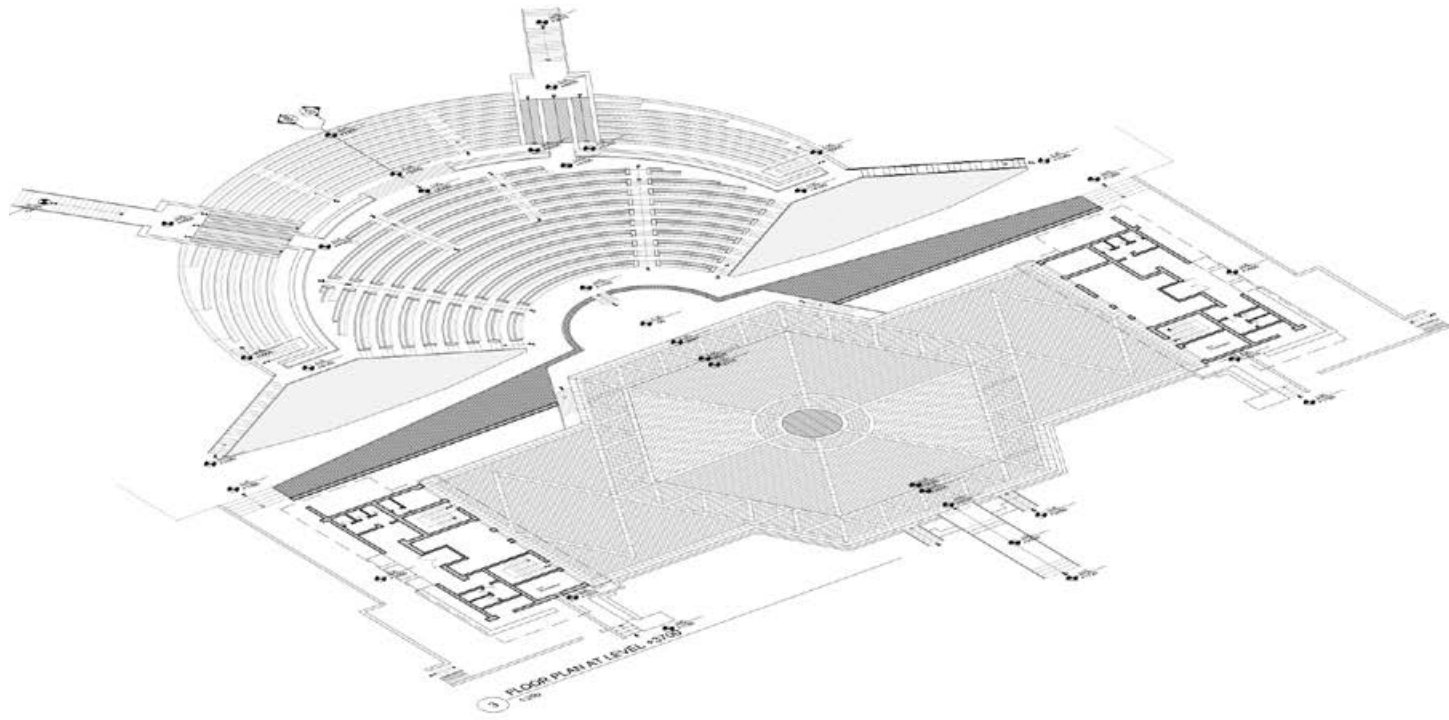


The ten Vatican Chapels, designed for the first Holy See Pavilion at the 16th International Architecture Exhibition of the Venice Biennale in 2018, were also included in the recording of January 2022. The data was processed into 3D models of the interior and exterior of all ten buildings.

Recording pictures and 3D renders of the Vatican chapels. Overleaf: 3D renders from the aerial photogrammetry scanning. Architectural drawings of Teatro Verde generated from the recordings.







Italgas — Archiving Heritage

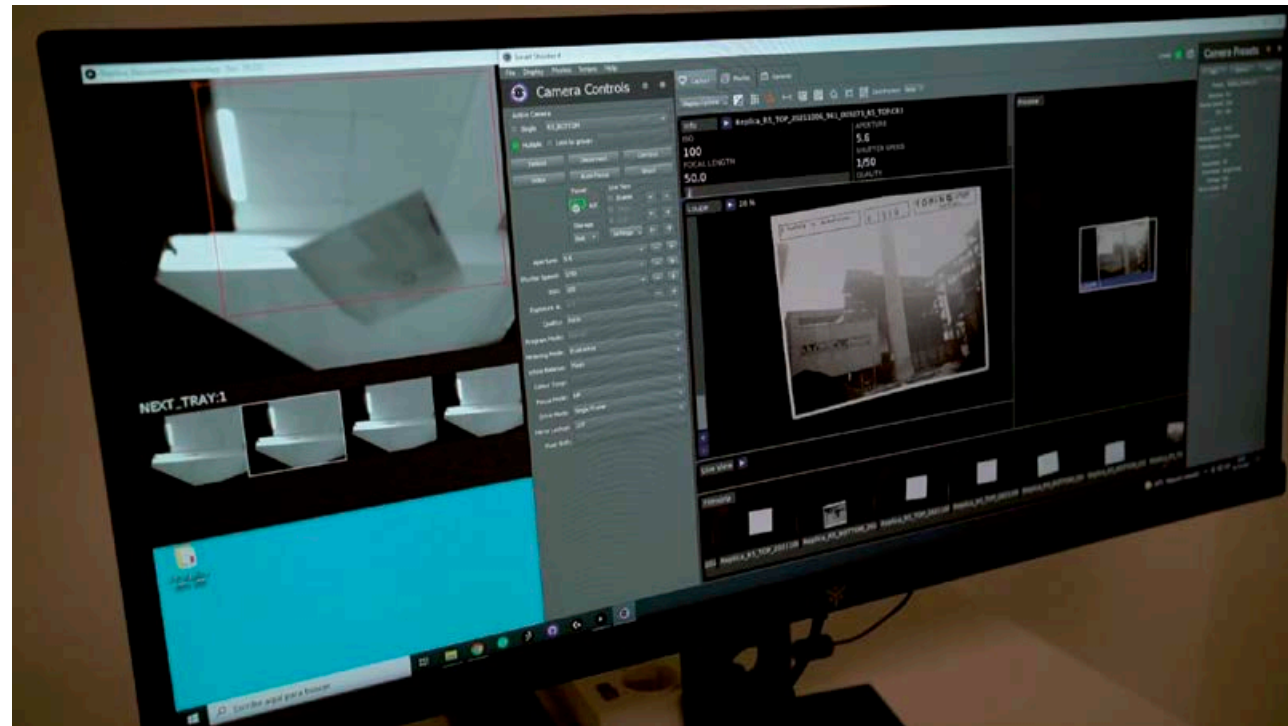
In 2021, Italgas (Italy's main gas provider, founded in 1837) partnered with ARCHiVe to record and publish online its historical archive: a multi-layered and complex collection of documents, pictures, historical papers, scientific journals, and essays. To achieve this, a custom Replica 360 Recto/Verso, a recording system developed by Factum Arte and Factum Foundation, was installed in a dedicated space within the Italgas headquarters in Turin in October 2021.

The Replica 360 Recto/Verso Scanner was originally designed for the rapid digitisation of the vast photo-archive belonging to the Fondazione Giorgio Cini, and has been successfully operating since its installation in Venice in 2018. It is designed as a rotary table that moves continuously during a digitisation session run by two operators, simultaneously photographing both sides of single-page documents and automatically downloading the images onto a computer.

After a training session carried out by the Factum team, the Replica started the digitisation program in the Italgas Heritage Lab at the end of 2021. In November 2022, Italgas launched the Heritage Lab website, where readers

can browse almost 900,000 digitised documents for free. Among these are archive papers and bank records of Jewish people, digitised in collaboration with the Fondazione Centro Documentazione Ebraica Contemporanea (CDEC) in order to preserve historical documents of anti-semitic persecutions during the Fascist era.

Top: A team from Heritage Lab during the training sessions. Bottom: Live results of the Replica 360 Recto/Verso scanning.



ISIA Urbino: Palazzo Grimani Workshop

In 2019, Factum Foundation's 3D scanning department delivered a five-day workshop focusing on non-contact recording technologies for cultural heritage to ten students from the Photography MA course at ISIA Urbino.

Taking place at ARCHiVe's studios within the Fondazione Giorgio Cini, this workshop reflects one of Factum's core principles; to provide practical training on real digitisation projects, an experience that provides students with a better insight into the realities of onsite work. In this case, participants carried out fieldwork recordings at various institutions around Venice, and the valuable data they obtained could give rise to larger projects for ARCHiVe.

During the workshop, students utilised photogrammetry to produce 3D recordings of a series of classical busts at the 'Domus Grimani' exhibition at Palazzo Grimani. These recordings demonstrate the capability of our technology to generate high-resolution photogrammetric scans of even reflective materials. Students also used photogrammetry on two porphyry busts, a series of Maiolica pottery and a small terracotta head by Antonio Canova at the Colnaghi exhibition held at Abbazia di San Gregorio. On San Giorgio, the Lucida 3D Scanner was used to record high-resolution data for the surface of a painting on canvas by Girolamo Brusaferrero.

The students recording different objects at Palazzo Grimani.



The cordiform world map of Hajji Ahmed

The cordiform (heart-shaped) world map (c. 1560) is attributed to the Tunisian Hajji Ahmed and is currently located in the Biblioteca Marciana in Venice, a city in which some recent studies suggest it was originally made and by multiple authors rather than one. The woodblocks were found in 1795 in the Criminal Archive of the Council of Ten within the Palazzo Ducale. Twenty-four 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 a memoranda of understanding between the Venetian institutes of IUAV University Venice (Istituto Universitario di Architettura di Venezia) 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. This initiative, led by ARCHiVe, sought to compare and assess the respective merits of the three recording techniques – photogrammetry, laser scanning, and the Lucida 3D Scanner.

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).

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 has been compiled with the data from the front, to generate a full record of the condition of the woodblocks.

The front of the woodblocks have also been recorded with high-resolution panoramic composite photography, which can be registered alongside the 3D data obtained by the Lucida.

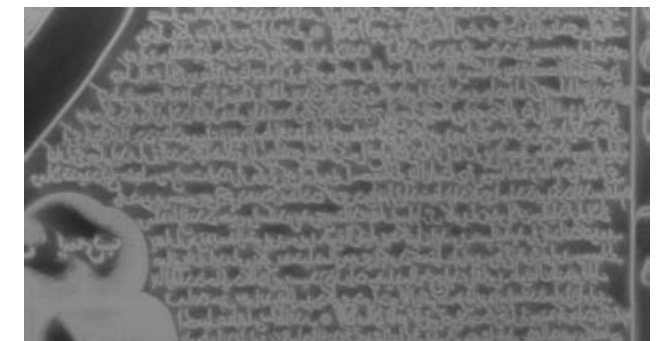
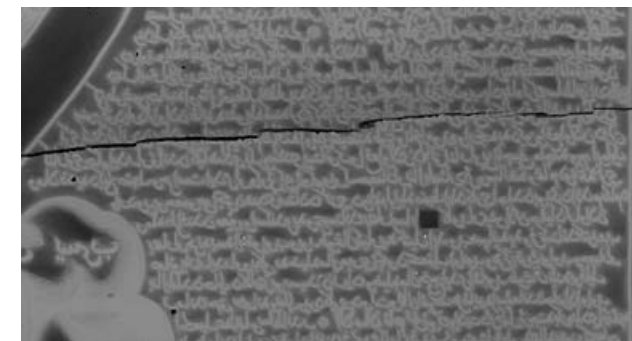
DIGITAL RESTORATION

In the most recent phase of this project, Factum Foundation's Teresa Casado completed a 'digital repair' of the surface of the woodblocks. Using the greyscale depth-map information gathered by the Lucida, cracks and lacunae on the surface of the woodblocks were virtually restored, enabling a new version of the map corresponding to the 1795 prints to be created. The copy of one of these prints at the Biblioteca Marciana has been used as the reference.

Different tests made with both CNC-milling and with Canon CPP's Elevated Printing, have been done in collaboration with Biblioteca Marciana to check the restored version of the surface. Further tests will be completed to determine the best prototyping method, before re-materialising the complete set of panels as prints.

Top: Detail of the 3D data. Bottom: Detail of the digital restoration of the holes left by woodworms; original scanned data (bottom left) and post-restoration (bottom right).

Opposite: Recording the map's surface with the Lucida 3D Scanner (top left). Small sections of one of the printing blocks, rematerialised with CNC-milling, top, and with CPP's Elevated Printing, bottom left. Initial printing tests have been made out of the CPP surface, bottom right (top right). Copy of the map, printed from the recreated woodblocks (bottom).



Assumption of Mary and Saints by Sandro Botticelli's Workshop

In early 2020, the *Assumption of Mary and Saints*, entered the preliminary phase of research and diagnostics preceding its restoration in the Open Care facilities, as part of a project sponsored by Open Care and Factum Foundation, with the support of Euromobiliare Advisory SIM. Part of the collections at the Monumental Complex of the Pilotta in Parma, this painting has been attributed to the workshop of Sandro Botticelli and depicts a serene Mary above the heads of Saint Benedict, Saint Thomas and Saint Julian.

The painting was recorded in high-resolution using the Lucida 3D Scanner, documenting its surface and providing significant information to inform and guide the Open Care's restoration, completed in early 2022.

Top: Lucida 3D Scanner surface recording. Bottom: Before and after the restoration.

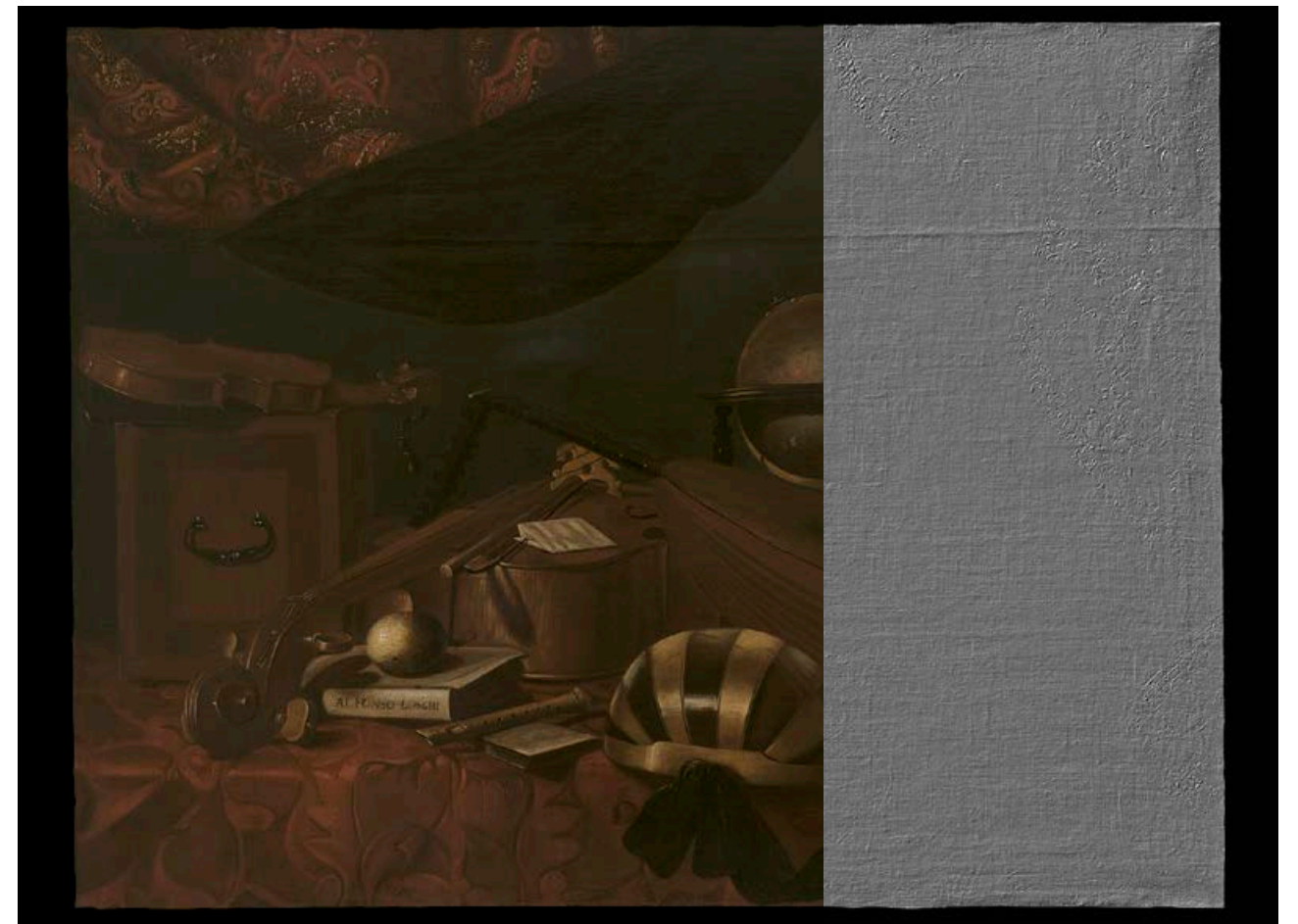


Musical still lives by Evaristo Baschenis

In early 2020, Factum Foundation recorded two paintings regarded as studio works from a series of still lives of musical instruments by Evaristo Baschenis, belonging to Museo Arte Tempo in Clusone, Italy. This is the first step in a collaboration between ARCHiVe and the Fondazione Giorgio Cini's Early Music Seminars, directed by Pedro

Memelsdorff, which aimed to identify eight paintings belonging to a series previously belonging to the monks of San Giorgio Maggiore, Venice.

Top left: The facsimile of one of Baschenis' still lives. Top right: recording the painting in Clusone. Bottom: Recorded data, colour (left) and surface (right).



Newspaper archive, *Il Giornale dell'Arte*

To celebrate the 40th birthday of the newspaper *Il Giornale dell'Arte*, founded by Umberto Allemandi in 1983, ARCHiVe conducted specific digitisation tests and recorded 80 earlier copies of the newspaper. The issues were digitised to be freely available online, with a digital OCR-supported function to make the texts easily searchable.

All the copies, as well as their 220 additional issues, were digitised using high-resolution colour photography. Following the post-processing phase, all the digital files were organised using different file formats: high-quality .JPG, lower quality .JPG, CR2 (raw digital photography file format), high-quality .PDF and compressed .PDF. The OCR engine was then added to each PDF file.

The Photographic Manuscript Scanner was used to record the archive.



The Migrant Child by Banksy

During the 2019 Venice Biennale, the pink flare of Banksy's *The Migrant Child* first appeared just above the waterline on Dorsoduro. In the same year, amid flooding and rumours that the mural was scheduled for removal, the Fondazione Giorgio Cini and ARCHiVe decided to record *The Migrant Child* in high-resolution to demonstrate the urgent need to preserve and document cultural heritage before it is lost or damaged. The ARCHiVe team were able to record the mural in such great detail that an exact facsimile could be made, down to the water stains and crumbling brickwork. In the future, when the painting is restored or disintegrates, Banksy will be able to instruct the resurrection of the mural on the island of San Giorgio or elsewhere in Venice. The recording of the graffiti demonstrates the integral role technology is playing in the preservation of diverse forms of heritage.



Gabriel Scarpa uses composite photography to record the Banksy mural (top). Printing the facsimile of the mural (bottom).



The painting collection at the Galleria di Palazzo Cini

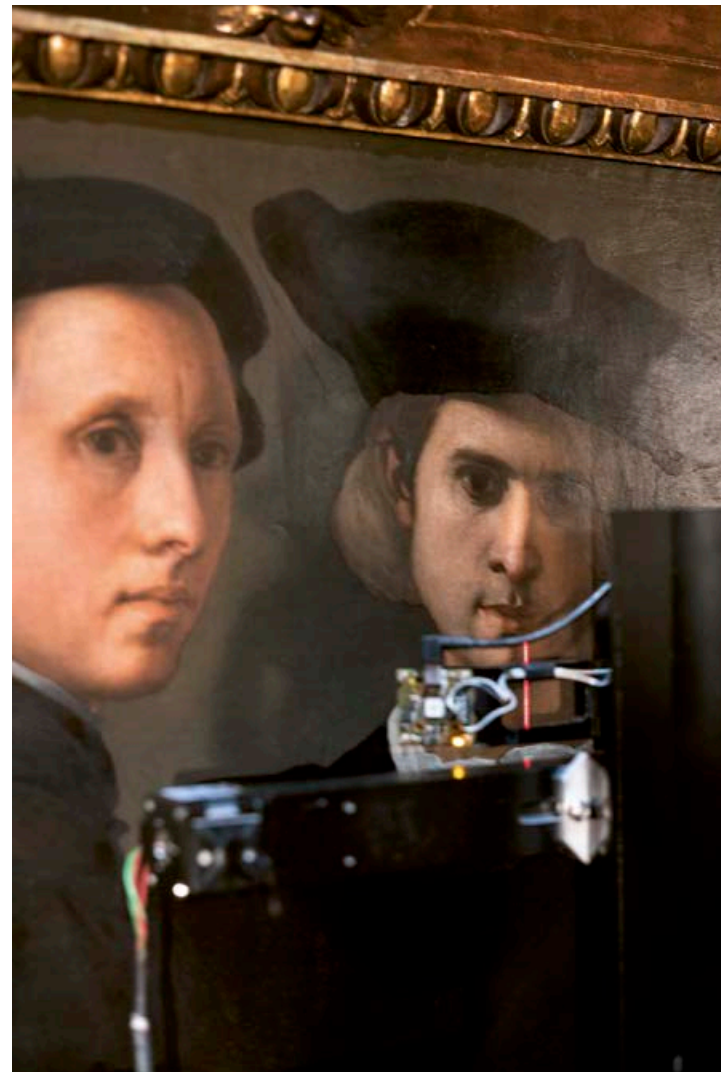
After scanning the Island of San Giorgio Maggiore, the Teatro Verde, the Vatican Chapels and a large Franco-Flemish tapestry on San Giorgio Maggiore, Factum recorded a selection of paintings in the Galleria di Palazzo Cini in San Vio in March 2023. Thanks to the collaboration between the Fondazione Giorgio Cini's Istituto di Storia dell'Arte and Factum, this unique group of artworks at the core of Vittorio Cini's art collection is being digitised in high-resolution.

The recording was carried out over a period of three weeks by Gabriel Scarpa, Carolina Gris and Marina Luchetti, part of Factum's team in ARCHiVe, employing the Lucida 3D Scanner in combination with composite photography. Their work will provide an accurate database that will help monitor the conservation state of the paintings over time, support the twofold study of the artworks as images and

objects, and disseminate their artistic and historic value. The data was then processed to create high-resolution digital viewers available to both experts and the general public to inspect every detail of both surface and colour.

The information that was recorded will become part of the holdings of the Fondazione Giorgio Cini and contribute to the preservation and dissemination envisaged by Vittorio Cini and his advisor Bernard Berenson. Two of the paintings were part of the *Polittico Griffoni* and have already been reproduced as facsimiles on permanent display in the Museo della Città in Bologna.

The Lucida 3D Scanner recording one of the *Polittico Griffoni* panels (left) and Pontormo's *Portrait of Two Friends* (right).



The Entry into Palestine of the Army of Vespasian by Master Coëtivy

Dated between 1470 and 1480, the Franco-Flemish tapestry *The Entry into Palestine of the Army of Vespasian*, created from cartoons by the Master of Coëtivy, is one of the two earliest and most significant works in the whole Giorgio Cini collection, and forms part of a series about the destruction of Jerusalem (70 AD). The tapestry was recently identified as the right half of a textile work within the collection of the Musée des Arts Décoratifs in Lyon, making its recording, conservation and restoration a priority for the Fondazione Giorgio Cini. The digital documentation of the tapestry's surface is an essential step towards understanding its material structure. ARCHiVe carried out the complete documentation of the tapestry's shape, texture and colour, thanks to a combination of 2D and 3D non-contact scanning technology.

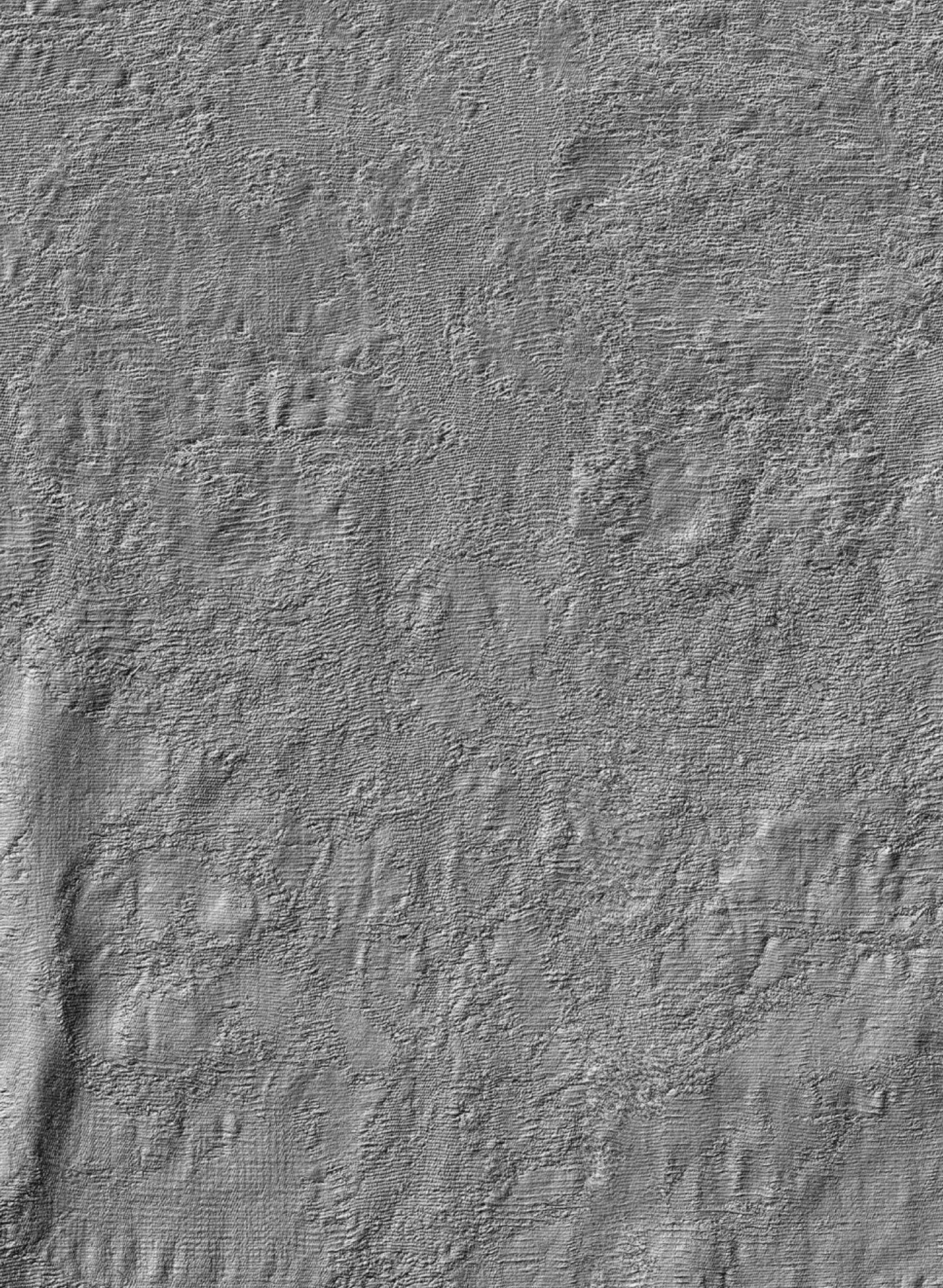
The digitisation of the first historic tapestry from the Giorgio Cini collection required adapting the Lucida 3D Scanner's structural frame to record large horizontal areas. The Lucida was primarily designed to scan paintings vertically, while they are mounted on an easel or on the wall. The conservation requirements of the Cini tapestry did not allow it to be positioned vertically, so the recording had to be completed with the tapestry lying flat. The Lucida components were re-designed and re-arranged to allow a usable span of 4.5m, enough to accommodate the tapestry's width.

The structure was then adapted to be used for the composite photography recording, varying the capture distance.

A specially designed pulley system allowed the photographer to slide the camera (with its mounted flash unit) along the beam from a fixed position.

The Lucida 3D Scanner recording the surface of the tapestry. Overleaf: Detail of the tapestry showing the surface data (left) and the merged surface and colour data (right).





Medardo Rosso: Analysing Differences in Wax Castings

Factum Foundation is collaborating with Dr Sharon Hecker on a project aimed at contributing to the conservation, study, and dissemination of the work of Medardo Rosso (1858-1928). The project involves the application of non-contact digital technology to obtaining high-resolution 3D data of a series of bronzes and wax sculptures by Rosso. Apart from creating an archive of highly detailed models of the shape, texture, and colour of the different artworks, the main goal is to establish an objective comparison (in terms of form, dimensions, etc.) among the existing versions of famous serial sculptures – such as *Bambino Ebreo* or the *Portinaia*.

One line of work has involved recording a selection of the busts, comprising both wax and bronze casts, from the *Bambino Ebreo* series using close-range photogrammetry, and in specific cases, complementing it with structured-light scanning as an additional technique. Factum Foundation has recorded five *Bambino Ebreo* busts in different museums and private collections, around Venice and other locations in Italy.

Based on the captured information, 3D models have been prepared and made accessible as online viewers, enabling Dr Hecker and other experts to inspect the data from any computer or device. In addition to the items recorded by Factum Foundation, another 9 models previously recorded have been added to the viewing platform, making a total of 16 items. Thanks to the viewer, it is possible to compare side by side any pair of models (zooming in on specific details, rotating the viewpoint, etc.) facilitating a close inspection of the busts in an intuitive, easy way.

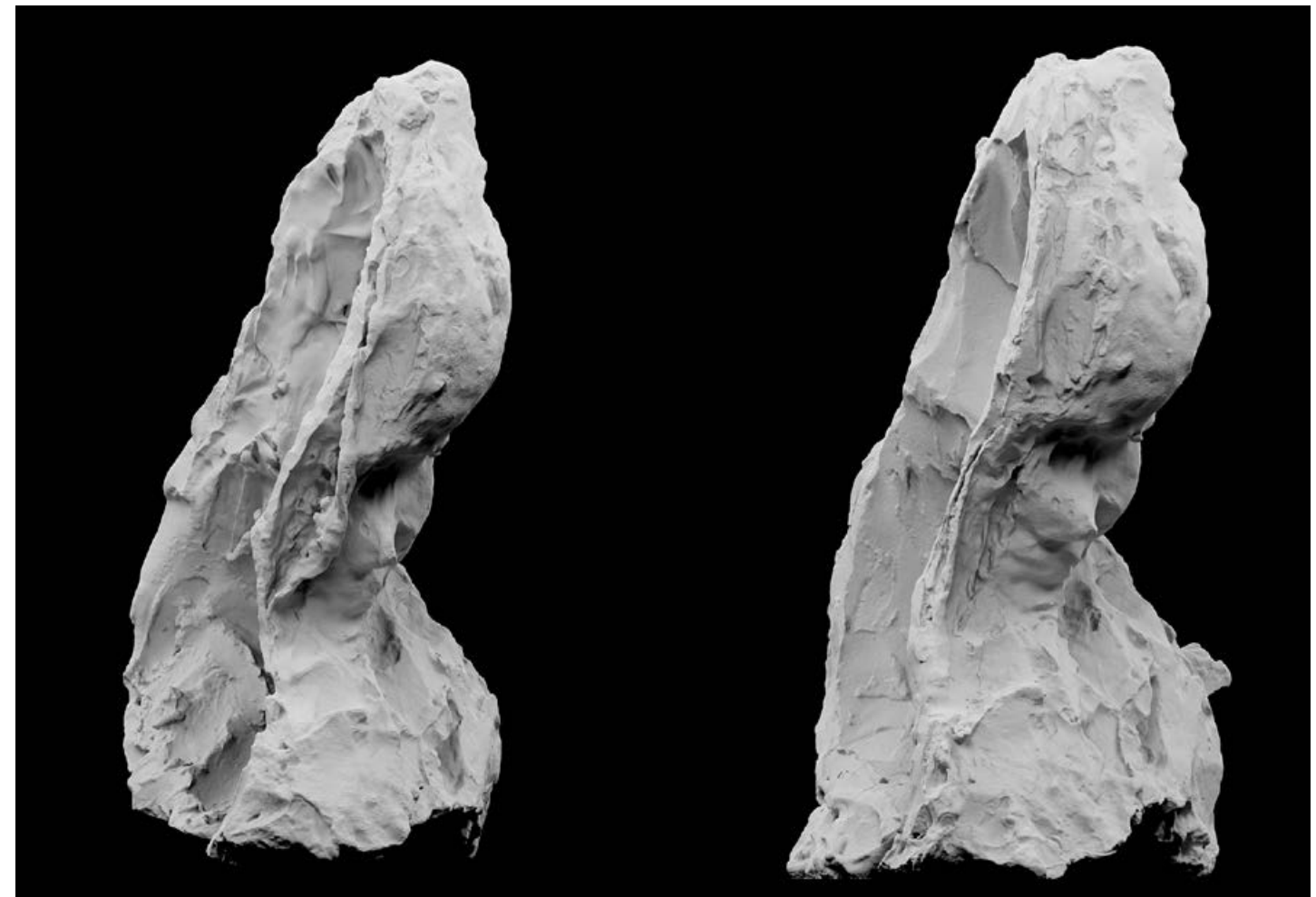
A second line of work has focused on the *Portinaia*, another relevant work by Rosso of which various versions exist. Factum Foundation has recorded the sculpture at Tortona's Museo Il Divisionismo and Venice's Museo Ca'Pesaro.

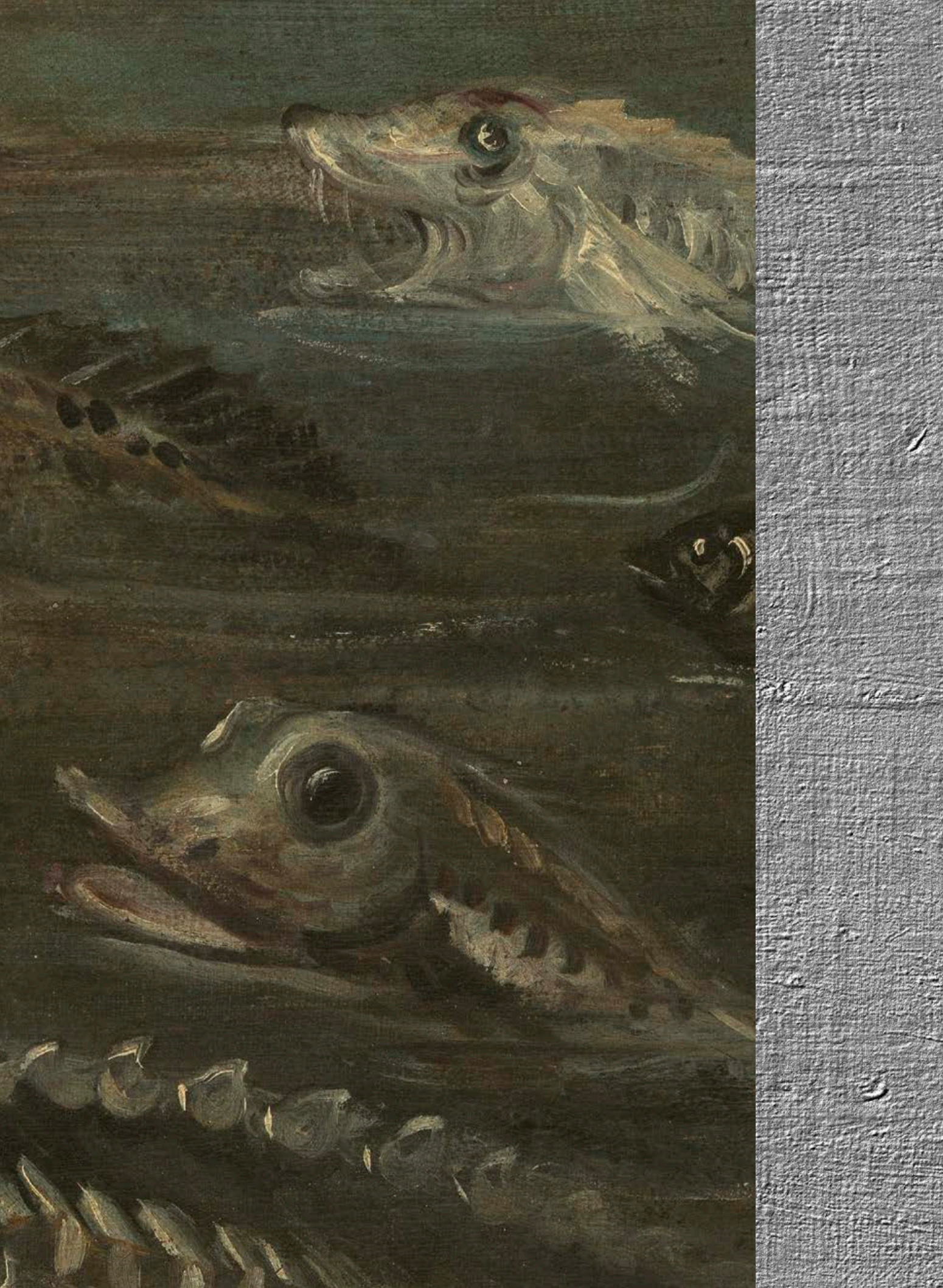
3D models of the *Bambino Ebreo*.

Opposite: Juan Carlos Arias working on the facsimile of the beeswax maquette (top). Render from the 3D model (bottom).

On June 9th 2023, Factum Foundation was invited to participate in the Study Day exploring Medardo Rosso's sculpture *La Portinaia* (The Concierge). The event was organized by Fondazione Cassa del Risparmio di Tortona and curated by Dr. Sharon Hecker.

Among the speakers, Carlos Bayod presented Factum's digital recording of the original sculpture, which took place last October and resulted in the creation of a detailed 3D model for on-screen inspection of the Concierge's shape and surface. By request of the Pinacoteca Il Divisionismo, Factum also produced two physical reproductions of the artwork: a white 3D print and a facsimile made in natural beeswax and plaster. The reproductions were presented during the study day and will remain in the museum's collection to facilitate the conservation, study and dissemination of Rosso's working process.





The Creation of Animals by Tintoretto

ARCHiVe has just completed a new high-resolution recording of Tintoretto's painting *The Creation of Animals* from the Gallerie dell'Accademia in Venice. This is a pilot project in collaboration with art historian Cleo Nisse from Columbia University, who has examined several paintings from the museum over the past two years as part of a research agreed with the Gallerie.

Nisse's research focusses on the transition from panel to canvas as the primary support for painting in Renaissance Venice. While this transition came about partly for practical reasons, her research reveals how working on a flexible textured surface changed the essential processes of painting, including the way brush marks were made and conceived on the canvas, and how the substrate impacts the final appearance of pictures.

Tintoretto frequently used canvases composed of fragments stitched together, as in *The Creation of the Animals*. Comprised

of three irregularly sized pieces of canvas with two different weave patterns, the topography of the canvas interacts with the subject matter: one of the seams connecting two panels runs along the edge of a tree trunk, almost imitating the irregularity of bark. The thin paint layer allows the varied topography of the textile foundation to emerge into the painting, while the occasional punctuation of impasto brushstrokes provides further dimensionality. The 3D imaging by the Lucida Scanner will help probe more deeply into this dynamic painting, understanding and communicating the relationship between texture and colour.

Left: The Lucida 3D Scanner recording the surface. Right: The Director of the Gallerie dell'Accademia, Giulio Manieri Elia, and PhD candidate Cleo Nisse discussing the painting's recording with Factum Foundation's Marina Luchetti. Bottom: Colour merged with 3D (left) and surface 3D (right) data.

Opposite: Colour (left) and surface 3D (right) data.



The Daniélou Collection

Text by Rashmi Gajare

Originally published in 'The Aura in the Age of Digital Materiality',
Silvana Editoriale, 2020

Early digitisation projects created vast amounts of data in formats that might not be easily adaptable to ever-evolving technological processes. The current challenge is twofold – to make older data usable in the present day and to ensure that future digitisation projects consider the inevitable process of technological obsolescence.

In 1949, Alain Daniélou, a French musicologist living in India and studying Hindustani classical music for over a decade, launched an ambitious project to create an archive of all available treatises on Indian music – Sangita S'astra. The process he followed involved recovering the texts, making copies (microfilms), transcribing the works into modern Devanagari script, and comparing them with other manuscripts of the same works. A translation of the texts followed. During this process, almost 300,000 index cards were made with key information about the manuscripts, the authors, various musical instruments, Ragas and so on.

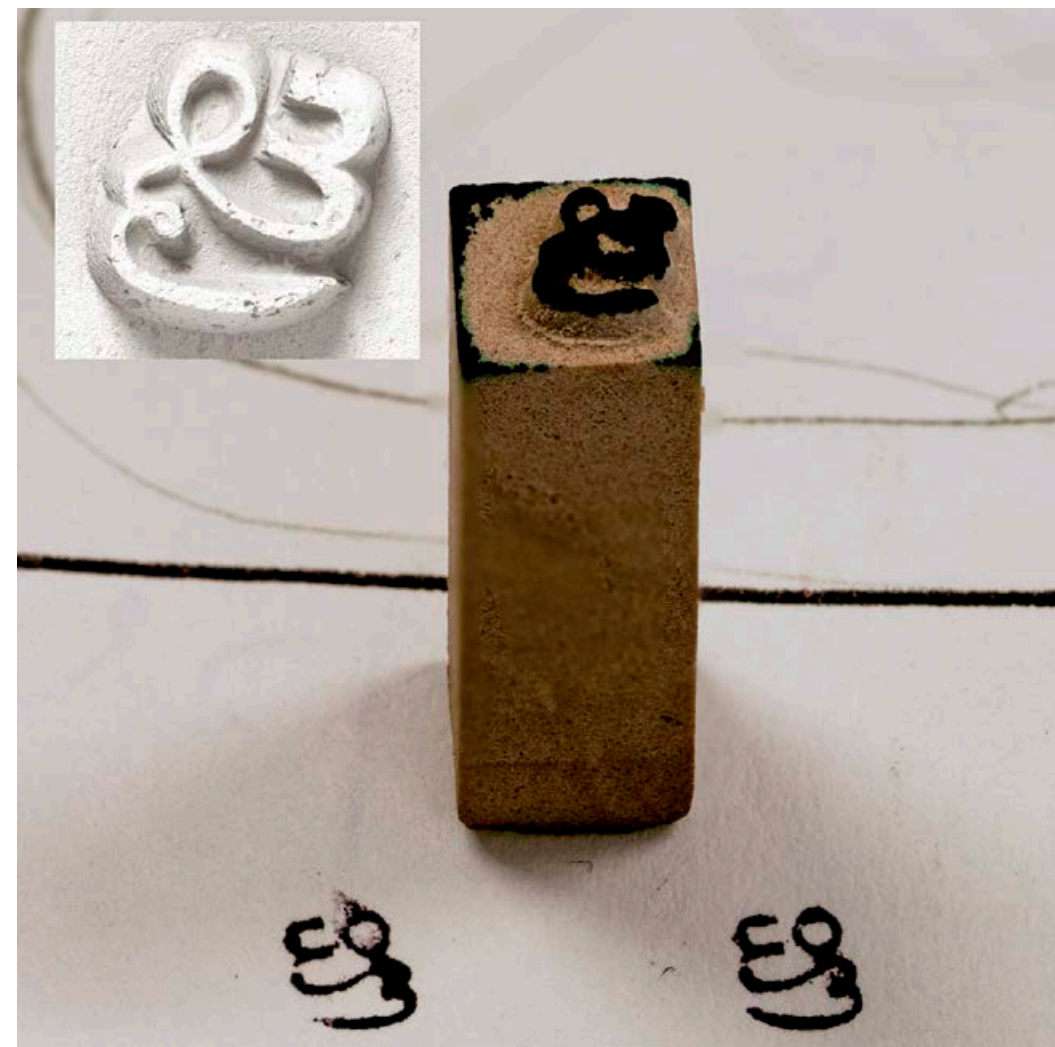
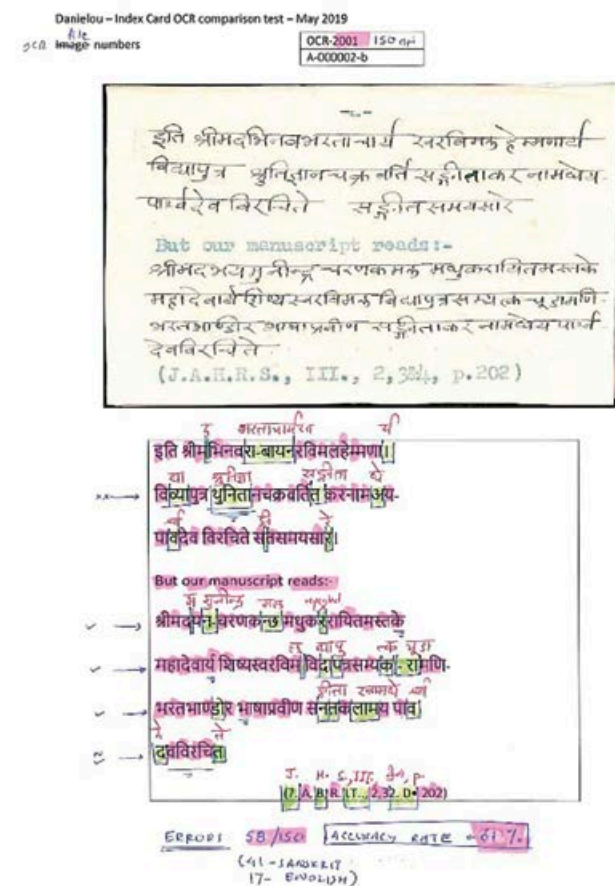
From 2001-04, a majority of the Alain Daniélou collection index cards (about 250,000 items in total) were scanned using a desktop office scanner. In 2019 the ARCHiVe research team, headed by Professor Giovanni Giuriati, started a project to convert these older scans into machine-readable, transliterated text. However, the low resolution of the 2001-04 images (150 dpi) as well as the diversity of data on these cards posed a challenge for the creation of both a searchable and a semantic database using Optical Character Recognition (OCR) and Handwritten Text Recognition (HTR) processes. This more recent project explored various methods to find the optimal solution to automatically transcribe all the index cards (approximately 300,000 in total) from the Alain Daniélou collection.

The first stage involved running Optical Character Recognition (OCR) algorithms on a set of 30 scanned cards from the 2001-04 images and analysing the results; the same set of cards was then redigitized using different instruments and settings, and the OCR was run once again to compare results. Both steps used the free, cloud-based Google Vision API for OCR. For the re-digitisation, two scanning methods were adopted: digital photography using CANON EOS 5D (50mm lens, EOS Utility software); and FUJITSU Image Scanner fi -7160 (portable with 80 sheets Automatic Document Feeder), iSOP (Intelligent Sonic Paper Protection) and PaperStream Capture 2.5. RawTherapee 5.5 was used for image processing.

The results from the three scanning methods – office desktop scanner (150dpi); FUJITSU Image Scanner fi -7160 (600 dpi); and CANON EOS 5D (300 dpi) – were compared for error rates and estimated time for scanning and analysis.

The accuracy of the OCR algorithms increased by an average of 7% when using present-day digitisation techniques – probably due to the increased image resolution, from 150 dpi to 300 dpi and 600 dpi.¹ Despite the marginal increase in accuracy, it was decided that the estimated time required for re-scanning the entire collection could be better employed to manually create a set of transcriptions that could be used as a training model for a Handwritten Text Definition (HTR) software.

1. It must be noted that a larger sample size might offer more precise results, but these preliminary observations could lead to time saving measures.



For the Daniélou collection index cards, error rates were higher for the Devanagari script than the Roman alphabet, probably due to the large database of Roman alphabet transcriptions available online for the Google Vision cloud-based software. By training the machine reading model with a manually transcribed sample, the error rates could be reduced. The recommendation is to use an HTR software, such as Google Auto ML Vision or Transkribus, a READ project with funding from the European Union's Horizon 2020 Research and Innovation program. Another suggestion is to create an online project to crowdsource corrections by uploading the Google Vision API OCR results (even with high error rates). This would create a platform for public participation, while fostering a sense of stewardship of heritage and creating awareness about the collection.

While enhanced OCR techniques can make it far easier to read the textual information on these low-resolution scans, low-resolution image documents might present a very

different set of challenges; it would probably make more sense to re-record those at a higher resolution.

Once Alain Daniélou's index cards become machine-readable, the next step in the project will be to do the same for the manuscripts and link them to the relevant index cards. Where the present archive is hard to navigate even for those researchers working within the Cini Foundation Italian version, the new digital archive will make this unique resource on Indian music accessible to researchers across the world.

Automatic transcription of an index card, with mark-up revealing the degree of accuracy of the OCR software.

Opposite: In a separate initiative relating to typography, Factum Foundation has been working with the Type Archive, London, on a pilot project to establish digitisation methods for their unparalleled collection of historic type matrices. The Foundation used a focus stacking scanner (in collaboration with the Natural History Museum, London) and CNC-milling to produce a new positive from the original matrix for this Gujarati character.



ARCHiOx

ARCHiOx (Analysis and Recording of Cultural Heritage in Oxford) is a research and development partnership between the Bodleian Libraries, the University of Oxford and Factum Foundation. It was launched in February 2022. As with ARCHiVe, ARCHiOx is supported by The Helen Hamlyn Trust.

The project was established as a free exchange of knowledge that sought to demonstrate the potential of non-contact 3D and colour recording technologies for the study of materials held by the Bodleian Libraries. The Bodleian's Imaging Department is one of the leading photographic recording centres within a university library. ARCHiOx aimed to introduce 3D recording to supplement their ongoing work and to integrate 3D and colour data into the IIF initiative for inter-library sharing.

John Barrett, the senior photographer at the Bodleian Imaging Services, has taken a lead role in all the work at ARCHiOx. He has been working with Factum's Selene Photometric Stereo System to record the surface of a wide range of objects, in each case revealing the importance of their materiality. Working closely with Jorge Cano, the lead developer at Factum for both hardware and software related to 2.5 D objects; they are digitising dominantly flat objects where the surface is critical for a more complete understanding of its character, fabrication and career.

Over the first year of the project, John Barrett initiated an open call to all departments in the university to suggest objects that could be understood in different ways if 3D recording was carried out alongside colour photography. The elegance of the Selene system is that photographic techniques are used to produce high-resolution 3D data (see page 326) by lighting from different angles and using advanced software to accurately map the surface. Working with 'normal maps', 'depth maps', 'Albedo maps' and shaded renders, it has been possible to give scholars

access to the data recorded with the Selene, both in the imaging studio with technical support, and online without specialist knowledge or equipment. As a coherent workflow was established, attention turned to the creation of user-friendly and intuitive software for handling objects in a digital space. The new version of the IIF-compatible 'digital torch' will be available on the Digital Bodleian platform over the next 12 months.

The results of the first 2022 pilot exceeded every expectation in both accuracy (with surface information recorded in the range between 12 and 25 μm) and speed. The Selene system has allowed for complex and reflective surfaces (such as copper printing plates) and fragile objects (including unfired clay seals and palm leaf manuscripts with minute Sanskrit inscriptions) to be recorded with extreme precision. The result of this approach to digitisation has informed new theories and discoveries relating to maps, drawings, manuscripts and bindings.

The 'Selene Circle' has been formed encourage dialogue and share the technology and software with other institutions. The first member of the 'Selene Circle' was the University of Princeton who have been using the Selene system since it was installed in the University Library in July 2023. Many other libraries and institutions are now seeking to join this approach to treating books, manuscripts and other objects as material evidence that requires dynamic interaction in order to be correctly understood.

John Barrett has been publishing regularly about the work of ARCHiOx. The text that follows, on specific examples of the work carried out, has been extracted from several texts published in the Conveyor (the online magazine for the Bodleian Libraries *Centre for the Study of the Book*).

Opposite: John Barrett with the Selene Photometric Stereo System in the Imaging studio at the Bodleian Libraries, Oxford.

Shaded renders make it possible to view the surface texture of an original while removing their tone and colour. This allows for academic research from originals that contain textural details which are difficult to see and cannot be adequately recorded using traditional photographic techniques. Alternatively, the data may be used to produce 3D facsimiles from items within collections, allowing the material nature of the original to be reproduced.

John Barrett, Bodleian's Senior Photographer and ARCHiOx Technical Lead at the Bodleian

18th-century copper printing plates

The Selene Photometric Stereo System and the Lucida 3D Scanner were first tested on a selection of 18th-century copper printing plates from the Rawlinson, Lister and Gough collections. The plates were selected by Dr Alexandra Franklin and Chiara Betti, a PhD student at the University of London specialising in the research of the Bodleian copper plate collections on a Collaborative Doctoral Partnership.

The reflective and finely etched surface of copper printing plates is usually difficult to record effectively and accurately, requiring a case-by-case approach that depends on the individual plate's etching, conservation status and usage.

Selene proved to be an extremely successful method for recording the subtle surface information on etching, aquatint and mezzotint plates. The ARCHiOx team have focused on how to streamline the data capture while Factum have focused on data output.

After Giovanni Battista de' Cavalieri, *Cerchio di Antonino Callo* (Rawl. Copperplates g.21), possibly early 18th-century, engraving on copper plate, colour and 3D render data.

Overleaf: Front of the copper plate Rawl. g. 140. Colour (left) and mirrored shaded render (right).

For over twenty years, the Bodleian have archived hundreds of thousands of digital images captured from our collections. Through the use of technologies like the Selene and Lucida, we now have the capability of reproducing items more accurately than ever, not just as two-dimensional representations, but as tangible 3D recreations.

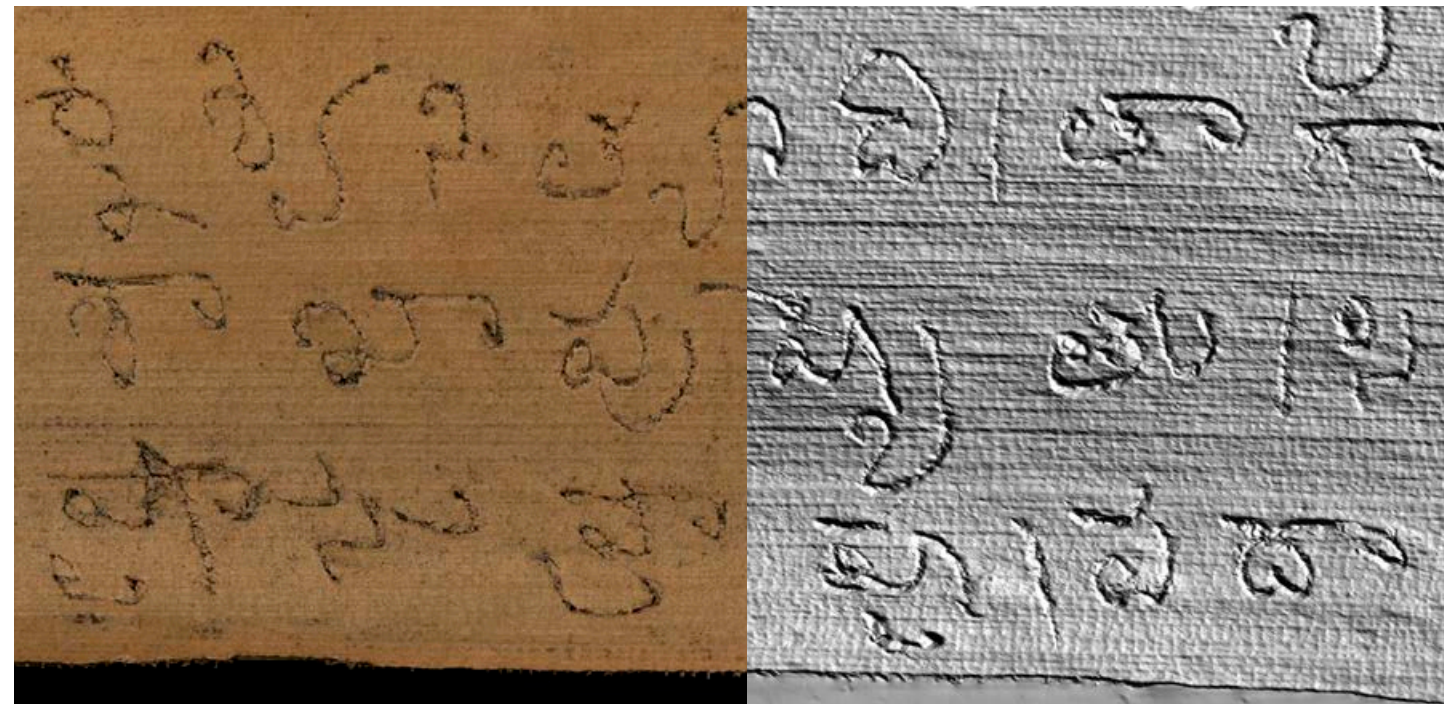
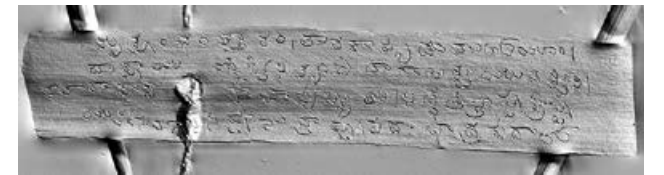
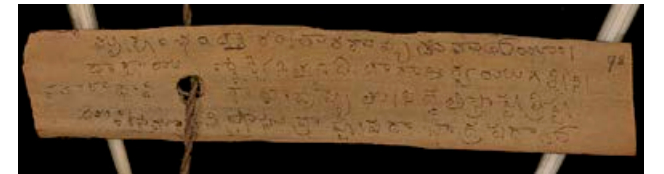
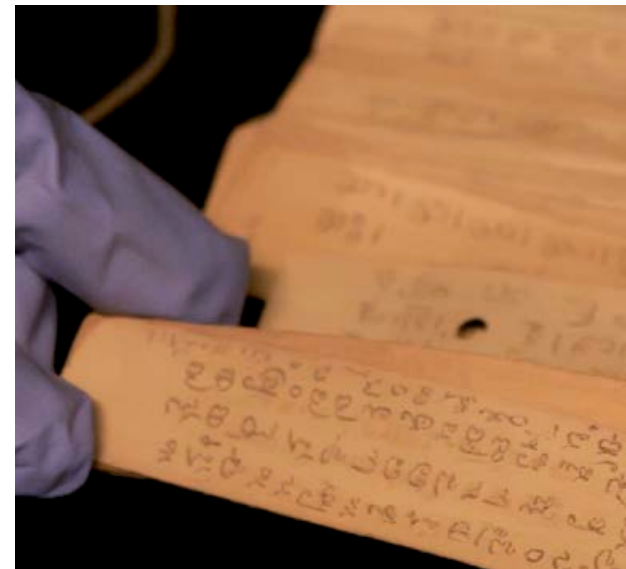
John Barrett, Bodleian's Senior Photographer and ARCHiOx Technical Lead for the Bodleian

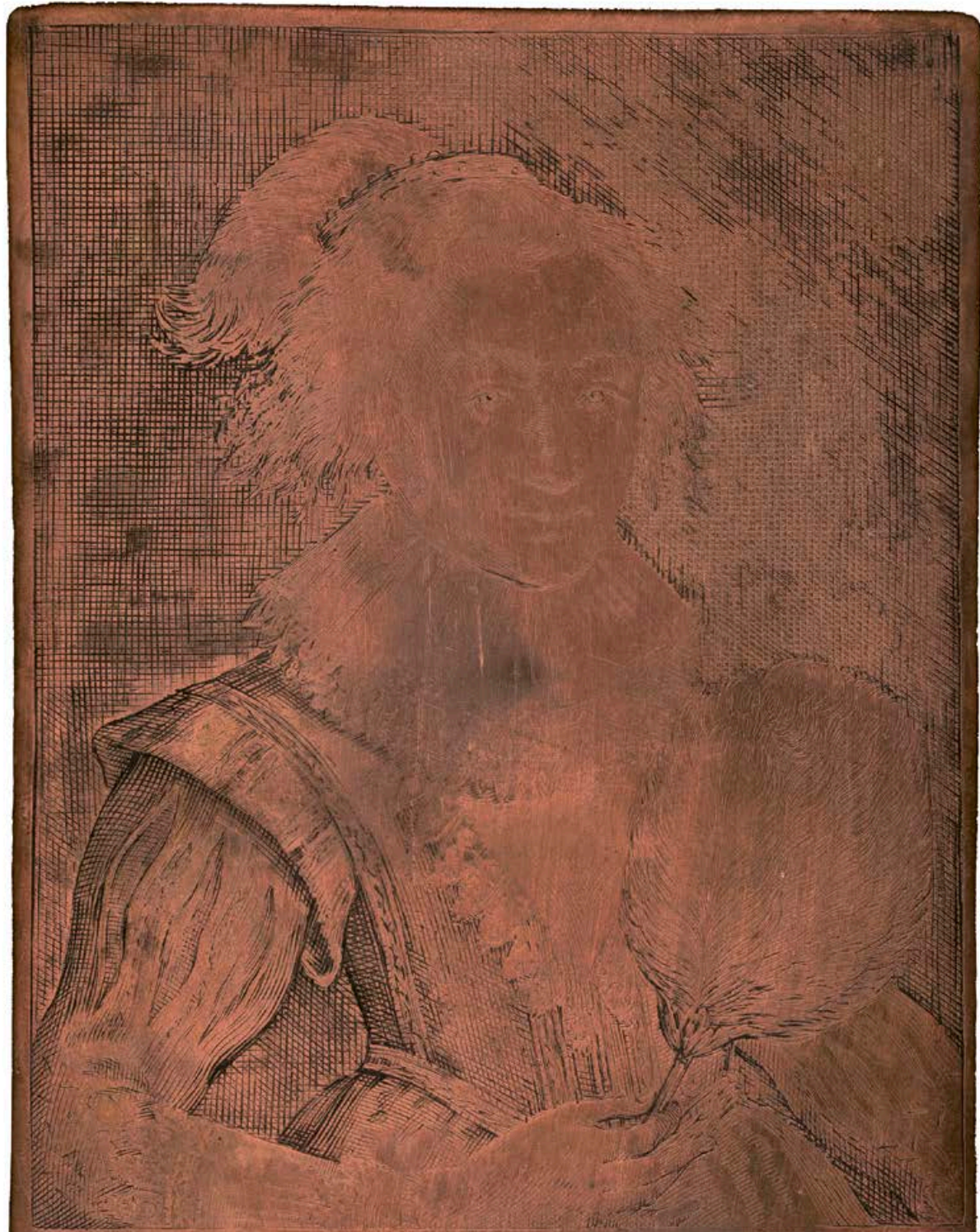


Palm leaf manuscripts

During the first months of ARCHiOx, several items from a rare collection of Sanskrit texts inscribed into palm leaves were digitised using the photometric stereo system. The very fine, almost unreadable markings made on such fragile material make the objects difficult to access and study. With high-resolution recording, ARCHiOx has been able to create digital editions which can be analysed virtually in great detail without endangering the original manuscripts.

Top: The fragile material makes these manuscripts difficult to access and study. Bottom: Colour and shaded render of one of the palm-leaf manuscripts from MS. Sansk. collection, with a detail.





The lively portraiture of the most noble
and right honourable Lady The Lady Katherine
Marchionesse of Buckingham &c.
M. de la Roche



The lively portraiture of the most noble
and right honourable Lady The Lady Katherine
Marchionesse of Buckingham &c.
M. de la Roche

Dürer sketch and Rembrandt portrait with Agnews Gallery

In April 2022, *The Virgin and Child with a Flower on a Grassy Bench*, a drawing by Albrecht Dürer, was recorded using the Selene Photometric Stereo System as part of a collaboration with Agnews Gallery. The aim of this digital recording was to help researchers and the general public to study one of the most important Old Master drawings to surface in living memory. The recording has also facilitated insights into the materiality of the drawing, offering a new dimension of appreciation for scholars and enthusiasts alike.



A small *Portrait of a Man* by Rembrandt was also recorded using the Lucida 3D Scanner and the Selene system. The recording of both front and back of the panel has informed its attribution to the dutch master.

Top: The original Dürer drawing during the recording process (left) and detail (right). Bottom: Colour data of the small wood panel painting believed to be the missing 'Old Man' by Rembrandt van Rijn, circa 1627-29 (left) and back of the panel (right).

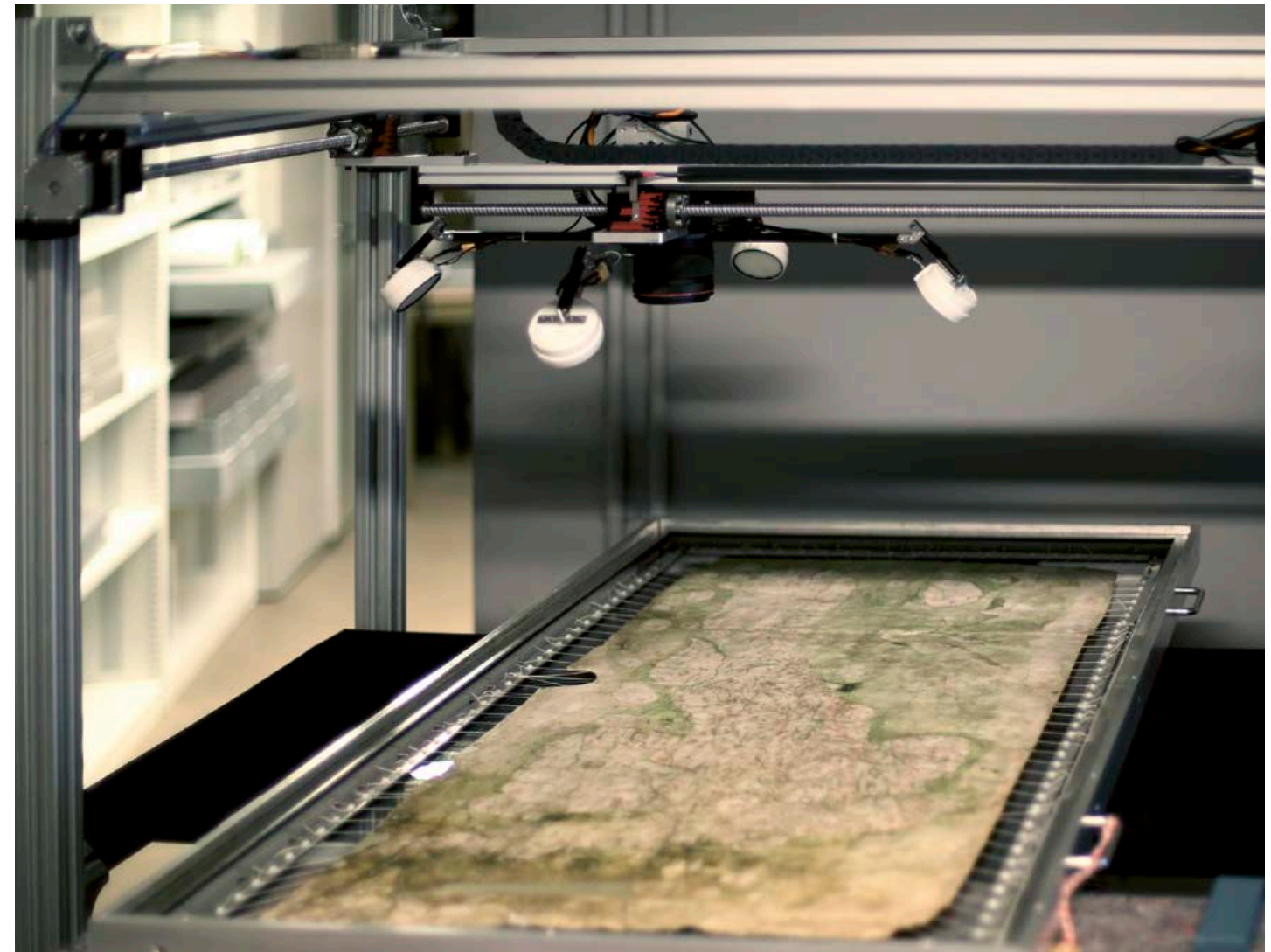


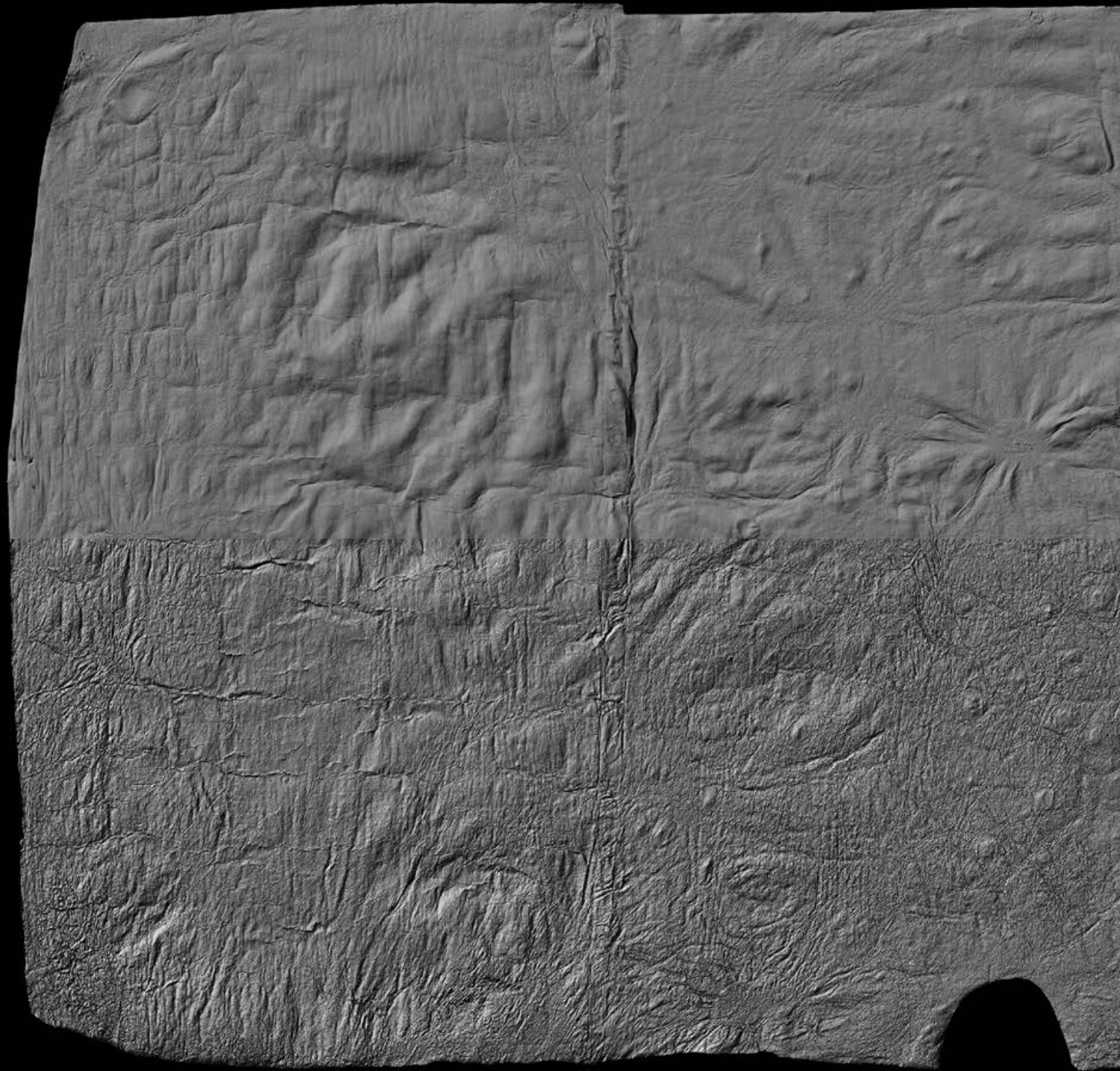
The Gough Map and the Selden Map

The Gough Map is a mid-14th-century map of the British Isles, formerly and mistakenly regarded as the earliest road map of the country. A Leverhulme-funded research project is currently reconsidering its date, development, authorship and function.

The Gough Map was first recorded by Factum Foundation in 2014 using the Lucida 3D Scanner, but a new recording carried out at ARCHiOx with the Selene Photometric Stereo System, at four times the resolution of the previous scan, has revealed more information about the pouncing marks, creases and historic repairs. The Selden Map of China was also re-recorded at a higher resolution after its first scan in 2014. Both maps have been rematerialised as facsimiles for study and dissemination.

Right: Selden Map of China (MS. Selden supra 105) with a detail. Bottom: The Selene PSS recording the Gough Map (MS. Gough Gen. Top. 16) in ARCHiVe.



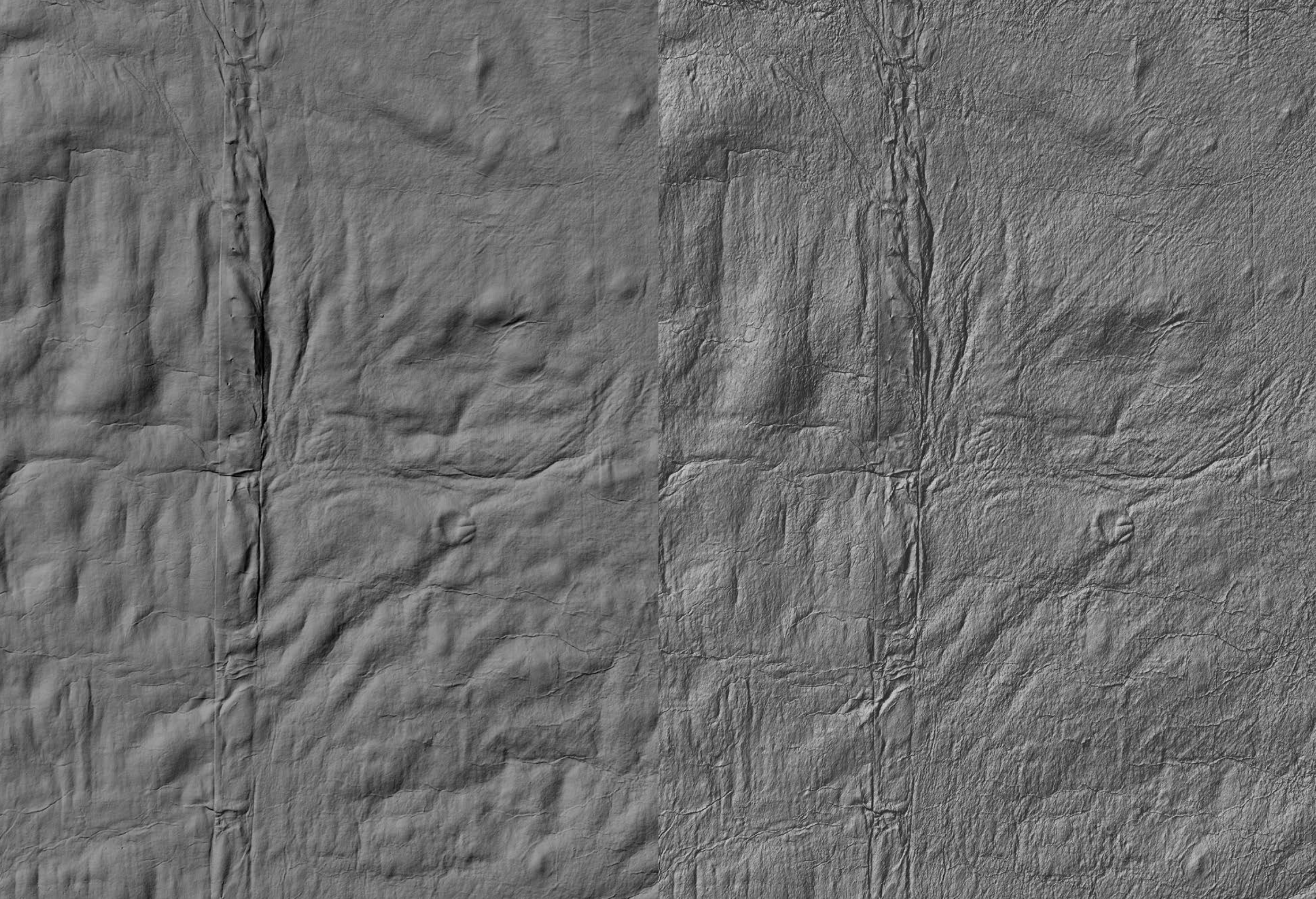


Top: Colour data of the Gough Map's front. Bottom: the facsimile of the back of the Gough map.

Opposite: The difference of the data recorded in 2014 using the Lucida 3D Scanner and in 2021 with the Selene PSS is evident (top). Depth map of a detail (bottom).

Overleaf: detail from the 3D data recorded with the Lucida 3D Scanner (left) and the Selene PSS (right).





The Laud Ragamala Album

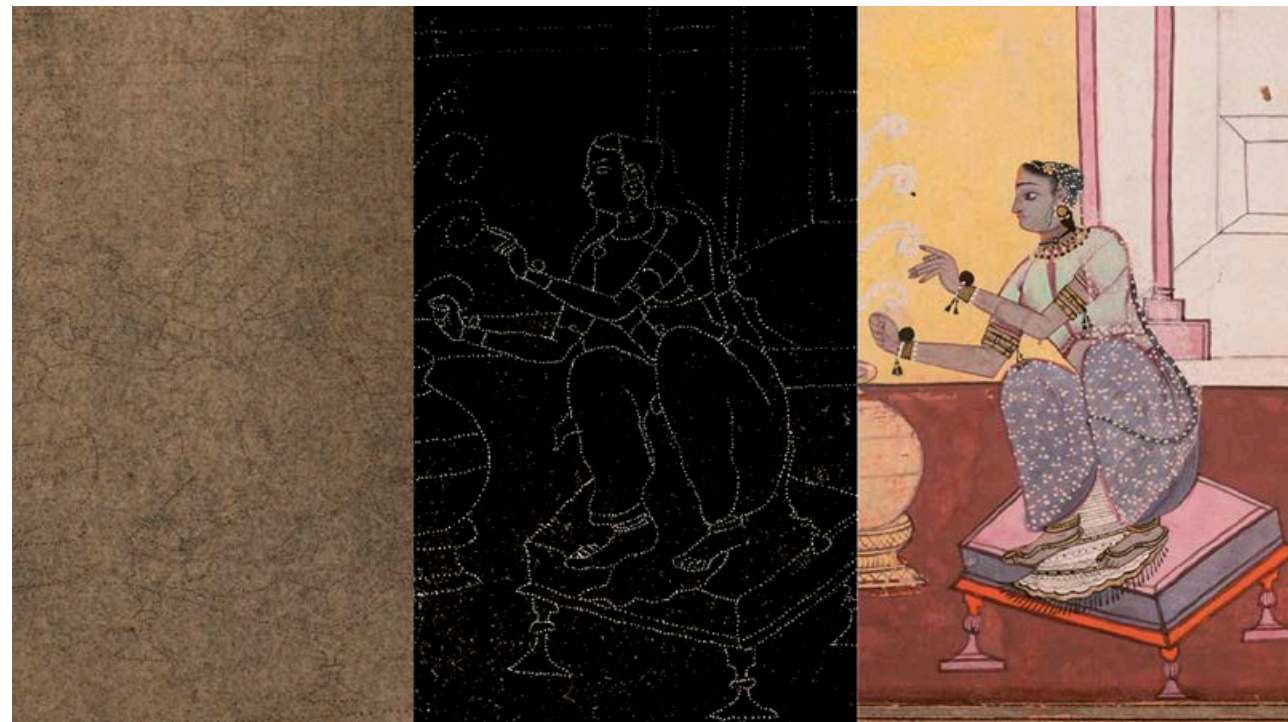
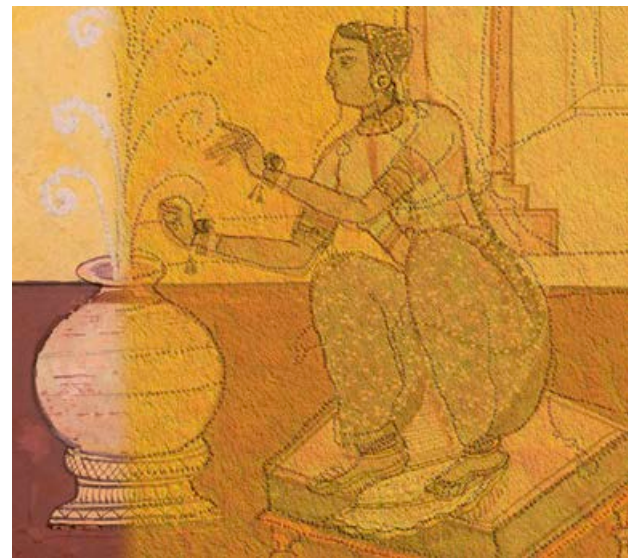
The Laud Ragamala Album is a beautifully painted South Asian manuscript, dating from the early 17th-century. Shortly after it was produced, the volume was donated to the Bodleian by Archbishop William Laud between 1635-41.

It has been proposed that three recently discovered paper pouncing patterns may have been used in the production of paintings within the manuscript. The patterns, which have subsequently been loaned to the Bodleian, are skilfully made. Tiny pinpricks form the outline of illustrations on three of the paintings within the Laud Ragamala Album. Pouncing is a less obvious method of copying than pricking. Charcoal dust would have been transferred through the holes, duplicating the form of a design from pattern to page. Whether or not the three pouncing patterns were indeed the source of the paintings from the Bodleian's 17th-century volume remains a mystery. In order to examine how closely the two align, a set of renders was generated from 3D recordings of the pouncing patterns and overlaid with the colour images from the manuscript.

Though some elements within the designs differ, there are clear and extremely close correlations between the patterns and paintings. 3D imaging of the paintings themselves shows no evidence of holes or depressions due to tracing, only the layers of pigment that have been applied to the paper. Though the 3D recordings have not provided a definitive

answer as to whether the patterns may be the origin of the paintings, it is hoped that they may serve as a template for similar analysis.

Top: A layered image comprising a conventional recording of a painted page from the Laud Ragamala Album (MS. Laud Or. 149) and a 3D render of the reverse of its associated pouncing pattern. Bottom: A paper pouncing pattern, photographed conventionally, left. An edited version of the previous image showing the position of the tiny pinholes, centre. A detail from fol. 8 of the Laud Ragamala Album, right.

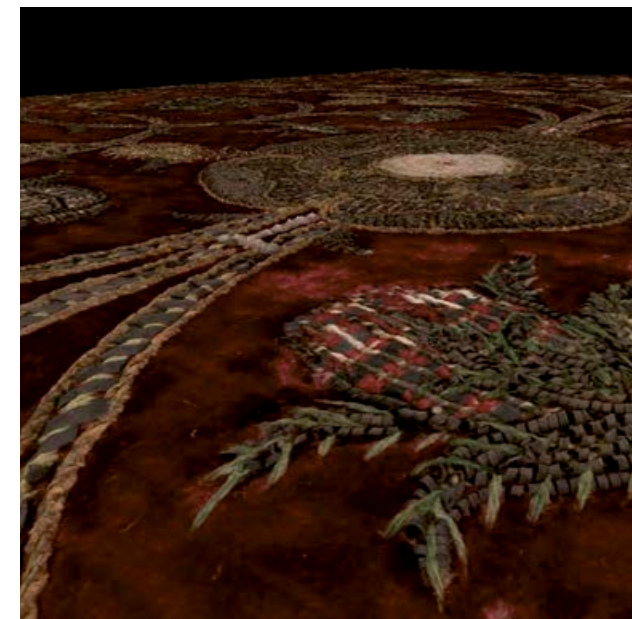


The Geneva Bible

The beautifully bound 16th-century Geneva Bible shown below is one of the Bodleian Libraries' treasures. This Geneva Bible was presented to Elizabeth I on New Year's Day in 1584 by the printer Christopher Barker (1529-1599) and was bequeathed to the Bodleian by Frances Douce in 1834. The incredibly intricate embroidered cover is decorated with gold, silver and silk threads with seed pearls, which sit on a crimson velvet background. The imagery includes a symmetrical arrangement of gold stems with Tudor roses. It is believed that Queen Elizabeth I preferred textile to leather covers.

The Geneva Bible, the first mechanically printed, mass-produced Bible, was the primary Bible of Protestantism in 16th-century England, replacing the Catholic Bible in use during Mary Tudor's reign. It is one of the most important translations of the Bible into English and bears witness to a period of great religious turmoil. The Geneva Bible is of particular significance to the Bodleian Libraries whose founder, Thomas Bodley, was among those who fled to Geneva during Mary's reign. He returned only after the accession of the Protestant Queen Elizabeth in 1558.

Despite its fragility, this 400-year-old binding is surprisingly well preserved; given its importance, access to the original is limited. Even the very best conventional photography can only offer a static, single perspective of an original. 3D imaging with the Selene has allowed researchers a far closer experience to handling the original than has previously been possible.



The Selene recording has captured every stitch and embroidered element from the original – even its tiny seed pearls. Rather than simply making a render of the 3D surface by loading both the depth map and albedo (colour) image into mapping software, it is possible to zoom in, fly over the surface of the recording, and re-light it from any direction or height.

This embroidered Bible has significant material features which became increasingly common during Elizabeth I's reign. During this period the Bible gained an important place in the reading life of women, encouraging deeper engagement, both intellectually and physically, through annotations. Probing more deeply into the materiality of these manuscripts can help us to better understand the piety of the period.

Left: A screen capture of the photometric stereo recording, displayed using a 3D viewer in GIS software. Right: Render of the Geneva Bible (Douce Bib. Eng. 1583 b. 1), with the colour and the surface information.



Gregory the Great, *Homiliae XL in evangelia*

The 9th-century Latin manuscript *Gregory the Great, Homiliae XL in evangelia* was authored by Pope Gregory IV, the last, traditional, Latin Father of the Church and the first exponent of a truly medieval, sacramental spirituality. His title 'The Great' reflects his status as a writer and ruler.

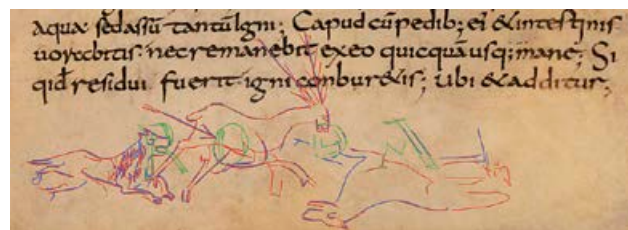
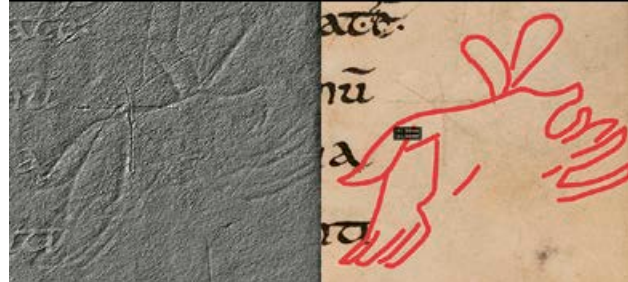
This manuscript has a 15th-century shelf mark on folio 2, which reveals that this volume was in the possession of St. Kilian Cathedral in Würzburg. The Selene recording has uncovered twenty-five pages from this volume with annotations made by scratching the surface of the parchment using a drypoint stylus, rather than ink.



The catalogue description for the recto of folio 74 shown in the image above, describes a drawing in the lower margin. A hunting scene, barely visible through conventional photographic recording, but clear enough to make a partial digital annotation. As displayed above, the 3D render reveals not only the illustration, but also four camouflaged letters, R, O, D, A, demonstrating how 3D recording with the Selene is complementary to traditional imaging in revealing new discoveries and contributing to the biography of an object.

The drypoint annotations recorded on folio 60r are inconsistent with the majority of others from this manuscript. These annotations recorded on folio 60r are dotted between passages of text rather than confined to the margins. These appear to be relatively deep incisions, marking the position of punctuation. Far less obvious and perhaps only recognisable from the 3D render is a small, marginal illustration showing two hands, tied together with a bow.

In order to determine whether or how this annotation might relate to the text, the image above was shared with Jo Story, Professor of Early Medieval History, Leicester University. Her interpretation reveals a clear link between annotation and text. The text from this homily describes the stoning of Stephen. The translation of folio 60r begins 'when Stephen



was dying for his faith, Saul kept the clothes of the stoners. Therefore, he himself stoned them all with his own hands, who returned all the works to the stoners'. The connection between inscription and text is most evident from the passage at the end of the fourth line 'multi autem sunt vocati pauci vero electi' – 'because many are called but few are chosen' – Chapter 22:14 from the Gospel of Matthew. This passage immediately follows the verse 'Then said the king to the servants, Bind him hand and foot, and take him away, and cast him into outer darkness, there shall be weeping and gnashing of teeth'.

Left: A digital annotation from folio 60r (MS. Laud. Misc. 429), showing numerous drypoint additions. Top right: A hidden marginal annotation, inspired by Chapter 22:14 from the Gospel of Matthew – revealed through 3D imaging. Bottom right: A compiled digital annotation using conventional and 3D recordings, showing the position and form of the addition.

Manuscript recording and the discovery of Eadburg

At the end of 2022, a major discovery was made thanks to a 3D recording carried out with the Selene Photometric Stereo System on an important 8th-century manuscript in the Bodleian Libraries, MS Selden Supra 30.

MS. Selden Supra 30 is a copy of the Acts of the Apostles, a book of the New Testament, written in Latin. It is a small volume, measuring only 229 x 176mm (only slightly bigger than an A5 piece of paper). Prayers inscribed upon p. 70, which was originally left blank, suggest that very early in its history MS. Selden Supra 30 was owned and used by a woman, or a group of women.

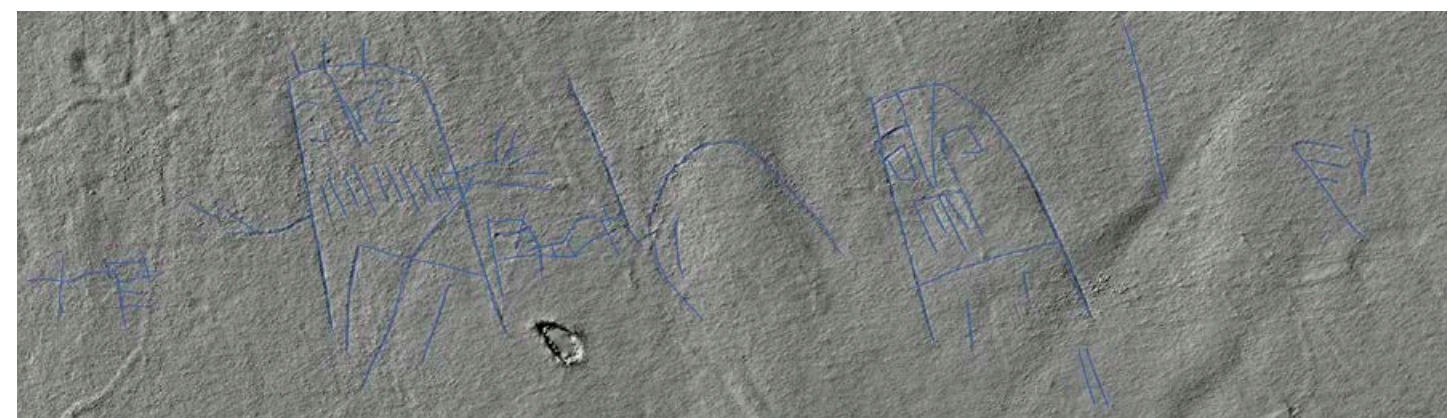
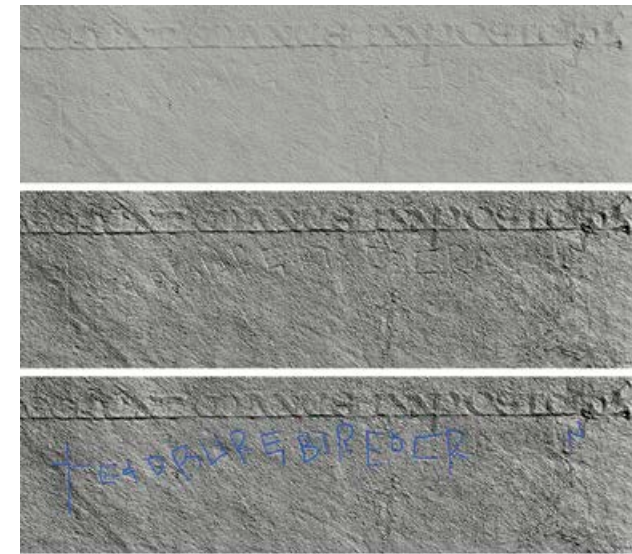
This was confirmed after Jessica Hodgkinson, a PhD student at the University of Leicester, funded by the AHRC Midlands4Cities consortium, spotted traces of an inscription on the margins of page 18, never discovered before. High-resolution 3D recording revealed marginal annotations made by a woman called Eadburg, dating to 8th-century England.

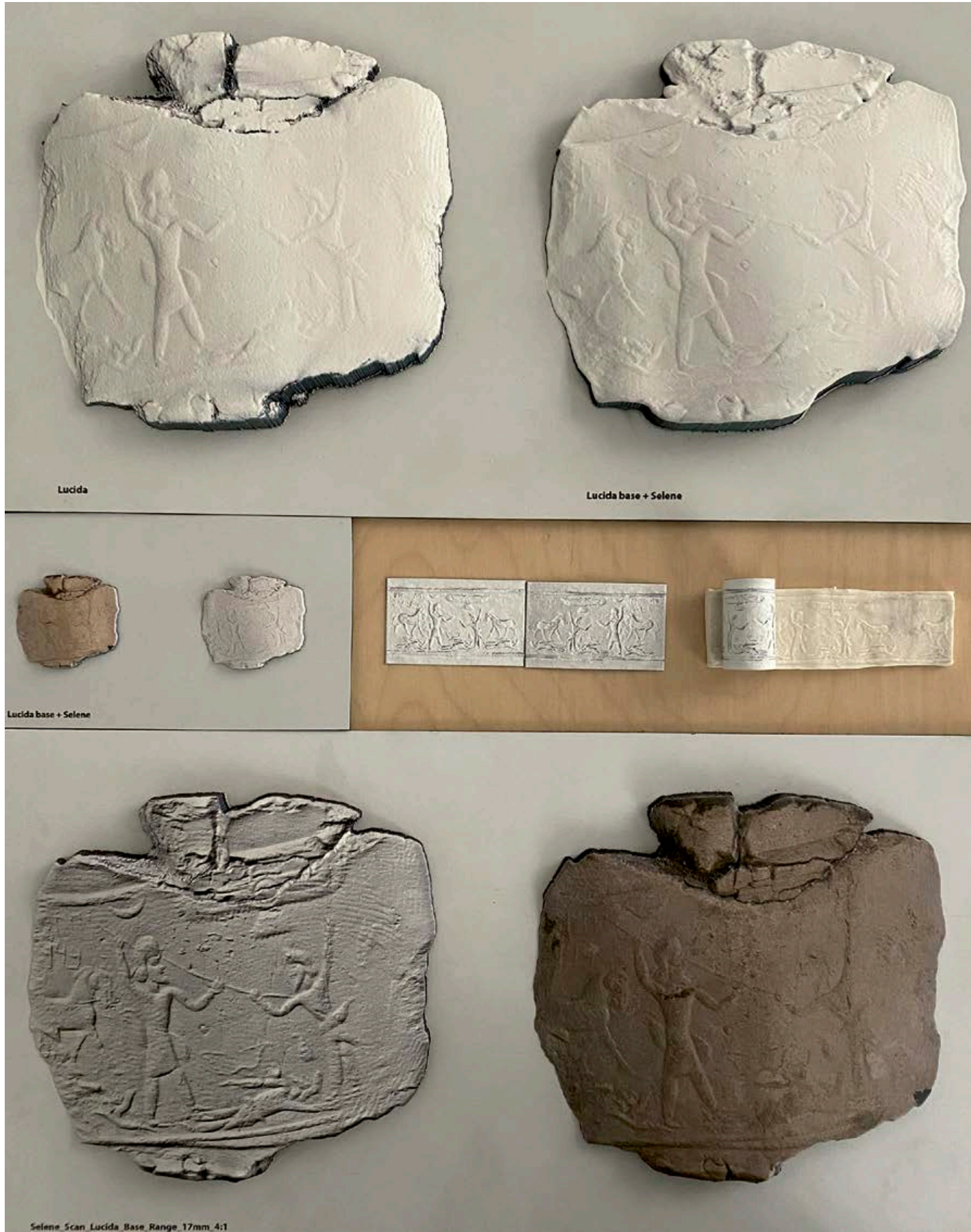
Further recordings have also revealed several other instances of Eadburg's name, alongside other early marginal additions, incised into the parchment of MS Selden Supra 30.

Alongside Eadburg's name, several intriguing drypoint drawings have also been discovered. Some are clearly human figures, though further investigation is needed to establish exactly who or what they depict. All the figures are very small. Several seem to have been made by incising a line around a thumb or finger to form the outline of the figure.

This discovery, made possible by the Selene Photometric Scanner, was featured in articles published by the BBC, the *Guardian* and *Ars Technica*.

Left: (top to bottom) An unedited render of the 3D surface of the bottom of page 18 with the inscription now visible. An enhanced version made through tonal remapping. A digitally annotated version. The digital annotation with the render removed. Right and bottom: Recording of the dry-point addition in the lower margin.



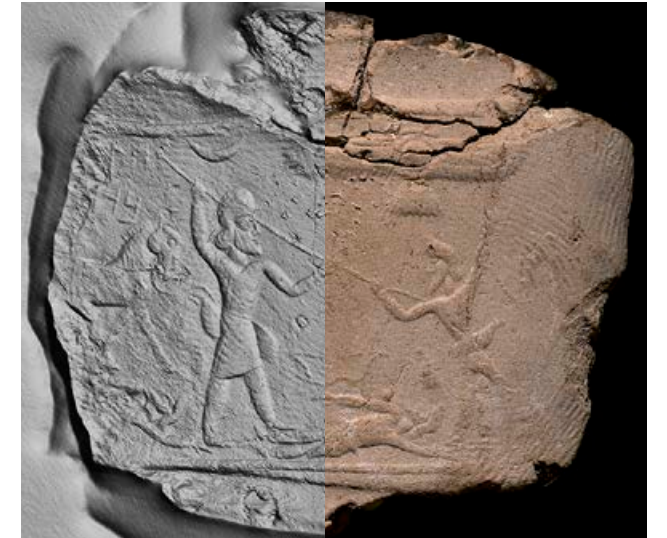


Aršāma Seals of the Achaemenid Empire

A collection of 2,500-year-old clay impressions (also known as letter-bulla) bearing the seal of Aršāma, a Persian prince and regional governor of the Achaemenid Empire, is the earliest group of objects to be recorded by ARCHiOx. The impression was made by an intricately carved tool, rolled over the surface of seven small unfired clay pieces – just over four centimetres in width.

As the clay is unfired, and in some cases the seals are held together by a string used to attach them to the letter they accompanied, these artefacts are extremely fragile. They are therefore, both difficult to handle but of great importance as objects for study. Recording them is critical to ensure their preservation. Detailed records of all clay seals and a fragmented letter were made using both the Lucida 3D Scanner and the Selene Photometric Stereo System. The data can now be studied in depth and the seals recreated as facsimiles for exhibition display.

A further part of the project involved recreating the carved cylinder used to make the original impression. Working back from the design captured by the recordings, the image was inverted and printed in 2.5D using Factum's elevated printing technology developed by Canon Production Printing (previously Océ - A Canon Company). The elevated print was then fixed onto a cylinder and rolled across a

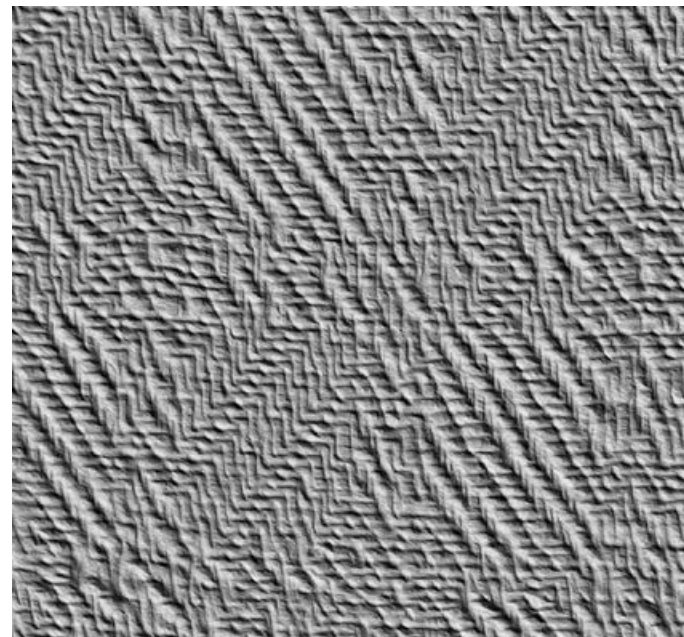
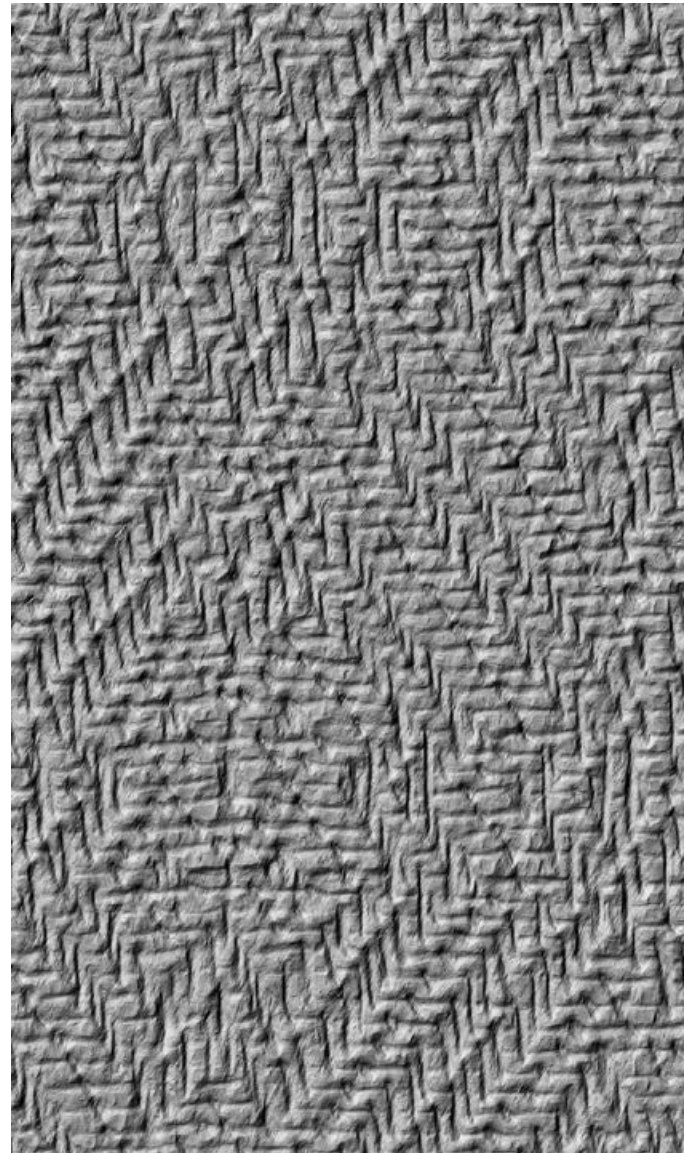


plasticine surface to create designs incredibly similar to those found on the original.

Top: 3D render showing the colour and surface information (Sigil. Aram. V). Bottom: The lost cylinder seal, remade through reverse engineering. The recorded image of the original impression was inverted and printed in 2.5D. The elevated print was then fixed onto a cylindrical form to recreate the original seal.

Opposite: Enlarged 3D prints of one of the seals, showing data in different forms.





'Selene Circle': Democratising Access to Cultural Heritage through Technological Innovation

The 'Selene Circle' has been developed to promote the use of the Selene Photometric Stereo System (see page 326 for more detailed information about Selene PSS). To encourage libraries and collections to record the surface of objects, Factum Foundation is offering a complete package so that a fully operating system can be installed with training (etc) and support provided.

Factum Foundation will send a specialist team to install the hardware, instruct in the use of the system and software and offer continued access to Factum Foundation's knowledge base and technical innovation. The aim is to create a community of imaging specialists, feeding scholars with the information they require to understand the subject of their study in new ways. Books and manuscripts come alive when shared and discussed. This used to be done in the physical domain. Increasingly for preservation reasons, it needs to be done virtually. In the future, the physical object and its digital form will offer an equivalent level of access and understanding. They are both essential to preserve and promote understanding.

IMPLEMENTATION AND TRAINING: THE INITIAL STEPS IN ADOPTING THE SELENE PSS

Following the acquisition of the Selene PSS system, a specialised team from the Factum Foundation will install the system and provide onsite training.

The goal of the training is not only to familiarise the designated operator with the technical aspects of the Selene PSS system, but also to help in the selection of the objects which will most benefit from 2.5D recording. This initial training phase lasts approximately 40 hours and is conducted on-site to ensure a deep understanding of the system in its operational environment. The training programme has been developed by Jorge Cano, (the system designer and head of technology at the Factum Foundation) and John Barrett (Senior Photographer at the Bodleian Imaging Services).

THE DIGITISATION AND ANALYSIS PROCESS

The digitisation is part of a broader focus aimed at maximising access to cultural heritage artefacts digitally, in the most intuitive and physical way. The Selene PSS captures both the colour and texture of objects with a resolution of approximately 1000 dpi. The capture time takes a few seconds per object. Once data is digitised and processed it can be analysed, shared and studied.

We employ complex GIS tools and spatial analysis algorithms that facilitate in-depth scientific study.

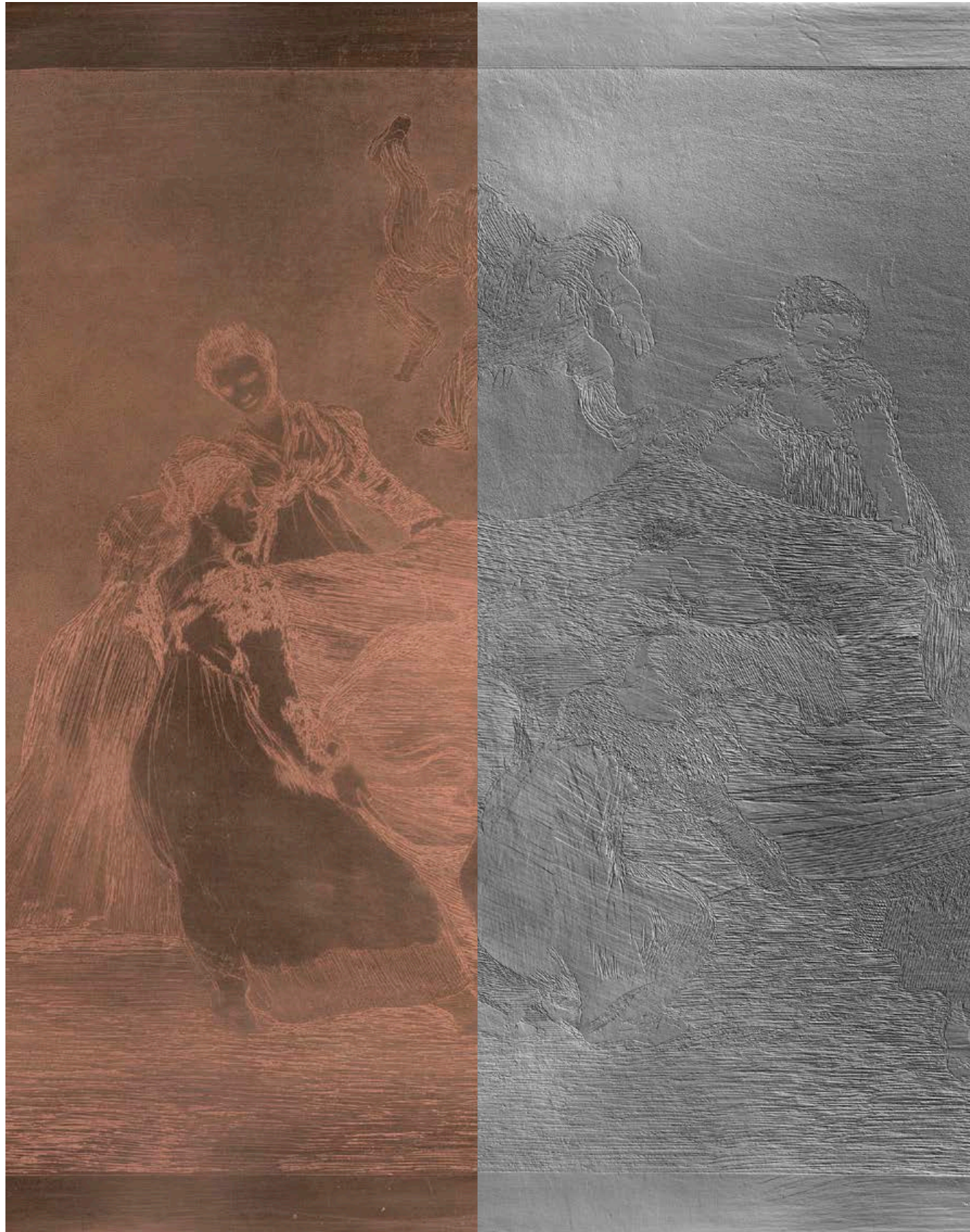
The Selene system employs cutting-edge software based on depth-maps and shaded renders to integrate the 3D data into the IIIF protocol, a standard widely accepted in libraries and universities around the world.

By joining 'The Circle', institutions become part of a global community of experts dedicated to recording materiality. The community-focused approach of the 'Selene Circle' brings about new ways of sharing library collections with both specialists and non-specialists. The 'Selene Circle' aims to democratise access to cultural heritage in a sustainable and effective way. By encouraging libraries and collections to record the surface of objects, Factum Foundation is committed to supporting institutions that install the system and to working with them to understand the importance of the materiality of objects.

The full Selene Package consists of the following parts:

- Camera and lens: Canon R5 + EF 50 mm f/1.2
- Adjustable camera holder
- Lighting system electronics: Selene Flash Sequencer PCB
- Lighting system unit; 4x custom-made xenon flash lamps
 - aluminium bracket with arms and adapter for tripod
 - aluminium bracket with arms
 - control box (inc. Arduino controller, protection shield and 3x stepper drivers)
 - 24 VDC PSU
 - aluminium frame with 3 motorised slides for X-Y movement (max. 110 x 100 cm)
 - pre-adjustable recording area
 - desktop PC: i9 processor with NVidia Graphics Card RTX (inc. Windows OS installed)
 - Selene software: Selene Processor; a custom-made photometric-stereo post-processing application. This software is provided both as a Windows executable and in its source code form (note: part of this will be made available as open source in the future)
- Updates and access to any new tools as they are developed
- Commercial software: Stitching app (perpetual license)
- Shipping and onsite installation
- Initial training period (estimated 30-40 hours)
- Offsite, ongoing technical and conceptual support

Opposite: Canvas samples made by Helena Loermans (Lab O) recorded using the Selene PSS. Top: The fabric used for El Greco's *The Burial of the Count of Orgaz*, recorded with 100 mm lens, colour and surface. Bottom: The same weave sample recorded with a 50 mm lens.



Recording Goya plates at Calcografía Nacional in Madrid



Factum Arte grew out of the work Adam Lowe and Manuel Franquelo were with the Calcografía Nacional in Madrid. One of the earliest projects was focused on the state of Goya's etching plates. The copper had been steel faced in the 19th-century. The steel rusting and presented a challenge for the conservation of the subtle information on the surface of the etching plates with aquatint.

Working with the master printmaker Hugh Stoneman, we tried to scan the surface of the plates and merge tone (dustgrain heliogravure) with CNC-milling to recreate the etched lines. The results were positive but were dependent on Hugh Stoneman's skill and experience. In November 2023, with permission from Javier Blas Benito, an long-time

collaborator and director of the Calcografía, we used the Selene Photometric Stereo system to record the plates after the steel facing had been removed. The image, reproduced here, is a digital image derived from the subtle variations in depth on the surface of the plate. It is an objective representation of the aquatint and etched lines on the surface of the copper.

A detail of *Disparate Femenino* produced digitally using the depth of the copperplate to produce tone. This suggests a potential area of study comparing the surface of the copperplates before and after the removal of the steel facing.

Opposite: Albedo (colour) and shaded render of *Disparate femenino*, one of the plates recorded at Calcografía Nacional.

Colnaghi & Factum: A 3D recording Studio in Central London



Colnaghi & Factum was formed in 2022 to celebrate the materiality of artworks and encourage a new age of digital connoisseurship. Through the fusion of Colnaghi, the oldest art dealership in the world, with Factum Foundation, a partnership has been created in which art and science merge, opening up the possibility for new insights, connections and innovations.

The studio in London's St James's focuses on high-resolution surface recording and composite colour photography. Colnaghi & Factum makes 3D scanning of the surface of paintings easy and accessible. The services are aimed at the custodians of paintings (museums, collectors, dealers, owners, and those fortunate enough to look after works of art), who wish to create a digital record of their artworks. This approach has already resulted in a groundswell of interest and a significant change in attitude to both the value and the preservation of works of art.

The goal is to provide clients with a digital passport for their artwork, which acts as an accurate certificate of its condition at a specific point in time. The digital passport is an extremely valuable and multidimensional asset: it can help curators monitor the condition of artworks, support researchers in their study, aid conservators in the process of restoration, and enable audiences from all over the world to view the original artwork in high-resolution online.

The Colnaghi & Factum digital passport is a single digital document that compiles diverse types of information in one place, at the same scale. Using Factum Foundation's Lucida 3D Scanner, in conjunction with composite colour recording and photometric-stereo, the passport will enable diverse users to analyse specialist data on any computer, using free software.

Colnaghi & Factum's data viewers combine the topographical surfaces of artworks with colour and multi-spectral analysis (X-ray, infrared, ultraviolet and other frequencies of light) to reveal what lies beneath. In addition to paintings, sculptures and relief panels can also be recorded.

Both private and public collections can digitally preserve and monitor their paintings through high-resolution scanning. This process demystifies technology and assists in detailed and objectively accurate condition monitoring. It can be used for long-term preservation, recording loans and analysing the changes that occur when works of art are moved, or to facilitate a new way of accessing works of art.

Colnaghi & Factum's recording studio in London.
Opposite: Creating a facsimile of a bust of Emperor Didius Julianus.

Ecce Homo attributed to Caravaggio

The 'rediscovered' Caravaggio was originally attributed to the circle of José de Ribera, considered to be one of the best artists working in a Caravaggesque manner. The painting, depicting Pontius Pilate displaying Christ, was put on sale by the Pérez de Castro Méndez family through the Madrid auction house Ansorena. It was pulled from auction in April 2021, following a decision by the Spanish Ministry of Culture.

Experts from the Museo del Prado agreed there were multiple reasons to attribute the painting to Michelangelo Merisi da Caravaggio, and an export ban was subsequently imposed. According to historical sources, Caravaggio was commissioned to paint an *Ecce Homo* in 1605 by Cardinal Massimi, then at the height of his fame in Rome.

Our recording of the painting in April 2021 allowed us to produce a digital passport of *Ecce Homo*, in its unrestored state. The painting has since undergone a light restoration and consolidation by a team of experts at Museo del Prado.

This recording coincided with the launch of Colnaghi & Factum, as a logical convergence to make 3D scanning of the surface of paintings easy and accessible to a wider range of public and private clients. Following the restoration of the painting, Colnaghi & Factum have re-recorded it, to demonstrate the importance of documenting works of art at key stages in their biographies.

Lucida 3D Scanner recording the surface of the *Ecce Homo*.



Saint Paul and the Burning of Pagan Books tapestry by Pieter Coecke van Aelst

Of the nine tapestries commissioned by Henry VIII depicting the life of Saint Paul, only one survives. Portraying the burning of pagan books, this powerful work, rediscovered in 2018, is a critical document of a nation in the grip of religious change.

It was woven in Brussels around 1535 following a design and cartoon by Belgian Renaissance master Pieter Coecke van Aelst (1502-1550), who created tapestry designs for the major courts of Europe at the time, using wool, silk and gold and silver threads. The tapestry was delivered to Hampton Court between 1538 and 1539 and remained one of the most expensive objects in the Royal Collection (the cost of a gold-embroidered tapestry was almost equal to a fully-armed warship). It was later used for the redecoration of Windsor Castle around 1670.

Under the reign of George IV, the whole series was displaced from Windsor Castle in the 1820s and disappeared from the records, only known through fragments of the cartoon and preparatory sketches. The *Saint Paul and the Burning of Pagan Books* tapestry was then registered in the collection of Drayton House, Northamptonshire in 1939; the border was

most likely removed in the 19th-century for the purpose of adapting the object for display in a much smaller room.

As part of the ongoing collaboration between Factum Foundation and Colnaghi, the tapestry was recorded on both sides in June 2021, using the Lucida 3D Scanner and composite photography. The resulting digital passport of the object will be useful for conservation and research purposes.

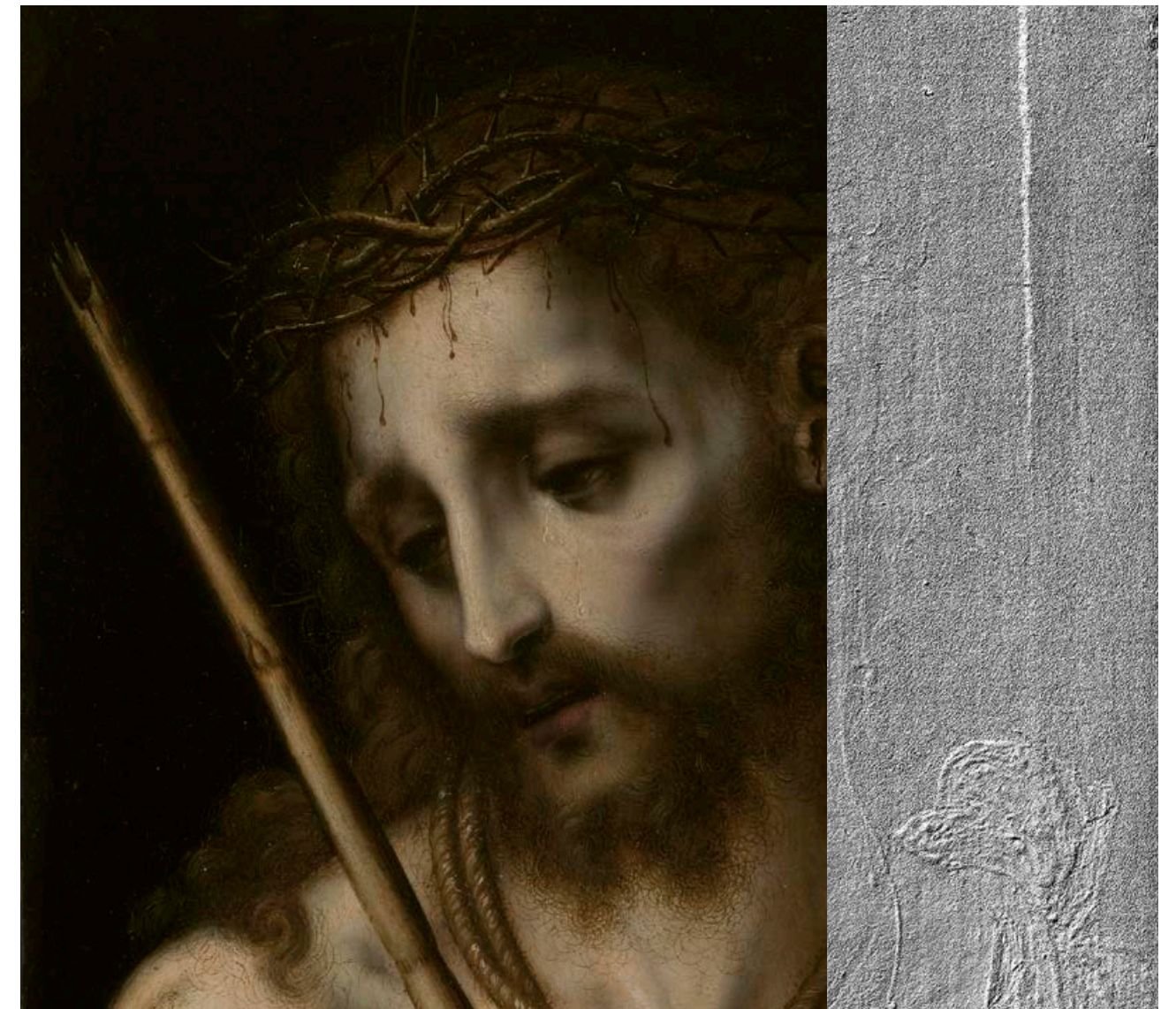
The original tapestry and the Lucida 3D Scanner recording its surface.



TEFAF Maastricht, 2023

On March 10th 2023, during a private event organised within the framework of TEFAF Maastricht, a team from Factum Foundation was invited to present and demonstrate the technologies and results offered by Colnaghi & Factum. The event, held inside the Château Neercanne and attended by the representatives of several major museums and art institutions, featured a display of selected objects, scanners and surface reliefs, as well as a side-by-side comparison of Luis de Morales' *Ecce Homo* and a high-resolution facsimile produced by Factum Arte.

The Colnaghi & Factum display at TEFAF Maastricht, showing various digital and physical output techniques.





Left: *Christ on the Cross*, Doménikos Theotokópoulos, known as El Greco, c. 1610. Oil on canvas, 179.4 x 103.5 cm. Spanish Gallery, Bishop Auckland. Right: *Christ on the Cross*, El Greco, c. 1600-1610. Oil on canvas, 193 x 116 cm. The Cleveland Museum of Art. While these two versions of El Greco's crucifixion have slightly different crops they are otherwise so similar in composition and details that they must have been made using some kind of transfer or copying system. The shift in colour is due to age and cleaning.

Palazzo Te and Factum Foundation

In early 2022, Factum Foundation and Fondazione Palazzo Te partnered up to carry out a vast high-resolution digitisation project inside three rooms within Palazzo Te, Mantua. This marked the first of several collaborations between the two foundations, which then evolved into an ongoing approach to the use of technology for the creation of exhibition content and didactic displays.

The palace, built as a place of leisure for the Gonzaga family in the mid-16th-century, was designed and frescoed by Giulio Pippi, better known as Giulio Romano.

A brilliant pupil of Raphael, with whom he collaborated on the Vatican Rooms and many other works, Giulio Romano

moved to Mantua shortly after the death of his teacher in 1520. Arriving in Mantua in 1524 as the official court artist of Marquis (later Duke) Federico II Gonzaga, he received the commission to 'build a small residence to which he [the Marquis] could retire sometimes to feast, or dine for pleasure' (G. Vasari, *Lives of the Artists*).

According to biographer Giorgio Vasari, the elaborate model that Giulio Romano presented to the Marquis was enough for him to immediately begin construction, and the finished palace soon became a source of inspiration for artists and architects alike, thanks to its innovative designs and frescoed rooms.

Recording of the three rooms within Palazzo Te



From January 17 until February 7, 2022, a team of digitisation specialists from ARCHiVe and Factum Foundation recorded in high resolution the **Chamber of the Giants**, the **Chamber of Cupid and Psyche** and the **Hall of the Horses**. The data, acquired using LiDAR, photogrammetry and composite photography, now belongs to Fondazione Palazzo Te to support the documentation, preservation, study and dissemination of the rooms, and to be used in projection mapping and VR displays for both educational and entertainment applications.

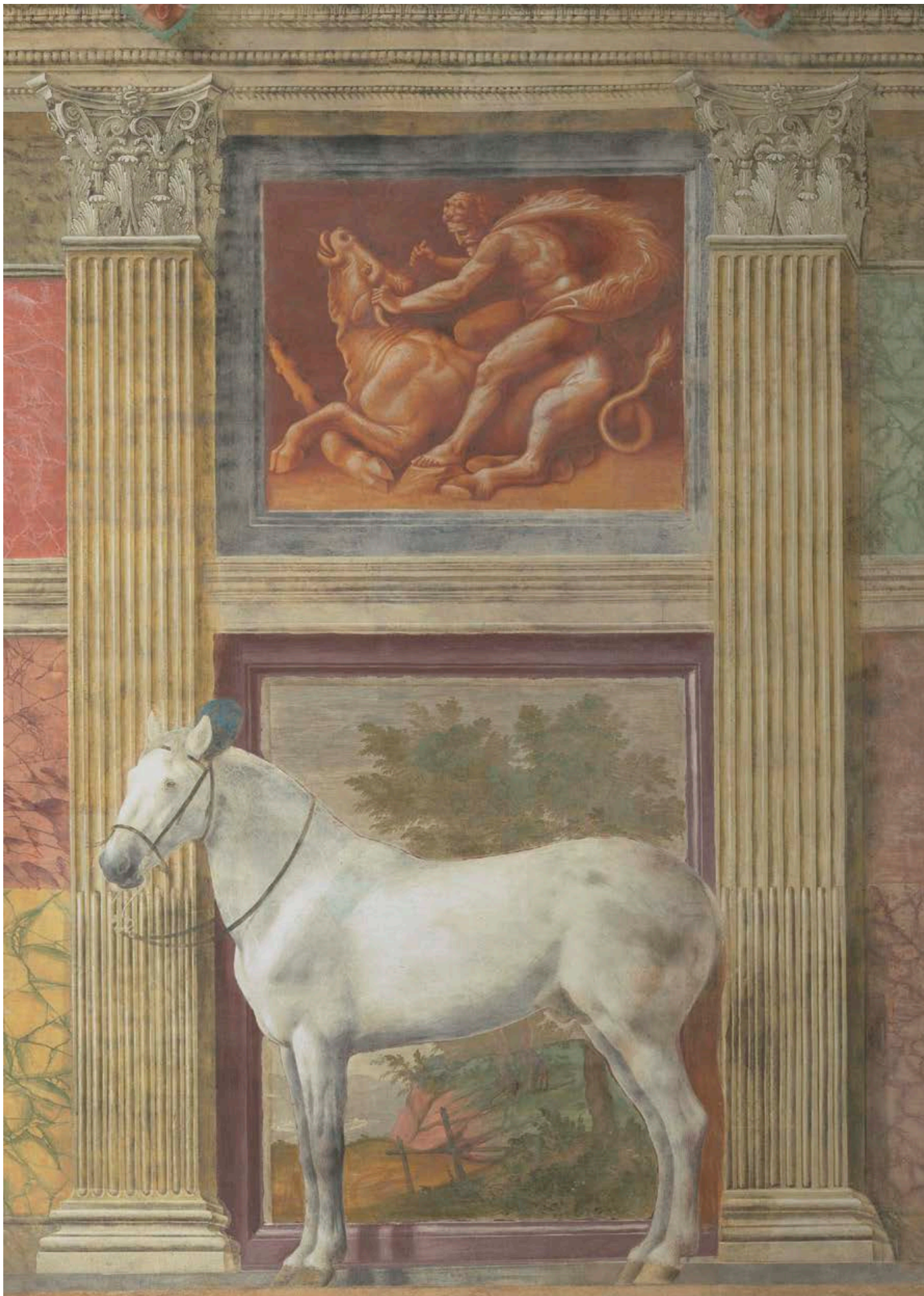
HALL OF THE HORSES

Probably frescoed between 1526 and 1528, this room was dedicated to the welcoming of guests and for hosting events of the greatest importance. The Duke Federico II took thoroughbreds from his own stables to give to prestigious guests and friends. Life-size frescoes of these horses decorate the walls. Francesco II Gonzaga, husband of Isabella d'Este and father of Federico II, raised horses around the Palazzo Te in the early 16th-century. Both father and son were passionate horse breeders, and Gonzaga thoroughbreds were considered among the best.

A rich painted structure frames the horses, landscapes and busts. On the upper side, a painted bronze low-relief depicts Herakles' twelve labours.

Top: Ortophoto of the Hall of the Horses. Bottom: Render of a ceiling detail.

Opposite: Detail of the north wall of the Hall of the Horses showing Dario, the fairest steed.





CHAMBER OF CUPID AND PSYCHE

It is in this cuboid chamber that the purpose of the whole building is proudly declared in Latin: a place of respite and 'honest leisure' from the tiresome troubles of governing the province (*honesto ocio post labores ad reparandam virt[utem] quieti constrvi mandavit*). The frescoes depict the story of Cupid and Psyche, taken from Apuleio's *Metamorphosis*, and were painted between 1526 and 1528.

Left: Renders of the ceiling (top) and colour data from the ceiling frescoes (bottom). Top right: Ortophoto of the Chamber of Cupid and Psyche. Bottom right: Ortophoto of the ceiling. Opposite: Panoramic composite photography and photogrammetry recordings.





CHAMBER OF THE GIANTS

The most famous of all the rooms of Palazzo Te was painted between 1532 and 1534 by Giulio Romano and his assistants, Rinaldo Mantovano, Fermo da Caravaggio and Luca da Faenza. The chamber itself is a work of art, from its shape (resembling a cave) to its highly theatrical and elaborate decoration spiralling from walls to ceiling, which aimed to leave guests awestruck. The fight between the Olympians and the Giants, which saw Jupiter emerge triumphant, can be read as a subtle political nod to the victories of Emperor Charles V over rebellious Italian 'signorie'. The Gonzagas, political allies of Charles V (and thus Jupiter), triumphed over rival provinces by allying themselves to the Imperial side.

Left: Ortophoto of the Chamber of the Giants. Bottom: Pedro Miró recording the 3D surface of the Chamber of the Giants using close-range photogrammetry.

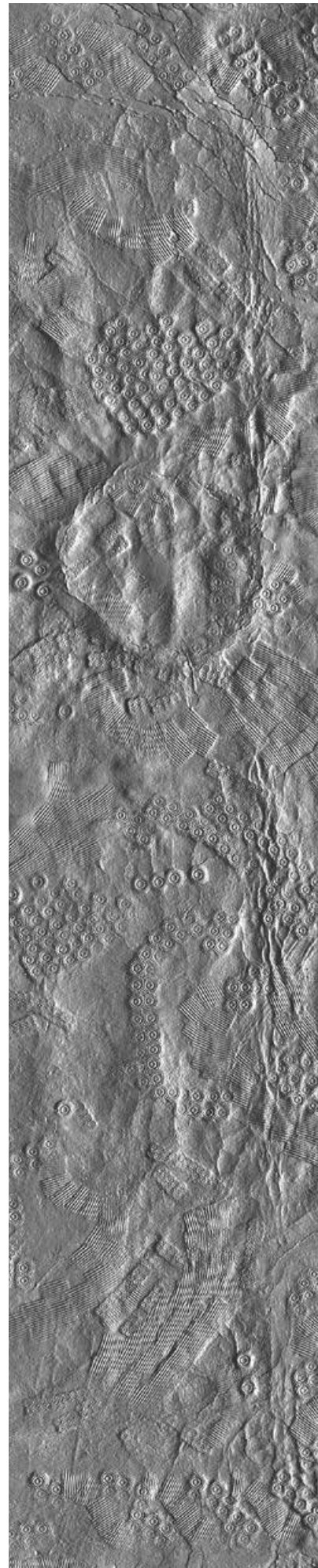
Opposite: Gabriel Scarpa using a ColorChecker passport to record the colour of the Chamber of the Giants.

Overleaf: Detail from the Chamber of the Giants showing the colour information.





Recreating a leather wall hanging



In parallel with the recordings of the three rooms, Palazzo Te commissioned Factum Foundation to recreate for visitors to the exhibition *Le Pareti delle Meraviglie* (26 March - 26 June, 2022) the atmosphere that once welcomed guests of the Gonzaga family.

Not much is left of the sumptuous leather wall hangings (also called *corami*, from the Latin *corium*, 'leather') that once covered some of the walls of Palazzo Te. The craft required great leatherworking skills and expensive materials, and was considered an alternative to tapestries during the warmer months of the year.

During the 16th-century, the main production centres of leather wall hangings were Cordoba, where the craft was imported from the city of Gadamis in Libya during the Moorish rule (giving it the name *quadamecil*), and Venice, where leathercrafters acquired guild status in 1569 at the Scuola dei Pittori. Bologna was also a notable centre for leatherworking.

In January 2022, Factum recorded at high resolution a 17th-century *Leather wallpaper with flower vases*, at the Musée des Arts Decoratifs in Paris. Both the Lucida 3D Scanner and photogrammetry were used to accurately capture the subtly carved surface of the large hanging. Colour was recorded using composite photography. The reflective nature of leather and its silver and gold embossings made the task a complex one.

Once the different sets of data were processed and merged in Factum's studios, the modular nature of the *corame* that enabled a recreation to be scaled to fit into the spaces of the Camera dei Venti.

The 2D department played with both relief and colour, expanding and adapting the original data so that the new object could offer a variety of natural undulations and tonal variations on its surface. In response to Palazzo Te's request, the object needed to be free-standing inside the room without touching the wall. A base panel simulating the leather undulations was therefore CNC-milled in polyurethane, and later mounted on an aluminium structure.

The embossed surface was recreated in 'tiles' using elevated printing, moulded in silicone and cast in a series of thin, gelatin-based skins, before being painted gold. The colour was printed over the skins using Factum Arte's custom-made inkjet flatbed printer, gradually building layer upon layer of tone over the textured surface in perfect registration with the creases, punchmarks and surface details.

The printed 'tiles' were then applied to the CNC-milled panels and the joints were hand-finished before a final layer of wax was applied to the whole piece, simulating the gloss of traditional *corami* wall hangings.

The recreation of a leather wall hanging installed inside the Camera dei Venti.

Opposite: Different steps of the recreation process, from data processing to printing, gilding and assembling.

Recreating Giulio Romano's designs

In 2022, Factum Foundation and Factum Arte worked with Fondazione Palazzo Te on recreating five designs by Giulio Romano as physical objects for the exhibition 'Giulio Romano. La forza delle cose'. Curated by Barbara Furlotti and Guido Rebecchini, the show focuses on the artist's talent and ingenuity in object design – both for leisure and for war.

Detailed exchanges of letters document Ercole and Ferrante Gonzaga's interest in silverware, and many pieces of their collections were designed by Giulio Romano, who was the official artist at the Gonzaga's court. The artist had no training in metalworking, and therefore several of his designs, while looking almost effortless on paper, were very complex and often challenging to produce.

None of these objects survives today, and Factum Foundation, in collaboration with Factum Arte's 3D team, made physical

recreations inspired by a selection of drawings:

- A vase *all'antica*
- A pair of tongs
- A salt cellar
- An ewer in the shape of a sea monster
- An ewer made for Ercole Gonzaga

The intricate designs were rematerialised as elaborate 3D models by Irene Gaumé, Jordi García Pons and Manuel Franquelo at Factum Arte, before being 3D printed in sections and cast in a variety of materials depending on the size and complexity of the details.

Opposite: Detail of the vase *all'antica* within the frescoes of the Chamber of Cupid and Psyche (top). The two-dimensional vase and its 3D model (bottom).



Today we accept a division between artist and craftsman. The conceiving of something is valued above the making of it. The artist is king. Benvenuto Cellini was a goldsmith. Despite Giulio Romano having had no training as a metalworker, he oversaw the production of his designs, often frustrating the craftsmen.

Romano's voice is not here to supplement the drawings or resolve the complexities in transforming a graphic notation into an object. His salt cellars, ewers and sculptures were intended to feel effortless and fluid, despite a profusion of flora, fauna, human and mythological forms in a world made of gold, silver, shells and coral. They celebrate man's ability to transform natural materials into unnatural artefacts made with great skill.

The process of modelling in clay or wax and working in silver and gold has been reinvented in today's world of digital mediation where voxels ('volumetric pixels') exist in virtual space. The haptic working of physical materials now happens on screen. It requires different skills and methods but the same sensibilities. Z Brush, Autodesk, Maya and other softwares build forms, while Materialise Magics converts the virtual back to physical. Stereo-lithographic printing uses light to create form from a liquid resin. The Birth of Venus, where she emerges fully formed from the waves, is a perfect metaphor for additive technologies where complete objects emerge from liquids.

The merging of craft skills and technologies now takes different forms, but making still depends on an intimacy with the behaviour of the physical world. Once formed, analysed and approved, models are broken into elements that can be cast. From here, the process resembles that of the gold or silversmith of the 16th-century.

Adam Lowe

Wall panel at the exhibition, 'Giulio Romano. La Forza delle Cose'

ALL'ANTICA VASE

Silver-plated brass
528 x 400 x 350 mm

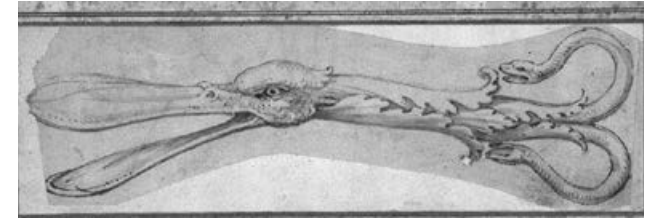
This design appears on the walls of the Chamber of Cupid and Psyche, and in an etching within the collection of the Victoria & Albert Museum (published by Agostino Veneziano in 1531). The definition of *all'antica* ('in the manner of the antique') refers to a design in the style and principles of the classical past. The vase was rematerialised in brass at Fademesa Foundry, with silver leaf added in Factum.



PAIR OF TONGS

Pewter
70 x 260 mm

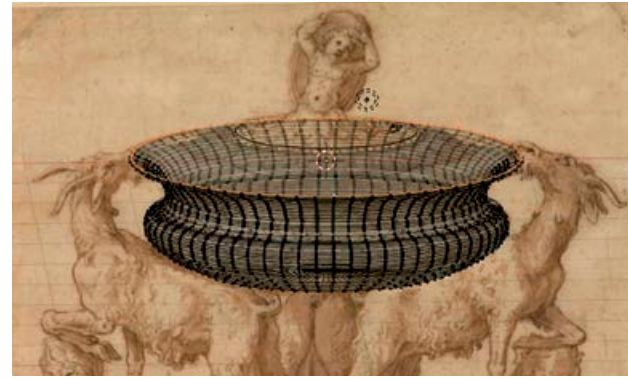
This pair of tableware tongs was one of the most complex designs to conceive in 3D as the team also needed to focus on its functionality. After trying various configurations for the scale of the object and the positioning of the hidden adjusting screw, each section was cast in pewter and assembled at Calser Peltrex 98, in Badajoz, Spain. Pewter is a malleable alloy of tin, antimony and copper that has been widely used for tableware since Roman times.



SALT CELLAR

Silver-plated brass
188 x 225 x 225 mm

The elaborate design, featuring small goats and an ornate lid, was made at Esfinge Foundry in Madrid.



EWER IN THE SHAPE OF A SEA MONSTER

Silver-plated brass and pewter
310 x 222 x 136 mm

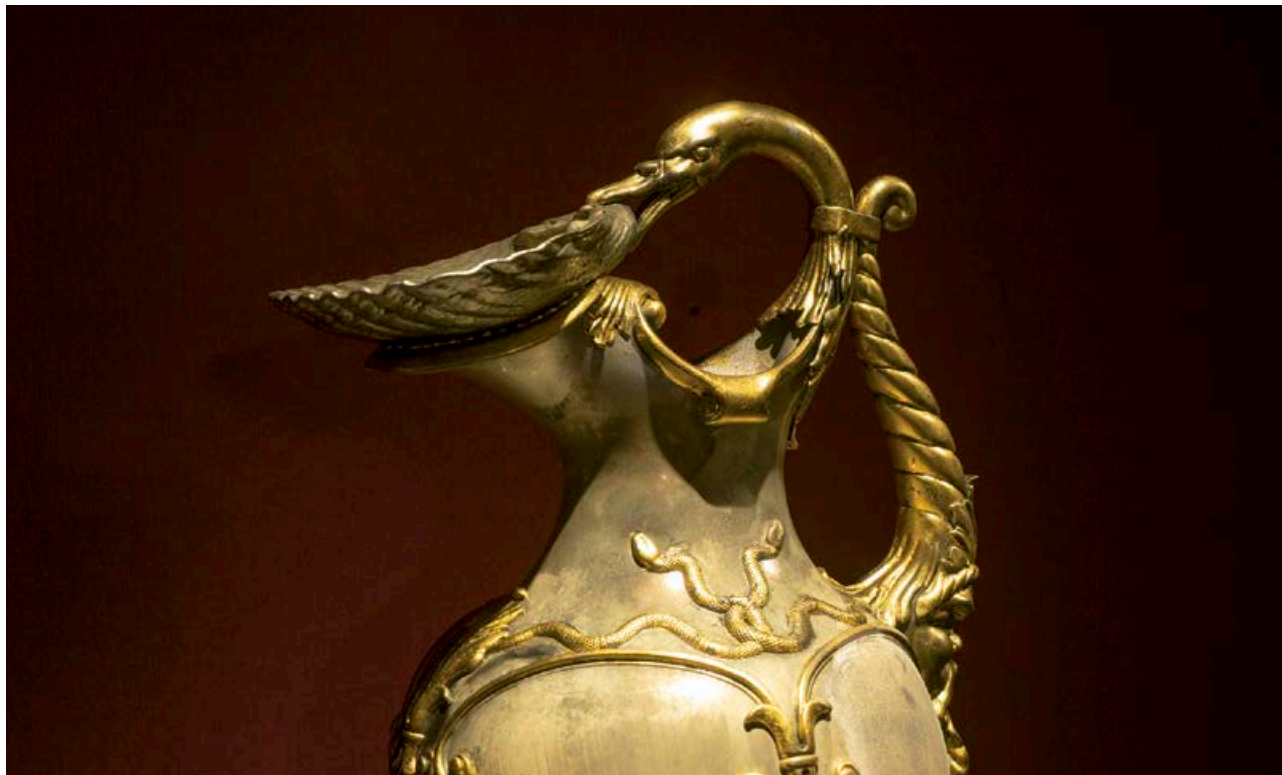
The several sections of the ewer were made in silver-plated brass at Fademesa Foundry in Madrid, with the finer details cast in pewter at Calser Peltrex 98 in Badajoz.



EWER FOR ERCOLE GONZAGA

Silver-plated resin and gold foil
400 x 165.25 x 198 mm

This design for Cardinal Ercole Gonzaga was 3D printed and then silver plated, with gold leaf applied onto the raised areas of ornamentation.



Scuola di Palazzo Te Workshop

RECORDING GIULIO ROMANO: SHAPE & SURFACE 12-16 September 2022

The workshop *Recording Giulio Romano: Shape & Surface*, was organised by Factum Foundation and ARCHiVe as part of the Scuola di Palazzo Te's programme 'Fare Arte'. It introduced students and professionals to the techniques and methods of digital preservation pioneered by Factum Foundation through a number of international projects around the world.

On the 12th to the 16th of September 2022, the 30-hour workshop demonstrated theoretical and practical methods for digital recording, while carrying out a live digitisation project in Palazzo Te. Nine international professionals, PhD researchers and graduate students from Italy, Canada, Estonia and India participated in the initiative in Mantua, Italy. Their diverse backgrounds and interests in Art & Cultural Heritage, Digital Humanities, Industrial Design, Political Science and Marketing enriched the workshop, offering new insights and points of view on digital recording.

The workshop focused on recording specific art and architectural elements in Palazzo Te (mainly frescoes and stucco reliefs) employing non-contact systems such as close-range photogrammetry, panoramic photography, the Lucida 3D Scanner and LiDAR 3D Scanning (for interior and exterior spaces). Working with Factum and ARCHiVe's experts to carry out the digitisation tasks on-site, the students' work resulted in high-resolution digital recordings of Giulio Romano's architectural masterpiece. In line with Factum Foundation's principles, all data was then provided to Palazzo Te for the preservation and study of the artworks.

Each day was divided into three complementary sessions:

- Theory:** introduction to general concepts and strategies of digital preservation (1.5 h/day)
- Tutorial:** introduction to a specific recording methodology, from capturing to processing (1.5 h/day)
- Fieldwork:** digitisation of selected elements in Palazzo Te (3 h/day)

Teachers: Carlos Bayod, Osama Dawod and Gabriel Scarpa (Factum Foundation, Madrid), Carolina Gris and Marina Luchetti (ARCHiVe), Costanza Blaskovic and Ilenia Maschietto (Fondazione Giorgio Cini).

Additionally, Nick Walkley from the Oslo School of Architecture and Design was invited to present his research about digital ornament.

Some of Giulio Romano's designs for Palazzo Te's decorative elements were subject to a comparative study at ARCHiVe. The research has been carried out thanks to the rich bibliographical collections in the Fondazione Giorgio Cini's Library specialised in art history, establishing a unique link between the two projects.

The students benefited from theoretical and practical sessions with Factum's experts.



Two Facsimiles

TITIAN, *FEDERICO GONZAGA, 1ST DUKE OF MANTUA* (1529), MUSEO DEL PRADO, MADRID

In early 2023, a team from Factum Foundation recorded in high-resolution a portrait of *Federico Gonzaga, 1st Duke of Mantua* (1529) by Titian in the collection of the Museo del Prado. The oil painting was scanned using the Lucida 3D Scanner, and composite photography and accurate data of both the surface and colour were used to make an exact facsimile of the artwork.

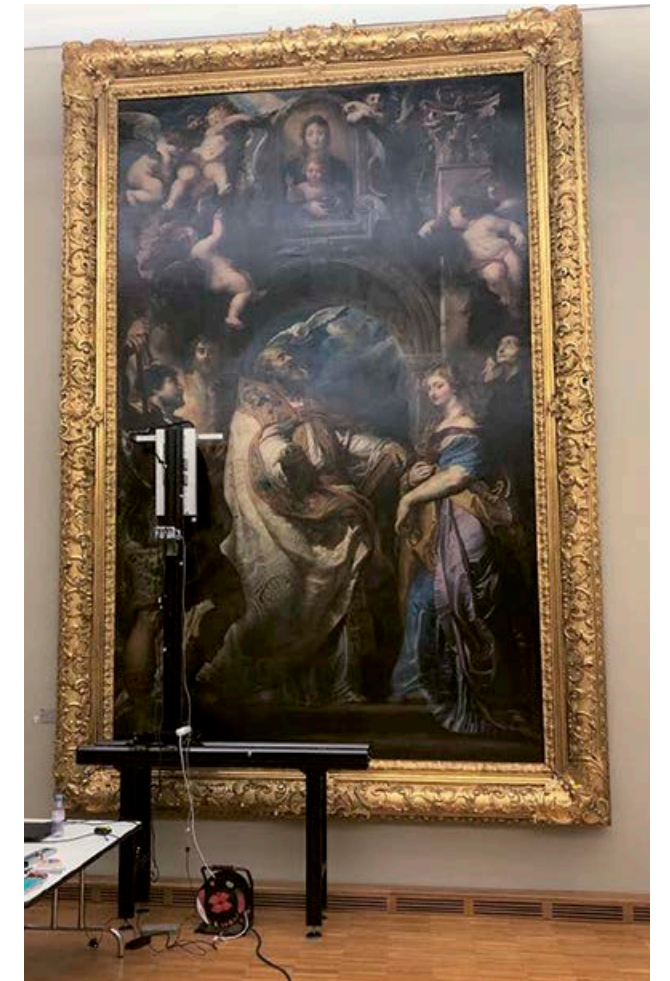
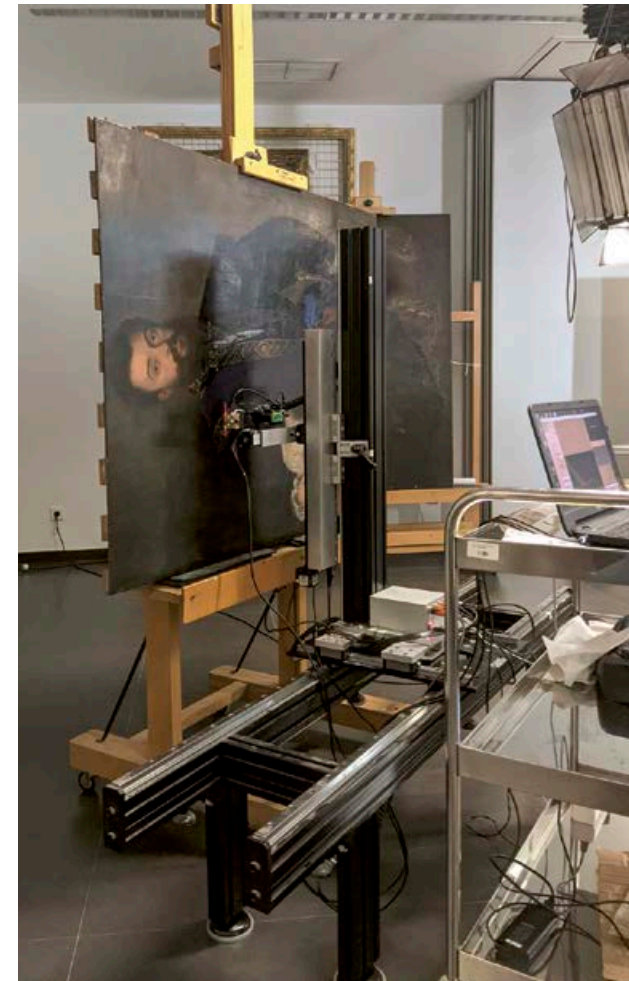
The exhibition 'L'imperatore e il Duca. Carlo V a Mantova' (March 24 – June 25, 2023) explored the relationship between Emperor Charles V and Federico II Gonzaga, who was appointed Duke of the city of Mantua in 1530. Charles V visited the city while Palazzo Te was still undergoing decoration. He was building a net of alliances in order to strengthen his empire.

RUBENS, *THE ECSTASY OF ST GREGORY THE GREAT* (1608), MUSÉE DE GRENOBLE

A major work by Rubens, *The Ecstasy of St Gregory the Great*, was recorded in the Musée de Grenoble in order to produce a facsimile for 'Lo Sguardo di Rubens su Palazzo Te. Pittura, Trasformazione e Libertà', an exhibition about the Flemish artist that opened in October 2023 at Palazzo Te.

In line with Factum Foundation's policy, the digital archive relating to the painting was given to The Musée de Grenoble, providing an accurate record of their surface and colour at the time of recording.

The Lucida 3D Scanner recording the surface of *Federico Gonzaga, 1st Duke of Mantua* (left) and *The Ecstasy of St Gregory the Great* (right). Opposite: Jordi García Pons adding the final touches on the facsimile of Rubens' painting.



The Raphael Cartoons at the V&A

In August 2019, a team of 3D-scanning and photography specialists from Factum Foundation carried out the recording of the Raphael Cartoons at the Victoria and Albert Museum in London. The cartoons constitute probably the most important series of artworks from the Italian Renaissance in the UK, and are on long-term loan from the Royal Collection to the Museum by His Majesty the King.

Raphael was commissioned to make the tapestry cycle for the Sistine Chapel. While the final ten tapestries have survived, they are rarely on display, and only seven of the preparatory cartoons are still extant. In 1623 these are recorded in the collection of King Charles I. Since 1865 they have been on display at the V&A Museum, most recently in the Raphael Court.

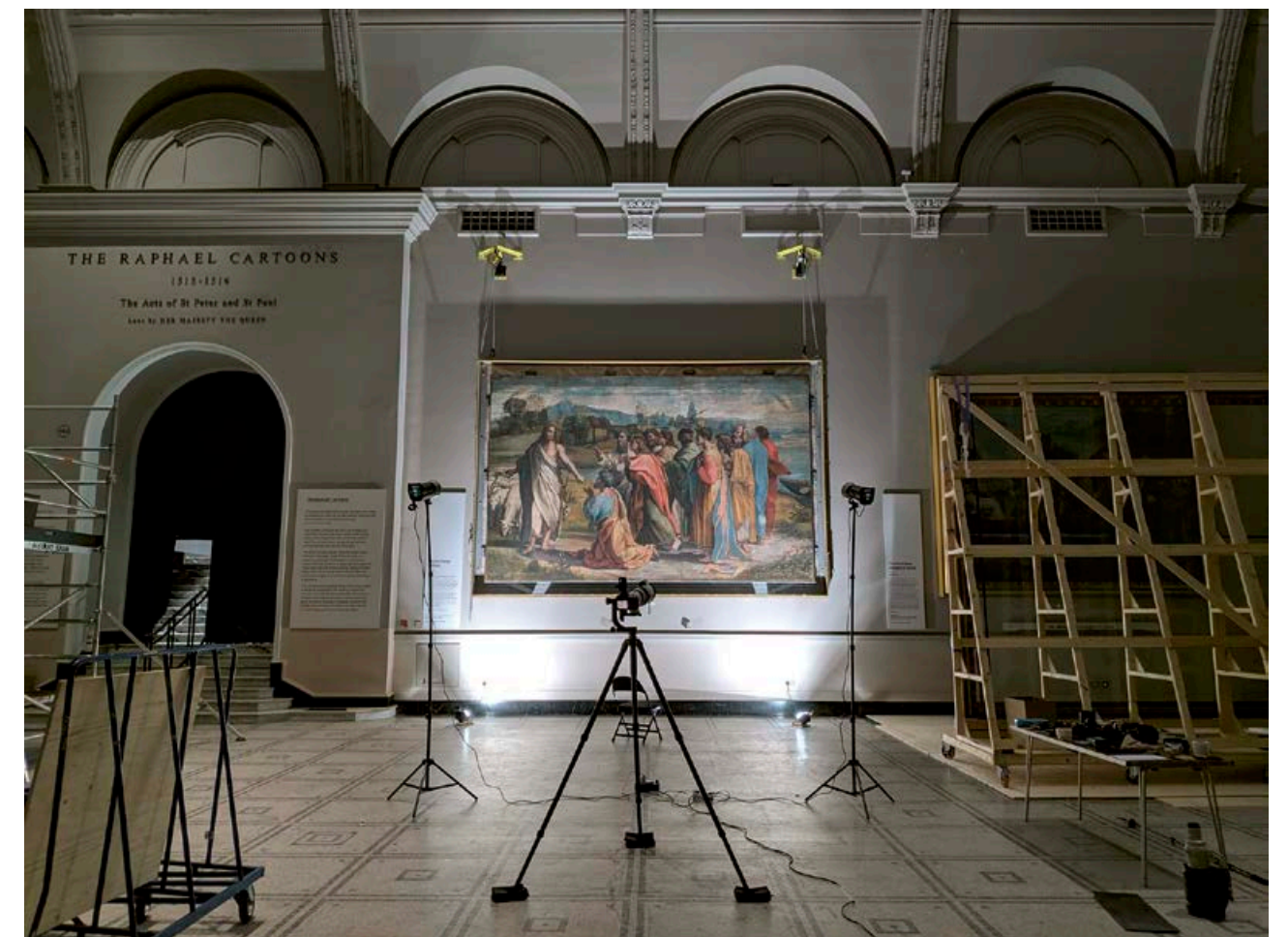
This project remains one of Factum Foundation's most ambitious digitisation projects, and has set new standards for large-scale, high-resolution digital documentation of

low-relief surfaces. The project raised many questions about the cartoons and has resulted in further recordings of both tapestries and cartoons by Raphael and his studio held in other collections.

The recording used non-contact digital technologies to capture detailed information from the surfaces of the seven monumental cartoons. The original and processed data was provided to the V&A for study and dissemination.

In order to complete the recording in the limited time available, Factum's team worked in three eight-hour shifts, around the clock, for five weeks, during which time the gallery was closed to the public. By following a carefully planned schedule, it was possible to coordinate the recording of the cartoons with the removal and

Bottom and opposite: Panoramic composite photography employed to record the colour of the monumental cartoons.



replacement of the vast frames, the production of conservation condition reports, and other tasks carried out by the Museum's staff. Fluent communication and coordination between the different teams was key to the success of the project's recording phase.

RECORDING SURFACE, COLOUR AND INFRARED

In the first phase, a total area of about 115 square metres was digitised, using two complementary non-contact methods: high-resolution panoramic photography, for recording both colour and infrared, and the Lucida 3D Scanner.

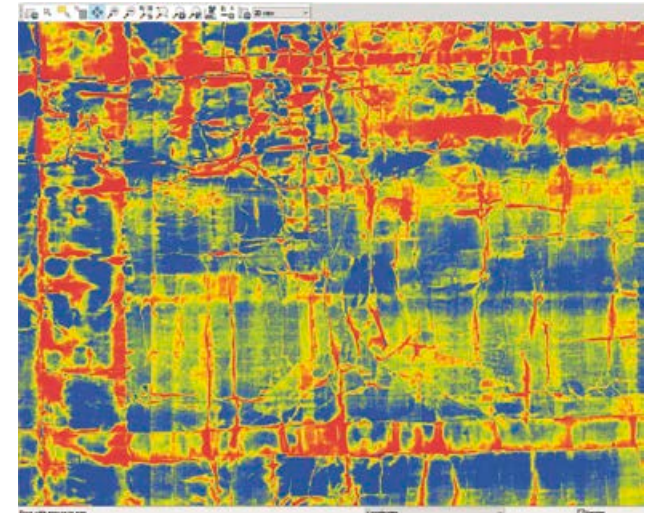
The use of the Lucida allowed for a meticulous recording of surfaces which, while apparently flat, are in fact remarkably complex, as they are made up of composite sheets of paper. The goal was to document the character of the surface in order to reveal the painting process, the pouncing marks that cover the surface, the folds and the previous restoration treatments.

To produce accurate digital records of the cartoons, four Lucida 3D Scanners were employed simultaneously to record the relief at a resolution of 100 μm (generating render images at 254 dpi at 1:1 scale). The scanners were mounted on scaffolding towers, reaching a maximum scanning height of about 5.5 m. The stability of the scaffolding, built by Momart, was essential to guarantee the highest level of safety for the cartoons and to produce optimal data quality.

At night, the Raphael Court was animated by hundreds of camera flashes, part of the process of panoramic photography. Factum's photographers have spent many years perfecting this technique, which they use to create high-resolution colour recordings of flat or gently undulating surfaces. The cartoons were recorded in colour and infrared at a resolution of 400-450 dpi at 1:1 scale.

CREATING THE MULTI-LAYERED BROWSERS

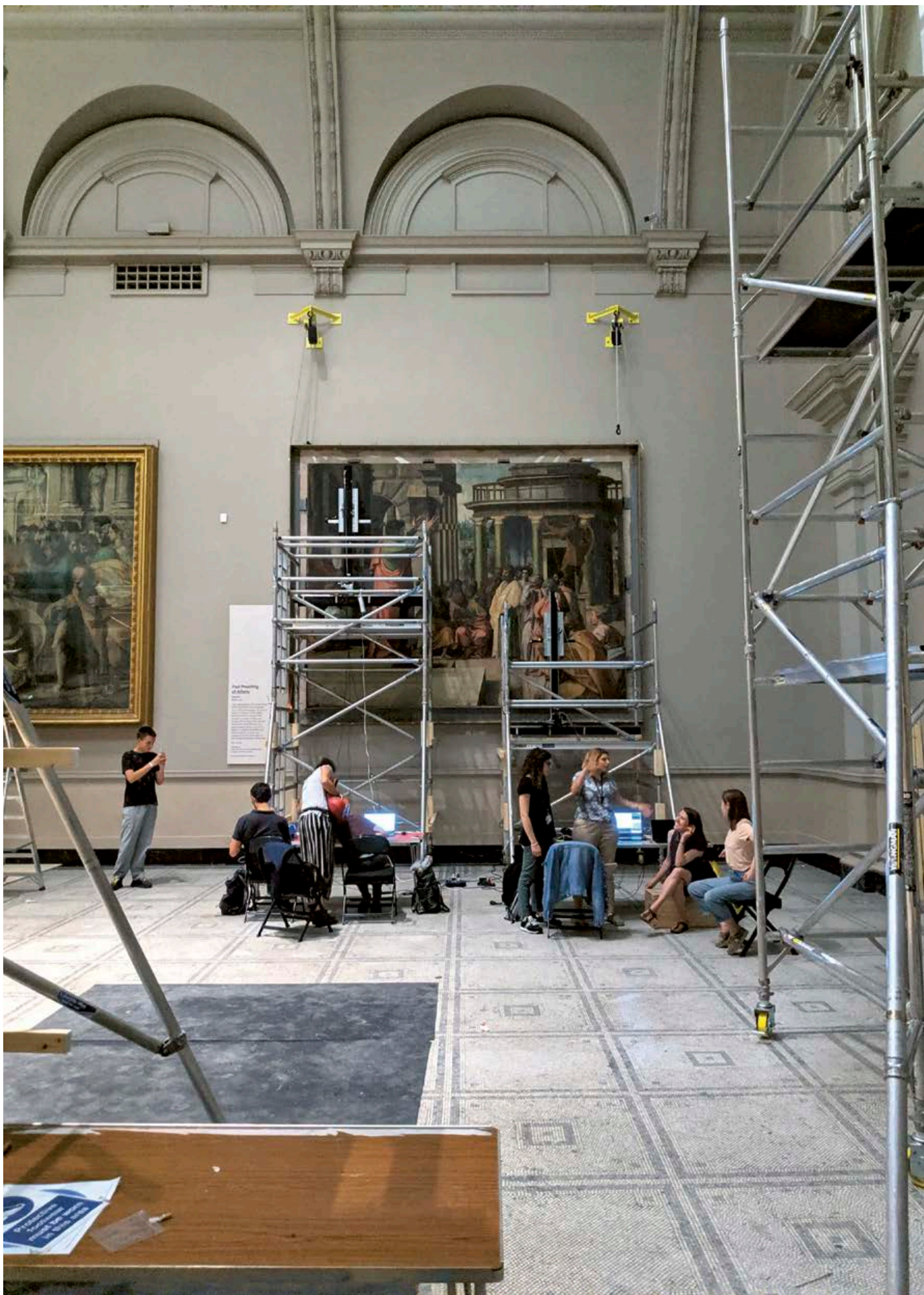
The second phase involved processing the digital information captured on-site to render it suitable for different applications. Between late 2019 and the start of 2020, the raw files were carefully analysed, edited and stitched together to create high-resolution composite images. Since the 3D data recorded by the Lucida system is generated as a greyscale depth-map and shaded image renders, it is possible to employ image-based software like PTGui to align the tiles; a similar semi-automatic process is followed with the photography and infrared images. As a result of these stitching operations, three panoramas are generated for each cartoon: a 3D render (which is used as a base), a colour file and an infrared file.



Viewing high-resolution files like these on an ordinary computer can be problematic: simply to open a file of 40GB (the size of one of the panoramas) or to compare three different datasets would be extremely memory-intensive. This is, however, a critical part of the work, as multi-layered navigation (of different types of data) is key to understanding the surface of complex artworks. To make this possible, Factum has produced a multi-layer browser that is easy to use and can be accessed via the internet. Paintings and other low-relief artifacts can now be studied and shared in ways that render their historic trajectories evident and traceable. This ability to focus on a specific detail and to turn the different layers (relief, colour and infrared information) off and on in an intuitive way has introduced a new way to study paintings and works of art.

On January 25th 2021, the V&A launched a new online platform where the data from the Raphael Cartoons was made available to the public for the first time. Through a new digital environment on the V&A's website, users are now able to engage with the cartoons at an unprecedented level of detail. The dataset from the recording, which was supported by the Royal Commission for the Exhibition of 1851, is accessible through a high-resolution multi-layer viewer.

Colourised depthmap showing variations in relief of a recorded cartoon. Opposite: The team worked around the clock in three shifts for a period of five weeks. Four Lucida 3D Scanners were employed simultaneously to record the relief.



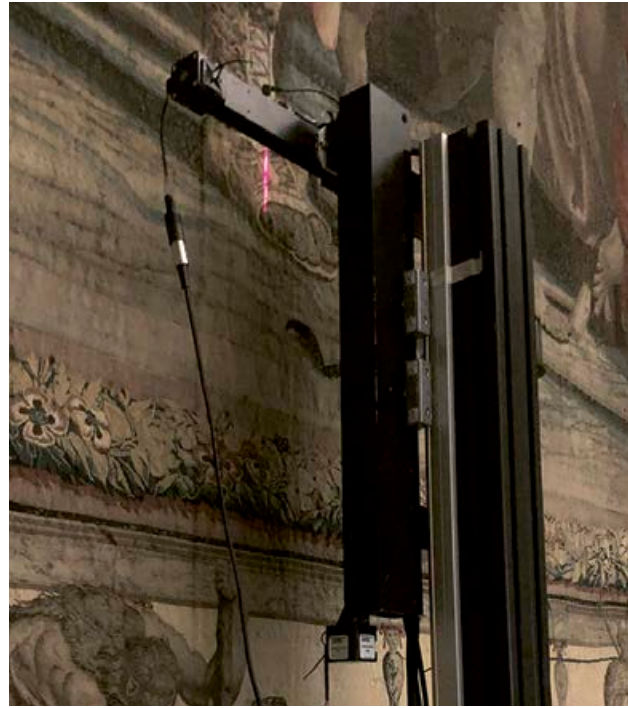
The Sacrifice at Lystra Tapestry

Following the recording of the Cartoons at the V&A, Factum Foundation has been working with art historian Arnold Nesselrath to understand the relationship between the designs for the Sistine Chapel and the tapestries woven from them.

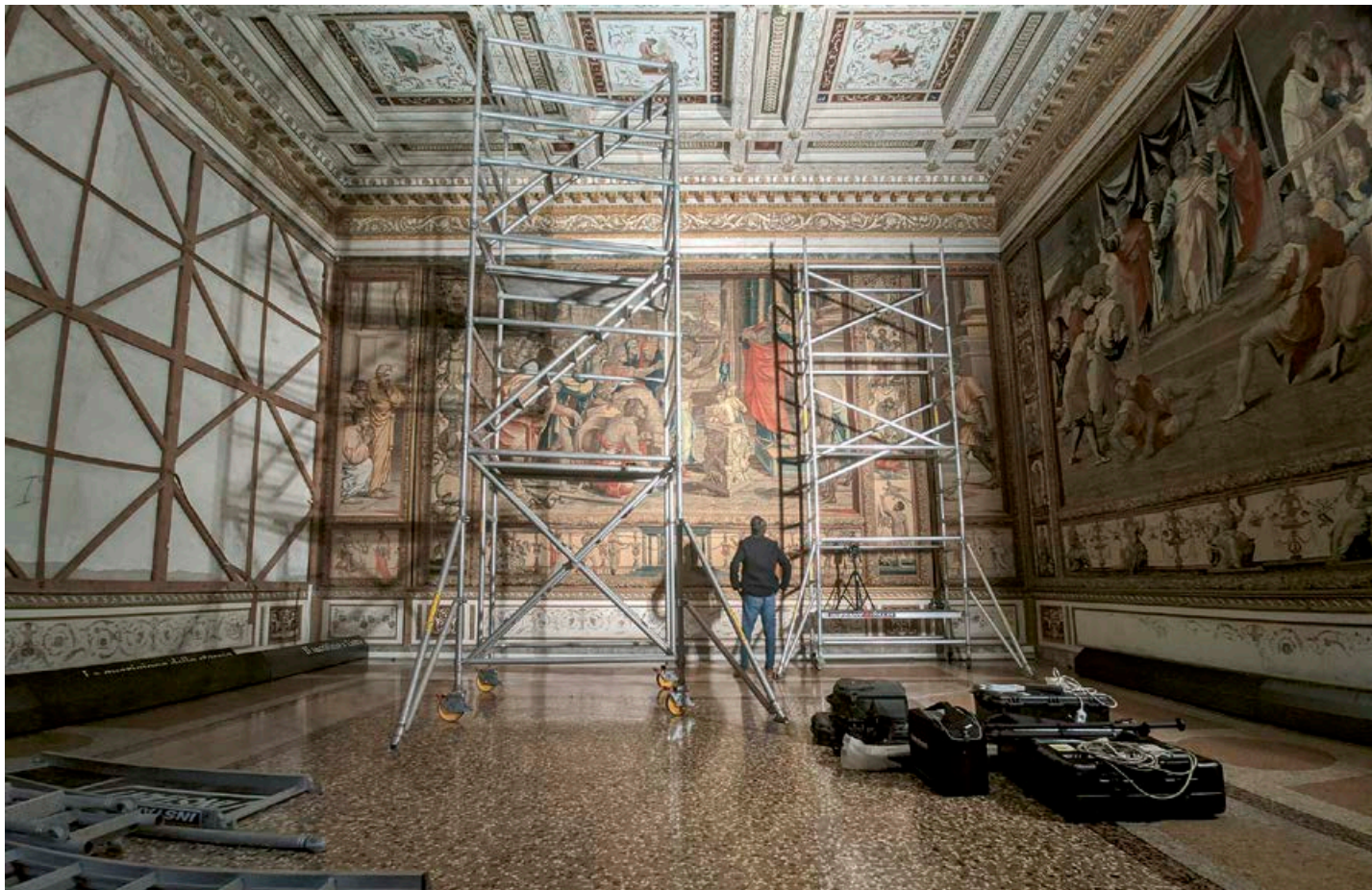
In February-March 2021, Factum Foundation recorded *The Sacrifice at Lystra*, one of the tapestries on display at Palazzo Ducale in Mantua.

Produced around 1550, Cardinal Enrico Gonzaga managed to acquire the tapestries, purchasing them directly from Brussels to decorate Mantua's cathedral. Arnold Nesselrath wanted to investigate whether it could be asserted that these tapestries were woven from the cartoons in the V&A.

The tapestry, measuring 5 x 7 m, was recorded with close-range photogrammetry in order to obtain high-resolution data of its colour and surface relief. The recording consists of a mosaic of images made in conjunction with a parallel recording carried out from a scaffold at a constant distance, while the tapestry remained mounted on the wall. The recording was made before the tapestry was cleaned, as part of an ongoing restoration project for Palazzo Ducale.



The 3D surface and photogrammetry recordings of the tapestry at Palazzo Ducale.

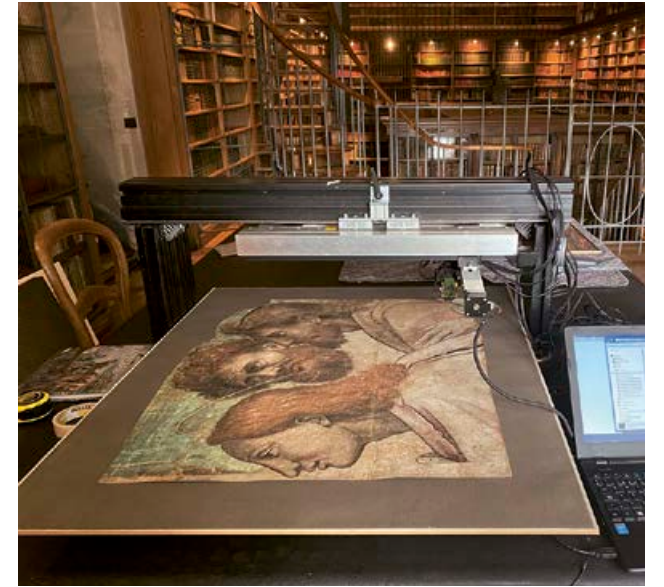


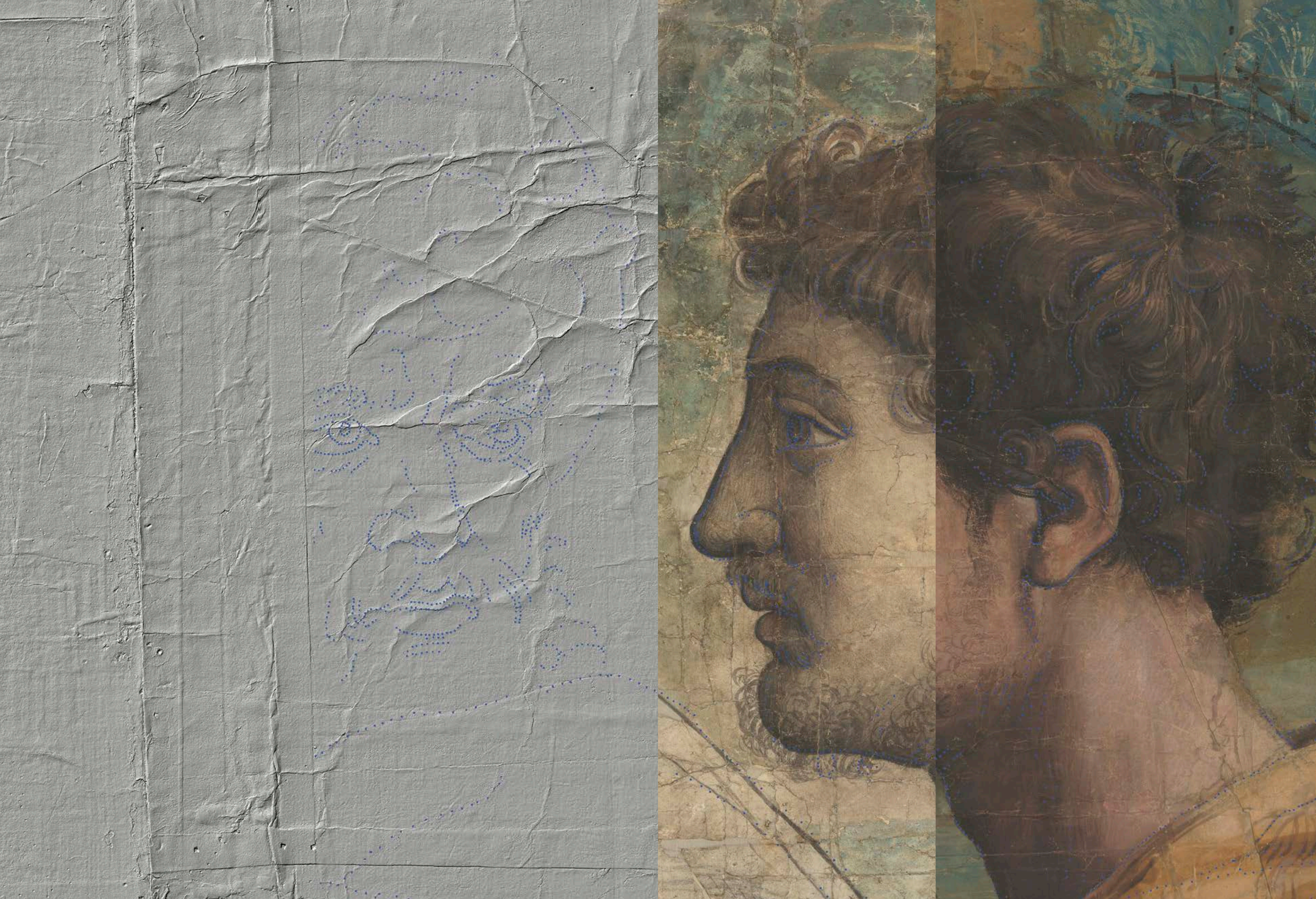
Fragments of a Raphael cartoon

After recording the original cartoons in the V&A in 2019, and the tapestry depicting the *Sacrifice at Lystra* in Mantua in 2021, three cartoon fragments from the Musée Condé at the Château de Chantilly were digitised in 3D, colour and infrared in January 2022.

The three details from the cartoon *Christ's Charge to Peter* present interesting variations of the cartoon in London. A multi-layer browser was created to allow inspection of the different data that was obtained in the Musée Condé, Chantilly, aligned to the corresponding section of the cartoon that was recorded in the V&A Museum. The pouncing of the original cartoon fits perfectly with the fragment.

Surface recording (top) and colour and infrared recording (below). Overleaf: Detail of the surface of Raphael's *Christ's Charge to Peter* with the puncture marks in blue (left); detail of the colour with puncture marks (right).





The Raphael Cartoons; exact facsimiles

In 2020, the cartoon depicting *The Sacrifice at Lystra* was rematerialised as a facsimile for the exhibition 'Raffaello (1520-1483)' at the Scuderie del Quirinale in Rome, for which Factum Arte also rematerialised the tomb of Raphael.

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 Foundation has collaborated on many projects. CPP's revolutionary printing method involves building up relief in 8 µm 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 gesso mix. This 'skin', which forms the base surface of the final facsimile, is then fixed to a backing canvas in a process that is similar to re-lining a painting. In the case of *The Sacrifice at Lystra*, a CNC-milled polyurethane panel replicating the undulations of the original was used as support.

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 are exact. The final stage is varnishing and hand-finishing. In the exhibition in Rome, the facsimile was on display at eye level and without glass. The experience of seeing the tapestry and the cartoon side by side opens many new avenues for study.

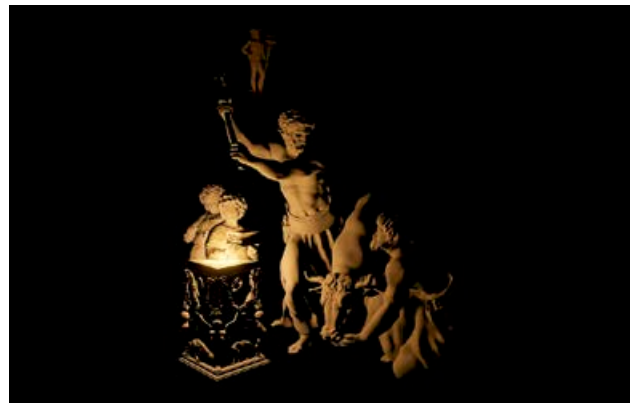
In 2022, Factum Foundation made the facsimile of a second cartoon, *Paul Preaching at Athens*, for 'The Credit Suisse Exhibition: Raphael' (9 April – 31 July 2022) at the National Gallery in London.

In 2023, the two facsimiles of the cartoons were loaned to the Palladio Museum in Vicenza, Italy, for the exhibition 'Raffaello. Nato architetto' (6 April – 9 July 2023). Curated by Guido Beltramini, Howard Burns, and Arnold Nesselrath, the exhibition emphasised the role played by architecture in the work of the Renaissance master.

The facsimile of *Paul Preaching at Athens* at the exhibition 'Raphael (1520-1483)' at the Scuderie del Quirinale.

Opposite: The facsimiles on display at the National Gallery in London.





Stills from the animation produced by Jordi García Pons, Jorge Cano and Óscar Parasiego.

3D projection mapping the cartoons

The data from the recording of the Raphael Cartoons can also be used for projection mapping where a 3D animation will reveal the complexity of the composition, its narrative, its content and its significance.

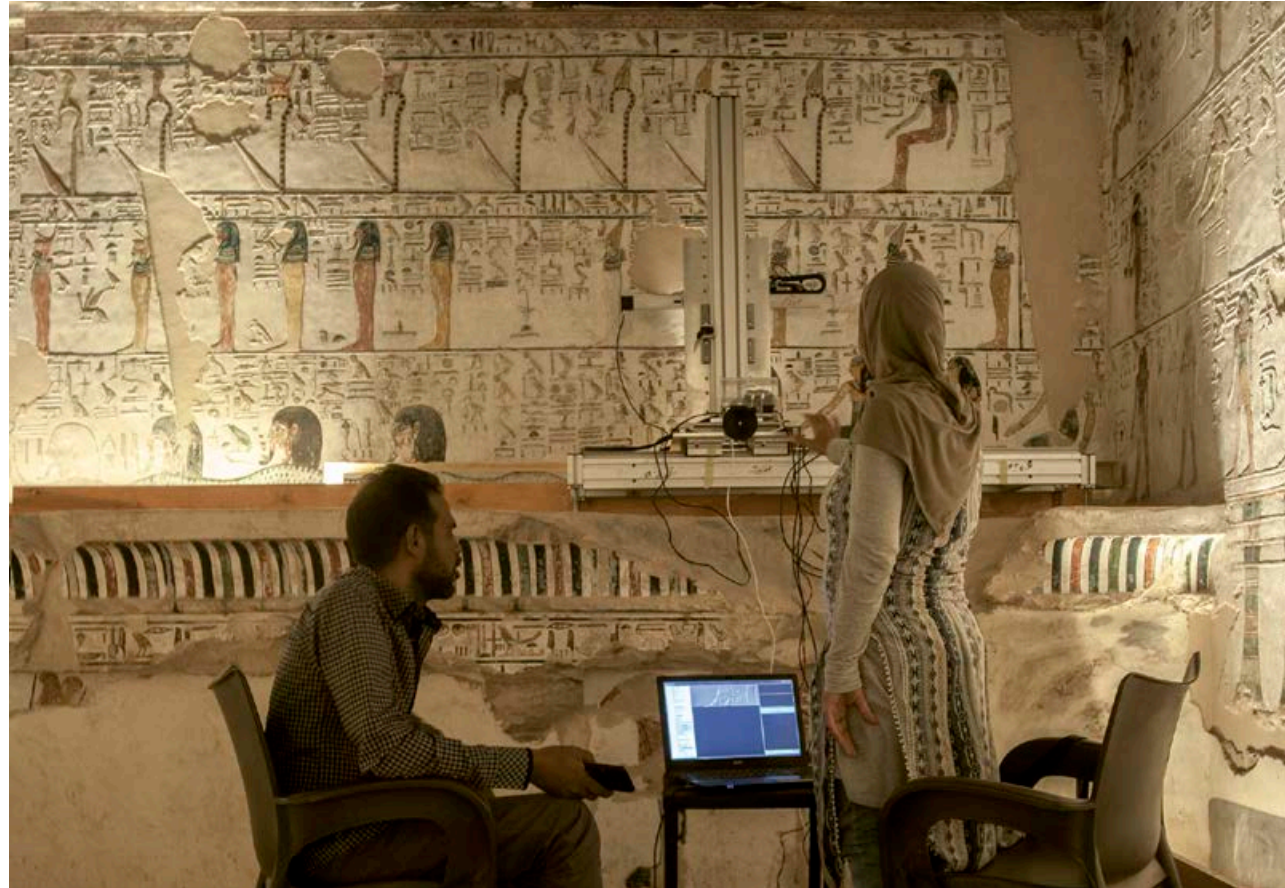
This is a new form of presentation that can be both spectacular and revealing opening up new possibilities for both in education, and as a new source for generating revenue for museums.

For a period of six months Irene Gaumé, Factum's lead 3D modeller, worked to transform the perspectival composition of the *Sacrifice at Lystra* into logically coherent virtual model.

This process requires thousands of decisions and assumptions, each leading to a deeper understanding of the decisions made by Raphael and his team.

Renders from the 3D modelling by Irene Gaumé.





The Theban Necropolis Preservation Initiative (TNPI) in Egypt

In 2001, Factum Arte started working in the Valley of the Kings on a pilot recording project in the Tomb of Seti I with the intention of recording the whole tomb and ultimately making a facsimile of the whole structure. It was a time of great developments in digital recording and facsimile production: 2001 was the year in which the reconstruction of the cave of Altamira opened, and the copies of the Lascaux cave produced since 1983 had proved that facsimiles can become major visitor attractions if people understand the conservation issues involved in visiting originals. In 1988, the Society of Friends of the Royal Tombs of Egypt suggested that a facsimile of the tomb of Seti I would be the best way of ensuring the tomb's survival and accessibility.

For the 2001 recording project, 16 square metres of the tomb's surface were recorded at a resolution of 100 µm, which even today is rarely matched by digital recording specialists – the 3D recording in the tomb of Seti I is 2,500 times higher resolution than the recording from which the Altamira facsimile was made. The first Seti facsimile was followed in 2002 by a replica of the tomb of Thutmosis III, the centerpiece of a touring exhibition, *The Quest for Immortality: Treasures of Ancient Egypt* (National Gallery of Art, Washington 2002 and on tour until 2007).

In 2009, the not-for-profit Factum Foundation was formed to take over Factum Arte's cultural heritage work, with the immediate aim of recording the tomb of Tutankhamun. Subsequently, Factum Foundation created The Theban Necropolis Preservation Initiative (TNPI), as a collaboration with egyptologists Erik Hornung and Susanne Bickel at the University of Basel, and Theodor Abt from the Society of Friends of the Royal Tombs in Egypt. TNPI recorded the tomb and made the data public, allowing scholars and conservators to monitor its condition.

In 2012 Factum Foundation gave a physical facsimile of the burial chamber of Tutankhamun to the people of Egypt. Since 2014, the facsimile has been installed in an underground building next to Carter's House at the entrance to the Valley of the Kings. The facsimile of the burial chamber is presented exactly as it is in the original tomb; the antechamber and annexe, while they retain the same proportions and materials as the original, are designed as an exhibition space. This permanent exhibition explains the degradation of the tomb since its discovery and the impact of mass tourism. It also contains a recreation of the

missing section of the South Wall of the burial chamber, which disappeared after the tomb's discovery in 1922.

In 2016, the TNPI embarked on the complete recording of the tomb of Seti I and the first local Egyptian operators were trained. In parallel with the scanning in Luxor, painted wall fragments and other objects removed from the tomb were recorded at museums and in private collections around the world. When it is finally finished, the facsimile will be even more complete than the original as it now stands, integrating within the reproduction many of the fragments removed from the tomb in the 19th-century. The fragments will be shown in their current condition, focusing attention on the dynamic nature of originality: over the course of two centuries, different fragments have aged, and been restored, in very different ways. The aim is that the facsimile will also incorporate all the painted fragments discovered in recent excavations by the University of Basel.

In October 2017 the first facsimiles were exhibited as part of the exhibition *Scanning Seti: The Regeneration of a Pharaonic Tomb* at the Antikenmuseum in Basel, marking the bicentenary of the discovery of the tomb. The full-scale exhibition included facsimiles of Rooms I and J, and a facsimile of Seti's sarcophagus, the original of which is housed in Sir John Soane's Museum, London.

Also in 2017, the restoration of Hassan Fathy's Stoppelaëre House – a major work of Egyptian mid-20th-century vernacular modernism – was completed. This provided a base for the TNPI in Luxor, and a new 3D Scanning, Training and Archiving Centre was established there for the training of Egyptian digital cultural heritage specialists. The restoration was funded by Factum Foundation in exchange for use of the house for 10 years.

Following the restoration, the Theban Necropolis Preservation Initiative team moved into Stoppelaëre House and recording work restarted in the Sarcophagus Room within the Tomb of Seti. A training program began at the Centre, which by 2022 had trained ten local people in a range of recording technologies, providing them with skills which can be transferred to other projects within the Valley of the Kings and beyond.

Opposite: Abdo Ghaba and Amany Hassan scanning above the niche in Chamber Jb, tomb of Seti I (top). The Egyptian team from TNPI, back to work in the tomb of Seti I after more than 100 days of interruption due to the Covid pandemic. Setting up the Lucida 3D Scanner on the scaffolding in the tomb of Seti I (bottom).



In 2019, the Initiative received the official patronage of the Egyptian National Commission for UNESCO. From 2019 to the completion of the scanning of the entire tomb in early 2022, Factum's team continued to work in the tomb of Seti I, in addition, parts of the tomb which historically had been removed from the structure itself, were also recorded. The new centre was equipped with scanning, data processing and archiving equipment.

By the end of 2022, the complete tomb of Seti I had been recorded with high-resolution colour photography and 3D using both close-range laser scanning, photogrammetry and LiDAR scanners. Since this time, the TNPI team has focused on data processing while we await permission to record other tombs.

Work to make a high-resolution virtual experience from this data is ongoing alongside the preparation of an exhibition for the Grand Egyptian Museum (GEM) based on the reconstruction of the Hall of Beauties and facsimiles of fragments removed from the tomb in the early 19th-century.

In late September 2023, the Supreme Council of Antiquities reclaimed possession of Hassan Fathy's Stoppelaëre House, which Factum Foundation restored in 2017 with Tarek Waly. Before this restoration, the building was unused and in poor condition, sliding off a scarp slope, breaking apart and disintegrating. Now it is the best-preserved building by Hassan Fathy on the West Bank in Luxor. It has been the headquarters of the Theban Necropolis Preservation Initiative, and it has served as the 3D Scanning, Archiving and Training Centre since it was opened in 2017 by the former Director-General of UNESCO, Irina Bokova, and the former Minister of Tourism and Antiquities, Khaled El-Enany.

The building is now in good condition and Factum Foundation was very happy to have been able to work with Egyptian architect and close friend of Hassan Fathy, Tarek Waly, to ensure the building survives for other uses.

VIRTUAL TUTANKHAMUN

In an initiative that blends innovative technology with the communication of Egypt's rich cultural heritage, Factum Foundation and the Supreme Council of Antiquities are working on the launch of *Virtual Tutankhamun*. This educational initiative has been made possible with the support of the U.S. Embassy in Cairo.

This state-of-the-art Virtual Reality (VR) experience is designed to ignite the imaginations of Egypt's youth and foster a deep appreciation for their country's historical legacy.

Virtual Tutankhamun draws on the virtual data recorded by Factum Foundation for the Ministry of Tourism and Antiquities in Egypt in 2009. The resolution of this data offers a remarkable opportunity to explore the famous tomb of Tutankhamun. The goal is to inspire the children of Egypt as part of a new approach to sharing, learning, and engaging with cultural heritage.

The experience transports users to a virtual environment that replicates the accurate colour and surface detail of Tutankhamun's Burial Chamber. It provides a level of detail and immersion impossible to achieve in the original tomb where you cannot enter the burial chamber. In *Virtual Tutankhamun*, the walls can be seen at close range in ways that can assist in academic study and stimulate general interest.

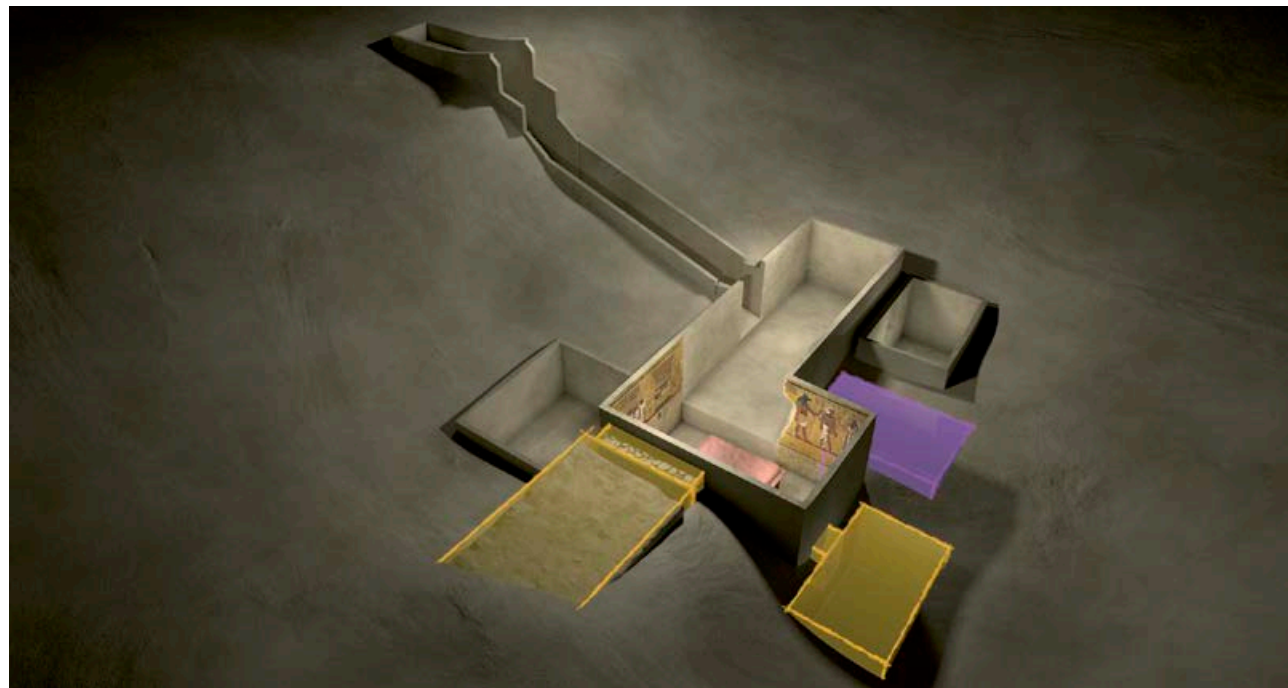
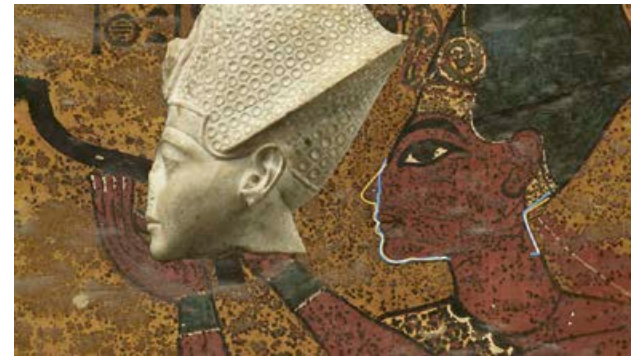
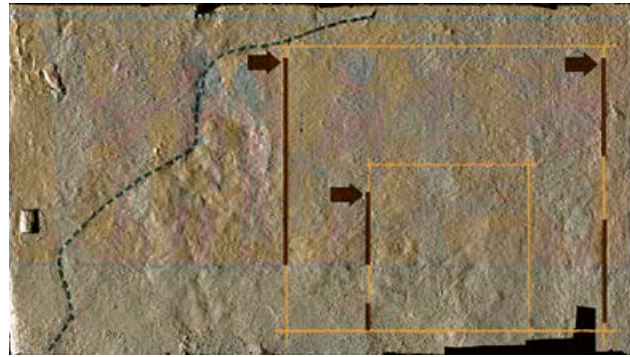
Photographs by Harry Burton and historical records from the Griffiths Institute in Oxford are merged to enrich the visitor experience and recreate the excitement that was felt by Howard Carter and other archaeologists.

A dedicated two-member team, supported by inspectors from the Supreme Council of Antiquities will deliver the experience to students at STEM schools.

One hundred years after the discovery of Tutankhamun's tomb by Howard Carter and his team, *Virtual Tutankhamun* represents a milestone in the ongoing efforts to preserve and safeguard Egypt's cultural heritage. It demonstrates that the sustainable preservation of this heritage is not only possible, but that it puts the experience of it within reach of a much wider audience.

A second facsimile of the tomb of Tutankhamun is being made in Factum's workshops in Madrid. This was commissioned by the Minister for Tourism and Culture Khaled El-Enany and the head of the Supreme Council of Egypt, Mustafa Wasiri. It has been financed by Google Arts and Culture and will be gifted to Egypt when a location has been finalised.

The 3D model of the Burial Chamber of Tutankhamun developed in Unreal Engine by Irene Gaumé and adapted for the virtual reality experience.



Tutankhamun: technical innovation, new data, and unexpected discoveries

Text by Nicholas Reeves

Egyptologist and author of 'The Complete Tutankhamun'

Archaeologists have been seeking to record, and figuratively preserve, the decorated surfaces of Egypt's tombs and temples for centuries, the techniques employed meeting with varying degrees of success. In the case of relief sculpture and inscriptions, an early solution was to prepare paper squeezes, a process which, though quick and easy to do and producing accurate physical impressions, nevertheless caused damage and would soon be abandoned. A safer approach was to draw or trace, methods which are nonetheless slow and with their scientific value wholly dependent on the copyist's skill. And then, of course, there is photography—quick, safe and the best of the lot but which, with poor lighting, may still obfuscate and even lie. While the traditional 'Chicago House technique' has been happily combining the two for years, tracing and photography, nevertheless that particular process is massively labour-intensive, with the recording of a complete monument sometimes extending over several decades.

Although perfection was far from being achieved, Egyptology would muddle along well enough with various combinations of pencil and camera until 2014, which was when Factum Arte unveiled its facsimile of Tutankhamun's decorated Burial Chamber. Overnight, everything that had gone before was rendered obsolete, with completely new horizons opened up in the process. With the pass of a digital scanner and carefully developed workflow, Factum had been able to capture, and combine, in highest resolution, not merely the *imagery* of a decorated wall but also something quite new: however shallow, the *physical, relief detail*, of not only the artistic process itself but also the underlying surface on which the design had been executed. What is more, made freely available online, this twin resource could be accessed from anywhere in the world, with the two strands of data, visual and surficial, viewed separately or in combination as required, and enlarged, reduced or otherwise manipulated at will.

Factum had developed nothing less than a method to record, preserve and—as their Tutankhamun replica demonstrates—*physically recreate*, with total accuracy, and it was a technique applicable to any monument in the world. But far more even than that: with this technology came the ability to *interrogate*,

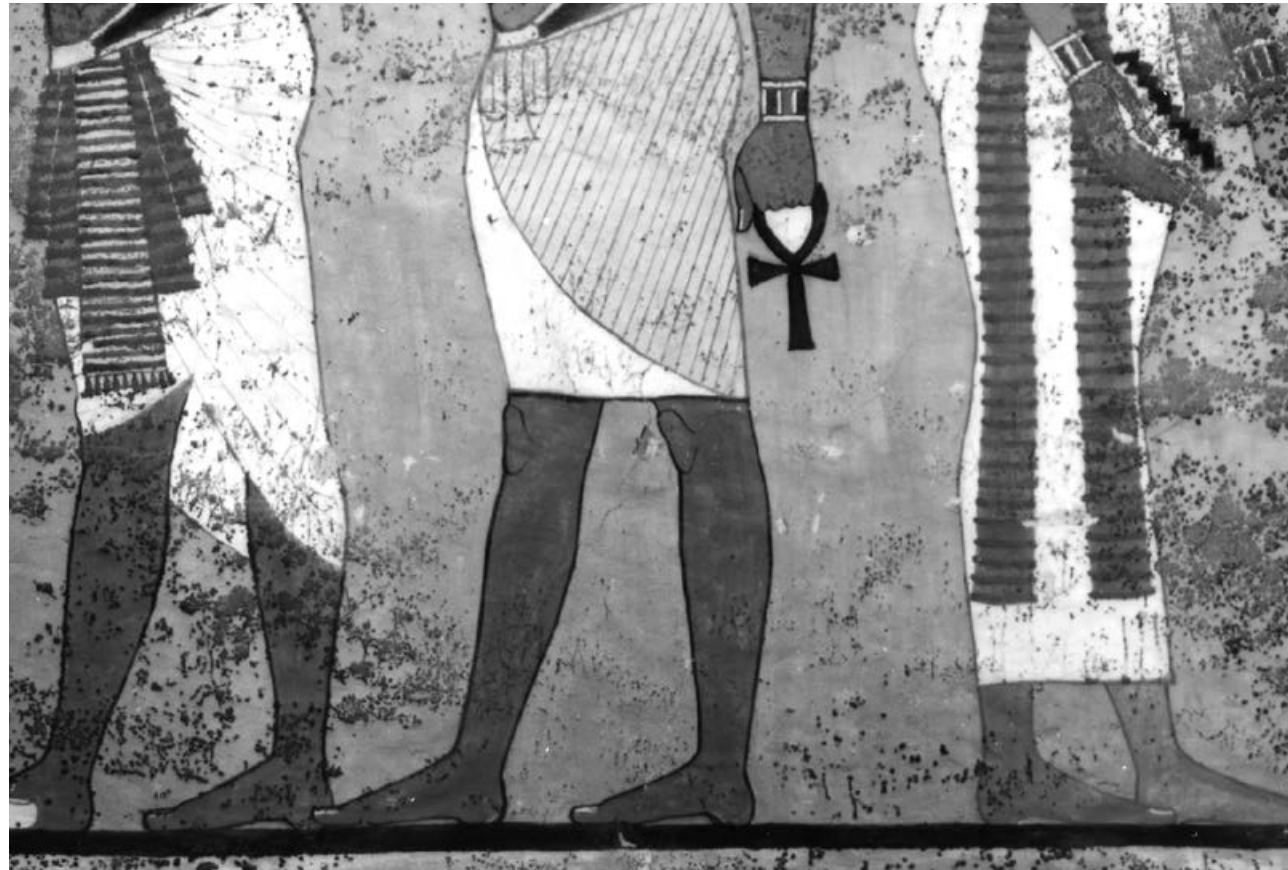
and with greater efficiency than if one were standing in front of the original wall. In the case of Tutankhamun's tomb, KV 62, Factum's data-capture marked a whole new beginning.

Today, almost a decade since that first publication of the Factum scans and a long century and more beyond Howard Carter's 1922 initial find, what Egyptologists are able to see in KV 62, and to explain, has changed profoundly. Thanks to this new and unexpected Factum data, our eyes have been opened to an extraordinary possibility: that the small, self-contained king's tomb we see today is nothing of the sort—

Opposite: Top left: Factum surface scans of the Burial Chamber's north wall reveal not only a large structural fault on the left, but also linear traces of a potential blocked doorway on the right. In other words, the tomb appears to continue, and in precisely the manner one would expect—with a smaller doorway set within a large, corridor-sealing partition. Evidence of similar, smaller doorways may be discerned beneath the decoration of the west and south walls also, where they seem to identify one or more additional Tutankhamun-era storerooms. Top right: What further evidence might be mustered for a continuation of KV 62? Close study of the painted north wall highlights the chubby, child-like face of the figure labeled as Ay, Tutankhamun's successor. The profile is uncannily similar to that of the young Tutankhamun himself; in fact the outlines tally precisely. At the same time, the facial features of the mummy facing this figure, now labeled as Tutankhamun, bear no resemblance to the boy but match instead the standardized imagery employed for Akhenaten's widow, Nefertiti.

Centre: Intriguingly, Carter himself had suspected as much—that the tomb might continue to the north. This we learn from Factum's documentation of the north wall decoration, which reveals a large patch of previously unnoticed restoration—evidence of a surreptitious investigation made around 1932 to check for a further blocked doorway. In the event, Carter found nothing: having failed to recognize the reversed, *queenly* plan of KV 62, he had quarried into the wrong (i.e. left-hand) side of the wall. Carter's subsequent restoration of the destroyed decoration was careless: it shows an incorrect number of stripes on the kilt, differences in the shapes of the knees, and painted spots of camouflaging mould where mould had not previously been present—disparities established by comparison with an earlier photograph of the same wall taken in advance of Carter's 1932 exploration.

Bottom: And finally: such an original decoration would have had no place in the burial of Tutankhamun himself—which is why the scene was then adapted. What the north wall decoration clearly signals is that it had enjoyed an earlier, pre-Burial Chamber role: as the outer blocking of a corridor giving access to Nefertiti-Smenkhkare's own, still hidden burial apartments beyond.



that it likely represents, in fact, merely the restricted *outer part* of a much larger whole. What is more, thanks again to the Factum documentation, we see that Carter himself had sensed the same, secretly investigating (albeit in the wrong place) before surreptitiously covering his tracks.

And not only do we perceive a significantly larger tomb: traces in the Burial Chamber's north wall decoration reveal



its precise nature. By its plan, KV 62 had demonstrably been begun for a queen; and subsequently the tomb been adapted, architecturally and decoratively, to accommodate a *queen become king*—none other than Akhenaten's widow, Nefertiti; a woman ultimately raised to the dizzying heights of pharaoh in her own right, Smenkhkare. Beyond the tomb we see now, there is evidently more to come.

*

The images that accompany this text summarise the full and unexpected story of KV 62 as this is beginning to reveal itself: of this potentially larger tomb's nature and ownership, and of Tutankhamun's relationship to it—as metaphorical cuckoo in the nest of his powerful female predecessor.

Close inspection of the two cartouches which today identify the leopard-skin-wearing Ay confirm this impression of reattributed figures: the names of Tutankhamun's successor are overwritten, with the original, underlying prenomen and nomen being those of Tutankhamun himself: 'Nebkheperure' and 'Tutankamun-ruler of Upper Egyptian Heliopolis'. Demonstrably, the north wall scene of KV 62 had originally been created to commemorate not the burial of Tutankhamun by Ay, but Tutankhamun's burial of his own predecessor. Opposite: Harry Burton's picture from 1935 (top). Colour and 3D data (bottom).

ARCE: The Mausoleum of Ikhwat Yusuf monument

The Mausoleum of Ikhwat Yusuf is a Fatimid monument with later Ottoman additions located in Cairo's Southern Cemetery at the foot of the Mokattam outcrop. The mausoleum is one of very few surviving Fatimid period (AD 969-1171) monuments in Egypt, and contains an elaborately carved stucco mihrab (prayer niche), a brick dome, stone arches, vaults, and secondary domes.

In 2022, ARCE, the American Research Center in Egypt, began a conservation and restoration project at the monument that will include a digital restoration, in collaboration with Factum Foundation, followed by the conservation of the mihrab.

Factum Foundation recorded the mausoleum's stucco mihrab in high-resolution using photogrammetry, and provided hands-on photogrammetry training at the site for inspectors from the Ministry of Tourism and Antiquities, as part of a field training program coordinated by ARCE.

Render of the carved stucco mihrab with a detail of the surface scanned using photogrammetry.



The Middle East Falconry Archive (MEFA)

Falconry, the practice of training birds of prey as hunting partners, has deep roots across the world. The tradition has produced a rich assortment of texts and images which reflect the relationship between falconers and their birds. The Middle East Falconry Archive (MEFA) seeks to study this rich tradition in the MENA region and share it with global audiences. It focuses on the identification, exploration and digitisation of Arabic texts relating to all aspects of falconry. By working in close collaboration with the libraries responsible for these manuscripts, MEFA hopes to digitise or collect digital copies of the original texts and unite them in a single, online platform, dedicated to the heritage and history of Arabic falconry literature.

A NEW DIGITAL LIBRARY

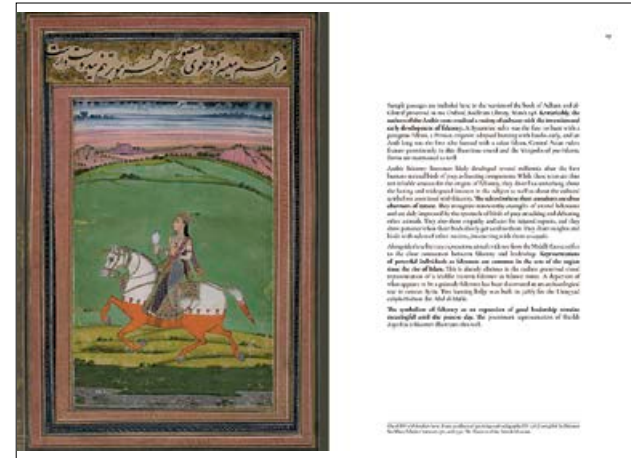
The digital records of each manuscript are supported by bibliographical and historical information. The online archive is managed using a ContentDM / OCLC platform, and since 2022 it is also configured to comply with the IIF (International Image Interoperability Framework) protocol. The Mirador IIF viewer offers book, gallery and scroll view, allowing users to zoom and pan, and compare images from one or more manuscripts, from any digital library with an IIF manifest.

In June 2020, the Mohammed Bin Zayed Raptor Conservation Fund (MBZRCF) appointed Factum Foundation to digitise medieval, early modern and modern Arabic falconry manuscripts. The manuscripts are located in libraries across Europe, the Middle East, North Africa, North America and South Asia. Recording and archiving experts from the Factum Foundation are based between Madrid (Factum's headquarters) and ARCHiVe (Analysis and Recording of Cultural Heritage in Venice), of which Factum Foundation is a founding partner, on the Island of San Giorgio Maggiore, Venice.

MEFA has been designed to be an ongoing research and archiving project, with digital manuscripts added as they become available. By June 2023, the objective is to have published digital records of the 56 Arabic manuscripts identified to date by the scholar working on the initiative. More than half of these are already available on the platform. The manuscripts contain texts on falconry written between the 8th and 16th-centuries in the Middle East. Concerned with the training and care of birds of prey, they cover falconry literature from poetry to technical treatises.

Some of the famous texts, such as the book of Adham and al-Ghitrif (one of the earliest Arabic texts on falconry) exist in multiple copies, while others only survive as a single exemplar.

Pages from the MEFA's project booklet.



A GROUND-BREAKING DISCOVERY

Some books, despite being reportedly influential in the field, appear to have been lost. For several decades, for example, scholars have been looking for the Arabic original of a book written for al-Mutawakkil, the Abbasid caliph who reigned from 847 to 861 in Iraq. This handbook about falconry and hunting circulated in the multi-lingual Mediterranean world of the 13th-century. Kings Frederick II and Alfonso X of Castile both had translated versions of the Arabic text, and a Latin adaptation was also widely disseminated. Through her research and collaboration with MEFA, Dr Anna Akasoy (Graduate Center of the City University of New York) discovered a manuscript which contains a near-complete version of the Arabic text.

The manuscript is part of the collection of the University of Lund Library in Sweden. The Swedish diplomat and linguist Johan Gabriel Sparwenfeld (1655-1727) acquired this manuscript in September 1691 in Tunis. Until now, the most significant known Arabic traces of al-Mutawakkil's book had been extensive quotations in a compilation of excerpts from several sources. This *Book on the Hunt* had been put together for the Hafsid ruler al-Mustansir (ca. 1227-1277) who ruled from Tunis. It may very well have been from here that Frederick II and Alfonso X obtained the Arabic originals for their translations.

Dr Anna Akasoy says, about the discovery:

'So far, no manuscripts have been identified which would allow us to document the presence of al-Mutawakkil's falconry book in the Middle East independent of quotations in *The Book of the Hunt* and an entry in a library catalogue from 13th-century Damascus. One may speculate that the near-simultaneous presence of the manual in several places around the Mediterranean was not a coincidence, but rather reflected the common exchanges of gifts among rulers of different cultures and faiths. The discovery of the Lund manuscript allows us to understand the process of translation from Arabic into Latin and medieval Spanish much better.'

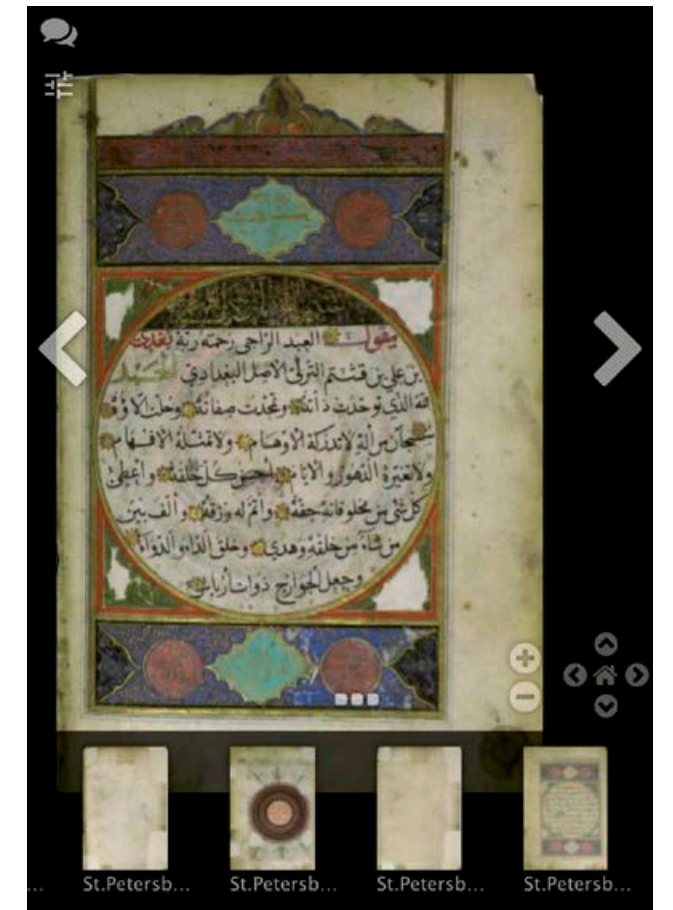
A digital version of the manuscript was added to the MEFA digital archive in December 2022. This near-complete copy will be fundamental to documenting and analysing the history and transmission of this important falconry manual across the different languages and cultures of the medieval world.

THE NEXT PHASE OF THE MEFA DIGITAL ARCHIVE

Considering the potential of the new online archive, Factum Foundation was asked in 2023 to expand the MEFA digital archive into a larger archive, dedicated to communicating the importance of Arabic falconry not only through literature, but also imagery and artefacts. The new scope of the archive consists in gathering material on falconry as both cultural heritage and living practice, for example, sculptures and other objects that witness the practice of falconry, or the symbolic importance of falcons in various parts of the world, as early as in the first millennium BCE. Research will also draw parallels between Arabic texts and European, Urdu and Persian texts on falconry.

Screenshot of the MEFA online platform.

Overleaf: The discovered manuscript. Österländsk litteratur, Tornberg XXI.



بسم الله الرحمن الرحيم

بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ صَلَّى اللَّهُ عَلَى سَيِّدِنَا وَمَوْلَانَا مُحَمَّدٍ

المقالة الأولى من الكتاب للتوفيق في الجوارح وخواص الآيات الطبيعية والعرضية

مراكيب الله محمد بن عبد الله بن محمد بن علي بن الحسين بن علي بن أبي طالب بن عبد المطلب بن هاشم بن عبد مناف بن قصي بن كلاب بن مرة بن كعب بن لؤي بن غالب بن فهر بن مالك بن النضر بن كنانة بن خزيمة بن مدركة بن إلياس بن مضر بن نضر بن معد بن عدنان بن كنانة بن خزيمة بن مدركة بن إلياس بن مضر بن نضر بن معد بن عدنان
في الجوارح وخواص الآيات الطبيعية والعرضية وهو مختصر
مقالات وستذكر عن كل مسألة عدة فصولها فأما
التي هي الأولى من عدة فصول المقالة الأولى وهي أربعة عشر فصلاً
الفصل الأول من الأركان والركن من الشريعة
الفصل الثاني من الأركان وهو تحرير الجوارح المستعصية بها
الفصل الثالث من الأركان وهو ذكر الآيات

تتناول فيها الجوارح وقصائد وتفويض
الفصل الرابع من الأركان وهو دراسة الجوارح المستعصية على
قراحتها على حسب ما ذهب إليه أهل النجوم والتواقيت
الفصل الخامس من الأركان وهو توجيه الكعبة من القرائن على

والعرض على حله وعمارة لها ليلة والشمس على قدرها
الرؤوس السبعة بالعرض والشمس الواضح وسمت الكتاب
والتهذيب ومن أي ذكر آخر هو وتفسير مقالته **فأما**
العرض بغيره كهيئة أمور الجوارح الطبيعية والعرضية وسياسة
والتهذيبها **وأما** الطبيعة فنيل العرض الذي هو القدر **وأما**
من الكتاب فلهذا نرى في غير القرآن البارز **وأما** سمته بالكتاب الموكب
في الجوارح وكيف جاز الآيات الطبيعية والعرضية **وأما** التهذيب
فإن نرى في كل كتاب في بيته **وأما** من أي ذكر آخر هو من آخر العلم
والتي هي من آخر الأعمال يحتاج إليها السياسة وغيرها المستعصية
في الأوقات الواجبة **وأما** لكم مقالته يفسر بأنه يتفهم
لخصر مقالته **أما** المقالة الأولى فيها أربعة عشر فصلاً وهي
العلمة الطبيعية المستعصية من الأوقات المتأخر من الجوارح وخواص الآيات الطبيعية
والعرضية وكيفية سياستها والتهذيبها والأوقات الواجبة
فيها **وأما** المقالة الثانية فيها اثنا عشر فصلاً وهي
علمة الباطنية وأسمائها **وأما** المقالة الثالثة فيها أربعة عشر فصلاً
فصلاً وهي خواص الآيات الطبيعية والعرضية وهي ما استفاد الخاهرة
وأسمائها **وأما** المقالة الرابعة فيها ستة فصول وهي خواص



The Digitisation of Cultural Heritage in Hegra, Dadan, Jabal Ikamah and Abu Ud For the Royal Commission for AlUla (RCU)

From September 2020 until February 2022, Factum Foundation worked with the Royal Commission of AlUla to carry out a 3D recording of the sites of Hegra (UNESCO World Heritage Site since 2008), Dadan, Jabal Ikamah and Abu Ud in and around the town of AlUla, Saudi Arabia.

This information will be critical for the preservation of this extraordinary site as it becomes the focus of the country's drive to attract cultural tourism. High-resolution recording will not only help attract visitors, but it will be essential to record a site that has been overlooked for many years. Condition monitoring and conservation mapping will provide a detailed framework for the archaeologists working on the site.

METHODOLOGY

Each area was recorded with photogrammetry from the ground and air, in addition to LiDAR laser scanning. Factum's LiDAR technology recorded the basic geometry of the site, and also enabled the scaling of the photogrammetry data recorded. To ensure that the most detailed and comprehensive model could be generated, supplementary aerial photogrammetry was used to scan the areas the LiDAR couldn't reach. Finally, photogrammetry gathered from the ground was used primarily to fill in any remaining gaps. This mixture of technologies and layered approach enabled sophisticated high-resolution 3D models to be calculated. Complementary data was recorded in the form of GPS coordinates in both the LiDAR and aerial photogrammetry.

When combined, these three datasets would provide a highly detailed 3D model capable of use as a tool to monitor and predict the condition of the various sites over time. The recording side of the project involved six one-month trips with a rotating team of six people. Each trip had a team of two, conducting the recording. Season five was an exception, which had a team of three.

THE RECORDING

The recording was divided into six seasons, which began in Hegra with LiDAR scanning and the marking out of GPS points in each area. The first season sought to establish file organisation and recording protocols. Having never visited the site prior to the recording, this information would

guide the remaining seasons. As Factum had never been to the site prior to recording, it was essential to establish protocols early on in the project, to avoid confusion at the processing stage. Areas were named and numbered according to the conventions of the site map created by Rut Ballesteros (Royal Commission For AlUla (RCU)).

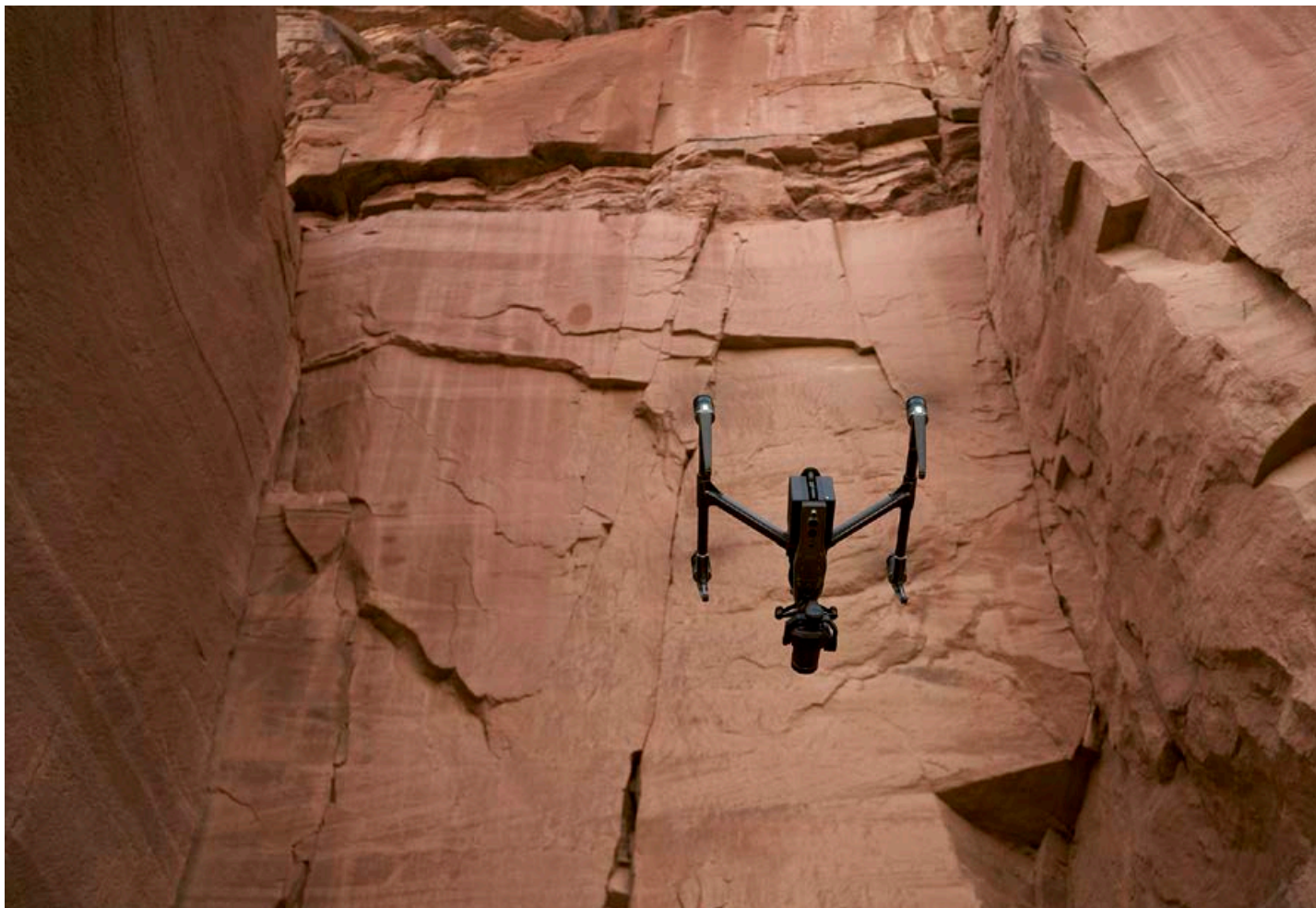
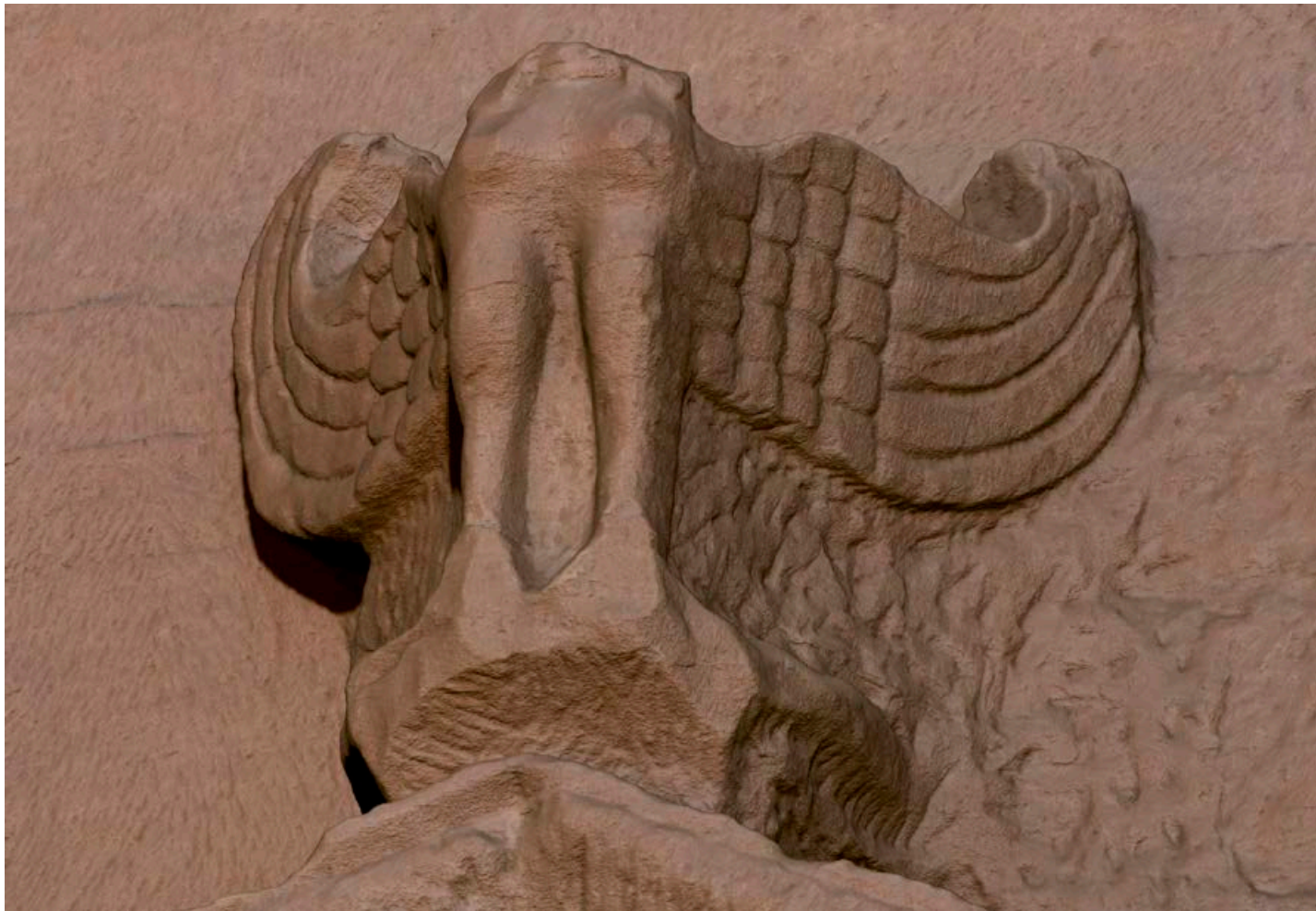
Ground recording was carried out during the remaining first five seasons, comprising the bulk of the work, and the aerial photogrammetry was conducted across all sites during the last phases.

The aerial recording was left to the final two trips. This delay was due to the difficulty in obtaining the requisite permissions to use the equipment in Saudi Arabia. Concerns over terrorism and surveillance have led to a lot of local restrictions around the use of drones in the Kingdom.

Throughout the recording time, the team was continually kept abreast of newly discovered features at the site, and made efforts to ensure that these were included in the data. On average, 3000+ images were used to record each area and roughly 2000+ images for each individual tomb.

While Hegra was predominantly composed of tombs, the sites of Jabal Ikamah and Abu Ud were all epigraphic. Dadan was mainly epigraphic with some carved niches which made up the small number of tombs. The unique nature of each site demanded different approaches. For instance, at Hegra, many more images were required to accurately record the comparatively more complex geometry of the tombs' interior and exterior. With the other sites, the geometric recording was limited to the site as a whole, with focused photogrammetry to cover the high-resolution texture of the inscriptions. These differences were not confined to the land. As Factum took to the air, the recording had to adapt to the specific needs of each site to capture the data as comprehensively as possible. At Hegra, the drone was used to fill in information on the geometry of the tombs, whereas in the epigraphic areas, the drone was used for high-resolution recording of inscriptions that were out of the reach of the scanning team on the ground.

Opposite: Three images from an experimental high-resolution VR environment being tested for the RCU.



PROCESSING

Processing was carried out throughout this project. Keeping a close eye on the data as it was gathered meant that any gaps or insufficiencies in the recording could be identified and rectified. The processing phase began with the extraction of a point-cloud from the LiDAR scanner data. This formed a base to which both the aerial and ground-level photogrammetry data was added. Each area was processed in its entirety as a general model using only photogrammetry, to ensure that the colour was correct and that the amount of input data did not exceed the existing hardware's ability to process. More detailed renderings of each individual tomb were then processed one by one, by adding the detailed capture into the general model. At Jabal Ikmah, Dadan and Abu Ud, the process was largely the same, without the necessity of processing individual tombs. In Jabal Ikmah and Abu Ud, we were able to process these areas in their entirety all at once due to their smaller size.

The final outputs were all exported with in-depth reports on the model's quality and accuracy.

OUTPUT

The data was output in OBJ and Orthographic TIFF formats. The files were also exported in XYZ point-cloud format, useful for geometric analysis of areas. The OBJ files have all been optimised for visualisation purposes. The 3D models were vast, up to 13 billion polygons in size (for reference, a standard video game environment is considered to be almost too big if it is 1 million polygons). This large size allows for highly-detailed 3D models of the most minutely detailed aspects of each site, such as a high-resolution rendering of the inscriptions in some of the tombs. This level of detail makes the data considerably more future-proof. For instance, should the RCU require a report on a particular detail of a specific part of a tomb, Factum can comb through the data to extract an exact and accurate profile of the detail in question. All the delivered models were optimised to 10 million polygons, a format that can be visualised easily. Factum Foundation is now working with the Royal Commission of AlUla to develop creative ways for the recording of the site to be engaged with by the wider public.

3D model of Jabal AlBanat (Area 3).

Opposite: Zoom in of an enlarged detail from the door of Area 2: Lihyan bin Kuza, also known as AlFarid (top). Aerial recording (bottom).



2. CULTURAL HERITAGE AT RISK

‘In the spirit of the ongoing repatriation of cultural artefacts to Nigeria, especially the Benin Bronzes, the restitution of this ancestral carved stone by the Chrysler Museum is a welcome and laudable development. This action, as well as the roles played by Factum Foundation and the Carène Foundation, will contribute immensely to support conservation and protection of cultural heritage with the participation of host communities.’

*Professor Abba Tijani,
Director General of the National Commission for Museums and Monuments, Nigeria*



Cultural Heritage at risk – Innovative approaches

Over the last few decades, cultural heritage has been increasingly promoted to attract tourism. Yet associating culture with leisure neglects its significant potential as a transformational instrument that can not only create local economies, but heal the emotional and physical damage resulting from violence and conflict.

Digital recording 'post facto' – after the damage is done – will not allow 3D reconstructions or re-materialisations of the lost objects. It is increasingly urgent to act in times of peace; and to show that there is both the capacity and willingness. In unstable political situations, there are more and more examples of premeditated, orchestrated destruction or mindless vandalism. Technology is a powerful force to help face fundamentalist or commercially motivated destruction of cultural heritage.

Wars or iconoclastic attacks are not the only causes of degradation or destruction. In 2019, the world was transfixed by the mortifying images of Notre Dame de Paris burning. Words fail to capture the devastation of watching a monument of such beauty and power, one which has stood for hundreds of years and survived two World Wars, burn. Notre Dame was immortalised by Victor Hugo in *The Hunchback of Notre Dame*, as a space of literal and symbolic refuge, its architectural facade legible as a written language before the arrival of the printing press, a language that spoke to generations. Through literary narrative, Hugo made the architecture itself resonate with emotion, and he dedicated an entire chapter to the building's immense importance as a voice that linked past and present.

After 'wrinkles' and 'scars', Hugo writes of the 'furrows and blotches' left by time, the 'brutalities, bruises and fractures' caused by revolution, and the 'mutilations, amputations, dislocation of members, and restorations', the result of well-intentioned meddling.

After the 2019 fire, while the embers were still burning, more than a billion euros were pledged to 'restore' the Cathedral. Had some of this money been available before

the tragedy, a complete recording of Notre Dame could have been made, preserving this astonishing monument in sub-millimetric detail. The National Museum of Brazil fire, one year before that of Notre Dame, is another example. It is estimated that around 90% or more of its archive and about 20 million items were destroyed in the fire. Those are stark numbers, and they should focus our thoughts.

All too often there is a lack of willingness to make funds available for preservation. Factum Foundation is working to change this, and to see the world's most precious cultural heritage recorded in times of peace, and before disaster strikes.

Transferring skills and technology, one of our core missions, places the emphasis on local responsibility and brings with it new skills and new types of employment. Digitising the materiality of tangible heritage and the ephemeral nature of intangible heritage is fundamental to preserving culture and enabling it to be shared in diverse ways, stimulating interest and building bridges between different groups and communities.

The training and 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.

Notre-Dame on fire, April 15, 2019. At relatively regular intervals, the fire intensifies, with sudden bursts of flames tripling in height and emitting yellow smoke.

The Bakor Monoliths: a new model for repatriation

Since the publication of the previous Factum Foundation book, the project to document and preserve the Bakor monoliths of south-eastern Nigeria has developed in a number of significant ways. In May 2022, an exhibition featuring the monoliths titled *Rock Arts of Nigeria* was held at the Nigerian National Museum in Lagos, before travelling to Calabar and Jos. Launched by Professor Abba Tijani, the Director General of the National Commission for Museums and Monuments (NCMM). The centrepieces were two facsimiles of monoliths: one which reunited the bottom half of a monolith still at a site called Ntitogo with its top half now in the Metropolitan Museum of Art; the other, a monolith now in the Musée du Quai Branly, which the community of Etinghi Nta claim was stolen from them in the 1970s. Following the conclusion of the exhibition in July 2022, these two monolith facsimiles were returned to their original communities. In June 2023, an authentic Bakor monolith from the village of Njemetop in the collection of the Chrysler Museum was repatriated to Nigeria at a ceremony at the Nigerian Embassy in Washington, at which Factum Foundation simultaneously presented a facsimile of the monolith to the Chrysler on behalf of NCMM.

Research into the trafficking and trade of the Bakor monoliths was transformed by the visit of Ferdinand

Saumarez Smith and Terry Little to Fouban in western Cameroon in 2022. In the process of researching other monoliths being sold as authentic Bakor monoliths on the international antiquities market, Narcisse Tchandeu, an art historian at the University of Yaoundé II, discovered five large monoliths verifiable from the Philip Allison survey conducted in the early 1960s and now in the collection of Njitari Allahamdou, a dealer in African arts based in Fouban. Allahamdou kindly agreed to be interviewed on his life as a dealer. His story is published in Factum Foundation's book *The Bakor Monoliths: Preserving Ancestral Stones in South-Eastern Nigeria* (2022). Tchandeu also introduced Factum's team to contemporary carvers producing a style of monoliths recognisable from examples held at the British Museum, the Israel Museum, and the New Orleans Museum of Art. The monolith in the British Museum was the centrepiece in an exhibition on the project, *The Bakor Monoliths: Endangered Heritage*, held at the museum in February-March 2023.

In September 2023, the Bakor monoliths were officially submitted to UNESCO for World Heritage Site status, a process generously supported by the Carène Foundation.

A libation is poured for the facsimile of Ebi Abu.
Opposite: Fire damaged monolith at Nlol.





Top: Juan Carlos Andrés Arias in Factum's workshop, making the facsimile of the Eting Nta monolith (recorded in the Musée du Quai Branly).

Bottom: Exhibition views of 'The Ancient Rock Arts of Nigeria' in the Nigerian National Museum in Lagos (left) and the National Museum in Calabar (right).



Collaborative work to preserve and re-think ownership was clearly demonstrated by the return of a Bakor monolith from the collection of the Chrysler Museum in Norfolk, Virginia. In February 2023, during the exhibition 'The Bakor Monoliths: Endangered Heritage' at the British Museum, Factum put out a call to all institutions with monoliths acquired since 1970, asking for their return in exchange for an exact copy produced and funded by Factum Foundation.

The Chrysler Museum replied, agreeing to return a monolith from the village of Njemetop that had been bequeathed to them in 2012. It was removed in the 1970s in the aftermath of the Nigerian Civil War and is thought to date from the 15th to the 17th-century. The monolith was either sold or stolen, probably travelling over the nearby border with Cameroon before entering the international antiquities market via Brussels or Paris. Factum made an exact facsimile, and in June 2023 there was an exchange between the museum and the Nigerian ambassador in the United States. The facsimile is now part of a display about looting and restitution. The original is currently in Calabar but will soon be returned to its original location. At a time when the debate on restitution and repatriation is centre



stage in cultural conversations, digital technologies are presenting new ways of thinking about – and perhaps even resolving – some of the issues.

Top left: The Njemitop monolith as documented in Philip Allison's 1960s survey. Top right: Facsimile of the monolith. Bottom: Uzoma Emenike, the Ambassador of the Federal Republic of Nigeria to the USA, and Erik H. Neil, Director of the Chrysler Museum of Art.

'We hope that the Chrysler Museum is the first of many museums to explore this solution to the debate on restitution. Factum Foundation welcomes the opportunity to work with any museum or private collection wishing to return cultural artefacts to their rightful owners.'

Ferdinand Saumarez Smith, Director of Projects in Africa for Factum Foundation

Toledo Symposium: AI, Tech Diplomacy and Conflict Resolution

Organised on the 18th – 19th of June 2021 by the Universidad Politécnica de Madrid and the Instituto de Resolución de Conflictos de la Universidad de Castilla-La Mancha in collaboration with Factum Foundation, CITPax and the Spanish Ministry of Foreign Affairs, the Toledo Symposium was the first of a series of planned events in Toledo focused on redefining the role of cultural heritage as a tool to facilitate mediation and conflict resolution. It provided a platform for diplomats, academics, private sector individuals, preservation specialists and mediators to assemble and discuss their respective areas of research. They addressed both the negative implications of machine learning and AI, as well as the creation of new tools to facilitate peace-building processes and help nurture deeper understanding.

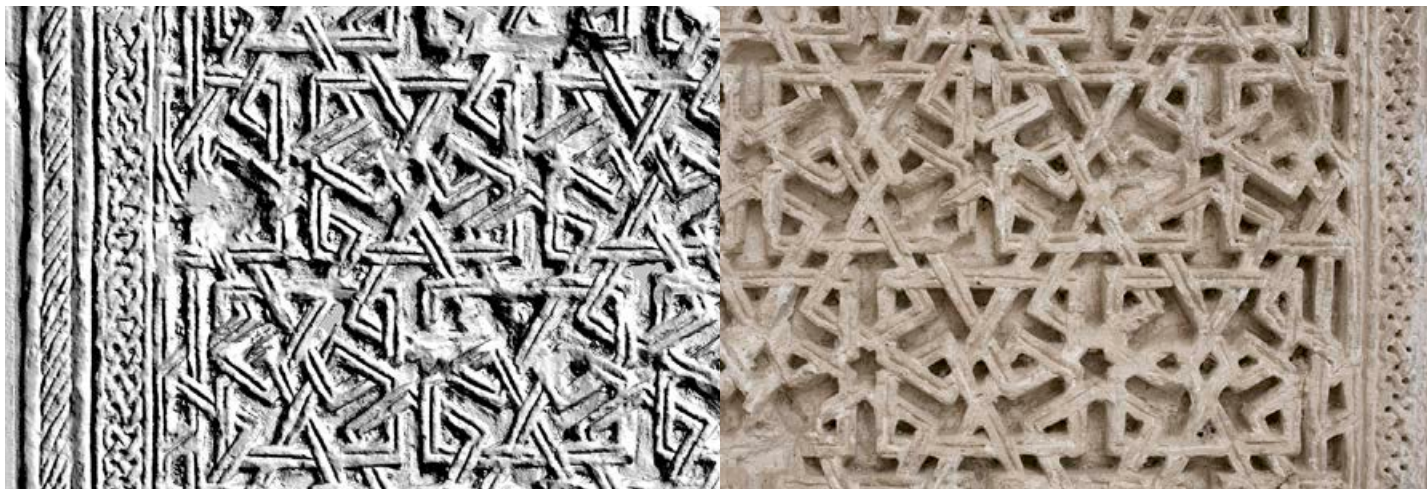
Factum Foundation's involvement in the Toledo Network is now linked to Sultan Barakat's Global Institute for Strategic Research (GISR) at the College of Public Policy at Hamad Bin Khalifa University in Doha. The goal of GISR is to strengthen the capacity of decision makers to address

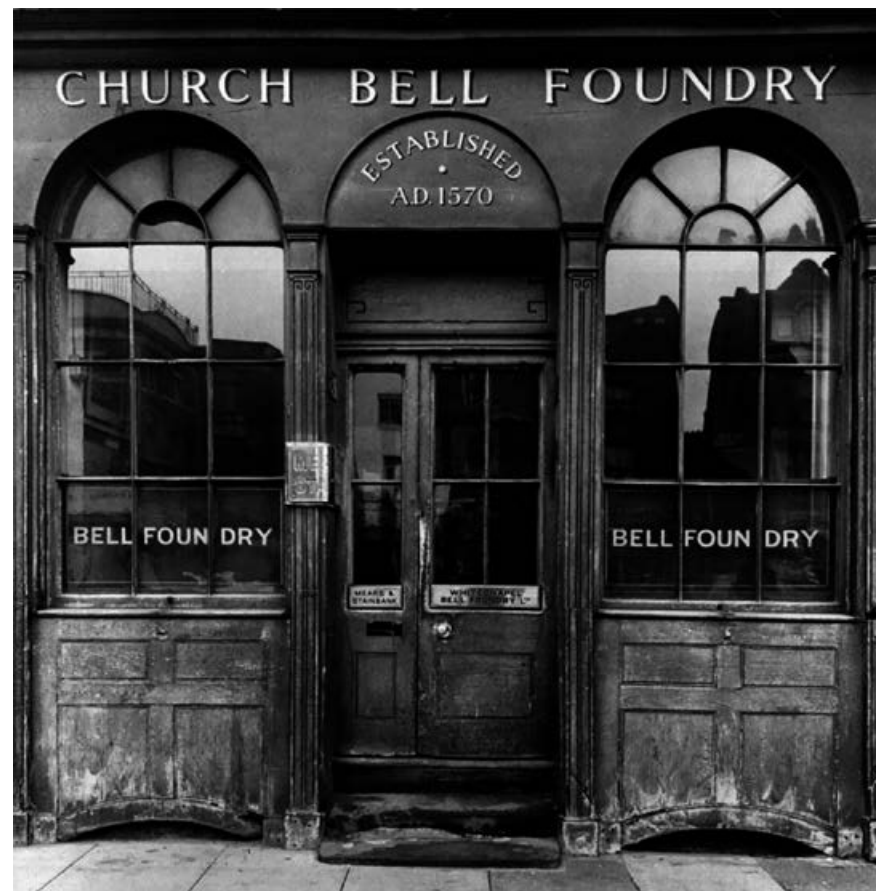
global and regional challenges by employing independent and forward-facing frameworks of analysis that stimulate critical thinking, foresight, and innovation. GISR fosters diversity of thought and understanding to collaboratively tackle pertinent global governance, advancement and peace challenges from an Arab, as well as a regional, perspective.

Factum Foundation is committed to help make the preservation of cultural heritage a part of any peace building initiative. The aim is to assist in establishing long-term, practical solutions in line with the Foundation's core mission: the transfer of skills and technologies to local communities for the recording of sites and objects and the creation of sustainable local economies based on heritage preservation.

Pedro Miró recording the *yasería* in the monastery of Santa Clara la Real, Toledo.

Opposite: Depth map and facsimile of the *yasería* decorating one of the walls of the 12th-century home of the Islamic scholar Hamete Xarrafí, in the monastery of Santa Clara la Real, Toledo (top). Depth map and surface detail (bottom).





Re-thinking Bell Casting in London



The Whitechapel Bell Foundry is a cultural heritage site of worldwide importance in the borough of Tower Hamlets in the heart of London. This renowned foundry has been based in Whitechapel since the reign of Elizabeth I, producing iconic bells such as Big Ben, the Liberty Bell, Bow Bells and the Bells of St Clements. Until recently, it was Britain's oldest manufacturing company, a working community and a repository of invaluable craft skills.

In June 2017, the historic Whitechapel Foundry was acquired by a US property developer, and the use of these Grade 2* listed buildings for the making of bells ceased. Despite its unique and profound cultural importance, campaigns in the national press, and an enormous emotional public outcry, the Whitechapel Bell Foundry was sold and closed.

The new owner, Raycliff Whitechapel LLP, submitted a planning application seeking to secure a Change of Use and development of the site as a 100-bed hotel, private members club, restaurant, bar, café and shop, with desk-sharing workspaces. The Foundry activity on site, in the Raycliff Whitechapel proposal, was reduced by nearly 90%, to a small shop and studio for the casting of hand bells, in a corner of a restaurant and café.

Re-Form Heritage (formerly United Kingdom Historic Building Preservation Trust, or UKHBPT), an independent charity under the founding patronage of The Prince of Wales,

now King Charles III, teamed up with Factum Foundation, Sir Charles Saumarez Smith and Nigel Taylor (who worked in the Bell foundry for 40 years) to save the Whitechapel Foundry, its building, and its human and technological skills. Through this partnership, the Whitechapel Bell Foundry could once again become a viable foundry that specialised in bells. The viability would be achieved in part through the production of special edition Artist Bells made with selected artists committed to saving the art of bell making and preserving traditional craftsmanship.

CAMPAIGN TO SAVE THE WHITECHAPEL BELL FOUNDRY AND THE PUBLIC INQUIRY

Supported by art historians such as Dan Cruickshank, collaborators from the museum world such as Tristram Hunt (Director of the Victoria and Albert Museum), internationally-renowned artists such as Grayson Perry, Antony Gormley, Michael Nyman, Paula Crown and Conrad Shawcross, the campaign to save the Whitechapel Bell Foundry also gathered more than 28,000 signatures on a petition largely distributed within the UK.

Protest before the planning meeting on 14th November 2019.

Opposite: The campaign's logo commissioned by The Gentle Author (top left). Entrance to the Whitechapel Bell Foundry in 1976 (top right). The Whitechapel Bell Foundry in 2018 and 2023 (bottom).



HERITAGE AT RISK

The Spitalfields Life blog was instrumental in providing the campaign's followers with daily updates. The fight to save the Whitechapel Bell Foundry also received significant support from the neighbouring East London Mosque and the London Muslim Centre.

A campaign led Robert Jenrick, the Secretary of State for Housing, Communities and Local Government, to issue a Holding Direction to Tower Hamlets Council in December 2019 prevented Tower Hamlets from proceeding with approving the Whitechapel Bell Foundry planning application, for change of use to a boutique hotel, and resulted in it being 'called in'.

The Public Inquiry, which began on 6 October 2020 to decide the future of the Whitechapel Bell Foundry, ended on 28 October 2020. On 13 May 2021, consent was granted to permit the development of a hotel on the site of the historic Whitechapel Bell Foundry with certain conditions.

THE LONDON BELL FOUNDRY

Since the decision of the Secretary of State in 2021, Re-Form Heritage and Factum Foundation have proceeded with the launch of a new entity, the London Bell Foundry, which demonstrates that the business model presented during the Public Inquiry is viable.

The London Bell Foundry's business model consists of working with the world's greatest artists to produce bells, giving them a value far above production costs. The commercial approach revolves around the sale of 'Art bells' to support traditional bell-making. This will secure the continuity of the same artisanal skills that have undergone continuous development in Whitechapel since the casting of the 12th-century bells for Westminster Abbey and earlier.

This formula was proven with the first bell made by the newly-formed London Bell Foundry in collaboration with contemporary artist Grayson Perry, a supporter of the campaign to save the Whitechapel Bell Foundry from an early stage. Grayson Perry's *Covid Bell* heralded both a new demand for bells and a new financial model.

The *Covid Bell* was commissioned by the London Bell Foundry, fabricated by Factum Arte, cast by Pangolin Foundry in Gloucestershire and tuned by Nigel Taylor working with Nicholson Engineering in Dorset. It was unveiled at the Summer Exhibition at the Royal Academy of Arts (21 June – 21 August 2022). The *Covid Bell* was made during the pandemic. It marked this unprecedented period through the celebration of London's great bells and their long history of marking time, mourning death



and celebrating life. Members of the public visiting the Summer Exhibition were invited to ring the *Covid Bell* as a sonorous symbol.

The sale of 'Artist Bells' has fast become an international market. Conrad Shawcross and Paula Crown are the next artists who will be designing bells for the London Bell Foundry. Through Factum Foundation, two large bells have been commissioned by the Mexico-based artist Jan Hendrix, and the Argentine artist Inés Civile is making a bell with Factum and Fademesa in Madrid.

Finally, a documentary in production celebrates traditional bell casting. It follows a former Tower Bell Manager who worked at the Whitechapel Bell Foundry for 40 years, and is one of the very few people to have worked on every stage of bell making.

At the time of publication, the hotel scheme has stalled and The London Bell Foundry is actively seeking to acquire the Whitechapel Bell Foundry once again provide a permanent home for bell casting in the UK. It will be a showcase of modern technology while retaining traditional skills. The London Bell Foundry will be a showcase of modern technology while retaining traditional skills. Its vision is to provide high-skilled jobs and training for craftsmen in Whitechapel. As a working foundry, it will be open to public tours and educational school visits.

Will the heritage authorities act in favour of the preservation of this important cultural asset? Will they acknowledge that the model proposed by the London Bell Foundry has already proven successful, demonstrating that bell making can be revitalised? These questions foreground the increasingly important need to unite technological advances with artisanal traditions in order to protect our cultural heritage.

3D render of the *Covid Bell*. The tuning of the *Covid Bell* by Nigel Taylor. Opposite: Installation view of the *Summer Exhibition 2022* at the Royal Academy of Arts, London, 21 June – 21 August 2022.

Dabous Giraffe, Niger

With TARA - Trust for African Rock Art

In February 2022, Factum Foundation accompanied the Trust for African Rock Art on a project to record the Dabous Giraffe, a petroglyph located in the Aïr mountains in the north-east of Niger. This region has long been a stage in the trans-Saharan caravan route and today the Tuareg still use camel-trains to transport salt south to the Sahel to trade for millet, cloth, and other staple goods. As well as transporting such basic necessities, recent years have also seen massive expansion in the trafficking of arms, drugs, and people through this area, and heightened tensions on account of the recent discovery of gold (exploited by 'artisanal' miners) alongside the uranium mined since the late 1960s by the French government-backed company Areva NC.

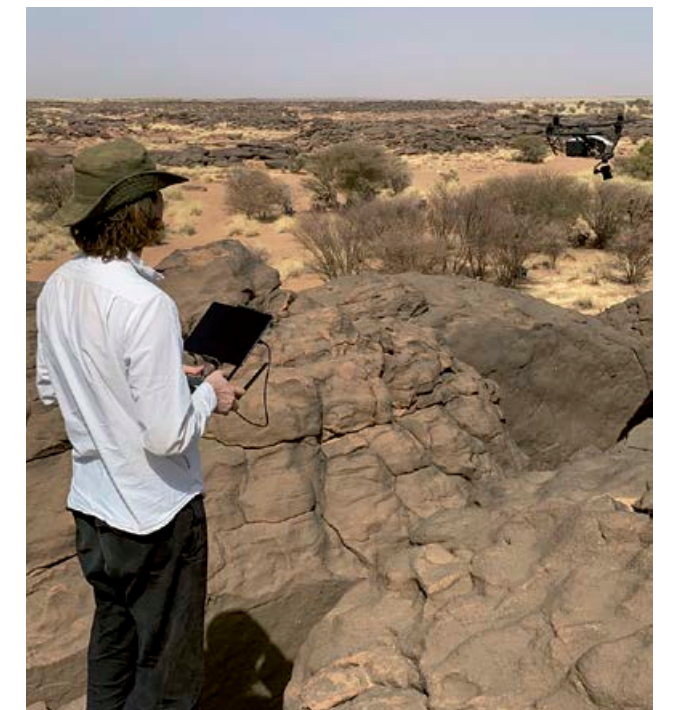
Yet, 6,000 to 8,000 years ago, the landscape of crumbling mountains and the high dunes of the Ténéré was very different: changes in rainfall patterns (known as the Neolithic Subpluvial) allowed the desert to bloom and transform into expanses of Savannah, which in turn supported African megafauna. It was at some point in this temperate window and against such a radically contrasting backdrop that the Dabous Giraffe was carved into the soft sandstone of a rocky outcrop in the south-west of the Aïr mountains. The remarkable engraved panel contains lifelike depictions of a larger and a smaller giraffe, with the former measuring 5.4m, as well as small human figure. Although it is impossible to

tell exactly what the significance of the engraving was to the artists who created it, Dabous remains an extraordinary link with a bygone world.

The site was recorded in 1987 by the French archaeologist Christian Dupuy, but the increased attention created challenges for its preservation, including graffiti, trampling, and the removal of fragments. Facing such challenges to preservation, a silicon mould was made of the panel in 1999, resulting in a cast in aluminium that is installed at the regional airport of Agadez. Unfortunately, the original mould was not kept in good condition, and in 2022 a second, digital recording of the site was commissioned. This was carried out using a mixture of aerial (using a DJI Inspire 2) and terrestrial photogrammetry. The project was a timely one as it was discovered that sections of the cheek of the large giraffe had been damaged since the previous visit, perhaps removed for human consumption, as sacred stone is believed by many in the region to contain spiritual power. As well as recording the main panel, two other important panels on the outcrop were recorded, and several other sites in the nearby region, including Touareg, Tireghamis, and Tezirzek.

Left top : Picture of the Dabous Giraffe and the landscape. Left bottom: Aziz Kountché setting up the drone. Right: Ferdinand Saumarez Smith operating the drone.

Opposite: 3D render of the petroglyph.



The rock art of Laas Geel

In collaboration with the Hargeysa Cultural Centre and the Redsea Cultural Foundation, Factum's Adam Lowe, Otto Lowe and Ferdinand Saumarez Smith travelled to Somaliland in July/August 2021 to transfer skills and technology while recording buildings, manuscripts and several sites containing neolithic paintings.

The team carried out a high-resolution 3D documentation of the painted rock art panels at Laas Geel: a complex of 22 rock shelters containing some of the earliest known rock art in the region, dating back to an estimated 5,000 years and remarkably well preserved. Despite the impressive condition of the paintings in Laas Geel, both human and natural changes require condition monitoring, new documentation skills and proper infrastructure to preserve the integrity of the site. The Somaliland Government, through its Ministry of Tourism and the Redsea Cultural Foundation, are committed to ensuring this happens.

In close collaboration with Dr. Jama Musse Jama, director of the Hargeysa Cultural Centre, Factum Foundation recorded seven individual caves using LiDAR, photogrammetry and panoramic composite photography. The complete 3D and colour datasets of Laas Geel, Dhagax Kure and Dhagax Marode were handed to the Hargeysa Cultural Centre, to ensure the high-resolution data stays in the country. It will be shared with the Somaliland authorities when it is fully processed.

As part of Factum Foundation's policy on data ownership, the data belongs to the Somaliland authorities for all current and future applications. It will serve as an invaluable resource

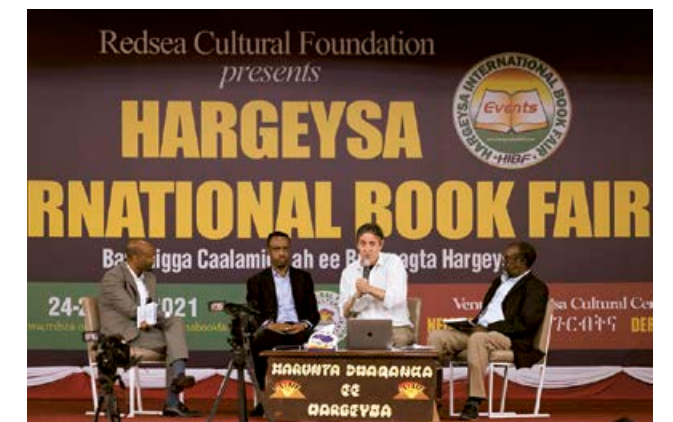
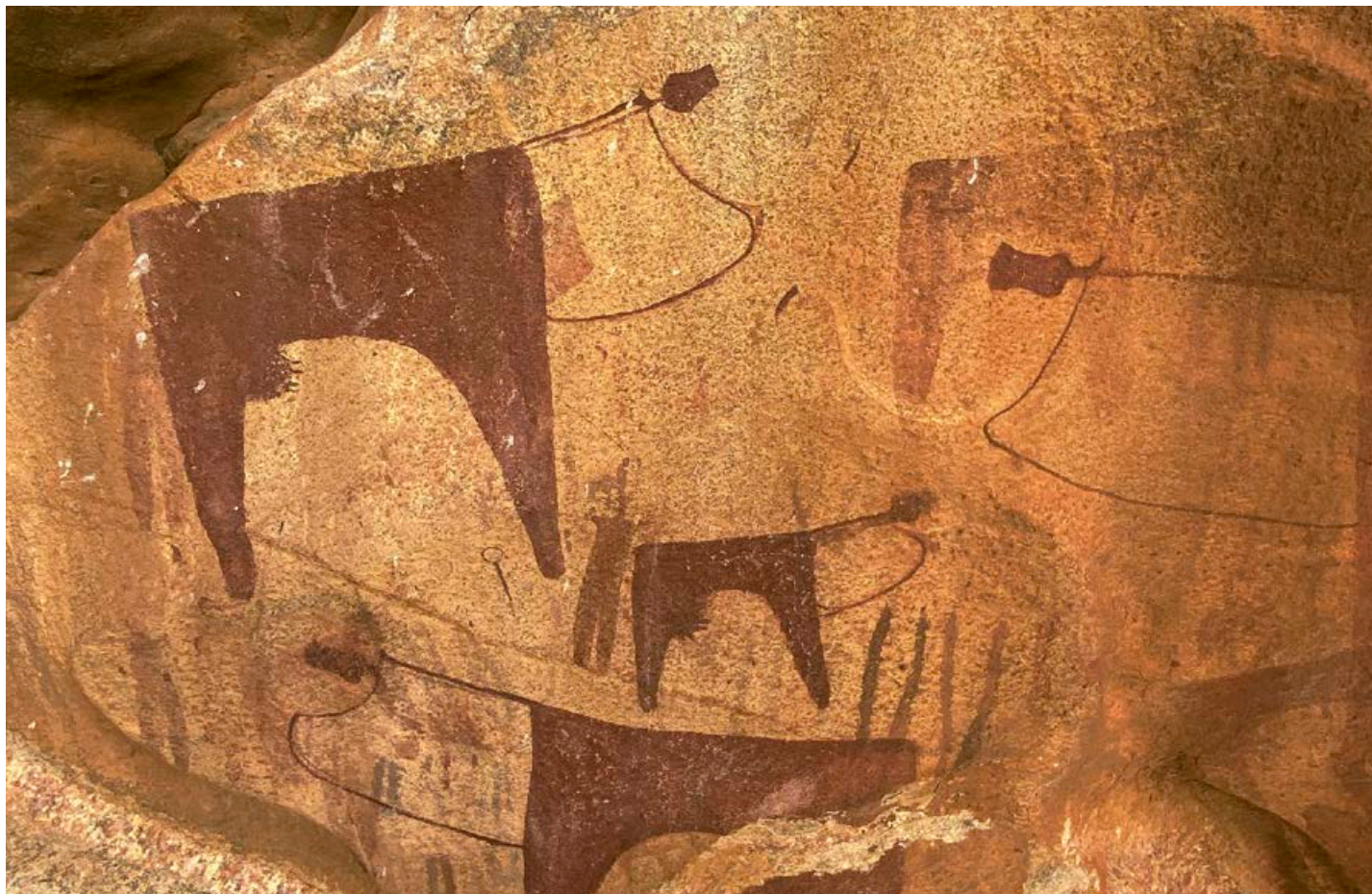
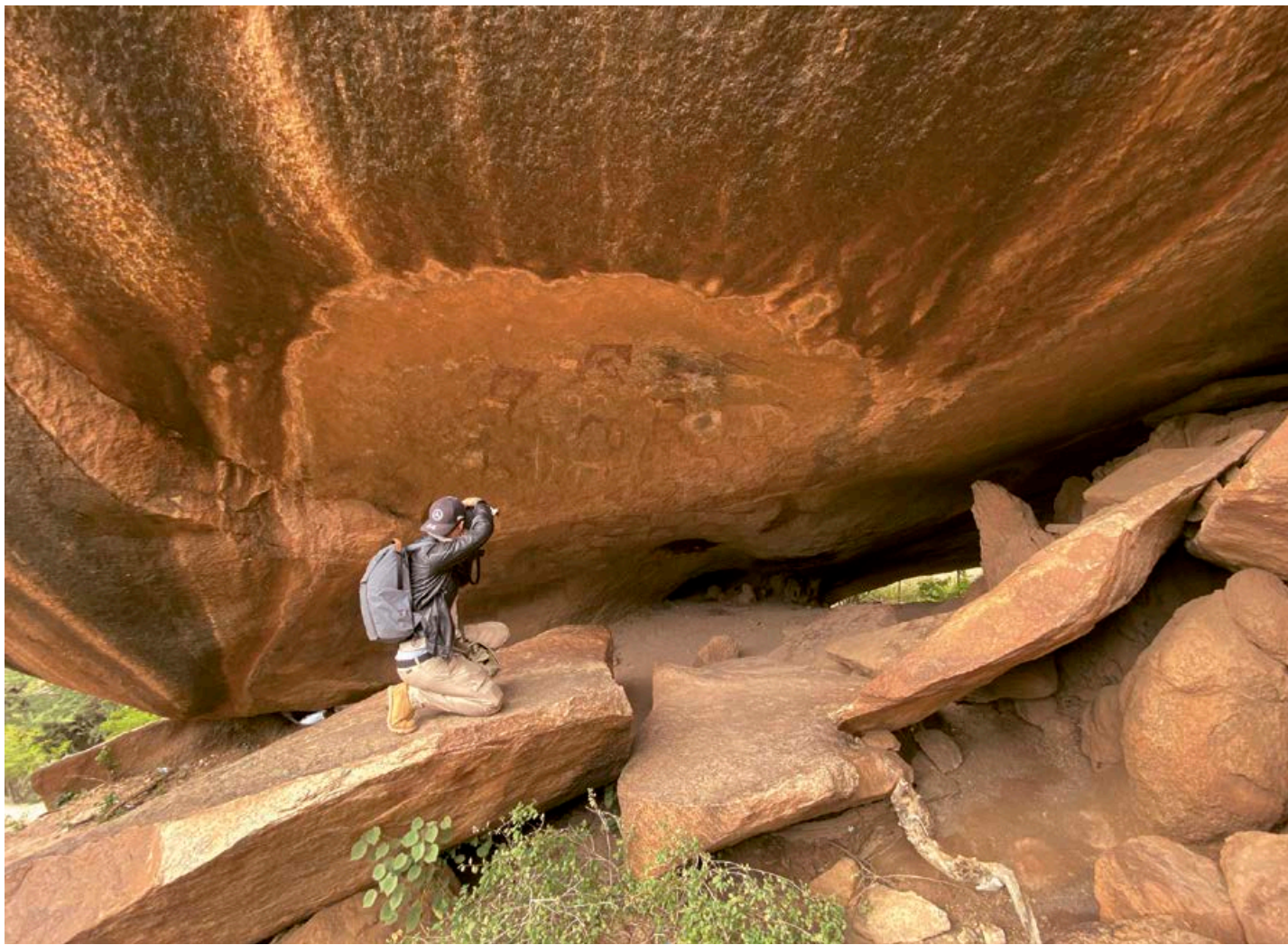
for monitoring the condition of the rock sites. This project will hopefully encourage further international interest and support, in a way that will ensure the site's long-term physical preservation, while enabling access to this historically important site to become more freely available. The recording was complemented by a transfer of skills in 3D recording and the hardware and software required.

The trip was arranged to coincide with the 14th Hargeysa International Book Fair, organised by the Redsea Cultural Foundation. On 25 July, Adam Lowe was part of a panel presentation focused on Heritage Management with H.E. Elyaas Abiib (Minister of Culture and Tourism of the Somali regional state of Ethiopia) and Yikunnoamlak Mezgebu (Director General of the Ethiopian National Archives and Library Agency). He presented the Foundation's work on manuscript recording, designing specialist hardware and software, archiving and remote access support.

We wish to thank Ambassador Nicolas Berlanga, the then EU Ambassador to Somalia, for the support he gave to this initiative.

Left: Otto Lowe showing the first processing of the data during the training session at the Hargeysa Cultural Centre. Right: Adam Lowe at the panel presentation on 25 July.

Opposite: Otto Lowe recording one of the caves using photogrammetry (top). A detail of one of the painted caves at Laas Geel (bottom).





HERITAGE AT RISK

The donation of the lamassu to the University of Mosul
 With the British Museum, the Spanish Ministry of Defense,
 the Embassies of Iraq and Spain and the Rijksmuseum van Oudheden

In 2019, two facsimiles of lamassu, from the Palace of Ashurnasirpal II at Nimrud, whose originals are currently in the British Museum, were sent to the University of Mosul, as a donation from Factum Foundation, the British Museum and the Rijksmuseum Van Oudheden. The transport of the statues to Mosul was made possible thanks to the generous support of the Spanish Ministry of Defense and the Embassy to Iraq.

Factum's project to create facsimiles of the two lamassu and send them to Mosul is one which has extended over 15 years. In 2004, Factum Arte (prior to the creation of Factum Foundation in 2009), used white-light scanners to record these 3.5m-high winged guardians in the British Museum and all the relief panels removed by Austen Henry Layard from the throne room of Ashurnasirpal II in the 1840's. Artefacts removed by Layard are now scattered across museums in Europe and North America. Efforts were also made to record the reliefs still in situ in Nimrud, 30km to the south of modern Mosul, but instability in the region in the wake of the invasion of Iraq made this impossible to accomplish at the time. Sadly the destruction of the site in 2015 means that this is a lost opportunity.

A decade later, in May 2014, the British Museum gave Factum Foundation permission to create a facsimile of one of the relief panels from the throne room of Ashurnasirpal II and send it to Baghdad. The originals are composed of Mosul marble, but Factum's facsimiles are made of scagliola (a composite substance made from gypsum, animal glue and natural pigments). The panel arrived in Mosul shortly before it fell to Isis militants in June 2014. The whereabouts of this panel are currently unknown.

In 2016-2017, the lamassu were routed in sections, assembled, moulded and then cast in scagliola. A final coat of wax completed the facsimile of the original Mosul marble surface, bringing the colossal, winged lions back to life in Factum Arte's Madrid studios. They were then exhibited together at the Rijksmuseum van Oudheden in Leiden, which had facilitated the creation of the scagliola replicas.

After several stalled attempts, the lamassu facsimiles finally reached Mosul in October 2019, a feat which would not have been possible without the help of Ali Aljuboori, the Director of the Centre for Assyrian studies at the University of Mosul. High-resolution recording, exact facsimiles and digital restorations can never replace the Assyrian carvings that were destroyed in Nimrud and at the Mosul Museum, but they can play an important role in keeping their memory alive and in sharing their cultural and political significance. The hope is that the installation of the facsimiles will be seen as a gesture of solidarity, emphasising the role that technology and cultural heritage can play in the reconstruction of the Republic of Iraq. Amjad, a remarkable welder who helped to install the facsimiles, said in a very moving interview: 'Our heritage will never die; our enemies and our friends know this. We don't care if this statue is made of marble or gypsum. It's a statue. It's a symbol. It's our identity'.

Left: Lamassu facsimiles created for the exhibition 'Nineveh' (2017-2018) at the Rijksmuseum van Oudheden. Right: A flamenco concert was organised by the Spanish Ambassador in Iraq, Juan José Escobar Stemmann for the unveiling of the lamassu.

Opposite: Scanning of the lamassu at the British Museum in 2004 (top). Installation of the facsimile at the University of Mosul in 2019 (bottom).



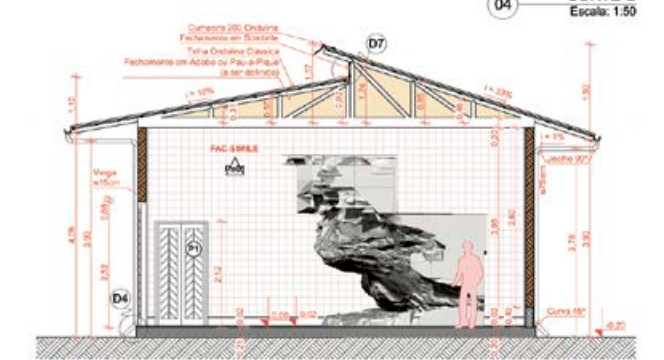
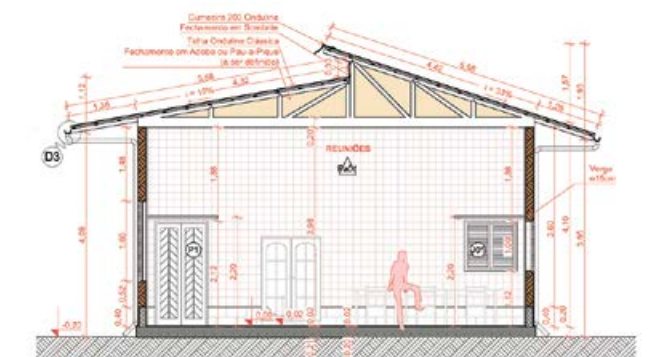
Kamukuwaká Cave returned to Upper Xingu



A team from People's Palace Projects/ Queen Mary University of London, with the support of Iron Mountain/ Crozier, Notre Dame University and the Wauja people from Ulupuene village are currently building a cultural and monitoring centre to house the facsimile of the cave of Kamukuwaká, which Factum restored following the vandalism of the original in 2018. The building will also house a research centre for monitoring the Wauja territory and the river Batovi. The building is due to be completed in early 2024. The digitally restored facsimile will be shipped as soon as the building is ready.



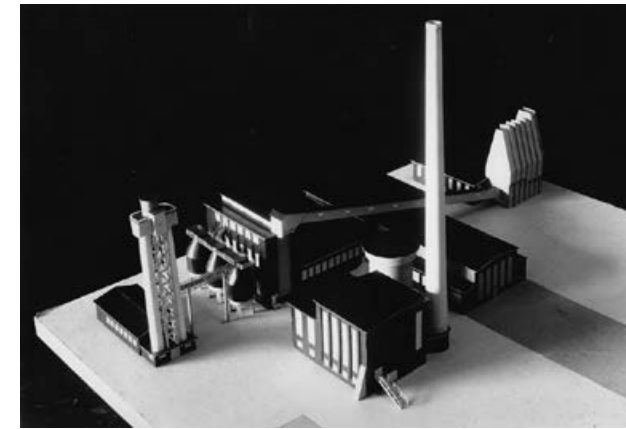
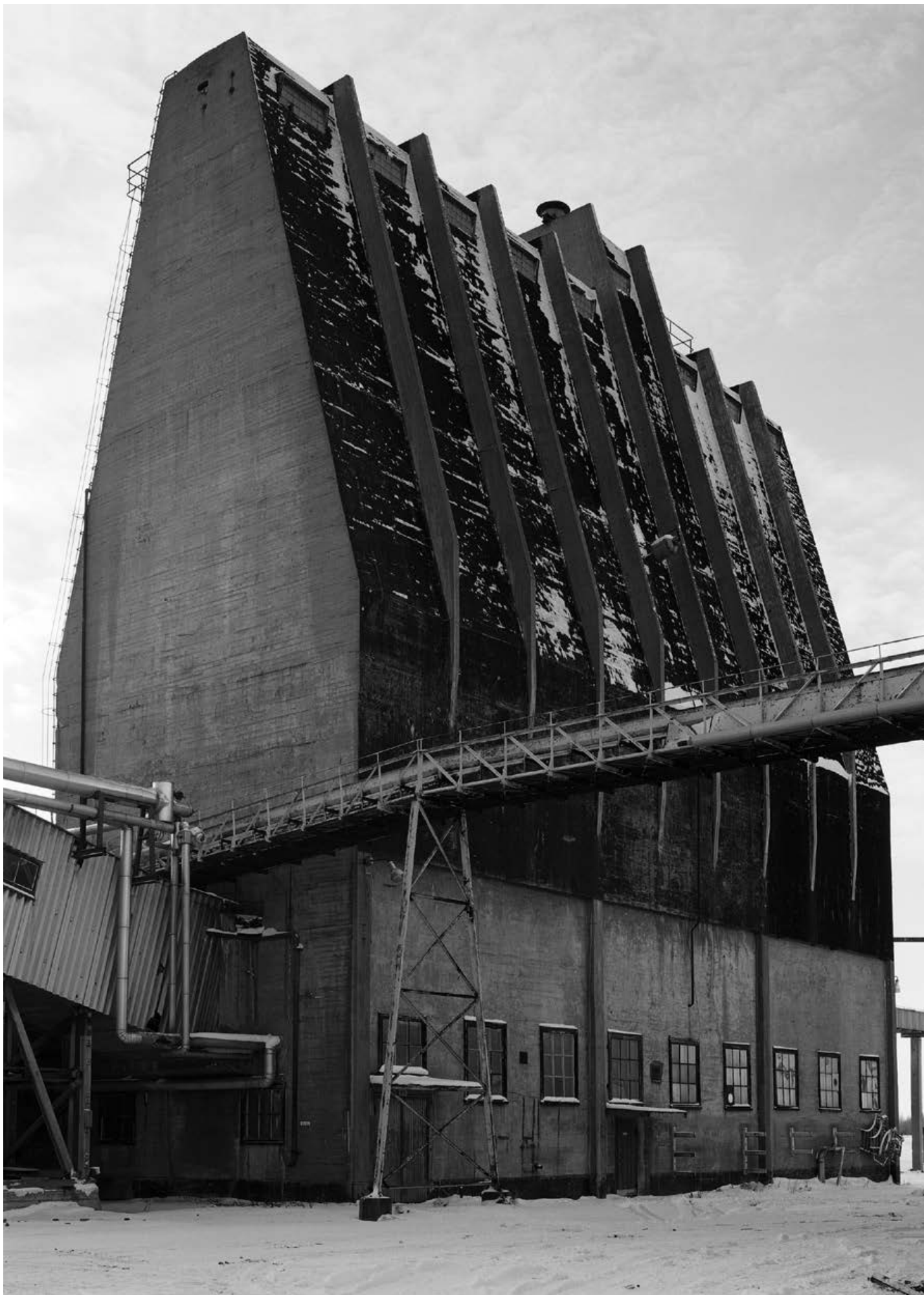
Top left: Wauja people working on 3,000 adobe bricks, using a bio-construction technique. Top right: Construction of the new Cultural and Monitoring Centre at Ulupuene village in the Xingu Indigenous territory to house the facsimile of the cave. Bottom left: Model of the Centre by Aterra architecture studio. Bottom right: Internal plan of the Centre designed by Aterra architecture studio. Opposite: Akari Wauja with the sacred cave in Madrid.



The AALTOSILO, Oulu

'Being unused for decades, the Silo provides possibilities, unique challenges and great potentials in reuse as well as in architectural and structural innovations. Rehabilitation of the landmark building will hail a new period, not only in the neighbouring Toppila area but also in the City of Oulu. The Alvar Aalto Foundation looks forward to the rise of the Phoenix!'

Alvar Aalto Foundation, 2022



In the August lockdown of 2020, Factum Foundation bought the iconic concrete woodchip silo by Alvar Aalto and Aino Marsio-Aalto, located just below the Arctic Circle, in Oulu, Finland. It is the first industrial building designed by Finland's most revered architects. The sulphite cellulose factory thrived when exploitation seemed natural and resources infinite. It closed in 1985 leaving behind a ravaged landscape. Until now, Factum Foundation has focused on preserving cultural heritage. In Oulu, working with Skene Catling de la Peña, the focus will be on the environment. Oulu has been made the European Capital of Culture 2026, for which the AALTOSILO and Research Centre have been identified as Oulu's 'legacy project' for the future.



The AaltoSiilo has the potential to address the urgent realities of the Anthropocene and current concerns about the future of architecture. Ephemeral structures of steel and glass, using vast quantities of concrete, are constructed and torn down every day, contributing to the existential crisis we are all facing. What is the role of the architect in our time? How can industrial architectural heritage be preserved and reused? Is the legacy of the impact of industry on the environment in the Arctic North insurmountable? How should buildings and nature be used, engaged with, enjoyed, sustained, and preserved? Can changes in current architectural practice tackle some of the destructive industrial residue of the 20th-century?



These industrial sites once generated and defined communities; physically, socially, and economically. Abandoned, they are melancholy remnants of 20th-century capitalism and architectural utopianism. It is time to rethink these spaces for a post-industrial era and use them to examine every aspect of the way we currently live. The

Scale model of the Toppila Ltd Sulphite Cellulose Factory. Alvar and Aino Aalto. Toppila Pulp Mill shortly after completion (1930's), snow-covered wood in the foreground.

Opposite: Toppila Pulp Mill shortly after completion (1930's).



AaltoSiilo rethinks materiality for the 21st-century and the role industrial heritage plays in memory, shaping place, and cultural identity.

SILO DREAMS

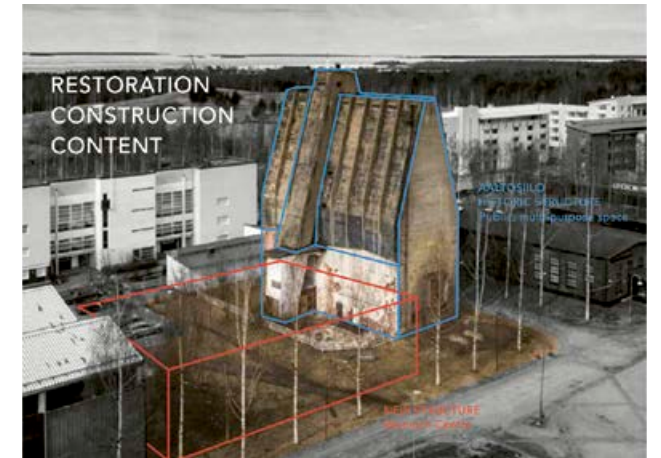
The AaltoSiilo, completed in 1931, is a radical concrete construction that pushed engineering tolerances to the limit. 28-metres high, its ultra-thin, cast-in-situ, steel-reinforced concrete shell is held rigid by fins that punctuate its façade. The roof barely tapers off the vertical, with a parallel conveyor chute that carried wood chips to the top for distribution through steel funnels, suspended from concrete ring beams by flexible steel joints. Bitumen painted directly onto the concrete surface served as weatherproofing. It has the austere dignity of a secular cathedral, but one elongated and exaggerated as if imagined by an expressionist filmmaker. It is close to one hundred years old and represents the dreams and priorities of the modernists at the beginning of the 20th-century. It can also be used to reveal how much priorities have changed in the 21st.

The silo was photographed by Aino and László Moholy-Nagy and published in *Arkkitehti Magazine* in the year of its completion. Because it was designed by Aalto, and thanks to the Aalto Foundation, there is a very rich archive of material around it which is unusual for industrial buildings of this period.

The building sits in Meri Toppila, a neglected suburb on the frontline of climate change; a place in urgent need of urban regeneration. It has a transient population that includes newcomers and students, with over 100 different nationalities having passed through it. Refugees, many from Syria, Somalia and South Sudan, arrive as the Arctic ice melts and 'post-glacial rebound' causes the land to rise by over 8 millimetres a year.

DESIGN FOR TRANSFORMATION

With the help of project manager Valentino Tignanelli, the Silo is currently the focus of a significant transformation. A central goal of the AaltoSiilo is to create a vibrant place where people want to be and interact. The public sauna, cafe, rooftop 'Tar Bar' and outdoor amphitheatre will provide spaces for social encounters and economic viability. The iconic industrial silo will be the only Aalto building in northern Finland accessible to the public. Its restoration, and the exhibitions and events in and around it, will be a source of pride, identity, and employment, preserving cultural memory and forging a positive new identity. Furthermore, by imaginatively reusing this concrete building, it is possible to save 933,145 kgCO₂,



which will almost entirely mitigate the new operational kgCO costs needed to expand the building's lifespan for another 100 years.

GLOBAL NETWORK

A transfer of knowledge will empower the local community, creating a new generation of digital artisans. The AaltoSiilo Research Centre will focus on the application of technology in the preservation of culture and the environment, with a range of activities related to the work carried out globally by Factum Foundation. These will include digital technologies, 3D scanning, Machine Learning (AI) and creative software design. The Research Centre will be linked to Factum's other centres around the world: ARCHiVE, ARCHiOX and Colnaghi & Factum. The creation of a centre of technology applied to creative preservation in Oulu, is meant as a thoughtful and provocative call to action. The AaltoSiilo, once a space for storing wood chips, will become a store for knowledge.

THE FRONTLINE OF CLIMATE CHANGE

Oulu sits at the top of the Bothnian gulf, at the edge of the Arctic Circle. An ancient trading site founded in 1605, it is the most populous city in northern Finland with 210,000 inhabitants. Once known for salmon and supplying the pine tar used to waterproof the British boats that established the colonial empire, it has evolved into a major high-tech centre, particularly in IT and wellness technology. It is one of Europe's 'living labs', where residents experiment with new technology.

The revival of the Silo has been conceived of in two core parts: the restoration of the AaltoSiilo, and the construction of a new Research Centre and sauna.

Opposite: Transistori performing at the AaltoSiilo in September 2022. Over 1,000 people attended the event (top). Conceptual drawing for the public sauna and auditorium constructed from spolia (bottom).





GHOST PATH

The Silo was once part of an industrial process, one event along a prescribed series of events and actions. The trunks of trees arrived from the Bothnian Bay by boat and were stored in stacks between the shore and the factory until needed. In a building adjacent to the Silo, tree trunks were stripped of their bark and chipped, before being taken by conveyor belt to the top of the Silo.

The new route through the building will follow the original industrial process. The path the woodchips once took will form the basis for a new 'architectural choreography'. Beginning at ground level where trees were processed, the route rises to the top of the building by conveyor lift as the woodchips once did, before filtering down through a 'Cabinet of Curiosity' arranged on platforms along the stair route, passing through the concrete hopper and exiting through the opening that once connected the Silo to the next stage of cellulose production. This 'ghost path' enables each visitor to re-enact the navigation of the industrial process. As part of the transformation of Meri-Toppila, the AaltoSiilo is also proposing a new boat route between the historic centre of Oulu and the new marina.

In Meri Toppila, the Silo is used to critique itself. The restoration retains the complexities of the building: its

past from a very different time in Finland, its present as an evocative ruin, and its future, as a beacon of sustainability. This way the Silo remains exciting, thought-provoking, and even disruptive; an entity 'in-between' time.

Material choices and treatments add another layer of resonance. The 'Toppila Oy' was a plant that turned trees into cellulose using sulphuric acid and other corrosive chemicals. Here, a place once destructive and wasteful of resources, becomes an exemplar for imaginative sustainability. The restoration uses all the possibilities inherent in pine tar, timber, and cellulose, to resonate with the former use of the building.

THE AALTOSIILO RESEARCH CENTRE

The AaltoSiilo Research Centre is a courtyard structure that will occupy the space of the demolished factory building where trees were once turned into wood chips. At ground level, an entrance to the new inclined elevator generates an intimate, animated public space. Amphitheatre stairs, leading to a raised planted courtyard, direct attention back towards the Silo, with a view over the new urban landscape of

AaltoSiilo showing the incline elevator access to the rooftop Tar Bar, the Sculptural Stair, the Mezzanine Viewing Platform and the Main Exit Stair.



Meri-Toppila. The stairs double as seating for outdoor screenings and performances with the newly renovated Silo as a projection surface. A sauna at its centre will reanimate and bring it to life: a warm heart.

The new AaltoSiilo Research Centre will focus on environmental sustainability, both natural and cultural, in this rapidly changing part of the world. While Venice sinks, post-glacial rebound is causing Oulu to rise. The pollution in the Gulf of Bothnia, the change in the salinity of the sea and the emergence of new islands are all evidence of the changes taking place. The rapidly melting ice and permafrost and the changes in the Arctic Circle are resulting in the collapse of industrial buildings in the region (many constructed without foundations), but also the potential to study soil, flora, and fauna where it was previously impossible. By merging new recording technologies, with both online and offline display, this dynamic environment will attract global interest.

CONCRETE SPOLIA AND THE 'OULU PROTOCOL'

The word 'spolia', from the Latin for 'spoils', describes repurposed building stone for new construction or decorative sculpture reused in new monuments. While the Silo itself demonstrates the importance and viability of reusing existing concrete industrial heritage, the Research Lab is an opportunity to develop the concept of 'Concrete Spolia', where buildings scheduled for demolition are 'surgically' dismantled, and large pieces reused in new constructions, to beautiful effect.

Waterjet cutting is one of the most effective ways of cleanly and efficiently slicing through concrete. The source buildings

for this concrete waste have already been identified with the Oulu planning department. Building with concrete 'spolia' creates a new aesthetic that recalls Aalto's Muuratsalo or 'Experimental House', combining innovative recycling with design excellence.

Concrete has one of the longest useful lives among building materials, yet buildings made from it account for an overwhelming majority of demolition projects. Concrete is usually completely crushed, and if reused at all, only as landfill or aggregate. The structural behaviour of cut-out and reused reinforced, precast, and cast-in-situ concrete will be very different to newly formed concrete structures. The team is working closely with structural engineers to develop a new approach that considers the less predictable nature of large-scale, recycled concrete pieces.

Ultimately the aim is to develop a protocol in relation to the demolition and reuse of concrete structures, including how buildings are taken down, who pays for the process of 'surgical demolition' and who benefits from it, who is responsible for the execution, and how the process is monitored. Inspired by the extremely effective Montreal Protocol of 1987 that tackled damage to the ozone, this is to become known as the 'Oulu Protocol'.

Charlotte Skene Catling and Adam Lowe in the AaltoSiilo.

RENOVATION

More than four containers of waste, accumulated over years of neglect, were removed from the building between 2021 and '22. The surfaces of the lower interior were pressure-cleaned, and pest control measures rid the Silo of the pigeon colony that endangered further drone surveys. Arctic Drone Labs, in partnership with OAMK (University of Applied Sciences in Oulu), recorded the outside of the Silo to enable a 3D model of the building to be made. The building and plot were recorded using drone-based LiDAR and photogrammetry during the summer of 2022. The model serves as a record of the building prior to restoration and also provides a base for the architectural work. At the beginning of 2022, for the first time in 40 years, the inside was lit up with a new electricity supply and dozens of brilliant lights.

PERFORMANCES & EVENTS

While Factum Foundation is collaborating with Oulu 2026 to fund a series of events leading up to, and including, 2026 and the official launch of the AaltoSiilo project, the completed AaltoSiilo will be Oulu's great legacy project that thrives long into the future.

The first public performance at the AaltoSiilo in September 2022, was headlined by Transistori who turned the entire Silo building into a musical instrument. Attracting over 1,000 people. The performance was filmed, broadcast live, displayed on LED screens and projected onto the building to demonstrate how the Silo will be used in the future.

*'El duende, then, is a power, not a work.
It is a struggle, not a thought.'*

*'Duende is not a question of ability,
but of true living style, of blood,
of the most ancient culture, of spontaneous creation.'*

Federico García Lorca

In June 2023, SCREAMING DUENDE was a world premiere, pairing the radical Sevillian flamenco master, Isráel Galván, with the world-famous Screaming Men of Oulu, *Mieskuoro Huutajat*, in the spirit of Federico García Lorca's concept of El Duende. 'El Duende' is usually associated with flamenco culture, but Lorca defines it as a universal artistic concept.

DESIGN FOR TRANSFORMATION

Positive change is in the air. Tech – and gaming – related start-ups thrived in Oulu with the growth of Nokia and now have their own identities. Research into sustainable building materials is ongoing in Oulu University and

OAMK (Oulu University of Applied Sciences). With the rise of mobile telephones, cellulose is being used once again for communication, but at a nano-scale in 5G and 6G technologies.

There is rising awareness of the urgent need for a new approach to the global role of this overlooked locality. The world is now being forced to confront its deepest prejudices as national boundaries, identity, consumption, materiality, preservation, and sharing are all being renegotiated. There is global rethinking about what is valuable and even the nature of value itself.

The Silo is on the frontline of change and Oulu is rising. Both literally and metaphorically.

The AALTOSIILLO project was granted planning permission in June 2023 by the Oulu City Council.

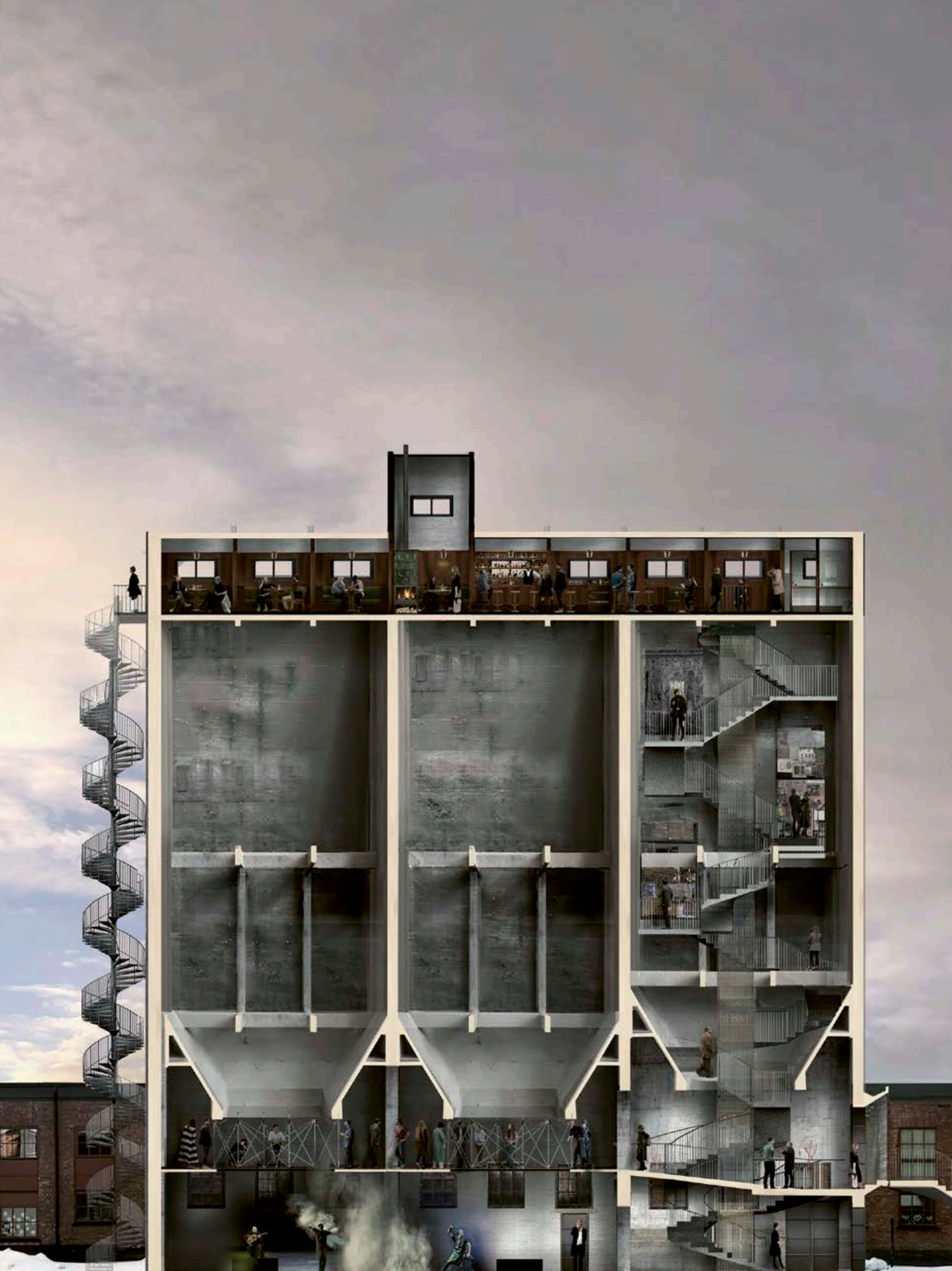
aaltosiilo.com



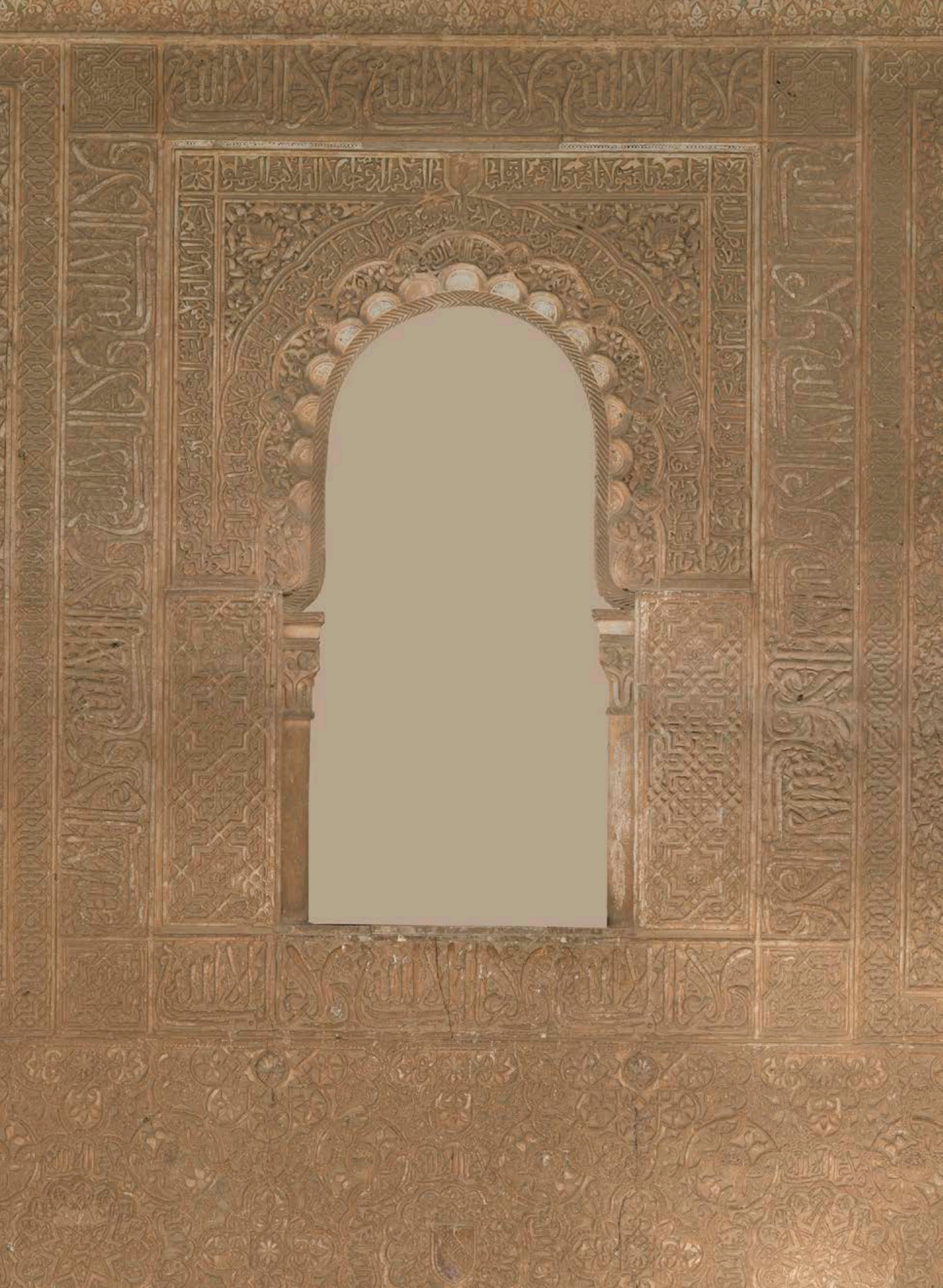
In 2021, a limited edition of 100 bottles of La Mejorada's 'Las Cercas' 2015 wine was donated by Raphael Moneo to the AALTOSIILLO project to raise funds for the preservation of the Silo in Oulu. The wine has a specially designed label by Rafael Moneo with a drawing of the building that has become the logo for the Silo restoration project. Rafael's motivation has been to recognise the importance of architectural and industrial heritage. The winery of El Monasterio de La Mejorada has, itself, undergone extensive restorations to ensure its survival and now houses an award-winning winery.

Opposite: Section of the AaltoSiilo restored with minimal intervention. The two bays to the left, spaces for performance and events, are virtually untouched. Visitors are brought to the 'Tar Bar' at the top level by a dramatic inclined lift, and are returned to ground level through the exhibition bay by a stair sculpted to follow the form of the building.

Overleaf: The Screaming Duende performance: Israel Galván and the Huutajat (Screaming Men) Choir. The success of Screaming Duende directly and immediately led to the second collaboration between Israel Galván and the Screaming Men: a ground-breaking adaptation of Bizet's Carmen in 2024. The coproducers are the Maestranza of Sevilla Opera House with the Bienal de Flamenco, Lyon Fourviere with the Opera of Lyon, Paris Theatre de la Ville.







3. SELECTED RECORDINGS

‘... but perhaps the most radical achievement of Factum, and one that’s acutely welcome in our new world of lockdown, is the way its creations can dissolve museum walls and reconnect their treasures not just with new audiences but with the raw, real world they came from. Lowe is certainly no fan of the way great art gets isolated and fetishised.’

*Jonathan Jones
The Guardian - November 2020*



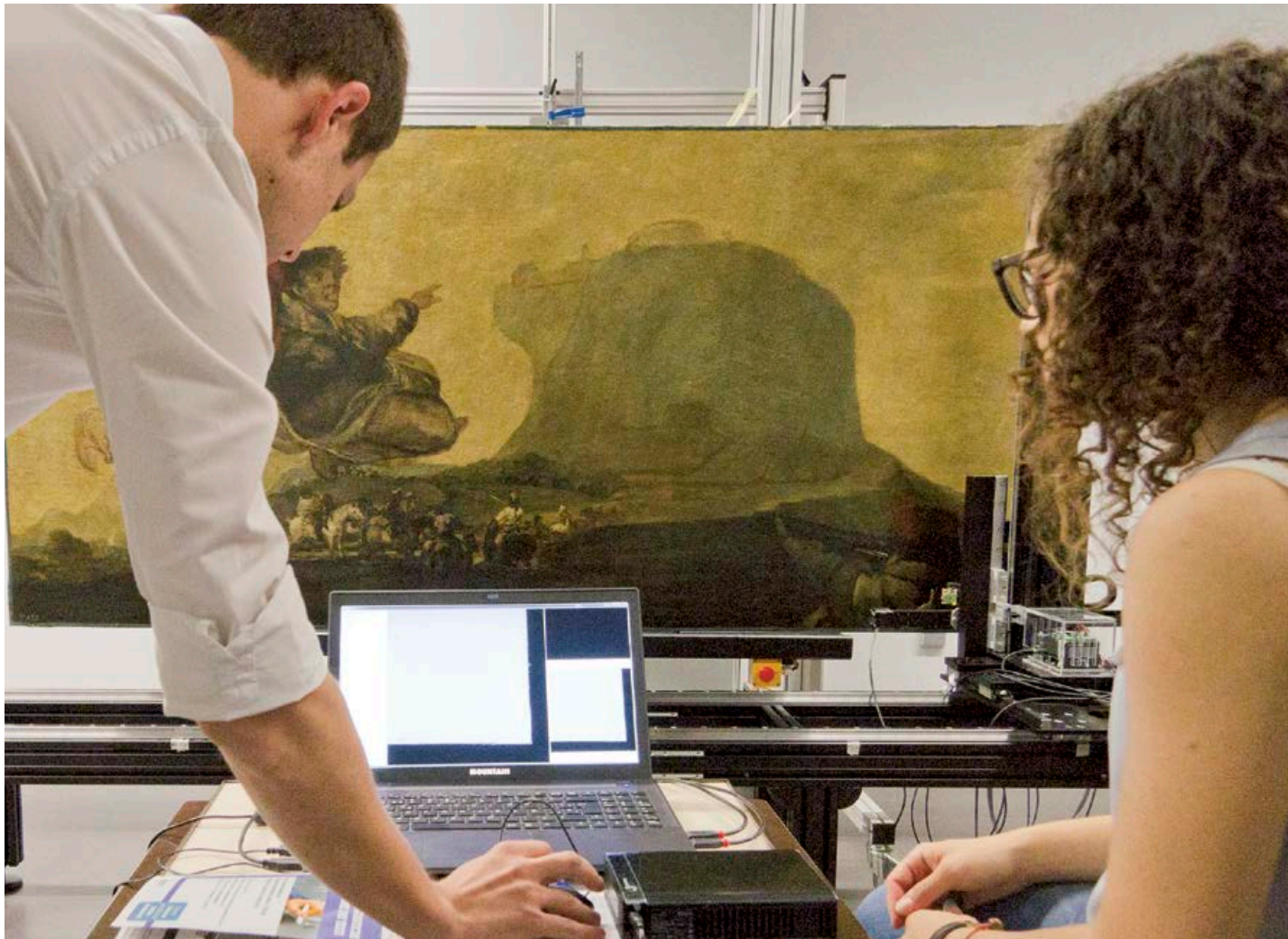
Goya's *Black Paintings* At the Museo del Prado, Madrid

The *Black Paintings* are a series of fourteen works that Goya painted with oil directly onto the walls of his house in Madrid, known as La Quinta del Sordo. Located by the Manzanares River, Goya acquired the property in 1819 and bequeathed it to his grandson Mariano in 1823 when he left for France. Today, there are no traces of La Quinta. The paintings were transferred onto canvas in 1874 by Salvador Martínez-Cubells, a restorer at the Museo del Prado, and donated to the Spanish State in 1881 by their owner, Baron Frédéric Émile d'Erlanger. The artworks were then assigned to the Museo del Prado, where they are housed today.

In 2014, the Museo del Prado commissioned Factum Foundation to carry out high-resolution 3D scanning and composite colour photography of each of the *Black Paintings* for documentation and research purposes. The Museum chose to make this project public in the

summer of 2021. The work involved the combination of the 3D and colour data obtained by Factum with other layers of information provided by the Prado's Technical Department. This included X-ray, infrared and ultraviolet analyses, as well as a series of old photographs taken by Jean Laurent showing the pictures in-situ on the walls of the original house. The project was initiated by Manuela Mena, former Curator of Goya and 18th-century Paintings, and enthusiastically supported by Miguel Zugaza, former Director of the Museo del Prado.

The Lucida 3D Scanner capturing the surface of *The Drowning Dog*. Opposite: Carlos Bayod operating the Lucida 3D Scanner to record the surface of *The Pilgrimage to San Isidro* at the Museo del Prado (top). Carlos Bayod and Guendalina Damone supervising the 3D scan of *Asmodea* (bottom).





Today, nearly ten years after this pioneering research project, a new initiative has the potential to alter our perception and appreciation of Goya's creations. Drawing upon the 3D and colour data recorded at the Museo del Prado, Factum Foundation proposes the production of exact facsimiles to be showcased in a reconstruction of the Quinta del Sordo's two main rooms. Envisioned as an immersive exhibition, this new undertaking will recreate the interior of Goya's house, encompassing both the ground and top floors. The facsimiles will be arranged in their likely original layout, granting visitors a unique opportunity to step into the intimate world that Goya created for himself. To complete the installation we are seeking to make a facsimile of *Heads in a Landscape*, regarded as the 15th Black Painting, which is presently held in Stanley Moss's collection in New York. This painting was the first to be removed from the walls of the house, preceding the removal and transfer of the main body of paintings onto canvas by several decades.

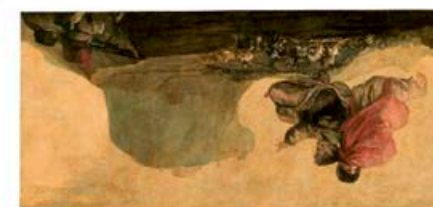
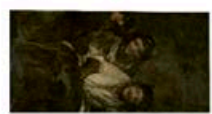
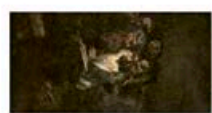
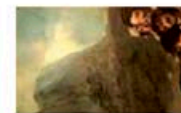
By documenting this painting and including its facsimile in the exhibition, we can arrive at a more comprehensive understanding of these paintings, perhaps triggering a new wave of interest in the series. Indeed, the ongoing research required to carry out this initiative is generating new hypotheses concerning the significance of the *Black Paintings*, which can be explored and tested through physical reconstruction. The material reproduction of digitally recorded surface information will shed new light on Goya's creative genius.



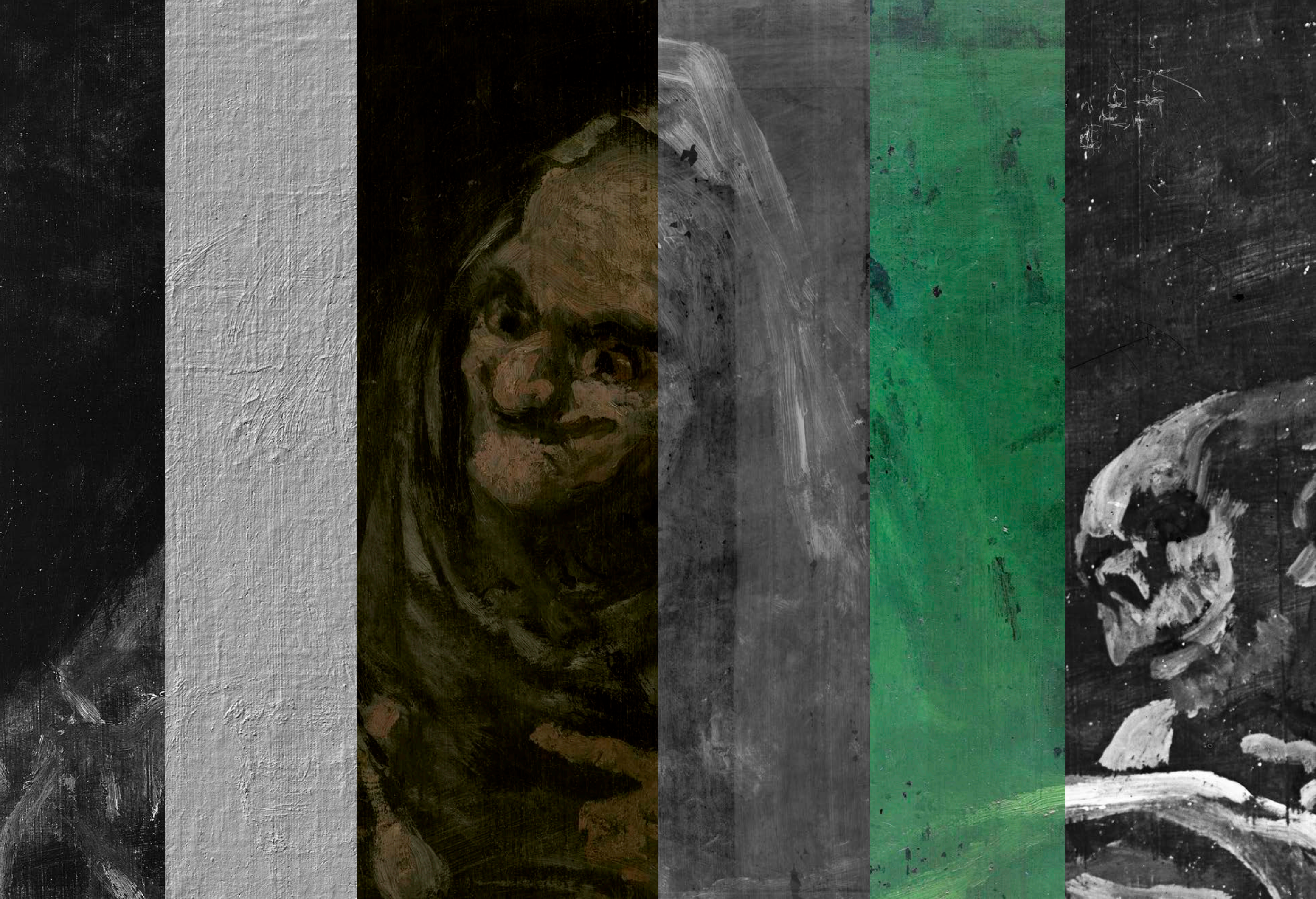
Top: Close up of the surface of *The Drowning Dog*, reproduced as a physical facsimile with the 3D and colour information captured in 2014. Bottom: Facsimile of a detail of *The Drowning Dog*, realised with permission of the Museo del Prado.

Opposite: F. Goya, *Capricho con Cinco Cabezas*. Fotografía de J. Laurent, 1866. *Goya 1020, Groupe de Têtes, (Galerie de San Telmo à Séville)*, Instituto del Patrimonio Cultural de España, Ministerio de Cultura y Deporte (top left). *Cabezas en un Paisaje (Heads in a Landscape)*, 112 x 67 cm. Stanley Moss & Co collection (top right). Alternative layout of the paintings on the upper floor, which includes *Heads in a Landscape*, for the upcoming reconstruction of the paintings and the space as an immersive installation (bottom).

Overleaf: Detail of Goya's *Two Old Men Eating*, 1820-1823. Layers of data (from left to right): infrared; 3D relief; colour; x-ray; ultra-violet; historical photograph.



The proposed layout of the upper floor of the Quinta del Sordo incorporating the section that is now in New York. The level of the land carries around the room with a few incongruous details that are possibly the result of the removal process and the subsequent restorations.





Photographs taken by Jean Laurent in 1874, when the paintings were still on the walls of Goya's house: *The Inquisition*(top); *Two Old Men Eating* (bottom); *Judith and Holofernes* (opposite).





Lamentation over the Dead Christ by Niccolò dell'Arca

The sculptural group of the *Compianto sul Cristo Morto* (*Lamentation over the Dead Christ*) by Niccolò dell'Arca is located in the main chapel of the Church of Santa Maria della Vita, Bologna. This dramatic depiction of sorrow and death was commissioned by the brotherhood of the Battuti Bianchi around 1463 and consists of a group of figures, slightly smaller than life-size – the Madonna and the Three Marys, St John the Apostle and Joseph of Arimathea – weeping over the dead body of Christ.

The fragility of the seven statues led Factum Foundation, in collaboration with Genus Bononiae, to record the group in December 2019 as part of the exhibition 'La Materialità dell'Aura. Nuove Tecnologie per la Tutela' at Palazzo Fava, commissioned by Fabio Roversi Monaco.

While the primary aim of the recording was to provide accurate data for condition monitoring, it will also facilitate

new research into the figures, particularly with regard to their original positioning. In the current display, the terracotta figures are fixed to the ground, with visitors and scholars kept at a safe distance from the group. Now they are in a digital form it is possible for researchers to reposition the group of mourners around Christ, moving them in both subtle and dramatic ways to explore the spectrum of possibilities of Niccolò dell'Arca's work. Digital recording will thus open up new possibilities for the display of the sculptures – certainly within the virtual sphere, but perhaps even in the physical space of the sanctuary.

3D model, front (top) and from an elevated point of view (bottom), something that is not possible in the original location.

Opposite: The recording of Mary Clopas using an Artec Spyder structured white light scanner (top). 3D model of John the Baptist (bottom).

Overleaf: 3D models of Mary of Clopas from different angles.





Rembrandt at the Mauritshuis Museum

At Canon Production Printing, The Hague

In 2018-2019, Factum Foundation collaborated with Canon Production Printing (previously Océ – but now part of the Canon group of companies) and the Mauritshuis in the recording and reproduction of Rembrandt's *Portrait of an Elderly Man* (1667). With 2019 marking the 350th anniversary of the Dutch Master's death, this joint effort aimed to demonstrate how new technologies for non-contact digitisation and elevated printing could contribute to the preservation, study and dissemination of one of the artist's most notable works. This project, which resulted in further collaborations with Canon Production Printing, consisted of recording the original painting's relief and colour, in the museum in the Hague. Both data sets were then used by CPP to create an exact 3D reproduction.

The recording was undertaken at the Mauritshuis in December 2018, with the Lucida 3D Scanner employed to capture the relief of the canvas, and panoramic composite photography carried out for the colour. The colour and relief information recorded by the Factum Foundation was used by Canon Production Printing to create a replica with Elevated Printing technology, which was presented to the Mauritshuis in January 2019.

Top left: Carlos Bayod Lucini recording the painting's surface with the Lucida 3D Scanner. Top right: detail of the recording. Bottom: Detail of the elevated printing process in two images (left and right), showing a lower relief printed layer and subsequent.



Annunciation by Fra Angelico

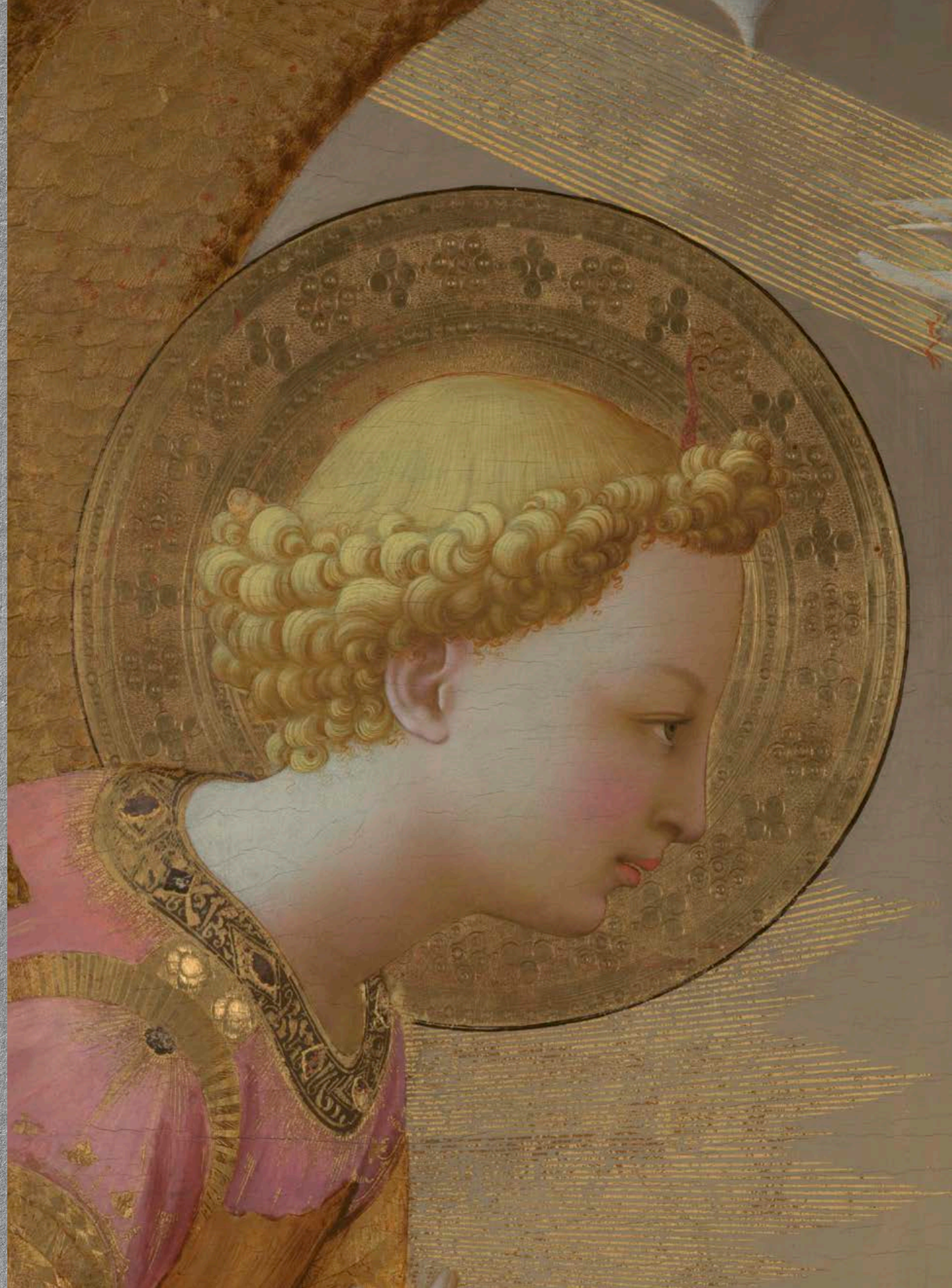
At the Museo del Prado, Madrid

The foreground of Fra Angelico's *Annunciation* (1425-26) depicts in hues of cobalt blue and shimmering gold, the Archangel Gabriel's Annunciation to the Virgin, while the background stages the sombre scene of Adam and Eve's expulsion from Paradise: these biblical episodes unite the Fall and the salvation of man on a single canvas. It was painted as an altarpiece for the Convent of Santo Domenico in Fiesole, where Fra Angelico himself was a friar. This exquisite work, governed by the use of a Euclidean perspective and an almost scientific attention to the natural world, is one of the most significant paintings in the collections of the Museo del Prado, Madrid. In 2018-2019, the *Annunciation* underwent a complex process of cleaning and conservation with the

intention of restoring its visual integrity and removing the detrimental effects of pollution. The results were presented to the public as the centrepiece of the exhibition 'Fra Angelico and the Rise of the Florentine Renaissance' at the Prado (May to September 2019). Factum Foundation contributed to the documentation by carrying out a 3D and colour recording of the painting after the completion of the restoration. The 3D scan is of particular interest in this case, due to the superb surface work executed by the artist.

Carlos Bayod and Teresa Casado recording the surface of *The Annunciation* in the Prado's Conservation Department. Overleaf: The renders show some of the remarkable details from the painting together with the corresponding surface relief.





The Retablo del Maestro de Perea altarpiece

At Casa de Pilatos, Seville

In 2019, Factum Foundation collaborated with Fundación Casa Ducal de Medinaceli on a digital preservation project involving the surface and colour recording of a late-15th-century altarpiece known as the *Retablo del Maestro de Perea*. The recording allowed the creation of a database documenting the current state of conservation of the altarpiece, whose 14 panels had recently been restored by the Fundación, permitting close study and wider dissemination.

The recording of the 14 panels was carried out over a period of two and a half weeks at the Casa de Pilatos in Seville. The

Lucida 3D Scanner was used to record the surface relief of the painted wooden panels and panoramic photography was used to record colour.

The project followed previous collaborations with the Fundación Medinaceli, for whom Factum Foundation has also recorded the Sepulchre of Cardinal Tavera and architectural elements of the Casa de Pilatos.

The Lucida scanner recording the surface of the central panel of the altarpiece.



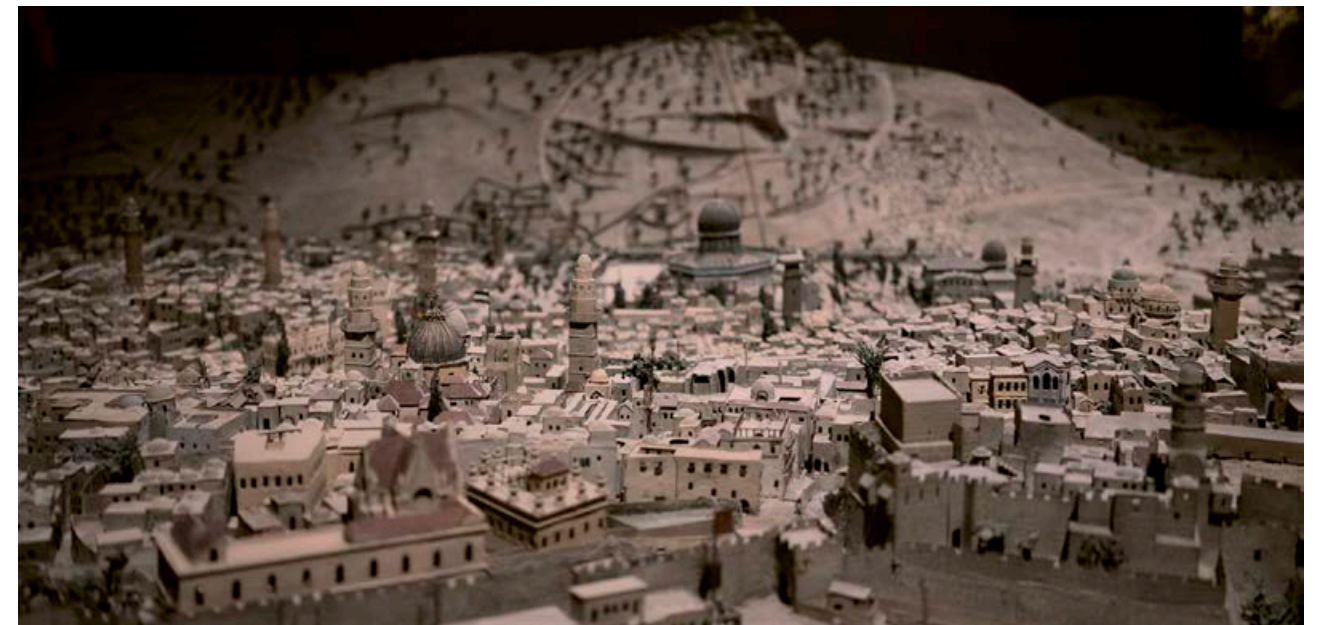
The Illés relief

At the Tower of David Museum, Jerusalem

In July 2019, a team from Factum Foundation used photogrammetry to record a 19th-century 1:500 scale model of Jerusalem – the first topographic relief to aim for scientific accuracy. The hand-painted zinc model, which measures 4.5x5m, was made between 1864 and 1873 by a Hungarian Catholic bookbinder, Stephen Illés, and shows the city when it was still under Ottoman rule before the British Mandate divided it into four quarters.

A sensation at the 1873 World's Fair in Vienna, the map was eventually purchased by the City of Geneva by public subscription and displayed there for four decades. In 1984, it was sent on permanent loan from the Maison de la Réformation S.A. in Geneva to the Tower of David Museum in Jerusalem, where it is currently on display. Factum Foundation recorded the model for ARCH (Alliance to Restore Cultural Heritage in Jerusalem).

Photogrammetry recording and a detail of the map of Jerusalem.



Epifania by Michelangelo

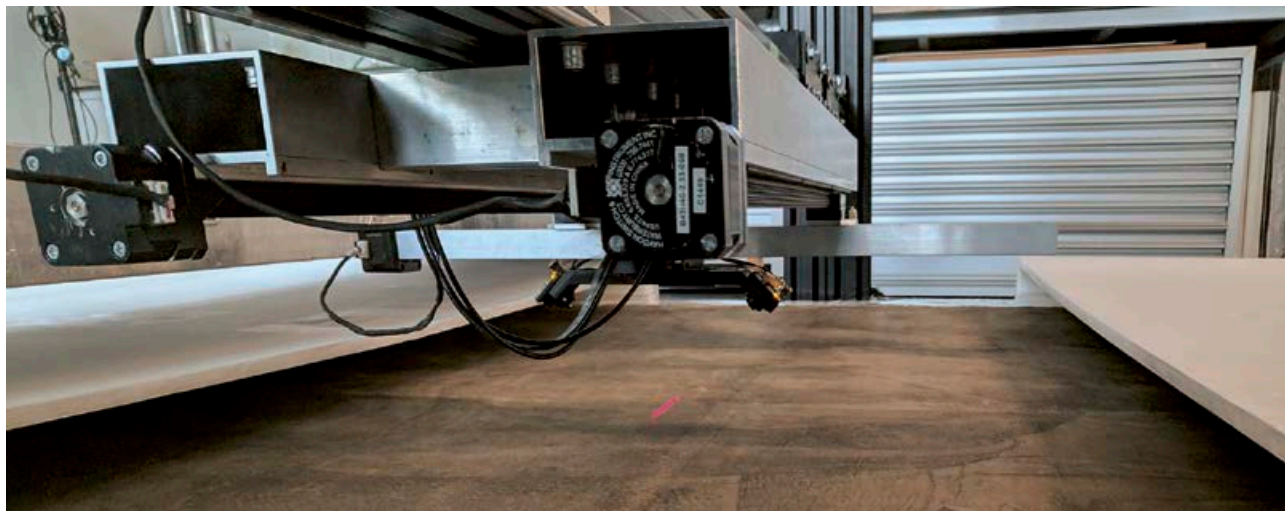
At the British Museum, London

The magnificent cartoon *Epifania* was given by Michelangelo to his friend, the artist Ascanio Condivi, to be used as the preparatory drawing for a painting. It positions the Virgin as the central figure in the composition with the Christ Child hiding between her legs and St John the Baptist looking over at him. Its importance stems in part from the fact that it is one of only two known cartoons – preparatory drawings at full scale – in Michelangelo's oeuvre. The drawing in black charcoal is on twenty-six sheets of paper with total dimensions of 2.32 x 1.65 m – its size and fragility complicated the digitisation process.

The novel aspect of the *Epifania* recording at the British Museum in 2019 was in the configuration of the Lucida

setup. Due to the specific requirements of the fragile object, the cartoon could only be positioned flat on a purpose-built supporting platform and had to be partially covered for protection during the week-long scanning period. A team at Factum worked around the problem by designing a new Lucida setup to allow horizontal scanning of large-scale works. With the horizontal Lucida structure as a frame for the camera, Factum used composite photography to create a high-resolution colour recording of the *Epifania*, which was mapped onto the 3D data as part of the process of creating a layered archive for the work.

The horizontal structure of the Lucida 3D Scanner.

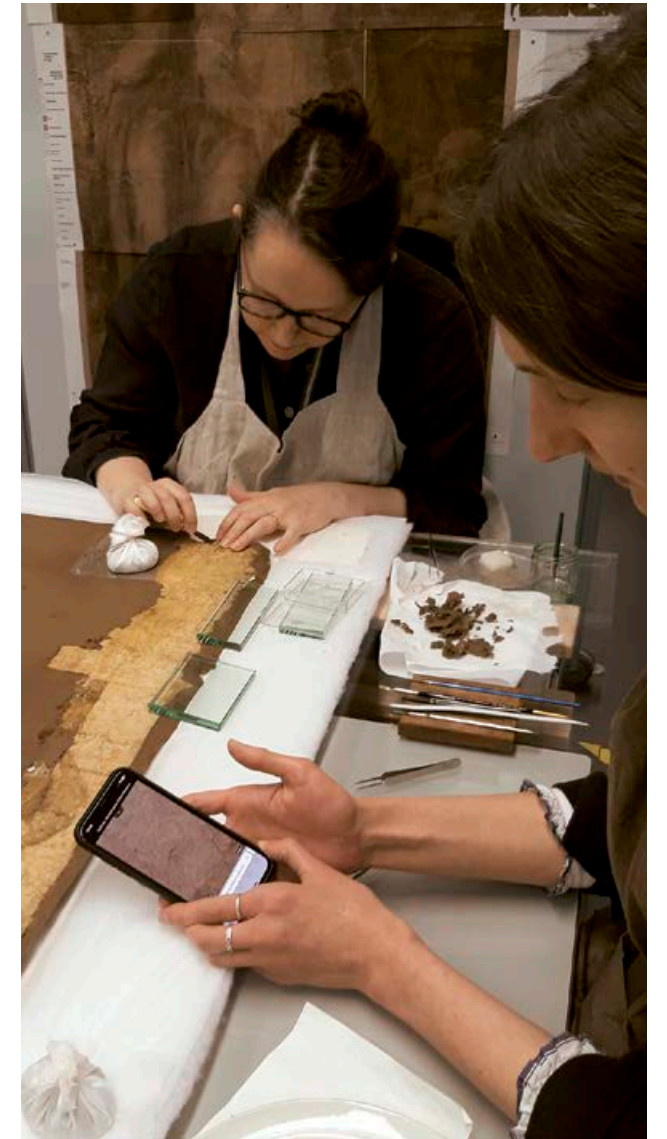


In early 2023, the team at the British Museum began the removal of the cartoon's degraded 19th-century backing paper. As the cartoon is large and fragile, they were unable to turn it to check the front, as they were working. The 2019 scans of the surface proved invaluable during this conservation process, allowing conservators to view the scans on their mobile phones while working on specific areas of the cartoon.

To facilitate the conservation process, the British Museum asked Factum to create variations on the images, such as mirrored versions of the cartoon, to overlay on other layers of data, making the process more intuitive.

A new version of the multi-layered viewer has been updated with this information. Recording the surface of a painting before any physical intervention is essential for a deeper understanding of an object undergoing changes, and this project is a perfect example of such an application.

Left: Detail from the high-resolution viewer provided to the British Museum. Right: The British Museum team using the scans of the cartoon during the conservation process.



Recording in the Hirayama Studio

At the British Museum, London

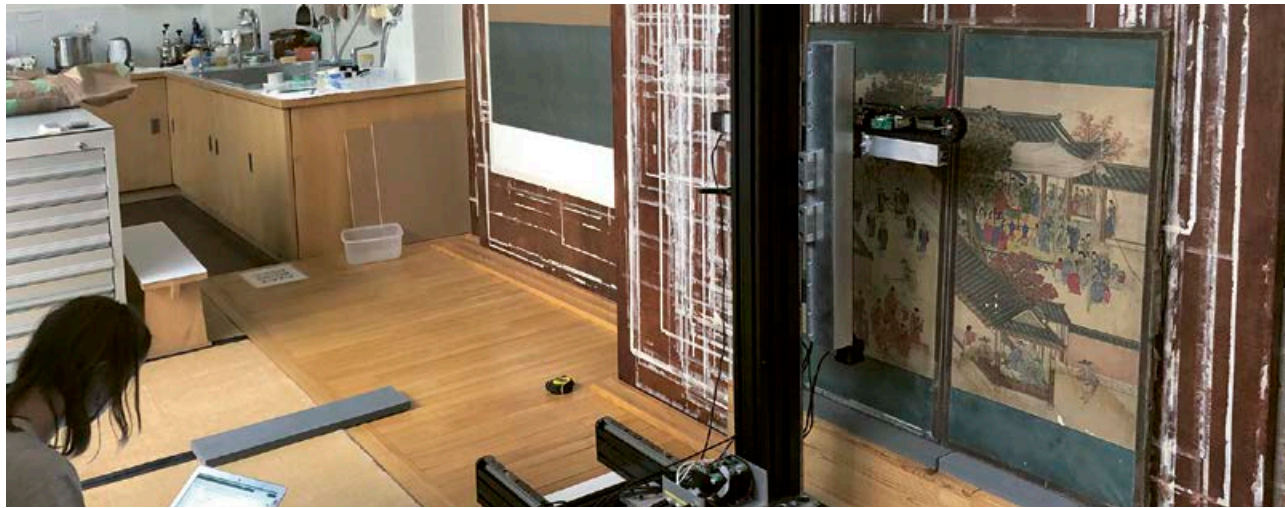
In July 2019, Factum Foundation was invited to carry out two recordings at the British Museum's Hirayama Studio – a specialist studio for the conservation of East Asian paintings. Conservators at the Hirayama Studio employ traditional East Asian scroll-mounting techniques combined with digital technology and contemporary approaches to cultural heritage conservation; aligning with Factum's approach to preservation in the combination of digital and traditional methods.

Hirayama conservators were working on an exquisite 14th-century Japanese scroll-painting – *Amida sanson raigo zu* (BM 1938,0108,0.1) – depicting Amida (the Japanese name for the celestial buddha Amitābha) on a lotus pedestal, with two attendant bodhisattvas. The painting falls within the Japanese *raigō-zu* genre, in which Amida, accompanied by bodhisattvas, descends on clouds to greet the dying. The Hirayama Studio was particularly interested

in using 3D scanning to investigate the cut-gold leaf, or *kirikane*, used to decorate the figures' garments.

A second object was also recorded at the Hirayama Studio: two panels from a 19th-century Korean screen (BM 2016,3028.1) of *pyeongsaeng-do* (scenes of daily life) depicting successful stations in a man's life. *Pyeongsaeng-do* consist of six or eight painted scenes. This two-panel screen is likely part of a larger screen: the right panel reflects a 60th wedding anniversary, while the left panel commemorates the 60th anniversary of an unknown official passing the civil service examination. The screen is of particular interest to conservators because it has retained its original cotton support.

Recording the surface of the 19th-century screen painting using the Lucida 3D Scanner (top). Recording the colour of the 19th-century screen painting (bottom).



Easter Island

At Museo Antropológico Sebastián Englert, Hanga Roa

In early March 2020, a team from Factum Foundation travelled to Easter Island to collaborate on a series of projects with the Museo Antropológico Sebastián Englert.

The first items to be recorded were a collection of painted stone panels from the Birdman Cult period that were removed from their original location at a site called Orongo by the Thomson expedition in 1886. The team also recorded the only female Moai on the island of Rapa Nui, some petroglyphs, and an unusual object that is believed to be the eye of one of the giant Moai.

The trip was made possible by a generous donation from Sir Paul Ruddock. Further projects on the island and a training initiative were discussed with Francisco Torres Hochstetter and members of the indigenous community who oversee the care of cultural heritage on the island.

Top: Ferdinand Saumarez Smith recording one of the painted stone panels from the Birdman Cult period. Bottom (from left to right): The only female Moai on display inside the Museo Antropológico Sebastián Englert, and 3D render. Render from the 3D model of the 'eye' from the Museo Antropológico Sebastián Englert.



Philip Herbert, 4th Earl of Pembroke, and his Family by Van Dyck

At Wilton House, Wilton

Philip Herbert, 4th Earl of Pembroke, and his Family (1635) is the largest painting made by Anton van Dyck, a portrait of the 4th Earl of Pembroke, his wife and children. All figures are slightly larger than life-size, and the impressive painting dominates the so-called Double Cube Room at Wilton House, the Pembroke's ancestral home for over four and a half centuries.

In March 2020, before museums closed across the UK, a team from Factum Foundation recorded the portrait using the Lucida 3D Scanner and panoramic composite photography. Through a high-resolution recording in 3D and colour, it is possible to generate an archive of the

painting's surface as a resource for conservation, study and dissemination purposes. The data now belongs to the owner of the painting and could also be used to make an exact facsimile of the painting if required in future.

During the recording, it was noted that airflow and air pressure fluctuations in the room were causing slight movements of the surface of the canvas, which were picked up by the scanner but were hardly noticeable to the naked eye. Observations of this kind illustrate the importance of recording for long-term preservation of paintings.

Gabriel Scarpa recording the colour using panoramic composite photography.



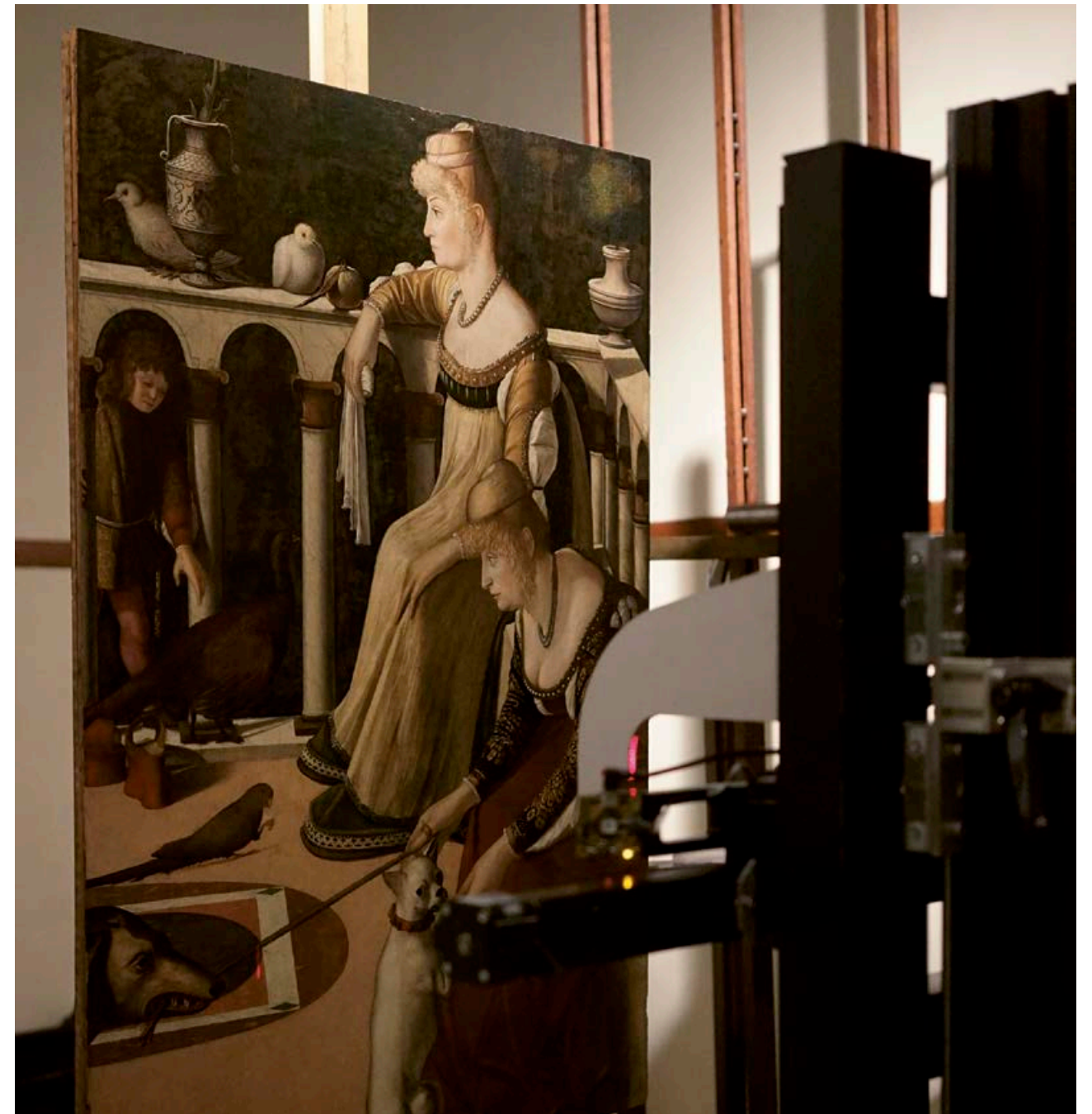
Two Venetian Ladies by Vittore Carpaccio

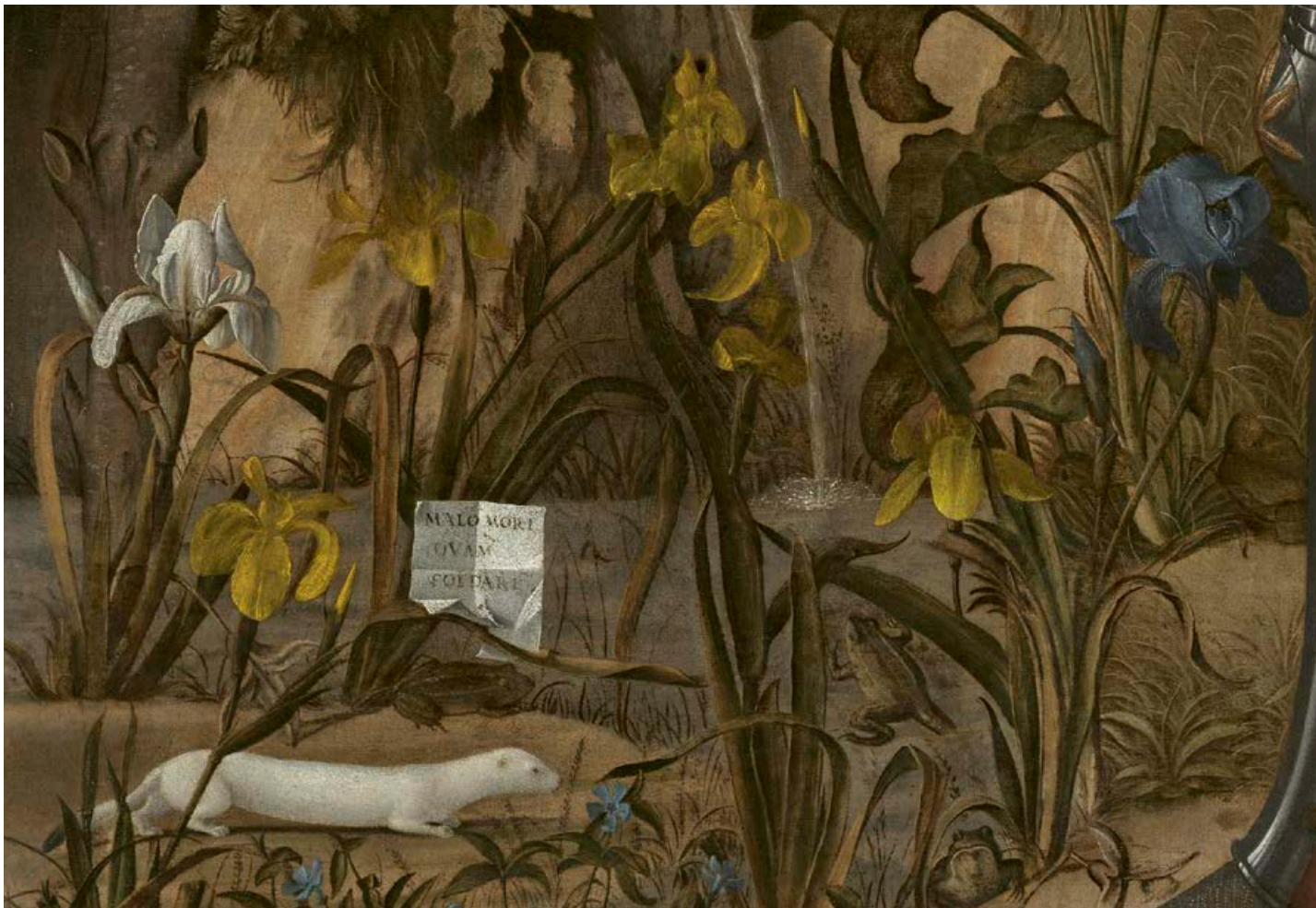
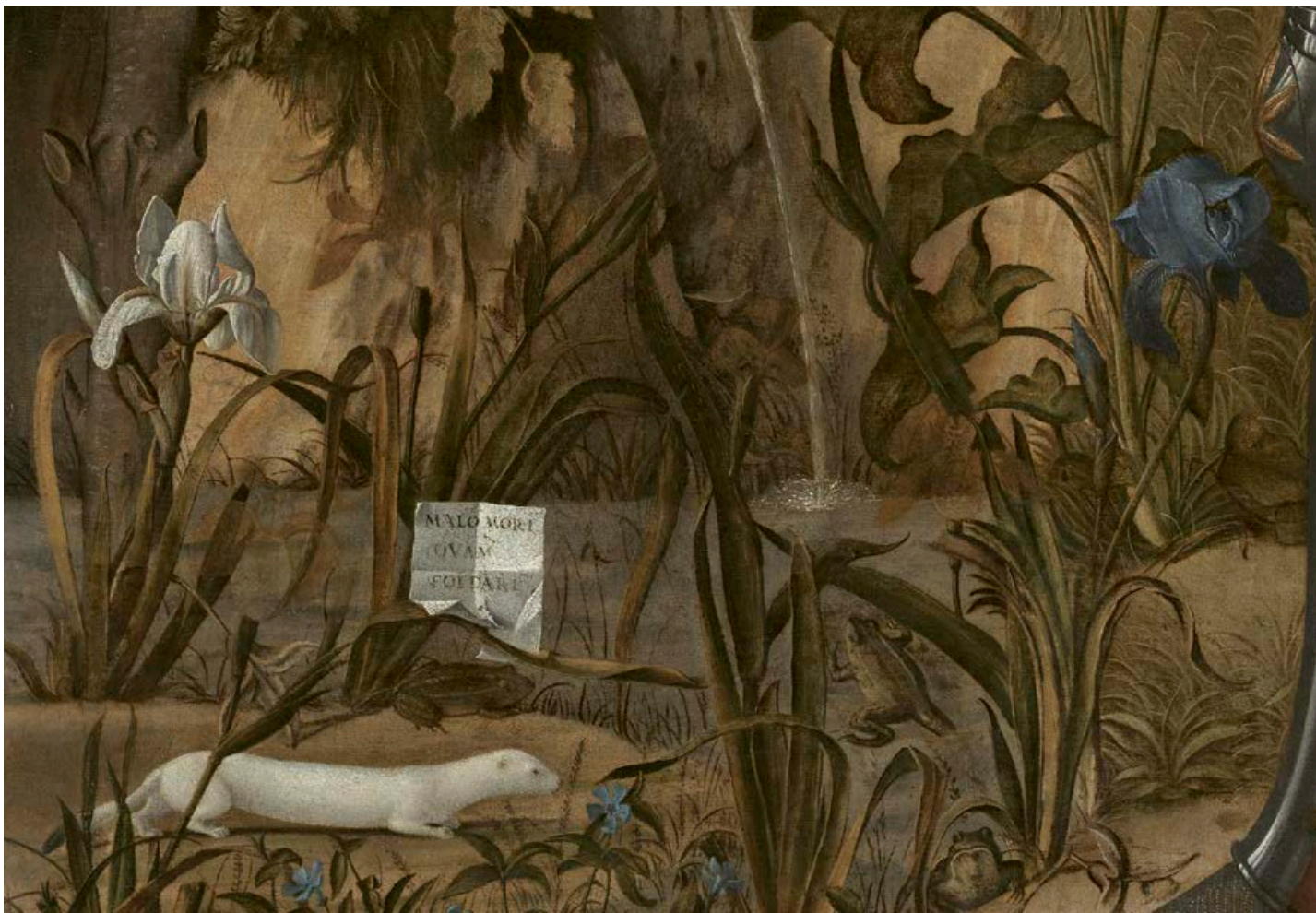
At the Museo Correr in Venice

Between 2020 and 2021, Factum Foundation worked on a panel painting by Carpaccio that had been cut into two pieces. The aim is to record both fragments and understand how much of the painting has been lost. The painting known as *Two Venetian Ladies* (c. 1490), located at the Museo Correr in Venice, is the lower half of the painting. The upper half *Hunting on the Lagoon*, is at the J. Paul Getty Museum in Los Angeles, California.

The recording in the Museo Correr has been completed. The recording in the Getty Museum is still awaiting permission. When they have both been recorded, the data will be used to make a facsimile of the two panels as one, as originally intended. It is hoped that a facsimile of the reunited image could be shown in each institution alongside the original fragments.

The Lucida 3D Scanner recording the surface.





RECORDINGS

Young Knight in a Landscape by Vittore Carpaccio

At the Museo Nacional Thyssen-Bornemisza, Madrid

Working with the Museo Nacional Thyssen-Bornemisza, Factum Foundation recorded the *Young Knight in a Landscape* (1510) by Vittore Carpaccio. The painting is one of the most celebrated works in the museum's collection and, if considered a portrait, is the first known example in which the sitter is depicted full-length in western painting tradition.

The *Young Knight* underwent a cleaning and restoration process that formed part of the exhibition 'Carpaccio's Knight: Restoration and technical study' (May to November 2021). The Thyssen-Bornemisza's conservation team showed great interest in pushing the analysis of the painting further using Factum's high-resolution recording methods, and the *Young Knight in a Landscape* was digitised in 3D and colour in May 2021, along with its frame.

The dataset was handed over to the museum's team and now serves as a point of reference for any future analysis

and research, while the museum retains full ownership of the data recorded by Factum Foundation.

Botanist Eduardo Barba then worked with Factum Foundation's Eduardo López, proposing a digital restoration of the shade of the yellow irises on the bottom left side of the painting. The opacity and colour of the pigment has been lost due to oxidation and previous restoration attempts, but thanks to the use of non-contact digital restoration, new layers of information have been unveiled without imposing upon the original. As the yellow irises reappear, the spatial complexity is transformed, ushering a new balance in the composition with the white Iris, the piece of paper and the white ermine, now contextualised by the yellow flowers.

The Lucida 3D Scanner recording the surface.

Opposite: The original colour and proposed digital restoration of the yellow irises.



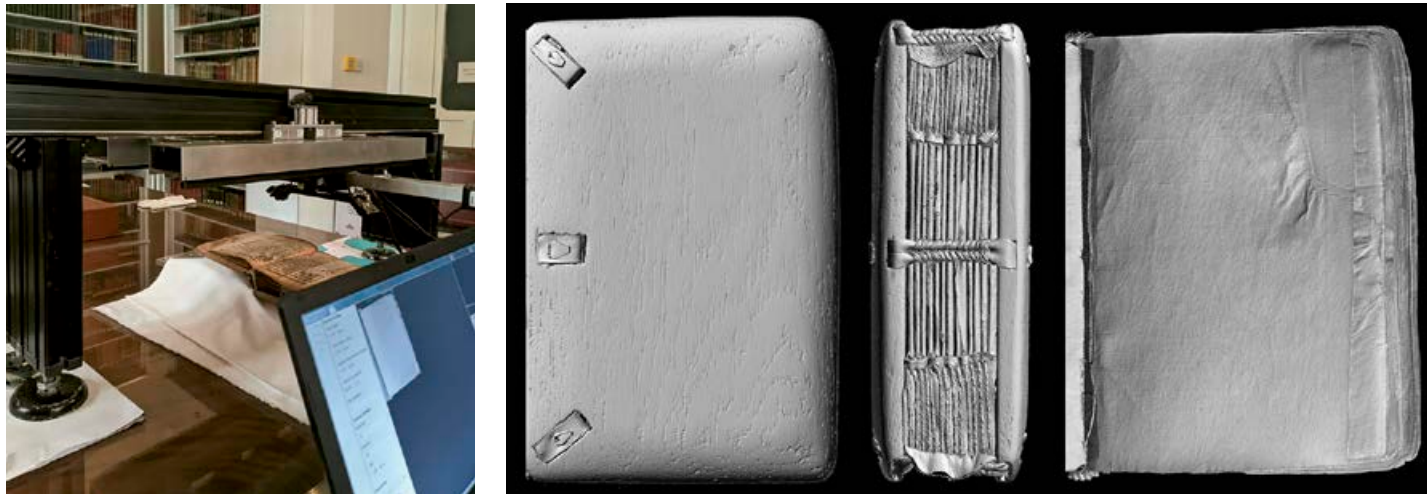
Glosas Emilianenses

At the Real Academia de la Historia, Madrid

Factum Foundation worked with the Fundación San Millán de la Cogolla on the digitisation of the *Glosas Emilianenses*, in Madrid's Real Academia de la Historia. The *glosa* (annotations) in the Codex Emilianense 60 manuscript are considered to be the earliest surviving Castilian-language text. Factum Foundation initially recorded several pages of the *Glosas Emilianenses* in high-resolution, accurately photographing the colour and using the Lucida 3D Scanner for the surface texture. The aim of the project was to enable further philological investigation into the parts that, until then, had been proving more difficult to read.

After recording the whole manuscript in high-resolution, Factum Foundation worked with paper conservator and bookbinder Pedro Barbachano on the production of a facsimile of the Codex Emilianense 60 (Real Academia de la Historia) for the Fundación San Millán de la Cogolla. The color information on the pages was printed with Factum's flatbed printer, and each page was hand-finished and varnished in Factum's workshop before being stitched into a custom-made facsimile of the book's wooden cover.

Top left: The Lucida 3D Scanner recording the surface. Top right: Lucida data from the wooden cover and side view of the closed manuscript. Bottom: Silvia Álvarez working on the final touches of the facsimile before the binding.



La Sapienza by Titian

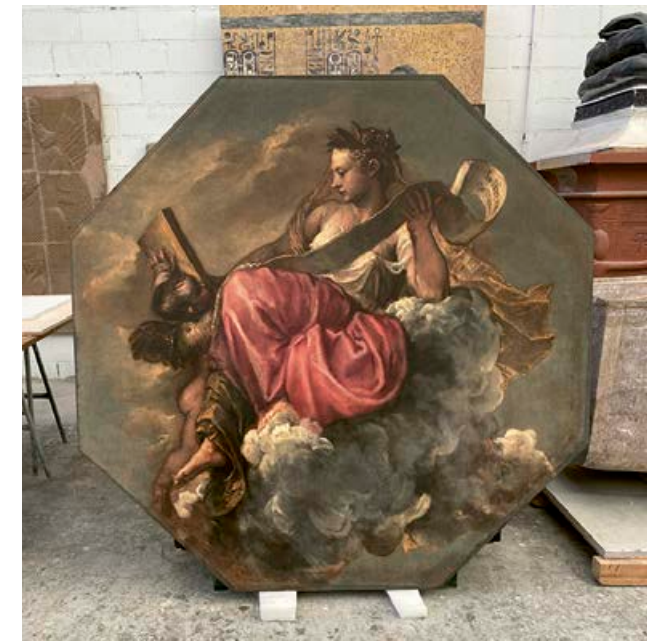
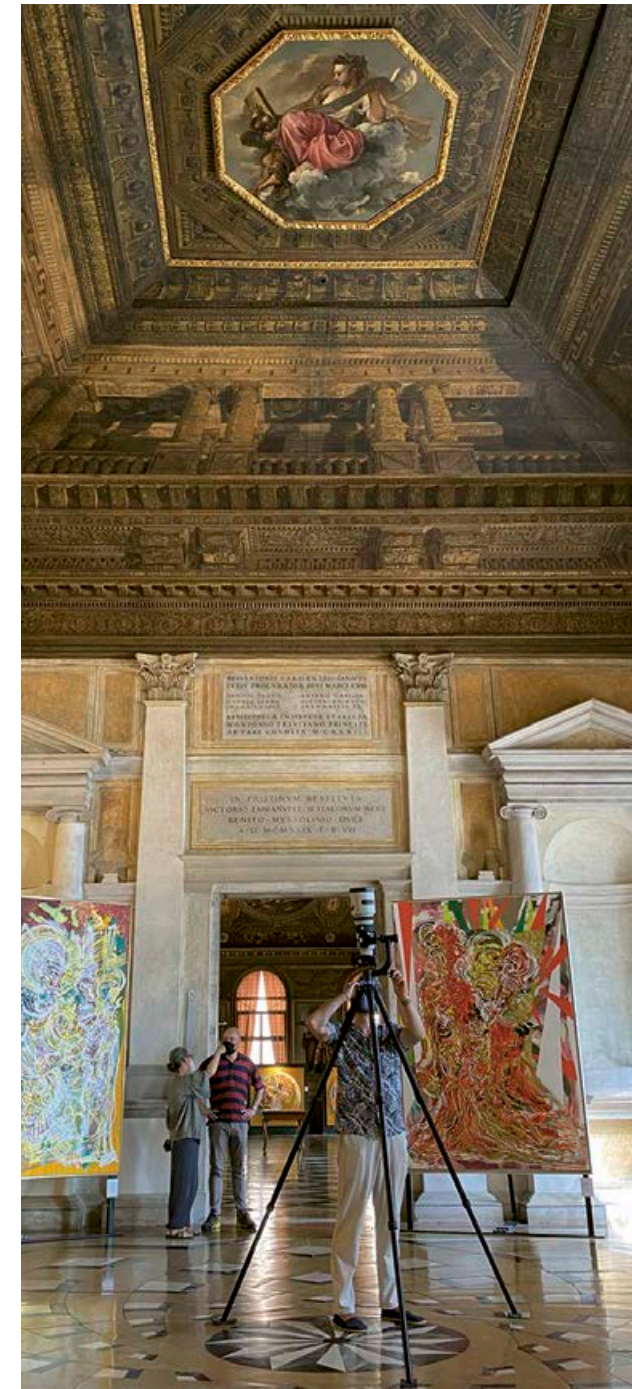
At the Biblioteca Marciana, Venice

Titian's *La Sapienza* (c. 1560) at the Biblioteca Marciana, Venice was taken down to be shown in the exhibition 'Tizians Frauenbild' (5 October 2021 – 16 January 2022) at the Kunsthistorisches Museum, Vienna.

Factum Foundation made a facsimile of the painting to replace the original for the duration of its absence. The recording was carried out in June 2021, using composite

photography, and the facsimile was displayed on the vaulted ceiling during the period the original was in Vienna. The facsimile display in Venice also enabled the exhibition to tour to Palazzo Reale, Milan (23 February – 5 June 2022).

Left: Gabriel Scarpa recording the colour of Titian's *La Sapienza*. Right: Silvia Álvarez working on the edges (top) and final facsimile in Factum's workshop (bottom).

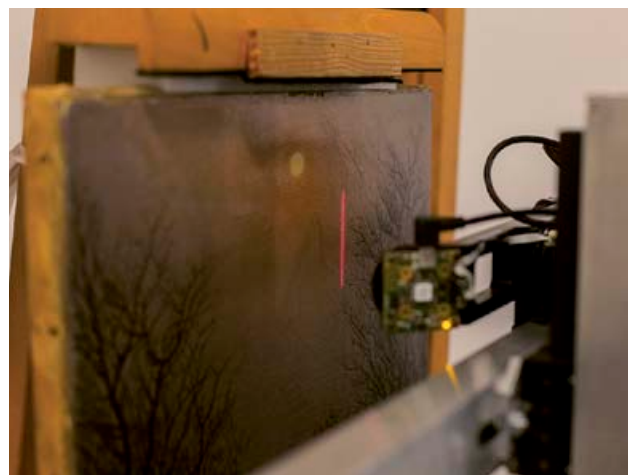
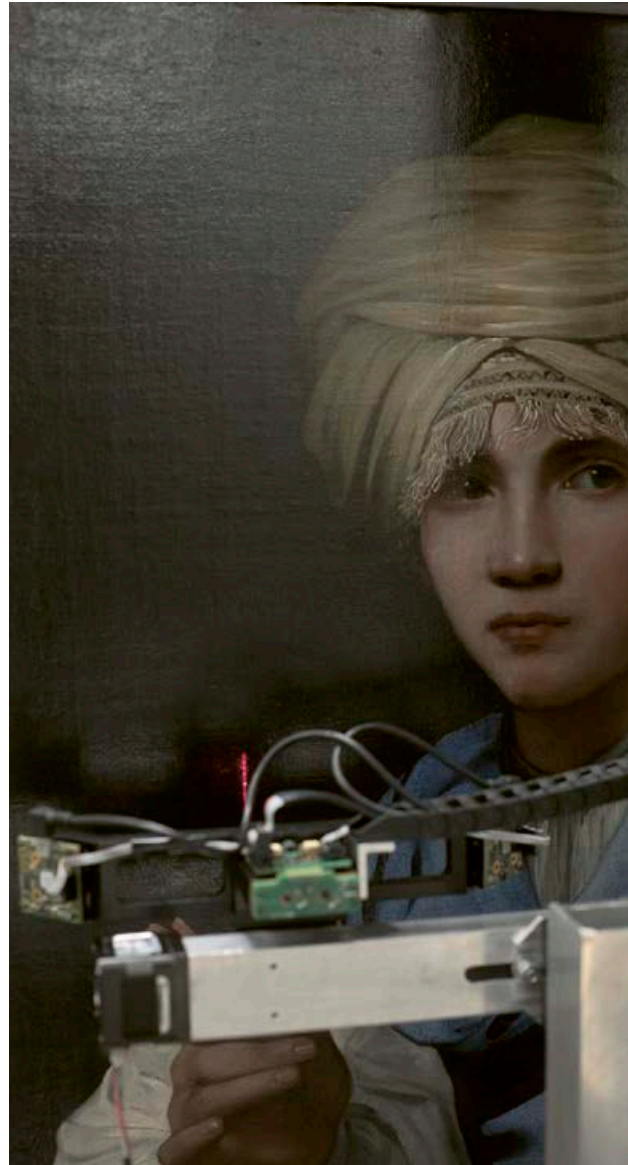


Thyssen-Bornemisza Collection for Santa & Cole

In April 2021, Factum Foundation worked with the Museo Nacional Thyssen-Bornemisza in Madrid to digitise a selection of 15 paintings in high-resolution. All works were recorded using the Lucida 3D Scanner and composite colour photography, providing extensive and accurate digital information about their surface that will form part of their condition report for future study or restoration.

The selection was also rematerialised as facsimiles in collaboration with the design studio Santa & Cole. These facsimiles are for sale in Santa & Cole shops and a new project is being launched with MNAC that will demonstrate how facsimiles can generate revenues for the museums involved.

Left: The Lucida 3D Scanner recording the surface of *Composition XX* by Theo van Doesburg. Top right: Detail of the Lucida 3D Scanner recording the surface of *Boy in a Turban holding a Nosegay* by Michiel Sweerts. Bottom right: Detail of the Lucida 3D Scanner recording the surface of *Easter Morning* by Caspar David Friedrich.

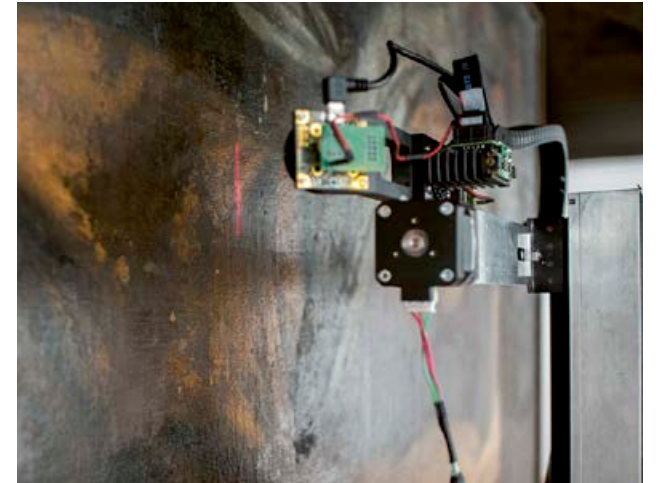


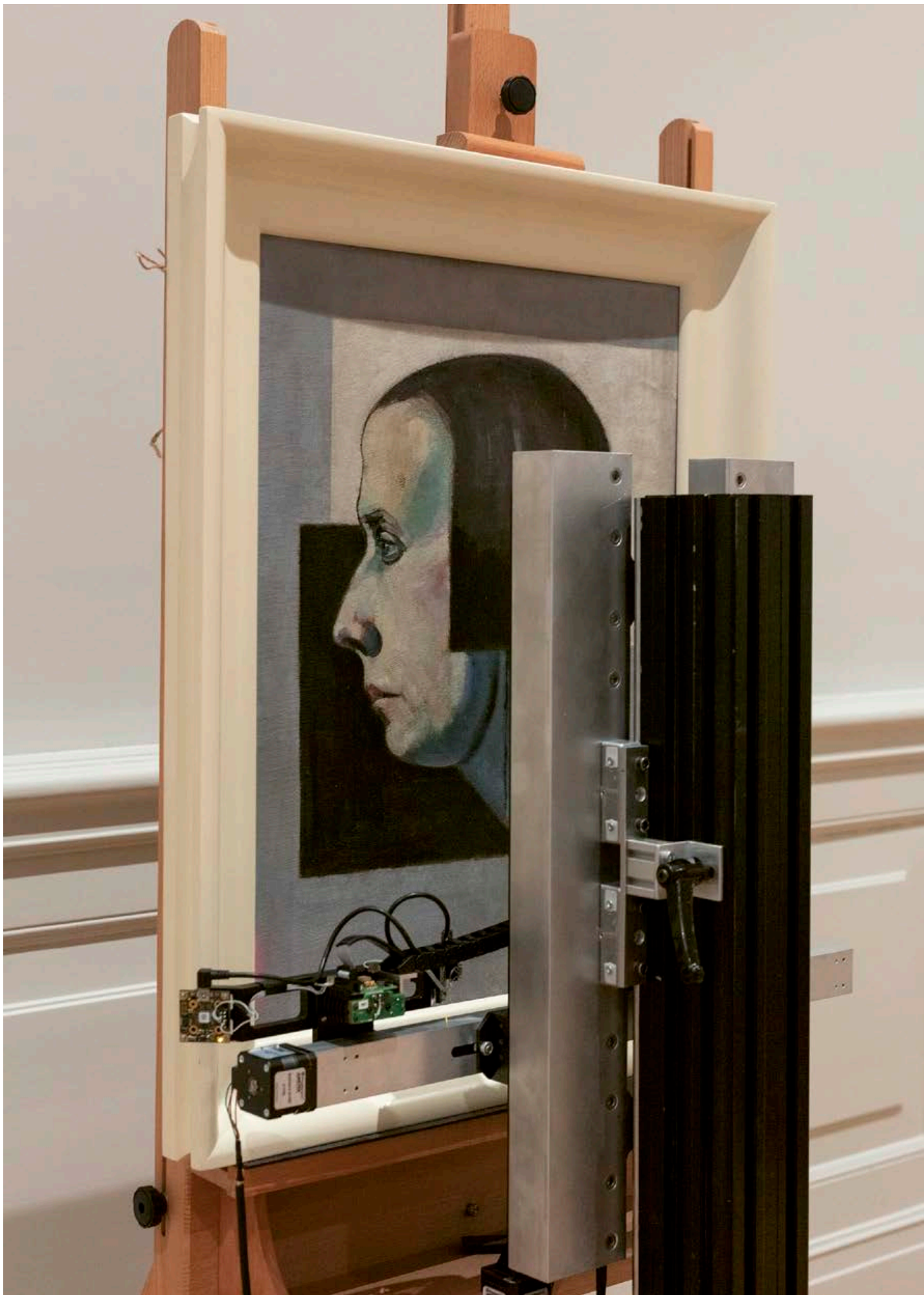
A copy of *Crucifixion of St Andrew* by Caravaggio At the Museo de Santa Cruz, Toledo

Following conversations about the extraordinary painting of the *Crucifixion of St Andrew* with Dean Yoder, Conservator of Paintings at the Cleveland Museum of Art where the original hangs, a copy of the painting in the Museo de Santa Cruz in Toledo was recorded in 3D and colour.

The painting in Toledo – in poor condition but of great interest – is one of three copied versions of the original. In 2021, it was digitised in 3D and colour, using the Lucida 3D Scanner and composite photography, over a period of four days. A detailed study of the painting is now ongoing.

Top: Recording the surface of the *Crucifixion* using the Lucida 3D Scanner. Bottom: Detail showing the merged colour and surface data (left) and the 3D data (right).





RECORDINGS

Museum De Lakenhal Collection

In November 2022, as part of a seminar organised by the Centre for Global Heritage and Development at Museum De Lakenhal in Leiden, a team from Factum Foundation recorded two paintings by Theo Van Doesburg using the Lucida 3D Scanner and composite photography.

- *Portrait of Pétro (Nelly van Doesburg)*, c. 1922, oil on canvas, 64.3 x 48 cm
- *Contra-Composition VII*, 1924, oil on canvas, 65.8 x 65.8 cm

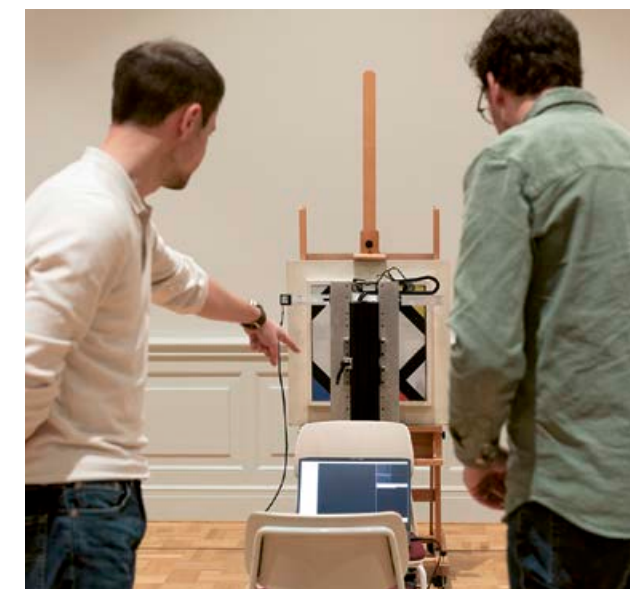
Both the surface layer and 3D recording were acquired in high-resolution, and the data will be used to help the preservation of the two paintings.

Carlos Bayod Lucini, Project Director at Factum Foundation, later presented Factum Foundation's work at the seminar, illustrating the potential of high-resolution 3D recording for the conservation of works of art.

In addition to its collection of paintings, Museum De Lakenhal has a rich history in textiles, as the building used to function as a quality inspection hall for cloth during the 17th and 18th centuries. From this period, 33 sample books (1690 – 1791) remain in the collection. These books were used to keep track of the dyeing quality of black woven woollen fabrics. Each volume includes two rows of approved fabric samples adhered with sealing wax and accompanied by information such as the name of the dyer, the dyeing quality of the fabric, and the date of inspection.

Left: Surface recording of *ContraComposition VII*. Right: Render of one book page.

Opposite: Surface recording of the *Portrait of Pétro*.





The main issue facing these sample books is a strong deformation of the pages caused by the relief of the wax and cloth. Each page has a distinct wave-pattern (see left), and the level of this deformation varies between volumes. Even within the volumes themselves, each page has its own wave style. These books are therefore difficult to open without inflicting further damage. The fabric samples that sit alongside the information add to the complexity of studying these historical objects, as they risk being ripped from the page when turning the pages of the book.

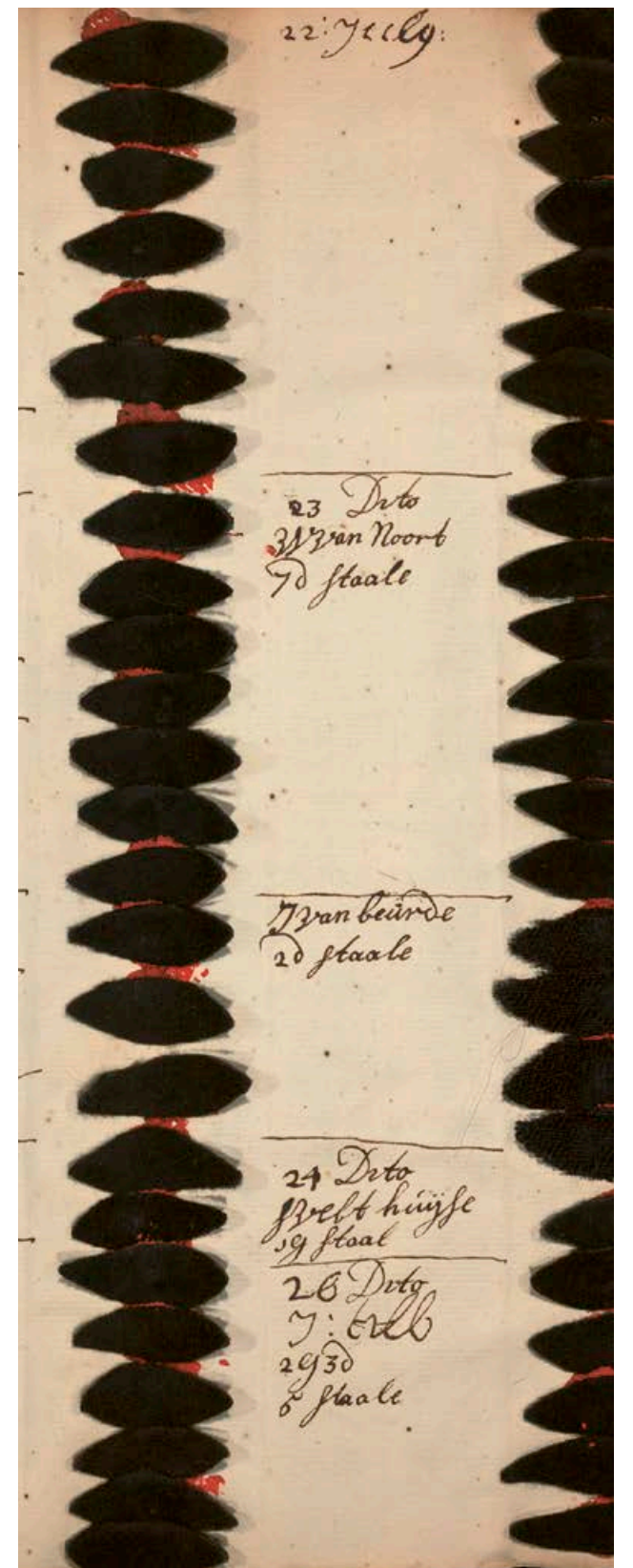
The complications faced when handling such delicate artefacts has hindered research. It was therefore desirable to digitise the collection to increase accessibility. Funded by Metamorfoze, Museum De Lakenhal started a research project to explore how the books could be safely digitised in their current, deformed condition. Factum Foundation has been involved in digitally recording, digitally flattening and making the content of these archival volumes available to a new generation of researchers.

The Lakenhal sample books are very valuable, both as research objects for art historians, and for historians focusing on fabric manufacturing and trade (such as dyeing techniques, quality of material, and information on the makers of these fabrics). The book collection spans almost 100 years, providing significant evidence of alterations in production and quality.

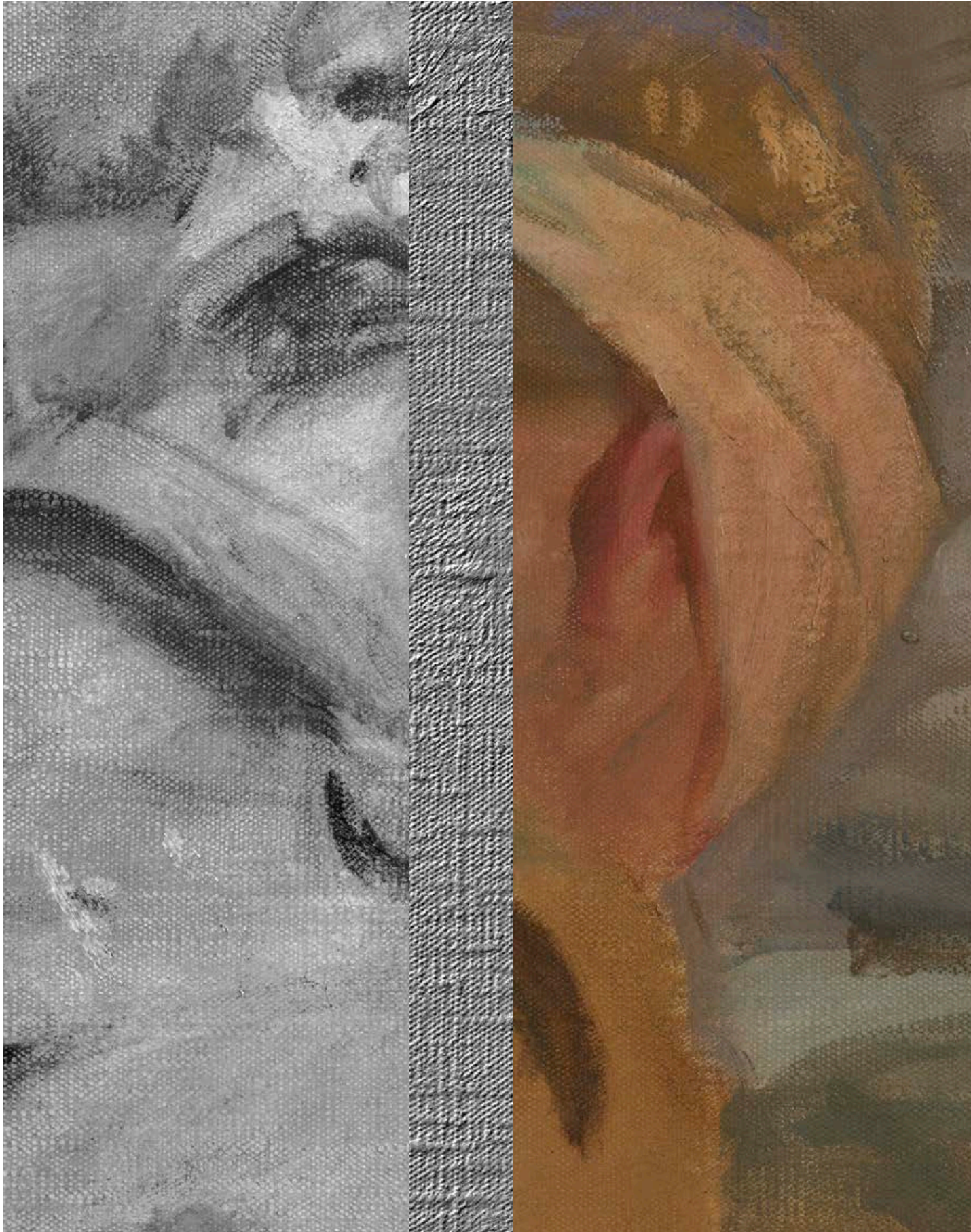
PROCESS

This complex and delicate digitisation task began in December 2022 with a photogrammetry test on a heavily distorted page. This test facilitated the assessment of the best methodology to virtually flatten the books in post-processing, making the text readable again. This initial test paved the way for the next steps in the collaboration. In July 2023, two of Factum Foundation's technicians conducted the scanning of a total of 15 pages from eight different volumes in high-resolution. They used both close-range photogrammetry and the Selene System. The results of these preliminary tests are promising, and will help determine the specific methods to be applied if the rest of the volumes are to be digitised.

The Selene Photometric Stereo System, developed by Jorge Cano and Factum's engineering team, is proving to be essential for the rediscovery of information hidden on the surface of manuscripts. This project is helping to demonstrate that historical books need to be recorded as three dimensional, dynamic, material objects. This approach is revealing the layers of meaning that co-exist with the text, in this case manuscript notations accompanying cloth samples.



Detail of a digital flattening test. Opposite: 3D model showing a lateral view of one of the volumes (top). Recording with the Selene PSS (bottom left) and a detail of the gutter of one of the books (bottom right).



Gassed by John Singer Sargent At the Imperial War Museum, London

In May 2023, the Imperial War Museum reached out to Factum Foundation to carry out the high-resolution recording of *Gassed* by John Singer Sargent, considered one of the most important works of art to emerge from the horrors of World War I. The imposing painting, measuring 2.3 m x 6.11 m, depicts British soldiers after a mustard gas attack, seeking treatment. An improvised game of football is going on in the background while biplanes, painted with extraordinary economy and realism, fly overhead.

The recording was planned as part of a major restoration of the painting that has revealed the original colours suppressed under a layer of yellowed varnish. The high-resolution data of the painting's surface and colour acquired by Factum Foundation will form part of the artwork's conservation

history, providing evidence of Sargent's working method and his great technical facility. The restored painting was revealed in the Imperial War Museum's new Blavatnik Art, Film and Photography Galleries in November 2023.

Over the span of a week, Marina Luchetti and Celestia Anstruther recorded the surface of the painting using two Lucida 3D Scanners working in tandem (a usual practice to efficiently record the surface of large paintings), while Gabriel Scarpa acquired the accurate colour using composite photography.

Top and left: Surface recording. Bottom right: Marina Luchetti and Celestia Anstruther showing the data of the painting scanned with the Lucida in real time to the Imperial War Museum staff.

Opposite: Different datasets of a detail of the painting, from left to right: infrared, shaded render, colour.





Two bronze Ephesos from Pedro Abad With IAPH and the Museo Arqueológico de Córdoba

Factum Foundation and IAPH have initiated a collaborative framework to aid in the preservation of cultural heritage managed by the Andalusian Institute of Historical Heritage.

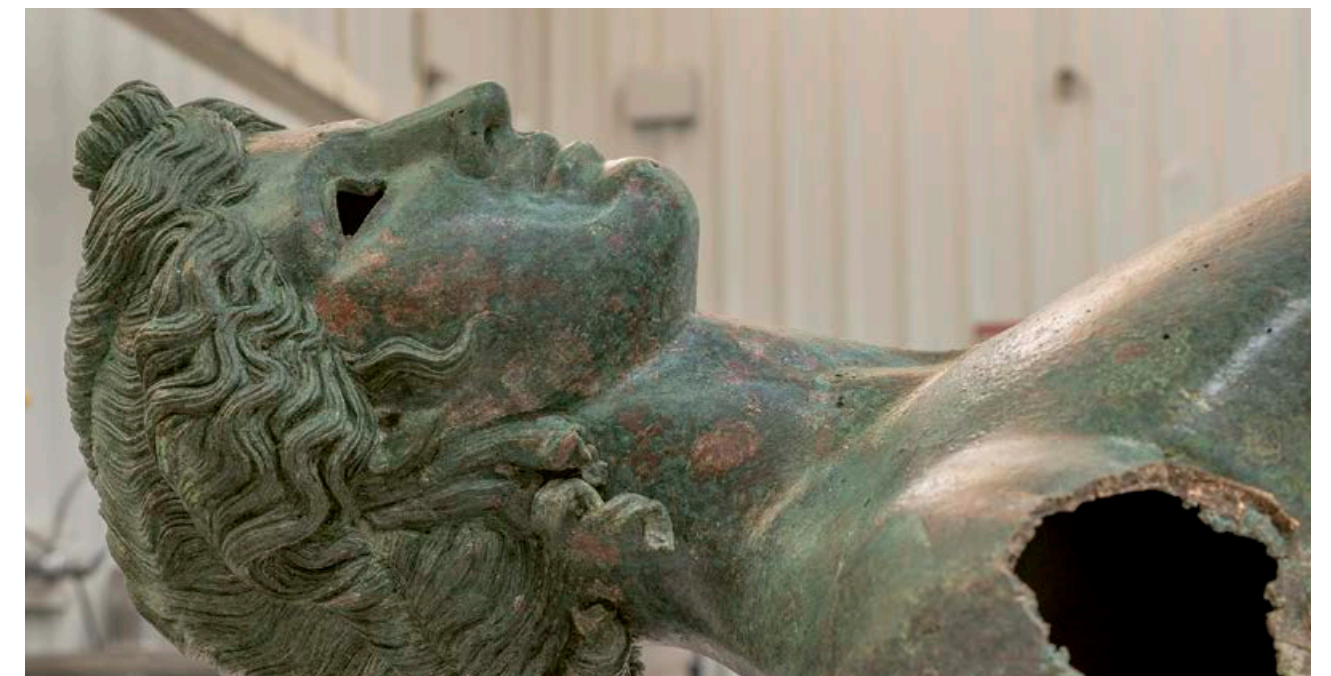
The first of several planned recordings was the digitisation of the two Roman bronze ephesos from Pedro Abad (Córdoba). The project is part of the study carried out by IAPH in their workshops in Seville, part of an R&D conservation programme sponsored by Fundación Magtel. The study aims to learn more about this type of artwork and assist in the restoration process before the sculptures return to Museo Arqueológico de Córdoba for display.

The two sculptures from Pedro Abad were recorded in high-resolution at the end of July 2022 by Pedro Miró, Imran Khan and Ana Carrasco Huertas using photogrammetry and white-light structured scanning.

The study of the two sculptures by IAPH has included analysis and identification of different materials (copper, lead, mortar, etc.) and the use of other analytical techniques, such as gammagraphy or computerised tomography, which will obtain non-visible information without affecting the integrity of the pieces: discovering hidden cracks and determining the thickness of the metal in any section are among the possibilities. The study will also include visual documentation, and possible digital restoration interventions, in addition to the exhibition of the sculptures.

The recording of both sculptures will aid efforts to reconstruct them by offering high-quality documentation of their surface and facilitating an understanding of the different distortions and damage caused by time. Having a digital model will help in analysing their posture and facilitate re-assembly, bypassing the need to manipulate the original pieces which are in a very delicate state. It will also help technicians to design internal structures to support each figure without putting unnecessary stress on the original bronze.

Top: Imran Khan recording the Dionysian ephesos using photogrammetry. Bottom: Detail of the Apollinean ephesos. Opposite: 3D model of the Apollinean ephesos before restoration.





Crucifixion by the Master of the Lindau Lamentation

At the Museum Catharijneconvent, Utrecht

The Gothic panel depicting the *Crucifixion* (c. 1425) by the Master of the Lindau Lamentation was discovered in poor condition after having been kept in the Museum Catharijneconvent depot for decades. While the panel has been cleaned of dirt and discoloured varnish, the damaged state in which it was found has prompted an analysis and investigation into the original colours, prior to the historical interventions. The background is now thought to consist of blue azurite over-painting of the original tooled gilt surface.

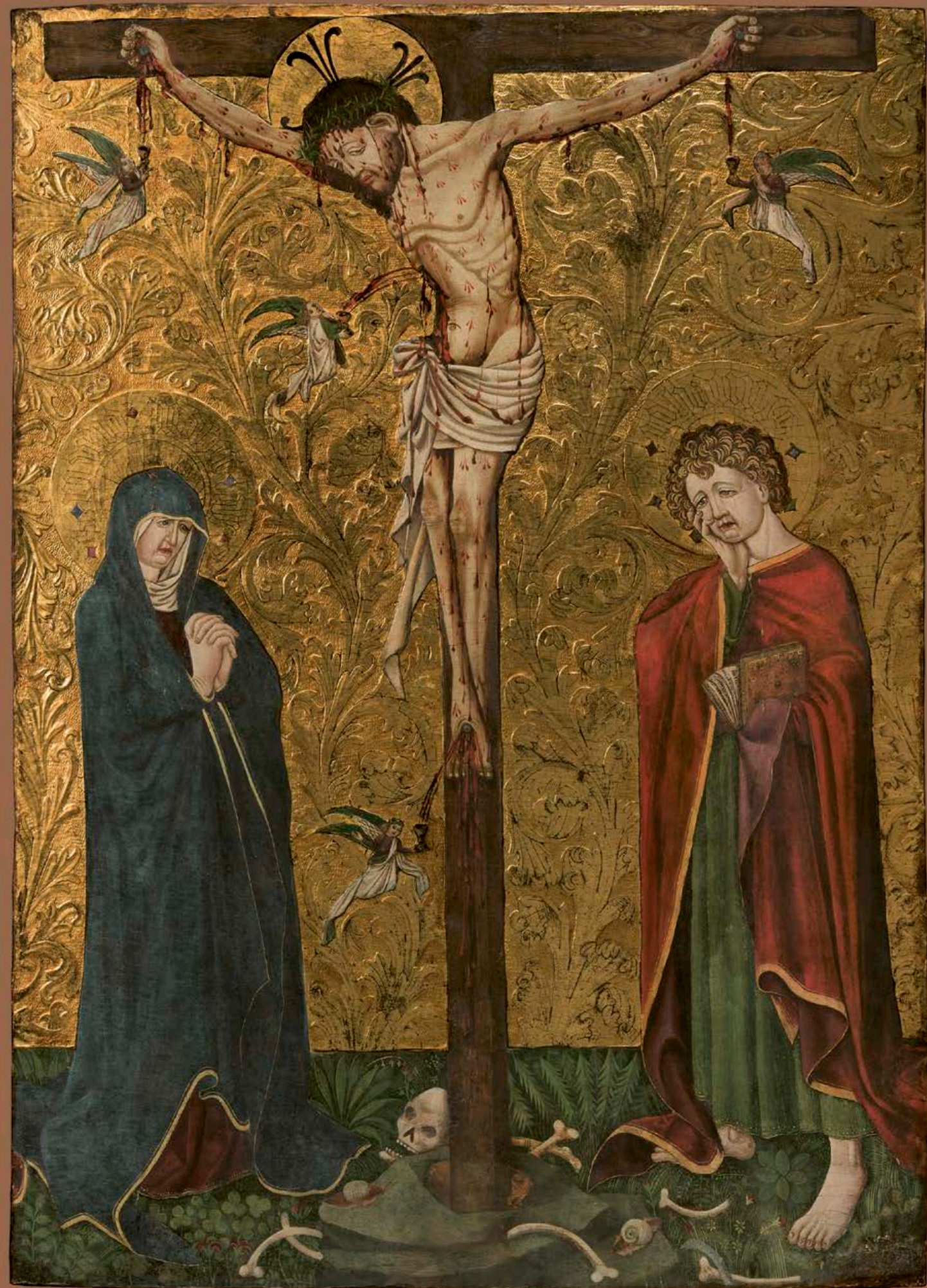
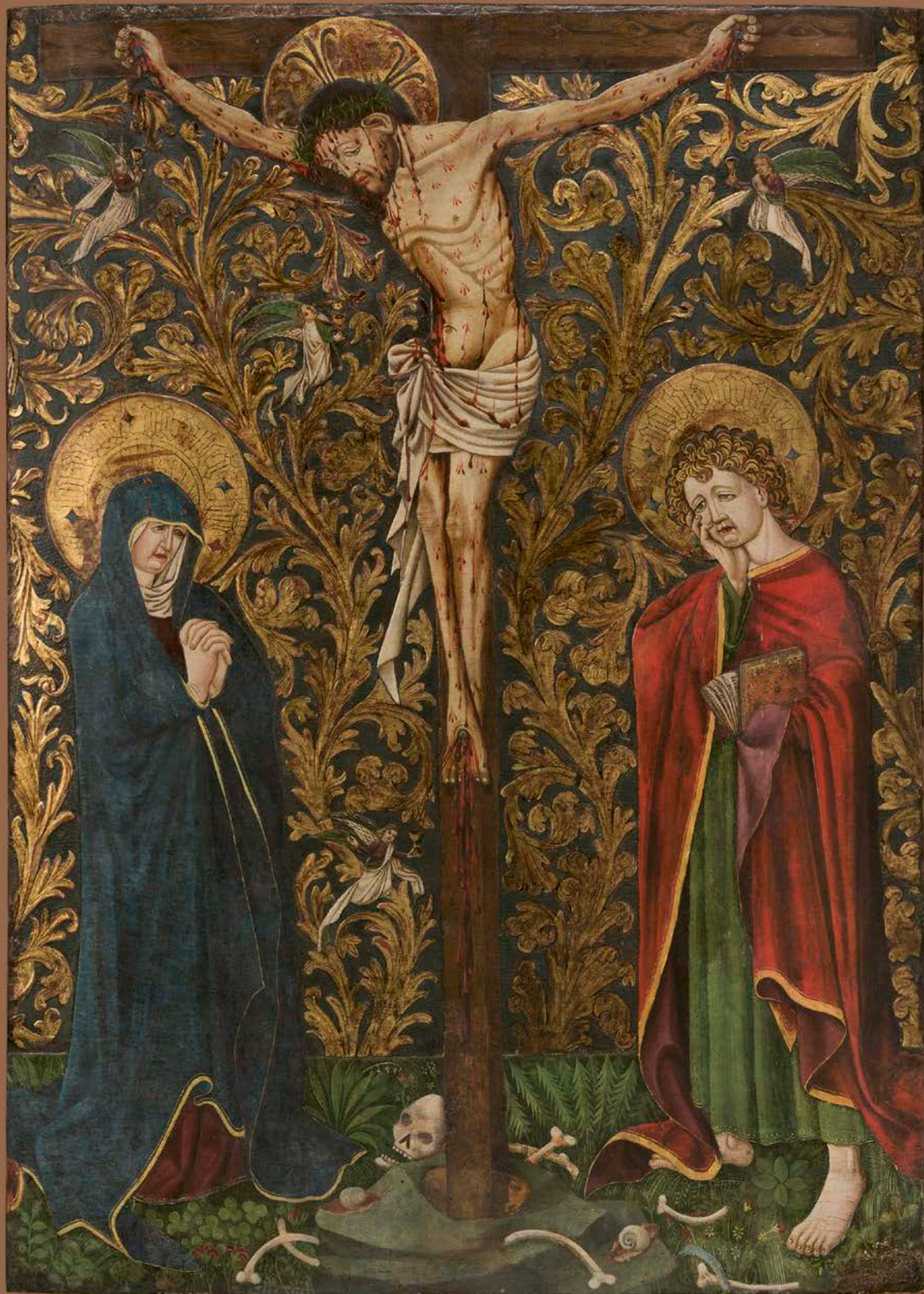
In July 2021, in collaboration with the Museum Catharijneconvent, Utrecht University, Leiden University and Technische Universiteit Delft, the Factum Foundation carried out a non-contact, high-resolution 3D and colour recording of the painting.

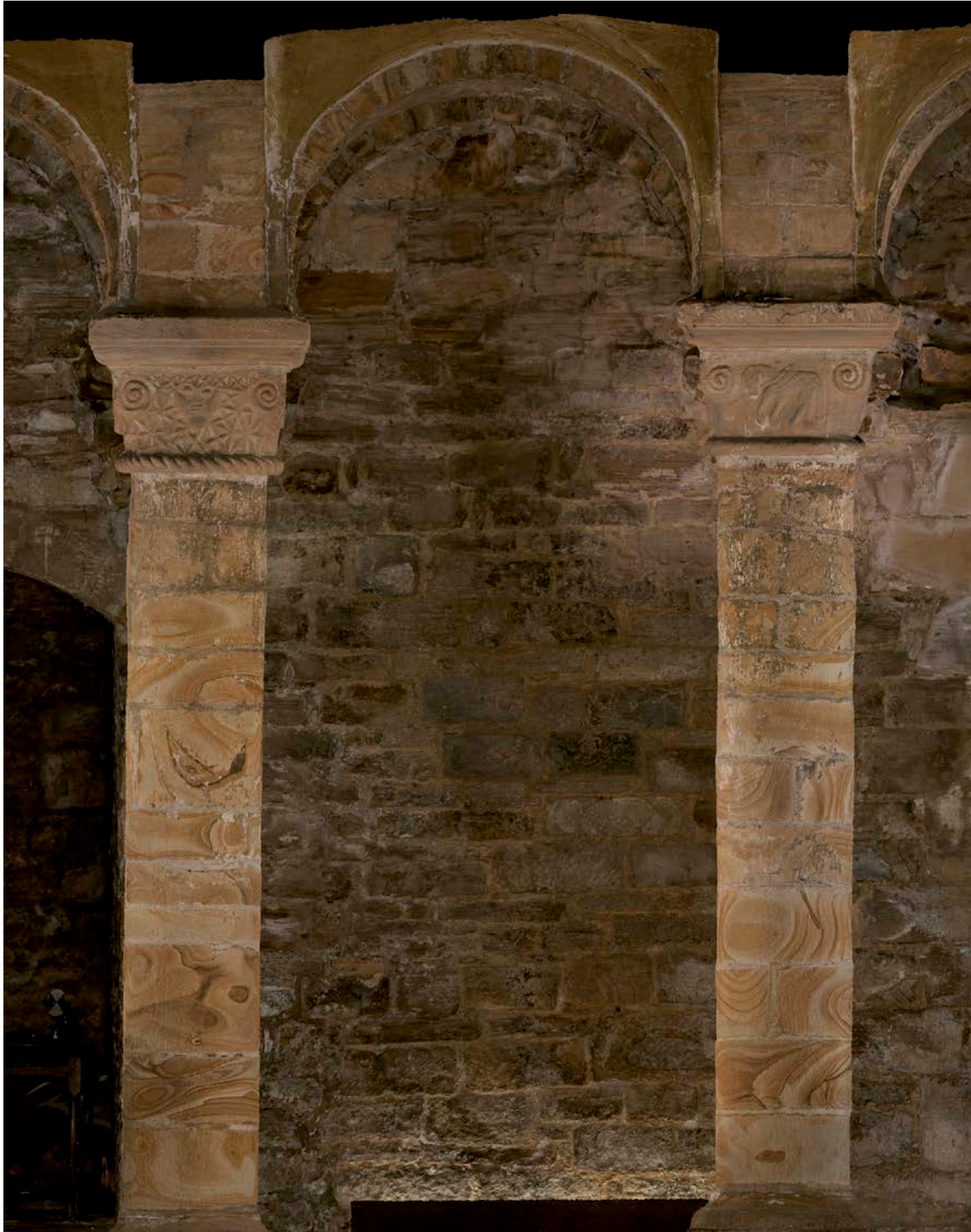
In 2022, the project moved to its next phase, with the creation of two physical facsimiles of the *Crucifixion*. A grant by the Netherlands Institute for Conservation+Art+Science has allowed academics Liselore Tissen and Sanne Frequin to use Factum's non-contact technology to reinterpret this painting using digital restoration. In November 2023, the facsimiles of both versions of the painting were the subject of a talk by Sanne Frequin to a group of experts and the Dutch royal family at the Royal Palace in Amsterdam.

3D Lucida Scanning, output tests with elevated printing, gilding tests. Opposite: Sanne Frequin and Silvia Álvarez inspecting the facsimile (top). Detail of the colour of the facsimile compared with the surface information obtained using elevated printing (bottom).

Overleaf: *Crucifixion* by the Master of Lindau Lamentation as it appears now (left) and without the overpainting on the gold background (right).







The Norman Chapel

With Durham University

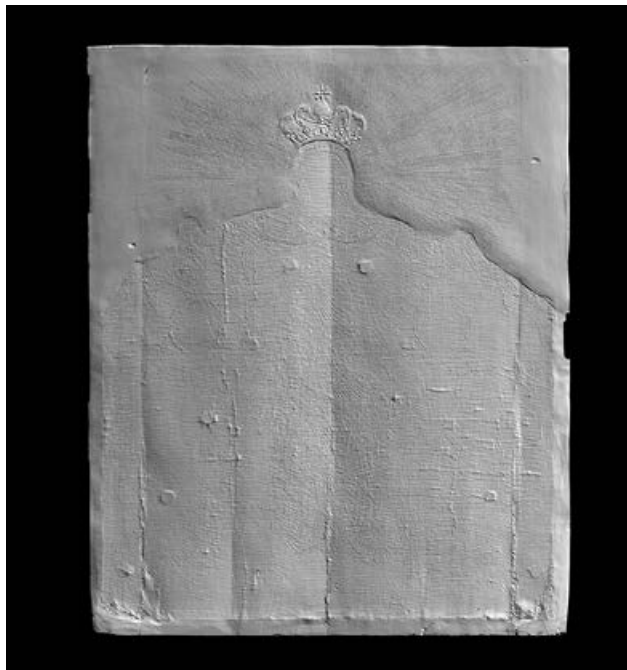
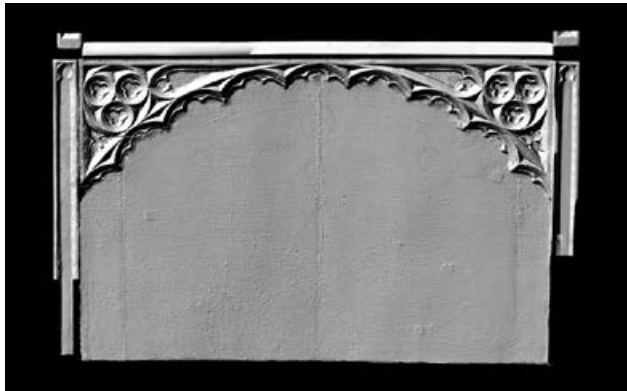
In January 2023, a team from Factum Foundation carried out the complete 3D recording, using photogrammetry and a LiDAR scanner, of the Norman Chapel inside Durham Castle, in the north of England. In collaboration with Durham University, the aim of the 3D recording is to provide further insight into the questions that still surround the making and materials used in the 11th-century chapel, in order to inform an upcoming restoration project by providing accurate surface and colour information.

During the recording process, students, experts and visitors to the Chapel were able to inquire about the technologies and methods employed by Otto Lowe and Ferdinand Saumarez Smith. The data was then processed at Factum's headquarters and given to Durham University.

Top: Shaded render of the data. Bottom left: Shaded render of a capital. Bottom right: Ferdinand Saumarez Smith recording using photogrammetry.

Opposite: Detail of the 3D model.





An innovative intervention on a panel painting by Antoni Peris

At the Museo del Prado

Enrique Quintana, Head of the Paintings Conservation Department at the Museo del Prado, approached Factum with a request to apply digital technology to the preservation of a panel painting by Antoni Peris (Valencia, 1388-1424). The panel, currently part of the Prado's collection (and, until recently, not on display) is titled *Nuestra Señora de Gracias y los grandes maestros de Montesa*, and used to act as the altarpiece in the archbishop's palace in Valencia.

How to intervene on the gilded background presented a challenge for the conservators at the Prado: the image of the Virgin was significantly altered during a 19th-century restoration, shifting the meaning of the artwork as a whole. Any direct intervention to remove these recent additions would have resulted in the permanent elimination of a layer in the painting's historic trajectory, imposing in its place a new subjective interpretation. This is an example of the role digital technology can play in the preservation and understanding of works of art.

Instead of performing a physical removal of the non-original background, the project defined by the Prado and Factum's experts consisted of making a 'new background', a textured skin to cover the panel's background, thus avoiding the need of transforming the painting forever. The surface characteristics of the skin have been taken from the 3D scanning of the gilded background of other original panels that still form part of the altarpiece in Valencia. The general craquelure, as well as details of pouncing that decorate the background in the other panels by Peris, were adapted to the shape and dimensions of the panel in the Prado. This initiative has made it possible to present the painting in a way that resembles its original appearance. The altarpiece is now coherent even if the alteration is new and the previous restoration remains unchanged.

The first phase of the project, carried out in July 2022, consisted of recording one of the central panels of the altarpiece in Valencia. Using the Lucida 3D Scanner, the complete panel's surface was captured in high-resolution, in order to obtain texture data that would be reworked to fit the panel in Madrid. In spite of the shiny, gilded surface of the background and frame, Lucida was able to capture every detail of the painting's surface. The recording was carried out by Carlos Bayod with Ana Carrasco (PhD candidate in the Universidad de Granada's Department of Painting). In September 2022, the panel in Madrid was recorded using the same system, with the goal of obtaining a precise

documentation of the dimensions, shape, curvature and surface of the original panel, onto which the new 'artificial' skin would be placed.

The second phase has involved an experimental combination of digital processing techniques and manual craft production. Starting from the 3D depth map of the panel scanned in Valencia, Factum's Eduardo López has reworked the surface to adapt it to the background of the panel in Madrid. This new surface was printed in 3D with the Elevated Printing technology, then cast as a semi-flexible skin containing the relief. The CNC routing of the Prado's panel was used as a base as a test during the process, thus avoiding the need to employ the original panel. Once the silhouette, thickness and other aspects of the skin were sorted, gold leaf was applied. This task, as well as the general supervision of the production process, was done by Silvia Álvarez with the help of Mar García Sánchez in constant coordination with the Museo del Prado's conservators.

In the last step of the process, performed at the Prado's workshop, the textured skin made by Factum was fixed to the original panel in a few contact points along the perimeter of the area to be covered, so the added surface could be removed in the future if required. The line of contact between the original painting and the 'new background' was reintegrated to fill the gap and guarantee a correct relation between the main figure and its surrounding area.

This innovative project is an excellent example of how digital technologies of non-contact 3D recording and fabrication can help the challenging task of art conservation. Between the direct, transformative intervention on the original and the creation of an exact facsimile, there are infinite possibilities in which old and new materials can coexist and relate to each other, opening the door to a more creative approach to preserving authenticity.

Opposite, from top left to bottom right: Detail of the original panel with the background altered in the 19th-century. Carlos Bayod scanning another original panel by Peris in Valencia, to be used as a reference for surface texture. Shaded render of the panel scanned in Valencia. Silvia Álvarez working on the reconstruction. Shaded render of the panel scanned in the Museo del Prado. Final result of the project: a new 'background' and moulded frame as a removable addition to the original.

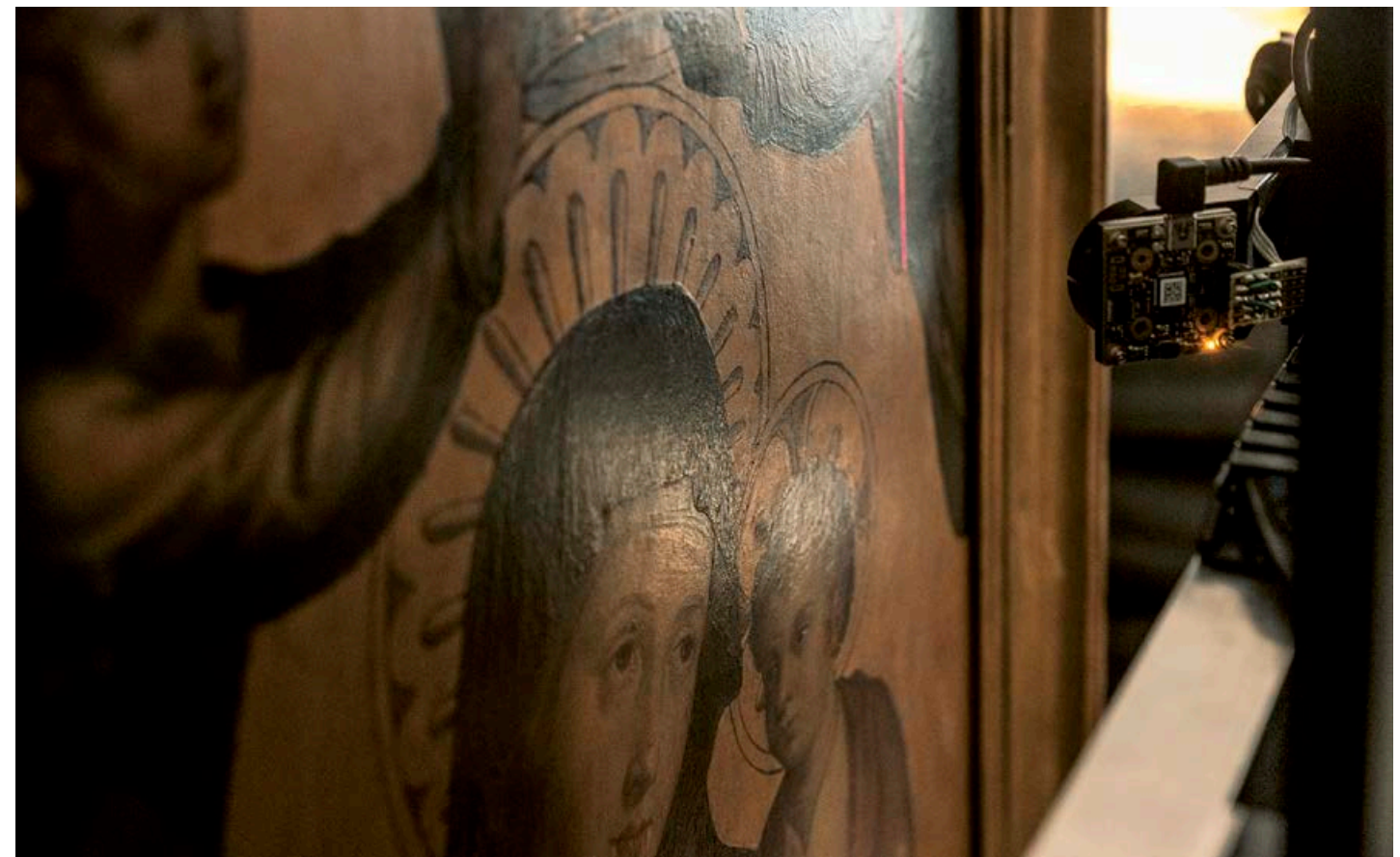
Recording a painting by Pacheco (before and after restoration)

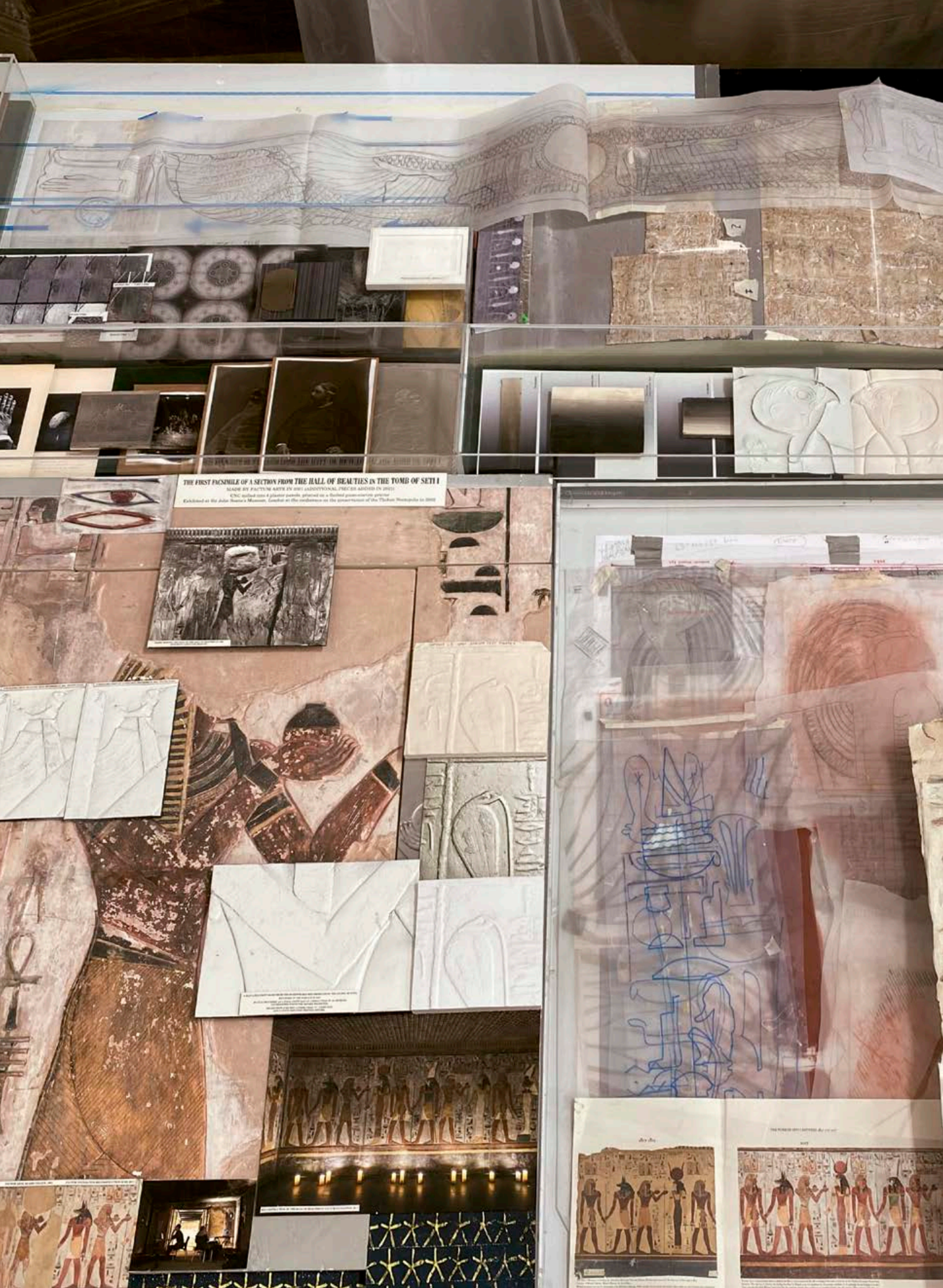
Factum Foundation's research into the art and life of the young Diego Velázquez, led to the recording of a panel painting by Francisco Pacheco, his master and father-in-law. The panel, which depicts the *Virgen del Popolo*, belongs to a private collection in Madrid. It was recorded with the Lucida 3D Scanner and composite colour photography before and after restoration, to demonstrate Factum's approach to painting conservation through the incorporation of non-contact digital recording within the process.

The digitisation of paintings in private collections is becoming increasingly relevant, as it provides a 'digital passport' of the artworks' condition. Documenting the original surface, both in 3D and colour, in successive stages (i.e. before/after treatment, etc.) allows the dynamic nature of originality to be monitored. The Lucida 3D Scanner is now available to individual collectors through the Colnaghi & Factum initiative in London.

Carlos Bayod recording the *Virgen del Popolo* with the Lucida 3D Scanner (top); detail of the recording (bottom).

Opposite: A composite image showing the painting before and after restoration.





4. FACSIMILES

‘Indeed, the healing of historical wounds has become an essential aspect of Factum’s endeavours as, fittingly for a postquantum era, it enables iconic objects to exist in two places simultaneously.’

*Emma Crichton-Miller
Country Life Magazine - August 2019*



FACSIMILES

The Tomb of Raphael

With the Scuderie del Quirinale and the Pantheon, Rome

April 6th 2020 marked the 500-year anniversary of Raphael's death, and a number of exhibitions in this quincentenary year re-examined the significance of one of the most important artists of the Italian Renaissance.

On March 5th, the Scuderie del Quirinale in Rome opened 'Raffaello (1520 - 1483)', an exhibition beautifully curated by Marzia Faietti and Matteo Lafranconi, with contributions from Vincenzo Farinella and Francesco Paolo Di Teodoro, and the supervision of Sylvia Ferino-Pagden as President of the scientific committee.

The exhibition looked in depth at the artist's life, his diverse works of art and his wide-ranging influence. This colossal exhibition saw more than 200 artworks, 100 of them by Raphael, loaned from all over the world.

The COVID-19 emergency forced the shutdown of all museums in Italy for more than two months, during which the loans were re-negotiated and confirmed for an additional re-opening on June 2nd, extending the exhibition until August 30th.

In October 2019, Factum Foundation worked in the Pantheon to digitise the various elements of Raphael's tomb. The team worked at night when the building was closed to the public, conducting the recording with permission from the Italian Ministry of Cultural Heritage.

Recording allowed Factum to accurately catalogue all the elements of this complex monument, which according to Giorgio Vasari's *Lives* was conceived by Raphael himself.

The first and most important detail was the sheer size of the rematerialisation: an exact facsimile would not fit inside the Scuderie del Quirinale's exhibition spaces, so the entire tomb was scaled down to 82% of its original size.

At the request of the curators, two alterations were then made to the rematerialised design: the two busts on each side of the *Madonna of the Rock* were replaced by marble panels, and the niche containing the sarcophagus was remodeled in brickwork. The original tomb was opened in 1833 to ascertain the presence of Raphael's bones within the sepulchre, and small but significant alterations were made to the overall design during the 19th and 20th centuries. Factum's rematerialisation followed two historic sources: an oil painting made in 1836 by Francesco Diofebi depicting the tomb only three years after its opening (held in the Thordvaldsen Museum in Copenhagen) and a 19th-century

lithograph showing Raphael's skeleton laid within a brick sarcophagus (part of the Royal Collection Trust in the UK).

Almost all of Factum's departments were involved in the rematerialisation project, with engineers, architects, sculptors, artists, welders and digital experts working side by side on the various elements making up the tomb. Careful planning and teamwork allowed Factum to achieve this ambitious result.

The *Madonna of the Rock* sculpture and the sarcophagus were CNC-routed from the 3D model in medium density polyurethane using a seven-axis robot, with details retouched by hand. Factum's artists then carefully worked the model until it resembled the original white marble, using the colour references acquired through composite photography. A similar process was used to recreate the mouldings decorating the tomb.

The tomb's marble panels were recorded using composite colour photography and then printed onto gesso-coated aluminium sheets using Factum's flatbed printer, which allows multiple layers of colour to be printed on a surface in perfect registration (matching the colour information and the 3D information). Retouching was performed by hand.

The various elements of the tomb were assembled on an aluminium structure that could be easily dismantled and shipped to the exhibition space. A team of four people was sent to assemble the final result in time for the opening on March 5th 2020. Following the end of the exhibition at the Scuderie del Quirinale in Rome, Factum Arte installed the recreation in Urbino. The monumental structure will be on display in the Chiesa dei Carmelitani Scalzi until 2031.

This project began before the pandemic and has focused attention on many of the core principles that motivate Factum's work. Making an exact facsimile can help nurture a new form of connoisseurship. It can also allow works to be seen in different contexts that can have both an emotional and an intellectual function.

Opposite: Teresa Casado recording the colour (top). 3D model of the Pantheon made using LiDAR data (bottom).

Overleaf: Printed marble panels (left). Assembling process in Factum's workshop (right).

Next overleaf: Detail of the facsimile *Madonna of the Rock* that adorns Raphael's tomb (left). The recreation of the tomb, on display at Chiesa dei Carmelitani Scalzi in Urbino. (right).









FACSIMILES

Baptismal Font from Santa Maria delle Carceri With the Frick Collection, New York City

The Frick Collection in New York houses the only signed bronze sculpture by Francesco da Sangallo (1494–1576), son of the Renaissance sculptor and architect Giuliano da Sangallo. Francesco was appointed *capomastro* (master builder) of the Basilica di San Pietro in 1542 and later of the Church of Santa Maria del Fiore in Florence in 1543, and he is best known for his marble and architectural works.

Although he worked on some small bronze pieces (mainly medals) during his life, the 53cm-tall bronze sculpture depicting St. John the Baptist, created for the baptismal font of the church of Santa Maria delle Carceri in Prato, is his only known signed bronze figure. Dated between 1534 and 1538 and solid-cast in a single pour, the sculpture was intended for the top part of the marble *acquasantiera* (holy water basin) commissioned by the greengrocers and watermelon sellers of Prato and carved by Giovanfrancesco Pagni in 1534. Divorced from its marble support in the 1890s and replaced with a copy by Oreste Ghilleri in 1902, the original was later acquired by The Frick Collection in New York, where it has been on display since 1916.

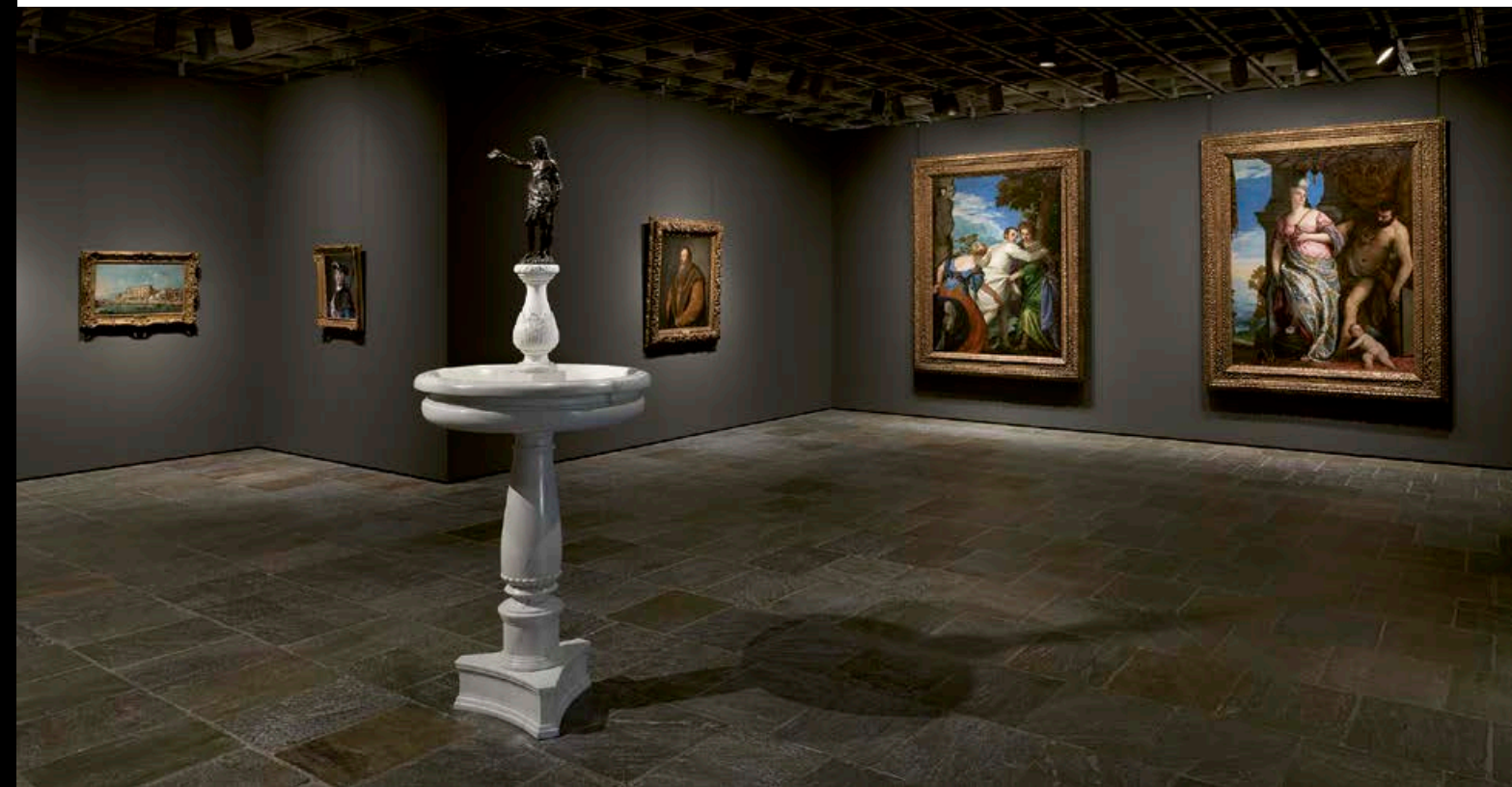
New York's celebrated Frick Collection is currently renovating its historic buildings and has moved to a temporary new home during the duration of this project. Since March 2021, the museum and library are presented as Frick Madison in the former site of the Whitney Museum of American Art (until recently the Met Breuer), a relocation that has permitted the museum to show its collection in

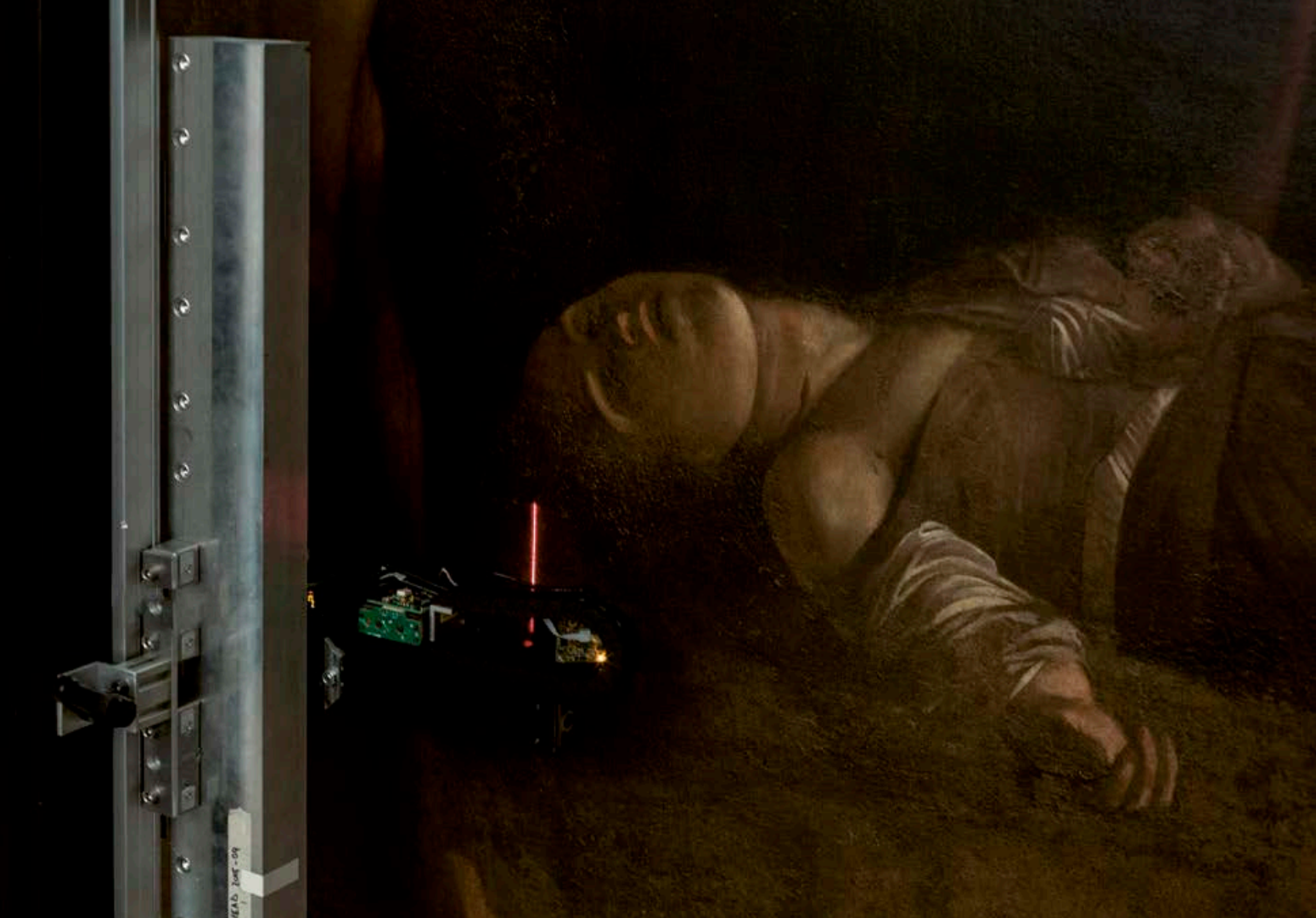
a new light. Towards that end, the Frick and Factum Arte partnered on a recontextualisation of Sangallo's bronze figure, pairing it with a recreation of its original baptismal font, made possible through the generous gift of Fabrizio Moretti. Sangallo's remarkable work is now shown in the center of a grand cross-shaped gallery of Italian masterpieces from the Frick Madison.

In the summer of 2020, the original font was recorded by Pedro Miró using structured white light scanning. A team of craftsmen from Factum Arte then worked on recreating the marble stoop without the oxidisation, discolouring and cracking that are present on the original font after more than four hundred years of use.

As the bronze sculpture is quite heavy, weighing 20.5kg, an inner steel structure was used in the recreation to help better distribute its weight. The 3D model of the font was directly prototyped in polyurethane on 1:1 scale, using a 7-axis robot. The prototype was then retouched using plaster to smooth out the surface and fill in the cracks, while the finer details, such as the flower and acanthus leaves ornaments on the stoop, were 3D printed and added to the surface.

The original bronze statuette by Francesco da Sangallo, placed on top of the facsimile of its original base, inside Frick Madison.
Opposite: The facsimile of the baptismal font.





FACSIMILES

The Burial of St. Lucy by Caravaggio

With the Church of Santa Lucia al Sepolcro and Mart Rovereto

Caravaggio was commissioned to paint *The Burial of St. Lucy*, a large painting which originally belonged to the Basilica di Santa Lucia al Sepolcro, during his stay in Syracuse. The painter fled Malta in 1608 after his expulsion from the Order of the Knights of Malta, arriving in Sicily in October of the same year. 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 first of Caravaggio's final series of paintings, produced on a whirlwind tour between Syracuse, Messina and Palermo before his departure from the island and death in 1610.

The painting, which measures 4.08 x 3 m, was recorded in high-resolution using the Lucida 3D Scanner and panoramic colour photography. Permission to record was granted by the FEC (Fondo Edifici di Culto), to whom the digital data now

belongs, and the recording was conducted at the request of the Mart – Museo di arte moderna e contemporanea di Trento e Rovereto.

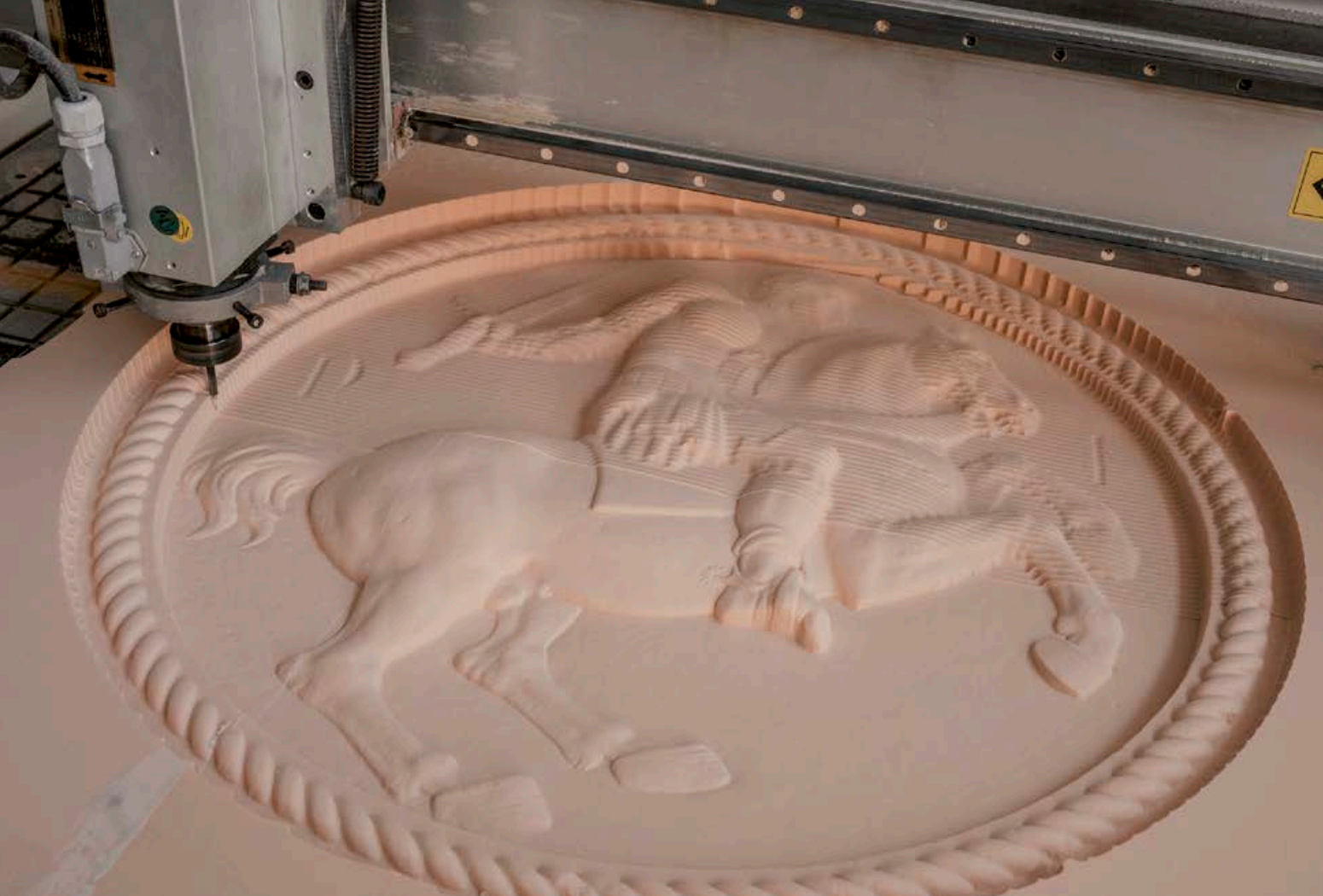
A facsimile of the *Burial of St. Lucy* was created by Factum Arte for the exhibition 'Caravaggio. The Contemporary' at Mart Rovereto (October 2020 - April 2021). The original was on display along with a selection of contemporary works and photographs, encouraging new conversations and emphasising Caravaggio's spiritual relevance. Like contemporary artworks, facsimiles can generate new ways of engaging with the art of the past.

A second facsimile of Caravaggio's *Burial of St. Lucy* was also made for the Church of Santa Lucia alla Badia. In December 2020, the original painting was brought back to Syracuse and installed in the location for which it was intended, the Basilica of Santa Lucia al Sepolcro.

The original (right) and the facsimile (left) in the exhibition. Neither was identified as the original or copy, inviting the visitors to engage with both works.

Opposite: The Lucida 3D Scanner recording the surface (top). Rafa Rachewsky checking the registration. Inset: surface detail (bottom).





FACSIMILES

Jacopo della Quercia's *Tondo Ludovisi* With Carisbo Foundation

In July 2021 a team from Factum Foundation was sent to the castle of Rocchetta Mattei, at a short distance from the city of Bologna, to record a 15th-century circular bas-relief (*tondo*) recently attributed to the early Renaissance sculptor Jacopo della Quercia (1374-1438). It represents the Bolognese captain Niccoló Ludovisi on horseback and is carved in limestone.

The tondo was part of the lost tomb dedicated to Niccoló Ludovisi and his father Giovanni, originally located in the church of San Domenico in Bologna before it was dismantled. Around 1850, Count Cesare Mattei acquired some of the sculptural works from the tomb to decorate his moresque-style castle in Grizzana Morandi. The tondo which led to the majority being thought lost for almost 150 years. The tondo was placed in the courtyard at a height of about 4m, over an archway leading to the first floor. In 2019, it was identified and attributed to Jacopo della Quercia.

Carisbo Foundation commissioned a facsimile of this important proof of Jacopo della Quercia's activity in Bologna. Pedro Miró and Ferdinand Saumarez Smith

digitised the bas-relief using photogrammetry, in order to create a 3D model that could be rematerialised as a physical replica for exhibition purposes.

Top: The facsimile in progress in Factum's workshop. Bottom: Detail of 3D model of the *Tondo Ludovisi*.

Opposite: CNC-milling the relief (top). Moulding the relief (bottom).



Portrait of John, Count Capo d'Istria by Sir Thomas Lawrence

With The Royal Collection and the Rothschild Foundation

In honour of the 200th anniversary of the formation of the Greek State, the Rothschild Foundation commissioned a facsimile of Sir Thomas Lawrence's portrait of *John, Count Capo d'Istria*, painted at the Congress of Vienna in 1818-19. The painting normally hangs in the Waterloo Chamber at Windsor Castle, forming part of the Royal Collection, in the company of other major figures who participated in the remoulding of post-Napoleonic Europe.

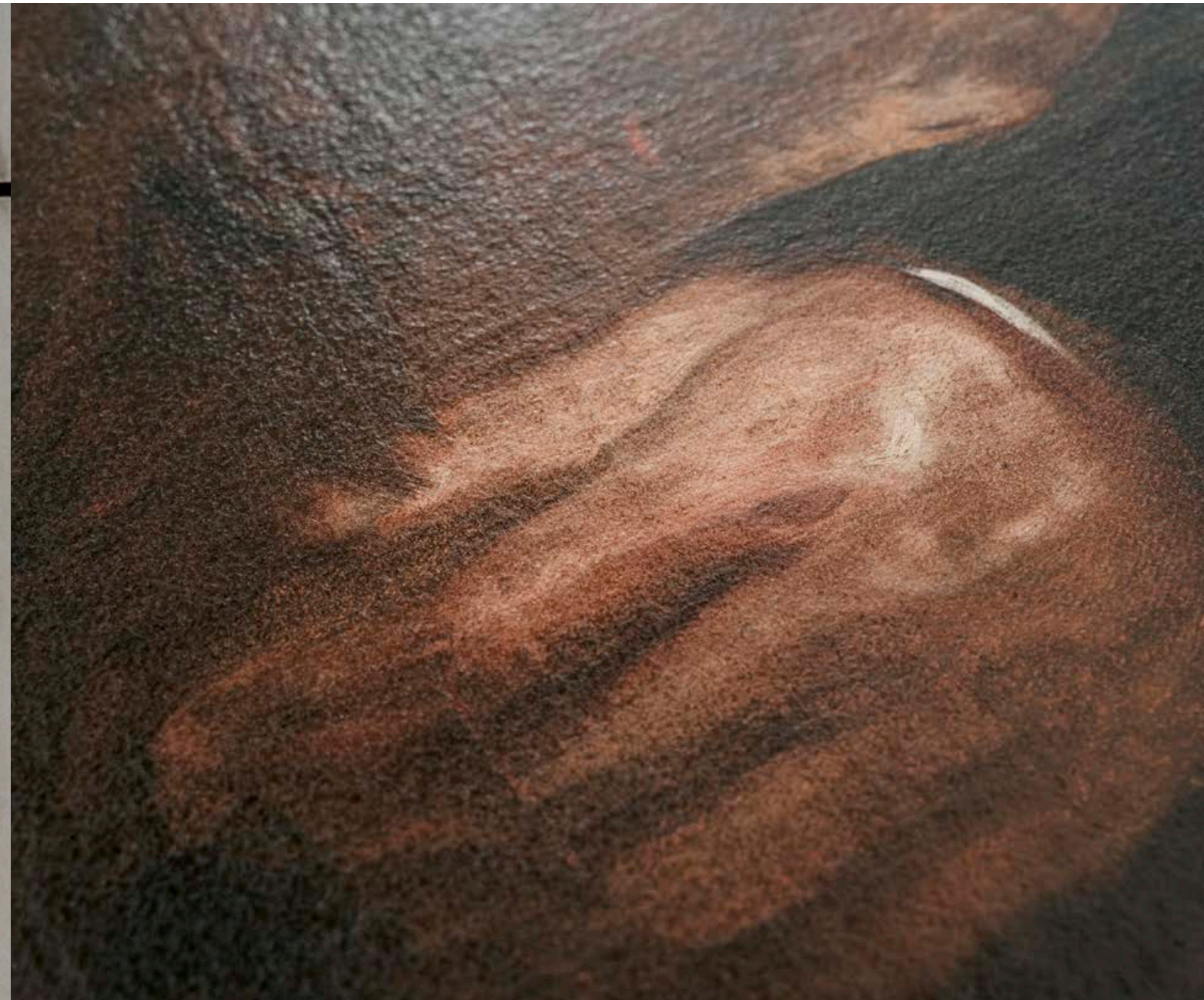
With the generous permission of Her Majesty Queen Elizabeth II and the Royal Collection, the portrait was recorded in August by a team from Factum Foundation at the Queen's Gallery, Buckingham Palace, where it formed part of the Royal Collection exhibition 'George IV: Art

and Spectacle'. It was then re-materialised as a facsimile in Factum's Madrid studios. The facsimile was presented in an early 19th-century English gilt frame in the exhibition '1821 Before and After' at the Benaki Museum (March - November 2021).

The facsimile of *John, Count Capo d'Istria (1776-1831)* is on display at the Capodistrias Museum in Corfu as part of their permanent display.

Left: The Lucida 3D Scanner recording the surface. Right: Printing the colour on the surface.

Opposite: Checking the printed colour (top left). The framed facsimile (top right). Detail of the facsimile surface (bottom).



Angel Heads by Max Klinger

With the Museum der Bildenden Künste, Leipzig

'One fine evening at the piano' in 1885-86, Max Klinger was inspired to create his monument to composer Ludwig Van Beethoven. Klinger's first plaster model can be dated to 1886, when he was still a student in Paris. After his return to Berlin in 1887, he worked on finishing the polychrome edition, and the model shows little change from the final sculpture, which was unveiled at the exhibition of the Vienna Secession in 1902. The *Beethoven Frieze* by Gustav Klimt was on display in the same room.

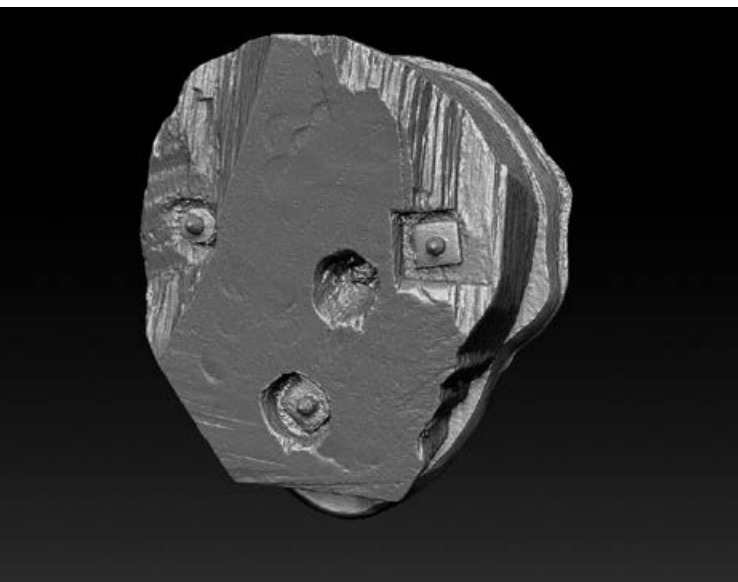
The polychrome sculpture was created using bronze and a variety of marbles, and the five angel heads behind the figure of Beethoven were made in ivory. Due to their fragile preservation status, the Museum der Bildenden Künste in

Leipzig approached Factum Foundation to create facsimiles of the heads and fit them into the original sculpture.

The ivory heads were recorded in high-resolution by Factum Foundation in September 2021 using photogrammetry. After creating the 3D models, the heads were 3D printed at Materialise and moulded in Factum's workshops in Madrid, before being cast in a mix of resin, calcium carbonate and silica to emulate the delicate polychromy of the original.

The final heads installed on the original sculpture (top left) and 3D renders in 3D and/or colour.

Opposite: Juan Carlos Andrés Arias making the moulds from the 3D printed models (top left). Head #2 during the polychromy process (top right). Two of the final five facsimiles (bottom).



A Neo-Assyrian relief

With the British Museum, London

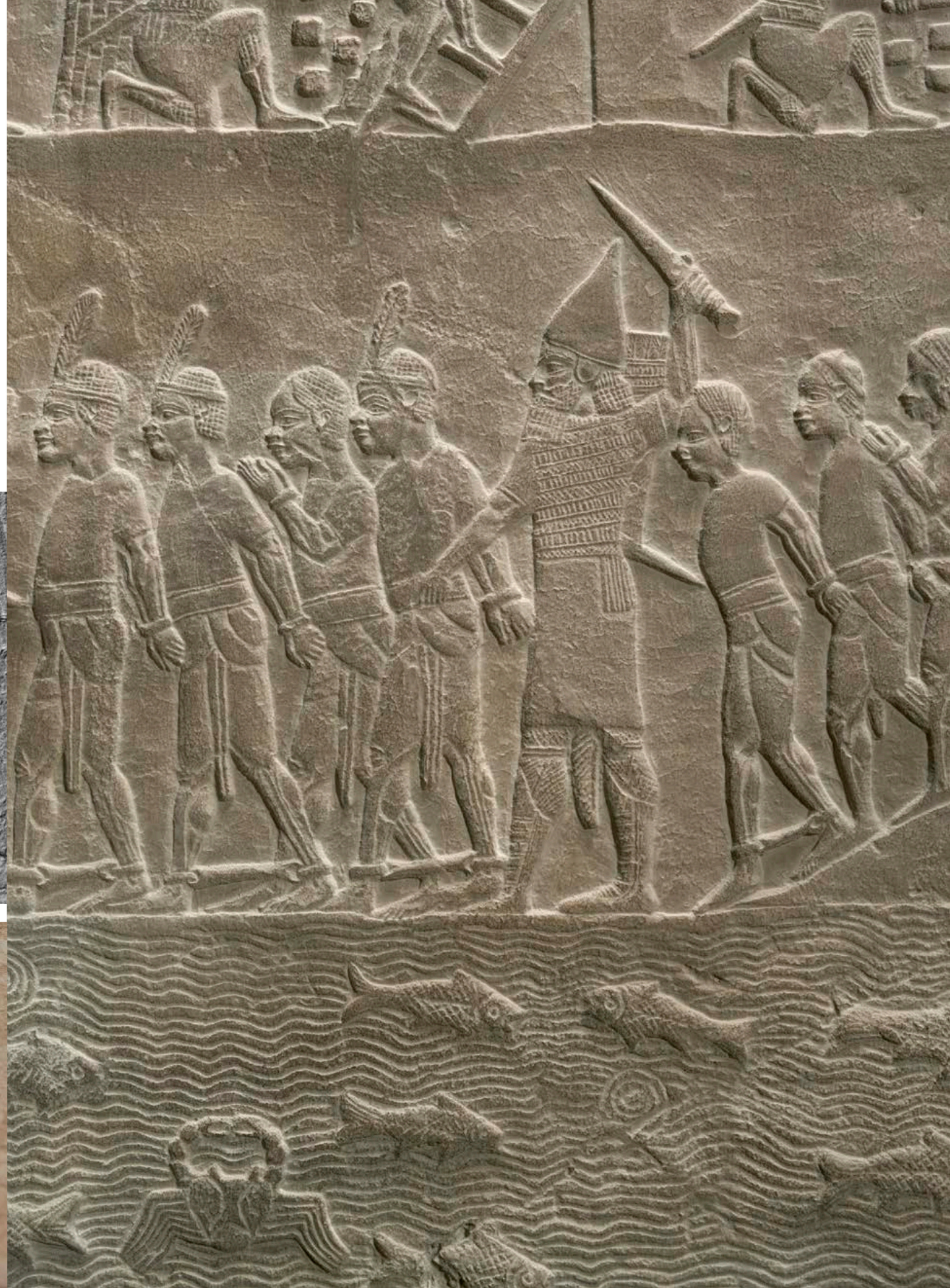
In 2022, Factum Foundation worked with the Middle East Department of the British Museum to record in high-resolution a Neo-Assyrian relief depicting the Assyrian capture of a fortress in Egypt. This panel, excavated from Nineveh and acquired by the Museum in the 19th-century, was part of the low-relief decoration of the palace of King Ashurbanipal.

It is estimated that Nineveh contained over fifteen kilometres of wall reliefs, with the king often featured as the heroic protagonist in military campaigns, royal hunts, and more domestic and ritual scenes. Both the city and the royal palace were destroyed in 612BC, and only legends alluded to their existence before their rediscovery in the 19th-century.

Ahead of the loan of the original panel to the exhibition 'Pharaoh of the Two Lands. The African Story of the Kings of Napata' at the Musée du Louvre (April – July 2022), Factum Foundation worked with the British Museum on the recording and production of a facsimile. The high-resolution recording was carried out using the Lucida 3D Scanner and composite photography to acquire accurate surface and colour information. A facsimile of the relief panel was produced for display inside the British Museum for the duration of the loan.

Top: Detail of the 3D data. Bottom: CNC-milling the surface on polyurethane.

Opposite: Detail of the facsimile.



The Booker Prize trophy

With the Booker Prize Foundation, London

Factum Foundation collaborated with the Booker Prize Foundation to recreate, on a smaller scale, the original Booker Prize trophy. The original trophy was commissioned by Booker Prize founder Tom Maschler from Jan Pieńkowski, who based it on an art deco lamp he found in a junk shop in the Portobello Market. The prestigious literary prize was first awarded to P. H. Newby, in whose home the 60cm tall trophy became a plant stand and key bowl. His wife also spray painted the pewter-coloured statuette gold.

The Booker Prize 2022 trophy is based on a 3D scan of the original awarded to P. H. Newby, whose daughter, Sarah Schenk, kindly provided it for scanning. The recreated trophy, standing at 38cm tall, commemorates Jan Pieńkowski, the beloved children's author, illustrator and designer, who passed away in February 2022.

3D model of the original Booker Prize, recorded at ARCHiOx.
Opposite: The new award in silver and gold.



St. Peter altarpiece by Nicolò da Voltri

In March 2023, a team from Factum Foundation recorded the *St. Peter* altarpiece from the 15th-century by Nicolò da Voltri in the Castle of Gabiano, overlooking the river Po in Piedmont, Italy. It was originally painted for the monastery church of San Pietro in Vesima, near Genoa.

The altarpiece was scanned in high resolution using the Lucida 3D Scanner and composite colour photography in order to produce a facsimile that will form part of the

restoration project of the church, which has undergone many transformations since 1159.

The work will also consist of an analytic study to identify the original parts of the frame and the additions made when it was installed in the chapel in the castle of Gabiano.

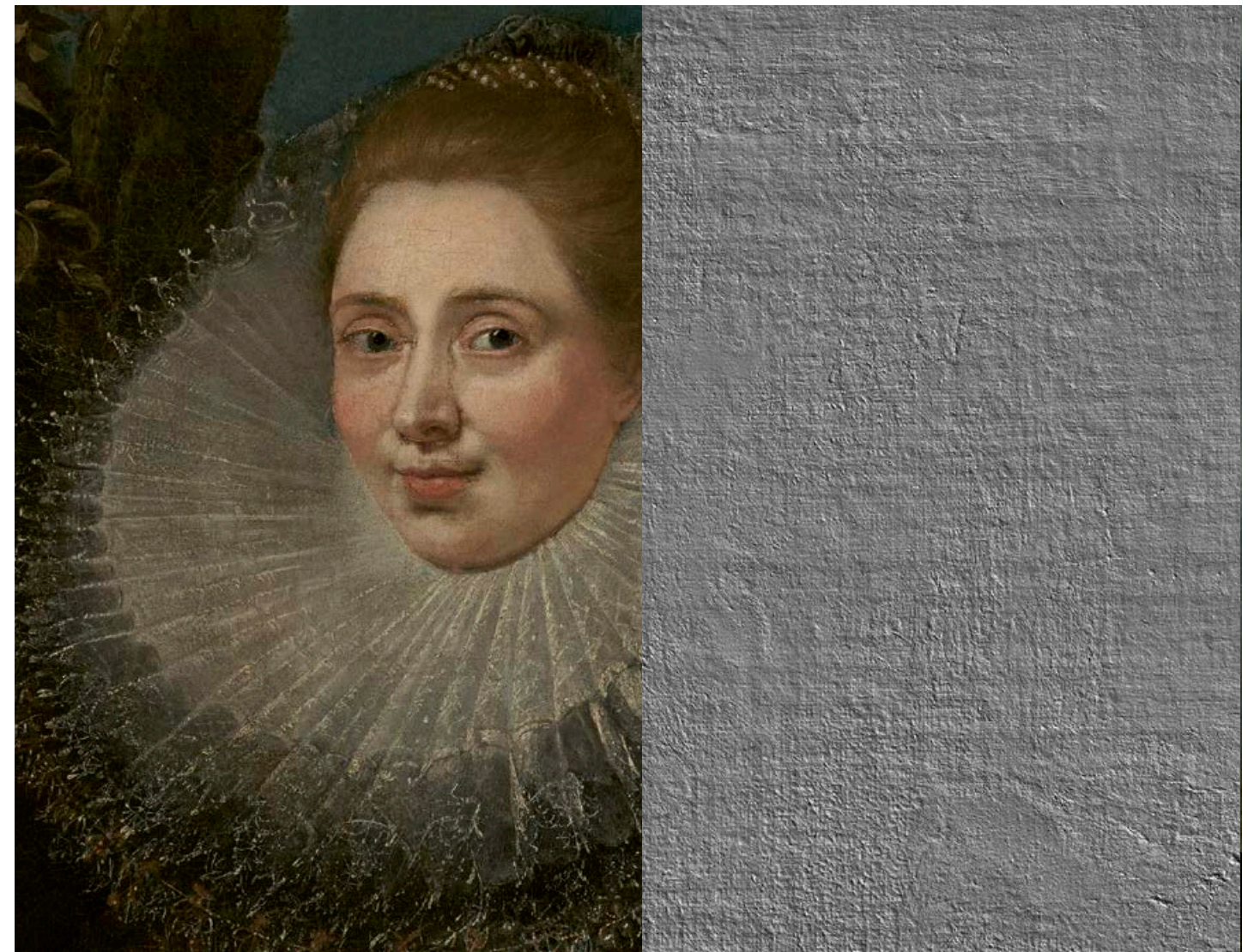
Recording the *St. Peter* altarpiece.



Two portrait paintings by Rubens and Tintoretto

As part of a new series of digitisation works with the Friends of Genoa foundation, the ARCHiVe team carried out the 3D and colour recording of two paintings belonging to a private collector inside Palazzo Spinola: the *Portrait of Andrea Doria* by Tintoretto and the *Portrait of Maria Rosa Spinola* by Rubens. The captured data was processed in ARCHiVe's studios. Other projects to follow include the recording of books and a digital reconstruction of a unique fresco for eventual reinstatement in its original ceiling.

Top: Colour data of *Portrait of Andrea Doria* by Tintoretto and the *Portrait of Maria Rosa Spinola* by Rubens. Bottom: Colour (left) and surface data (right) from the recording of the Tintoretto painting.



St. Sebastian by Bernini

With the Museo Nacional Thyssen-Bornemisza, Madrid and Palazzo Barberini, Rome

For the exhibition 'L'immagine sovrana. Urbano VIII e i Barberini', Factum Foundation produced a full-scale facsimile of the *St. Sebastian* (1615) by Gian Lorenzo Bernini, to be part of the display at Palazzo Barberini in Rome from March to July 2023. The original sculpture, belonging to a private collection and on long-term loan to the Museo Thyssen-Bornemisza, was recorded in high-resolution in September 2022 using a structured white light scanner and photogrammetry.

The exhibition at the Gallerie Nazionali di Arte Antica celebrated the 400th anniversary of the election of cardinal

Maffeo Barberini as Pope Urban VIII. A great patron of arts, his 21 years as Head of the Catholic church (1623-1644) deeply transformed Rome's cultural and architectural landscape. Pope Urban VIII showed extensive patronage to Bernini, exemplified by his commission of the *St. Sebastian*.

Imran Khan, Pedro Miró and Silvia Álvarez recording Bernini's *St. Sebastian* in the Museo Thyssen-Bornemisza.

Opposite: Details from the 3D model (top). Aniuska Martín preparing the 3D print for moulding (bottom).

Overleaf: Colour tests for the facsimile of Bernini's *St. Sebastian* (top left). Detail of the facsimile (bottom left). Facsimile of Bernini's *St. Sebastian* (right).





Salvator Mundi by Bernini

With Fondo Edifici di Culto and Aeroporti di Roma

Just before his death in 1680, Gian Lorenzo Bernini completed his final sculpture, the *Salvator Mundi* (the Saviour of the World). Intended as a gift for Queen Christina of Sweden, the bust now forms part of the Fondo Edifici di Culto (FEC) of the Italian Ministry of Domestic Affairs, and was on display at Rome Fiumicino Leonardo da Vinci Airport from April to August 2023. This display was part of a broader initiative by the Aeroporti di Roma to celebrate Italian cultural heritage and create a space for artistic engagement in the heart of Italy's main airport, where countless passengers from all over the world come together.

FEC's loan of the original sculpture for the reopening of one of the airport's major terminals required that a facsimile be produced to sit within the niche at the Basilica of San Sebastiano Fuori le Mura. Thousands of visitors regularly flock to the Basilica to see the *Salvator Mundi*, and a facsimile enabled visitors to continue to experience the artwork in its original context. Factum Arte and Factum Foundation's expertise were recommended by Peter Glidewell for this project.

The bust was recorded in March in high-resolution by Voula Natsi and Imran Khan. In close collaboration with

FEC and the Appia Antica Archaeological Park, the recording was completed using white light scanning and close-range photogrammetry, while Montenovi Srl supported the transportation. The data will assist in the condition monitoring of the original marble sculpture, and led to the production of a facsimile that was visually indistinguishable from the original.

Recording the *Salvator Mundi* (top) and making the facsimile (bottom).
Opposite page: the finished facsimile of Bernini's *Salvator Mundi*.



The Celtiberian rock inscriptions of Peñalba

With Ayuntamiento de Villastar and the MAC – Museu d'Arqueologia de Catalunya, Barcelona

More than 100 years after their discovery, high-resolution 3D reproductions of the so-called 'Peñalba pieces' will be made accessible to the residents of Villastar (Spain) and visitors to the new Peñalba Interpretation Centre.

In 1909, Juan Cabré, an archaeologist from Calaceite, was commissioned to produce a catalogue of the monuments in the province of Teruel. When he arrived at Peñalba, Cabré found about twenty Paleo-Hispanic and Latin inscriptions, and numerous human, animal, and geometric figures engraved into the rock of the sacred mountain. Some of the inscriptions were removed from the rock wall, and a number of them were sold to the Archaeology Museum of Catalonia

in Barcelona, where they remain. The whereabouts of the others which were carried to the neighbouring village of Villel are unknown. These inscriptions are now considered of significant importance for the epigraphic study of the Celtiberian language.

Factum Arte and Factum Foundation worked with the town of Villastar to reproduce 12 of the inscriptions that are currently in the collection of MAC. After 3D scanning the fragments, exact facsimiles were made for the Interpretation Centre.

The 3D data and the finished facsimile of one of the Peñalba pieces.



The Sir John Soane Room at Aynho Park

With RH England and Sir John Soane's Museum

Factum Foundation was commissioned by RH England to make a series of facsimiles that now form part of the restoration and refurbishment of Aynho Park, a 17th-century country estate in Oxfordshire. Among England's rare Grade I listed buildings – which include Buckingham Palace and the Houses of Parliament - Aynho Park was expanded and refurbished by preeminent British architect Sir John Soane in the early 19th-century, serving as an exceptional example of his commissioned work for elite clients. First constructed in 1615, the Cotswolds property remained in the ownership of the Cartwright family until the mid-20th-century.

Factum Foundation created a facsimile of a bust of Sir John Soane by Sir Francis Chantrey and four architectural models of ancient buildings and their respective plinths.

The rematerialised pieces are a tribute to Sir John Soane's work to remodel Aynho in 1798. They were all recorded by Pedro Miró using a white light scanner and close-range photogrammetry in Sir John Soane's Museum, London in April 2023.

In addition to the facsimiles, Factum Foundation also produced a physical rematerialisation of the façade of Sir John Soane's Museum. Closely working with the museum

authorities (who provided the recorded data) Factum worked on scaling and achieving an accurate and detailed reproduction in physical form. The façade was CNC-milled in high-density polyurethane before being primed and painted. Some details, such as the brickwork and the sculptural elements, were 3D printed.

Top: The finished facsimile of Sir Francis Chantrey's bust of Sir John Soane. Bottom: The facsimile of one of the four architectural models and its plinth.



FACSIMILES

The Husillos Sarcophagus

With Husillos' Town Hall and the Museo Arqueológico Nacional, Madrid

Husillos is a municipality located on the banks of the Carrión River in Palencia, Spain. Through its mayor, Don Juan Jesús Nevares Heredia, the town succeeded in bringing back, in the form of a facsimile, a sarcophagus that was removed from the local church in the late 19th-century. Sent to the National Archaeological Museum, following the policies of that era, the sarcophagus left the town against the opposition of its inhabitants. The extraction of the last vestige of the once well-known abbey remains engraved in the collective memory of the people of Husillos.

The sarcophagus, known as 'La Orestíada' or the 'Husillos Sarcophagus', as referenced in the National Archaeological Museum, dates to the 2nd-century AD and is crafted from Carrara marble. It arrived in the village of Husillos in the late 10th-century, thanks to the connections with Rome and the Vatican of the then Abbot. In this context, the arrival of the sarcophagus at the Abbey of Husillos represented not just the acquisition of a unique and valuable object but also one of the pillars of our Western culture. It brought with it a compendium of the oral Mediterranean legacy, classicism, and the tragedy narrated on the faces of the sarcophagus, turning the town's Abbey into a pinnacle of the culture of the time.

Through European funds, the mayor of Husillos launched

a public tender for the creation of a replica, won by the Factum Foundation in 2022.

The project was carried out in collaboration with the National Archaeological Museum in Spain, and with the necessary permissions from the Spanish Ministry of Culture and Sports. The sarcophagus was recorded using photogrammetry and colour checkers, allowing for the creation of a replica that reproduces the original work down to the millimetre.

The team was led by project director Pedro Miró and reproduction coordinator Aniuska Martín. Monserrat Fornés was responsible for the polychrome process, and Voula Natsi handled the disassembly and digital reproduction of the 3D prototype. The 3D recording works were coordinated by Imran Khan from the Factum Foundation.

In August 2023, the replica of the sarcophagus was delivered and placed inside the Church of Husillos, the only remaining part of the ancient abbey. It was inaugurated the following October and the ceremony was attended by representatives from the National Archaeological Museum and scholars of the sarcophagus.

Monserrat Fornés and Aniuska Martín making the final touches to the facsimile.

Opposite: The 3D model and facsimile of the Husillos Sarcophagus.





5. SPECIAL PROJECTS & RECREATIONS

*‘Our heritage will never die;
our enemies and our friends know this.
We don’t care if that statue is marble or gypsum.
It is a statue. It is a symbol. It is our identity.
It is the name of our country, our home.’*

Amjad, craftsman at the University of Mosul, Iraq, 2019.



SPECIAL PROJECTS & RECREATIONS

Crucifixion by Grinling Gibbons With The National Trust, UK

On the tercentenary of the death of 17th-century master woodcarver and sculptor Grinling Gibbons, Factum Foundation was asked by the Grinling Gibbons Society to record a wood-carved *Crucifixion* in the collection of Dunham Massey, Cheshire, managed by the National Trust.

Grinling Gibbons' *Crucifixion* after Tintoretto is an incontestable masterpiece of intricate wood carving. The horses' legs, the muscular arms of crucifixion functionaries, and a deluge of heads, bottoms and elbows jut out into the foreground. The flowers which compose the frame are structured like lacework, supported on impossibly slim stems and half-concealing a network of voids (or 'undercuts') beneath the detailed carving of petals.

To take on this challenge, Factum Foundation employed two complementary non-contact recording methods. First, the relief was recorded using photogrammetry – a method often used for sculptures and other objects in-the-round, which involves taking hundreds of photos of the object, capturing every curve and every plane in perfect focus from all possible angles. A specialist software, RealityCapture, was later used to process these photographs into a single 3D model. About 3,400 photographs were necessary to capture Gibbons' *Crucifixion*. Following the photogrammetry, a second recording was undertaken using the Lucida 3D

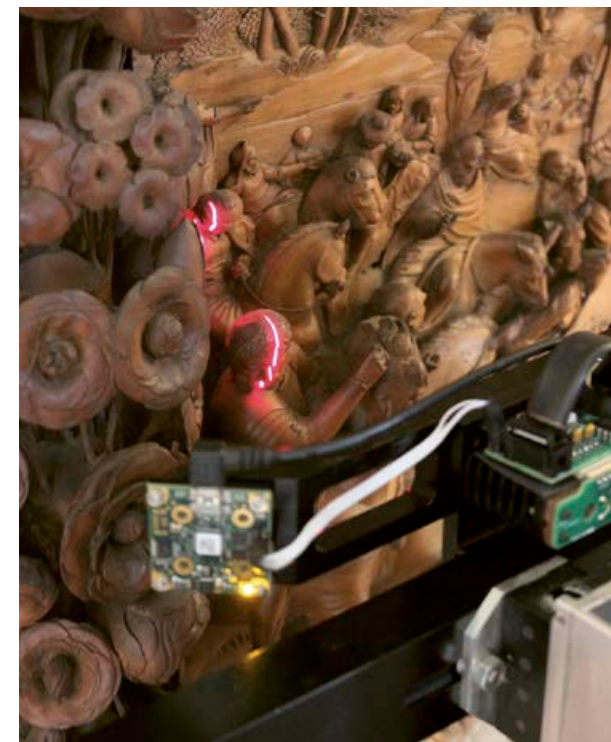
Scanner. The scanner is usually used on paintings and other low-relief surfaces such as frescoed walls, and is capable of recording at extremely high-resolution – accurate to 0.1mm. The Gibbons *Crucifixion*, however, has a much deeper relief and it was necessary to substantially modify the usual scanning method in order to record as much as possible of the surface of the work – sometimes recording the same area up to five times.

Merging the two datasets was not a simple task. Factum's 3D sculptors had to develop a new workflow to integrate the photogrammetry and Lucida data keeping the best parts of both methods. The finished 3D model, complemented by a video detailing the processing at Factum Foundation, was on show at 'Grinling Gibbons: Centuries in the Making', organised by the Grinling Gibbons Society at Bonhams Bond Street showroom in London (August 2021) and at Compton Verney Art Gallery, Warwickshire (September 2021 – January 2022).

Gabriel Scarpa recording the Crucifixion with photogrammetry and the Lucida 3D Scanner.

Opposite: Colour (left) and 3D data (right) of the *Crucifixion*.

Overleaf: 3D model of Grinling Gibbons' *Crucifixion*.





Portrait of Lady Anne, Duchess of Cumberland by Sir Joshua Reynolds With BBC4 and Glasgow Museums

In May 2021, the producers of 'Britain's Lost Masterpieces', Tern TV, contacted Factum Foundation to enquire about the digital restoration of a portrait by Sir Joshua Reynolds. The portrait, initially thought to depict Elizabeth Linley, was being held in the collections of the Glasgow Museums and at that time under the temporary keeping of conservator Simon Gillespie. The sitter was later identified as Lady Anne, Duchess of Cumberland.

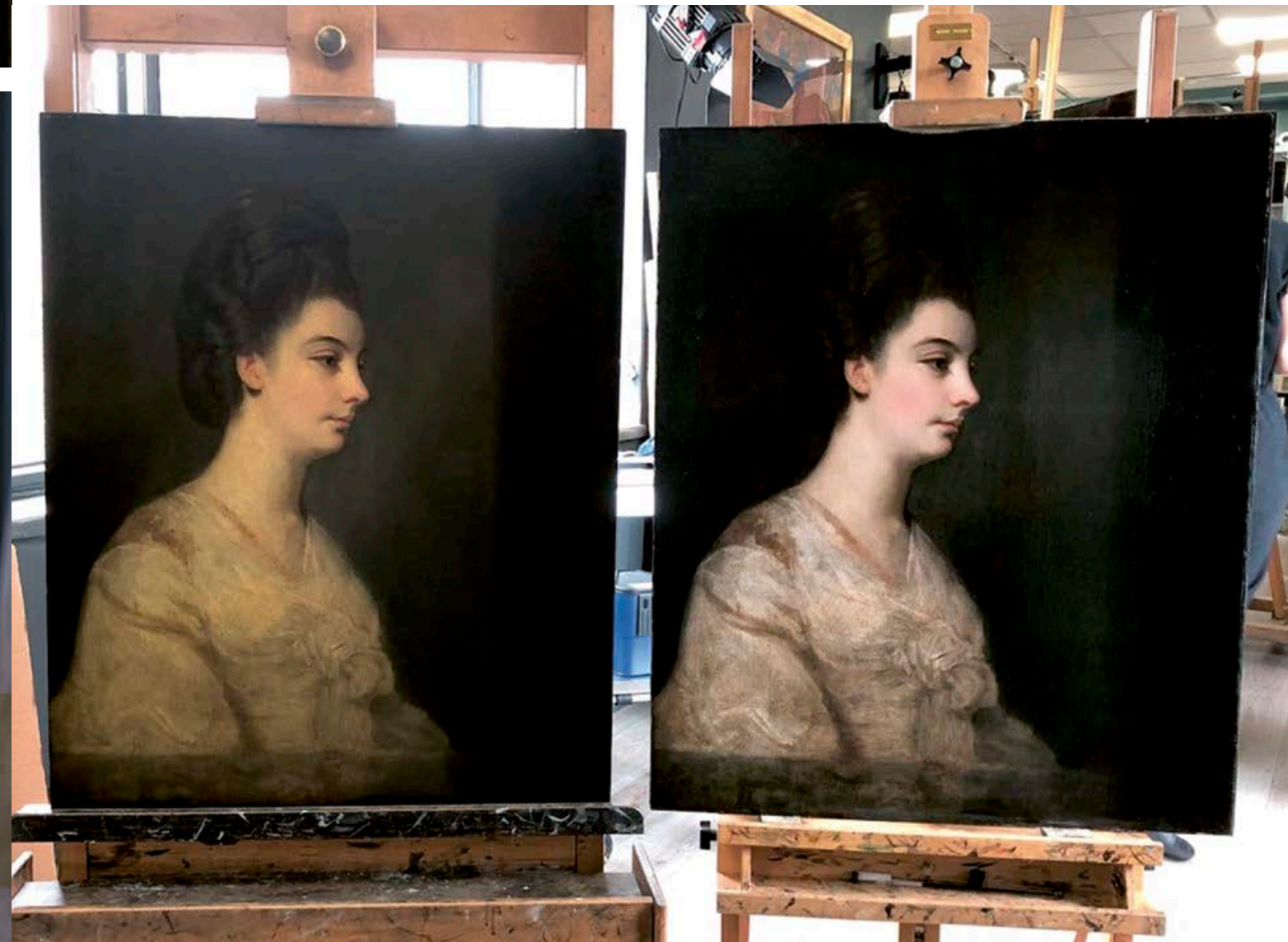
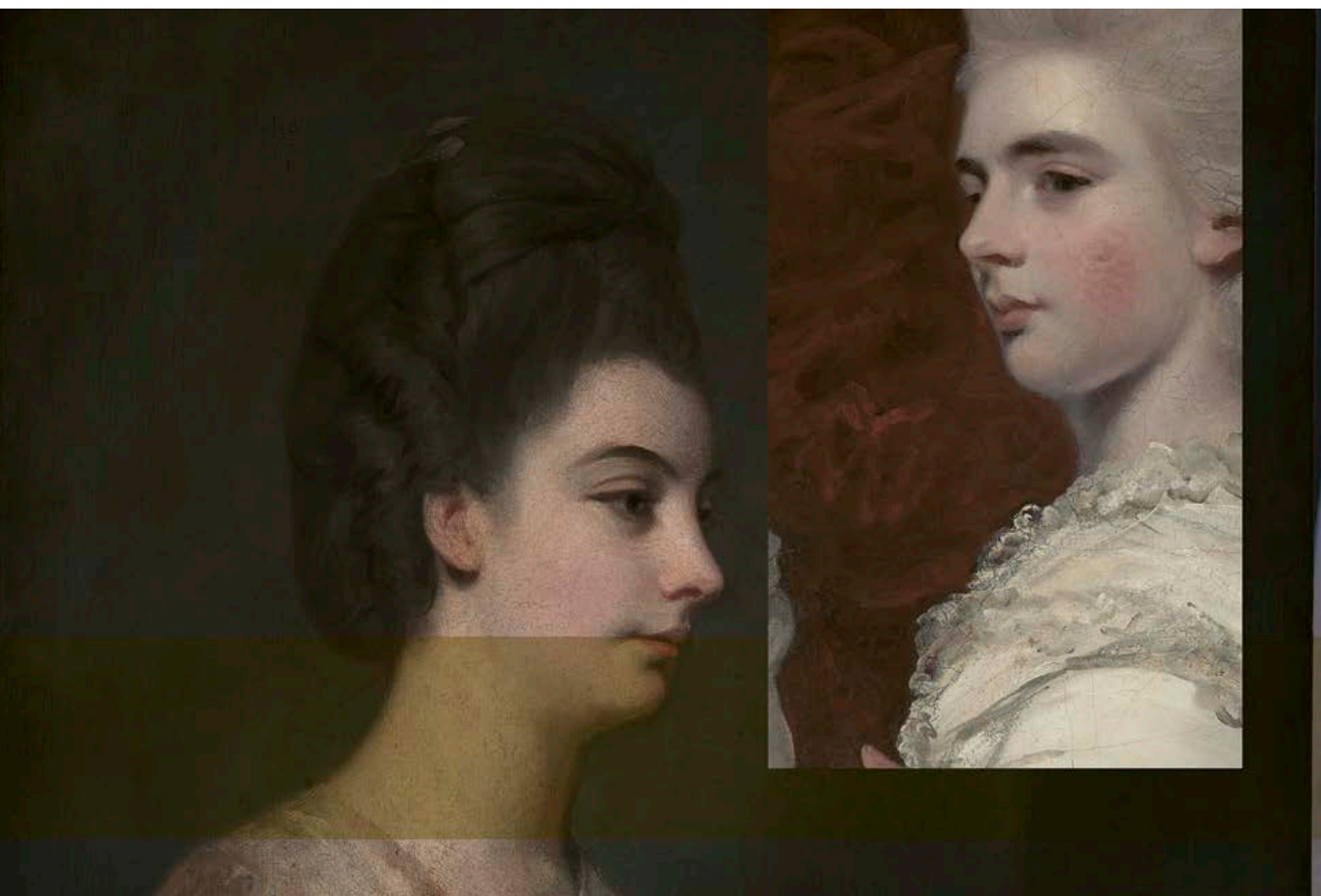
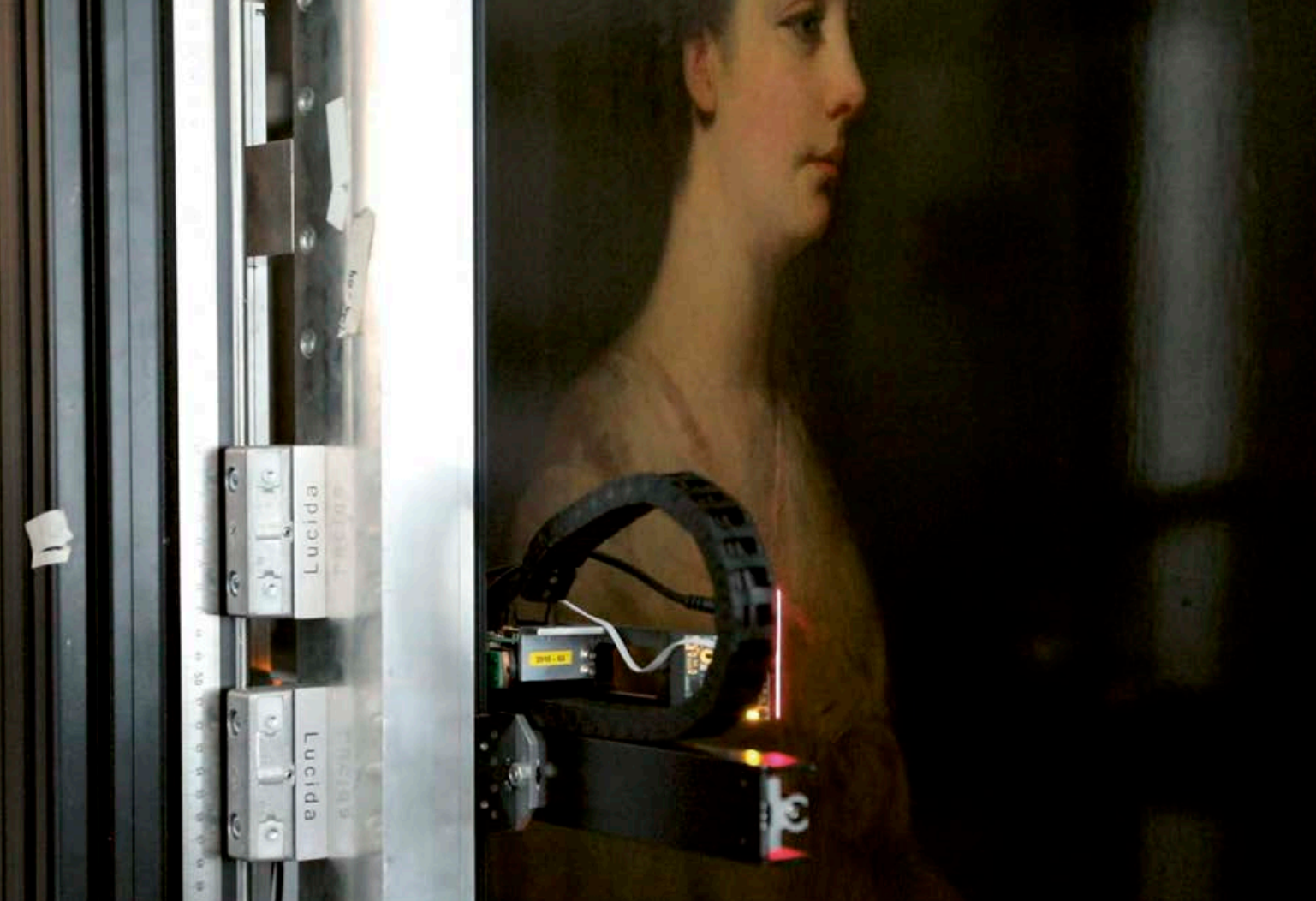
The portrait, which formed the key object for an episode of the programme presented by Emma Dabiri and Bendor Grosvenor, had proved impossible to restore using ordinary conservation techniques due to the presence of a yacht varnish, which had given the whole work a strong yellow cast. Reynolds worked with transparent layers of coloured glaze and the removal of the varnish would also remove this paintwork. After recording the painting, Factum Foundation digitally restored the colour profile as closely as

possible to the original, offsetting the yellow cast without losing the colour in the glaze.

The first stage began with tests that removed the yellow cast of the Glasgow portrait. It was decided that the colours appeared to resemble the colour palette of the *Ladies Waldegrave*, another portrait by Reynolds that had been recorded by Factum. After consulting with Simon Gillespie and Reynolds experts, it was decided to also digitally remove some varnish spots around the face and neck of the portrait.

As the project developed, it was agreed that a physical facsimile would be created from the restored data, which was donated to the Glasgow Museums and now forms part of their collection.

The original painting and its restored facsimile, side by side. Opposite: The Lucida 3D Scanner recording the painting (top). Details of the colour digital restoration process. Inset is one of the faces from *The Ladies Waldegrave* (bottom).



Brexit mural in Dover by Banksy With Dover District Council

In September 2022, Dover District Council acquired land in and around Bench Street for the purpose of regenerating a derelict part of the town centre. The Council had submitted a Levelling Up Funding bid in August 2022. The bid was successful, and in April 2023 the Council was awarded a grant of £18.1m that, together with Council match funding of £1.8m, will deliver, among other things, a new Further Education campus building and a business centre.

In 2017 Banksy created an original artwork on one of the buildings on the site. In 2019 the artwork was painted over by anonymous hands. Following thorough investigation, it was found that the mural, prompted by the artist's thoughts on the UK's exit from the European Union, could not be saved in its present form – not least because the building on which it is painted is in a dangerous condition.

In March 2023, in collaboration with Dover District Council, a team from Factum Foundation was tasked with the recording of the shape and surface of the wall in high-resolution. The digital data gathered by the LiDAR and photogrammetry will become part of the town's historical record, alongside countless pictures taken of the work before its disappearance, in order to preserve the story of this historic, painted wall.

The high-resolution data and digital reconstruction can now be used to recreate the artwork in digital or even physical form as a facsimile, in a new location, subject to Banksy's approval.



The high-resolution viewer (top) and Pedro Miró recording the painted over wall (bottom).
Opposite: Banksy's mural before 2019.



The Colossus of Constantine

With Fondazione Prada and Musei Capitolini

The *Colossus of Constantine* was an early 4th-century monumental statue depicting Emperor Constantine the Great. It is believed a pagan statue was repurposed to celebrate Constantine's reign and the recognition of Christianity within the empire. The statue was later broken up and pillaged for bronze, before its rediscovery in the 15th-century following an excavation at the Basilica of Maxentius. Michelangelo arranged the remaining marble fragments of the Colossus for display inside the courtyard of the Palazzo dei Conservatori (today, part of the Musei Capitolini in Rome) where they remain. The statue fragments include an additional right hand.

Factum Foundation has worked with the Musei Capitolini and Fondazione Prada on an ambitious project to recreate the large-scale sculpture of the *Colossus of Constantine* (313-324) for the exhibition 'Recycling Beauty' (November 2022 – February 2023), curated by Salvatore Settis. The 13m-tall (42 feet) work, displayed inside the Cisterna at the Fondazione Prada, was the result of months of close collaboration between the 3D team at Factum Foundation and a team of experts under the supervision of Claudio Parisi Presicce, the Capitoline Superintendent of Cultural Heritage.

RECORDING AND 3D MODELLING

At the end of March 2022, Factum travelled to the Musei Capitolini to record the ten fragments in high-resolution, using photogrammetry and LiDAR. Some of the fragments are placed against the walls of the courtyard, making the scanning process challenging. A recording was also made of an additional fragment from the Parco Archeologico del Colosseo. A gypsum copy of a statue of *Emperor Claudius as Jupiter*, inside the Ara Pacis Museum, was digitised as a reference for the general posing of the sculpture.

In total, ten fragments were recorded and used for the reconstruction: the head, the right arm, hand, knee, foot and shin, the left foot and wrist, as well as the fragment of a calf and of the chest (the latter belonging to the Parco Archeologico del Colosseo). The high-resolution data and 3D models of each fragment were given to the museums responsible for the objects to contribute to the condition monitoring of the sculptures.

Over the course of several months, Irene Gaumé, Factum Arte's 3D sculptor, worked in close collaboration with the team of curators and experts at the Musei Capitolini in order to recreate the colossal statue's shape and pose, and



the way the *paludamentum* (a type of cloak worn by generals) was draped on the body. Each fragment was 3D modelled and placed on a digital body created using statues in similar poses as references, including the *Emperor Claudius as Jupiter* from the Ara Pacis Museum, a seated Jupiter from the State Hermitage Museum in Saint Petersburg, and a Hercules from the Museo Nazionale Romano.

Meanwhile, the engineering team worked to develop the internal structure and materials of the physical rematerialisation, to guarantee structural integrity. Working in tandem with the team at Fondazione Prada, they ensured that the sculpture would fit inside the rooms of the Cisterna, and could be transported and assembled on site.



Top: LiDAR recording of the courtyard where the *Colossus'* fragments are displayed in the Musei Capitolini. Bottom: Shaded render of the *Colossus'* left foot.

Opposite: 3D model showing the the recreated (dark grey and gold) and facsimile (light grey) sections of the *Colossus*.



MAKING THE COLOSSUS OF CONSTANTINE

Ahead of the rematerialisation phase, it was decided to visually distinguish the facsimile fragments from the digitally reconstructed body and cloak.

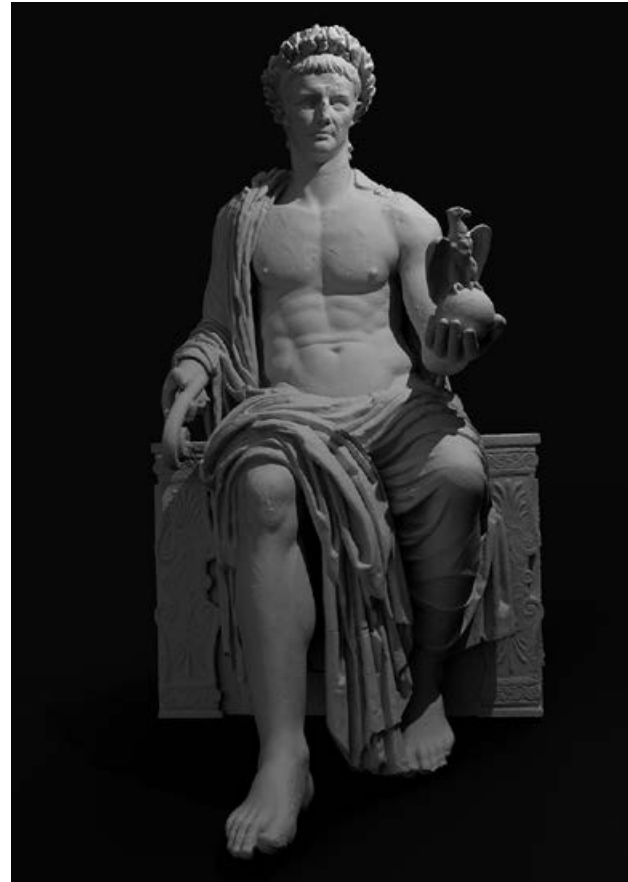
The recorded digital data of each fragment was rematerialised as a 1:1 3D print; these were subsequently used to make a positive cast in reinforced resin. The surface was treated to resemble the original marble, weathered by exposure to the elements. The result of this process was a set of perfect facsimiles of the original fragments.

The recreated sections of Constantine's body were milled in polyurethane, and coated in several layers of resin mixed with marble powder and mica, to achieve a clean, neutral marble-white colour. The cloak was made in milled polystyrene, coated with acrylic resin mixed with bronze powder, over which a distressed gold foil gilding was applied.

The vast scale of this project saw more than half the Factum team working on different aspects of the sculpture in various areas of the workshop.

After completing the final inner structure and the base, a team of six assembled the thirty sections of the *Colossus* over the course of a week inside the exhibition space at the Fondazione Prada.

Top: 3D model of *Emperor Claudius as Jupiter*, one of the sculptures used as a reference for the *Colossus*' pose. Bottom: 3D print and mould of a section of the *Colossus*' head.



Overleaf: The recreated *Colossus of Constantine* on display inside the Cisterna (left). Adam Lowe looking at the *Colossus*. One of the original hand fragments was also on display, on loan from the Musei Capitolini (right).





The Beaune Altarpiece

With Hospices Civils de Beaune

In January 2023, a team from Factum Foundation carried out the colour and 3D recording of the polyptych known as the *Beaune Altarpiece*, inside the Hôtel-Dieu Museum in Beaune. This large work was painted by Flemish artist Rogier van der Weyden and his studio for the 'great hall of the poor' in the Hôtel-Dieu.

The work underwent a major restoration from 1875 to 1878, during which the restorers split the six panels painted on both sides in order to present the altarpiece in its two configurations simultaneously. When open in its original configuration, the nine panels presented a continuous rendition of the Last Judgement. In its 'closed' configuration, the panels present the portraits of the founders, Nicolas Rolin and Guigone de Salins, in prayer before Saint Sebastian

and Saint Anthony, surmounted by an Annunciation painted on six panels. The altarpiece is thus presented today in two parts; prior to restoration it formed a single work.

The state of conservation of the altarpiece is regularly checked by conservator-restorers specialising in painting and wooden supports. These require preventive conservation interventions to guarantee the polyptych's integrity.

The high-resolution colour and 3D surface data scanned by Factum Foundation allows the monitoring of the state of conservation of the altarpiece with a degree of precision unmatched to date.

Factum's Carolina Gris and Marina Luchetti recording the surface of the altarpiece.

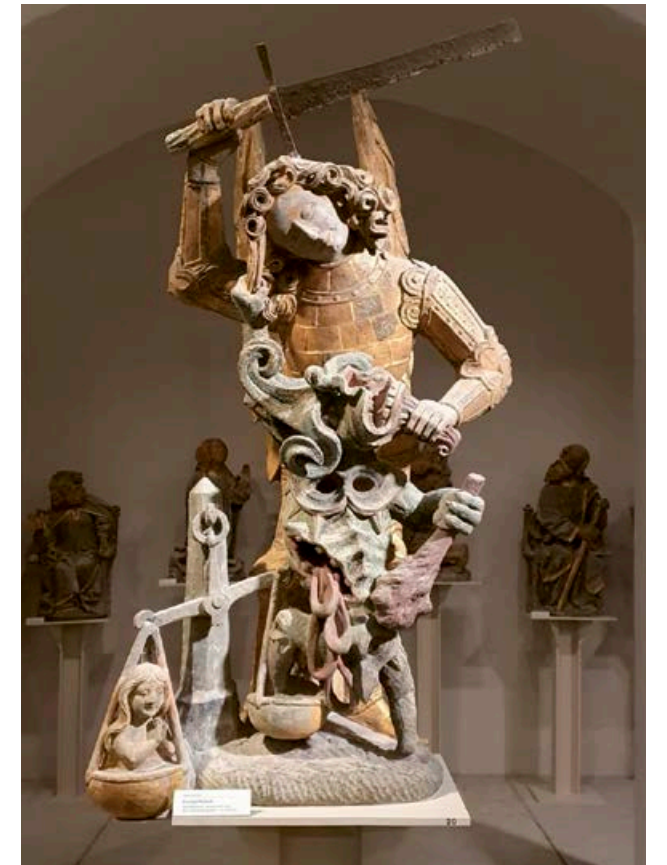


In tribute to Bruno Latour (1947-2022), a research initiative has been launched to unpack the intricate materiality of *The Last Judgement* by Rogier van der Weyden.

Through an in-depth study of the surface data, the colour of the altarpiece and historical research into previous recordings of the painting, the aim is to reflect on aspects of the painting to reveal its complexity and meaning.

In comparing X-ray photographs with the surface data, Simon Schaffer noticed that there has been a major change in the scales that Saint Michael holds at the centre of the panel. In the finished version of the painting, the blessed souls are lighter than the damned. But it appears that originally they were heavier: the scales were positioned with the good souls outweighing the damned. The X-ray (plate CXCIV) published in *L'Hôtel-Dieu de Beaune* written by Nicole Veronee-Verhaegen for the series *Les Primitifs Flamands* confirms that the scales were originally lower on the left and higher on the right (as you look at the altarpiece from the front). At the time, in many works of art, weight was associated with goodness while the damned souls literally 'lacked gravitas'.

Research is now ongoing into when and why Rogier Van der Weyden made this change. Part of the focus will also look at why Michael is weighing souls in the first place. The painting was made between 1445 and 1450. The text for *The Hieroglyphics of Horapollo* was found in Greece in 1415 and made its way to Florence, where it was much discussed in humanist circles and was relatively well-known by the end of the 15th-century. Is it possible that Van der Weyden was introduced to this text and made the change as a result?



In Ancient Egyptian literature, it is Maat who weighs the souls of the dead against her ostrich feather representing truth. If the soul is heavier than the feather, it is doomed to oblivion. If it is lighter, it is blessed and re-enters the cycle of life. The end is a new beginning.

By chance, for the exhibition 'In Ictu Oculi' at the Spanish Gallery in Bishop Auckland, Factum made a facsimile of a painting by Juan de Valdés Leal, *Finis Gloriarum Mundi*, in which the hand of Michael holds a perfectly balanced scale with the Seven Deadly Sins on one side and the Seven Works of Mercy on the other. According to an entry in the records of the Hermandad de la Santa Caridad (28th December 1672), the two vanitas paintings by Valdés Leal were known as *Jeroglíficos de las Postrimerías – Hieroglyphs of the Afterlife*. Miguel Mañara, who commissioned the paintings for the Hospital of Charity in Sevilla, said they contained a secret message known only to the initiated.

Deciphering the meaning of the relationship between the weight of the soul and Maat's feather will take more time and reflection.

Left: Colour data of a detail from the painting *Finis Gloriarum Mundi* by Juan de Valdés Leal. Right: *Archangel Michael* by Erhart Küng and master masons, 1485, Historical Museum (Bern). The praying blessed soul is heavier than the ferocious devil being slain by Michael as he tried to weigh down the soul of the damned.

Firing the Arabic kiln in Úbeda

With the Tito family and Fundación Huerta de San Antonio

For over a year, Factum Foundation worked with Melchor Tito Sr. and Melchor Tito Jr., from the celebrated family of potters, on a project to revive and fire a traditional Arabic kiln in the city of Úbeda, Spain. On the night of the full Harvest Moon between September 29th and 30th 2023, the kiln was brought back to life for the first time since 2007, and more than 500 objects were fired over the course of 35 hours.

This project was funded by Factum Foundation and made possible by Nicolás Berlanga Martínez, founder of Fundación Huerta de San Antonio. It counted on the support of Marcelino Sánchez Ruiz, who was the Mayor of Úbeda from the late 1990s to the early 2010s. Contemporary artist Rachid Koraïchi – whose work is in dialogue with traditional crafts – joined the project and spent weeks working in the Titos' workshop to produce and decorate two big, Alhambra-type vases which were eventually fired in the Arabic kiln.

The Tito family, owners of the Alfarería Melchor Tito, have lived and worked in Úbeda for generations. The town is renowned for its Renaissance architecture and has been inhabited over the centuries by the Romans, the Visigoths, and the Moors. The production of ceramics is Úbeda's most notable craft activity and the city is home to several fine potters, heirs to generations of craft and skills. Most of them, including the Tito family, are strategically located right outside the historic centre, in Calle Valencia, as the town's wind conditions usually blow the smoke from traditional kilns further east without affecting its inhabitants.

The slow, complex process started with loading the kiln with the objects before sealing it with bricks and clay, leaving only a small opening in the lower section to feed the fire chamber. The Titos and their friends started a low, gentle fire using wood waste, letting the chamber gradually heat until the hue and vigour of the fire changed by the late afternoon. More than five tons of *orujo*, the pomace made from crushed olive pits, were rhythmically added to the fire by the Titos and their friends in 12-scoop bursts, in intervals over 24 hours, burning up into dense clouds of smoke. Each scoop was added with controlled strength and movement, uniformly increasing the carefully monitored temperature inside each part of the monumental kiln.

Around 2AM on the night of September 30th, flames began to emerge from the kiln through openings in the roof and gradually, as night turned into day, the temperature inside



the kiln approached the desired 1,020°C. Four days were needed to let the kiln cool down before removing the bricked door and unloading the objects.

Hundreds of pieces, from jugs, pots and oil cans to jars and plates emerged from the kiln; all unique in their materiality and small imperfections. The shops supplying the tourist market have demanded uniformity and predictability and as a result, kilns fired with recycled materials were made redundant as the fire produces unpredictable results. Even, different parts of the kiln can perform in different ways. But thankfully aesthetic values change, and the result is a beautiful collection of objects produced by the poetic transformation of fire and earth.

The entire process, including the modelling, carving, glazing, and bathing of the pieces, was meticulously documented by two cameramen from Factum Foundation. The Foundation's goal was to create a film that would capture and immortalise months of dedication, culminating in the firing of the Arabic kiln.

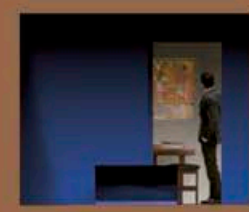
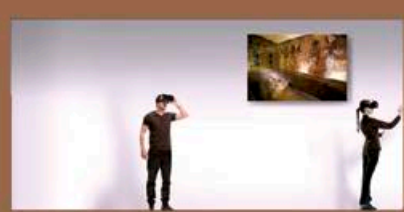
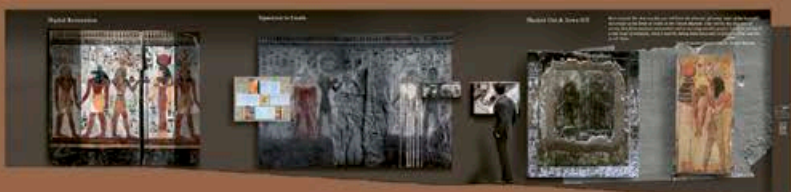
This ambitious project aimed not only to revive the pottery tradition in Úbeda but also to provide a record of the firing process for both functional and artistic objects.

The incandescent glow could be seen from the roof at night.

Opposite. The roof of the kiln at the beginning of the firing (top). Some of the first objects photographed after the firing required a wait of four days for the temperature inside the kiln to cool down (bottom). Overleaf: View of the finished objects that emerged from the kiln.







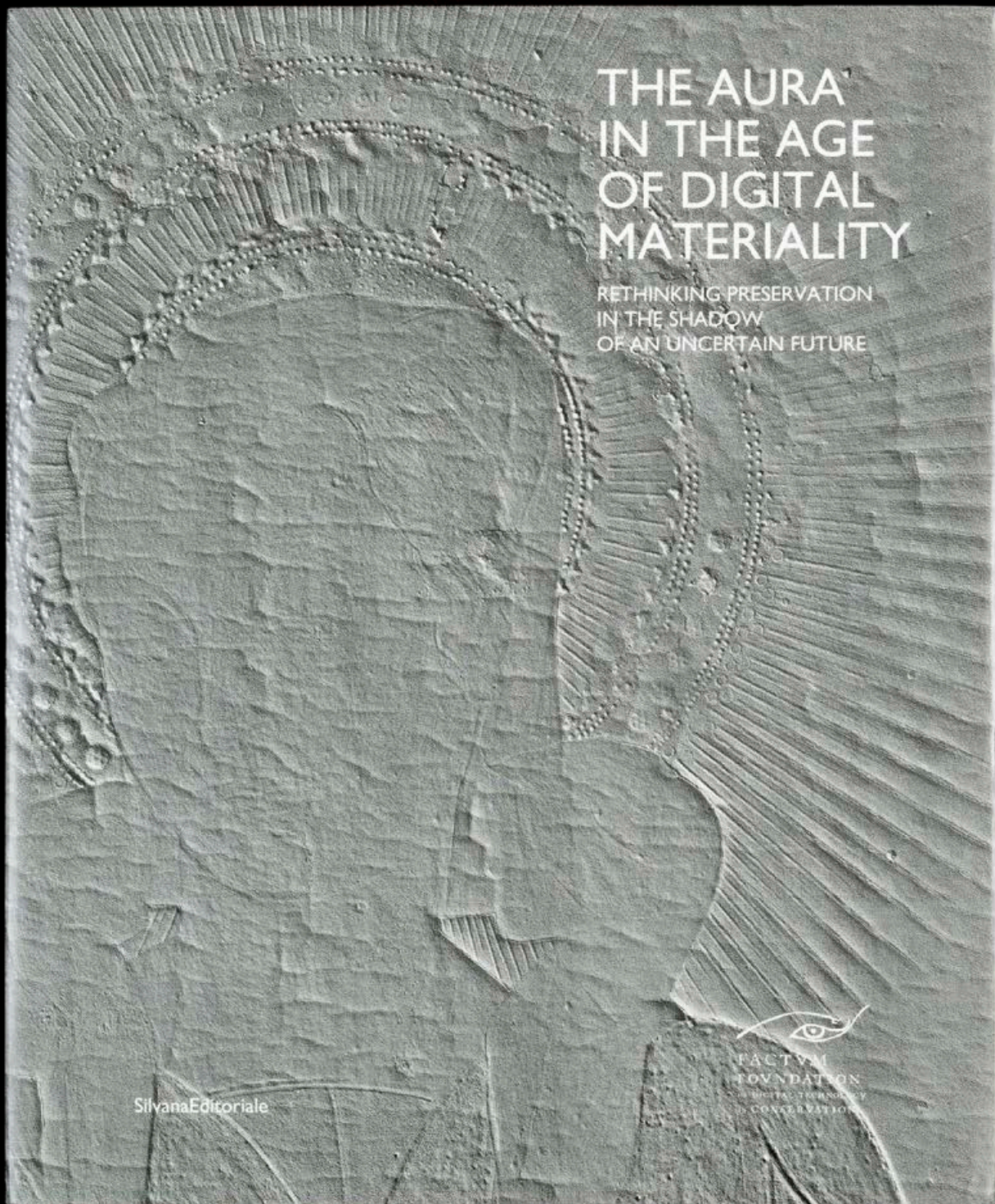
6. EXHIBITIONS

‘The Aura in the Age of Digital Materiality’ is essential reading for everyone in the art, museum, and cultural heritage field. It is an extraordinary collection comprising some fifty essays by art historians and professionals in museums, architecture, the sciences, ethics, indigenous rights and other fields. Altogether, it is remarkable work of advocacy for connecting individuals, communities and countries through art.

The book and its many influential authors go far beyond the convention-bound approaches of institutions such as UNESCO and ICOMOS to challenge how we think about monuments and objects of art – how we stockpile or share them, and how digitization and documentation can facilitate a new dialogue about art across cultures.’

*Kate Fitz Gibbon
Cultural Property News - Spring 2020*

Exhibition designs by Skene Catling de la Peña for 'Avoiding Oblivion: the Preservation of Pharaonic Knowledge', presented during Masterpiece London Art Fair 2022.

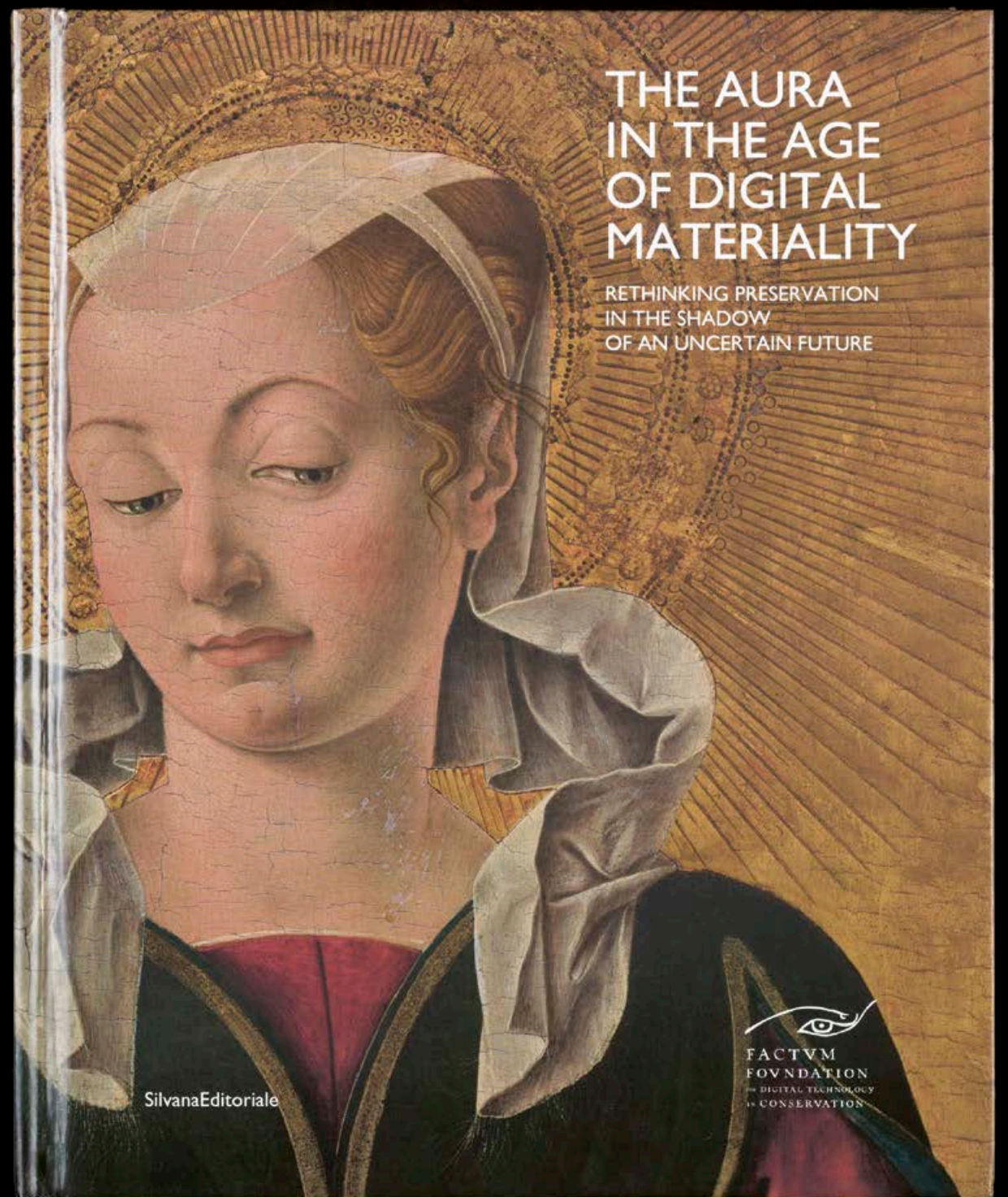


THE AURA IN THE AGE OF DIGITAL MATERIALITY

RETHINKING PRESERVATION
IN THE SHADOW
OF AN UNCERTAIN FUTURE

SilvanaEditoriale

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REVIVING WALPOLE'S NARRATIVES AT STRAWBERRY HILL HOUSE

Silvia D'Amico

Herbert Walpole's narrative paintings, like the one shown here, are a testament to the artist's ability to capture the essence of a scene in a single, powerful image. The artist's use of light and shadow creates a sense of depth and atmosphere, drawing the viewer into the scene. The figures are rendered with a soft, almost ethereal quality, and the overall composition is balanced and harmonious.



The Aura in the Age of Digital Materiality. Rethinking Preservation in the Shadow of an Uncertain Future, Milano, Silvana Editoriale and Factum Foundation, 2020.

This publication is freely accessible online in the Resources section of our website. It is also possible to buy a physical copy through on our online bookshop.



THE MIGRATION OF THE AURA, OR HOW TO EXPLORE THE ORIGINAL THROUGH ITS FACSIMILES

Boris Lohmeier and Adam Lowe

Something that is unique to the digital age is the ability to create facsimiles of physical objects. This technology allows us to explore the original through its digital copies, providing a new way of experiencing art and history. The migration of the aura is a process that involves the transfer of the original's essence into the digital realm, where it can be accessed and shared by anyone, anywhere.





EXHIBITIONS

'La Riscoperta di un Capolavoro', Palazzo Fava

In 2020, the city of Bologna celebrated the return of the *Polittico Griffoni*, one of the greatest altarpieces of the Bolognese Renaissance. Two exhibitions were commissioned at Palazzo Fava by Fabio Roversi Monaco, president of Genus Bononiae, 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 extended to February 2021.

'Il Polittico Griffoni rinasce a Bologna', an exhibition on the first floor of Palazzo Fava, was curated by Mauro Natale in collaboration with Cecilia Cavalca. It 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 San Petronio in Bologna, dismembered and sold when the chapel was patronised by the Aldrovandi family in 1725.

On the second floor of the Palazzo, the exhibition 'The Materiality of the Aura: New Technologies for Preservation', curated by Adam Lowe with Guendalina Damone and designed by Carlos Bayod Lucini, explored the role of digital technology as a medium between an object's materiality and its 'aura'. Walter Benjamin, in his seminal essay *The Work of Art in the Age of Mechanical Reproduction*, argues that mechanical reproduction techniques cannot capture the 'aura' of a work of art, which is the product of a specific artwork's unique situation in space and time.

The exhibition aimed to challenge Benjamin's notion of an unreproducible aura. Each of the six rooms allowed visitors to engage with works of art in new ways, showcasing

projects carried out by Factum Foundation since its inception in 2009, guiding them through selected themes. High-resolution 3D scanning and printing, coupled with projection mapping, digital restoration, digital recreation, diverse display systems and exact facsimiles raised important and contemporary questions regarding an object's materiality and its 'aura'.

These questions are integral to our explorations of the material surfaces of paintings. They also inform how Factum remakes destroyed and damaged works of art. The 3D printed surfaces of each of the *Polittico Griffoni* panels were displayed under raking light, alongside two other works recreated during 'The Mystery of the Lost Paintings' (*Five Sunflowers in a Vase* by Van Gogh and *Water Lilies* by Monet). These focused attention on the fundamental importance of the surface of paintings. Visitors were able to engage with the altarpiece's material history, while also appreciating its beauty. The recreation of al-Idrisi's world map celebrated the enduring technologies of cartography and geometry, while the focus on Wenzel Jamnitzer, who established principles of 3D modelling as early as 1569, demonstrates the longstanding history of 3D recreations. Examples such as Amico Aspertini's *Deposition* showcased the extent to which new technologies can be of immense help for the conservation of sculpture. New possibilities were demonstrated with the 'character heads', made using the Veronica Scanner, that respond to Franz Xaver Messerschmidt's busts of bizarrely contorted facial expressions.

The 3D surface of each of the *Polittico Griffoni* panels was on display inside 'The Materiality of the Aura' under raking light.

Opposite: Detail from the stereolithographic print of Amico Aspertini's *Deposition of Christ*, from the Basilica of San Petronio.

Overleaf: Exhibition view of 'Il Polittico Griffoni Rinasce a Bologna', with the facsimile panels made by Factum Foundation on display.

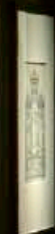




Castello Sforzesco, galleria di Oscar Tassinari
Ricerche e restauri di Alberto Goffi
in collaborazione con il Museo di Storia e Arte
di Milano



Castello Sforzesco, galleria di Oscar Tassinari
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di Milano



1425

1469



di quei quadri che sono assai considerati per poterli ponere in qual si volia ga

EXHIBITIONS



Exhibition views of 'The Materiality of the Aura'.
Opposite: The 3D surface of the reconstructed *Five Sunflowers in a Vase* by Van Gogh (right).

EXHIBITIONS



'In Ictu Oculi – In the Blink of an Eye', The Spanish Gallery

As part of Jonathan and Jane Ruffer's extensive cultural projects in the town of Bishop Auckland, they commissioned Factum Foundation and Skene Catling de la Peña to rethink the concept and role of a museum for the top floor of the Spanish Gallery. The result, *'In the Blink of an Eye, Transience and Eternity in the Spanish Golden Age'* (open since October 2021), is a space filled with a range of objects, each with its own unique biography and significance.

The original pieces were all chosen, digitally recorded and rematerialised as physical facsimiles to reveal some of the defining characteristics of the Spanish Golden Age. A New World vellum map, paintings – portraits, biblical scenes, two *vanitas* and a baptism – sit alongside Renaissance wall tiles, carved architectural plasterwork or *ysería*, elaborate, geometric-patterned timber ceilings, sculptures, a tabernacle and a tomb. All were made in Madrid, over the course of three years of delicate negotiations with major cultural institutions in Spain and intense digital and physical work. The outcome is a portal into Spanish Renaissance and early Baroque thinking, and a collection of mutually beneficial collaborations that redefine sharing, connoisseurship and preservation.

Curated by Charlotte Skene Catling and Adam Lowe, *'In Ictu Oculi - In the Blink of an Eye'* aims to create a new narrative through juxtaposition by which objects can be seen as if for the first time. Great art grants the power to see through the eyes of others. The exhibition celebrates a uniquely Iberian view of the world, and the ability of art to compress and transcend time and place.

THE VISION

The title of the exhibition, *'In the Blink of an Eye'*, is taken from one of the extraordinarily visceral facsimile paintings on display, a *vanitas* by Juan de Valdés Leal. *In Ictu Oculi* speaks of the transience of life (that momentary flash between birth and death) but also of transformation and of resurrection.

As you enter this mirror-world, issues of originality and authenticity, market and aesthetic value, museum display and classification, dissolve. In a traditional museum, both the concept and construct can make you feel like an outsider looking in. Here, you are an insider, inhabiting the same world as the objects.

Rapture, transience, transformation, and resurrection are at the core of this exhibition, which was designed to provoke

questions while generating a sense of wonder and empathy. What is the function and purpose of art? What does it reveal? Where does its value lie? Can copies be new works of art in themselves, enabled by technology?

NEW TECHNOLOGIES, REMATERIALISATION AND DISPLAY

The objects in the installation at Bishop Auckland have all been selected because of their ability to reveal characteristic complexities that underlie Spanish art: the philosophical and religious constraints imposed on the makers, the craftsmanship and material transformations that were developed to high levels, the aesthetic and financial values and many other ingredients that make a work of art specifically what it is.

The most pressing challenge faced by Factum Foundation and Skene Catling de la Peña was just how to install the exhibition within the museum. This curated collection of exact facsimiles of the Spanish Golden Age needed to create a coherent and immersive narrative, while also developing organically from the adjacent Main Gallery. In the end, two facsimiles of masterpieces by Bartolomé Esteban Murillo *The Miracle of the Loaves and the Fishes*, and *Moses Drawing Water from a Rock of Horeb* (1669-1670) were selected to lead into the exhibition space.

The two large paintings act as a gateway into this immersive experience of the Spanish Golden Age, where even the architectural elements of the exhibition space are as much a part of the exposition as the artworks they contain. Brushstrokes of Velázquez paintings are mapped onto cornices, friezes and pilasters of grotesque arabesques to create the wall coverings. A facsimile of the Chart of Juan de la Cosa (1500) from the Museo Naval in Madrid pinpoints the moment in history where the power of the Spanish Crown was at its peak, not even a decade after the discovery of the New World – a geography represented in the Chart for the first time.

Opposite and overleaf: The facsimiles of the tiles from Casa de Pilatos, Seville were produced from data recorded using composite photography and the Lucida 3D Scanner. The surface was 3D printed with an elevated printing system (by Canon Production Printing) to mimic the relief. The surface was then moulded, cast in acrylic resin, gesso coated and printed on Factum's custom flatbed inkjet printer.





The second room is lined with facsimiles of the gleaming, immortal and unchanging 16th-century ceramic tiles of the Casa de Pilatos in Seville, recorded and reproduced with permission of the Fundación Casa Ducal de Medinaceli. The painted surfaces and plays of figure-ground and pattern make them appear alive, animated and curiously modern.

A 'lapidarium' of *yeserías* (carved plasterworks) follows, where the intricate lace-like plaster panels reiterate the complex intertwining between Jewish, Islamic and Christian cultures in Spain, with relationships as delicate and complex as these frozen geometries. The *yeserías* were recorded in various locations across Seville and Toledo and recreated in Factum using plaster.

The fourth room presents religious ritual and ecstasy through a reconstruction of the gilded tabernacle where the polychrome *Risen Christ* (c. 1598), one of the few sculptural works of El Greco, is mechanically raised and lowered as sacred spectacle. On the opposite wall is the facsimile of El Greco's painting *The Baptism of Christ*, whose dramatic vertical split between reality and visionary experience is played out by the tabernacle.

Death is instead the subject of sombre celebration in the room that follows, where Alonso Berruguete's magnificent *Sepulchre of Cardinal Tavera* lays under the stern gaze of the Cardinal's own death mask and two portrait paintings of him. While it is thought that Berruguete worked on his version while the Cardinal was alive, El Greco's portrait (c. 1610) – brutally defaced during the Spanish Civil war – used the mask as a model, painting from 'death' rather than life. On one of the walls, restored recreations of the *Virtues* adorning the sepulchre show the physical potential of digital restoration: the original marble sepulchre was damaged during the Civil War and fragments of the only surviving plaster cast were used as reference for the restoration.

Life is fleeting, and earthly glory is ultimately meaningless: this is the message behind the two *vanitas* paintings by Valdés Leal from the Hospital de la Caridad in Seville, which decorate the last room under the facsimile of the plaster *yesería* designed by the painter himself. On one side (*Finis Glorae Mundi*) the rotting body of a bishop, and on the other (*In Ictu Oculi*), the Grim Reaper straddling the globe with scythe and coffin in hand.



The recording and the production of facsimiles was only possible as a result of the generosity and vision of the following institutions whose responsibility is to look after and communicate the importance of the objects in their care: Fundación Casa Ducal de Medinaceli, Casa de Pilatos (Seville), Hospital de San Juan Bautista / Hospital de Tavera (Toledo), Hermandad de la Santa Caridad, Hospital de la Caridad (Seville), Ministerio de Defensa de España, Museo Naval de Madrid, Centro de Estudios Europa Hispánica (CEEH), Casa de Mesa (Toledo), Ministerio de Cultura y Deporte de España, Museo Sefardí – Sinagoga del Tránsito (Toledo), Museo Nacional de Escultura (Valladolid), Museo del Traje (Madrid), Ayuntamiento de Seville, Real Alcázar (Seville), Hermanas Clarisas Franciscanas, Convento Santa Clara la Real (Toledo), Junta de Andalucía-Consejería de Cultura y Patrimonio Histórico, Filmoteca de Andalucía (Cordoba).

Exhibition views of 'In Ictu Oculi – In the Blink of an Eye'.



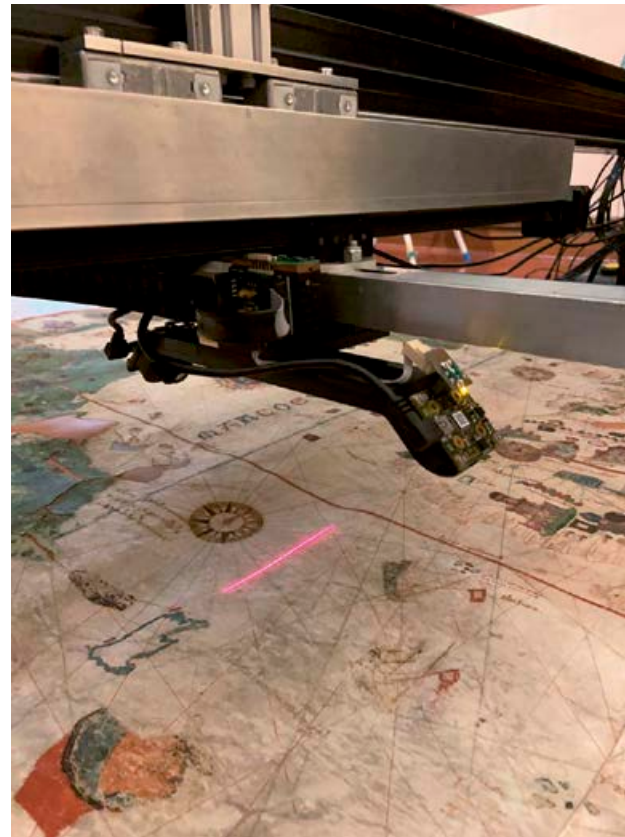


LIST OF FACSIMILES ON SHOW, IN ORDER OF ROOM

- Bartolomé Esteban Murillo, *The Miracle of the Loaves and the Fishes* (1669-1670) – in collaboration with the Instituto Andaluz de Patrimonio Histórico and the Hermandad de la Santa Caridad, Seville
- Chart of Juan de la Cosa (1500) – in collaboration with the Museo Naval de Madrid
- *The Good Shepherd* (late 4th-century AD) from Casa de Pilatos – in collaboration with Fundación Casa Ducal de Medinaceli
- Tiles from Casa de Pilatos, Seville – in collaboration with Fundación Casa Ducal de Medinaceli
- *Yeserías*:
 - Casa de Mesa, Toledo in collaboration with Centro de Estudios Europa Hispánica (CEEH)
 - Sinagoga del Tránsito (Museo Sefardi), Toledo – in collaboration with Museo Sefardi
 - Real Alcázar, Seville – in collaboration with the Ayuntamiento de Sevilla
 - Convento Santa Clara la Real, Toledo – in collaboration with the Hermanas Clarisas Franciscanas
 - Casa de Pilatos, Seville – in collaboration with Fundación Casa Ducal de Medinaceli
- Ceiling in Room C: recorded in Casa de Mesa, Toledo – in collaboration with Centro de Estudios Europa Hispánica (CEEH)
- El Greco, *Risen Christ* (c. 1598) and gilded wood tabernacle (c. 1595) from the Hospital de Tavera, Toledo – in collaboration with Fundación Casa Ducal de Medinaceli
- El Greco, *Baptism of Christ* (1608-1624) – in collaboration with Fundación Casa Ducal de Medinaceli
- Alonso Berruguete, *Sepulchre of Cardinal Tavera* (1561) from the Hospital de Tavera, Toledo – in collaboration with Fundación Casa Ducal de Medinaceli
- Fragments from the plaster cast of the Sepulchre of Cardinal Tavera – in collaboration with Museo del Traje, Madrid, Museo Nacional de Escultura, Valladolid and Ministerio de Cultura y Deporte
- Alonso Berruguete, *Death Mask of Cardinal Tavera* (c. 1560) from the Hospital Tavera, Toledo – in collaboration with Fundación Casa Ducal de Medinaceli
- Alonso Berruguete, *Portrait of Cardinal Tavera* (late 16th-century) from the Hospital Tavera, Toledo – in collaboration with Fundación Casa Ducal de Medinaceli
- El Greco, *Portrait of Cardinal Tavera* (c. 1610) from the Hospital Tavera, Toledo – in collaboration with Fundación Casa Ducal de Medinaceli
- Valdés Leal, *In Ictu Oculi* and *Finis Glorae Mundi* (1672) from the Hospital de la Caridad, Seville – in collaboration with Hermandad de la Santa Caridad, Seville
- Valdés Leal, *Yesería* ceiling from the Hospital de la Caridad, Seville – in collaboration with Hermandad de la Santa Caridad, Seville



The two Murillo paintings (*The Miracle of the Loaves and Fishes* and *Moses Drawing Water from the Rock in Horeb*) from the Hermandad de la Caridad in Seville each measure 2.36 x 5.75 m. In 2018, they were the largest single artworks ever recorded with the Lucida 3D Scanner, at a resolution high enough for rematerialisation as a facsimile.



The Lucida 3D Scanner recording the surface of the Chart of Juan de la Cosa in the Museo Naval, Madrid. The Lucida is a non-contact laser scanner designed by artist-engineer Manuel Franquelo and Factum Foundation, able to capture the surface layer of paintings and low-reliefs with an accuracy of up to 0.1mm.



Recording the tiles in Casa de Pilatos, Seville, using composite photography to acquire the accurate colour.



Recording the original *yesería* in Casa de Mesa using photogrammetry.



Retouching some of the finer details on a plaster cast *yesería* from Casa de Mesa.



CNC-milling in polyurethane of the *yesería* ceiling in the Hospital de la Caridad.



Working on the recreation of the wooden *mudéjar* ceiling from Casa de Mesa. The facsimile ceiling was produced from data recorded using composite photography and photogrammetry, producing a 3D model of its shape, surface and colour.



The ceiling of Room B is a tribute to traditional style *mudéjar* timber ceilings from 16th-17th-century. The installation was designed to incorporate the existing timber trusses of the original roof structure in the exhibition space.



The original Tabernacle was damaged during the Civil War, losing its top half. For its recreation, Factum Foundation created a 3D model based on a historical picture, which was then split into several parts to be 3D printed or CNC-milled individually.



The various elements of the Tabernacle were CNC-milled or 3D printed depending on size and level of detail, before being gilded by hand in gold leaf and assembled. The installation included the design of a small pulley system able to lift and lower the *Risen Christ* within the Tabernacle.



Detail of the finished facsimile of the *Risen Christ*, one of the few sculptural works by El Greco. After being recorded using photogrammetry, it was 3D printed, moulded and then cast in synthetic resin, which was finished by hand to recreate the complex polychrome surface.



Recording the surface of the original *Portrait of Cardinal Tavera* by El Greco using the Lucida 3D Scanner.



Printing the colour of Alonso Berruguete's *Portrait of Cardinal Tavera* over the textured surface created using elevated printing by Canon Production Printing.



The facsimile of *Finis Gloriarum Mundi* by Valdes Léal, next to several colour and printing tests.



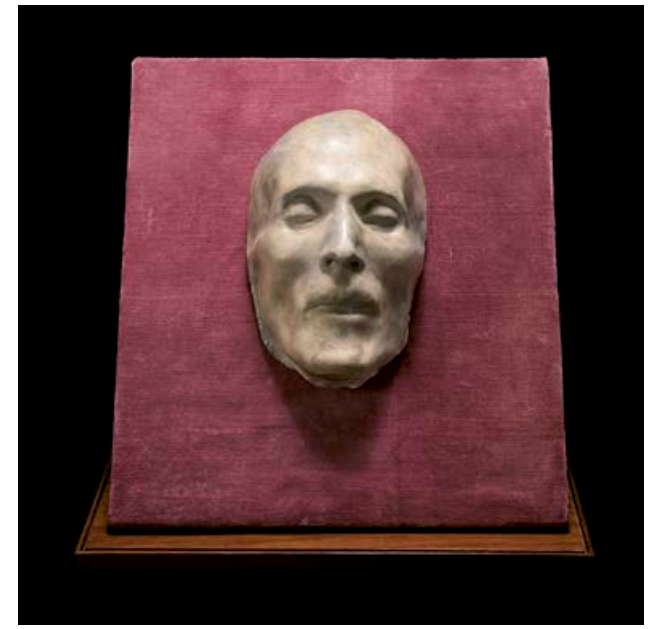
The facsimile of *In Ictu Oculi* by Valdés Leal, in Factum's workshops.



The original *Death Mask of Cardinal Tavera* by Alonso Berruguete, located in the Hospital de Tavera, Toledo was recorded using photogrammetry in collaboration with the Fundación Casa Ducal de Medinaceli.



The photogrammetric data was 3D printed, moulded and cast in plaster, applying the final colour by hand.



The finished facsimile of the *Death Mask of Cardinal Tavera* by Alonso Berruguete.



The original sepulchre was recorded in the Hospital Tavera (Toledo) using non-contact technologies such as LiDAR scanning, high-resolution photogrammetry and composite photography to create a high-resolution 3D model.



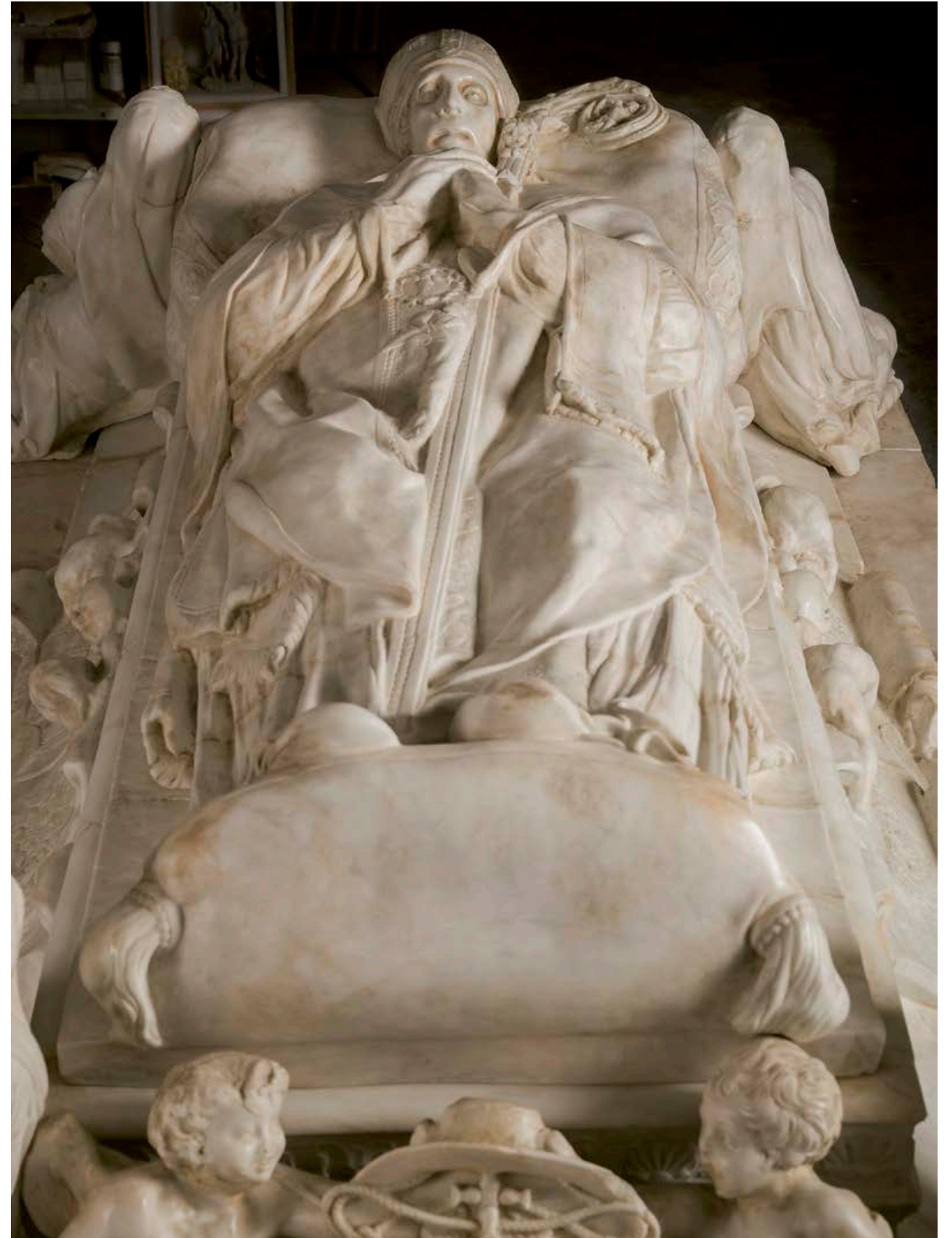
Details of the finished facsimile of Alonso Berruguete's *Sepulchre of Cardinal Tavera*.



Render of one of the *Virtues* (Prudence) decorating the *Sepulchre of Cardinal Tavera*, which was damaged during the Civil War.



After recording the surviving fragments from the plaster cast of the *Sepulchre of Cardinal Tavera* made before the Civil War, it was possible for Factum to carry out a digital restoration project. The *Virtues* were rematerialised as individual facsimiles and restored with 3D printed parts.



The finished facsimile of Alonso Berruguete's *Sepulchre of Cardinal Tavera*. Factum's facsimile demonstrates the current state of the art of 3D scanning and printing, CNC-milling, moulding and casting.



EXHIBITIONS

The early years: Velázquez in Seville

In 2019, Factum Foundation and CEEH (Centro de Estudios Europa Hispánica) started working together on a display and exhibition that aimed to offer new perspectives the life and work of Diego Velázquez. The exhibition was set to open in the new Casa Natal de Velázquez in Seville a space intended to enable exploration of the artist's life and work inside the building known as his birthplace. The relationship between Casa Natal de Velázquez, CEEH and Factum Foundation did not develop as envisaged. Factum Foundation and CEEH are still working together to develop the idea of recording all of Velázquez's works from his time in Sevilla.

Carlos Bayod from Factum Foundation worked closely with CEEH's director José Luis Colomer to carry out digital recordings of several works from Velázquez's early years, before rendering them as facsimiles. These paintings were the first of a longer list of artworks to be recorded and reproduced by Factum Foundation. The work started with the recording of the painting believed to be Velázquez's first painting done when he was still a teenager.

Recording *An Old Woman Cooking Eggs* (top) and printed colour tests in Factum's workshop (bottom).

Opposite: Detail from *An Old Woman Cooking Eggs* colour data.

AN OLD WOMAN COOKING EGGS

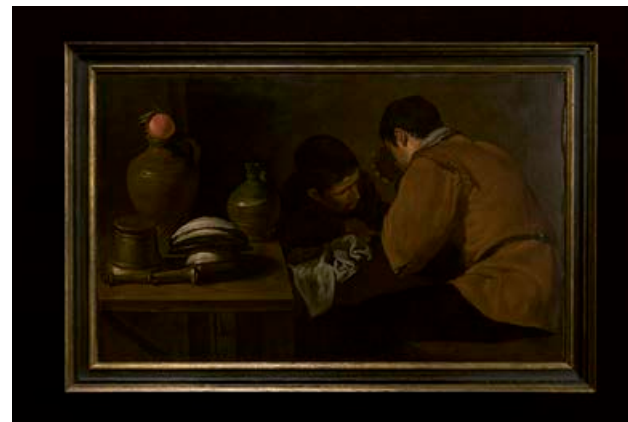
In February 2020, with the assistance of Aidan Weston-Lewis, Factum Foundation carried out the high-resolution digitisation in 3D and colour of *An Old Woman Cooking Eggs* by Velázquez at the National Galleries of Scotland, Edinburgh. Painted between 1618 and 1623 during the artist's early life in Seville, this is considered one of the most significant works painted while Velázquez lived in his hometown.



THE WATERSELLER OF SEVILLE AND TWO YOUNG MEN EATING AT A HUMBLE TABLE

In August 2020, Factum's scanning specialists worked in London's Apsley House to record *The Waterseller of Seville* and *Two Young Men Eating at a Humble Table*. This recording, which took an extra effort to organise due to COVID-19 complexities, represented an important step forward in the initiative to digitise and make facsimiles of the most representative artworks from the Velázquez's early life in Seville (1618-1623). The recording of the two paintings at the Wellington Collection was made possible by the generosity of the Duke of Wellington and the assistance of the Keeper and Paintings Conservators of the Wellington Collection.

Left column: Recording the painting using the Lucida 3D Scanner (top) and finishing touches before mounting the facsimiles on canvas (bottom). Right column: Gabriel Scarpa recording the colour (top) and the two facsimiles framed (bottom).



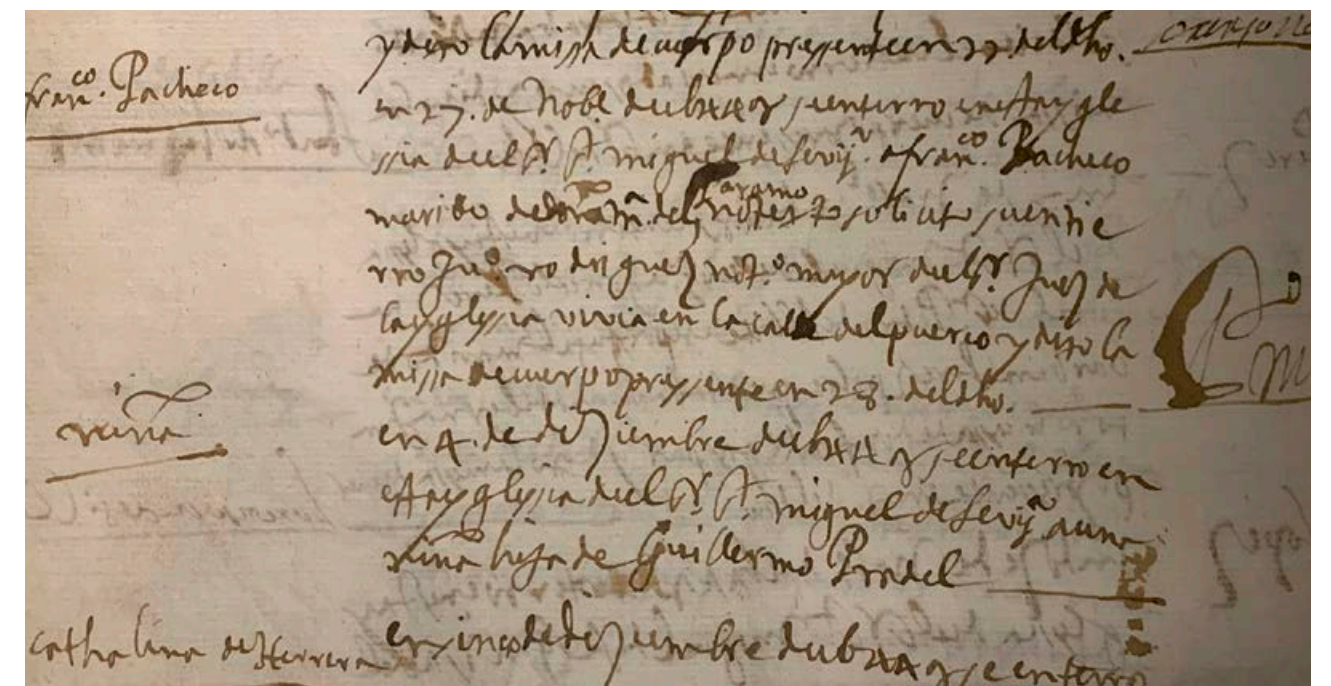
SAINT THOMAS

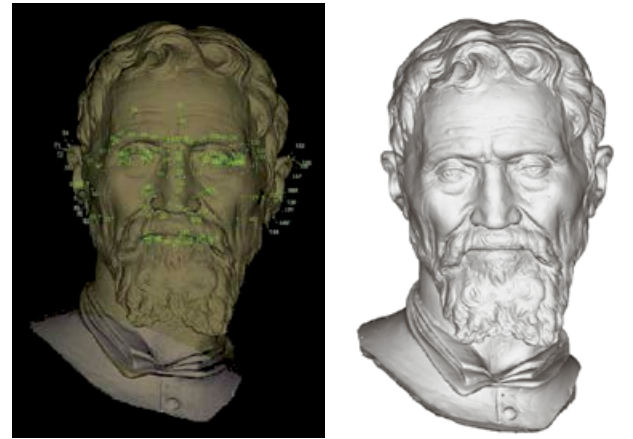
In the months following the recordings at Apsley House, Velázquez's *Saint Thomas* was also scanned in 3D and colour at the Musée des Beaux-Arts in Orléans. Painted around 1618-1620 and one of Velázquez's early works, the painting was recorded using panoramic composite photography and the Lucida 3D Scanner. The data gathered during this recording was handed over to the Musée des Beaux-Arts and has been used to create an exact facsimile.

FRAGMENTS OF VELÁZQUEZ'S LIFE

In collaboration with Seville's Archivo Histórico Provincial, the Parroquia de San Pedro and the Parroquia de San Juan Bautista, Factum Foundation recorded a selection of documents related to Diego Velázquez's life. These unique documents include the apprenticeship agreement with his master Francisco Pacheco (1611), the certificate of Velázquez's examination and acceptance into the guild of painters (1617), in addition to some papers related to his private life and marriage to Juana (Pacheco's daughter). The artist's birth certificate (1599), belonging to the Iglesia de San Pedro y San Juan Bautista, was also recorded. The data obtained was provided to the institutions for archiving and study purposes.

Top: Gabriel Scarpa and Carlos Bayod Lucini recording Velázquez's *Saint Thomas*. Centre: Gabriel Scarpa recording the documents. Bottom: Detail of Velázquez's baptism certificate.





Top: Data analysis of the bronze cast in Casa Buonarroti. Colour mask comparing Buonarroti's cast against the Castello Sforzesco's bust. Right: On each bust, specific key points were researched and mapped in order to help comparisons in both digital (using 3D modelling softwares) and physical (using 3D printed models cut in half) environments.



The cast bronze portraits of Michelangelo

Daniele da Volterra, a close collaborator and friend of Michelangelo, inherited the house of the artist in Rome after his death. In two years, he produced several bronze casts of a portrait of the Renaissance master, which are often thought to have derived from Michelangelo's death mask. The exhibition 'The Bronze Effigy of Michelangelo by Daniele da Volterra' (February - July, 2022), curated by Cecilie Hollberg at the Gallerie dell'Accademia in Florence, reunited, for the first time, nine bronze busts from various collections around the world. Direct comparison has revealed both similarities and differences, and much debate still surrounds the 'genealogy' between the different casts.

Each of the nine busts was recorded by Factum Foundation's experts using non-contact technologies: a structured white light scanner (Breuckmann Smartsan3D-HE) and photogrammetry. The use of both techniques, even on shiny surfaces such as bronze, can obtain an extremely accurate relief of the surfaces once the two sets of data have been combined into a 3D model using specialised software.

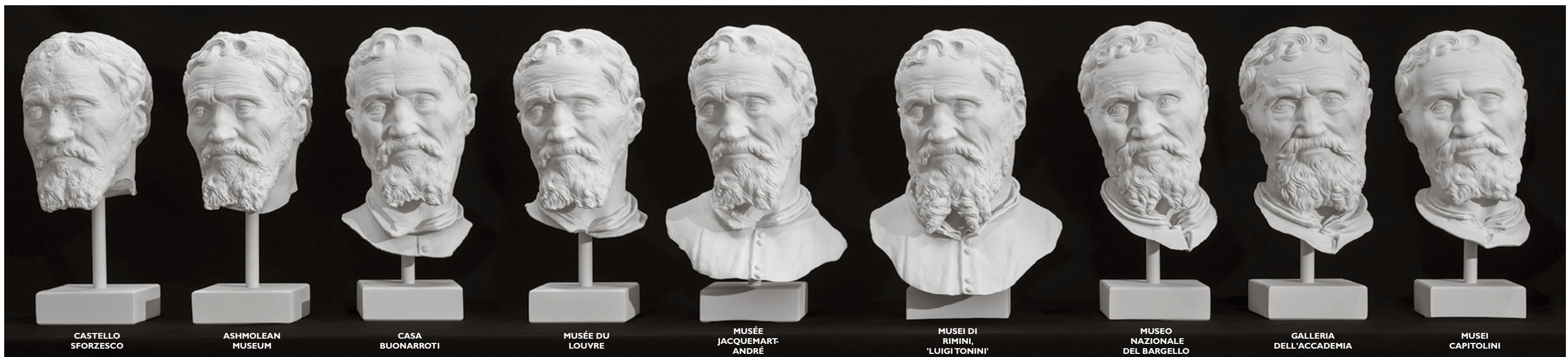
The first busts digitised were those in Florence (Gallerie dell'Accademia, Casa Buonarroti and Museo del Bargello), followed by those in the collections of the Museo della Città 'Luigi Tonini' in Rimini, the Castello Sforzesco in Milan and the Musei Capitolini in Rome. The team then worked on the busts in the Musée Jacquemart-André and the Louvre

in Paris, finishing with the one in the Ashmolean Museum in Oxford. Coordination and collaboration with the respective institutions enabled the work to be completed in just over two weeks. In January 2022, the bust inside the Musée Bonnat in Bayonne was also added to the recordings.

During several months of work with Cecilie Hollberg (Gallerie dell'Accademia) and Mario Micheli (Università Roma 3) in the studios of Factum Foundation in Madrid, the busts were digitally 'mapped' in their key points and correspondences. These were then overlaid and compared in unique research that combined for the first time digital expertise with academic rigour to help identify the original busts in Daniele da Volterra's studio, and the 'genealogy' of the other variants.

The high-resolution 3D models were then printed both at 1/3 of the original and life-size, to allow for comparisons prior to viewing the original busts inside the Gallerie dell'Accademia. Both 3D printed versions, together with the digital data, were on display in the exhibition. In addition, the 3D printed models also served as a valuable 'snapshot' of the surface conservation condition of the works. The digital data remains property of the respective institutions for all uses – in line with Factum Foundation's core missions.

The 3D printed busts in Factum's workshop.





EXHIBITIONS

'Avoiding Oblivion: the Preservation of Pharaonic Knowledge', Masterpiece London Art Fair 2022

On the 100th anniversary of the discovery of the Tomb of Tutankhamun, the exhibition 'Avoiding Oblivion: the Preservation of Pharaonic Knowledge', held at Masterpiece London Art Fair 2022, explored the beginnings of our centuries-old fascination with Ancient Egypt. Masterpiece [Re]discovery, a new platform at the fair that explored the impact of a cultural moment in the history of Egyptomania, invited visitors to engage with a prescient and powerful display that charted changing attitudes to preservation, the impact of time and the dynamic nature of originality. This exhibition was initiated by Philip Hewat-Jaboor, chairman of Masterpiece London who died in March 2022, and became a tribute to him.

Curated by Adam Lowe and Charlotte Skene Catling and designed by Skene Catling de la Peña, 'Avoiding Oblivion' embedded the plan of Tutankhamun's tomb within a larger labyrinth that traces how Ancient Egypt has captured the public imagination for over five hundred years, from the Renaissance to the Romantics, through colonial discovery and scientific excavation, and looking towards the future with virtual or augmented experience. The exhibition façade was Giovanni Piranesi's *Caffè degli Inglesi*, an 18th-century Egyptian architectural fantasy, originally created in Rome as a place where travellers on the Grand Tour would meet. Cut-out windows revealed an animated journey through his *Carceri*, or 'prisons of the mind'. Original objects and books such as Horapollo's *Hieroglyphica* (first printed in 1505), sat alongside Factum Foundation's 21st-century technologies specifically

designed to record in the Theban Necropolis; Howard Carter's carefully observed watercolours and Harry Burton's vintage photographs (on loan from Rupert Wace) captured the greatest archaeological discovery of our time.

Our knowledge of Ancient Egypt and the Theban Necropolis is founded on tombs that were built to last for eternity and have survived for over 3,000 years. These profound monuments, the *Book of the Dead* and the Pharaonic approach to magical transformation and the cycle of life, remain enigmatic and captivating. Looking back at Egyptomania through the ages, we see very different behaviours and attitudes. Displays in the exhibition included: 'Cannibalism in Europe in the 19th-century', illustrating the way Egyptian mummies were bought, sold and eaten. 'Squeezed to Death', 'Tomb Raiders' and 'Hacked Out and Sawn Off' detailed the destruction of the tombs by antiquarians and tourists alike.

A stark white space with the dimensions of Tutankhamun's sarcophagus chamber contained an experiment in virtual display that allowed visitors to look through the eyes of others. This innovative installation for Masterpiece [Re]discovery encouraged visitors to experience the interior of the burial chamber.

View of the 'Avoiding Oblivion' exhibition façade.

Opposite: The 3D model of the Burial Chamber of Tutankhamun was presented as a virtual reality experience for the visitors, developed in Unreal Engine by Irene Gaumé.

Overleaf: Exhibition views of 'Avoiding Oblivion: The Preservation of Pharaonic Knowledge'.

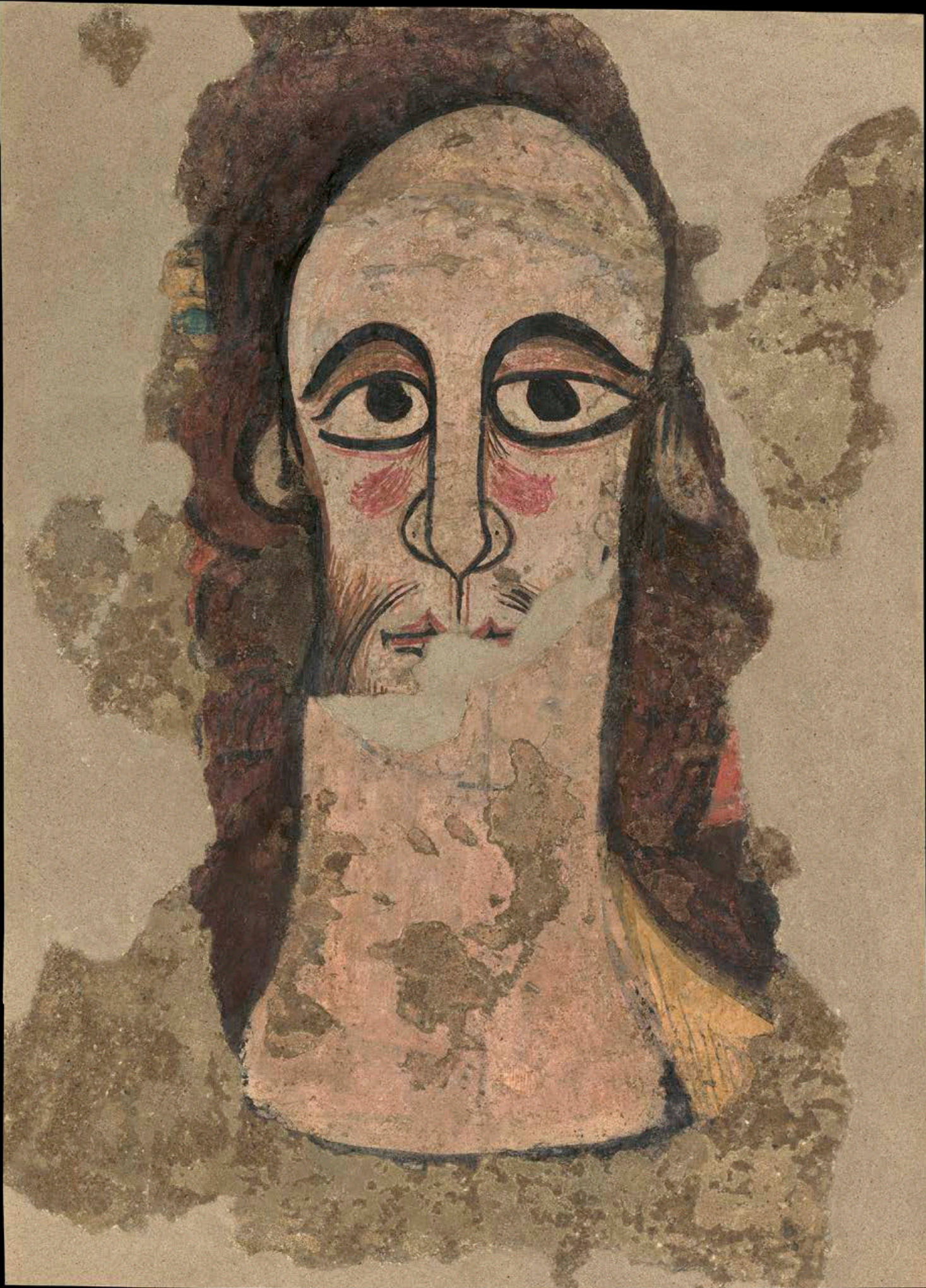


EXHIBITIONS



EXHIBITIONS





7. TRAINING AND WORKSHOPS

‘It was the first time I had immersive, hands-on training, with the possibility of trying cutting-edge technologies. My previous training was primarily by online workshops, by self-guided learnings, and through work experience on specific projects. The opportunity to acquire hands-on experience with these technologies during the workshop was a significant advantage. Some equipment types, such as Replica and Lucida scanners, are both unique and exclusive so it was a great opportunity to get in contact with it and learn from the teams’.

Feedback from a student after the ARCHiVe Onsite Academy - October 2023



Training

A VISION FOR THE FUTURE OF EDUCATION: UNIVERSAL ACCESS TO HIGH-RESOLUTION DATA

During the Covid pandemic the approach to online education changed dramatically. Universities were forced online and had to adapt to the reality that students react differently online to the way they do in class. Some professors thrived in this new environment, others did not. Zoom-based classes have opened new ways to share and impart knowledge but the medium imposes restrictions of its own.

What if it were possible to engage with people as if they were in the same room? Or if you could occupy the same virtual space and interact with the avatars of others, in an environment where the virtual and the physical merge? Would this democratise education? Will it change the commercial models that universities increasingly apply? As display technologies develop, will the educational models change? Will 'foreign students' decide to stay at home and acquire the same qualifications at a fraction of the cost? Will universities change their business models? What will happen when high-quality education exists 'wherever someone with a certain apparatus happens to be'? (see page 337).

Netflix and Google use algorithms to suggest films or provide targeted advertising. Similar algorithms can be used to open up archival and library resources to those without professional guidance and tutorship. Can machine learning applications analyse our interests and patterns of activity and function like an open shelf library with a great librarian? Can this approach bypass the 'card index' as the way to locate the topics and themes that will direct our personal research? The question has always been: 'how do we find what we don't know we are looking for?'

The Ancient Greeks had no word for 'art'. They used the word *techne* to describe the creative use of the intellect to transform and re-present. *Techne* is a philosophical concept that refers to making and doing. The merging of Art, Science and Technology has the potential to re-evaluate the importance of cultural communication through the celebration of material evidence.

More than half the world now has online access to the printed word and iconographic search tools. The word and the image are starting to cross fertilise in new ways. It is now possible to engage with a book, manuscript or object as material evidence in an online screen-based environment. The artifact can be moved in ways that simulate handling, re-orientated and lit from any angle, creating a physical

relationship with a virtual object. Factum Foundation has been pushing this technology for preservation and cultural heritage management. Others are starting to investigate the educational potential with exciting results. There are companies leading the way in terms of innovation, storytelling and user experience. Dreamscape Learn, based in California, has developed virtual environments where the boundaries between the virtual world within the headset and the material world are blurred. A handrail can be grasped, an animal's head touched, an object handled. They are applying this technology to education with the Arizona State University, exploring new pedagogical applications.

'Students study; they apply knowledge and concepts; they learn by doing and they do in order to learn; they learn from text, from lecture, from visual and audio media, from hands-on experience and from each other'
from Dreamscape Learn's website

What would happen if the high-resolution data Factum Foundation has been gathering enters an educational environment? Factum Foundation has a clear approach to data ownership and commercial potential for the data that must benefit the custodian/owner of the artwork. It is equally clear that for sharing knowledge and preserving artefacts the potential has hardly been touched. As the quantity of information available in the public domain increases exponentially, its educational potential is amplified and the diverse narratives it can communicate are altering the dominant professional values that define the role of education and the resulting qualifications educational establishments issue.

We are in a time of change. In the past 40 years we have gone from free three-year MA courses in which students received means-tested financial support, to a model that leaves students significantly in debt. What happens over the next 40 years is up to us... now.

LEARNING-BY-DOING

Factum Foundation is committed to the preservation of cultural heritage not as an end in itself, but to reveal the enriching communication that is embedded in diverse types of objects. Education is an essential part of Factum Foundation's mission. In collaboration with some of the most important universities and cultural institutions in the world,

Two Columbia University students recording the colour of the *azulejos* in Casa de Pilatos.



Factum Foundation has developed cutting-edge training initiatives for more than ten years, including through a long-term teaching position at Columbia University GSAPP (2016-2019) where the 'learning-by-doing' approach was fine-tuned. The Preservation Technology Studio was created within the Masters of Historic Preservation programme. This approach has spread; ARCHiVe is based in Venice and ARCHiOx is embedded within the Bodleian Libraries in Oxford. ARCHiVe's Online Academy offers free, remote access to masters-level content. The goal is to encourage a learning-by-doing approach, in order to train a new generation of preservation specialists and heritage managers who understand the technologies that are available even if they are not practitioners. The aim is to disseminate the important role of digital technology in cultural preservation.

Factum Foundation's 'learning-by-doing' approach includes the potential to participate in real projects, to operate cutting-edge recording technology, and become part of a multi-disciplinary team working alongside Factum's experts. The courses are aimed at students and professionals from diverse backgrounds (with or without previous technical knowledge). They provide a direct, onsite, hands-on experience working with some of the main museums and cultural institutions in diverse locations. The recordings carried out as part of the workshops are done to the highest quality, so they can benefit the owners of the artifacts or custodians of sites.

The training initiatives take various formats. The in-person courses usually vary from one-day-long intensive seminars to introduce one specific technique, to one-week-long (about 30 hours) workshops which provide time to deepen knowledge of the concepts and practicalities of different technologies and methods. Additionally, longer courses have also been developed as part of formal training within graduate programs, with weekly- or bi-weekly classes over one semester, making a total of about 90 hours of teaching. Specific masterclasses and other formats are also part of this activity.

The focus is usually on the non-contact, high-resolution 2D and 3D recording of shape, surface and colour. The information that is recorded can be viewed on-screen, in virtual applications, or re-materialised as facsimiles. The concepts and ideas surrounding the objects that are selected for recording, and their complex historic trajectories, are an integral part of Factum Foundation's approach.

ARCHIVE ONLINE ACADEMY

ARCHiVe Online Academy (AOA) is an initiative that has grown exponentially in recent years. It has become one of the main pillars of ARCHiVe. So far, 154 hours of high-level training have been taught. The Cini Foundation's YouTube channel has a total of 30 videos that offer about 60 hours of training free of charge. This will be developed over the next phase of ARCHiVe (starting in January 2024).

Since 2020, a selected list of experts have presented topics including: preserving museum collections, building archives, making archives accessible, the educational impact of blurring the boundaries between remote (online) and presential (on site) learning, the history of libraries, preservation and more. AOA's content is carefully curated so that over time a rounded and complete repository of lessons can be made available. The format varies slightly from session to session, but they follow the successful approach developed over the past three years: an academic specialist talks about a specific subject followed by a technical expert discussing the technologies used.

CONTENTS: THEORY AND PRACTICE

Some of the areas and topics of interest that are usually explored (and put in question) within Factum Foundation's training initiatives include:

- The capacity of non-contact, digital preservation to help with the preservation of cultural artefacts.
- The role of high-resolution data to understand and communicate the biography of objects.
- The relevance of digital fabrication and production techniques (producing exact facsimiles) as a way to protect originals.
- The relationship between the concepts of *originality* and *authenticity* in light of new technologies.
- The definition of 'sustainable tourism' and access to fragile sites, artworks and monuments.
- The potential of digital reproductions (virtual and physical) to address issues of repatriation.
- The transfer of technologies and skills to local communities creating new economies and resulting in effective heritage management.

Opposite: Students inspecting the facsimile of the leather wall hanging installed in Palazzo Te during the workshop in September 2022 (see page 103).

Teaching at the Museo Nacional del Prado

Factum Foundation is a frequent contributor to the different seminars organised by the Museo del Prado, with the goal of disseminating the importance of new technologies for the field of art and conservation. In March 2019, Carlos Bayod was the invited professor of the annual course on 'Técnicas Artísticas Contemporáneas' (Contemporary Art Techniques), organised by Fundación Amigos Museo del Prado. In four lessons, with a total duration of 6 hours, Carlos described some of the main processes and

methodologies pioneered by Factum Foundation with direct application in the conservation, study and dissemination of cultural heritage. More recently, in July 2022, Carlos gave a lecture at the Summer workshop 'Pensar con las manos. El proceso del arte y la vida de las obras', with a focus on Factum Arte's approach to contemporary art creation. New sessions are being planned for 2024, to address the issue of the copy in the 21st-century – a subject that, still today, is often misunderstood.

Workshop for the MA Photography - ISIA Urbino

In June 2019, Factum Foundation's 3D scanning department held a five-day workshop, focused on non-contact recording technologies for cultural heritage, for ten students from the Photography MA course from the design university ISIA Urbino. Factum was invited to teach this workshop on the recommendation of Armin Linke, professor at ISIA.

The theory classes took place at ARCHiVe's studios at the Fondazione Giorgio Cini. The workshop followed Factum's ethos of always providing practical training on real digitisation projects, an experience that gives students a better insight into the realities of on-site work. In this case, participants carried out fieldwork recordings at various institutions around Venice, and the valuable data they obtained could give rise to larger projects for ARCHiVe.

Students used photogrammetry to 3D record a series of classical busts and statues at the 'Domus Grimani' exhibition

held at Palazzo Grimani. The workshop also demonstrated the potential of high-resolution photogrammetric scanning with reflective materials. Students used photogrammetry on two porphyry busts, a series of maiolica pottery and a small terracotta head by Antonio Canova at the Colnaghi exhibition held at Abbazia di San Gregorio.

At the Fondazione Giorgio Cini, the Lucida 3D Scanner recorded in high-resolution the surface of a painting on canvas by Brusaferrò. Students also had the chance to learn more about ARCHiVe, visited the IUAV's Photogrammetry Lab, and spoke to Rashmi Gajare, an architect and specialist in digital humanities (see the essay on pages 54-55).

Left: Otto Lowe teaching photogrammetry in Palazzo Grimani. Right: Photogrammetry workshop on objects at Colnaghi's exhibition 'The Grand Tour in Venice', in Abbazia di San Gregorio.



Fitch Colloquium 2019 - Columbia University

In 2019, Carlos Bayod Lucini, head of Factum's Lucida 3D Scanning department and Adjunct Assistant Professor at Columbia GSAPP, participated in the Fitch Colloquium: 'Record/Replay: Data, Technology and Experimental Preservation'.

The 2019 Fitch Colloquium aimed to explore the future of Historic Preservation through the lens of experimental approaches to digital documentation, analysis, interpretation, archiving, sharing, visualisation and

rematerialisation of data. The symposium examined cutting-edge processes involving the development and application of digital tools to projects of all scales, including high-resolution 3D scanning, gaming, computer-based visual pattern recognition, blockchain encryption, behavioural geo-tracking and interactive projection mapping among others. Carlos focused on the application of non-contact and non-invasive 3D recording methods as a new approach to the preservation of cultural heritage.

Fieldwork for the Graduate School of Architecture, Planning and Preservation (GSAPP) at the Palace and Church of San Giovanni in Malta, Venice - Columbia University

In 2019 the students of the Advanced Preservation Technology Studio, taught at Columbia University's GSAPP in collaboration with Factum Foundation, employed a range of 3D recording technologies to document specific elements of art and architecture in the Palace and Church of San Giovanni di Malta in Venice. Crossing boundaries between academic and professional practice, the team worked on the digitisation, processing, analysis and reproduction of the obtained data as part of a comprehensive approach to the preservation of this unique building.

The on-site fieldwork was carried out under the supervision of Factum Foundation's experts, operating from the centre ARCHiVe (Analysis and Recording of Cultural Heritage in Venice) at the Fondazione Giorgio Cini on the island of San Giorgio. Former IUAV student and intern Emanuele Zampieri participated as a Teaching Assistant. The work demonstrated once again the importance of digital preservation, especially in fragile locations like Venice where historic artefacts can suffer tragic damage and change forever.

Workshop for the Master's Degree in Digital Architecture - IUAV, Istituto Universitario di Architettura di Venezia



In early January 2020, Factum Foundation's Carlos Bayod was invited to teach a workshop on digital preservation to the graduate students of IUAV's Master's Degree in Digital Architecture. Through a learning-by-doing approach that combined theory and practice, a group of students spent three days in ARCHiVe learning to apply 2D and 3D digital recording systems to the documentation of cultural heritage. A selection of artworks from the Cini Collection, including a canvas painting and sculptural artifacts, was offered to be digitised with photogrammetry and the Lucida 3D Scanner. Former IUAV student and intern Emanuele Zampieri participated as a Teaching Assistant. The workshop concluded with a public lecture by Bayod about 3D scanning, as part of the AperiMADI series, which took place at the IUAV's campus in Venice.

Carlos Bayod demonstrating the Lucida 3D Scanner to the students.

Online discussions: *The Art Newspaper* and Factum Foundation

Before COVID-19, 15 million people visited the Forbidden City every year; every day tourists packed into the Sistine Chapel, and crowds jostled in front of the Mona Lisa. What will happen to museums and heritage sites in the wake of the pandemic? Will we see changes over the coming months and years to the ways in which we share, enjoy and learn from the material evidence of the past? What role will technology play in ensuring access to collections and keeping attention focused on vulnerable heritage from across the world?

In May 2020, when the ongoing coronavirus outbreak forced us all to reflect on what we valued and why, Factum Foundation and *The Art Newspaper*, with *Il Giornale dell'Arte*, launched a series of discussions on the role of digital technologies in the preservation of cultural heritage.

The three 80-minute, online discussions brought together contributors to Factum Foundation's new book, *The Aura in the Age of Digital Materiality – Rethinking Preservation in the Shadow of an Uncertain Future*, with other experts from a wide range of disciplinary backgrounds. The discussions considered the increasing prominence of high-resolution recordings of cultural heritage and their place in the display spaces of the present and the future.



Workshop at the Cuarto Real - University of Granada

In April 2022, Factum's Pedro Miró and Osama Dawod ran a workshop with students from the Universidad de Granada, focused on presenting practical applications of high-resolution technologies for recording cultural heritage. Over the course of two days, the team taught the students the basic principles of digitisation (equipment, formats and processing) and the different techniques employed by Factum, such as photogrammetry and LiDAR scanning, and how to combine them.

During the discussions, questions were gathered from the online audience. Everyone asking a question was invited to provide a few words about their involvement in heritage preservation and their areas of interest. Each panel was recorded and will remain online and available to all. In total, the three online discussions were viewed more than 22,000 times on *The Art's* YouTube channel.

In hosting these discussions and making them freely available online, the aim was to generate enthusiasm and increase knowledge in the field of digital technologies for cultural preservation. In the shadow of the pandemic, this platform enabled interested minds, expert and amateur alike, to come together and reflect on the future of cultural heritage and the role innovative technologies will play in how best to preserve, document, monitor, study, recreate, disseminate and share it.

The three discussions were:

- Discussion 1 - 1 May 2020
THE FUTURE OF MUSEUMS, EXHIBITIONS AND THE OBJECTS THEY DISPLAY. Rethinking the role and value of culture in the shadow of an uncertain future
- Discussion 2 - 2 May 2020
THE CIRCULATION OF OBJECTS: THE POLITICS OF RECORDING, TRAINING, PRESERVING AND SHARING. Creating a cultural economy based on sharing skills, technologies and knowledge
- Discussion 3 - 3 May 2020
AN INTIMACY WITH THE PHYSICAL WORLD: NEW TECHNOLOGIES GENERATING NEW KNOWLEDGE. Compiling, analysing, presenting information in an age of machine learning

The students worked on recording architectural details of the Cuarto Real de Santo Domingo, a 13th-century Nasrid palace turned into a Dominican convent in 1492, and Espacio V Centenario, which formerly housed the Faculty of Medicine.

Following the training, Carlos Bayod Lucini, Project Director, participated in a seminar hosted by the University inside the Palacio de la Madraza, where he presented Factum's projects.



The photogrammetry workshop in Espacio V Centenario (left) and in the Cuarto Real de Santo Domingo (right).



Summer Institute for Technical Studies in Art (SITSA) - Harvard Museums

The Summer Institute for Technical Studies in Art (SITSA), organised by the Harvard Art Museums, enables participants to engage with conservators, conservation scientists, curators, art historians, artists, and other creators in the collaborative environment of the Museums and the neighbouring Department of History of Art and Architecture. In June 2022, under the direction of Francesca Bewer, Research Curator for Conservation and Technical Studies Programs at the Harvard Art Museums, SITSA

brought together an expert faculty to engage a cohort of 15 students in close-looking, art making, and the scientific investigation of objects from the Museums' collections. It is in this framework that Carlos Bayod, Director of Projects at Factum Foundation, gave a lecture on *Digital and Material restitutions of Surface Relief*, which was followed by an online presentation by Factum's founder Adam Lowe.

Fieldwork for the Master's Degree in Cultural Heritage Management at the Church of San Juan de Ruesta - University of Zaragoza

In March 2022, Factum Foundation partnered with the University of Zaragoza on a digitisation and training initiative focused on the unique series of Romanesque wall paintings removed from the Church of San Juan de Ruesta (Huesca) and other churches. These paintings form part of the 'French route' of the Camino de Santiago. The aim of the work was to obtain high-resolution records of the condition of the paintings (both in colour and 3D) as the basis for digital restoration, and future facsimiles.

In the 20th-century, the removal of paintings from churches in north-eastern Spain using the *strappato* technique was a normal part of their preservation. The wall paintings originally covered the apse of the Church of San Juan de Ruesta. After their removal, the church ceased to be an active religious space and fell into near-total disrepair. An extensive restoration project carried out by Sergio Sebastián Arquitectos has recreated a new space from the old ruin.

The apse still exists, with traces of original paint – the production of a facsimile would allow the painting to be seen in its original context once again.

A team from Factum Foundation worked with a group of graduate students from the University's Cultural Heritage Management Master to record the wall paintings, now within the collection of the Museo Diocesano in Jaca. As part of Factum's learning-by-doing educational model, the students recorded in the museum and in the church, employing different recording methodologies to understand the strengths and limitations of each.

Over the course of the following months, the students applied their knowledge of cultural heritage and digital technologies to propose a digital restoration of the damaged areas of the frescoes. Following the methodological and technical direction of the University of Zaragoza professors and the Factum

Foundation team, the students worked in groups to propose different strategies for the reconstruction of the missing areas, using the best-preserved sections as a reference.

The results suggest different approaches to the recovery of the lost colours and shapes. This information could be included as part of the conservation history, or used to inform the study and the dissemination of the paintings.

This project was a collaboration of Factum Foundation with Universidad de Zaragoza, Sergio Sebastián Arquitectos and Confederación Hidrográfica del Ebro.



Theoretical class inside the Church of San Juan de Ruesta.

Benin Bronzes Digital Documentation Training

In November 2022, a team from Factum Foundation conducted a two-week training programme in digital heritage documentation, focusing on photogrammetry, for participants from the Edo Museum of West African Art (EMOWAA) and the National Commission for Museums and Monuments, Nigeria (NCMM).

In the first week, the training was hosted by the Nigerian National Museum in Lagos; the second week was arranged inside the National Museum Benin City. Both institutions hold significant collections of material from the Benin

Kingdom. Objects digitised included bronze plaques and heads, wooden and terracotta heads, and other ceremonial regalia. The aim of the training was to establish a team of digital heritage specialists able to carry out recording projects both in Nigeria and on projects abroad.

Left: Participants from EMOWAA and NCMM with the Director General of NCMM, Professor Abba Tijani, with Factum's Ferdinand Saumarez Smith at the Nigerian National Museum, Lagos. Right and bottom left: Participants from EMOWAA and NCMM recording bronze head using photogrammetry at the National Museum, Lagos.



Workshop for the Bartlett School of Architecture

Over two days in April 2023, a group of students and professors from the Bartlett School of Architecture participated in a workshop organised at Factum Foundation's headquarters in Madrid. The students were introduced to Factum's activities in both contemporary art production (through its sister company Factum Arte) and new technologies applied to the preservation of cultural

heritage. The workshop, taught by Factum's 3D Recording team, included photogrammetry and LiDAR training, and live demonstrations of the Lucida 3D Scanner and the Selene Photometric Stereo System.

Opposite top: Imran Khan teaching photogrammetry (left). Pedro Miró teaching LiDAR scanning (right).



ARCHiVe Workshop 2023

The first ARCHiVe Workshop was held from October 9th to 13th, 2023, in Venice. Evolving from the ARCHiVe Online Academy programme, this initiative aimed to provide practical and theoretical on-site training in the use of high-resolution, non-contact recording technologies for the preservation of cultural heritage. The workshop was attended by a group of 12 participants from Italy, the UK, Spain, the Netherlands, and Brazil, encompassing a diverse range of professionals from different fields (conservation and restoration, technical art history, photography, heritage wood carving, archival studies, museology, etc.), as well as students from the Digital Humanities and Digital Knowledge (DHDK) graduate program at the University of Bologna.

Taught in English, the workshop employed a hands-on, learning-by-doing approach to introduce participants to the primary techniques and methodologies used in documenting cultural objects, both in 2D (e.g., the Replica 360 Recto/Verso Scanner or the Apis Scanner) and 3D (Lucida, close-range photogrammetry, and LiDAR). Participants, under the guidance of experts from the Factum Foundation and Fondazione Giorgio Cini, recorded a selection of historic books, canvas paintings, stone reliefs, wooden sculptures, and architectural elements from the Cini Collection (located in both San Giorgio Maggiore and San Vio).

Views of the theory and practice classes.



Teaching at the Máster Interuniversitario en Métodos Avanzados en Conservación y Restauración de Bienes Culturales - University of Granada

Following the photogrammetry workshop carried out in April 2022 by invitation of Universidad de Granada, Factum Foundation has been invited to teach at the new Master's Degree in Advanced Methods for Conservation and Restoration of Cultural Heritage, a graduate program created by Universidad de Granada and Universidad Internacional de Andalucía. Teaching has been organized in two sessions: first, an in-depth review of the concepts of

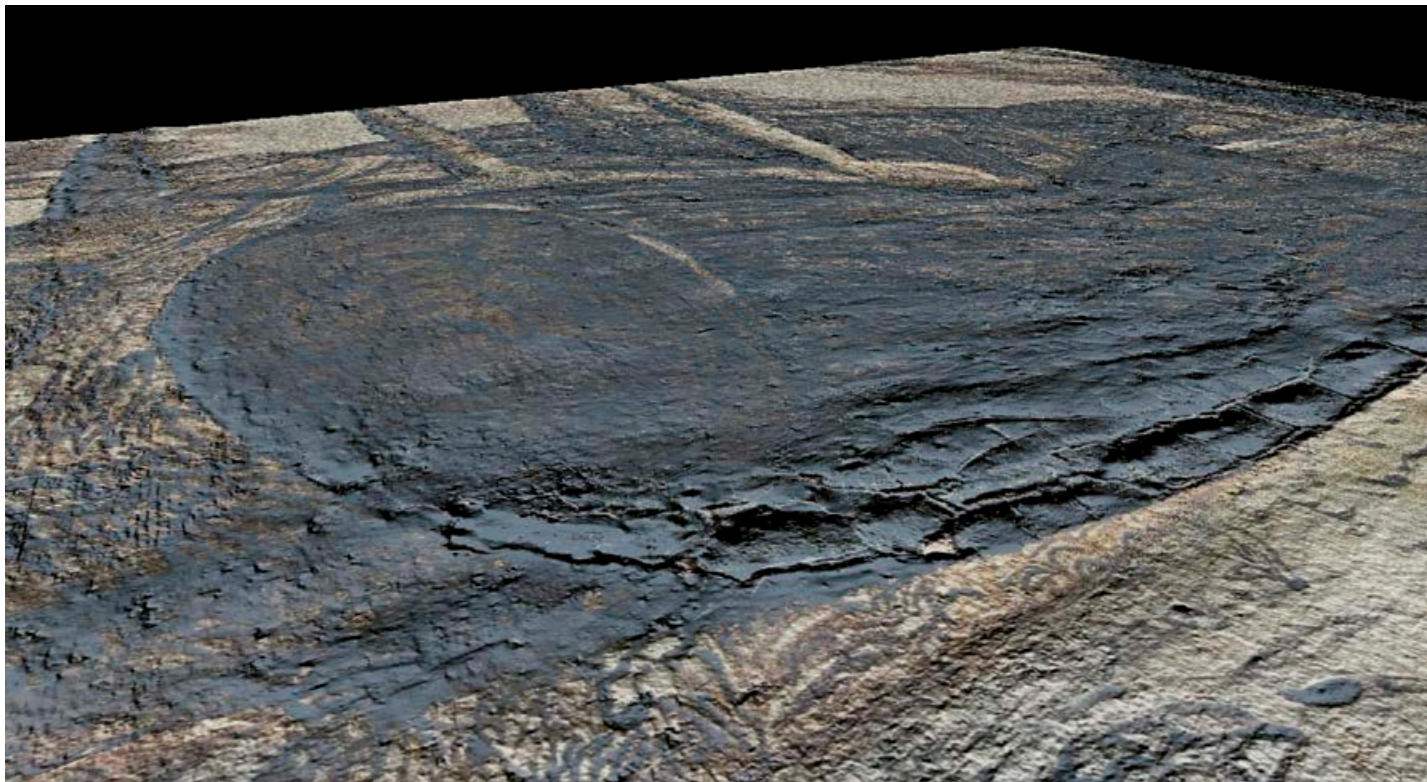
digital, non-contact preservation, through the analysis of selected case studies, which took place in November 2023 in Baeza. Second, a practical workshop to introduce the students to the application of close-range surface recording technologies, such as the Lucida and Selene scanners, scheduled for February 2024 in Granada. The collaboration will also provide the opportunity for one student to do an internship in Factum Foundation for three months.



8. TECHNOLOGY

‘Technology, provided again by Factum Arte, enables the juxtaposition of a facsimile of Raphael's cartoon of ‘The Sacrifice at Lystra’ (around 1515-16) with the respective Vatican tapestry. The educational impact for the general public is indisputable: now scholars have to face the challenge of inserting these new tools into their research and exploiting their potential, before they are once more outwitted by commercial applications. The exhibition implicitly urges collaborations beyond the borders of museums and disciplines.’

*Arnold Nesselrath
Review in ‘The Art Newspaper’ - July 2020*



Three visualisations of Samuel Palmer's pen and ink drawing of Shoreham recorded by John Barrett in the Ashmolean Museum with the Selene PSS in November 2023.

Mapping and Imaging

In the popular imagination photography is considered to be an accurate representation of reality. Now, as the curious innovators of photography knew at the time it was being invented, a photograph can be a three dimensional representation as well as a two dimensional illusion. In other words, a photograph can both be an object and an image. A print can be on paper or a 3D form in diverse materials. In this mix of representational methods the materiality of objects has moved centre stage. When digitising a manuscript, the aim is not only to extract the text from the pages, but to reveal many aspects of the material object leading to new insights and understanding.

Factum's preferred form of representation is the map and cartography, the meticulous measuring and capturing of the unique topological characteristics of objects. Methods of extracting and condensing information, while adapted to art and cultural objects, are fundamentally rooted in terrestrial mapping practices. Challenging professionally accepted boundaries, this approach to the recording of cultural heritage merges art, science and technology. As with the great maps of the past and the material evidence of scientific research, the pursuit of truth and discovery generates its own aesthetic validity.

In cartography, Digital Terrain Models (DTM) hold a pivotal position. These models transcend standard visual representation; their precision affords a detailed understanding of the terrain's rises and falls. A DTM delineates elevations at various points on a land surface, creating a data structure that computer systems can interpret to produce three-dimensional visualisations, slope calculations, hydrological analyses, and various other studies. This precision and depth in representing terrain is mirrored in the 'depth maps' employed at Factum. Mapping the surface of objects rather than a vast landscape presents different challenges. Instead of mountains, valleys, and rivers, Factum's technology is designed to document subtle imperfections, brush marks or the textural features that give an object its specific character. Rather than recording shape which can be done accurately with relatively few points, the accurate recording of surface requires millions of points per square metre: capturing and depicting minute details and variations in elevation is a subtle task and the human eye is an exceptionally sensitive organ, it can detect the minute rounding of surfaces – something that is still referred to as the 'sucked sweet test' in Factum.

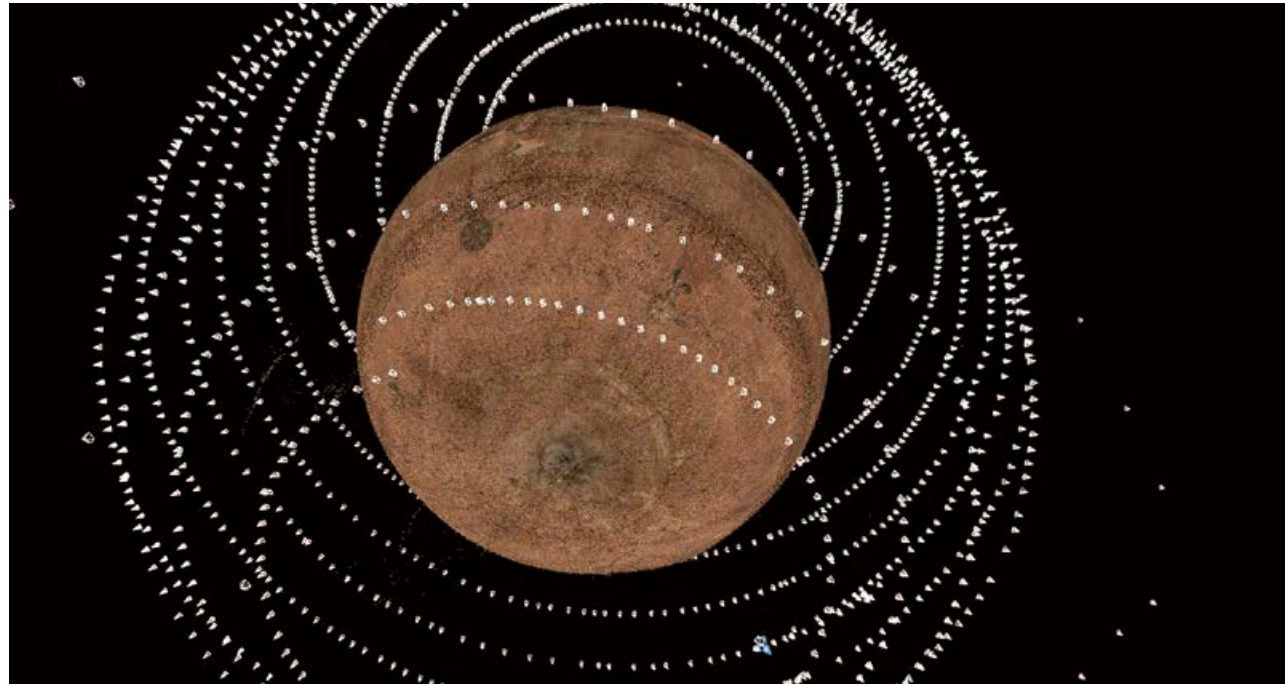
Digitally speaking, a 'depth map' is an image representation of the distances or heights of a surface relative to a specific

viewpoint. By adding multiple viewpoints with different lighting directions a feature space is generated that can be converted into a surface and displayed as a tonal (greyscale) image. Each shade of grey corresponds to a particular height on the scanned surface, allowing the object's three-dimensionality to be represented in a two-dimensional image. This relationship between relief and tone has been at the heart of mechanical printing techniques for centuries. The advance in computer processing and the development of increasingly sophisticated 'graphics cards' may have been commercially driven by the gaming industry, but they are having a great impact on the recording and display of cultural artefacts.

The workflows that have been developed are powered by Geographic Information Systems (GIS) software, the same platforms cartographers employ to chart our world as DTMs. The relationship between DTMs and height maps is more than just conceptual. Factum's engineers work alongside the experts who use the data in different ways – these may be art historians and intellectuals or digital artisans and craftsmen producing physical objects. It is this approach, similar to a renaissance workshop where everyone is working together towards the same goal, that is driving innovation and new developments. The challenge is to find the most elegant and simple ways to mediate and transform information and ideas.

Most 3D software works using DWG and STL files. These are highly abstracted representations where the world is reduced to points that are connected together to produce triangulated (polygon) meshes. Averaging and optimisation procedures can reduce the data so that it is easily handled for different tasks. One can increase the 'resolution' by adding points, but this does not create more accuracy or add more detail. Working with depth maps the data is condensed as tonal information rather than being abstracted as a cloud of points. By processing at 8 bit, 16 bit or 32 bit, more information can be extracted from the subtle tonal shifts that have been recorded.

- **Albedo Map:** Represents the inherent diffuse reflectance of the object's surface or the colour without any shadow or glare
- **Normal Map:** Provides pixel level information about the orientation of each point on the surface of any object.
- **Depth Map:** Displays the depth or relative distance of each point on the surface as tonal information.
- **Shaded Map:** Simulates the object under different lighting conditions to reveal its surface.



Surface data as greyscale maps and advanced processing of height data in depth map format

Factum has an intrinsic relationship with mapping and surveying, meticulously measuring and capturing the unique topological characteristics of objects. Our methodologies for extracting and condensing information, while adapted to art and material culture, are rooted in terrestrial mapping practices, and storing surface data as greyscale maps is one example of this.

Greyscale maps are 2D images where each pixel represents a single value corresponding to a shade of grey that has a certain intensity or brightness. In an average greyscale image, each pixel is an 8-bit value ranging from 0 (black) to 255 (white), where the intermediate values represent various shades of grey. Factum typically uses a 16-bit greyscale file, representing 32,767 different shades of grey. This enables a higher level of detail and smoother gradients than the 8-bit greyscale image. These 2D maps are commonly used for 3D visualisation, image processing, geological surveys and increasingly AR/VR.

The Shape from Shading (SfS) technique developed by Berthold K.P. Horn (1989) forms the basis for estimating the 3D shape of a surface from a 2D greyscale image. This uses the variations in brightness intensity, or shading to unveil surface 'normal' information and infer the three-dimensional shape of objects. Imagine a photograph of a human face. Even though the reflective properties of the skin are consistent, brightness variations are evident. Why? These variations arise because different parts of the surface are oriented in such a way that they reflect the incoming light to the viewer differently.

Greyscale maps are the result of a long history of cartography and artistic representation techniques. In the realm of cartography, they share similarities with Digital Terrain Models (DTM) as both use shades of grey to represent terrain data. However, DTMs are a specific type of digital representation that focuses on elevation information (slope calculations, hydrological analyses), while greyscale maps can represent various types of data in a simplified, monochromatic form.

Factum uses recording technologies (Lucida and Selene) that store high-resolution data as greyscale depth maps, where the various shades of grey correspond to a particular height on the scanned surface, thereby allowing the object's three-dimensionality to be represented in a two-dimensional image.

Here, illumination transcends being a mere visualisation tool. Instead, it uncovers and enriches our understanding of these objects. Through the variations of light and shadow three-dimensional data is recorded with the utmost precision.

While greyscale maps provide a great foundational analysis of an object's topology, incorporating other data visualisation methods and technologies can further enhance our understanding and appreciation of material culture under observation. Greyscale can be complemented by capture methods like Shape from Motion (better known as photogrammetry). These varied techniques mean that the capture protocol leverages the collective capabilities and strengths of several methods and ensures comprehensive and detailed documentation, capturing not just the visible, but also the minutiae that might elude a single-method capture.

Depth maps are directly generated or measured from a 3D object, and each pixel value represents the depth information. While SfS techniques can provide depth estimation indirectly from greyscale images, depth maps themselves are not typically used as inputs for SfS algorithms.

Digitally speaking, a depth map is a 2D image representation generated or measured from a 3D scan of an object. Unlike greyscale images, they encode the depth or distance information for each pixel rather than just intensity values. They are usually used to visualise the 3D structure of an object and each pixel corresponds to the distance from the camera to the surface. While Shape from Shading (SfS) techniques common to greyscale maps can provide depth estimation indirectly from greyscale images, depth maps themselves are used for more certain 3D data visualisations.

Opposite: Photogrammetry of a ship's globe in the Centraal Museum, Utrecht (top). A portable version of Selene PSS recording the same globe (bottom).

Selene Photometric Stereo System

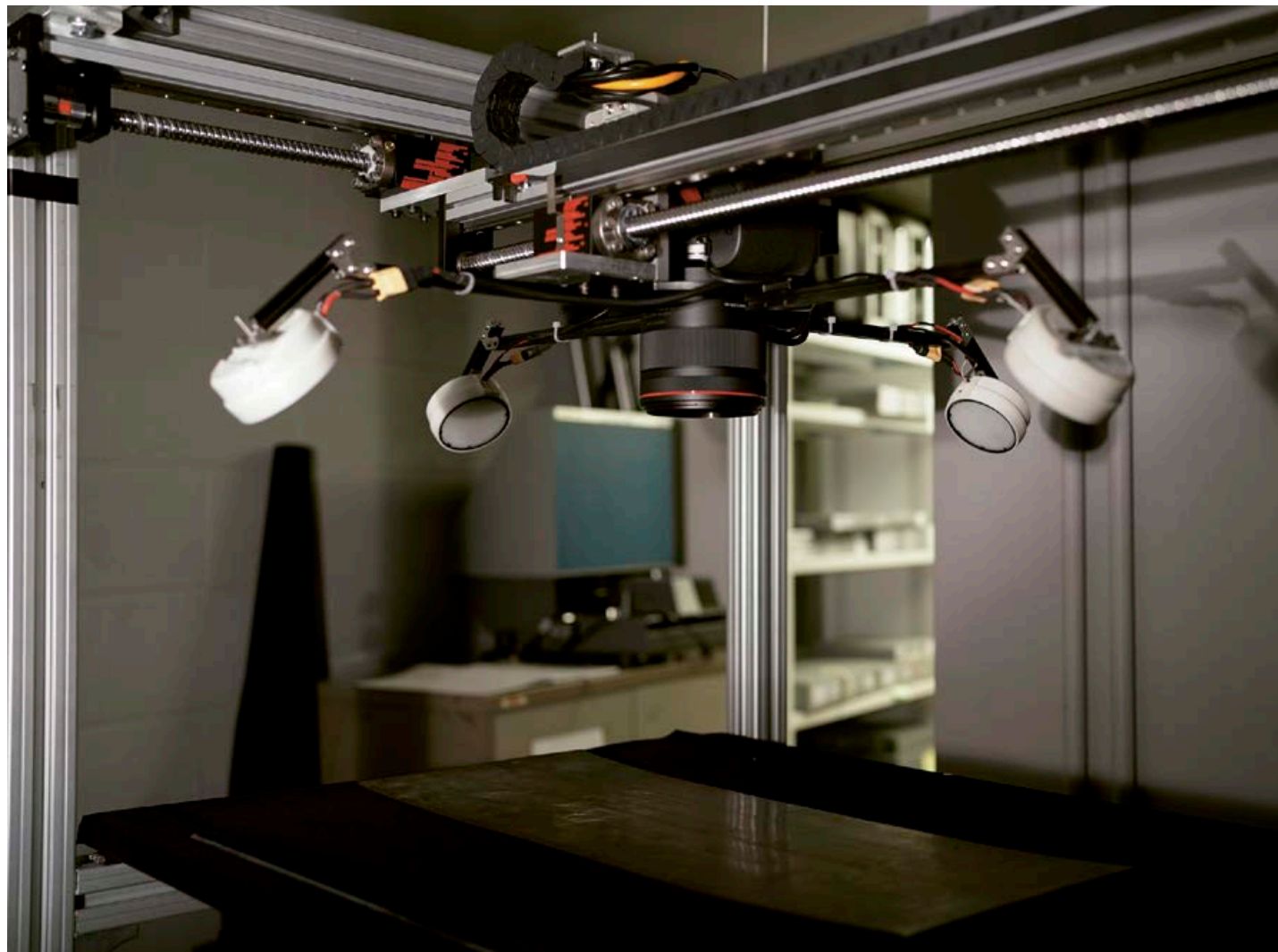
The Selene photometric stereo system (SPSS) is Factum's latest non-contact, ultra high-resolution 3D- and colour-recording system and workflow. It is designed specifically to record the surface texture of flat or semi-flat surfaces such as paintings, murals, manuscripts, books, book bindings, prints, copperplates, palm leaf manuscripts etc., capturing details and information invisible to the human eye. This system merges non-contact 3D recording technologies, depth maps, albedo colour and GIS with image stitching software, lighting and CNC software.

The Selene is the culmination of many years of research into surface recording and 3D capture by Factum Foundation. The system is based on the photometric stereo technique, which captures 2D images under different directional lighting and extracts ultra-high-resolution information

about the surface of an object. This is achieved by four synchronised flashes linked through a custom electronic board to a mirrorless camera. The advanced algorithms merge the information in each image, calculating surface normals and revealing fine details, such as brushstrokes, texture and surface imperfections.

Until the advent of the Selene PSS, material culture (paintings, textiles, works on paper, etc.), though rich in three-dimensional details and textures, was reduced to a two-dimensional representation. The system captures both colour and 3D surface concurrently – a marriage of dimensions and aesthetics. By combining surface relief capture with colour, details that previously went unnoticed are unveiled. From subtle marks without pigmentation to

The Selene Photometric Stereo System installed at ARCHiOx.



barely perceptible drawings on engraving plates, the Selene PSS is pushing the boundaries of knowledge in the realm of research and conservation, and is transforming the way we look at artefacts.

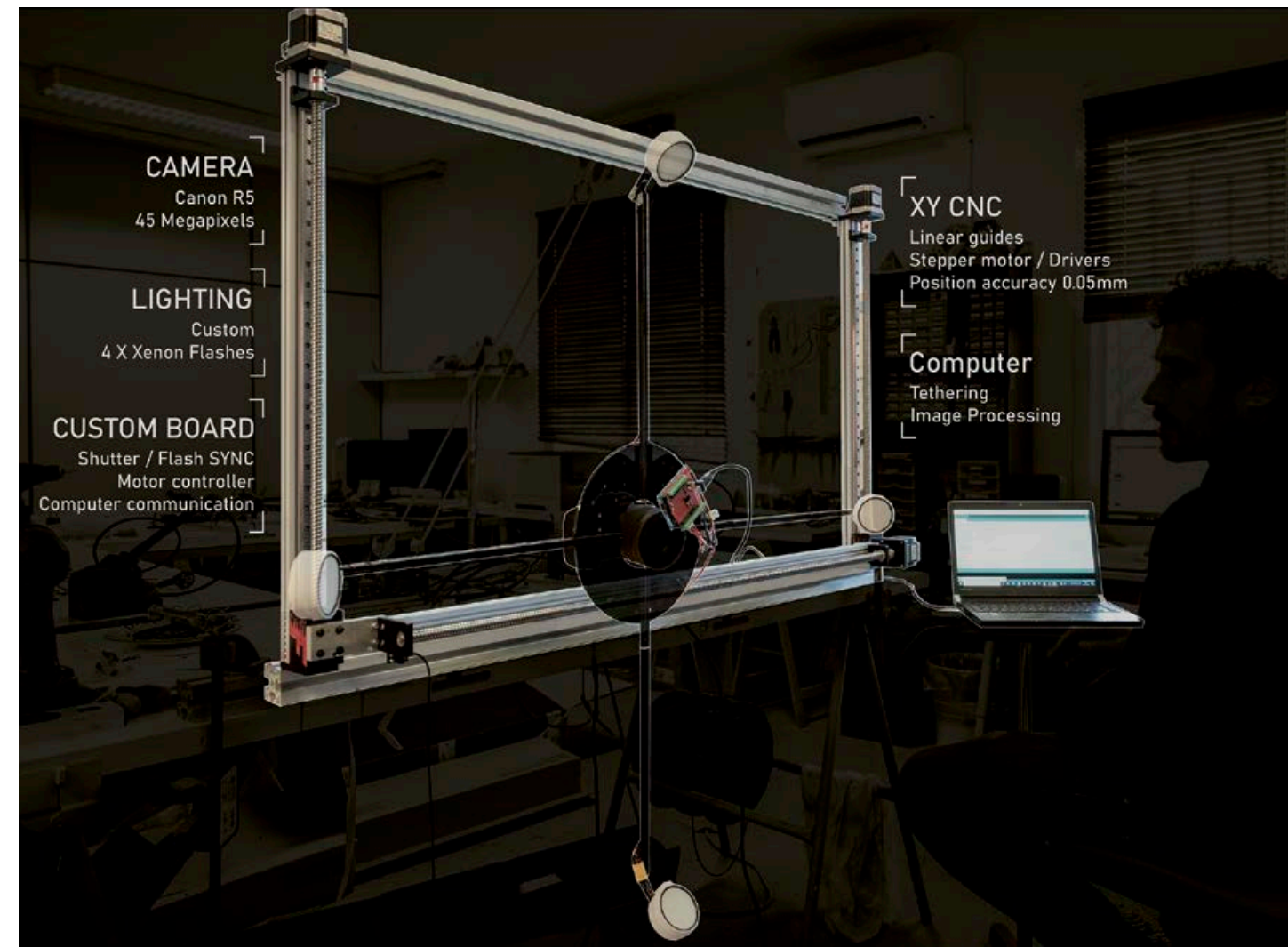
The objectives of the Selene are to:

- Capture the colour with a resolution of 1040 dpi
- Process the depth maps at 32 bits
- Capture depth resolution below 20 μm
- Make the recording process as efficient as possible
- Scan surfaces of 1m²

The Selene motorised unit is adaptable and user-friendly, and the camera position can be adjusted over an object as each shot records an area of 20 x 14 cm. Working at maximum resolution (1000 dpi), the capture distance is approximately

40 cm. The standard system uses a 45-megapixel camera in combination with a 50mm lens. The combination of advanced camera technology and precise optics results in highly detailed and accurate scans suitable for various applications. A supremely simple ambition lies at the core of the Selene's design: to digitise surfaces with an unparalleled level of detail. Eight different pieces of software applications are employed in post-processing in order to achieve the high-resolution derivatives.

In our mission to document surfaces with unparalleled precision, we lean on the foundations of geographic science, merging the domains of artistic documentation and spatial mapping. Selene's workflows are powered by Geographic Information Systems (GIS) software, the same platforms cartographers employ to chart the world.



In January 2022, a Selene PSS and a Lucida laser scanner were installed in the Imaging Services at the Bodleian Libraries in Oxford launching ARCHiOx (Analysis and Recording of Cultural Heritage in Oxford). The aim was to use this technology to contribute to the study, conservation and dissemination of key items in the collections. All the work at the Bodleian Libraries has been carried out by John Barrett, Senior Photographer and ARCHiOx Technical Lead for the Bodleian, with support from Factum's Jorge Cano, Carlos Bayod, Celeste Anstruther and Adam Lowe. The work at ARCHiOx, focused on the implementation of the Selene system, has been supported by the Helen Hamlyn Trust.

The work with the Selene Photometric Stereo System was the first time a 3D scanning technology had been systematically integrated into the Bodleian's workflow, offering a new way to access and interact with the unique items in their collections. This project has demonstrated that 3D surface recording can create new possibilities in how libraries handle and preserve their collections. By customising and adapting the International Image Interoperability Framework (IIIF) for 3D integration, the Bodleian is paving the way for a more immersive and engaging experience for researchers, educators, and other users worldwide.

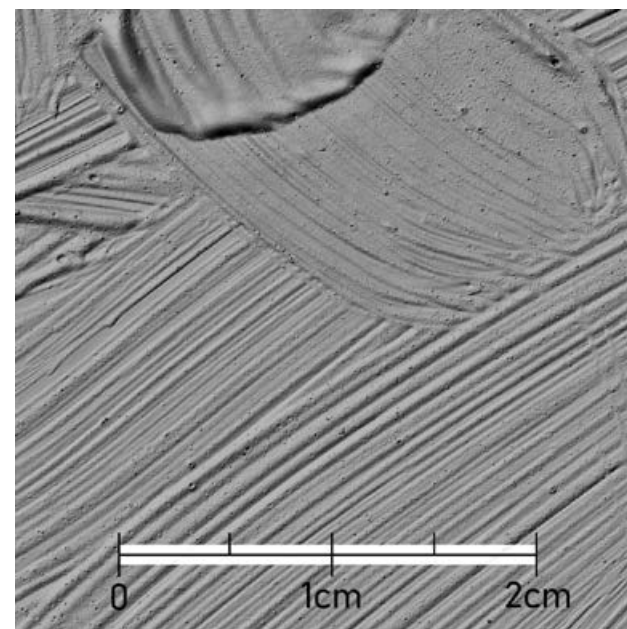
Beyond academic and conservation discoveries, this technology has had an unexpected cultural impact: revitalising interest in collections that were accumulating dust in storage. A tangible example of this renaissance is the Rawlinson Copperplates collection, which was digitised by John Barrett within the framework of the ARCHiOx project with researcher Chiara Betti. The 3D recording of one of the plates revealed a piece of music (notes and text) inspired by verses 1-2 of Psalm 9. The back of another plate revealed

lines that Mark Crosby has proposed are the earliest tests made by William Blake.

In the Selene PSS, light and shade are not merely tools to generate aesthetic images. They are being used as a tool to develop an intimate understanding of materiality. Through the use of the SfS technique (Shape from Shading) the Selene succeeds in capturing and reproducing surfaces with a fidelity and detail that goes beyond mere visualisation, merging cartography, history, and science into a high-quality 3D scanning system.

Learn more about ARCHiOx on pages 57 to 75 of this publication.

The 3D data of a brushwork detail, recorded with the Selene.



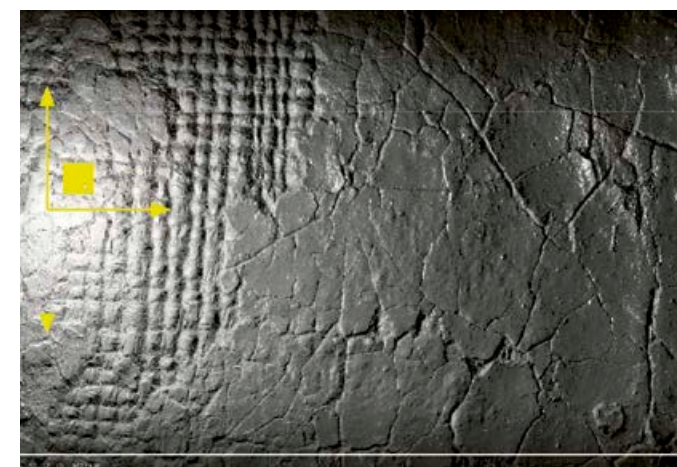
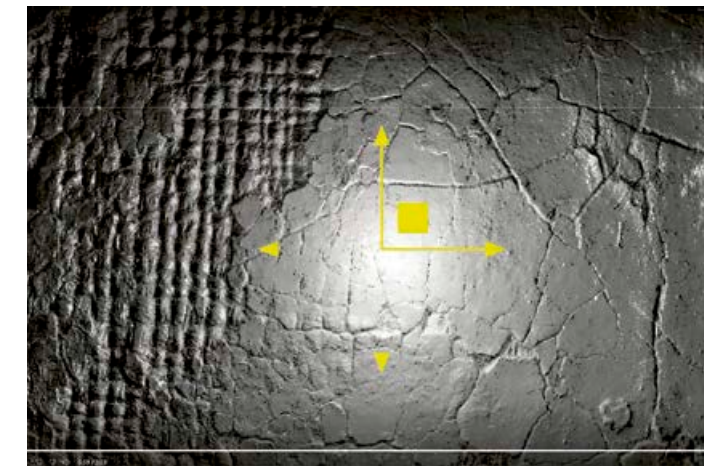
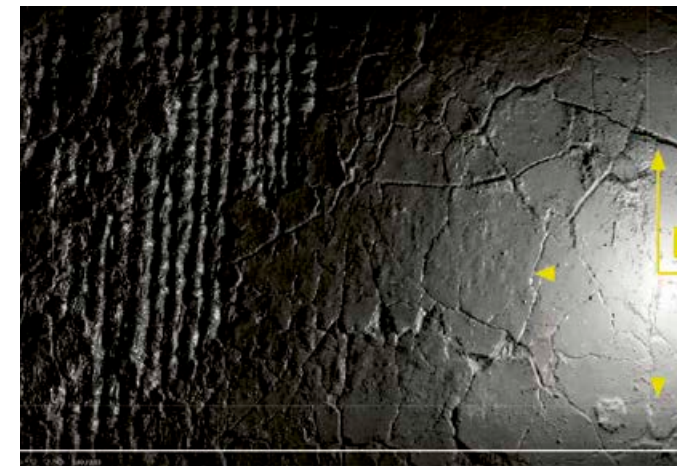
The Importance of Accessing 3D Information Using IIIF

3D surface recording creates new possibilities for the ways in which libraries and collections can handle, preserve and share their collections. By incorporating 3D scanning technology into the Digital Bodleian platform, ARCHiOx has enhanced the display of item-level metadata and enabled users to view and download the highest-quality images and 3D models for non-commercial research and teaching purposes.

The integration of 3D data into the International Image Interoperability Framework (IIIF) is transforming the way objects can be studied by researchers; the object can be manipulated in a virtual space and the light source can be moved and its intensity changed. Digital Bodleian used the Mirador image browser, but until the innovations developed in 2022 by the ARCHiOx team, viewing 3D data within IIIF protocols was not possible. At the end of 2022 a Mirador plug-in was developed to allow researchers to view depth-

map renders with a 'digital torch'. This facilitates highly localised control over the surface of objects. This application will soon be available on Digital Bodleian. Work is now focused on how to make this tool more user-friendly and intuitive so that it can be used for epigraphic study and research by academics without specialist 3D knowledge and without technical support. The ability to both move the object and the light source opens a new way to work with screen based interfaces, where the materiality of an object is diminished by the form of display.

Factum Foundation's Jorge Cano is also working on the development of a real-time 3D data viewer. In this 3D environment, users can inspect objects from multiple angles. The goal is to provide full control over the visualisation and optimised performance. This tool allows manipulations such as camera movement, virtual light adjustments, and specific settings such as relief exaggeration.

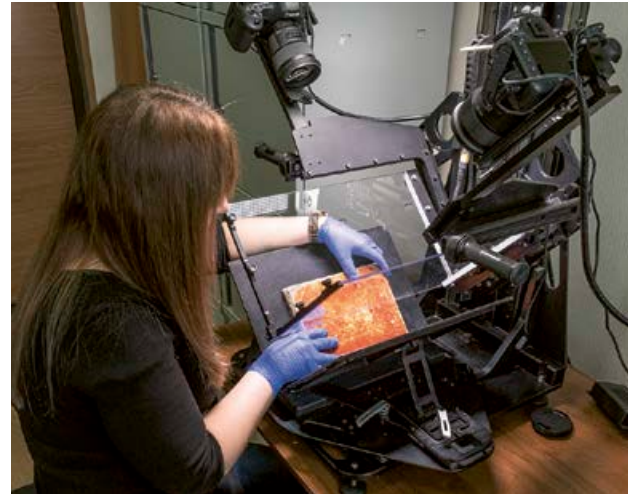


'Right now, we're in a sweet spot that's also exciting: seeing the good results that we've been working towards for several years is a powerful motivator to keep going. At the same time, we know that there's a lot of software development and testing ahead of us. The processing pipeline is made up of different parts, each of which is handled by different software, and our goal is to unify it all into a single open-source software.'

Jorge Cano, Head of Technology, Factum Foundation and Factum Arte.



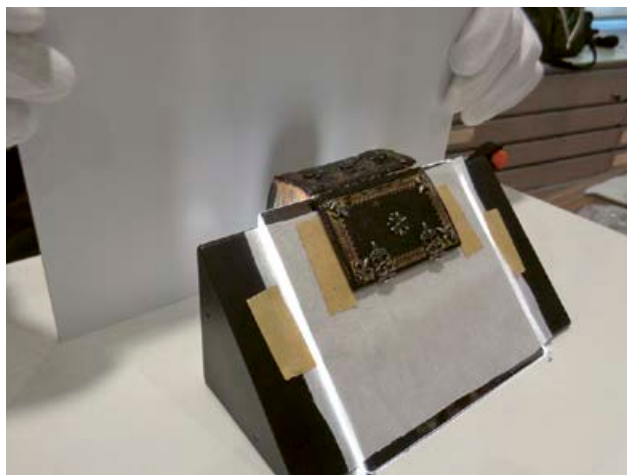
Portable Manuscript Scanner being used at the State Archives in Makhachkala, Dagestan to record their collection of Arabic manuscripts.



Photographic Manuscript Scanner for the IHAE in Makhachkala, Dagestan.



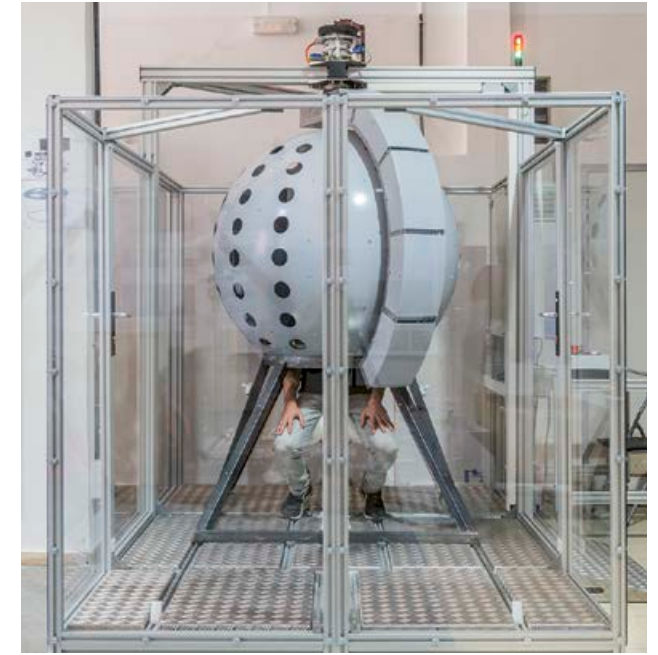
Replica 360 Scanner for the Heritage Lab at Italgas, Turin.



Miniature Book Scanner recording the Offiziolo of Charles VIII.



Diagrammatic image of the Veronica Chorographic Scanner.



The Veronica Chorographic Scanner.



Photometric Stereo prototype.



Selene Photometric Stereo System.



Lucida 3D Scanner.



Canon Elevated Printing Technologies

Factum Foundation and Factum Arte have been working with Canon Production Printing (previously named Océ) since 2015, adapting and applying their elevated printing technology for the reproduction of exact facsimiles.

Elevated printing technology allows the creation of full-colour, textured prints with a maximum area of 2.44 x 1.19 m and a height of up to 15 mm. Its operation is similar to flatbed printing, although in this case, layer upon layer of UV-cured ink is deposited to produce high-resolution three-dimensional surfaces. The thickness of each layer is about 8 µm.

The printed data consists of a CMYK or RGB bitmap for colour and a 16-bit grayscale height map for elevation/texture. The combined full-colour texture data is fed into the elevated print Raster Imaging Processor. The RIP creates a stack of image files to be printed one by one on top of each other in order to create the full-colour textured print.

Aside from the possibility of printing in colour, Factum saw the potential of this technology for the production of facsimiles of 2.5D surfaces (such as paintings and low reliefs) and has been employing the high level of accuracy of elevated printing as a way to transform depth-map data, acquired from the Lucida 3D Scanner, into a physical, textured white form.

The blank textured surface is then moulded using liquid silicon and cast in a specially prepared gesso. This thin,

flexible 'skin' is fixed to a canvas in a process that is similar to re-lining a painting. It forms the base surface of the final facsimile. The colour of the painting is printed separately, using Factum's custom flatbed inkjet printer.

One of the first projects that saw the collaboration between Canon and Factum was the recreation of the Renaissance altarpiece known as the *Polittico Griffoni*: the sixteen surviving panels from the altarpiece were scanned with the Lucida and then 3D printed using the elevated printing system to produce a surface that could be studied with or without colour.

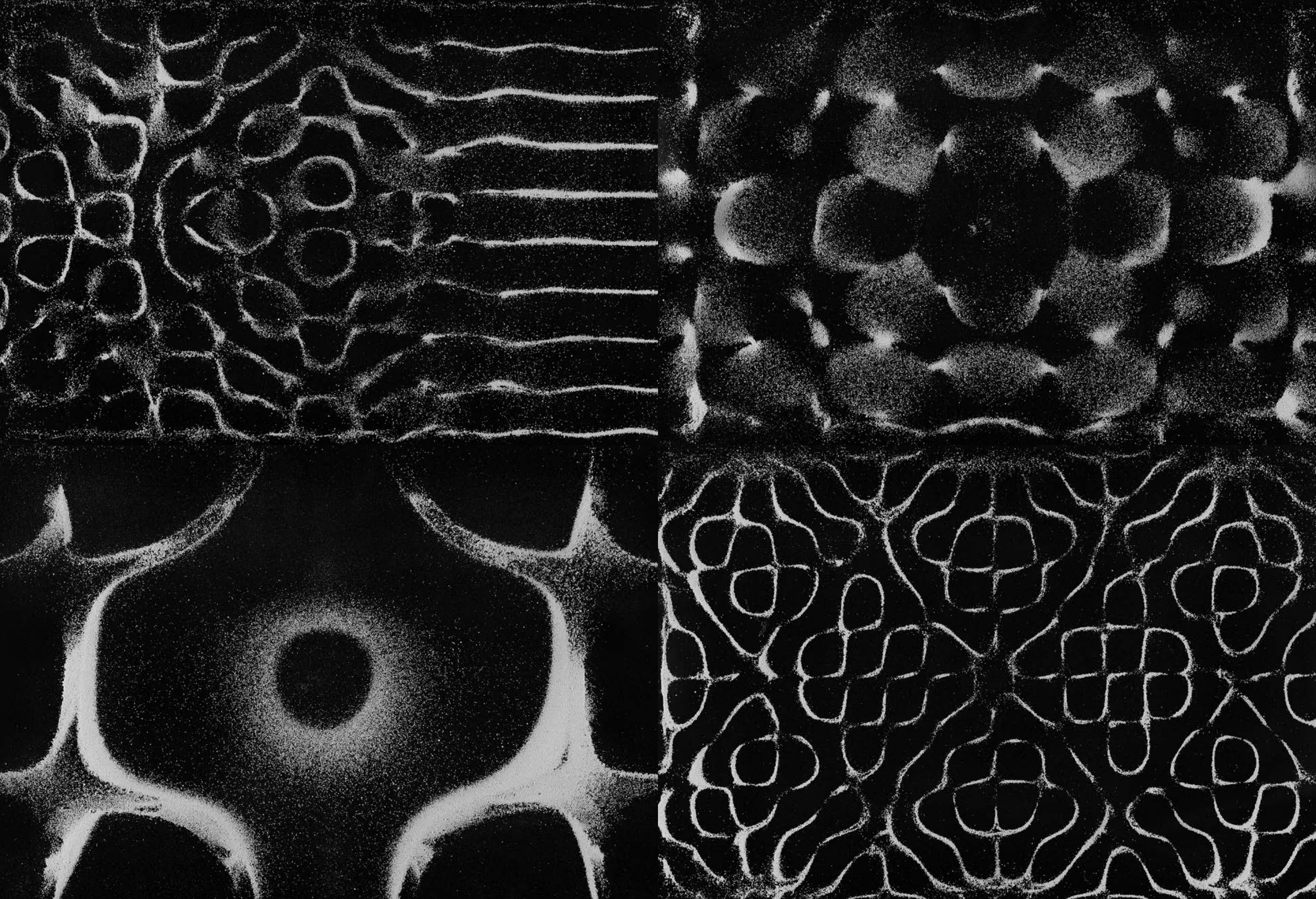
In 2021, a custom Canon Arizona flatbed UV printer was installed in Factum's workshop in Madrid, bringing the collaboration with Canon Production Printing to the next level. The Canon end-to-end solution comprises Canon ALPS (Advanced Layered Printing System) technology and a Canon Arizona wide format flatbed printer. The reliability and accuracy of this flatbed printer, combined with the ALPS technology, has enabled Factum to speed up the process of production of facsimiles and low reliefs.

Elevated printer.

Opposite: Elevated print of the (enhanced) surface of a Goya painting (top). Detail of the elevated printing process, building the colour layer upon layer (bottom).

Overleaf: *Material Sound, Standing waves*, Factum Arte.





‘La conquête de l’ubiquité’
Paul Valéry, 1928

Nos Beaux-Arts ont été institués, et leurs types comme leur usage fixés, dans un temps bien distinct du nôtre, par des hommes dont le pouvoir d’action sur les choses était insignifiant auprès de celui que nous possédons. Mais l’étonnant accroissement de nos moyens, la souplesse et la précision qu’ils atteignent, les idées et les habitudes qu’ils introduisent nous assurent de changements prochains et très profonds dans l’antique industrie du Beau. Il y a dans tous les arts une partie physique qui ne peut plus être regardée ni traitée comme naguère, qui ne peut pas être soustraite aux entreprises de la connaissance et de la puissance modernes. Ni la matière, ni l’espace, ni le temps ne sont depuis vingt ans ce qu’ils étaient depuis toujours. Il faut s’attendre que de si grandes nouveautés transforment toute la technique des arts, agissent par là sur l’invention elle-même, aillent peut-être jusqu’à modifier merveilleusement la notion même de l’art.

Sans doute ce ne seront d’abord que la reproduction et la transmission des œuvres qui se verront affectées. On saura transporter ou reconstituer en tout lieu le système de sensations, – ou plus exactement, le système d’excitations, – que dispense en un lieu quelconque un objet ou un événement quelconque. Les œuvres acquerront une sorte d’ubiquité. Leur présence immédiate ou leur restitution à toute époque obéiront à notre appel. Elles ne seront plus seulement dans elles-mêmes, mais toutes où quelqu’un sera, et quelque appareil.

Elles ne seront plus que des sortes de sources ou des origines, et leurs bienfaits se trouveront ou se retrouveront entiers où l’on voudra. Comme l’eau, comme le gaz, comme le courant électrique viennent de loin dans nos demeures répondre à nos besoins moyennant un effort quasi nul, ainsi serons-nous alimentés d’images visuelles ou auditives, naissant et s’évanouissant au moindre geste, presque à un signe. Comme nous sommes accoutumés, si ce n’est asservis, à recevoir chez nous l’énergie sous diverses espèces, ainsi trouverons-nous fort simple d’y obtenir ou d’y recevoir ces variations ou oscillations très rapides dont les organes de nos sens qui les cueillent et qui les intègrent font tout ce que nous savons. Je ne sais si jamais philosophe a rêvé d’une société pour la distribution de Réalité Sensible à domicile.

La Musique, entre tous les arts, est le plus près d’être transposé dans le mode moderne. Sa nature et la place qu’elle tient dans le monde la désignent pour être modifiée la première dans ses formules de distribution, de reproduction et même de production. Elle est de tous les arts le plus demandé, le plus mêlé à l’existence sociale, le plus proche de la vie dont elle anime, accompagne ou imite le fonctionnement organique. Qu’il s’agisse de la marche ou de la parole, de l’attente ou de l’action, du régime ou des surprises de notre durée, elle sait en ravir, en combiner, en transfigurer les allures et les valeurs sensibles. Elle nous tisse un temps de fausse vie en effleurant les touches de la vraie. On s’accoutume à elle, on s’y adonne aussi délicieusement qu’aux substances justes, puissantes et subtiles que vantait Thomas de Quincey. Comme elle s’en prend directement à la mécanique affective dont elle joue et qu’elle manœuvre à son gré, elle est universelle par essence ; elle charme, elle fait danser sur toute la terre. Telle que la science, elle

devient besoin et denrée internationaux. Cette circonstance, jointe aux récents progrès dans les moyens de transmission, suggérait deux problèmes techniques :

- I. – Faire entendre en tout point du globe, dans l’instant même, une œuvre musicale exécutée n’importe où.
- II. – En tout point du globe, et à tout moment, restituer à volonté une œuvre musicale.

Ces problèmes sont résolus. Les solutions se font chaque jour plus parfaites. Nous sommes encore assez loin d’avoir apprivoisé à ce point les phénomènes visibles. La couleur et le relief sont encore assez rebelles. Un soleil qui se couche sur le Pacifique, un Titien qui est à Madrid ne viennent pas encore se peindre sur le mur de notre chambre aussi fortement et trompeusement que nous y recevons une symphonie.

Cela se fera. Peut-être fera-t-on mieux encore, et saura-t-on nous faire voir quelque chose de ce qui est au fond de la mer. Mais quant à l’univers de l’ouïe, les sons, les bruits, les voix, les timbres nous appartiennent désormais. Nous les évoquons quand et où il nous plaît. Naguère, nous ne pouvions jouir de la musique à notre heure même, et selon notre humeur. Notre jouissance devait s’accommoder d’une occasion, d’un lieu, d’une date et d’un programme. Que de coïncidences fallait-il !

C’en est fait à présent d’une servitude si contraire au plaisir, et par là si contraire à la plus exquise intelligence des œuvres. Pouvoir choisir le moment d’une jouissance, la pouvoir goûter quand elle est non seulement désirable par l’esprit, mais exigée et comme déjà ébauchée par l’âme et par l’être, c’est offrir les plus grandes chances aux intentions du compositeur, car c’est permettre à ses créatures de revivre dans un milieu vivant assez peu différent de celui de leur création. Le travail de l’artiste musicien, auteur ou virtuose, trouve dans la musique enregistrée la condition essentielle du rendement esthétique le plus haut.

Il me souvient ici d’une féerie que j’ai vue enfant dans un théâtre étranger. Ou que je crois d’avoir vue. Dans le palais de l’Enchanteur, les meubles parlaient, chantaient, prenaient à l’action une part poétique et narquoise. Une porte qui s’ouvrait sonnait une grêle ou pompeuse fanfare. On ne s’asseyait sur un pouf, que le pouf accablé ne gémit quelque politesse. Chaque chose effleurée exhalait une mélodie. J’espère bien que nous n’allons point à cet excès de sonore magie. Déjà l’on ne peut plus manger ni boire dans un café sans être troublés de concerts. Mais il sera merveilleusement doux de pouvoir changer à son gré une heure vide, une éternelle soirée, un dimanche infini, en prestiges, en tendresses, en mouvements spirituels.

Il est de maussades journées ; il est des personnes fort seules, et il n’en manque point que l’âge ou l’infirmité enferment avec elles-mêmes qu’elles ne connaissent que trop. Ces vaines et tristes durées, et ces êtres voués aux bâillements et aux mornes pensées, les voici maintenant en possession d’orner ou de passionner leur vacance. Tels sont les premiers fruits que nous propose l’intimité nouvelle de la Musique avec la Physique, dont l’alliance mémoriale nous avait déjà tant donné. On en verra bien d’autres.

‘The Conquest of Ubiquity’
Paul Valéry, 1928

In 'Paul Valéry, Aesthetics', trans. Ralph Manheim, introduction by Herbert Read (London: Routledge and Kegan Paul, 1964), 226.

Our Fine Arts were developed, their types and uses were established, in times very different from the present, by men whose power of action upon things was insignificant in comparison with ours. But the amazing growth of our techniques, the adaptability and precision they have attained, the ideas and habits they are creating, make it a certainty that profound changes are impending in the ancient craft of the Beautiful. In all the arts there is a physical component which cannot be considered or treated as it used to be, which cannot remain unaffected by our modern knowledge and power. In the last twenty years neither matter nor space nor time has been what it was from time immemorial. We must expect innovations to transform the entire technique of the arts thereby affecting artistic invention itself and perhaps even bringing about an amazing change in our very notion of art.

At first, no doubt, only the reproduction and transmission of works of art will be affected. It will be possible to send anywhere or to re-create anywhere a system of sensations, or more precisely a system of stimuli, provoked by some object or event in any given place. Works of art will acquire a kind of ubiquity. We shall only have to summon them and there they will be, either in their living actuality or restored from the past. They will not merely exist in themselves but will exist wherever someone with a certain apparatus happens to be.

A work of art will cease to be anything more than a kind of source or point of origin whose benefit will be available and quite fully so, wherever we wish. Just as water, gas, and electricity are brought into our houses from far off to satisfy our needs in response to a minimal effort, so we shall be supplied with visual- or auditory images, which will appear and disappear at a simple movement of the hand, hardly more than a sign. Just as we are accustomed, if not enslaved, to the various forms of energy that pour into our homes, we shall find it perfectly natural to receive the ultrarapid variations or oscillations that our sense organs gather in and integrate to form all we know. I do not know whether a philosopher has ever dreamed of a company engaged in the home delivery of Sensory Reality.

Of all the arts, music is nearest to this transposition into the modern mode. Its very nature and the place it occupies in our world mark it as the first to be transformed in its methods of transmission, reproduction, and even production. It is of all the arts the most in demand, the most involved in social existence, the closest to life, whose organic functioning it animates, accompanies, or imitates. Whether it be a matter of speaking or walking, of meditation or action, of monotony or surprise in the temporal flow of our lives, music can take hold of us, combining and transfiguring the pace and sensory values of them all. It weaves us an artificial span of time by lightly touching the keys of our real life. We become accustomed to it, we give ourselves up to it as voluptuously as one might to the ‘just, subtle, and mighty’ substances praised by Thomas De Quincey. Since it directly attacks the emotional mechanism, which it plays on and manoeuvres at will, it is universal in essence; it delights the ear and sets people dancing the world over; like science it becomes

an international need and commodity. This circumstance, taken in connection with recent progress in the means of transmission, suggested two technical problems:

1. To make a piece of music instantly audible at any point on the earth, regardless of where it is performed.
2. To reproduce a piece of music at will, anywhere on the globe and at any time.

These problems have been solved. The solutions are being further refined every day. We are still far from having controlled visual phenomena to the same degree. Color and relief are still rather resistant. A sunset on the Pacific, a Titian in Madrid cannot yet be enjoyed in our living room with the same force of illusion as a symphony.

That will happen some day. Perhaps they will do still better and find a way of showing us something of what goes on at the bottom of the sea. But as for the worlds of sounds, noises, voices, tonalities, they are already ours. We evoke them when and where we please. Formerly we could not enjoy music at our own time, according to our own mood. We were dependent for our enjoyment on an occasion, a place, a date, and a program. How many coincidences were needed!

Today we are liberated from a servitude so contrary to pleasure and, by that same token, to the most sensitive appreciation of works of music. To be able to choose the moment of enjoyment, to savor the pleasure when not only our mind desires it, but our soul and whole being craves and as it were anticipates it, is to give the fullest scope to the composer’s intention, for it permits his creatures to live again in a vibrant milieu not very different from that in which they were created. In recorded music the work of composer or performer finds the conditions essential to the most perfect aesthetic returns.

I am reminded here of a fairy play that, as a child, I saw in a foreign theater. Or perhaps I only fancy I saw it. In the Sorcerer’s palace the furniture spoke and sang, took a poetic and mischievous part in the action. A door opening set off the piping or solemn tones of a village band. If anyone sat down on a pouf, it would sigh politely. At a touch everything breathed forth a melody. I sincerely hope we are not moving toward such excesses in the magic of sound. Even now one can no longer eat or drink at a cafe without being disturbed by a concert. But it will be wonderfully pleasant to be able to transform at will an empty hour, an interminable evening, an endless Sunday, into an enchantment, an expression of tenderness, a flight of the spirit. Days can be gloomy; there are men and women who are very much alone, and many whom age or infirmity confines to their own company with which they are only too familiar. These men and women, reduced to boredom and gloom, can now fill their sad and useless hours with beauty or passion.

Such then are the first fruits offered us by the new intimacy between music and physics, whose immemorial alliance had already given us so much. We shall see many more.

The role of Electricity in the Creation of Figures and Images
Adam Lowe, for 'Capturing Nature' published by Zucker Art Books, 2022

Philippe-Jacques de Louthembourg's painting of 'Coalbrookdale at Night' (1801) presents iron ore smelting in Ironbridge Gorge, Shropshire, as an image of the sublime. Picturesque buildings and village life are silhouetted against a skyscape of vast orange plumes of smoke, the centre of the painting white hot and hissing with sparks. Its semi-hidden subject might be the entrance to hell; the moon itself seems to shrink back in awe. A place of outstanding natural beauty was transformed into a blinding record of the industrial revolution. In 1800, the year before this painting was completed, Alessandro Volta revealed his 'voltaic pile', the first electric battery. It generated a flow of electricity using a stack of copper and zinc discs separated by wads of absorbent material soaked in brine. The arrival of the battery, and the ability to produce electricity on demand, was followed in 1831 by Michael Faraday's discovery of electromagnetic induction, paving the way for generators capable of producing electricity that powered a host of emerging technologies. These technologies shaped the photomechanical revolution and dominate almost every aspect of life today, particularly the way we create and communicate.

Volta was not alone in his work with electricity, Martinus Von Marum's work on the electric generator in Haarlem was published in 1786-88. He visualized electrical activity and generated 'figures' that record the action of man-made electricity. At the time, traces of the invisible forces of nature in visible form were normally called 'figures' as they were perceived as naturally formed abstractions rather than manual representations of the way we see. Georg Christoph Lichtenberg created his 'figures' to visualize electrical activity in the dust that formed on his electrical apparatus. While trying to repeat these experiments, Ernst Chladni discovered that the figures he created were graphic visualizations of sound—images made in sand and dust by the wave formations of sound—literally nature printing itself. 'Figures' were associated with mathematics, science and cartography. Images made by hand belonged in the domain of art.

In this context, the development of photographic images made using the direct action of light and a readily available supply of electricity needs re-contextualising. In many of the processes that were emerging between the 1780's and 1850's, electricity plays both a direct and an indirect role. Daguerreotypes, the first commercially available photographic process, required a highly polished silver-plated sheet of copper. Electro-plating and electro-forming coloured the collective imagination of both scientists and artists. In this environment the curious amateur was king.

The Modern Prometheus

While Volta was developing his battery, Luigi Galvan demonstrated that a circuit created by two metals caused a frog's leg to respond. This reanimation of a dead creature went beyond scientific research and blurred the boundaries between science, the occult and alchemy to create a new literary genre, 'Science Fiction'. In 1816, 'the year without summer' caused by the black clouds that followed the eruption of Mount Tambora, Mary Shelley focused on the ability of electricity to create life. 'Frankenstein;

or, The Modern Prometheus' (written in competition with Percy B. Shelley and Lord Byron) was published anonymously in 1818 but eventually carried her name.

Other important discoveries were taking place that impacted our awareness of human fragility and the limitations of our knowledge. In 1819 William Buckland discovered the first dinosaur, a *Megalosaurus*, at Stonesfield in Oxfordshire. Suddenly human history looked very short. Mary Anning had found a fossilised *Ichthyosaurus* skull at Lyme Regis in 1811 but it was initially thought to be a type of crocodile. The fossil-rich chalk that surfaces from Grimes Graves in East Anglia across the south of England to the coast contained marine remains from the Cretaceous Period (145–66 million years ago). Fossils are imprints of former life from deep time. They are rocky negatives of the positive organic structures of past worlds. If dinosaurs roamed the planet millions of years ago, all Abrahamic knowledge seemed to occupy little more than the blink of an eye.

Knowledge and Objectivity

With the arrival of electricity mankind had within its grasp both the creation of light and the animation of life itself. Alois Auer was born in Wels, Austria in 1813 into this fusion of art, science, religion, technology, fiction and the quest for knowledge and objectivity. Alois Auer became the director of the *Staatsdruckerei* (Austrian National Printing Office) in Vienna in 1841 and worked there until 1868. Under his direction he turned the *Staatsdruckerei* into a modern printing house employing over 900 people. The availability of electricity extended the range of what was technically possible in printing, significantly contributing to the photo-mechanical revolution. Several of the processes under Auer's leadership used galvanoplasty (electro-forming), electro-plating and electric light.¹ In Auer's hands electricity, photography, the impact of lead type on paper, mechanical precision and chemical reactions inspired an explosion of printing processes and the fusion of 'figures' dependent on physical process with 'images' that needed aesthetic and artistic interventions. His 1853 publication, 'Der Polygraphische Apparat' contained a selection of different processes developed and sometimes patented by the Imperial printworks.²

Image and Form

One of the most innovative processes Auer patented was 'Natureselbstdruck', and its close relative 'Mineralographie'. In these processes a physical specimen is transformed into a printing plate using lead, pressure, casting and electroforming to create a 3D negative that can then be printed like an etching plate by rubbing ink into the relief and wiping it off the surface. The result is a 1:1 scale, naturalistic colour print with many of the qualities of a pressed specimen stuck onto the surface of the paper. Aesthetic elegance and objective accuracy were fused into a colour image with volume. Electroforming was essential to produce a copper plate using a cast of the impression left in the lead that the plant was pressed into using mechanical force. With a copper plate

containing an exact negative relief of the plant, accurate multiples could be produced. The subjectivity of the botanical illustrator had been replaced with objective fact.

Other printing processes followed that focused on the relationship between depth and tone. By 1864 Walter Woodbury had invented the first continuous tone process, which created beautiful black and white images through the depth of the electroformed plate using similar principles to those developed by Auer. In the Woodburytype process the copper plate containing the relief functions as a shallow mould. When filled with pigmented gelatine it can transfer a continuous-tone image onto paper. Leopold and Rudolph Blaschka's work to make glass flowers and an assortment of creatures at the end of the 19th-century was described as, 'an artistic marvel in the field of science and a scientific marvel in the field of art'. The description could equally apply to Auer and others operating before the borders between art and science had hardened into the divide we know today.

The introduction of an electrical power supply has had more impact on the development of printing technologies, of which photography is a very interesting and significant sub-set, than the ability to fix silver nitrate to prevent the image fading away. It opened the door to rethinking the relationship between image and form by focusing on how things are mediated and transformed. It made nature printing possible and provided the artificial light source for early microphotography. Some fundamental assumptions about photography are starting to be addressed. Photo 'graphy' emerged slightly before photo 'sculpture'. It wasn't long until it captured motion and then started moving itself to become film. With the advent of digital technologies, diverse forms of representation are proliferating and finding both on- and off-line forms. We are in a time of virtual-, mixed- and augmented-realities that coexist with both additive and subtractive forms of re-materialisation.

Sculpting Light

The first sculptural photographic process was developed in 1859. It is attributed to François Willème, in Paris, using his 'ingenious devices'. He placed his sitter on a circular platform surrounded by twenty-four equally spaced cameras that were all triggered at the same time creating twentyfour silhouettes that together described the complete head. From the images he could extract profiles that he assembled like the segments of an orange. Later, others would find ways to layer (sinter) the data to produce complex forms. Willème needed electricity on demand, but the technology wasn't there to support the accurate and detailed output of forms.

In today's digital world electricity is the driving force but it has become so ubiquitous that it is almost invisible. It facilitates both input and output technologies, data storage and transmission. Digital archiving presents a real challenge as the volume of information of all kinds grow exponentially. Long-term archiving without electricity is still outside the realms of possibility. A small number of companies are focusing on storing digital data in material form. PIQL's 'Arctic World Archive' is perhaps the most

advanced with digital microfilm being stored in dry sub-zero conditions in the Svalbard Archipelago. Laser writing into glass is possible but very expensive and the next generation of CDs are being developed using recycled plastics that store the data within a three-dimensional matrix.

Without electricity the world would be a very different place and much of the last 200 years of human activity would vanish without a trace.

1. *The Museum and the Factory* by Alistair Grant and Angus Patterson Lund Humphries, 2018, is a detailed account of the impact of galvanoplasty on the formation of the Victoria & Albert Museum. In 1853 an experimental relationship was established between Elkington's factory in Birmingham the newly formed Victoria and Albert Museum. Elkington's was founded in 1840 to use the process of electro-forming metals for the creation of artworks and perfect replicas. Metals were being manipulated at a molecular level using electricity.
2. *Der Polygraphische Apparat* was published in 1853. It was intended for the Great Exhibition in 1851.



A voltaic pile, made by Apps, London 1860s.

AFTERWORD

beginning of this book, or an image or archive made by mechanical means.

The word 'record' derives from the Latin for heart (*cor*, cord) and refers to memory - not just learning by heart but literally re-membering, bringing all the parts together again. To record well is to commit a fact to memory as completely as possible in an objective and accurate way. For the Pharaonic Egyptians, remembering was a literal act. Isis gathered all the scattered pieces of the dismembered Osiris. With magic she uses his member to impregnate herself and gives birth to Horus, before wrapping the pieces together inside bandages. This is an inspired metaphor for archiving in which the seeds of knowledge continue.

As writing developed, it became the most objective means to record, one capable of both describing events and sharing the perceptions and thoughts of the writer. Images, by comparison, were subjective and dependent on their social context. With electricity and the ability to fix light as tone, the image achieved an objective accuracy that could equal or exceed the word; 'an image is worth a thousand words'. In the age of digital materiality, surface recording is the new frontier. X-rays and infra-red recording and the display of non-visible frequencies of light transformed art history in the second half of the 20th-century, 3D technologies are transforming it in 21st.

It is easy to understand that a sculpture has a materiality, hard to dispute that a painting has a material presence as well as an embedded image that may aspire to trigger a connection to the world around us or that may seek to avoid figurative registers. It is easy to put a vinyl record onto a record player and hear sound re-materialised. By recording material in the Bodleian Libraries using mechanical means (Photometric Stereo) at ARCHiOx, we have added another layer to the written word - its materiality.

For many scholars the written evidence still transcends the information embedded in the materiality of an object, but in a globally connected world increasingly dependent on Machine Learning technologies (often referred to as 'AI'), the more data that can be analysed, the greater the impact on the key issues of today: archiving, access, education, sharing, returning, preserving, and recording. When human endeavor and mechanical means work in tandem, the world of knowledge is an optimistic force that can fulfil us as individuals and transform societies.

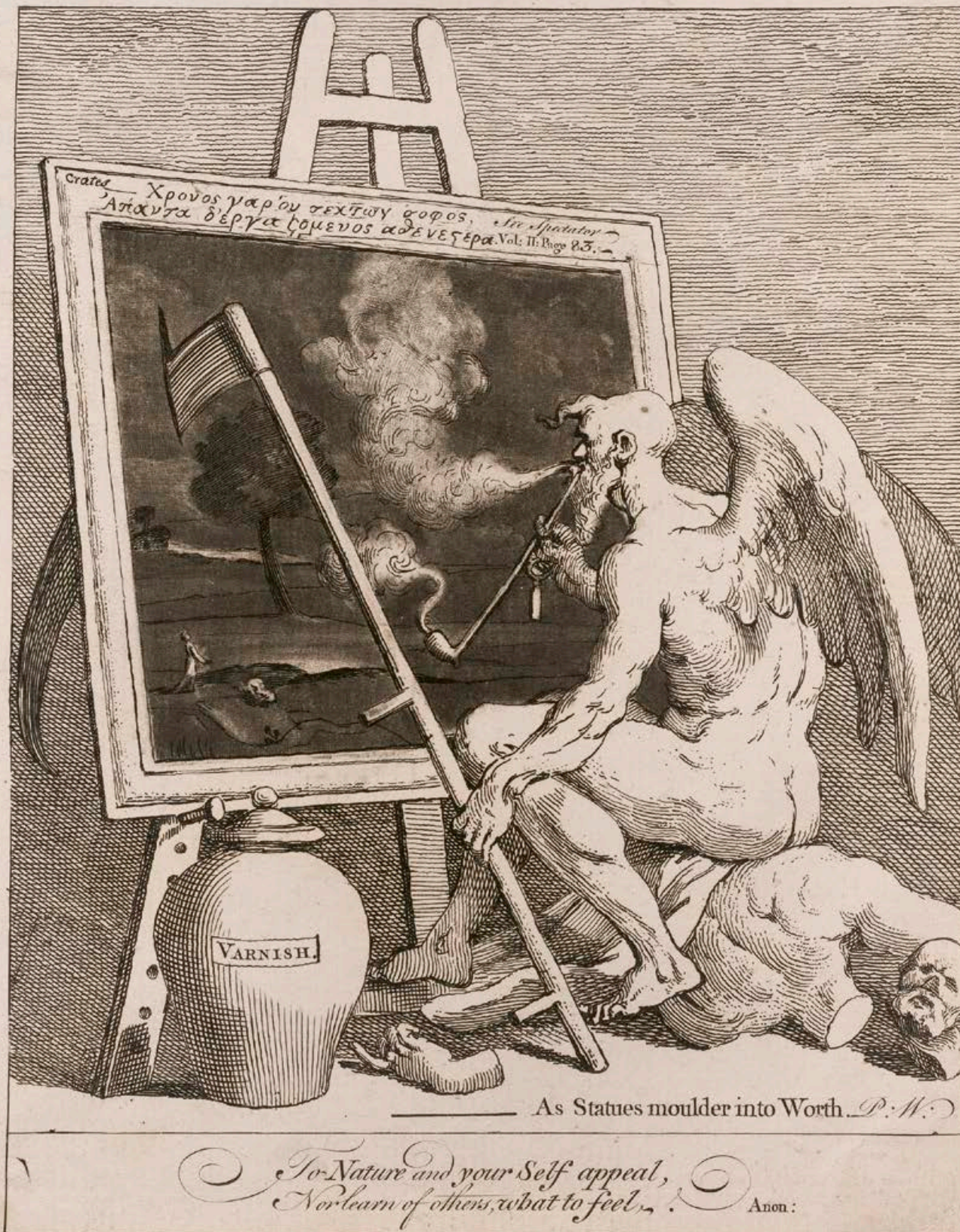
Opposite: *Time Smoking a Picture* by William Hogarth, 1761. Etching and aquatint.

Throughout this book there are words which still cause a great deal of confusion. 'Recording', 'high-resolution' and 'facsimile' appear often, sometimes on their own, at other times they converge. Factum is focused on recording at the highest resolution possible, in diverse ways. These recordings can result in facsimiles that are the test proof of 'good' data. Factum makes the scanners that record the data and writes the software that processes it. We develop the correct workflow to ensure objects are safe and results are of the highest quality. We build the printers and develop the technologies to ensure that facsimiles are meaningful equivalents to the originals in ways that help preserve and lead to a deeper understanding. A facsimile does not replace the original object, both co-exist and support each other. But there are cases when a facsimile can raise profound questions about the relationship between an authentic experience and an original object that changes over time.

It has been 95 years since Paul Valéry wrote *Aesthetics* and 88 since Walter Benjamin's essay, but the same assumptions are being made about originality and authenticity today. It is amazing how upset people still become at the idea they are looking at a facsimile. It doesn't matter that they can't see the 'original' hanging high on a wall behind thick green glass (the Raphael Cartoons at the V&A), that the original can't be moved to contextualise a selection of drawings (the Borgherini Chapel at the National Gallery) or that the original has been split up and now exists in various venues around the world (the Politico Griffoni). In the case of the sacred cave of Kamukuwaká, the original has effectively been destroyed and become a relic. The digitally restored facsimile, soon to reside near the remains of the 'original', has assumed the didactic and emotional role the original sacred cave once fulfilled among the indigenous people who still actively used it as the guide through their origin myths.

Rematerialisations can be identical to the originals under museum viewing conditions, but despite their obvious value in preserving fragile objects, there are many educated and knowledgeable people who feel they are being cheated by a good facsimile. Of course, there are bad facsimiles offering impoverished experiences, just as there are bad exhibitions and bad restorations. As soon as the debate is focused on 'quality' it will move on from obfuscating discussions about Benjamin's aura.

A 'record' constitutes evidence about the past. It can take many forms. It can be associated with written accounts, musical recordings, of the type Valéry described at the



As Statues moulder into Worth. P. H.

To Nature and your Self appeal,
Nor learn of others, what to feel.
Anon.

- A** Authenticity, Archiving, Access, Albedo, AR (Augmented Reality), AI (Artificial Intelligence), Arts, Aesthetics, Analogue, Analysis, Algorithm, Animation, Auer (Alois)
- B** Benjamin (Walter), Beauty, Bokeh, Babbage (Charles)
- C** Context, Content, Cartography, Communication, Care, Connoisseurship, CNC, Catalogue, Classification, Conservation, Copyright, Composite, Colour
- D** Display, Doing, Digital, DNA, Dynamic Data
- E** Exhibition, Enhance, Enlightenment
- F** Fact, Fetish, Fragmentation, Forensic, Fake, Focus, Facsimile, Fragility, Faraday (Michael)
- G** Greyscale, Grave-robbers, Giga-pixels, Grants
- H** History, Humanities, High-frequency, High-resolution
- I** Iconoclasm, Iconophilia, Images, Intellectual Property (IP), Intentionality
- J** Jurisdiction, Judgement
- K** Kontrast (CMYK)
- L** Learning, Layering, Laminar, Lens distortion, Laser, and Lucida (scanner), Lovelace (Ada)
- M** Making, ML (Machine Learning), Mediation, Mapping, MR (Mixed Reality), McLuhan (Marshall), Marginalia, Merging, Multi-spectral, Materiality
- N** Non-Contact, Normal map, Noumenal (as in Aura), Noise, Noema, Noesis
- O** Owning, Originality, Objects, Orientation, Objective
- P** Preserving, Protecting, Presenting, Prejudice, Politics, Palimpsest, Point-cloud, Photogrammetry, Polygon, Photography, Photometric Stereo, Place
- Q** Quantify, Question, Query, Quixotic
- R** Re-words including but not limited to; Repatriation, Representation, Replica, Return, Restoration, Reunification, Render, RTI (Reflectance Transmission Imaging)
- S** Sharing, Science, Simulacra, Scanning, Spectrum, Superficial, Selene (Photometric Stereo System), Space, Subject
- T** Transformation, Training, Transfer, Transformation, Topography, Texture, Texture Mapping, Things
- U** Understanding, Ultraviolet, Ultra-thin (Duchamp, Marcel), Ultra-rapid variation (Valéry, Paul)
- V** Verification, VR (Virtual Reality), Visualisation, Voxel, Value
- W** Words
- X** X Axis, X Ray
- Y** Y Axis, *Yseria*
- Z** Z Axis, ZBrush

The **FACTUM FOUNDATION FOR DIGITAL TECHNOLOGY IN PRESERVATION** is a not-for-profit organisation, founded in 2009 in Madrid. It works alongside its sister company, Factum Arte: a multi-disciplinary workshop in Madrid dedicated to digital mediation in contemporary art and the production of facsimiles.

The Foundation was established to demonstrate the importance of documenting, monitoring, studying, recreating and disseminating the world's cultural heritage through the rigorous development of high-resolution recording and rematerialisation techniques.

Factum Foundation's aims were recorded at the time of its formation – they remain the same today:

- Use non-contact recording methods to document cultural heritage sites and objects to the highest possible standards.
- Change attitudes towards the digital recording of cultural heritage, encouraging the creation of permanent and accessible public records of important objects and artworks.
- Develop new recording and display technologies, and new uses for existing technologies.
- Create practical, secure archiving and display systems for high-resolution data.
- Create facsimiles of recorded objects – copies so accurate that the naked eye cannot tell them apart from the original – and use these facsimiles to do things which the originals cannot: to allow fragile objects to travel, fragmented objects to be reassembled, and untouchable objects to be touched.
- Develop new techniques of digital conservation and restoration, expanding the range of possibilities open to curators and conservators by allowing objects to be restored in the virtual realm.
- Share recording skills and technologies as widely as possible. The Foundation has set up training courses and centers in locations from Egypt to Dagestan to create local experts in digital preservation who are able to record their own cultural heritage.
- Make digital records of works of art accessible to the widest possible public through the Creative Commons model.
- Develop exhibitions that allow audiences to understand the dynamic nature of objects, using digital models and physical facsimiles to challenge the idea that an artefact in its current state – perhaps restored, damaged, and enhanced over a period of centuries – is the only key to understanding and appreciating that object is the only key that can unlock its significance.
- Play an active role in the international effort to develop shared principles for the digital recording, archiving, and dissemination of cultural heritage.
- Leave to future generations an archive of raw, unmanipulated data which they can analyse according to their own questions and perspectives and using their own technologies, allowing them to inherit the past in a condition in which they can study it in-depth and emotionally engage with it.

The list has grown but at its core these principles remain unchanged.

Partners and collaborating institutions

We have collaborated and continue to collaborate with many global institutions, on both one-off projects and on a regular basis:

Austria

Kunsthistorisches Museum, Materialise, mumok – Museum moderner Kunst Stiftung Ludwig Wien.

Belgium

B&T Textilia (Lievegem), Flanders Tapestries (Wielsbeke), Koninklijk Museum voor Schone Kunsten Antwerpen (KSMKA), La Monnaie de Munt (Bozar).

Brazil

Associação Indígena Kuikuro Alto Xingu, People’s Palace Projects, Spectaculu.

Canada

Antimodular Research Inc, Canada Digitization, Think to Thing (Toronto), Carleton University (Ottawa).

Chad

Ministry of Culture, Ministry of Tourism.

Chile

Museo Antropológico Sebastián Englert (Rapa Nui).

China

University of Hong Kong, WorldSkills Museum.

Denmark

Aarhus School of Architecture, SMK – National Gallery of Denmark.

Egypt

American University in Cairo, Ministry of Tourism and Antiquities, Supreme Council of Antiquities, Tarek Waly Centre, TedX Cairo, United States Embassy in Egypt.

EU

European Commission.

Finland

Arctic Drone Labs, Alvar Aalto Foundation, City of Jyväskylä, Oamk – Oulu University of Applied Sciences, Tampere University, The Oslo School of Architecture and Design, University of Oulu.

France

Ateliers Jean Nouvel, Bibliothèque Nationale de Bordeaux, Centre des Monuments Nationaux, Fondation Cartier, Galerie Didier Claes, Hospices Civils de Beaune, La Conciergerie, Musée Condé du Château de Chantilly, Musée Cluny, Musée

des Arts Décoratifs, Musée des Beaux-Arts (Orléans), Musée du Louvre, Musée Jacquemart-André, Museum of Grenoble, Musée Quai Branly.

Germany

Alte Pinakothek Munich, Leipziger Museums der bildenden Künste (MdbK), Museum der bildenden Künste.

Greece

Benaki Museum, Kaparos Fine Art Foundry, Greek Ministry of Culture.

Netherlands

Mauritshuis, Rijksmuseum Twenthe, Rijksmuseum van Oudheden (Leiden).

India

Jamia Millia Islamia University.

Iraq

Iraqi Embassy in Spain, University of Mosul.

Italy

ABI – Associazione Banche Italiane, Aeroporti di Roma, ALES – Arte Lavoro e Servizi (Rome), Appia Antica Archeological Park, Autogrill, BALLANDI Multimedia, Basilica di San Petronio (Bologna), Berengo Studio (Venezia), Biblioteca Nazionale Marciana (Venice), Biennale di Venezia, CARISBO, Casa Buonarroti (Florence), Castello di Gabiano, Castello Sforzesco (Milan), Cavina Terra Architetti, Complesso Monumentale della Pilotta (Parma), Comune di Caravaggio, Comune di Urbino, Convento di Santa Maria delle Grazie e Cenacolo Vinciano, Diocesi di Bologna, FEC – Fondo Edifici di Culto, Fondazione Cassa del Risparmio di Tortona, Fondazione Giorgio Cini, Fondazione Palazzo Te, Fondazione Musei Civici di Venezia, Fondazione Prada, Fondazione Querini Stampalia, Galleria Continua (San Gimignano), Galleria Nazionale d'Arte Antica di Palazzo Barberini, Galleria Borghese, Gallerie dell'Accademia (Firenze), Genus Bononiae. Musei nella città, ISIA Urbino, Italgas – Heritage Lab, IULM Università, Mart – Museo d'arte moderna e contemporanea di Trento e Rovereto, Michele de Lucchi, Musei Capitolini, Musei Vaticani, Museo Archeologico Nazionale (Florence), Museo Canova (Possagno), Museo Civico Archeologico (Bologna), Museo Civico

di Bassano del Grappa, Museo Palladio (Vicenza), Museo Correr (Venice), Museo della Città di Rimini, Open Care, Oratorio di San Lorenzo (Palermo), Ordine dei Cavalieri di Malta (Venice), Palazzo Ducale (Mantua), Palazzo Grimani (Venice), Palladio Museum (Vicenza), Pinacoteca Ambrosiana, Pinacoteca di Brera, Pinacoteca Nazionale (Ferrara), San Luigi dei Francesi (Rome), Santa Maria dello Spasimo (Palermo), Scuderie del Quirinale (Rome), Sky Arte, The Art Newspaper, UNIBO – Università di Bologna, Università Ca' Foscari (Venezia), Università IUAV di Venezia, Villa Cagnola (Gazzada).

Japan

Tokyo University of the Arts.

Kingdom of Saudi Arabia

AFALULA French Agency for AIUla Development, Art Jameel, Athr Gallery, Community Jameel, MISK Foundation, Noor Riyadh Festival of Light, Royal Commission of Al-Ula, Royal Commission for Riyadh City, Diriyah Contemporary Art Biennale (Riyadh).

Lebanon

Arab Image Foundation, Association pour la protection des sites et anciennes demeures au Liban (APSAD), Ministry of Culture.

Mexico

Universidad Autónoma de México.

Netherlands

Canon Production Printing (formerly Océ), Centraal Museum (Utrecht), Mauritshuis (Den Haag), Museum Boijmans Van Beuningen (Rotterdam), Museum Catharijneconvent (Utrecht), Museum de Lakenhal, Leiden University, Rijksmuseum van Oudheden (Leiden), Rijksmuseum Twenthe, TEFAF, TU Delft, Utrecht University.

Nigeria

EMOWAA (Edo Museum of West African Art), NCMM (National Commission for Museums and Monuments Nigeria), The Trust for African Rock (TARA), University of Calabar.

Norway

Architectural Department of the University of Oslo, Henie Onstad Kunstsenter (Oslo), Norsk Folkemuseum, PIQL, Romsdal Museum.

Portugal

Faculdade de Engenharia da Universidade do Porto.

Russia

Archaeology and Ethnography of the Dagestan Scientific Center of the Russian Academy of Sciences (IHAE DSC RAS), Capturing Reality, Peri Foundation, Kala-Koreysh, Institute of History, Monastery of Ferapontov, Museum Sanctuary and Ethnographic Complex Dag-Aul Museum, Tretyakov Gallery.

Somaliland

Hargeysa Cultural Centre, Redsea Cultural Foundation.

Spain

Alfáreria Tito (Úbeda), Als Tapestries, Andalusian Institute of Historical Heritage (IAPH), Archivo Histórico Provincial de Sevilla, Archaeological and Ethnological Museum of Córdoba, Asociación de los Amigos de la Catedral de Tudela, Asociación Española de Museólogos, Ayuntamiento de Arroyo Molinos, Ayuntamiento de Barrado, Ayuntamiento de Priego de Córdoba, Ayuntamiento de Sevilla, Real Alcázar (Sevilla), Ayuntamiento Toralba de Ribota, Banco Santander, Bereti (Agullent), Biblioteca Nacional (Madrid), Bilbao Fine Arts Museum, Cabildo de Gran Canaria, Cabildo Insular de La Palma, Caixa Forum (Madrid and Valencia), Calcografía Nacional, Casa de Mesa (Toledo), Casa de Pilatos (Sevilla), Casa Natal de Velázquez (Sevilla), Casa Árabe, Catedral de Mejorada del Campo, Centro de Arte Botín, Patrimonio Nacional, CEEH – Centro de Estudios Europa Hispánica, CITpax – Centro Internacional Toledo para la Paz, Comunidad Valenciana, Conjunto Arqueológico Madinat al-Zahra, Consejo Superior de Investigaciones Científicas (and CSIC: Proyecto Djehuty), Convento Santa Clara la Real (Toledo), Esfinge Esculturas y Fundiciones (Madrid), ETSAM – Escuela Técnica Superior de Arquitectura de Madrid, Fademesa - Fundación Artística de Bronce (Madrid), Filmoteca de Andalucía (Córdoba), Finnish Cultural Institute, Finnish Embassy to Spain, Fundación Amigos Museo del Prado, Fundación Banco Santander, Fundación Casa Ducal de Medinaceli, Fundación Huerta de San Antonio, Fundación Juan March, Fundación María Cristina Masaveu Peterson, Fundación San Millán de la Cogolla, Fundación Telefónica, Galería Betty Guerreta, Generalitat Valenciana, Hermanas Clarisas Franciscanas, Hermandad de la Santa Caridad, Hermita de San Baudelio de Berlanga, Hospital de

la Caridad (Sevilla), Hospital de Tavera (Toledo), Instituto Andaluz de Patrimonio Histórico, Instituto Valencia de Don Juan, Junta de Andalucía-Consejería de Cultura y Patrimonio Histórico, LÓAC – Alaior Arte Contemporáneo (Menorca), Ministerio de Asuntos Exteriores, Ministerio de Cultura y Deporte de España, Ministerio de Defensa de España, Municipality of Villastar, Museo Arqueológico Nacional, Museo Bilbao Bellas Arte, Museo Cerralbo, Museo de Colecciones Reales, Museo del Traje (Madrid), Museo Nacional Centro de Arte Reina Sofía, Museo Nacional de Escultura (Valladolid), Museo Nacional del Prado, Museo Naval de Madrid, Museo Sefardi – Sinagoga del Tránsito (Toledo), Museo Sorolla, Museo Tiflológico de la ONCE, Museu d'Arqueologia de Catalunya, MAC (Barcelona), Palacio del Capricho, Real Academia de Bellas Artes de San Fernando, Real Academia de la Historia, Real Fábrica de Tapices, Real Santuario Insular de Nuestra Señora de las Nieves, Real Armería – Patrimonio Nacional, Spanish Embassy in Iraq, TEDx Madrid, Museo Universidad de Navarra, Thyssen-Bornemisza National Museum, Universidad Complutense, Universidad de Castilla la Mancha (UCLM), Universidad de Granada, Universidad Politécnica de Madrid, Vives y Marí (Valencia).

Turkey

Gerger Kültür Turizm, Sanat ve Hoşgörü Derneği (GKTSHD).

Switzerland

Antikenmuseum Basel, ARCH – The Alliance to Restore Cultural Heritage in Jerusalem, Art Basel, Carène Foundation, EPFL - École Polytechnique Fédérale de Lausanne, ETH Zürich: Department of Architecture, Michelangelo Foundation, Universität Basel, Vitromusée Romont, Wilde Gallery.

US

Adam Williams Fine Art, amfAR – The Foundation for AIDS Research, American Research Center in Egypt – ARCE, Case Western Reserve University, Chrysler Museum of Art (Norfolk), Cleveland Museum of Art, Columbia University, Divirod, Gannon University, Google Arts&Culture, Institute of Ecotechnics, Massive Change Network, Menil Collection, Miami Map Fair, MoMA – Museum of Modern Art, Morgan Library, Museum of Fine Arts Boston, National Gallery of Art in Washington, Princeton University, The Frick Collection, The Metropolitan Museum of Art, University of California (Berkeley), US Institute of Peace.

UAE

Al Ain Museum, Department of Culture and Tourism Abu Dhabi, Green Art Gallery, Hay Festival, Juma al Majid Centre for Arts and Heritage (Dubai), Louvre Abu Dhabi, MEFA – Middle East Falconry Archive, Mohammed Bin Zayed Raptor Conservation Fund.

UK

Agnews Gallery, Art UK, Ashmolean Museum, Bodleian Libraries, Book Works, British Library, British Museum, Bronze Oak Tree Project, Burgess Studio, C. Hoare & Co, Cambridge University, Colnaghi, Connaught Hotel, Courtauld Institute of Art, Dovecot Studio, Dover District Council, Durham University, Dust and Scratches, Ecotechnics Maritime Limited, English Heritage, Errol Fuller Collection, Glasgow Museum, Griffiths Institute, Grinling Gibbons Society, Helen Hamlyn Trust, Historic Scotland, Houghton Hall, ICRA – International Catalogue Raisonné Association, JamJar Flowers, Lisson Gallery, Littoral Arts Trust, London Bell Foundry, Made by Many, Mappa Mundi Trust – Hereford, Masterpiece London Art Fair, m-tec, National Galleries of Scotland, National Gallery (London), National Trust, October Gallery, Pangolin Foundry, Paragon Contemporary Editions, Photo London, Pitt Rivers Museum, Re-Form Heritage, RH England, Royal Academy of Arts, Royal Collection Trust, Rupert Wace Ancient Art, Scan Lab, Sir John Soane's Museum, Skene Catling de la Peña, Société Générale UK, Stonewall Equality, Strawberry Hill House, Structure Workshop, Tern TV, The Bartlett School of Architecture, The Booker Prize Foundation, The Frontline Club, The Rothschild Foundation, The Auckland Project, Tolkien Society, UCL – University College London, United Kingdom Historic Building Preservation Trust, Victoria and Albert Museum, Victoria Miró, Waddesdon Manor, Warburg Institute, Wellington Collection, Whipple Museum of the History of Science, Wilton House.

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To contact the Factum Foundation

info@factumfoundation.org
www.factumfoundation.org

in Madrid
c/ Albarracín, 28
28037 Madrid
tel. +34 915 500 978

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The Factum team

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Adam Lowe

Director of Factum Arte

and founder of Factum Foundation for Digital Technology in Preservation.

FACTUM ARTE

Iván Allende
Carlos Alonso
Silvia Álvarez
Juan Carlos Arias
Nicolas Béliard
Amanda Blázquez
Raul Candil
Jorge Cano
Francesco Cigognetti
Sol Costales Doulton
Dylan Dubson
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Giulia Fornaciari
Manuel Franquelo
Eduardo García
Carmen G. Figueras
Jordi García Pons
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Nuria Goytre
Miguel Hernando
Angel Jorquera

Eduardo López Rodríguez
Jemima Lowe
Marina Luchetti
Nathaniel Mann
Jacinto de Manuel
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Blanca Nieto
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Natalia Pérez Buesa
Rafa Rachewsky
Damián Rojo
Soledad Ruano
Pedro Salafranca
Carlos San Juan
Carlos Sanz Sayalero
Oak Taylor-Smith
Michael Ward
Charlie Westgarth

FACTUM FOUNDATION

Celestia Anstruther
Carlos Bayod Lucini
Teresa Casado
Osama Dawod
Mar García Sánchez
Carolina Gris
Imran Khan
Otto Lowe
James Macmillan-Scott
Pedro Miró Infante
Larissa van Moorsel
Ferdinand Saumarez Smith
Gabriel Scarpa
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Casilda Ybarra

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