

CHANGING ATTITUDES TO PRESERVATION
AND THE ROLE OF NON-CONTACT RECORDING TECHNOLOGIES
IN THE CREATION OF DIGITAL ARCHIVES FOR SHARING CULTURAL HERITAGE
IN VIRTUAL FORMS AND AN EXACT PHYSICAL FACSIMILE

FOR REACH (REPRODUCTION OF ART AND CULTURAL HERITAGE) A GLOBAL INITIATIVE LAUNCHED BY THE
VICTORIA AND ALBERT MUSEUM AND THE PERI FOUNDATION.

ADAM LOWE

*'Time, fire and water are of course bad for any painting's health. But the sad fact is that
two groups of people have done more damage to paintings than anything else:
those who sell art and those charged with looking after it.'*

Brendor Grosvenor, The Art Newspaper, 9 March, 2017

Articulate objects allow us access to the actions and thoughts of past generations. Mass tourism, war, vandalism, instability, political apathy, climate change, natural disasters, theft and iconoclastic attacks not only challenge their preservation but threaten their very existence as meaningful evidence.

New technologies permit highly accurate condition monitoring that can help the conservation community manage the changes brought about by a world population of over seven billion people. Preservation has always been a complex task that reflects the values of the time and geographic location. The evidence of the past is always seen through the filter of previous generations, and their actions condition our understanding in a way that will, in turn, shape the response of future generations. Education and applied technology were driving motivations at the time the V&A was established after the Great Exhibition in London. The relationship between technology and craftsmanship, aesthetic appreciation and content, originality and authenticity were being redefined by a generation of great scholars.

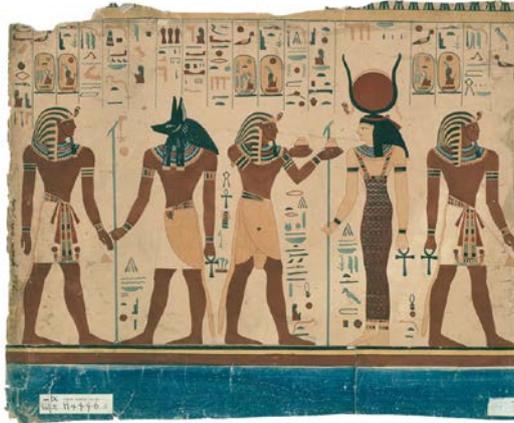
When Henry Cole wrote his 'convention' in 1867 he was in the capital city of a vast colonial empire that was undergoing an industrial and financial revolution. The role of museums and museum display was being changed by the arrival of new methods of recording and manufacture; electro-forming, photography (with a vast range of photo-mechanical printing techniques) and new methods for moulding and casting were the emerging technologies. Contrary to his assertion in the first paragraph of the convention that these technologies were 'harmless', moulding techniques caused extensive damage to many fragile objects.

Our challenge at the start of the 21st century is to apply digital recording and output technologies in a way that will be inclusive and enlightened. The internet has redefined the notion of access and now reaches a global community. It can be used to generate 'fake news' but it can also be a medium whose message will help preserve the planet and provide unfiltered access to the evidence of its past, both human and natural.

Preservation needs to embrace the 'career of objects' and follow principles based on the fact that everything is continually changing, especially our perceptions and understanding. Ageing is a process that can happen at a natural pace; or it can be accelerated by external events.

As diverse forms of documentation become more accurate and objective, and computational power increases exponentially, it becomes possible to analyse and understand these changes even where they are difficult to manage. After discovering the most important tomb in the Valley of the Kings, that of Seti I, Giovanni Battista Belzoni recorded the interior from 1817 to 1820 in watercolour. His written accounts and detailed watercolours reveal the

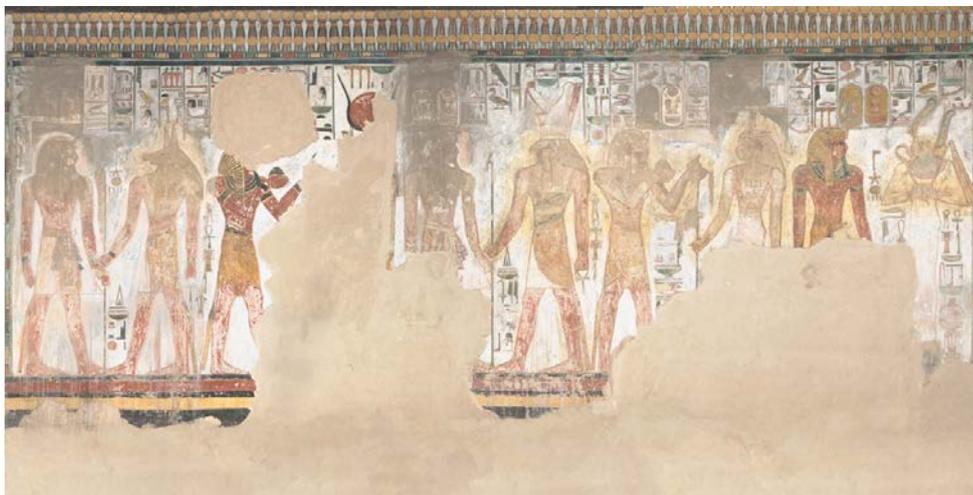
pristine condition of the tomb at the time of its discovery two hundred years ago. Harry Burton's black and white photographs from the 1920's tell a very different story; Factum Foundation's 3D and composite colour recordings made in 2016 document the tomb's current state. The different techniques used to recover and relocate sections of the since its discovery have been less than benign and have altered the tomb's appearance dramatically.



Giovanni Battista Belzoni and Alessandro Ricci made detailed watercolours of the images and hieroglyphs that cover every surface of this vast tomb between 1817 and 1820. Belzoni then took moulds from the relief surface removing much of the paint. © Bristol Culture / Bristol Museum & Art Gallery.



Harry Burton made a complete photographic documentation that provides a good record of the tomb in the 1920's. Evidence of the damage caused by the 'squeezes' and the removal of sections of the wall are clear. © Photo SCALA, Florence. Metropolitan Museum of Art, New York, 2017.



High-resolution 3D scanning and composite colour recording is changing the way we understand and protect the evidence of the past. They provide objective data to monitor future changes in the condition of the tomb caused by visitors and restoration techniques. 3D and colour recording by Factum Foundation, © Photo Ministry of Antiquities, Egypt

Most of the changes that have altered the appearance of the tomb between 1817 and the present were done in the name of preservation. The great Egyptologist Jean-François Champollion was proud of having removed a large section of the tomb and taken it to Paris where it now hangs, in a heavily restored state, in the Musée du Louvre:

'Rest assured, Sir, that one day you will have the pleasure of seeing some of the beautiful bas-reliefs of the tomb of Osirei in the French Museum. That will be the only way of saving them from imminent destruction and in carrying out this project I shall be acting as a real lover of antiquity, since I shall be taking them away only to preserve and not to sell.'
Champollion to Joseph Bonomi. (Quoted from; Stanley Mayes, *The Great Belzoni*, London 1959 p. 293.)

During the 19th, tourists started arriving at the Valley of the Kings. The casting of the carved and painted surface continued in parallel with the hacking out and removal of sections of the walls. At the beginning of the 20th century the industrialist Sir Robert Mond was shocked by the condition of the tomb and financed Howard Carter to stabilise the structure by building brick pillars, adding structural supports and installing electricity. While this helped protect the fabric of the tomb, it again changed its nature and appearance.

Mass tourism presents seven greater challenges – At the height of the tourist boom before the 2011 revolution thousands of people wanted access to the tombs of the Theban Necropolis every day. Air-conditioning and glass panels started appearing inside the tombs as a means of 'stabilising' the environment and protecting against damage. The infrastructure to support large numbers of visitors presented additional challenges. In the 1980's the removal of the visitor centre that had been built above the vast sarcophagus room caused a large section of the celestial ceiling in Seti's tomb to collapse and as a result the tomb was closed to the public in the mid 1980's. In the late 1990's the American Research Centre in Egypt undertook a conservation study and carried out some restoration and consolidation tests. These clearly demonstrate the problems of making remedial repairs with acrylic resins and contemporary paints.



Detail of a restoration carried out in 1999 showing the addition of white paint and the application of an acrylic consolidant. In raking light it is clear that it is now cracking and peeling from the wall.

In 2001, Factum Arte carried out the first high-resolution, non-contact 3D scanning in the tomb of Seti I. One-hundred million independently measured spatial points per square meter were recorded using a laser scanning system. 3D data was coupled with composite photography to produce colour data that is both accurate and can be enlarged many times without loss of detail.

In 2009, Factum Foundation teamed up with the University of Basel to form the **Theban Necropolis Preservation Initiative (TNPI)**. The *Theban Necropolis Preservation Initiative* is committed to ensuring that the sites on the West Bank of the Nile in Luxor are recorded at high-resolution using advanced non-contact technologies in projects that involve local people at every level. The TNPI has already yielded practical results. A facsimile of the Burial Chamber of Tutankhamun was installed at the entrance to the Valley of the Kings. It is now part of the Carter House Visitor Center. Stoppelaere's House, a domed mud-brick building by the great 20th century Egyptian architect Hassan Fathy, was restored by the Tarek Waly Centre for Architecture and Heritage. This building will house the TNPI's 3D Scanning, Archiving and Training Centre. It was opened in February 2017 by the director general of UNESCO, Irina Bokova, the Minister of Antiquities of Egypt, Khaled El Enany, and the Swiss Ambassador Markus Leitner. The initial equipment is already in Egypt and the first three Egyptian operators are working to establish the centre as a fully operational example of the application of recording technologies. The centre will contribute to the long-term survival

of the tombs through condition monitoring and will assist heritage managers in the complex task of preserving the Theban Necropolis in the 21st century. Its existence will ensure that any future documentation can be carried out locally and for the benefit of the community.

The complete recording and re-materialisation of the tomb of Seti I, and all the fragments removed from it since its discovery in 1817, is an important part of the *Theban Necropolis Preservation Initiative*. The aim is to reveal the changes to the tomb since it was discovered 200 years ago and to present a facsimile on a site next to Stoppelaere's House. With the potential to integrate fragments housed in museums around the world, as well as those uncovered by excavations carried out by the University of Basel from 1998-2005, the facsimile will be more complete than the original tomb in its current state; its narrative, meaning and importance made accessible to all.

The exhibition, *Scanning Seti: The Regeneration of a Pharaonic Tomb* at the Antikenmuseum in Basel, 29 October 2017–6 May 2018, is the first phase in the creation of the facsimile of the tomb of Seti I. A combination of original and facsimile objects reveal and explain the importance of the tomb, the texts it contains, and the role of documentation in preserving this site for future generations.

The final and most ambitious phase of the TNPI involves the building of workshops that will train and employ local artisans to manufacture high-resolution facsimiles of the tomb of Seti I and others. The workshops will be practical, but will also serve as a visitor centre in which the public can learn about non-contact approaches to conservation, and about the exciting technical innovations that go into documenting cultural heritage, facsimile fabrication, condition monitoring and assisting in the ongoing research into how to stabilise the condition of the tombs that were built to last for eternity – but not to be visited. *The Theban Necropolis Preservation Initiative* has been financed by Factum Foundation and has received no public funding. The TNPI demonstrates how technology can be applied in practice and suggests how, with the support of visitors, it could ultimately be self-financing.

THE CULTURAL PRESERVATION NETWORK – TRAINING, TECHNOLOGY TRANSFER, HELPLINE SUPPORT, REMOTE ACCESS AND POOLED SPECIALISED EQUIPMENT

In addition to the work in the tomb of Seti I, Factum Foundation is working on the launch the **Cultural Preservation Network**: a recording initiative and digital archive for collecting, preserving and disseminating cultural heritage in its many forms and at different scales. This project is actively working in Europe, but is currently being focused on cultural heritage sites in areas where the risk is most acute. The Middle East and North Africa are areas that are either under direct threat or suffering indirectly from the side effects of conflict in the region but sites in Chad, Nigeria, Daghestan and Brazil that are under threat in different ways are also being recorded and communicated.

The unique sites, buildings and artefacts that reflect the complex history of diverse parts of the world will be recorded by a network of local specialists trained in non-contact 3D digital and colour recording technologies using an approach designed for social and economic sustainability and exponential growth. Factum Foundation has established partnerships with respected, reliable and invested local partners. They will be responsible for managing the regional bases from which they will lead training activities, administer resources and coordinate projects. The initiative is based on transferring a set of core skills, supplying equipment and software for archiving and data processing and providing ongoing support.

Our current partners are:

Afghanistan: *Afghan Cultural Heritage Consultation Organization (ACHCO)*,
Egypt: *The Tarek Waly Centre for Architecture and Heritage*, and the *Theban Necropolis Preservation Initiative (TNPI)*
Iraq: *The University of Mosul* and the office of the Mayor of Nineveh,
Jordan: *Community Jameel* and *Columbia University*,
Lebanon: *APSAD* and the *Arab Image Foundation*,
Tunisia: *Institut National du Patrimoine (INP)*,
Syria: *The Association for the Protection of Syrian Archeology (APSA2011)*,
Libya: *Department of Antiquities*,
Occupied Palestinian Territories: *The Palestinian Museum*, *Birzeit University*, the *Qattan Foundation* and *RIWAQ*,
Saudi Arabia: *Community Jameel* and *MISK*,
Daghestan: *Peri Foundation* and *Juma al Majid Centre for heritage and Preservation*
Nigeria: *The Trust for African Rock Art (TARA)* and *Calabar University*,
Chad: *The Ministry of Tourism* and *TARA*
Brazil: *People's Palace Projects* and *Kuikuro People of Ipatse Village*

The goal is to gather a vast amount of digital data that can be used to attract interest from a global community of internet users. This interest will be used to promote a new approach to the preservation of original objects whilst creating a generation of informed cultural tourists who understand the complex relationship between originality and authenticity, preservation and alteration.

The value of cultural artefacts does not lie in their short-term financial worth as commodities, or in their fame, which can attract visitors to remote locations, but rather in their ability to communicate their meaning across time and religious divides. Conflict zones repel cultural tourism, but each of the countries identified has the capacity to generate a significant income stream for the local community if its cultural monuments are recorded and communicated in a way that ensures their protection and survival.

The network is centred on providing the local community (with an emphasis on youth, and regardless of gender or faith) with the necessary equipment and skills for high-resolution digital recording of cultural sites. The primary focus is on high-resolution photogrammetry and composite photography, data-storage, archiving and data processing. These useful and transferable skills will greatly benefit local communities and regions afflicted with youth unemployment and radicalisation. The initiative will provide skills in the latest recording techniques including: photogrammetry, white-light scanning, laser scanning, LiDAR scanning, manuscript and archive recording, composite colour photography, drone recording and multi-spectral photography.

It will also provide skills in: data processing and archiving, 3D modelling techniques, data visualisation and preparation for different platforms, data-naming and metadata tagging, short-term storage, data transfer, long term archiving, the uses of data and its dissemination, re-materialisation techniques, digital restoration and various applications for facsimiles.

It is essential that all trainees understand how to relate to, and work within, a fragile environment. To this end, training will be given in maintaining and repairing equipment and in working within sensitive environments with fragile objects without putting either at risk. The training will also provide a basic understanding of conservation theory and methodology.

These skills and technologies will not only help protect local heritage but will add a new dynamism to the cultural industries. New technologies are redefining the boundaries between cultural industries, artistic genres and career paths. Training in both recording and 3D output skills will provide critical information needed to better manage the sites, create new revenue streams for local communities, and send a positive message about local commitment to the preservation and importance of our shared cultural heritage.

WHAT DOES 'HIGH-RESOLUTION' MEAN?

3D scanning and composite photography are changing the ways in which cultural heritage is recorded, but the technologies are unfamiliar to most involved in heritage management. Moreover, misinformation is resulting in wasted opportunities. There is a need for commonly accepted definitions of terms.

The best definition of high-resolution data is that which allows the object to be re-materialised so that the physical copy is a replica of the original object in terms of colour, surface, shape and size. Resolution is of critical importance in re-materialisation but equally necessary for the intelligent computer vision software that is being developed to analyse and interpret digital archives.

A simple example can help to illustrate misunderstandings that exist around the term 'high resolution': Between 2011 and 2013 Factum Arte recorded the carvings by Jacopo della Quercia, Amico Aspertini and others that adorn the facade of the Church in San Petronio in Bologna. Different recording systems were used to capture different aspects of the carvings. The whole façade was recorded from Piazza Maggiore using a FARO Focus 3DX 330 scanner (LiDAR scanner), while white-light scanning with the Nub 3D Sidio recorded the surface of each sculpture from scaffolding that covered the façade during cleaning and restoration work: both are often referred to as 'high-resolution' scanning systems.

LiDAR technology is mainly used for topographic mapping, architectural recording and visualisations. The Nub 3D white light scanner was developed for reverse engineering and precise surface inspection. When the resulting 3D files from each system are re-materialised at actual size using precision CNC milling, the resolution of the recorded information is clear. If photographic data is mapped over the relief the data can look similar when viewed on a screen, but in the physical world the datasets prove dramatically different.



CNC milled data from a FARO Focus 3DX 330 LiDAR scanner (left image) and same section of the façade of the Church of San Petronio recorded with a Nub3DWhite Light scanner (right image). Both are milled at actual size.

The difference is obvious, but the comparison is not entirely fair: the recording distance was not constant. LiDAR systems are good for recording large objects like buildings or terrains, but less good for recording surfaces.

A direct comparison between 3D files recorded with the Faro Focus 3DX 330, working at its maximum resolution at its minimum distance from the object (between 60cm and 1 meter), and the same surface recorded with the Lucida Laser Scanner (designed and programmed by Manuel Franquelo with the team at Factum Arte) at its normal working distance of about 10 cm from the surface, clearly shows the different capacities of each system.



Maximum resolution recorded with the Faro scanner working at its minimum distance (left image) and the same section of the tomb of Seti I recorded with a Lucida scanner under normal working conditions (right image).

In all recording the relationship between information (what you are trying to record) and ‘noise’ (interference resulting from the limitations of the recording system as information is transformed from one state to another) is critically important. The aim of high-resolution recording is to ‘capture’ an object so that the data has the closest possible correspondence to the original in terms of shape, surface and colour.

Since its formation in 2009, Factum Foundation’s work can be encapsulated in a set of general goals and principles:

Transfer of Skills and Technologies: transferring skills and technologies to local communities is not only

possible, but has now been demonstrated on three continents. This approach ensures local guardianship and has the potential to generate income. While the practical training is focussed on 3D recording and composite multi-spectral photography (colour, X Ray, infrared, ultraviolet), the data gathering also seeks to assemble previous recordings of the same objects or sites from archival records. Simply bringing data together in a place where it can be found and accessed is fundamentally important. This is especially true with restoration records that can reveal the career of the object.

Diverse Recording Technologies: understanding the right technology for the right task is critical. While the core skills taught are high-resolution photogrammetry and composite photography, other recording technologies are required for specific tasks. These are being developed, pooled and shared according to need. In each case the data must be recorded in a way that is scientifically verifiable and contains the history of its capture, processing, and all stages involved in its transformation and mediation from one form to another.

Archiving: plans must be put in place to establish long-term archiving and to ensure compatibility and easy access without expensive proprietary software. Long-term archiving of digital data is a significant task on which there is little existing professional agreement. Metadata systems and archiving protocols can ensure it is possible to find digital data when it has been misplaced. The data in the public domain should be prepared so that it can be accessed easily. Ensuring future generations have access to archives in a post-nuclear scenario will require significant governmental infrastructure and investment.

Data Ownership: all rights to the data must belong to the custodian of the object for all current and future applications that can generate income. In return for this clear statement of ownership the 'custodian' will agree to make it freely available for academic and conservation applications. Data ownership (both current and future) is a key issue. Sharing and providing access to the data nurtures understanding and helps in the development of knowledge and human skills; it can generate new audiences and reveal the importance of cultural heritage as evidence that can communicate across temporal, religious and cultural divisions.

Condition Monitoring: The uses of high-resolution archives are extensive. Monitoring the condition of objects is one of the most critical. Demonstrating the rate of decay provides an objective basis for decisions relating to the protection of objects. Providing forensically accurate evidence before and after restoration procedures is also important.

Digital Restoration: The recording work that is being promoted is 100% non-contact. It aims to provide the data required by conservators and restorers for in-depth study and condition monitoring. Digital restoration is a fast-growing application of digital technology. Through diverse types of high-resolution information, it is possible to understand the physical nature of all objects and to create a forum in which consensus can be reached before any actions are carried out on original objects. Another important element of digital restoration is reuniting fragments of a single object that have been separated over time in both digital and facsimile form. The object can be the Tomb of Seti I, a renaissance altarpiece like the Polittico Griffoni or the contents of Strawberry Hill House.

Data Presentation: Digital technologies used to be associated with virtual representations. Augmented Reality, Virtual Reality and Mixed Reality are rapidly developing and will become a popular platform for sharing and communicating the importance cultural objects. But the primary target is to preserve the evidence of the past at the highest resolution allowed by the diverse technologies. Data can always be optimised to make it easier to access and share, but if it is not recorded correctly it does not exist. Evidence of the quality of the data can be seen when it is rematerialized as a physical object. Visualising 3D and colour files on screen requires less information than re-materialising the object using additive or subtractive technologies. This level of resolution normally produces vast files that cannot be handled by most computers. The packaging and presentation of data is of critical importance to ensure the widest access.

Intelligent Computer-Vision Software: Software developments are increasingly demanding high-resolution data to assemble a new and informed 'four-dimensional map' of the past based on both documents and visual evidence. As the algorithms get more precise, and as the data becomes freely available, these technologies will redefine the relationship between the past and the present.

CONCLUSION

Digital recording technologies are leading to a deeper understanding of works of art. Artworks, the repositories of evidence that reveal the many subtle decisions taken during their creation, can now be studied with forensic accuracy. Conservation is the management of change and the evidence uncovered by new recording technologies can help to identify changes that have happened over time, revealing how and why things have aged. Using these methods, we acquire the ability to read both original intention and the values of those who have 'looked after' the cultural object. This facilitates a detailed analysis of the interventions that have been made for different reasons at different times and in different places. The use of technology produces facts, not opinions, and is leading to new insights and discoveries.

This approach is creating a new type of connoisseurship, one which can unlock the complex history of an object, allowing it to be read and engaged with in new ways. The recording work carried out by Factum Arte's team in 2009 in the Tomb of Tutankhamun has proved to be a turning point in documenting and preserving the past through the application of new technologies. It has led to speculation about the existence of new chambers and it will be critical to monitor change to the walls of the burial chamber.

The work that is being done in the tomb of Seti I will set new standards and result in the transfer of skills and technologies to a local team. This approach is also being applied in other places affected by conflict, economic hardship, natural disasters and neglect, with the Middle East and North Africa an obvious focus of attention. The historical importance of the region and ongoing conflicts make it exceptionally vulnerable. The documentation of cultural heritage is now as important as ever. It is vital that recordings contain sufficient information to act as an accurate record in the case of damage or destruction, rather than as souvenirs or memories of things irretrievably lost.

The key to the successful recording of cultural heritage lies in the transfer of skills and technologies to local communities; the provision of training and support; the development of a distributed archiving system and ensuring the data is shared, disseminated and used.

Once universal guidelines for digital documentation are established, the role of both visualisations and physical facsimiles will become the central topic. The Cast Courts at the V&A are evidence of the C19th desire to use technology to protect and replicate. What will the cast courts of the C21st look like? Will they create a new generation of connoisseurs whose knowledge is based on fact informed by opinion... or will they be lowered to the status of a theme park?

ReACH is offering an international and considered response to the current application of technology to the preservation of the past. With the right political and financial support, the new convention could have a real impact. The technology improving all the time. The skills exist in all communities. All it requires is that people with technical skills and cultural understanding are allowed to do the work.



Aliaa Ismail and Moussa Sayd Mohamed recording in the pillared part of the Sarcophagus Room (Room J) in the Tomb of Seti I, 2016.



The facsimile of the Hall of Beauties looking towards the Sarcophagus room. This facsimile is based on 3D scans and composite photographs made by Factum Foundation in 2016, installed at the Antikenmuseum, Basel in 2017.



The facsimile of the sarcophagus of Seti I made from photogrammetric data recorded in Sir John Soane's Museum rematerialised using Océ elevated printing technology by Factum Arte.

ABOUT ADAM LOWE

Adam Lowe is the founder of Factum Foundation and director of Factum Arte. He has been pioneering the application of technology to the recording of cultural heritage since 2001, when the first high-resolution laser scanning was carried out in the Tomb of Seti I. The work in Egypt has grown into the Theban Necropolis Preservation Initiative and to the creation of the Centre for 3D Scanning Archiving and training at Stoppelaere House.

He is an Adjunct Professor in the Graduate School of Architecture, Planning and Preservation at Columbia University and teaches and lectures widely in Europe and the US. He has written extensively on the subject of originality and authenticity. He is a central part of the initiative with École Polytechnic Fédérale de Lausanne and Fondazione Giorgio Cini to create a centre of Digital Humanities in Venice. His collaborations with the Fondazione Giorgio Cini started in 2006 and resulted in many successful collaborations including the facsimile of Veronese's *Wedding at Cana*, the touring exhibition *The Arts of Piranesi*, and exhibition of tapestries *Penelope's Labour: Weaving Words and Images* (with Jerry Brotton) and most recently *Mindful Hands- Masterpieces of Illumination from the Fondazione Giorgio Cini*.

He initiated the relationship between Factum Foundation and the Peri Foundation that has proved very successful and has led to the training of several Russian nationals in the complex tasks related to recording works of major importance to the Islamic and Orthodox religions.

Adam Lowe is currently working on a proposal to establish the Saudi Arts Institution, a collaboration with Community Jameel in Jeddah and Dubai, has collaborations in Brazil with People's Palace Projects, and is one of the core team in the ReACH initiative, a collaboration between the V&A and the Peri Foundation.

He has featured in many television and radio programmes and is currently completing a seven-hour series with Sky Arts that focuses on the re-creation of seven great works of art lost or destroyed in the C20th.

FACTUM FOUNDATION FOR DIGITAL TECHNOLOGY IN CONSERVATION

The Factum Foundation for Digital Technology in Conservation is a not-for-profit organisation, founded in 2009 in Madrid with 501(c)3 status in America. The Foundation is dedicated to the conservation of heritage through the application of digital technology. In addition to the work with the University of Basel in the Valley of the Kings the foundation is working with: The British Museum (London), Museo del Prado (Madrid), Bodleian Library (Oxford), Columbia University (New York), École Polytechnique Fédérale de Lausanne, Fondazione Giorgio Cini (Venice), Peri Foundation (Moscow), People's Palace Projects (Rio de Janeiro and London), Community Jameel (Jeddah) and many other organisations.

Working alongside Factum Arte, the Foundation specialises in heritage documentation, and is involved in developing equipment for heritage documentation, establishing training centres for new recording technologies across the world, compiling digital archives for the preservation and study of heritage, and designing and curating exhibitions focussed on disseminating the importance of preserving and understanding our shared cultural heritage.

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