



FACTVM  
FOVNDATION  
FOR DIGITAL TECHNOLOGY  
IN CONSERVATION

FACTVM arte

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A SELECTION OF TEXTS  
by Adam Lowe &  
Charlotte Skene Catling  
AND A SELECTION OF RECENT PROJECTS

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The 'techné' shelves for *Madame de Pompadour in the Frame* at Waddesdon Manor, May to October 2019. These shelves contain fragments and samples from a range of projects using diverse materials and processes.



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factumfoundation.org  
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The physical reconstruction of the digital restoration of the vandalised sacred cave of Kamukuwaká. A project carried out with the Wauja people of the Upper Xingu, Brazil.





Al-Idrisi's world map (a recreation) with a test for the facsimile of the burial chamber of Tutankhamun, a facsimile of the Raphael from Lo Spasimo in Palermo remade as a panel painting for its original frame and a recreation of an altar by Piranesi made for *The Arts of Piranesi* at the Fondazione Giorgio Cini.



In June 2019 Carlos Bayod, Guendalina Damone and Otto Lowe taught a five-days course for students from the Photography MA course at ISIA, Urbino. The practical workshop involved recording in Palazzo Grimani with Venetian Heritage and at the Abbazia di San Gregorio during Colnaghi and Charan's *Grand Tour* exhibition.



The Wauja community correcting the 3D renders produced in Madrid to ensure they function correctly.

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A chapter prepared by Bruno Latour & Adam Lowe  
For Thomas Bartscherer (editor) *Switching Codes*, University of Chicago Press, 2011.



Carlos Bayod and Aliaa Ismail working in the tomb of Seti I in 2017.

Something odd has happened to Holbein's Ambassadors at the National Gallery in London. The visitor does not immediately know how to describe her malaise. The painting is completely flat, its colours bright but somewhat garish; the shape of every object is still there but slightly exaggerated; she wonders what has happened to this favourite painting of hers. "That's it", she mutters, "the painting has lost its depth, the fluid dynamics of the paint has gone. It is just a surface now." But what does this surface look like? The visitor looks around, puzzled, and then the answer dawns on her: it resembles almost exactly the poster she has bought several years ago at the Gallery bookshop and that still hangs in her study at home. Only the dimension differs.

Could it be true? She wonders. Could they have replaced the Ambassadors by a facsimile? Maybe it's on loan to some other museums and they did not want to disappoint the visitors, so they put up with this copy. Or maybe they did not want to trick us and it is a projection, it is so flat and bright that it could almost be a slide projected on a screen... Fortunately, she composes herself enough not to ask the stern guard in the room whether this most famous painting is the original or not. What a shock it would have been. Unfortunately, she knows enough about the strange customs of restorers and curators to bow to the fact that this is indeed the original although only in name, that the real original has been irreversibly lost and that it has been substituted by what most people like in a copy: bright colors, shining surface, and above all a perfect resemblance with the slides sold at the bookshop that are shown in art classes all over the world by art teachers most often interested only in the shape and theme of a painting but not by any other marks registered in the thick surface of a work. She leaves the room suppressing a tear: the original has been turned into a copy of itself looking like a cheap copy, and no one seems to complain or even to notice the substitution. They seem happy to have visited in London the original poster of Holbein's Ambassadors!

Something even stranger happened to her, sometime later, in the Salle de la Joconde in Le Louvre. To finally get at this cult icon of the Da Vinci code, hundreds of thousands of visitors have to enter through two doors that are separated by a huge framed painting, Veronese's *Nozze di Cana*, a rather dark giant of a piece that directly faces the tiny Mona Lisa barely visible through her thick anti-fanatic glass. Now the visitor is really stunned, because she no longer recognizes in the Hollywood machinery of the miraculous wedding the facsimile that she had the good fortune of seeing when she was invited by the Fondazione Cini to the island of San Giorgio, in Venice, at the end of 2007. There it was, she remembers vividly, a painting on canvas, so thick and deep that you could still see the brush marks of Veronese and feel the sharp cuts that Napoleon's orderlies had to make in order to tear the painting from the wall, strip by strip, before rolling it like a carpet and sending it as a war booty to Paris in 1797 — a cultural rape very much in the mind of all Venetians, up to this day. But there, in Palladio's refectory, the painting (yes, it was a painting even though it has been produced through the intermediary of digital techniques) had an altogether different meaning: it was at a different height that make sense in a dining room, it was delicately lit by the natural lights of huge East and West windows and at about 5pm on a summer afternoon the light in the room exactly coincides with the light in the painting, it had of course no frame and, more importantly, Palladio's architecture merged with admirable continuity within Veronese's painted architecture giving to the refectory of the Benedictine monks such a *trompe l'oeil* depth of vision that you could not stop yourself from walking slowly back and forth up an down the room to enter deeper and deeper into the mystery of the miracle.

But here, in the Mona Lisa room, even though every part of the painting looked just the same (as far as she could remember), the meaning of the painting she had seen in Venice seemed entirely lost. Why such a huge gilt frame? Why the doors on both sides? Why was it hanging so low, making a mockery of the balcony on which the guests were crowding in Venice. For instance, the bride and groom, squashed into the left-hand corner, seemed peripheral here while in Venice they were of great importance articulating a scene of sexual intrigue that felt like a still from a film. In Paris the composition made less sense. Why this ugly zenithal light? Why this air-conditioned room with its dung brown polished plaster walls? — in Venice there was no air-conditioning, the painting was allowed to breathe by itself as if Veronese had just left it dry. And, anyway, the visitors could not move in and out of the painting to ponder those questions without bumping on the crowds momentarily glued (queued) to the Joconde turning their back to the Veronese.

A terrible cognitive dissonance. And yet there was no doubt that this one, in Paris, was the original; no substitution had occurred, no cheating of any sort – plenty of restoration and Veronese would certainly be surprised to see the painting looking as it does- but that’s different from cheating. She remembered perfectly well that in Venice it was clearly written: “A facsimile”. And there even was in San Giorgio a small exhibition to explain in some detail the complex digital processes that Factum Arte, the workshop in Madrid, had used to de- then re-materialized the gigantic Parisian painting; carefully laser scanning it, A4 by A4, then photographing it in similar sized sections, then white light scanning it to record the relief surface, then somehow managing to stitch together the digital files before instructing a purpose-built printer to deposit pigments onto canvas carefully coated with a gesso almost identical to that used by Veronese. Is it possible that the Venice version, although it clearly states that it is a facsimile, is actually more original than the Paris original, she wonders? She now remembers that on the phone with a French art historian friend she had been castigated for spending so much time in San Giorgio with the copy of the Nozze: “Why waste your time with a fake Veronese, when there are so many true ones in Venice?!” her friend had said; and she had replied, without realizing that she was saying: “But come here to see it for yourself, no description can replace seeing this original. . . oups, I mean, is this not the very definition of the aura? . . .”. Without question, for her the aura of the original had migrated from Le Louvre to San Giorgio: the best proof is that you had to come to the original and see it. What a dramatic contrast, she thought, between the Veronese and the Ambassadors that claims to be the original in order to hide that it is an expensive copy of one of its cheap copies!

“But it’s not the original, it’s just a facsimile!”. How often have we heard such a retort when confronted with an otherwise perfect reproduction of a painting? No question about it, the obsession of the age is for the original version. Only the original possesses an aura, this mysterious and mystical quality that no second hand version will ever get. But paradoxically, this obsession for pinpointing originality increases proportionally with the availability and accessibility of more and more copies of better and better quality. If so much energy is devoted to the search for the original — for archeological and marketing reasons— it is because the possibility of making copies has never been so open-ended. If no copies of the Mona Lisa existed would we pursue it with such energy — and would we devise so many conspiracy theories to decide whether or not the version held under glass and protected by sophisticated alarms is the original surface painted by Leonardo’s hand or not. In other words, the intensity of the search for the original depends on the amount of passion and the number of interests triggered by its copies. No copies, no original. In order to stamp a piece with the mark of originality you need to apply to its surface the huge pressure that only a great number of reproductions can provide.

So, in spite of the knee-jerk reaction —“But this is just a facsimile”—, we should refuse to decide too quickly when considering the value of either the original or its reproduction. Thus, the real phenomenon to be accounted for, is not the punctual delineation of one version divorced from the rest of its copies, but the whole assemblage made up of one —or several— original(s) together with the retinue of its continually re-written biography. It is not a case of “either or” but of “and, and”. Is it not because the Nile ends up in such a huge delta that the century-old search for its sources had been so thrilling? To pursue the metaphor, we want, in this paper, to behave like hydrographers intent in deploying the whole catchment area of a river -not only focusing on an original spring. A given work of art should be compared not to any isolated locus but to a river’s catchment, complete with its estuaries, its many tributaries, its dramatic rapids, its many meanders and of course also with its several hidden sources.

To give a name to this catchment area, we will use the word trajectory. A work of art —no matter of which material it is made — has a trajectory, or to use another expression popularized by anthropologists, a career<sup>1</sup>. What we want to do in this paper is to specify the trajectory or the career of a work of art and to move from one question that we find moot (“Is it an original or merely a copy?”) to another one that we take to be decisive especially at the time of digital reproduction: “It is well or badly reproduced?”. The reason why we find this second question so important is because the quality, conservation, continuation, sustenance and appropriation of the original depends entirely on the distinction between good and bad reproduction. We want to argue that a badly reproduced original risks disappearing while a well accounted for original may continue to flourish its originality and to trigger new copies. This is why we want to show that facsimiles, and especially those relying on complex (digital) techniques, are the most fruitful way to explore the original and even to help re-define what originality actually is.

To shift the attention of the reader away from the detection of the original to that of the quality of its reproduction, let us remember that the word “copy” does not need to be so derogative, since it comes from the same etymology

1. Appadurai, Arjun, ed. *The Social Life of Things. Commodities in Cultural Perspective*. Cambridge: Cambridge University Press, 1986; Tamen, Miguel. *Friends of Interpretable Objects*. Cambridge, Mass: Harvard University Press, 2001.

as “copious”, and thus designates a source of abundance. There is nothing inferior in the notion of a copy, simply a proof of fecundity. Is originality something that is fecund enough to produce an abundance of copies. So much so that, in order to give a first shape to the abstract notion of trajectory, we wish to rely on the antique emblem of a cornucopia: a twisted goat horn with a sharp end —the original— and a wide mouth disgorging at will an endless flow of riches (all thanks to Zeus). Actually, this connection between the idea of copies and that of the original should come as no surprise since for a work of art to be original means nothing but to be the origin of a long descendance. Something which has no progeny, no reproduction, no inheritors, is not called original but rather sterile or barren. To the question: “Is this isolated piece an original or a facsimile?”, it might be more interesting to substitute the other question: “Is this segment in the trajectory of the work of art barren or fertile?”.

To say that a work of art grows in originality thanks to the quality and abundance of its copies, is nothing odd: this is true of the trajectory of any set of interpretations. If the songs of the Iliad had remained stuck in one little village of Asia Minor, Homer will not be considered as a (collective) author of such great an originality. It is because —and not in spite of— the thousands of thousands of repetitions and variations of the songs that, when considering any copy of the Iliad we are moved so much by the unlimited fecundity of the original Aed. We attribute to the author (even though his very existence cannot be specified) the power of each of the successive reinterpretations by saying that “potentially” all of them “were already” there in the Ur-text —which we simultaneously know to be wrong (my reading could not possibly be already there in Greece) and perfectly right since I willingly add my little expansion to the “unlimited” fecundity of this collective phenomenon called “The Illiad”. If it is so unlimited, it is because I push the limit a little bit more. This does mean that there is nothing “inherently great” in the first versions of the great poem, and that to penetrate inside this inherent greatness, you need to bring with you all of the successive versions, adaptations and accommodations. Nothing is more ordinary than this mechanism: Abraham has become the father of a people “as numerous as the grains of sand” only because he had a descendance. Before the birth of Isaac, Abraham was a despised barren old man. That he became “the Father of three religions” depends on what happened to Isaac, and then to what happened to every one of his later sons and daughters. Such is the “awesome responsibility” of the reader, as Charles Péguy so eloquently said, because this process is entirely reversible and if we stop interpreting, if we stop rehearsing, if we stop reproducing, the very existence of the original is at stake. It might stop having abundant copies and slowly disappear<sup>2</sup>.

We have no difficulty raising questions about the quality of the entire trajectory when dealing with the performing arts, such as dance, music and theatre. Why is it so difficult when faced with the act of reproduction of a painting, a piece of furniture, a building or a sculpture? This is the first question we want to clarify.

No one will complain on hearing King Lear: “But this is not the original, it is just a representation!”. Quite right. That’s the whole idea of what it is to play King Lear: it is to replay it. In the case of a performance, everyone is ready to take into account the whole trajectory going from the first presentations through the long successions of its “revivals” all the way to the present. There is nothing extraordinary in considering that “one good representation of King Lear” is a moment, a segment, in the career of the work of art called King Lear, the absolute Platonic ideal of which no one has ever seen and that no one will ever be able to circumscribe. In addition, it requires no great sophistication to be fully prepared for disappointment at not finding “the” first original presentation by Shakespeare “himself”, but several premieres and several dozens of different versions of the written play with endless glosses and variations. We seem perfectly happy to be excited by the anticlimactic discovery of the source of a major river in a humble spring barely visible under the mossy grass. Third, and even more importantly, spectators have no qualm whatsoever at judging the new version under their eyes by applying the shibboleth: “Is it well or badly (re)played?” They can differ wildly in their opinions, some being scandalized by what they take as some revolting novelties (“Why does Lear disappear in a submarine?”) or bored by the repetition of too many clichés, but they have no difficulty in considering that this moment in the whole career of all the successive King Lears —in the plural— should be judged on its merit and not by its mimetic comparison with the first (entirely inaccessible anyway) presentation of King Lear by the Shakespeare company in such and such a year. It is now, what we see under our eyes on stage, that counts to make up our judgment, and certainly not the degree of resemblance with another Ur-event hidden from view (even though what we take to be the real “King Lear” remains in the background of every one of our judgments). So clearly, in the case of performance art at least, every new version runs the risk of losing the original —or regaining it.

2. See the commentaries of Péguy in Deleuze, Gilles. *Difference and Repetition* (translated by Paul Patton). New York: continuum International Publishing, 2005.



So free are we from the comparison with any “original”, that it is perfectly acceptable to evaluate a replay by saying: “I would never have anticipated this, it is totally different from the way it has been played before, it is utterly distinct from the way Shakespeare played it and yet I now understand what the play has always been about!”. Everything happens as if some of revivals —the good ones— had managed to dig out of the original novel traits, that might have been potentially in the source, but which have remained invisible until now, and that are made vivid again to the mind of the spectators. So, even though it is not evaluated by its mimetic resemblance to an ideal exemplar, yet it is clear, and everyone might agree, that, because of the action of one of its late successors, the genius of Shakespeare has gained a new level of originality because of the amazing feat of this faithful (but not mimetic) reproduction. The origin is there anew, even though it is so different from what it was. And the same phenomenon would occur for any piece of music or for dance. The exclamation: “It’s so original” attributed to a new performance does not describe one section along the trajectory (and especially not the first Ur-version) but the degree of fecundity of the whole cornucopia. In performance art the aura keeps migrating and might very well come back suddenly... or disappear altogether. When so many bad repetitions have so decreased the level of fecundity of the work that the original itself might be abandoned, it will stop being the starting point of any succession. Such a work of art dies out like a family line without any descendance. Like a river deprived, one after one, of all its tributary and that has shrunk to the size of a tiny rivulet, the work has been brought to its “original” size, that is, to very little, since it has never been copiously copied, that is, constantly reinterpreted and recast. The work has lost its aura for good.

Why is it so difficult to say the same thing and use the same type of judgment for a painting or a sculpture or a building? Why not saying, for instance, that the facsimile of Veronese’s *Nozze di Cana* has been replayed, rehearsed, revived thanks to a new interpretation in Venice in 2007 by Factum Arte, much as Hector Berlioz’s *Les Troyens* have been given at last for the first time in London by Colin Davis in 1969 in Covent Garden (a feat that poor Berlioz never managed to witness since it never had the money nor the orchestra to play his original work in full...). And yet what seems so easy for performance art remains far fetched for the visual arts. If we claim that the *Nozze di Cana* have been “given again” in San Giorgio, someone will immediately say: “But the original is in Paris! the one now in San Giorgio is just a facsimile!”. A sense of fakery, of counterfeiting, of betrayal, has been introduced in the discussion in a way that would seem absurd for a piece of performance art (even though it is perfectly possible to say of a very bad company that they made “a sham” at playing Shakespeare). It seems almost impossible to say that the facsimile of Veronese’s *Nozze di Cana* is not about falsification but it is a stage in the verification of Veronese’s achievement, a part of its ongoing biography.

One reason for this unequal treatment has obviously to do with what could be called the differential of resistance among all segments of the trajectory. In his much too famous essay, throughout a deep fog of art historical mystic, it is this gap in technology that Walter Benjamin pointed out under the name of “mechanical reproduction”<sup>3</sup>. In the case of performance art, each version is just as difficult to produce and just as costly as the former one (actually more and more expensive as time goes and certainly more than in Shakespeare’s time —just think of the wages for the security guards and all the health and safety standards!). It is not because there has been zillions representations of King Lear that the one you are now going to give will be easier to fund. The marginal cost will be exactly the same —with the only exception that the public will know what “a King Lear” is, coming fully equipped with endless presuppositions and critical tests on how it should be played (a double-edged sword, as any director knows). This is the technical reason why, in the case of performance art, we don’t distinguish between an original and a copy, but rather between successive versions of the same play each designated by the label “version n”, “version n+1”, “version n+2”, etc. It is also why the real play “King Lear” is localized nowhere specifically (and often not at the very beginning) but is rather the name given to the whole cornucopia itself (even though everyone of the spectators cherish those special moments in his or her personal history when, because of an exceptionally good “revival”, the genius of the real King Lear has been “instantiated” more fully than any time before or later). In those cases, the trajectory is composed of segments made, so to speak, of the same stuff or that at least require a roughly similar mobilization of resources.

The situation appears to be entirely different when considering, for instance, a painting. Because it remains in the same frame, encoded in the same pigments, entrusted to the same institution. One cannot help having the impression that every reproduction will be so much easier to do and that there will be no possible comparison of quality between the various segments of the trajectory. This is why the aura seems definitely attached to one version only, the autograph one. And certainly this is superficially true: if you take a picture of the *Nozze di Cana* in Paris with your digital camera, no one in his right mind can render commensurable the pale rendering on the screen of your computer and the 67m2

3. Benjamin, Walter. *The Work of Art in the Age of Mechanical Reproduction*. In *Illuminations*, 217-51. New York: Schocken Books, 1968.

of canvas in le Louvre... If you claimed that your picture was “just as good as the original”, people would raise their shoulders in pity, and rightly so.

And yet, the distance between “version n” called “the original” and “version n+1” called “a mere copy” depends just as much on the differential of efforts, of costs, of techniques as on any substantial distinction between the successive versions of the same painting. In other words, it is not because of some inherent quality of painting that we tend to create such a yawning gap between originals and copies —it is not because they are more “materials” (an opera or a play are just as “material” as pigments on canvas)—, but because of the differences in the techniques used for each segment of the trajectory. While in performance art they are grossly homogeneous (each replay relying on the same gamut of techniques) the career of a painting or a sculpture relies on segments which are vastly heterogeneous and which vary greatly in the intensity of the efforts deployed along its path. It is this asymmetry, we wish to argue, that too often preclude one to say that the *Nozze di Cana* in Paris has been “reprinted” or “given again” in Venice. And it is certainly this presupposition that angered so much the French art historian castigating her friend for wasting her time in San Giorgio instead of visiting the “genuine Veroneses”. Hidden behind the commonsense distinction between original and mere copies, lies a totally different process that has to do with the technical equipment, the amount of care, the intensity of the search for the originality that goes from one version to the next. Before being able to defend itself for re-enacting the original well or badly, a facsimile is discredited beforehand because it is associated with a gap in techniques of reproduction. A gap based on a misunderstanding of photography as an index for reality.

The proof of this claim can be obtained by showing what happened to our search for originality when we modify this differential —something that becomes easier and easier in the new digital age. That it is not limited to performance art might be made clear by the comparison with the copying of manuscripts. Before printing, the marginal cost of producing one more copy was exactly identical to that of producing the penultimate —a situation to which we are actually returning now when treating digital copies. Inside the scriptorium of a monastery, all exemplars were similarly copies and no copyist would have said that this one is the original while this one is only a copy —they were all facsimiles— even though great care was of course put into distinguishing a better, earlier, more illuminated version from an inferior one. Here again the aura was able to travel and might very well have migrated to the newest and latest copy excellently done on one of the best parchments and double checked against the best earlier sources. Naturally, once the printing press had started, the marginal cost of one extra copy soon became negligible compared to the time and techniques necessary to write the manuscript: then, but then only, an enormous distance was introduced, and rightly so, between one part of the trajectory —the autograph manuscript now turned into THE ORIGINAL— and another part, the print run —which, from now on, will be made of nothing more than mere copies (until of course the great art of bibliophily reintroduced endless subtle differences between each of the successive prints – and forensic digital analysis allowed us to date and order those copies).

There is no better proof that the ability of the aura to be retrieved from the flows of copies (or to remain stuck in one segment of the trajectory) crucially depends on the heterogeneity of the techniques used in the successive segments, than to consider what happens to THE ORIGINAL book now that we are all sitting inside that worldwide cut and paste scriptorium called the Web. Because there is no longer any huge difference between the techniques used for each successive instantiation of the originals of some segment of a hypertext, we accept quite easily not to make that great a distinction between one version, judged before as “the only original”, and later versions which would be said to be “mere copies”. We happily stamp successive renderings of the “same” argument with “version 1”, “version 2”, “version n” while the notion of the author has become just as fuzzy as the aura —not to mention the royalties from copyrights. Hence the popularity of collective scriptoria like Wikipedia. In effect, Benjamin confused the notion of “mechanical reproduction” with the inequality in the techniques employed along a trajectory. No matter how mechanical a reproduction is, once there is no huge gap of process between version n and version n+n, the clearcut distinction between the original and its reproduction becomes less crucial —and the aura begins to hesitate and is uncertain where it should land.

All of that might be very well, but is it possible to imagine the same migration of the aura in the reproduction or the reinterpretation of, say, a painting? After all, it is the contrast between the *Nozze* and the *Ambassadors* that triggered our inquiry that would have gone very differently had it be limited to performance art. One cannot help suspecting that there is in painting, in architecture, in sculpture, in objects in general, a sort of stubborn persistence that makes the association of a place, an original and some aura impossible to separate.

Let us first notice, however, that the difference between performance arts and the others is not as radical as it seems: a painting has always to be reproduced, that is, it is always a re-production of itself even when it appears to stay exactly the same in the same place. Or, rather, no painting remains the same in the same place without some reproduction. For paintings too existence precedes the essence. To have a continuing substance they need to be able to subsist. This requirement is well known by curators all over the world: a painting has to be reframed, dusted, sometimes restored, relit, it has to be represented in different rooms with different accompanying pictures, different walls, inserted in a different narratives, with different catalogues, its price changes over time, its insurance cost also. So, even though a painting might never be loaned and keep surviving inside the same institutional setting without undergoing any heavy restoration, it has a career all the same: to subsist and be visible again it needs to be taken care of. The best proof is that if you don't, it will soon be accumulating dust in a basement, be sold for nothing, or will be cut into pieces and irremediably lost. Such is the justification for all the restorations: if you don't do something, time will eat up that painting as certainly as the building in which it is housed will decay, or as surely as the institutions supposed to take care of it will start decomposing. If in doubt about this, imagine your precious works of art housed in the Kabul National Museum. . . . For a work of art to survive, it requires an ecology just as complex as to maintain the natural character of a natural park<sup>4</sup>.

If the necessity of reproduction is accepted, then we might be able to convince the reader that the really interesting question is not so much to differentiate the original from the facsimiles, but to be able to tell apart the good from the bad reproduction. If the Ambassadors have been irreversibly erased, it is not out of negligence, but, on the contrary, because of an excessive zeal in "reproducing" it. What the curators did was to confuse the obvious general feature of all works of art —to survive they have to be somehow reproduced— with the narrow notion of reproduction provided by photographic posters while ignoring many other ways for a painting to be reproduced. For instance they could have had a perfect facsimile registering in 3-D all its surface effects and restored the copy instead of the work itself. If they had done this they could have invited several art historians with different views to suggest different ways of restoring the copy and produced an exhibition of the results. Their crime is not to have offered to the visitors of the National Gallery a reproduction of the Holbein instead of the Holbein itself —"the Ambassadors" remains behind all the successive restorations much like King Lear does over each of its replay, granting or withdrawing its auratic dimension at will depending on the merit of each instance— but to have so limited the range of reproduction techniques that they have chosen one of the most barren: the photograph. As if a painting was not a thick material but some ethereal design that could be lifted out of its materiality and downloaded into any reproduction without any loss of substance. Actually, a terribly revealing documentary shows the culprits restoring the Holbein by using as their model photographs of the original and subjectively deciding what is original, what has decayed, what has been added and imagining the painting as a series of discrete layers that can be added or removed at will. A process that resembles plastic surgery more than an open forensic investigation.

Thus, what is so extraordinary in comparing the fate of the Ambassadors with that of the Nozze, is not that they both rely on reproduction —this is a necessity of existence— but that the first relies on a notion of reproduction that makes the original disappears for ever while the second adds originality to the original version by adding to it new dimensions without jeopardizing the penultimate version — without ever touching it thanks to the delicate processes used to record it.

But how could any originality be added, one could ask? One obvious answer is: by bringing the new version to its original location. The cognitive dissonance undergone by the visitor in the Mona Lisa room comes in part from the fact that in Palladio's refectory every single detail of the Nozze has a meaning entirely lost and wasted in the awkward situation provided for the version n-1 in Paris. In other words, originality does not come to a work of art in bulk, it is rather made of different components, each of which can be inter-related to produce a complex whole. New processes of reproduction allow us to see these elements and their inter-relationship in new ways. To be at the place for which it had been conceived in each and every detail is certainly one aspect —one element— in what we mean by an original. Well, on that ground, there is no question that it is the facsimile of the Nozze that is now original and that it is the version in Le Louvre that has lost at least this comparative advantage.

We should not however be too mystical about the notion of an "original location" in the case of the Veronese since the very refectory in which the facsimile has been housed is itself a reconstruction. If you look at photographs taken

4. Western, David. *In the Dust of Kilimandjaro*. New York: Shearwater/Island Press, 1997.

in 1950, you will notice that the original floor was gone and another had been installed at the height of the windows — the top was a theatre and the basement a wood workshop, the whole space had been altered. It was rebuilt in the 50's but the plaster and floor were wrong and the boiserie that surrounded the room and added the finishing touches to the proportion of the room was missing. In its stripped-down state it looked more like a high protestant space that almost seemed to laugh at the absence of Veronese's counter-reformation flourish. But now the effect of the facsimile is such that there are rumours that the return of the painting has triggered a plan for a new restoration that will retrospectively return the space to its former glory. A facsimile of a heavily restored original, now in a new location, was causing new elements to be added to an original in its original location that is in part a facsimile of itself. Originality once seemed so simple. . . .

The same is certainly true of availability. What angered the visitor so much in Le Louvre was that she could not actually scan visually the Nozze without bumping into Mona Lisa addicts. The Veronese is so full of incident and detail that it cannot be seen without time to contemplate its meaning, implications and the reasons for its continued importance. What does it mean to enshrine an original, if the contemplation of its auratic quality is impossible? This too is another element that can be prized away and distinguished from all the others. Actually, this component of originality does not need to go with the originality of the location: the best proof of this may lie in the facsimile of the burial chamber from the Tomb of Thutmose III in the Valley of the Kings<sup>5</sup>. It contains the first complete text of the Amduat to be used in a pharaonic tomb. The Amduat is a complex narrative mixing art, poetry, science and religion to provide a coherent account of life in the afterworld. The tomb was never made to be visited and the physical and climatic conditions inside the tomb are incompatible with mass tourism. As a result, the tomb is deteriorating rapidly and glass panels have had to be installed to protect the walls from accidental damage and wear and tear. However the interventions in the tomb change its nature and inhibit both detailed study of the text and an appreciation of the specific character of the place. Exhibitions that presented the facsimile and contextualize the text have now been visited by millions of people in North America and Europe. The delocalized facsimile has established the reasons for its continued importance, turned the visitors into a pro-active force in the conservation of the tomb and could become part of a long term policy that will keep the version n-1 safe but accessible to the small number of specialists who require access for continued study and monitoring. See? Each of the components that together comprise what we mean by a true original begin traveling at different speeds along the trajectory and begin to map out what we have called the catchment area of a work of art.

A third element of originality has to do with the surface features of a work. Too often, restorers make a mockery of the materiality of the original they claim to protect by limiting matter to shape only because they confuse 3D with 2D. If there is one aspect of reproduction that digital techniques have totally modified, it is certainly the ability to register the most minute three-dimensional aspect of a work without putting the work at risk. It is often forgotten that in its early years the British Museum used to take plaster casts of their objects and the first British Museum catalogue contains a list of copies that were available and for sale. It is often forgotten because the plaster cast collection was discarded at the end of the 20th century and valuable information about the surface of works when they entered the museum was lost. Many of the moulds still contained the paint that was removed during the casting process and subsequent restorations of the originals have dramatically altered the surface and appearance of many of the objects. So, even for a work of art to be material is a question of complex trajectories. Many Venetians, when they first heard of the Nozze facsimile immediately conjured up in their mind a glossy flat surface much like that of a poster and they were horrified at the idea of being given this in reparation for Napoleon's cultural rape of San Giorgio. Little could they anticipate that the facsimile was actually in pigment on a canvas coated with gesso, "just like" Veronese had used. When it was unveiled there was a moment of silence, then ecstatic applause and many tears. Large numbers of Venetians had to ask themselves a very difficult question: how is it possible to have an aesthetic and emotional response in front of a copy? This question is followed by another — How do we stop Venice from being flooded with bad copies without the criteria to distinguish between good and bad transformations?

Once again, digital techniques allow us to distinguish features that are being regrouped much too quickly into the generic term "reproduction". As we have seen exactly the same intellectual oversimplifications and category mistakes happened when Benjamin wrote about "mechanical reproduction". Surely the issue is about accuracy, understanding

5. The facsimile of the tomb (in its current condition but without the elements that turn the environment into a museum) has resulted in detailed publications by the egyptologist Erik Hornung and the psychologist Theodor Abt in both film and book form. Hornung, Erik and Abt, Theodor. *The Dark Hours of the Sun — The Amduat in the tomb of Thutmose III*, DVD, Published by Factum Arte, 2005. Hornung, Erik and others. *Immortal Pharaoh - the tomb of Thutmose III*. Madrid, Factum Arte, 2006

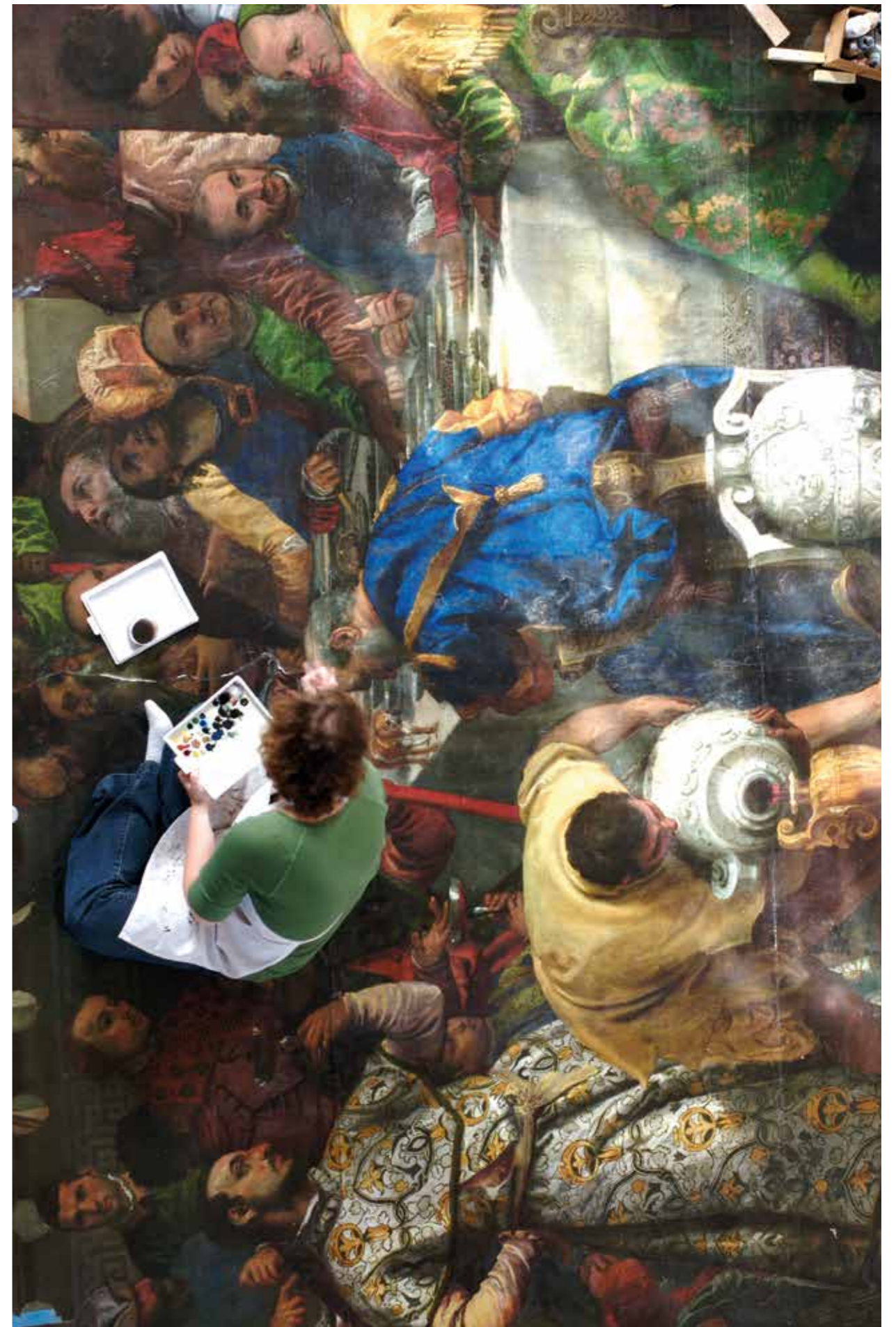
and respect - the absence of which results in “slavish” replication. The same digital techniques may be used either slavishly or originally. It depends again on what features one choses to bring into focus and which ones are left out. The use of tiny painted dots based on photographs rather than the broader brush marks used to make the original may give the restorer more control and hide the interventions but surely it proves that a manual reproduction might be infinitely more disputable and subjective than any “mechanical” one. The road to hell is paved with good intentions.

No doubt, it is an uphill battle: facsimiles have a bad reputation —people assimilate them with a photographic rendering of the original— and digital is associated with an increase in virtuality. So, when we speak of “digital facsimiles” we are certainly looking for trouble. And yet we claim that, contrary to common presuppositions, digital facsimiles are introducing many new twists in the century-old trajectory of works of art. There is nothing especially “virtual” in digital techniques —and actually, there is nothing entirely digital in digital computer either!<sup>6</sup> The association of digitality with virtuality is entirely due to the bad habits given by only one of its possible outputs: the pretty bad screen of our computers. Things are entirely different when digital techniques are only one moment to move from one material entity —Veronese’ *Nozze* version n-1 in Le Louvre— to another equally material entity —version n +1 in San Giorgio. At the time of mass tourism, increasingly vocal campaigns for the repatriation of spoils of wars or commerce, when so many restorations are akin to iconoclasm, when the sheer number of amateurs threaten to destroy even the sturdier pieces in the best institutions, it does not require excessive foresight to maintain that digital facsimiles offer a remarkable new handle to give to the notion of originality what is required by the new time. Since all originals have to be reproduced anyway, simply to survive, it is crucial to be able to discriminate between good and bad reproductions.

Intermédialités. *Histoire et théorie des arts, des lettres, et des techniques* number 17 (Reproduire/reproducing) published Adam Lowe and Bruno Latour’s text *The Migration of the Aura* in french for the first time (*La Migration de l’Aura ou comment étudier un original par ses fac-similés*). This important review was published by the University of Montréal in late 2011.

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6. Lowe, Adam, and Simon Schaffer. *No!se*, 2000. An Exhibition Held Simultaneously at Kettle’s Yard, the Whipple Museum of the History of Science, Cambridge, the Museum of Archaeology and Anthropology, Cambridge and the Wellcome Institute, London. Cambridge: Kettle’s Yard, 2000; Smith, Brian Cantwell. *Digital Abstraction and Concrete Reality*. In *Impressiones*, Calcografía Nacional, Madrid, 2003.





The sacred cave of Kamukuwaka during production.

An essay prepared by Adam Lowe for *In Harm's Way. Aspects of cultural heritage protection*, Edited by Roy Bacon for The British Council, 2017.

At a time of increasing awareness of the dangers to cultural heritage, the ability to accurately record – and if necessary re-create – cultural artefacts has never been greater. The application of digital technology and 3D recording to the field of cultural protection offers huge opportunities.

Factum Foundation grew out of Factum Arte – a 21<sup>st</sup> Century workshop in Madrid that uses digital technologies and traditional skills to produce physical objects for artists and clients around the world. Factum Foundation exists to develop and promote digital technology for the recording, documentation and dissemination of cultural heritage.

Building bridges between the institutionalised professions traditionally tasked with protecting cultural heritage, and the development and application of new technologies, has allowed the foundation to develop an original approach to documentation and preservation based on practical experience in the workshop and in the field.

In an age that holds so many threats to our cultural heritage, 3D scanning and composite photography are changing the way cultural artefacts are recorded – but different scanning systems do different things. Some are mainly for screen-based visualisations, while others are for re-materialising objects in three dimensions. The techniques are still unfamiliar, and there is not enough agreement about how and when to apply the technology, the terminology used to discuss the work, or the usage of the resulting data. This essay gives a brief account of the new technologies, and suggests some of the political and philosophical questions raised in consequence.

It is now possible to record objects in colour and 3D and to re-materialise them in forms that are almost indistinguishable from the original. But achieving this requires digital and physical artisans to work together, uniting technology and craft skills. The most dramatic technical developments with relevance to cultural heritage are going on with software used in photogrammetry (the extraction of 3D information from 2D images), composite photography (blending data from multiple images of the same object) and 3D output devices (both additive and subtractive technologies).

The 19<sup>th</sup> century was a similar time of technological advance, in which photography, electro-forming and plaster-casting were changing attitudes to originality and museum collections.

2017 is the 150<sup>th</sup> anniversary of Henry Cole's 'Convention for Promoting Universally Reproductions of Works of Art for the Benefit of Museums of all Countries'. Evidence of the success of the Convention can still be seen in the Cast Courts at the Victoria and Albert Museum. To celebrate the anniversary the V&A, funded by the Peri Foundation, have launched ReACH (Reproduction of Art and Cultural Heritage), 'a year-long programme of events devoted to the drafting of a new convention regarding the role of museums in digital preservation and the dissemination of works of art and culture'.

We are again living in an age of copying, and there is a realisation that the importance of cultural artefacts lies in the complex stories they communicate about people who lived in different places at different times, held different views, and often believed in different gods. Museum objects are a means to access knowledge and understanding; they are not primarily things of commercial value.

In the Convention, Henry Cole optimistically claimed that copying does not harm the original. While this is true in the case of photography, casting and electroforming both require a mould. The production of a mould will damage original artefacts and is no longer allowed in most museums. When moulds were made of the Portico de la Gloria of Santiago de Compostela Cathedral, for example, the fragile polychrome surface was damaged. This is deeply regrettable and thankfully is no longer necessary (the re-materialised gothic masterpiece in London has inspired generations and is itself now the subject of a major restoration that will rejuvenate the Cast Courts).

Before cheap flights and mass tourism, it was easier to move copies of architectural sculptures to London than it was to move people to remote sites. Now the situation is reversed. Millions of people each year want to visit sites of cultural interest. Many of those sites, like the tombs in the Valley of the Kings, were never intended to be visited – and cannot accommodate vast crowds without incurring significant damage. Tourism, which is vital for local economies,



Detail of petroglyphs inside the cave of Kamukuwaká, Upper Xingu, Brazil.

is now one of the main causes of the change and decay of our shared cultural heritage. It is increasingly difficult to balance the complex demands of protecting heritage sites while providing access to them.

Tourists are not the only threat to our cultural heritage. Other causes of damage and destruction include war, natural disasters, climate change, pollution, political apathy, vandalism, accidental damage, fire, iconoclastic attacks and theft. Cultural protection needs to address each of these destructive factors, as well as acknowledging the inevitable changes that occur to objects and buildings over time. Done properly, recording of cultural heritage can facilitate a deeper and more accurate understanding of the articulate artefacts left by previous generations.

Recently media attention has focused on iconoclastic acts of destruction, particularly those carried out by Daesh. While any attention is welcome, it is essential for public debate to be carried out in an informed way and within a considered and nuanced context.

The comments that attended the unveiling of a 'copy' of the central section of the Arch of Triumph from Palmyra in Trafalgar Square in 2016 were deliberately provocative, and had the effect of politicising the recording of cultural heritage. This is dangerous, because it puts both the technology and the people who operate it into a position of aggressive opposition to radicalised iconoclasts, making them a direct target.

It hardly needs to be stated that recording should ideally be financed and carried out in times of peace. War zones are not conducive to subtle, detailed and often slow work. Accurate recording results in data that can be stored or used for repair and possible 'rematerialisation' of the architectural forms. The whole question of anastylosis (authentic reconstruction) has re-emerged as a topic of importance. Do we re-erect and repair monuments using new and original material as was done in the past? Now we have the technology to create exact copies, what is the relationship between originality and authenticity, between the relic and the replica?

In this context the Cast Courts at the V&A are again a focus of attention and interest – both as practical means of preserving culture, and as a starting point for a philosophical exploration of creation and originality. Recording and understanding change is central to our view of an object, its history, where it has been and how it has been viewed. Comparing a 19<sup>th</sup> Century cast of one of the figures from the Parthenon frieze to its 'original' in the British Museum reveals that the surface is not the same. The mould contains forensic evidence of the 'original' eroded chisel marks that give access to a meaningful biography of the object. On the originals, these marks are overlaid with the toolmarks made by museum conservators in 1938.

All things change over time, yet the commonly held idea of an 'original object' is of something with fixed qualities that are integral to its being and character. While there is seldom an instant moment of creation, there are often periods of rapid change in its career. A series of actions and decisions, normally made by more than one person, are required to bring an object into being. This is then followed by decay, relocation, revaluation, conservation, preservation, imposition, addition, correction, alteration and 'improvement'. Originality is not a fixed state of being: it is a process in which many agents work together. In the digital age, diverse recording methods can accurately fix the object in a moment of time. The resulting archive acts as a record by which change can be measured.

So what is possible with the new technology?

The Theban Necropolis Preservation Initiative, by Factum Foundation and the University of Basel, has recorded the surface of some of the tombs in the Valley of the Kings that have since been re-materialised at a scale of 1:1. To the naked eye, from a normal viewing distance, they are indistinguishable from the originals. Not only are the surfaces of tombs recorded in colour and three dimensions with over 100 million ordered spatial points per square metre; key skills and technologies are simultaneously transferred to the local community.

As the project develops, the data generated will be stored locally and disseminated globally (the copyright remains with the Egyptian Ministry of Antiquities). It will reveal change to the surface, paint loss and alterations caused by the impact of tourism and restoration attempts to halt the tomb's decay. Hopefully it will also lead to new discoveries about the tombs themselves.

The aim of all Factum Foundation projects is to produce freely available, interactive, multi-layered archives for paintings, sculptures and low relief objects – as a means of preservation of cultural heritage, and a source for scholarship and research. In 2016 the Foundation undertook a major research project in collaboration with the Museo

del Prado, recording all of Goya's Black Paintings using a 3D surface scanner, composite photography, X-Ray, ultra violet photography and infrared spectroscopy, supplemented by photographs taken of the paintings in the 1870s.

The resulting documentation of the Black Paintings has been layered together so all the information can be seen at the same scale and aligned to facilitate direct comparison. The aim is to make them freely available on the museum website so they can be viewed on a normal computer, via the internet, without specialist software or advanced skills. These archives are an essential part of the preservation of any object, acting as 'digital passports' for works of art at a specific moment in time.

Recording cultural heritage requires operators who are sensitive to the vulnerable nature of the object. Imparting this idea of sensitivity is often more difficult than teaching technological skills. For this reason Factum Foundation always works with teams of people with different skills, knowledge and levels of experience.

The existence of 'big data' recorded with diverse technologies raises questions about storage, dissemination, and ownership of data. Who has access to the data, how it can be used, when it is freely available and when should it be commercialised; how it is used in restoration in the event of damage and to what extent it should be used to replicate damaged areas – these are all issues for top-level heritage managers. The question of when, where, and under what circumstances it should be re-materialised as a three-dimensional, physical object is emerging as a topic of great importance.

Long-term archiving is an important issue beyond the scope of this text, but it is essential that there are distributed servers capable of storing data in a secure format for many years, even in the absence of an electrical supply. Long term digital storage cannot be taken for granted.

There is an urgent need to establish guidelines for quality that cover the various types of digital recording. The common misunderstandings, based on a blind faith in technology and the myths of digital perfection, undermine the effective recording of cultural heritage. At the most fundamental level there needs to be a clear statement of intent: 'Digital recording should be carried out in a non-contact process using various technologies at a resolution sufficient to make an objectively accurate copy of the original object should the original be lost, damaged or destroyed'.

Guidelines are essential to give structure to the training initiatives that are at the core of Factum Foundation's work. The 3D Scanning, Archiving and Training Centre was opened by the director general of UNESCO, the Swiss ambassador and the Egyptian Minister of Antiquities in February 2017 as a central part of the Theban Necropolis Preservation Initiative. Recording and training initiatives in collaboration with the Peri Foundation are ongoing in Russia. A centre for Digital Humanities is being planned with the École Polytechnique Fédérale de Lausanne and the Fondazione Giorgio Cini in Venice. A centre for practical training in heritage recording is being developed with Columbia University and with Art Jameel in Dubai.

The emphasis is on building bridges between different skills and professional disciplines; between the traditional arts that celebrate the transmission of knowledge through manual skill, and the digital arts that express a similar understanding through algorithms and electronic engineering. In Saudi Arabia the first practical workshop to record the buildings and decorative details of Al Balad, Jeddah has recently been completed in collaboration with Community Jameel and the House of Traditional Arts. Other initiatives are being planned. The scale of the task should not be underestimated.

The training of local operators is at the heart of these initiatives, merging political permission, technological understanding and academic discipline. Different types of recording take different amounts of time to master, and the cost of the equipment varies greatly. There needs to be collective agreement about what data is needed for each application. There is no excuse for wasting opportunities to carry out recording as well as possible, and future generations will judge us harshly if we do. The field is developing fast and requires operators who understand both technology and art. Fortunately this is not as rare as it was in the pre-computer age. The brief is simple: record at the highest resolution possible sensitively using systems that capture the colour, shape and surface of an object.

Basic training to record objects and buildings can be done in a relatively short time depending on the photographic skills of the operator, while training to use drones or training in data processing can take years of experience. The skill of the operator and their attention to detail during processing will ultimately affect the quality of the data. This requires powerful computers, and the work can be very time consuming. Processing the Sarcophagus of Seti I in Sir

John Soane's Museum took a skilled operator, working with the software writers, several months. The resulting 3D model is made from five thousand 58-megabyte images, and consists of 13 billion polygons.

Other recording systems are more expensive and demand specialist software. These could be held in centralized pools and loaned (with trained operators) for specific purposes to ensure efficient and effective use. As technology is advancing so quickly, it is a mistake to put too much investment into hardware and software that is not intensively used.

This text should demonstrate that while the use of technology can be very expensive, it doesn't have to be. The secret lies in training and equipping local communities. This is a cost effective way to carry out recording and empower local people. Our work in Daghestan with the Peri Foundation has resulted in the training of two highly skilled operators, Shamil Gadzhidadaev and Gennady Viktorov who are now passing on their skills to others. The forthcoming work of the Peri Foundation to record Dionisy's frescos at Ferapontov Monastery in northern Russia will result in the training of more people.

Initiatives are also being developed in Cross River State in Nigeria, and the Ennedi Plateau in Chad, where we are working with the Trust for African Rock Art (TARA) to identify talented and highly motivated individuals who can be trained in photogrammetry. The people we have had the privilege to work with are as capable as (and often more ingenious and resourceful than) Oxford or Harvard graduates.

Digital and physical artisans are working alongside historians, scientists, restorers, museum directors, dealers, collectors, curators and others. Extraordinary things are possible when technical experts and cultural managers share the same goals and acknowledge each other's skills. Now is the time to focus part of the UK's Cultural Protection Fund on the documentation of sites and objects alongside (and in support of) the archaeologists and experts working on the ground.

This can be done through training, managing and equipping local photographers to undertake photogrammetry, creating a pool of equipment with operators that can be called upon, creating a chatroom and 'helpline' complete with remote access to the computers on the ground, and ensuring there is a network of servers that is capable of archiving the vast amount of data that will be generated. Once safely stored, the time consuming task of processing can be done as and when required. There has never been a more dangerous time for cultural heritage – or a moment of greater opportunity offered by the available technologies.

Those of us with the resources, experience and techniques have a responsibility to find the most effective way to transfer them to others. We must give local communities an incentive to record and preserve their own cultural heritage.

Through this approach historical objects will reveal themselves as complex and meaningful subjects, and in this way we can preserve the evidence of the past for study and sharing by future generations – in the hope of better and more enlightened times ahead.

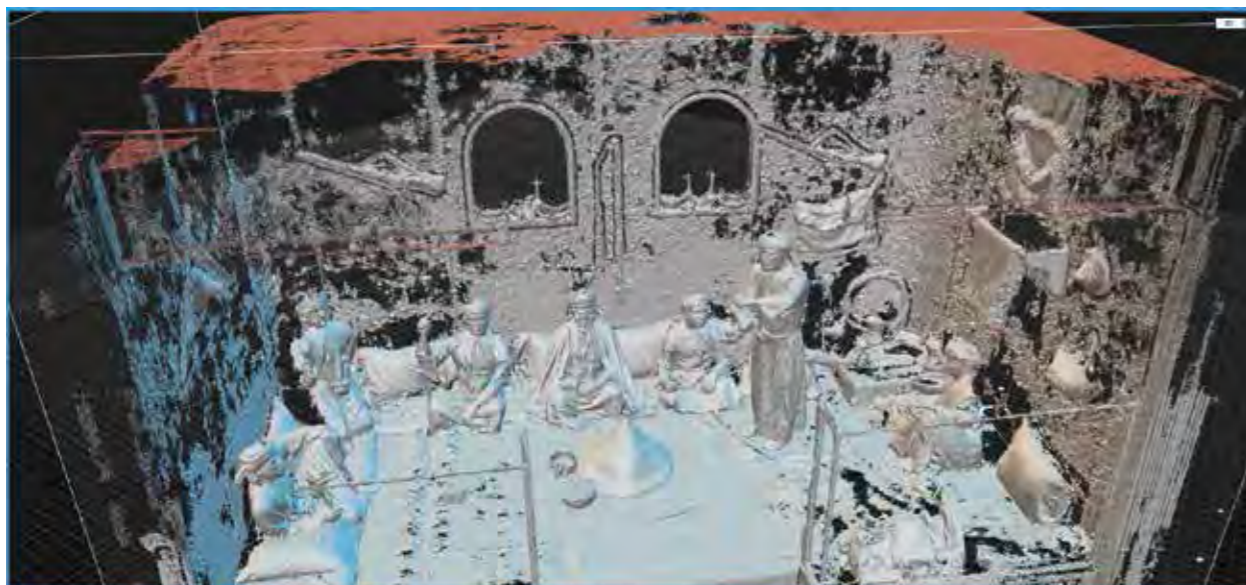


Render of a monolith from Eting Nta (Cross River State, Nigeria) now in the Musée Quai Branly, Paris.

In 2018 Otto Lowe carried out a training course for the Royal Commission in Al-Ula, facilitated by Art Jameel, to teach 15 local men and women the skills required for high-resolution recording. This "learning by doing" course resulted in high-resolution documentation at three important sites containing rock-cut inscriptions. This year, two of these students will spend two weeks in Madrid, they will then assist a second training initiative in the Autumn.








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3 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 AS EXACT PHYSICAL FACSIMILES

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A text by Adam Lowe for in *Copy Culture, Sharing in the Age of Digital Reproduction*,  
Edited by Brendan Cormier, V&A Publishing, 2018.

‘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 21<sup>st</sup> 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.

A Case Study: The Tomb of Seti I

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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. In a letter to Joseph Bonomi, he writes:

'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: *The Great Belzoni*, Stanley Mayes, London 1959, p. 293.)

During the 19<sup>th</sup> century, 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 20<sup>th</sup> 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 even 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 20<sup>th</sup> century Egyptian architect Hassan Fathy, was restored by the Tarek Waly Centre for Architecture and Heritage. This building will house the TNPI's and 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 21<sup>st</sup> 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, helping support, remote access and pooled specialised equipment

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In addition to the work in the tomb of Seti I, Factum Foundation is working on the launch of 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?

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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 Nub3D White 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 rematerialised 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 19<sup>th</sup> century-desire to use technology to protect and replicate. What will the cast courts of the 21<sup>st</sup> century 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 is 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.



The facsimile of the pillared part of the Sarcophagus Room from the Tomb of Seti I on display in Basel at the exhibition *Scanning Seti: The Regeneration of a Pharaonic Tomb* at the Antikenmuseum in 2017-2018.

A text by Adam Lowe for *The Oxford Handbook of the Valley of the Kings*,  
Published by the Oxford University Press, 2016.



Conserved and preserved not restored and renovated

“The authorities face agonizing decisions. Do they admit visitors to royal graves and witness the near-certain deterioration and perhaps disappearance of unique wall paintings from sheer people pressure? Or do they close everything to save it for future generations?...The dilemma pits the preservation of the priceless and finite archive that is ancient Egypt against the pressing economic needs of a developing country – altruism for future generations against short-term advantages.”

(Fagan 2004, 252)

The role of recording and reconstruction and the development of sustainable tourism



The final installation of the facsimile of the burial chamber of Tutankhamun, during its temporary installation at the Conrad Hotel as part of the EU Task Force, November 2012. Photo by I. della Valle, courtesy of Factum Arte.

In the Eighteenth Century Joachim Winckelmann proposed that sites and artefacts should be conserved and preserved, not restored, renovated or reconstructed. At the time Winckelmann and others were excavating Rome and shaping our image of ruins and antiquity – an image that embraced Greek, Etruscan, Roman and Egyptian influence. The comment was aimed at the imaginative and active approach of many of his contemporaries, especially Piranesi, who was restoring, renovating and reconstructing – treating the remains he found as a source-book for ideas and information. Piranesi was an artist. Winckelmann an academic who represents the philological approach that was in tune with the 20<sup>th</sup> century and his views reflect those of most heritage professionals today. It is an approach that was enshrined in the 1964 Venice Charter and other charters issued by ICOMOS, UNESCO and heritage professionals. However, as new technologies become available to record and study objects with forensic accuracy it is clear that the decision making processes of heritage managers and the practical tasks of conserving and preserving the past are neither simple nor an exact science.

However discrete the attempts to conserve might be, they alter the appearance of the original and often have unforeseen consequences that can be irreversible. They impose changes to colour, tone, texture and sheen, they condition the look and character of the sites and how we perceive them. They raise both moral and aesthetic issues. In the Valley of the Kings the glass panels installed in some tombs introduce a museum language that has nothing to do with the function or character of the tomb. The lighting, text panels, smell of human sweat, guards, tour groups and the ban on photography all play their part in imposing an aesthetic dimension onto the act of preservation.

When Winckelmann was writing in the middle of the 18<sup>th</sup> century tourism was limited to a few wealthy and acquisitive individuals. The problem facing the heritage managers of today is how to insure that our cultural heritage is preserved for the next generation in a meaningful way. Whatever practical and political arguments are put forward, an essential part of every approach is documentation – we have a duty to record what we have inherited. Twenty years ago it was not possible to digitize, store and then rematerialise an object that, side by side with the original and at a normal viewing distance, looked identical. Now it is possible. It requires time, understanding, technology and a different mindset. It demands new intellectual and professional framework. It requires the development of hardware and software designed in conjunction with the people who are working to preserve and conserve. It requires collaborations between different disciplines that struggle to share a common language.

Since the Tomb of Tutankhamun was discovered, tourism has been the biggest threat to its survival. Yet Egypt's economy is dependent on tourism. Andrea Byrnes has described the problems clearly in her essay *Replication of the tomb of Tutankhamun. Conservation and Sustainable tourism in the Valley of the Kings*. She observes that Flinders Petrie and others were aware of the problem and that Howard Carter commented on the impact on the fabric of the tomb caused by the humidity and dust brought in by the visitors. She cites Michael Jones' chapter in Wilkinson's *Egyptology Today* and she provides figures: 'In 2005, for example, Egypt earned 6.4 billion US dollars in tourist revenue, providing work for around 12 per cent of the nation's workforce.' According to Kent Weeks and Nigel Hetherington's *The Valley of the Kings Site Management Masterplan*, during the height of the 2004 season the Valley of the Kings received 7000 visitors per day and over 1.8 million visitors in total for that year. The Site Management Plan operates on the assumption that visitor numbers in the Valley of the Kings will reach 15,000-20,000 per day by 2014. The tombs were built to last but they were not built to receive visitors.

At the entrance to the tomb of Tutankhamun is a yellow sign that reads – EXTRA TICKET FOR TUTANKHAMON TOMB 100L.E. The celebrity of the tomb adds to its value and attracts visitors. While the political unrest has led to a temporary downturn, the growth of tourism and the continued public interest in Egyptology will undoubtedly lead to the return of the visitors once public confidence in political stability returns. In the 21<sup>st</sup> century the Valley of the Kings has to play a dual role. On one hand it is a repository of paintings and written texts that reveal essential insights into who we are. On the other it is essential for the economy of Egypt in general and Luxor in particular.

Tutankhamun's tomb is a tourist magnet. Schools around the world fill receptive and imaginative minds with the great stories of the boy king, pharaonic culture, adventure and archaeology, Howard Carter and curses, gold and symbolism. Hollywood and computer games turn this interest into entertainment. The treasures from the tomb were moved to the Cairo Museum following the discovery where they are seen by many more people than if they remained in Luxor. Touring exhibitions of selected objects attract wider audiences and remain popular. In London, the 1972 exhibition *Treasures of Tutankhamun* attracted 1,650,000 visitors. Now, in addition to exhibitions of original objects, several identical commercial touring exhibitions based on tourist-quality copies and dramatized documentaries are successfully touring the world. All of these generate interest and result in increased tourism.

Some of the measures carried out but the Supreme Council of Antiquities to protect the tombs have had a positive effect but all involve restricting access and keeping people moving through the tombs. Banning guided tours inside the tombs has made a significant difference and prevents large concentrations of people in one area. The restriction of each visitor to only three tombs per visit, the closure of the tomb of Seti I and the imposition of severe limitations on visits to the tomb of Nefertari and the use of a rotation system (similar to that used to protect the Etruscan tombs in Tarquinia) all help. But ultimately, as with the caves at Lascaux and Altamira, the only solution for long-term preservation is to radically reduce visitor numbers. The question is: can this be done in a way that keeps attracting the visitors and enhances our understanding of the importance of the site and the knowledge it contains? The use of new recording technologies is central to any answer. The role of facsimiles still needs to be defined and demonstrated. Since 1988 The Society for Friends of the Royal Tombs of Egypt under the direction of Erik Hornung and Theodor Abt have been championing this approach. The Supreme Council of Antiquities initiated a research project in the tomb of Seti I in 2001 and the recording work in the Tomb of Tutankhamun started in 2009. In 2012 the facsimiles of the burial chamber, the sarcophagus and the re-creation of the missing fragment from tomb of Tutankhamun were given to the people of Egypt by the Society of Friends of the Royal Tombs of Egypt, the Factum Foundation and Factum Arte. The work has taken almost four years to complete and has involved a large group of individuals, each with different skills, working together as a team. Permission has been granted by the ministries of Tourism and Antiquities to install the facsimile on a site next to Howard Carter's house at the entrance to the Valley of the Kings. The aim is to encourage the conservation community and the general

public to visit both the original tomb (while it remains open) and the facsimile and contribute to the debate about the problems of preserving and safeguarding fragile sites.

The work that was carried out by Factum Arte over the past decade in the tombs of Tutankhamun and Seti I is a start – it reflects a coherent approach to the development and use of digital technology to record the surfaces and structure of the tombs in astonishing detail. This data is essential for objective study and to monitor the decay that is taking place. The fact that the data is of sufficient quality to reproduce it physically in three-dimensions is evidence of its correspondence to the original. This work has involved the development of new technologies to record, inspect, archive and reveal the complex histories of these two tombs. It has involved the development of a complete working practice to re-materialise the data that can be communicated and taught. It is an approach that is rapidly gaining acceptance and has led to the creation of the Factum Foundation for Digital Technology in Conservation. The Foundation funded most of the work in Egypt and has two main aims – to provide the technology and human skills to satisfactorily record the condition of the tombs and to turn the public interest into a force that understands the difficulties of preserving the past and makes a positive contribution to its preservation.

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#### Observations on entering Tutankhamun's Tomb

You enter the tomb via a steep ramp that leads into the Antechamber, an undecorated, rough cut rock room. In one corner, in a complex acknowledgement of the original role of the tomb is the partially unwrapped, mummified body of Tutankhamun – his face revealed – is displayed under a Perspex covering. Near the body is an opening that leads to an undecorated room you cannot enter. Before Carter's excavation the antechamber was separated from the burial chamber by a 'mud-brick' wall, painted on one side and covered with stamped seals on the other. A photograph in the Griffith Institute in Oxford shows Howard Carter with an iron bar in hand, while a white-jacketed man peers into the darkness. It is impossible to imagine how Carter must have felt with only a thin layer of mud-brick between him and the greatest archaeological find of all time. To take out the objects this section of the south wall was removed. Now there is a wooden handrail preventing visitors from entering the space. The floor of the burial chamber is about one meter lower than that of the antechamber. The chamber itself is about 364 cm high, 411 cm wide and 630 cm long. The walls are painted with images above a dado line. The ceiling is unpainted and has a dramatic, heavily filled geological fault that runs in a north-south axis through both the burial chamber and the antechamber. In the middle of the burial chamber stands the vast deep-red quartzite sarcophagus appropriated rather than made for Tutankhamun. On the floor lies the broken sarcophagus lid made of red granite, according to M. Eaton-Krauss this was once tinted to match the sarcophagus. Carter described it as a 'crude granite slab'. Access into the treasury, leading off the east wall of the burial chamber is closed with a metal gate. Invisible to the general visitor, the treasury contains piles of sections of the south wall stamped with an assortment of seals. The treasury once used to contain the so-called 'missing fragment'. Carter, a fastidious archaeologist, preserved everything but since the loss of this large section of the wall the only evidence that remains of its text and images is a black and white photograph in the Griffith institute taken by Harry Burton. Hopefully the 'missing fragment' will be found. Perhaps it lies hidden in the basement of the Cairo Museum and it will come to light when all the objects that are stored there are moved to the new museum.

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#### Technical considerations based on non-contact surface observations

The craftsmen that made these tombs had a highly developed understanding of materials. It is probable that they attached symbolic significance to the materials they used, the order in which they were applied, the way they were mixed and their final appearance. They certainly understood the physical properties of the materials they worked with. They prepared the plaster layers and the application of the paint so the walls could breathe. They understood how to draw long black lines with even edges, they understood how to make and prepare both natural pigments and those that required human artifice in their production. It is equally probable that they knew that when the tomb was sealed the natural environmental stability would ensure their work lasted – guaranteeing immortality for the Pharaoh. The enemy of preservation is dynamic change – changes of temperature, changes of humidity, changes to the levels of dust, chemical changes and other diverse environmental fluctuations about which we are not yet aware.

The tomb was hacked out of the bedrock. Tool marks are visible underneath the plaster layers and brick holes. There is a visible raised line to the left of centre of the north wall as if the burial chamber was cut from both sides. The walls are coated with several layers of thinly applied plaster to smooth the irregularities in the bedrock before application of the priming coat and painted decoration. There is a skim of a greyish coarse plaster and then a coat of a creamy brown plaster wash. On the north wall there are many air bubbles that appear to be in this 'wash' layer. On the lower part of the west wall, there appear to be two layers of plaster while on the south wall there seem to be three, although it



generally looks as if the plaster was applied quickly and re-applied where necessary. On the west and north walls there are tool marks in the plaster as if it was applied by trowel but there are also areas where it has been smoothed by hand and traces of fingers can be observed. Over the plaster there is a coat of white priming paint in many places but it is neither uniform nor consistent and on the south and east walls the golden ochre paint was applied onto the plaster without the priming layer.

There are many dark brown spots that are the subject of ongoing research by the Getty Conservation Institute. These micro-organisms cover most of the painted area of the tomb appearing in places on the ceiling but not on the Sarcophagus. Based on the evidence of Harry Burton's photographs they haven't changed since Carter opened the tomb and therefore suggest that the walls were not fully dry when the tomb was sealed. Damp walls and the decaying offerings in the tomb provided the conditions that the micro-bacteria needed to grow. They 'grew' in interesting ways on the painted areas and seem to prefer the light red under drawing and the areas in or around cracks. They also seem to be attracted to fibres within the paint or plaster. The photograph by Harry Burton of the 'missing fragment' shows that there was no micro-bacterial growth on this area of the decoration. This section of the south wall could breathe and would have dried faster than the painted areas in contact with the bedrock.

On the north, west and east wall some areas of missing plaster were re-painted at the time of the original painting and as a result are now covered with brown spots. Others areas of loss have been filled since the opening of the tomb and the restorer has covered their work with splashes of brown paint in imitation of the micro-bacteria. Based on observational information it seems likely that the binder of the paint is primarily gelatine while the binder in the black lines is more glossy and brittle suggesting a natural resin, Gum Arabic, was (and still is) readily available in and around Luxor.

A close study reveals that the Baboons on the west wall were painted in the following order: 1.plaster 2.white priming coat 3.yellow paint 4.red under drawing 5.red face 6.blue 7.white hair 8.black lines. The Baboons are painted with a variety of tones of blue that appears to suggest a mixed colour varying in tone and hue. The Leopard on the north wall was painted in a slightly different way; 1.plaster 2.white priming coat 3.yellow paint 4.white paint 5.red under drawing 6.pale yellow skin 7.red dots 8.black outlines. There are many drips and splashes of yellow and red paint suggesting haste, or a lack of care.



The surface of the East Wall in the burial chamber of Tutankhamun showing flaking paint and a sheen from surface painted Paraloid. Photo by G. Dupond, courtesy of Factum Arte.

#### Problems inherent in remedial and aesthetic restorations

Even from a distance it is clear that the surface of the painted walls is heavily cracked and there is significant paint loss. The surface reveals that the paint layer is in a friable and fragile state. The surface decay suggests that what is going on under the surface may be more serious. Observation of the dust deposits reveals that in places the plaster is detaching from the wall. From the high-resolution photographs it is possible to see shadows behind some of the holes in the paint and plaster; it is clear that large sections of plaster are only held in place by the skim layer of plaster and the consolidant that has been applied. The scale and location of some of the refills and repainting (the largest is an area of about one square meter) confirm this and reveal the fragile condition of the paint surface.

On the west wall near the hand-rail there is clear evidence that human touch has smoothed and eroded the surface and that all areas within reach are significantly more degraded than the rest of the tomb. On the area around the figure of Tutankhamun, lying on his funeral sledge, you can see the cracked and flaking nature of the paint with the slightly glossier black lines lifting from the background golden ochre. Even from the position by the handrail you can make out an irregular surface sheen as if the large areas of the wall have at some point been given a wash of consolidant. The high-resolution makes it possible to study the surface in great detail and then test these observations against the actual wall. From close up the fragile state of the paint surface is instantly clear. Hundreds of injection marks reveal that significant work has been done in an attempt to bind the paint layer and plaster to the bedrock, white residues and drip marks from local surface applications of Paraloid can be found in many places. To fully understand what is happening the conservators from the Getty Conservation Institute will need to see if the application of Paraloid is the problem or the solution. If it has limited the ability of the paint surface to breathe it will cause a build-up of moisture and this will encourage the growth of salt crystals that are capable of pushing the paint off the wall. This mix of a fragile surface and dynamic change caused by fluctuations in temperature and humidity will eventually result in collapse. There has been significant paint loss since the tomb was opened. If the means of consolidation are now a cause for concern the treatment will need to be reversed.

#### Reversibility – a term in need of clarification

Reversibility is a central principle of conservation practice. The term refers to the ability to remove any addition or change that is made. Since the 1970's Paraloid, a product originally designed to make printing ink more flexible, has been used extensively in the tombs. Now many conservators now have serious reservations about its use and reversibility over time. When used to consolidate the painted surfaces in the tomb of Tutankhamun or Seti I, Paraloid cannot be removed without significant paint loss. The application of this acrylic resin also changes the colour and tone of the paint; this is a non-reversible change. Paraloid injected under the surface of the paint to stick the paint and plaster layer to the bedrock is also irreversible and changes the way the surface moves and breathes.

In the 1999 ARCE condition report on the Tomb of Seti I, Dr Bojana Mojsov comments:

'...during recent 'restoration' efforts plaster and several pigments have been added on top of uncleaned surfaces with varying results. This is particularly disturbing since it was done just recently and now only adds to the relatively numerous problems of the reliefs. All of this layer of *pentimento* ought to be removed and the surfaces cleaned before we can see what is left of the original decorations underneath or make any decisions about future restoration.'

At the time that the ARCE report was being prepared a new 'test' restoration was being carried out in Seti's tomb (Room F). This test has resulted in a significant change in tone and colour to a section of about 50x50 cm. 15 years after it was done this test clearly demonstrates the problems inherent in using Paraloid but it also reveals the way restorations change the appearance of the image. The white area on the left of the restoration has been over-painted with a white that is both a different 'colour' and a different character to the original white. The un-restored area to the left of the restoration reveals a matt white (almost certainly huntite) painted over a greyish under-painting that could be either the plaster base or intentional under-coat. The restored area appears to be a recently applied acrylic or gouache under a layer of Paraloid – the surface consolidation has slightly yellowed and the paint it covers is now flaking off the wall. All of this demonstrates the inherent difficulties of keeping things stable if the environment is dynamic and confirm the importance of high-resolution documentation.

#### Reasons for optimism

Despite all the reasons for concern the 21<sup>st</sup> century is providing us with new high-resolution recording technologies that can digitise the tombs with sufficient accuracy to monitor the speed of decay. With the correct political support and infrastructure the documentation could be carried out by Egyptian teams providing employment in Luxor and the surrounding area – in theory it could also be self-financing. The fact that it is possible to record the tombs in colour and three dimensions with forensic accuracy should become a central part any preservation policy. New technologies and software applications are resulting in innovative ways to study, analyse and elaborate information. The developments in technology are moving fast but a divide between technicians who understand the equipment and managers who understand the technical possibilities interferes with their application. The practical solution at present is to take advantage of the successful mechanisms that are in place and already applying technology – the Theban Mapping Project is one example.

In 2001 the Theban Mapping Project began work with Quantapoint to use their laser measuring system to produce accurate 3D plans and models. The Theban Mapping Project website was launched in August 2002 and its impact was immediate – by the end of its first month it had 150,000 unique visitors, clearly demonstrating a need and a receptive audience.

While the Quantapoint system can produce an accurate survey of the shape of a tomb it cannot map the details of the surface texture or colour. This requires different equipment and a different set of skills. The work that Factum Arte carried out in the tombs of Seti I and Tutankhamun recorded the surface of the walls with 100 million measured points per square meter. Colour was recorded at a resolution of 800 dpi at a scale of 1:1. This data could be aligned and added to the Theban Mapping Project website. This would allow the virtual visitor to study the structure and layout of the tomb, zoom into any area and see the decoration in colour, select any section and magnify it in order to inspect details, shift between colour and 3D data, connect to archives of historical photographs and other source material. The availability of this quantity of information in a virtual form does not reduce the desire to visit Egypt. On the contrary, it encourages it. It nurtures an intimacy with the site and facilitates new ways of study. But equally importantly it allows us to know what damage we are doing – to monitor the speed of decay and to make informed decisions about how to safeguard the Theban Necropolis and assist in the long-term preservation of the site.

#### The practical application of digital technology in non-contact conservation

Outlined below are the stages involved in the recording (de-materialisation) and the construction (re-materialisation).

The digitisation of the surface of a work of art is a relatively new field: if carried out at sufficient resolution it can be used both to study and monitor the surface of any object. It can also be used to re-materialise the object in diverse forms, ranging from multi-media presentations to the construction of exact facsimiles. The validity of this type of recording is dependent on the quality of the data gathered. Since its invention in the 1920's photographically based 3D recording systems have focused on capturing the shape of an object. It is only recently that the technology has been able to record surface data. Recording the relief and texture of a surface is now possible and is leading to new insights about why the surface looks the way it does.

#### De-materialising 1: The Lucida Laser Scanner – designed to record the tombs

*Lucida* is a 3D laser scanner designed by artist and engineer Manuel Franquelo, custom built by Factum Arte and funded by Factum Foundation. This system, the result of more than ten years of investigation into the high-resolution recording of the surface of paintings and relief objects, uses two cameras and one laser. A thin strip of red light is projected onto the surface of the object. As the line moves over the surface it is recorded by the two cameras positioned either side of the laser. The distortions of the line produced by the relief of the surface are recorded as a tonal depth map which is then converted into 3D information. The scanner moves parallel to the surface plane of the object, controlled by linear guides. *Lucida* uses a system of double exposure to extract the optimum data from both dark and glossy surfaces. The relationship between noise and information is critical: for any recording technology to be meaningful for cultural applications, it is essential that there is a close correspondence between the surface and the recording of the surface.

*Lucida* stores the data as raw black and white video. This is a radical innovation that significantly distances *Lucida* from other scanning systems, which use software algorithms to convert the photographic data into a three-dimensional mesh – this transformation is an irreversible abstraction of the data that results in a loss of information. *Lucida* condenses the raw (unprocessed) information, thus removing many of the obstacles that could limit future generations from accessing and re-processing it.

*Lucida* uses the raw files to generate 3D and rendered simulations of the surface relief. These can be exported into triangulated meshes (.stl), point clouds or a variety of different renderings. It is by virtue of the latter that the recorded data can be accessed without specialised (and usually expensive) 3D software: it can easily be opened with standard image viewers. Moreover, it can be incorporated into accurately aligned, multi-layered files that can also include additional types of recording such as infra-red, X-ray and colour information. Multi-layered files are proving very helpful for researchers and conservators alike and facilitate an accurate, objective and meaningful method for analysing the artwork.

*Lucida* is easy to use and transport. Due to its size, lightness and physical configuration, it allows the user to work in conditions that are normally incompatible with computer-based technologies. It can be powered by mains electricity

or battery. The battery can be recharged with solar energy by using a simple solar panel. In all the work that has been developed for use in Egypt the aim has been to reduce cost, reduce complexity and produce robust systems that can be used in the dusty, harsh conditions that exist in the tombs of the Theban necropolis.



The Sidio White Light scanning system recording the surface of the sarcophagus of Tutankhamun. Photo by G. Dupond, courtesy of Factum Arte.

#### De-materialising 2: White Light Recording

There are several white light scanning systems that could be used in the tombs of the Theban necropolis. Each has advantages and disadvantages. The system chosen and used by Factum Arte in 2009 was the NUB3D SIDIO. While it is heavier than many comparable systems and only has one camera the data it records has a close correspondence to the surface being recorded. The SIDIO system employs a conjunction of optical technology, 3D topometry and digital image processing to extract 3D coordinates from the surface of the object, a technique known as triangulation. Three-dimensional information is acquired by analysing the deformation caused when parallel lines are projected onto the surface of an object and recorded by the camera. With these images, SIDIO integrated software calculates a coordinated XYZ point cloud relating to the surface and shape of the object. The Sidio records the surface from many individually positioned shots that are then aligned. It requires a skilled and experienced operator to achieve good results.

#### De-materialising 3: Panoramic Photography System

After working with a parallel photographic recording system for many years, Factum Arte switched to panoramic recording when the technology became available to produce high-resolution images quickly and accurately. At the end of 2010 we started working with German company CLAUSS. They have been developing panoramic photographic equipment since 1993 and launched their pan-and-tilt head in 2003.

The automated equipment consists of a motorised panoramic head and a computer (to control the head) as well as the recording device (camera) and the archiving software to download and name the resulting photographs. The lighting, distance, speed of recording and resolution all depend on factors specific to each recording task. When recording the image many photographs are automatically taken in sequence and then stitched together at sub-pixel accuracy. The aim is to record a high-resolution image that is in focus and has a resolution of at least 600 DPI at a scale of 1:1. The camera used to record the tomb of Tutankhamun was a Canon EOS7DII DSLR with various lenses depending on distance. The use of a UV filtered high-speed flash is recommended but in conservation recording there is resistance to the use of flash. In the tomb a low-level cold light source was used. Depth of focus can be a problem but this can be overcome by combining a mix of focus stacking and panoramic recording. The different planes of photographs are stitched together using focus-stacking software technology. The merging process consists of multiplying control points between photographs on the same plane and photographs on different planes, until a stitching result of sub-pixel accuracy is achieved. The result is a gigapixel image with uniform sharpness.

When carrying out photographic recording for conservation purposes, all the normal colour and greyscale references are used. However Factum Arte have found it essential to develop their own colour reference system for use when printing the data. The main difficulty of recording the colour is to understand the extreme complexity of the painted surface. The paintings were executed as broad areas of paint with a limited palette, but a combination of centuries of ageing and modern interference has resulted in an inconsistent and intricate surface.

#### Re-materialising:

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At a time when many people are just starting to understand the role virtual models can play in studying and presenting cultural heritage, the technology is making it possible to go one stage further and return the data into a physical form. What has been carried out in the tomb of Tutankhamun is a two way process – from the real world to the digital archive and then from the digital files back into the physical world without significant change or loss of detail.

This has been possible for some time but the costs have been prohibitive. Now, due to a highly focused and motivated team at Factum Arte the protocol has been put in place to vastly reduce the costs and break down all stages of the work into tasks that can be taught to a local workforce in Luxor. The details of this work are not the subject of this text but it is important to outline the many stages that are involved.

The most time consuming and expensive part of the ‘re-materialisation’ process is routing the 3D data at high-resolution. To rout a 1 x 1 sq meter panel in 3D at a resolution of 250 microns takes approximately 400 hours. Once routed the sections need to be cast and joined together. A skeleton needs to be made to hold the panels in place and allow the entire surface of the tomb to be assembled with a floor and a ceiling.

Printing onto a relief surface presents its own difficulties and after experimenting with various transfer systems Factum Arte developed its own elastic membrane that can be printed as a flat sheet. The membrane is a layered mixture of three different materials – a thin flexible ink-jet ground, an acrylic gesso and an elastic acrylic support. It is built in seven layers rolled onto a slightly textured silicon mould. The printing of the facsimile was done using a purpose-built flatbed inkjet printer. For many years this printer has been at the centre of Factum Arte’s approach to the production of facsimiles as it allows the image to be built up in layers, each printed in perfect registration. This approach means that both the colour and the tone can be controlled and locally altered to ensure a perfect match.

The printed flexible skins are positioned using a slow-cure contact adhesive. Sight and touch are both essential to ensure the exact relationship between the surface and the colour. Working with a raking light the skin is positioned and re-positioned until all details in the printing correspond to the underlying surface. Once positioned correctly the skin and the relief are put into a vacuum chamber and pressure is applied evenly until the adhesive has cured. Due to the gossamer-like character of the skin when it is fixed to the surface it takes on the character of the wall of the tomb.

The burial chamber is assembled from interlocking panels that are bolted together from the outside. It has been designed for ease of transport and assembly. Once the tomb is assembled the final joins are filled and re-touched.

The proposed lighting for the facsimile in its eventual location should match the lights used in the Valley of the Kings. The acoustics, smell and temperature can also be controlled to increase the similarities between the original and the facsimile. Special effects can be used to control of the humidity and temperature, and projections onto the surface can inform the visitor of the problems in the tomb and the impact of these dynamic conditions.

#### The biography of objects – the object as subject

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The biography of any cultural artefact reveals various levels of human intervention at different times in its life. Many of these interventions have been made to preserve the object but others reflect changing attitudes towards our relationship with the past. Some actions that have disastrous consequences are well intentioned while others are not. The Tombs in the Valley of the Kings contain examples of mindless vandalism as well as acts of love, care and possession that have had equally ruinous and unpredictable consequences. The tomb of Seti I contains numerous examples of both; Graffiti from the 19<sup>th</sup> century and 20<sup>th</sup> century cover the walls, sections have been removed and are now in museums and collections around the world (the largest two sections are in the Musée du Louvre and the Museo Archeologico in Florence – interestingly these two fragments now look very different from the original tomb and from each other). Belzoni cast large sections of the tomb in wax and vegetable fibre in order to make the ‘first’ facsimile that introduced the wonders of pharaonic culture to London in 1820’s. The travel agents used to sell plaster-

casting kits to their tourists so they could take their own ‘handmade’ souvenirs home; both had grave consequences for the tomb. Evidence of erosion of the surfaces and accidental damage can be found everywhere.

Values and opinions change from generation to generation. Winckelmann’s statement that we must conserve and preserve is obviously correct but we now have tools that he never had. Perhaps we can engage once again with the act of reconstructing and re-thinking our relationship to the past in a way that makes it more accessible. Culture has wrongly been connected to leisure. This has led to many of today’s problems. The tombs are not being preserved to give future generations something to do when they are on holiday, they are being protected to safeguard the important knowledge they contain. It is essential that this is done without impositions on the original. The aim is not to turn an original into a reproduction of itself by altering its appearance, but to allow the next generation to inherit the past in full knowledge of the complexity this involves.

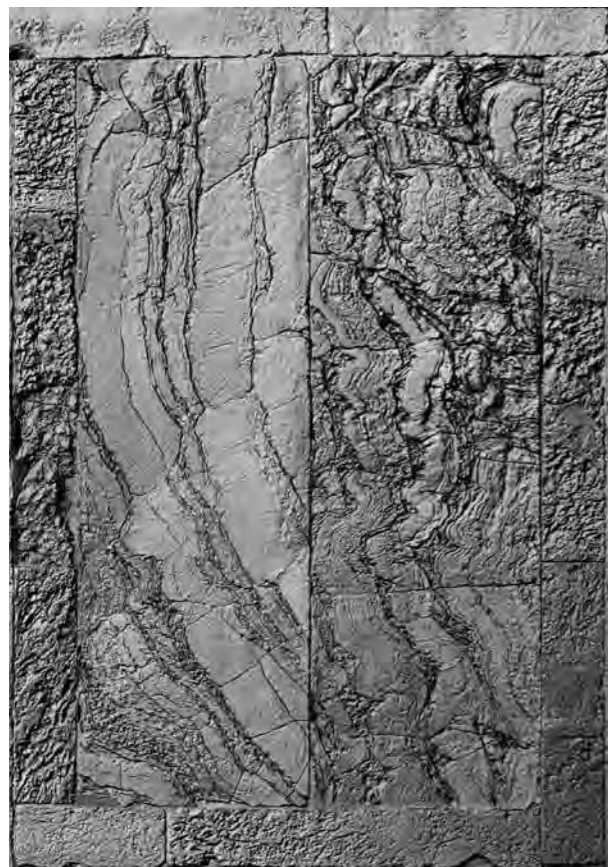
If the facsimile, in its site next to Carter’s house, can capture the public imagination in a similar way to the discovery of the tomb, then Tutankhamun can secure his immortality – at least for a while longer. With the right approach new technologies are making it possible to have both an altruistic approach that preserves the site for future generations and the commercial benefits of tourism that the people of Egypt need right now.

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3D photogrammetric recording of Sharaan Canyon recorded for Afalula and Jean Nouvel in May 2019, by Pedro Miró and Otto Lowe.



A text by Adam Lowe and Charlotte Skene Catling,  
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#### Introduction

"Beside each wrinkle one invariably finds a scar," Victor Hugo wrote when he compared the ravages of time with the—usually destructive—man-made alterations to the Cathedral of Notre Dame. Every object, as every person, has a biography that becomes legible on its surface.<sup>2</sup> The more precious an object, the longer it is likely to last and the more wrinkled and scarred it will become. Yet these marks are the means by which objects become articulate and reveal their histories.

Stone, measured in geological time, has been fashioned into a built history of human time, almost infinitesimal by comparison. Marble is a visual record of natural forces: violent tectonic shifts, turbulence and folding, extremes of heat, compression, and the raising and lowering of sea levels leaving behind traces of organic life. This is its 'pre-history.' There is then the purchase, extraction, transport, and working of marble into objects; what they represent or embody, and what takes place around them. Their stories morph and proliferate, shifting emphasis and meaning in translation. Almost imperceptibly, objects become less legible over time, until their original meanings are lost and replaced with newer ones. But objects are their own forensic evidence.

This essay is about looking, and the capacity of marble to embody multiple narratives. It takes the perspective of recording with lasers and photogrammetry, and re-materializing using digital printing and craft skills, focusing on three extraordinary and very different examples of worked stone: the panels from the Treasury Wall of the Basilica di San Marco in Venice, the Sarcophagus of Seti I and the Table of Teschen. In each case, history, use, and meaning are condensed into a material presence that is made more visible through digital technology, prompting new speculation on the past.

#### The Basilica of San Marco

The Venetian concept of time and its own mythology is as liquid as the city itself. The Basilica di San Marco, the magnificent Italo-Byzantine conglomerate of a building in Venice is an accretion over centuries, through building, tearing down and rebuilding, destruction, theft, repurposing, and reinvention: here architecture takes on a geo-archaeological depth. The marble cladding of the trophy wall of San Marco uses all the reverberative power of direct quotation. Cities were invaded and spolia used to create a civic identity for Venice with instantresonant gravitas, physical authority, and beauty. Here history is co-opted through the reconstruction and manipulation of collective memory. So what is 'original' or 'authentic' and where does emotional resonance lie? This is, after all, the *third* San Marco. Walter Benjamin develops the debate around reproduction and the "aura" of an artwork in *The Work of Art in the Age of Mechanical Reproduction*, but is this still useful in the twenty-first century?<sup>3</sup>

#### Ornament and Theft, Ornament and Crime

Of the capitals, mosaics, marble, and 600 columns used to refashion San Marco, much was made up of booty brought back from the Fourth Crusade. John Ruskin wrote of the building's "confessed *incrustation*,"<sup>4</sup> describing in romantic language an almost modernist honesty of architectural expression. Marble revetments were stripped from the interior of Hagia Sophia and pinned like butterflies to the external brick walls of the Venetian basilica. San Marco is a building where the construction is made explicit, where the visitor, "[...] will see that every slab of facial marble is fastened to the next by a confessed *rivet*, and that the joints of the armour are so visibly and openly accommodated to the contours of the substance within, that he has no more right to complain of treachery than a savage would have, who, for the first time in his life seeing a man in armour, had supposed him to be made of solid steel."<sup>5</sup> It is the precursor to Adolf

1. Taken from Victor Hugo 1836, vol. 3, p. 127.

2. Victor Hugo 1836, vol. 3, p. 124.

3. *The Work of Art in the Age of Mechanical Reproduction*, Walter Benjamin. In: *Illuminations*, edited by Hannah Arendt, translated by Harry Zohn, from the 1935 essay New York: Schocken Books, 1969.

4. Ruskin 1867, vol. 2, p. 74.

5. Ruskin 1867, vol. 2, pp. 75–76.

Loos' approach to decoration, crystallized in his thesis of honesty versus degeneracy, *Ornament and Crime* (1910)<sup>6</sup> and *Hands Off!* (1917), where he writes, "[...] consider that noble material and good work do not outweigh the lack of ornamentation, but that they are far superior in their delicacy. More than that, they make ornamentation redundant." The complexity and wonder lies within the marble itself.<sup>7</sup>

#### Born of Porphyry

The rivets Ruskin writes of raise questions as they are not consistently present but appear only in some of the marble panels, while others are fixed invisibly to the brickwork beneath, presumably with cement. This is also true of Hagia Sophia, and the Pantheon, where the Romans bonded marble to its surface with cement, delighting in the beauty of the stone itself with no pretense that it played a supportive, structural role. At San Marco, a clear distinction is made between the thin panels that clad the building and the pillars of solid marble that stand independent of it. Marble is located according to a hierarchy, and columns arranged by their value, color, and size. By far, the most precious stone was Imperial Porphyry, extracted only briefly during Nero's reign from a single site in Egypt's Eastern Desert. The quarries on Mons Porphyry had been closed for hundreds of years by the time of Justinian, whose monuments were constructed from those of Constantine, just as Constantinople itself was built partly from a dismantled Rome. After the seventh century, when the Romans lost control of Egypt and access to the Imperial Porphyry quarry, it was valued even more highly as there was simply no more to be had.

Porphyry, the rich, reddish-purple color of placenta, was used to line the birthing rooms of the Byzantine empresses, giving rise to the term *porphyrogenitos* (born of porphyry), indicating a legitimate imperial heir. Princes would be crowned emperor on a disc of porphyry like that in the Pantheon. At San Marco, the porphyry loot is displayed to maximize its implicit imperial authority. The darkly-gleaming embracing Tetrarchs protectively enfold the corner of the Treasury, and with the massive *Pietra del Bando*, whose truncated form seems only to compress and intensify its powerful presence, they were strategically placed between the Basilica and the Doges Palace, bridging church and state. Extraordinary sculptural details—the beards of the older Augusti against the smooth faces of the younger Ceasars, the draped cloth of the cloaks and decorative sword hilts, their wrinkled foreheads—are preserved by the hardness of the stone that resists the weather with impunity. As well as representing a sovereign provenance in both subject and material, the Tetrarchs were subsumed into local Venetian mythology as petrified Saracens in a cautionary tale: thieves who tried to break into the Treasury were turned to stone. The *Pietra del Bando* was used as a platform for announcing public executions and the Pillars of Acri for displaying severed heads; trophies were both mineral and human, symbols of past and present power, embodied warnings.

#### 'Image Birthing'

Deep purple porphyry flanks the main entrance of San Marco, followed by green marbles such as serpentine and Thessalian green, then Aquitaine black and white. Book-matched panels of Iassense with its expressive folded bands of red hematite punctuate the walls of the Treasury as focal points. Columns of precious Docimeum or Pavonazzetto are found in the apse. But perhaps San Marco's looted marbles are best understood through Paul the Silentiary's description that unfolds as a lapidary atlas of the empire, filled with sensuous delight. It was recited in 563 after the rededication of Hagia Sophia, and although today it is as though a thin, grey veil has been drawn over the remaining stones, one can imagine the brilliance of the space when they were all in place, gleaming with their full power.

There is a wealth of porphyry stone...besprinkled with little bright stars that had laden the river-boat on the broad Nile. You may see the bright green stone of Laconia and the glittering marble with wavy veins found in the deep gullies of the Iasian peaks, exhibiting slanting streaks of blood-red and livid white; the pale yellow with swirling red from the Lydian headland; the glittering crocus-like golden stone which the Libyan sun, warming it with its golden light, has produced on the steep flanks of the Moorish hills; that of glittering black upon which the Celtic crags, deep in ice, have poured here and there an abundance of milk; the pale onyx with glint of precious metal; and that which the land of Atrax [Thessaly] yields, not from some upland glen, but from the level plain: in parts vivid green not unlike emerald, in others of a darker green, almost blue. It has spots resembling snow next to flashes of black so that in one stone various beauties mingle.<sup>8</sup>

6. Loos gave a lecture of this title in the *Akademischer Verband für Literatur und Musik* in Vienna on 21 January 1910. It was published in 1913 in French in *Cahiers d'Aujourd'hui*, and later in *l'Esprit Nouveau* in 1920; in German in 1929 as *Ornament und Verbrechen in the Frankfurter Zeitung*.

7. Loos, 1962, p. 347.

8. Paul the Silentiary, *Description*, vv. 617–646.

San Marco turned Hagia Sophia inside out. These precious stones are now external cladding, facing the Lagoon, exposed to the heat, cold, wind and rain for centuries. For all the beauty of the weathered panels that now 'incurst' San Marco, there is an equal melancholy in looking at their painted replacements in Hagia Sophia. The flat and gaudy imitation marbling on plaster just serves to highlight the mysterious depth and complexity of the original stone.

The perception of San Marco emerges through the use of color and the effects of light. In Paul the Silentiary's ekphrastic eulogy, colors are presented as contrasts in an architecture of surface tension: "blood red and livid white," "pale yellow with swirling red," black with white "milk," vivid "emerald," and "darker green," in each case, qualified with reference to animation through light, "besprinkled," "bright," "glittering," "glinting," "flashing," "golden light."<sup>9</sup> Ruskin is adamant that 'incrusted architecture' is defined by 'chromatic decoration' and condemns the color-blind:

If, therefore, the reader does not care for color, I must protest against his endeavor to form any judgment whatever of this church of St. Mark's. But, if he both cares for and loves it, let him remember that the school of incrusted architecture is *the only one in which perfect and permanent chromatic decoration is possible*; and let him look upon every piece of jasper and alabaster given to the architect as a cake of very hard color, of which a certain portion is to be ground down or cut off, to paint the walls with.<sup>10</sup>

Through *eikonogenesis* or 'image birthing,' markings and shapes in the marble conjure themselves into recognizable forms where the viewer can pass through the surface, like Alice through the looking glass, into an imaginary world beyond. In his book *The Analysis of Sensations, and the Relation of the Physical to the Psychological*, first published in 1886, Ernst Mach examined "[...] the space sensations that physiologically condition the recognition of a figure [...]," and, by manipulating small, black amoeboid forms in relation to each other, demonstrated the point at which recognition requires intellectual intervention.<sup>11</sup> He concluded that "affinity of form" is instantly recognizable when objects are bi-laterally symmetrical, or rotated through 180 degrees, but recognition needs a secondary, intellectual process when they are orientated differently.

As a psychological tool, Hermann Rorschach chose to use symmetrical images as a shortcut into the subconscious because, in his experience, they were more "suggestive" than asymmetric ones. "Asymmetric figures are rejected by many subjects; symmetry supplied part of the necessary artistic composition [...] symmetry makes possible the interpretation of whole scenes."<sup>12</sup> A great deal of important work has been carried out on the effect of symmetry on perception and the human imagination, including that by Dario Gamboni, some in this book.<sup>13</sup>

The book-matched marble panels are one of the most striking characteristics of the wall at San Marco, the cipollinorosso panels stand out in particular, among their watery neighbors. Isolating the panels of book-matched marble using frames of contrasting stone, or the same marble double-billet mouldings as those found at Hagia Sophia, elevates them to the status of artwork. Cutting and unfolding the marbles not only multiplies a precious material, but also visually declares a human presence. The use of symmetry turns the patterns of the stone from being accidental to intentional, from being found objects to man-made. One can imagine how the tendency for images to materialise out of the symmetrically patterned panels of the basilica might have been harnessed as a conduit between the mundane and the divine.

#### Recording and Rematerialising the Treasury Wall of San Marco

After several months of negotiation with the *Procuratoria di San Marco*, the submission of detailed procedures to ensure that the scissor-lift would not damage underground drainage, the lights and recording system would not threaten the stone, the data would be useful for conservation, the tourist-flow would continue uninterrupted, and the students from the Department of Architectural Preservation at Columbia University could participate, work finally began on 9 October 2017.

Raised above the thousands of visitors in the *piazzetta* below, the recording process provides the time and proximity to notice subtle details and raises questions. Why is one stone heavily weathered and the next almost smooth? How different are the marbles when wet? Why is one veining captivating while another dull? Who chose these marbles?

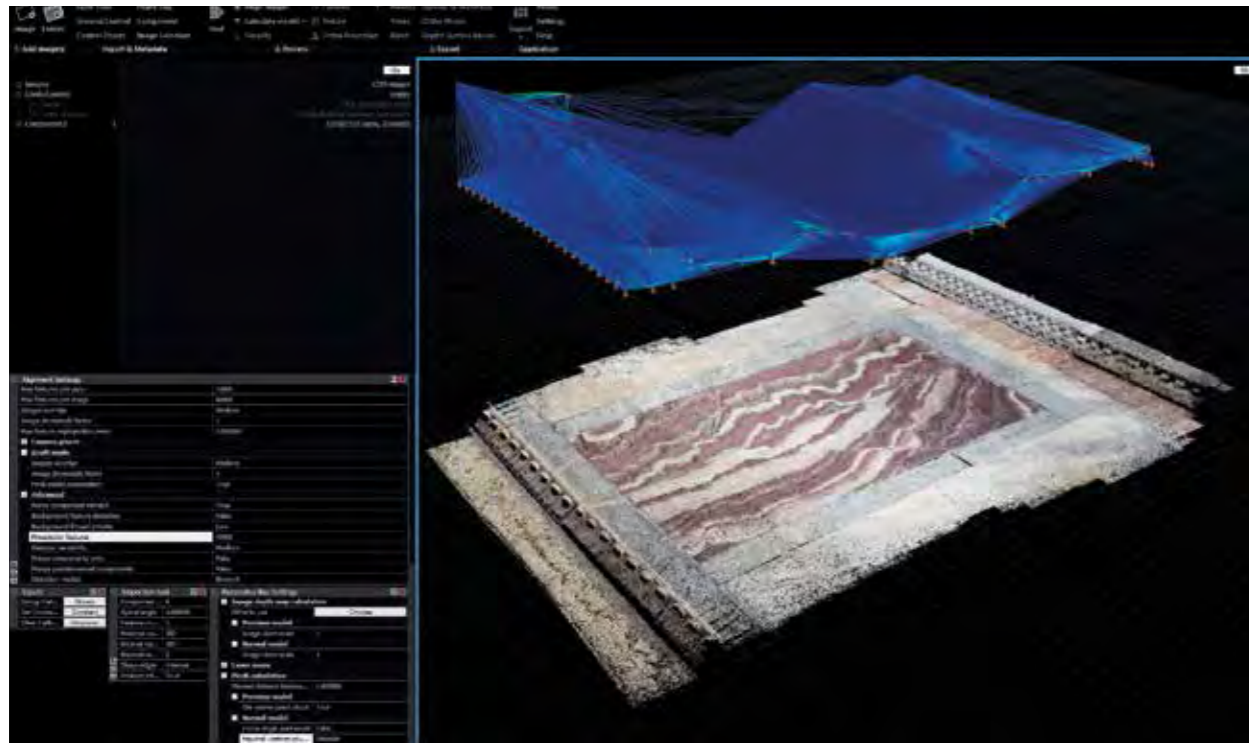
9. Schibille 2014.

10. Ruskin 1867, vol. 2, p. 79.

11. Mach 1914.

12. Rorschach 1942, p. 15, chapter 1, *The Method*.

13. Gamboni 2002.



Can we still perceive and understand the values that were once projected onto them, that led them to be so highly prized? The surface of San Marco can now be captured using only a DSLR camera; an area of about one by two meters, recorded in a few hours. Over 10,000 high-resolution photographs of selected marble panels on the Treasury wall were taken, following strict guidelines, despite the weather and ceaseless questions from curious visitors. It was unforeseen that the students would become temporary guardians of the Treasury wall, preventing errant tourists from using it as a urinal.

The time-consuming processing of the photographs took place in Madrid.<sup>14</sup> Once the renders were processed, the depth of the marble surface can be viewed independently of its color, revealing many qualities that may be otherwise overlooked. The breccia, broken mineral fragments bound together in a fine-grained matrix, reduces down over time to a variety of chunky surfaces with deep recessions. By contrast, the panel is a finer, slightly sandy material, with hard white veins of denser stone. The sandy areas erode faster than the veins, leaving a beautiful, fluid surface in relief. Each material reveals its formation as it ages, and condition monitoring is one of the valuable roles of photogrammetry.

But visualizations are still only virtual representations viewed on-screen. The data recorded is of sufficient quality to be translated into a triangulated mesh of over 200 million polygons, with an accuracy of 100 microns, and can be re-embodied using a range of 3D output technologies. In other words, the marble skin can be remade at a resolution that is indistinguishable from the original to the naked eye. The digital world returns to the physical.

The goal of the San Marco exercise was several-fold; first, to record the surface of selected areas of the panels in colour and 3D at the highest resolution; second, to prove that this technique could be taught and transferred to students in a matter of hours; finally, and perhaps most importantly, to demonstrate what can be achieved in practice. Recording our heritage is now possible, affordable and urgent: waiting any longer will mean real and irretrievable cultural loss.

#### The Body of the Stone

[...]and by that means formed those Representations which appear in the Body of the Stone [...] and may be artificially produc'd by several Bodies and Liquors, which have no affinity, either with Agate, Mochus, or Marble, I can make it plainly apparent by Experiment [...].<sup>15</sup>

14. Adobe Lightroom, Reality Capture and Global Mapper software were used to create zoomable visualisations that can be saved, sent and studied. Lightroom processing achieves ideal exposure, clarity and colour, while Reality Capture is a software that generates a point cloud using feature mapping and elegant algorithms.

15. Hooke 1705, p. 436.

Various attempts were made in the seventeenth century to manipulate and manufacture marble by those captivated by its corporeal form and symbolic power. Latent images seen in diverse markings made the material highly prized and were an endless source of inspiration. The idea that these representations were “productions of chance” and might be artificially made, or somehow insinuated into natural stone, began to appeal as Robert Hooke’s text illustrates.<sup>16</sup> Scagliola re-emerged as the cheapest and most effective way to mimic marble and pietradura inlays. Formed by kneading a pigmented dough of Plaster of Paris with animal glue, it shortcuts millions of years of heat, pressure and tectonic movements to produce a similar veined and patterned body.

In his article “*Painting in Stone; Early Modern Experiments with a Metamedium*,” Fabio Barry looks at a number of early attempts to make and color stone.<sup>17</sup> In the early seventeenth century, NiccolòTornioli and Michelangelo Vanni pioneered innovative techniques to make pigments penetrate the surface of marble, some of which Factum is trying to reproduce now, overcoming several hurdles. For instance, many of these texts were written in ciphers; the properties of some of the early ingredients have to be transferred to the present day laboratory, and archaic terminology translated.

By the mid-seventeenth century in Oxford, Hooke’s associate William Byrd was also able to stain marble, benefitting from the shared interests of experimental philosophy and science. By the eighteenth century, there was a revival of interest in controlling the markings of marbles and both the Comte de Caylus and the Principe di Sansevero were successful to varying degrees. However, it was not until the second half of the century, when Leonardo de Vegni developed a method of forming calceous deposits inside a mould, that anyone really attempted to ‘grow’ a stone resembling marble. These early experiments are the precursor to the work now carried out by Factum where some of the techniques, such as Scagliola, are regularly employed.

#### Form from Light

Current technologies seem almost alchemical, with equally magical results. In practice, they are either based on building up a form in layers, or carving it away from a solid block: ‘additive’ or ‘subtractive’ manufacturing. Both were used in parallel to make the facsimiles of the tomb and Sarcophagus of Seti I. However, it was the emerging technology of Océ’s elevated printing system that was chosen to remake part of the San Marco ‘skin’.

Elevated printing is a variation of the photocopy technology that was once Océ’s core skill. In 1937, Chester Carlson invented the xeroxograph based on the principle that Ultraviolet light neutralizes electrostatic charge. A charged surface is selectively *dis*-charged by exposure to light. The remaining charged area attracts a fine dust of resin-coated pigment that is then fused using heat. In the elevated printing system, this process is repeated many times, gradually building up a relief surface from five-micron-thick layers. The marbling process, where oil paint is floated on water, then lifted off onto paper, is comparable. If this were repeated thousands of times with the same sheet of paper while controlling the shape of each layer, the result would be something like elevated printing.

The initial layers of Océ’s electrostatic system are black toner, followed by white and, finally, color. It cannot print undercuts, nor deposit color on vertical or near vertical surfaces. Every system has its limitations and inherent characteristics, and as applications emerge, the process can be adapted and refined within the constraints of the material.

#### THE SARCOPHAGUS OF SETI I

The Sarcophagus of oriental alabaster, was found in the centre of the hall, without a cover, which had been removed and broken, and the body that had once occupied this superb coffin, had been carried away. We were not, therefore, the first who had profanely entered this mysterious mansion of the dead.<sup>18</sup>

On the 1 of October 1817, Giovanni Battista Belzoni, a 6’7” engineer and former strongman, discovered the rock-cut tomb of Seti I, the most magnificent and complete in the Valley of the Kings. For 3,100 years this tomb remained in almost the same condition as the day it was sealed. As few contemporaries could travel to Egypt, Belzoni made a facsimile of his spectacular find and brought it to London. The relief surface was cast from molds made on site,

16. Ibid, p. 436.

17. Barry 2017.

18. Belzoni 1821, *The Edinburgh Annual Register, for 1808-26*, volume 14, chapter 4, *Geography*, p. 358.



removing much of the original color and fabric in the process. The casts were then hand painted, following the meticulous watercolor records made on site by Belzoni and Alessandro Ricci. The facsimile caused a sensation when it opened at the Egyptian Halls on Piccadilly in 1821, and the following year was described in detail in Alfred Thornton's *Don Juan in London* with a color engraving of the gas-lit interior that fascinated fashionable Londoners.<sup>19</sup>

Belzoni also took Seti's sarcophagus to London, where John Soane eventually bought it for an enormous sum, more than the British Museum would pay. It remains in his house, under glass, which makes it difficult to examine the delicate carvings (or Belzoni's name graffitied into the foot of the sarcophagus, a very visible 'scar'). The stone was white when it arrived and is now honey-colored, stained by the nineteenth and early twentieth century London smog. The blue infill that originally delineated the carving fell out or was scrubbed away by over-enthusiastic cleaning. Now only traces of the blue remain, and most are nineteenth century.

#### Flesh-Eating Stone

Decay and change are inherent in the idea of a 'sarcophagus': literally a 'flesh-eating stone', which protects the body and the soul during their most vulnerable transformation. The Sarcophagus of Seti I contains the protective figure of the goddess Nut on the base and the hieroglyphic text of *The Book of Gates* on both its inside and outside surfaces; it is one of the world's most compelling objects and important Egyptian finds. *The Book of Gates* focuses on the Sun God's complex journey after death, through the "dark hours of the sun," to his rejuvenation each morning. Carved in white alabaster whose surface mimics youthful skin, it has a softness, luminosity, and depth that invites touch.

#### Recording and Re-materializing the Sarcophagus

Archaeologists and geologists use the term alabaster differently. 'Oriental alabaster' is a fine-grained, banded calcite (rather than the geologists' gypsum), with a low index of refraction, allowing light to penetrate several millimeters into the stone before it is scattered back out. This causes the ethereal translucency that makes it so desirable, but also almost impossible to scan with a laser. Factum tried and failed in 2001, as the noise in the data exceeded the information. In 2016, a second attempt was made, this time with a specially designed and lit camera rig. Over 5,000 photographs were taken and processed with the same *Reality Capture* software that was used for San Marco's marble panels. The outcome was a 3D file of over 12 billion polygons: vast, unwieldy, and impossible to handle in one piece.

19. Thornton 1821.



Factum's 3D studio ingeniously transformed the data and, using both photogrammetry and topographic-mapping software, separated the sarcophagus surface from its undulating form. The form was milled into a polyurethane block while the surface was distorted into a flat plane for elevated printing. The printing was built up in five-micron color layers of UV cured resin, and was finally mapped back onto the curvilinear structure.

This process of re-materialization was experimental from the outset and modifications were improvised as new difficulties were discovered. Byrd, Sansevero, and de Vegni must have experienced similar frustrations in their explorations, and felt the same exhilaration with success. The resin appears to be transformed from a synthetic material to an alabaster. The facsimile of the Sarcophagus of Seti I is an object with its own visual qualities, and in the same way that plaster casts were valued as objects with unique qualities and scientific value, so the sarcophagus has become more than an imitation. It is an object of wonder and excitement that reveals the evidence of the past through the technologies of the present.

#### THE TABLE OF TESCHEN

"I can think of nothing more devastating, more utterly smug than that hideous [Empire] style".  
 "But I believe, all the same, that they've got some lovely things;  
 why they must have that famous mosaic table on which the Treaty of [...]"<sup>20</sup>

The Table of Teschen or Table of Europe, was famous enough in the nineteenth century for Marcel Proust to give it a cameo role in *Swann's Way* as the General defends the arriviste Princess Iéna from the rarified Princesse des Laumes. Generally considered to be Johann-Christian Neuber's (1736–1808) masterpiece and one of the most important and dazzling pieces of eighteenth century furniture, even the Princess petulantly admits that the table is "interesting enough from the historic point of view." In 1781, the Elector of Saxony gave the table to the Baron de Breteuil for his role in negotiating the Treaty of Teschen, signed on the 13<sup>th</sup> of May, 1779. This effectively restored peace in Europe by ending the war between Austria and Prussia. It also established the principle of collective security, the foundation for the Covenant of the League of Nations and Charter of the United Nations.

20. Proust/Moncrieff 2013, p. 262.



To commemorate this historic event, Neuber created a table that was essentially an enlarged version of one of the *Steinkabinettabatières* (literally, ‘stone cabinet snuffboxes’) on which he had built his reputation in Dresden.<sup>21</sup> Using the principle of creating a decorative pattern from an encyclopedic collection of brilliantly colored local minerals, stones, gems and petrified woods, but much enlarged, the table has the dazzling effect of a geological kaleidoscope. In Enlightenment, spirit, and reflecting a growing interest in mineralogy, a number for each of the pieces is carefully engraved in its metal frame. This allows for the type and origin of each sample to be identified in an accompanying catalogue, beautifully handwritten by Carl Gottfried Nestler and housed in a secret drawer under the tabletop. Read with a *Petrografische* map of Saxony, the geologically curious can locate the specific source of each stone.

The table is clad in gilded bronze over a hardwood core. Its legs are divided into four sections with decorative acanthus leaves at its tiny feet, swags at the top, its ‘thighs’ wrapped in amethyst and divided from its ‘calves’ by jeweled garters of white quartz and pearls. Alternating gem-cut amethysts and quartz encircle its middle. Its golden surface is opulently set with 128 highly polished, petal-shaped, semi-precious inlays, arranged in four bands that radiate from the center, the edges encrusted with floral designs in colored glass. Meissen porcelain medallions are inset among the gleaming stone samples, with variously engaged fleshy putti. As a seductively dressed geological taxonomy, saluting scientific order while commemorating peaceful European collaboration, it is an object that carries many narratives.

#### Compressing Time

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Neuber’s travels to Saxon quarries in search of his multi-colored stones is part of the table’s mythology. In the 1770s the modern classification of stones was in its infancy with a new interest in all things underground. Abraham Gottlob Werner set out his systematic organization of minerals in his book, *On the External Characters of Fossils, or of Minerals* in 1774.<sup>22</sup> He also circulated his influential theory of Neptunism, the idea that rocks formed from the crystallization of minerals in ancient oceans, and demonstrated chronological succession in rocks. In reality, Neuber probably just visited Idar Oberstein, renowned center for gemstones, where traders mixed with craftsmen who cut and worked unpromising raw material to reveal dazzling interior worlds. These objects trigger some fundamental curiosity, as concentrations of the sublime, compressed to a scale that can be held in the hand. Polished stones with their glassy brightness are very alluring. Perhaps, as the Princesse de Laumes observed, even a little vulgar.

In 2015, the current Marquis de Breteuil sold the Teschen Table to the Musée du Louvre. One of the conditions of sale was that a single facsimile could be made to ensure the table’s continued existence at the Chateau de Breteuil. Factum recorded the table using 3D scanning and composite-photography supported by many detailed measurements and written notes. Digital technologies were then merged with established craft skills to produce a new version that is virtually identical to the original when compared side by side. The copy is now in place at the Chateau on permanent display to the public. The emotional impact of the facsimile in its original setting is a good counterpoint to the aesthetic presence of the original table in its new home.

#### Recording and Re-materialising the Table of Teschen

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When the Marquis de Breteuil approached Factum to remake the Table of Teschen, the first question to arise was, should the stones in the replica *be* like the ones in the original or *look* like them? In other words, was Factum being asked to source the same stones as the original, or replicate their exact patterns and colors? It was decided that there would be too much variation in new pieces of the different stone types. Instead, the two tables, when placed side-by-side, should *look* identical.

To that end, macro-photography and 3D scanning were followed by period of research into how to ‘extract’ the qualities of the stones. The exact shape of each original sample was water-jet cut from a sheet of 3 mm thick aluminum. These were then coated with a ground of animal glue, calcium carbonate and titanium white pigment (a recipe very similar to Scagliola). The coating was sanded to a smooth surface, then printed with pigment on a flatbed inkjet printer, often in layers to build a density of color. Once printed, the surface was covered with a thick layer of epoxy resin. This layer was then polished to the same finish as the original pieces. The results are staggeringly convincing, only just revealing their artifice through touch. As the original table had been protected with a layer of acrylic resins during a restoration, the feel of the original and the facsimile were far closer than had been expected.

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21. Kugel 2012.

22. Werner 1774; Werner/Weaver 1805.

To complete the facsimile of the whole table required many different processes; laser-scanning, photography, photogrammetry, detailed measurements, CNC milling, water-jet cutting, electro-plating, turning on a lathe, coating, printing, engraving, replicating the porcelain Meissen plaques, modeling, molding and polishing. Historically, in a pre-digital age, crafts were separated by materials and disciplines. Factum now focuses instead on the mediation of materials—both digital and physical—where disciplines overlap. There is a general view today that technology will kill craftsmanship. In a project like this, the reverse is true. People with the right skills appear, while others rapidly pick them up; craftsmanship is remarkably adaptive, and killed only by the absence of patrons commissioning work of the highest quality. A love of material transformation drives innovation and discovery.

#### LIVING STONE - CONCLUSION

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Recording, processing, and making prompts a rethinking of the way objects are displayed and experienced. Facsimiles can allow them to remain in the spaces for which they were intended as an alternative to the twentieth century museum that airlifted them out of their original contexts. The characteristics of light and color that define marble and fascinated Paul the Silentiary and Ruskin have been turned into technological tools: marble can be recorded using photogrammetry (‘measuring with light’); it can be ‘printed’ based on Océ’s system of exposure to light, and color can be separated from tone in the processed data. In addition to data that can be viewed as separate component parts, or enormously enlarged making it easier to decipher ‘wrinkles’ from ‘scars,’ the techniques developed to rematerialize objects give a deeper insight into the way objects were first made and how they have changed over time. This goes beyond the academic into a haptic relationship that allows an intuitive understanding.

Marble narratives proliferate like a Borgesian library. The sarcophagus leads into the Underworld, the youthful perfection of its smooth, white skin promising immortality. Once the mummified body is permanently enfolded in the softness of the alabaster, a stone partly soluble in water, there is a sense that the image and contents might dissolve into each other as part of the transformation into the afterlife and the boat journey to rebirth. San Marco, through pious pillage, turns an architectural facade into a map of the Roman and Byzantine Empire by literally assembling pieces of it into an architectural composition. Layering age, it becomes a catalogue of the known world through religious conquest. The Table of Teschen represents the geo-political world, but with Enlightenment optimism; its whole being is a physical assurance that the earth can be taxonomically structured. It implicitly suggests that control and order can be reached through knowledge and diplomacy, then refined and technically perfected into an object of beauty.

Perhaps ultimately it is anthropomorphism that underlies our passionate attraction to marble. It seems alive. It is both ‘skin’ and ‘body,’ capable of giving birth to images and emperors through *eikonogenesis* and *porphyrogenesis*. The Table, coquettish on its tiny feet and gartered thighs, unfurls its message like peacock feathers in an extravagant, self-conscious display. The sarcophagus consumes flesh in order to resurrect it. The watery patterns, mirrored and repeating on the walls of San Marco, unfold like a cardiogram tapping out a pulse of living stone. Time collapses through these articulate objects, and technology is amplifying their voice.



A text by Adam Lowe from *Antonio Canova. Atelier*,  
 Edited by Chiara Casarin, published by Marsilio for Musei Civici di Bassano del Grappa, 2019.



#### TECHNE AND SKILL: SENSUAL SKINS AND MAPPED SURFACES

Canova is defined by his interest in the “superficial”; it is in the qualities of his surfaces that his true ability to shape both hard and soft matter is revealed. The skin that covers his sensual forms invites touch. In an age of aesthetic alterations and volumizing, subtle modelling of living tissue reveals the importance of bone and soft tissue in creating idealised beauty. Canova was able to create a surface in marble, a material inherently hard and cold, that feels like flesh. He could do this because he worked up to the surface from the inside as he modelled and cast in clay and plaster, registered the surface with measurements and then carved down to the surface from the outside knowing its spatial coordinates. For many years his dependence on a mechanical technique operated by assistants to produce his marble works was seen as negative. Canova was considered a “modeller” not a “carver”, a “polisher and finisher” rather than true artist, a diplomat and salesman who could sell his own works to the grand tourists visiting his studio to obtain export licenses for their purchases of classical antiquities. Today his business acumen, and the fact that his sculptures are both mechanical reproductions and autograph works, is not problematic. But it does raise some interesting questions at a time when digital mediation and transformation are an essential part of manufacture for many artists.

#### PENCIL

Canova’s drawings are of their time and academic in style. Subtle notations in pencil reveal the turn of a plane and points of articulation rather than the gravity and volume associated with a sculptor’s drawing. Many of his drawings are concerned with measurements and proportions. While the drawings hint at something physical they lack the eroticism and presence of his sculptures.

There is a hesitancy and timidity in the way the pencil connects to the paper. They are measured, thoughtful, and tasteful, but hardly present. It is not clear if they are intended as working drawings to clarify ideas or presentation drawings to use as a commercial tool to communicate sculptural ideas to potential clients.

#### CLAY

The small number of terracotta models seem much closer to his first sculptural ideas than the drawings. The terracotta study for the *Three Graces* in the collection of the Museo Civico in Bassano del Grappa doesn’t reveal the full complexity of the composition, but it contains the seeds of the idea. Three intertwined naked women embrace each other in a fluid composition emerging from a circular base where each figure shifts their weight in a way that feels weightless. In the sketch, the central figure is dominant with one of the graces looking up and the other looking away. In the final composition they have found an equality and harmony.

The rapidly worked terracotta model shows anatomical understanding and technical skill. The back view is not resolved, but there is a fingerprint clearly impressed into the buttock of one of the figures alongside the rasp of the tools used to shape the clay. While the forms are simplified and idealized, it is possible to read the thought process that as the seeds of an idea mature into the finished work. Art lies in the transformation from one state to the next, in the many decisions taken as Canova moved from clay to plaster.

#### PLASTER

Gypsum plaster is a curious material; when working with it, as it cures, and when it becomes solid. It is a complex, white mass that absorbs light and moisture. Stable and inert but fragile and brittle, it can assume any form when cast. Mixing with animal glue slows the curing allowing it to be modelled, and once hard it can be carved. The finished plaster works by Canova show a total mastery of the material with evidence of both casting and modelling. The surface on the plaster is both dry and slightly granular, as if anticipating the smoothness of marble.

#### LIFE CASTING

When Paulina Bonaparte’s second husband Camillo Borghese commissioned an allegorical portrait from Canova, she rejected the artist’s suggestion to portray her as a chaste, robed Diana and chose the seductive Venus Victrix instead. Paulina evidently also enjoyed the scandalized response to her topless portrait and the speculation of her posing naked; she even invited Canova to immortalize her breasts as plaster casts. Casting the soft tissue of a breast and the dynamic nature of a nipple in plaster without deformation takes great skill, as Paulina’s breast at the Museo Napoleonico in Rome demonstrates. Today’s silicon moulding would make the task easier. Non-contact 3D scanning could capture the breast under its own weight without deformation.

#### BRONZE SCREWS AND MARBLE

Once the plaster “master” is finished it is covered with carefully positioned bronze screws, a process known as pointing. Using a *machinetta di punta* (pointing machine), Canova or his assistants could begin the process of translating the plaster original into marble. The plaster is easy to point but much less easy to transfer into a block of marble. This is achieved by drilling holes to a predetermined depth at a specific angle. The meticulousness of the craftsman takes over from the “touch” of the artist in this subtractive method of reproduction. It is physical but precise, based on teamwork from the cutting of the block in the quarry to the transfer of information and the sweaty, physical work in the workshop.

The *machinetta di punta* consists of an articulated needle held in place on a wooden structure. The bronze points can be spatially located, one at a time, as long as the supporting apparatus has three fixed points on the sculpture in addition to the point that is being measured. These fixed points must have corresponding points on the block of marble. The process is clearly demonstrated in a display at the Gypsotheca e Museo Antonio Canova in Possagno. The external coordinates are located using a point on the top and the head and two points built up on either side at the lower front section of the marble block – at each of these points is an inverted cone so that the sharpened needles only have one locating point. Keeping these universal coordinates, the block of marble can be drilled and the surface removed until the exact point is revealed. This is done for each point until the block of marble is “roughed out”. The marble block is essentially divided into the positive form that will remain and the negative space that is removed. The skin is effectively the barrier that demarcates the inside from the outside – the focus of the sculptor’s attention.

The sprinkling of black dots is not the dense cloud of points familiar in today's 3D scanning. They are strategically and economically placed in a way that allows the "unwanted" marble to be removed mechanically before the fine skills of the master carver cut in – transformations from one material to the next are at the essence of sculptural decision making.

Working on an industrial level, Canova was able to produce multiple marble versions from one plaster original. They do not contain the expressive carving found in Michelangelo's *Rondanini Pieta*, or his series of *Slaves* where there is a sense of finding a form within the block. Canova's figures emerge from each block as if perfectly idealized and only in need of finishing. Canova often showed his finished sculptures to his guests at night by candlelight. This focused attention on the beauty of his form as the candlelight animated a surface carefully worked with pumice and rottenstone to become skin. The finishing could take months, and there are even suggestions that he was applying chemical patinas to the surface to further enhance the qualities of living flesh.

#### ORIGINALITY

Looking at the dots on the surface of the plaster originals in the Gypsotheca e Museo Antonio Canova in Possagno, and in the Museo Civico in Bassano del Grappa, raises an important question. Is the plaster the autograph work made (to a greater or lesser degree) by the artist's own hands? Is this the original

Canova from which the marble carvings could be reproduced to order? The first marble version of the *Three Graces* was made in 1814 for Empress Joséphine and is now in the Hermitage in Saint Petersburg. A second was made for the Duke of Bedford (completed in 1817). They are not identical, but they are similar. Multiple copies of varying quality have been made since then, both during and after the artist's life.

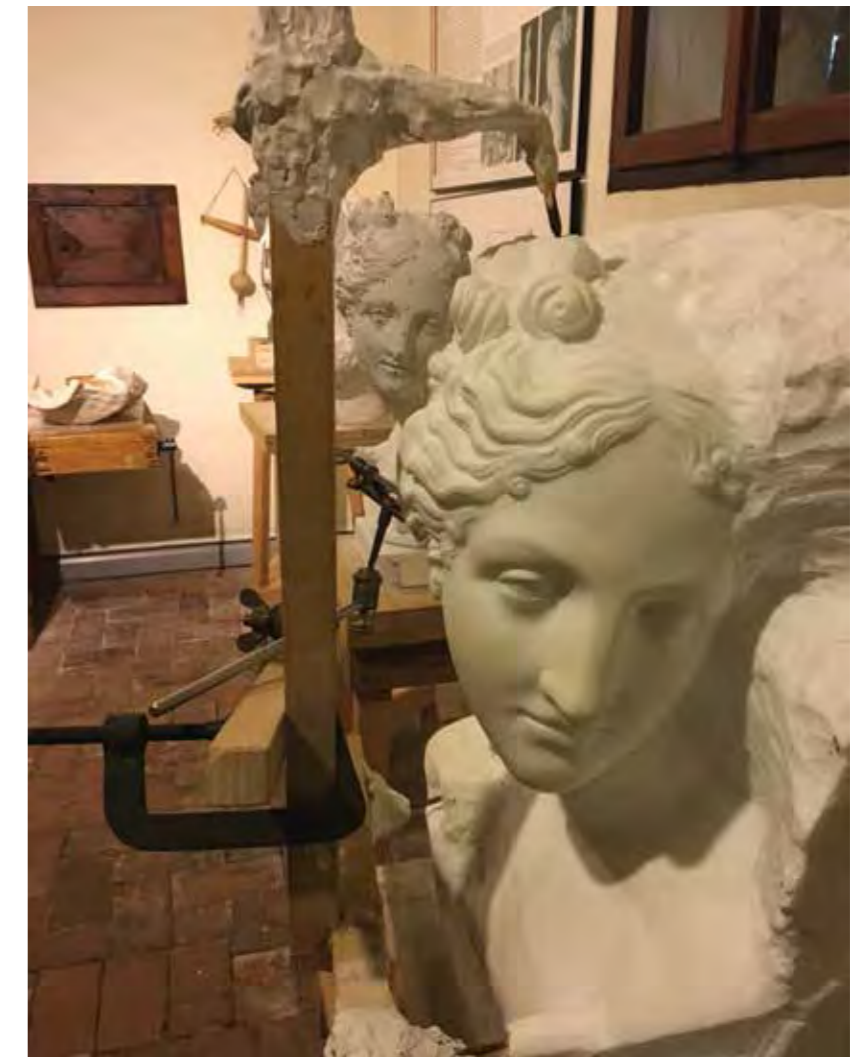
If the pointed plaster is the original work of art, would a copy get closer to the original if there were more dots describing the surface? Canova's *Venus Victrix* was transferred into marble using a few hundred individually hand-measured spatial points. Factum's scan made with a Nub 3D Triple scanner in Villa Borghese in 2013 consists of millions of independently measured spatial points. If these points were carved into marble using a 7-axis robot they would produce a marble version that only needed subtle finishing to create an exact replica. This mechanically produced object would be far closer to the original plaster than the marble copy in Rome is to the plaster original in Possagno. Would this bring it closer to the artist's original intention? Would the experience of engaging with a marble copy of this level of exactness to the plaster trigger a response that is closer to Canova's vision? How would Canova embrace today's technology? It answers most of his greatest needs. Would it bring him close to Jeff Koons's scanning and replicating of existing forms with exquisite levels of manufacture? Or would it free him to converse with the masters of antiquity with their unashamed love of physicality and erotic pleasure?

Replication is not simply a question of pushing a button. It requires teams of highly skilled people working together to achieve a common goal. Canova's studio was a mix of creativity and technology, ideas and materiality. His clients were members of an international elite demonstrating knowledge and taste, hungry to acquire and build collections reflecting their connoisseurship and insight. They were engaged in acquiring objects and knowledge. Canova provided both the means to send the antiquities they had purchased out of Italy and proof that the sensual pleasures enjoyed in classical Rome were alive in the creative (but collective) hands of a Venetian artist/diplomat.

#### DIGITAL RECORDING

The Museo Civico of Bassano del Grappa partnered with the Factum Foundation to digitize and create facsimiles of some of its collection of artworks by Antonio Canova. The collaboration began with the digitisation of Canova's *Three Graces* using a combination of recording techniques,

including photogrammetry and white light scanning. This was followed by the digitisation of more than two thousand drawings donated by Giambattista Sartori, the brother of the sculptor. The most ambitious collaboration consisted of the recording of all the plaster fragments of a colossal horse.



Technical display of the pointing machine, Fondazione Canova onlus, Possagno, Gypsotheca e Museo Antonio Canova

The work was carried out as part of Factum Foundation's commitment to ARCHiVe (the Analysis and Recording of Cultural Heritage in Venice), an international centre demonstrating the importance of the application of technology to the preservation of cultural heritage<sup>1</sup>.

#### RECONSTRUCTING THE HORSE

In 1806 Giuseppe Bonaparte, the new king of Naples, commissioned Antonio Canova to make an equestrian monument for Napoleon. Following the fall of the French emperor, the monument was reimagined to celebrate the new Bourbon rulers. Two plaster models of horses were made. However, the remaining plaster horse is not identical to either of the bronze horses now in Piazza del Plebiscito, Naples.

The plaster casts were given to the Museo Civico of Bassano del Grappa in 1851 by Canova's half-brother, Giovanni Battista Sartori-Canova. One was almost completely destroyed during extensive bombing of the city in 1945 while the other plaster model remained in good condition until 1969, when Professor Andreose was commissioned by the then Museo Civico director Professor Bruno Passamani to dismember the piece and move it into storage. Now in fragments, it ended up in Palazzo Bonaguro. In 2004 the head was restored and moved to the Museum, though the remaining pieces remained in storage (see the essay by Claudio Piscopo and Davide Tolfo, p. 165 of this volume).

In 2018, a team from Factum Foundation began the recording of all the existing plaster fragments. A dedicated area was set up where the pieces could be isolated and the light controlled. Over a ten-day period the team worked in the Palazzo Bonaguro carefully positioning and recording each of the pieces, some of which weighed more than sixty kilos. Two complementary scanning methods were used: a Breuckmann white light scanner and close-range photogrammetry. Documentary photography was also carried out.

#### BREUCKMANN

The Breuckmann smartSCAN 3D is a white light scanner that records at sub-millimetric resolution. This system projects light patterns onto the surface of an object as two cameras capture and extract 3D information from the projection. The object's surface is scanned in sections, which are then merged

together using OPTOCAT software. As it scans, the system tracks all recording distances, maintaining the scale of the information gathered. The scanning was conducted at an average resolution of around 250 microns, meaning that most of the superficial damage was recorded.



Point cloud of Paolina Borghese Bonaparte as Venus Victrix, 3D scanned with a NUB 3D Triple system at Galleria Borghese in 2013



Breuckmann white light scanner in Palazzo Bonaguro recording a fragment of the Colossal Horse, 2017–2018.

#### PHOTOGRAMMETRY

Photogrammetry is a 3D recording technique that employs 2D images to create a 3D model of an object or surface. It involves taking hundreds of overlapping photographs of an object from many different angles and processing them using specialized software. Factum uses RealityCapture. As a result of the composite nature of the photographs, both colour and form can be extracted. For the recording of Canova's work a Canon 5DSR camera was used with a Sigma 50mm Art 1.4 DSM lens. All the images were captured in RAW format (CR2).

Under ideal conditions, photogrammetry can record 3D data of a surface to an accuracy of 100 microns, on par with other close-range 3D recording systems available today. Once recorded, the digital 3D model can be used for study or output as a physical object via 3D printing or CNC milling.

#### DIGITAL RESTORATION

Over the past fifteen months the data has been processed and a complete digital restoration has been undertaken. This has resulted in a fully restored digital version of the horse capable of being printed at 1:1 and a small-scale version in bronze that resulted from the preparation of the data.

After processing the scanned data and the photogrammetry, all the fragments were aligned to form a recreation of the horse. The only reference to the complete horse was a selection of photographs taken before it was broken up. As none of the breaks was clean, and as significant parts of the horse are missing, the task of reuniting all the fragments was not simple. Due to the file size, the alignment of fragments was done in Z-Brush at low resolution.

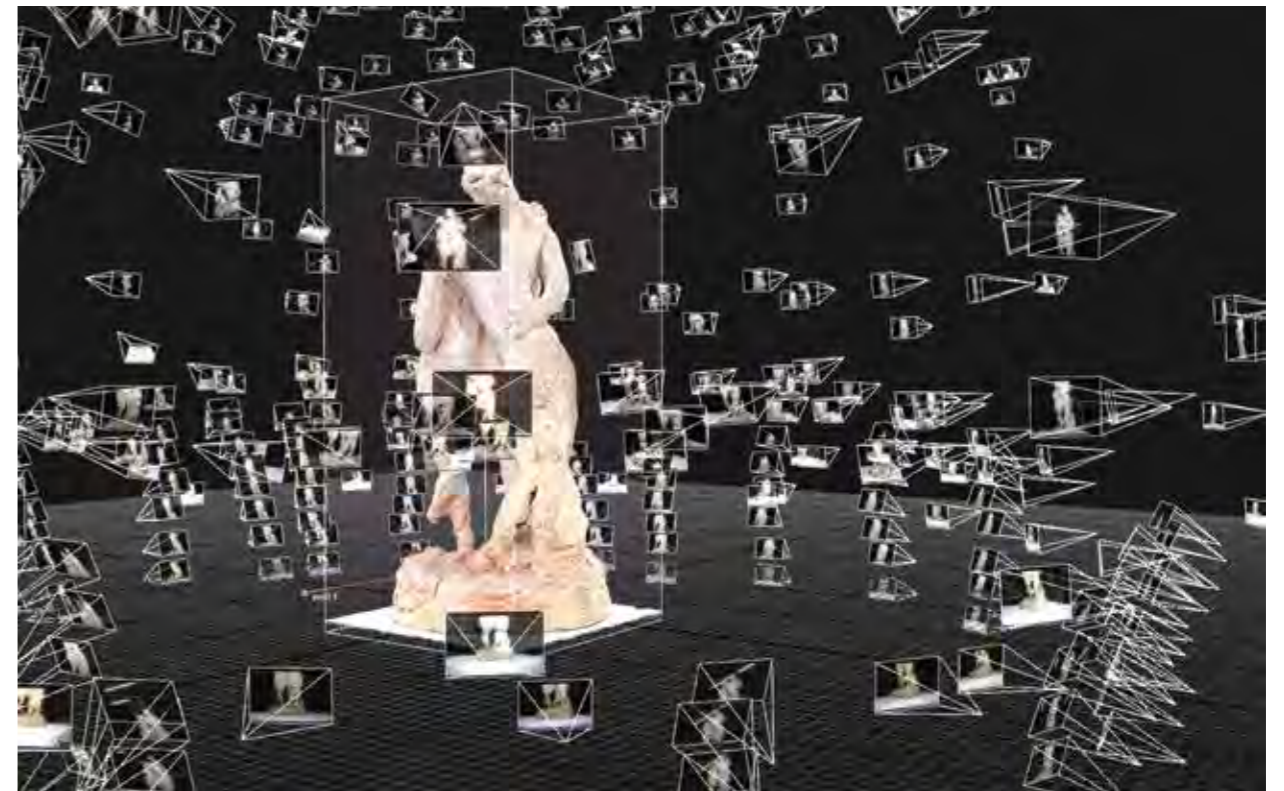
Once the pieces were assembled and the holes and missing areas filled in, a new topology was created to make a coherent surface. High-definition details from the scanned fragments were projected onto the surface of the new 3D mesh, creating overlapping and stepped surfaces while nonetheless retaining all the original information. The areas

created to fill in the gaps between fragments were delicately sculpted using a Smooth Brush tool to blend between the original and the recreated data. After several months of trying to perfect the horse it was decided that it was impossible to assemble the fragments in a virtual space. The only way to create the exact physical presence from the fragments was to 3D print them and work in a physical space. Working in a virtual world with X, Y, and Z coordinates is a high-level abstraction. The laws of gravity do not apply and the weight is not incumbent on a real floor.

Analysis of the gravity, structure, and presence of the horse in the physical world, using the 1:10 scale 3D-printed model was an essential part of the reconstruction process.

All the fragments of the horse were printed in resin on Formlabs stereo-lithographic printers. The process that was carried out digitally was then repeated by hand – a slow and painstaking process based on trial and error. The surface of the printed fragments and their edges were never altered. We were only focusing on the three dimensional coherence of the modelling. Subtle shifts can have a dramatic impact on the feel of the horse and its anatomy. As the pieces found their correct position and orientation, the sculpture started to assume the character of the plaster by Canova.


Once completed, the reassembled sculpture was rescanned. This gave a complete 3D model to work from. The low-resolution fragments were systematically replaced with the high-resolution data that could not be handled while trying to position the pieces. This was then carefully retouched by Irene Gaume working in Z-Brush to fill and rebuild all the missing parts; she went to great pains to fill in the lacunae while not in any way “faking” the surface. The final files have now been finalized. It is possible to produce an accurate physical version of the horse on a scale of 1:1 in bronze. Returning this iconic work to a prominent site in Bassano del Grappa could fulfil an important civic function.



IX. The camera positions used to create a point cloud of the Three Graces by Antonio Canova (Screengrab from RealityCapture software by Factum Foundation)



X. The point cloud up-close. Each individual point in the image above represents a common pixel found in more than one image (Screengrab from within RealityCapture)



A SERIES OF TEN ARTICLES WRITTEN FOR DOMUS  
MAGAZINE IN 2018 AND 2019  
BY ADAM LOWE AND CHARLOTTE SKENE CATLING.  
The articles were commissioned by Michele de Lucchi  
during his time as editor of the magazine.



A text by Adam Lowe & Charlotte Skene Catling,  
Published in *Domus* magazine, *Mediation over Time* articles, January 2018.

“Whoever effaces this statue of mine, may the Heaven god curse him, may the Earth below destroy his progeny, may the gods of heaven and earth diminish his kingship. Whoever changes or erases it, may IM, the lord of heaven and earth, and the great gods extirpate his progeny and seed from his land.”

The curse of King Idrimi, carved in cuneiform over his own effigy, speaks out in a voice that still resonates 3,500 years after being inscribed. This is the ultimate “articulate object”. To read his story of exile, tribulation, rebellion and eventual triumph – the world’s first autobiography – is to bless him.

“In Aleppo, my ancestral home, a hostile incident occurred so that we had to flee... I inscribed my achievements upon my statue. Read it and I will be blessed.”

Idrimi is the first recorded refugee from Aleppo, a precursor to the more than five million Syrian refugees so recently attacked and exiled. Idrimi’s foresight led him to protect his statue through his curse. Could he envisage the brutality and destruction that lay ahead? This figure, staring through broken glass eyes into the future with his hand over his heart, is carved from soft magnesite. He was discovered in 1939 by the British archaeologist Sir Leonard Woolley in Tell Atchana, the remains of the ancient Syrian city-state of Alalakh. His body separated from his head, someone in the past had carefully buried the broken pieces to prevent further damage.

Jessica Pocock founded the charity Making Light to share the stories of the Syrian diaspora in Britain, “highlighting threads that connect us both as individuals and culturally”, to encourage mutual understanding and empathy. They will be archived in the British Museum. Idrimi became the symbol for her project. In February 2017, Factum Foundation recorded Idrimi at the British Museum using two methods – a Breuckmann scanner and photogrammetry – in order to compare them. The Breuckmann projects patterns of light onto the surface of an object while a camera records the patterns, triangulating the position of surface points and converting them into points in 3D space. Photogrammetry, instead, creates 3D information from 2D images taken from multiple angles. Photogrammetry requires only a camera, while the new generation of software uses elegant algorithms to create highly accurate 3D models. From this data, the statue was rematerialised using the tools of the new technical revolution – digital mediation and 3D printing.

Idrimi was re-united with his head thanks to the conservators of the British Museum: literally “re-membered”. Now his doppelganger can carry his memory to places that the original sculpture will never be allowed to visit. It can do this as a “digital aura” in the form of virtual visualisations, or in physical form as a facsimile. Each encounter and engagement with an object and its stories is to honour those who made it, creating a connection and continuity that defines us as humans.

In the 19<sup>th</sup> century, culture was carried to the great cities of Europe in the name of preservation. Now it can reach everyone who is interested. We are at the start of a cultural rebellion where technology is allowing articulate objects to speak to anyone who has the time and desire to listen. The modernist age that reduced them to isolated pieces presented for aesthetic delight is over. The object is once again a complicated subject inviting engagement and inspiring thought. The muse has left the museum and found her wings.





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## 7.2 WHAT IS "ORIGINAL" AND "AUTHENTIC"?

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A text by Adam Lowe & Charlotte Skene Catling,  
Published in *Domus* magazine, *Mediation over Time* articles, February 2018.

"There is a time for everything... A time to tear down and a time to build... A time to scatter stones and a time to gather them... A time to be silent and a time to speak..."  
Ecclesiastes 3: 1, 3, 5, 7

We age and, as all things, we change over time. *The Basilica di San Marco*, the magnificent Italo-Byzantine conglomerate of a building in Venice, is a perfect self-declared manifesto illustrating the complex relationship between originality and authenticity. It is an accretion that has developed over time, through building, tearing down and rebuilding, destruction, theft, repurposing and reinvention. Here architecture takes on a geo-archaeological depth. Saint Mark's Basilica began with the pious theft of the relics of Mark the Evangelist in 828. This first building was violently destroyed with its doge inside, but the saintly remains miraculously reappeared from a column.

The Venetian concept of time and its own mythology is as liquid as the city itself. Its history was rewritten infinite times as it grew into an imperial power. Time itself was plundered to reinforce the Venetian narrative. Cities were invaded and spolia used to create a civic identity with instant historic resonance and physical authority.

Some of the looted building elements were absorbed seamlessly into the overall composition, some were copied, aping antiquity, while others were to be read as separate trophies, such as those from the Fourth Crusade: the four horses from the Hippodrome in Constantinople and the marble piers known as the Pillars of Acre. The porphyry treasures – the embracing Tetrarchs and the *Pietra del Bando* column fragment – were both strategically placed between church and state. The *pietra* was used as a platform for announcing public executions and the pillars for displaying severed heads; trophies were symbols of power – past and present. So what is "original" or "authentic"? The original four horses were looted by Napoleon, then returned, and now reside in the museum. The campanile collapsed in 1912 and was rematerialised. The only remaining 13<sup>th</sup>-century mosaic on the western facade is a self-portrait of the basilica as it once was, before radical changes made over time.

Saint Mark's uses all the reverberative power of direct quotation that extends time through the construction and manipulation of collective memory. Potent relics are displayed both as symbols of themselves and of Venetian conquest. Most of the booty was made up of building material: over half the 600 columns, capitals, mosaics and, not least, marble. Marble revetments were stripped from Hagia Sophia to be pinned like butterflies to the external brick walls of the Venetian basilica. Ruskin described the "muscular power of brickwork" clothed with the brightness of marble. He also used a metaphor of skin, suggesting that seductive flesh had been turned into "arousing artistic stone". We cannot stop ageing, but we are now at a point where we can record the surface of Saint Mark's exquisite watery panels of marble in just a few days, using only an elevated platform and a DSLR camera. Through photogrammetry, an area of about 1 x 2 metres was recorded in a few hours. The resulting photographs were processed in RealityCapture software, and then printed in colour relief using Océ's elevated printing technology. The result is remarkably similar to the original in terms of colour and relief, but not in terms of material. This data is an essential tool for monitoring the change on the surface.

The preservation of the past, and our connection to it, is never simple. But we now have the means of recording and monitoring, which facilitates a deeper understanding. Time collapses through these articulate objects, or in T.S. Eliot's words, "Time present and time past are both perhaps present in time future, and time future contained in time past."

A text by Adam Lowe & Charlotte Skene Catling,  
Published in *Domus* magazine, *Mediation over Time* articles, March 2018.



The debate about the “aura” of a work of art is focused on Walter Benjamin’s essay *The Work of Art in the Age of Mechanical Reproduction*, but is it still useful in the 21<sup>st</sup> century? The museum was the home of “aura” rich objects but the muse has migrated in search of a new habitat where inspiration can infuse receptive minds. Today’s debate is focused on the relationship between originality and authenticity, between commercial and philosophical value. You can now experience the physical symptoms of Stendhal’s syndrome when viewing a work of art you know to be a copy. From highly respected Egyptologists in the facsimile of the tomb of Tutankhamun, to art historians viewing Factum’s facsimiles at Strawberry Hill House and Venetians crying at the unveiling of the replica of Veronese’s *Wedding at Cana* in the Fondazione Giorgio Cini, the examples are well documented and grow in number. The work to re-make the Table of Teschen focuses the issue.

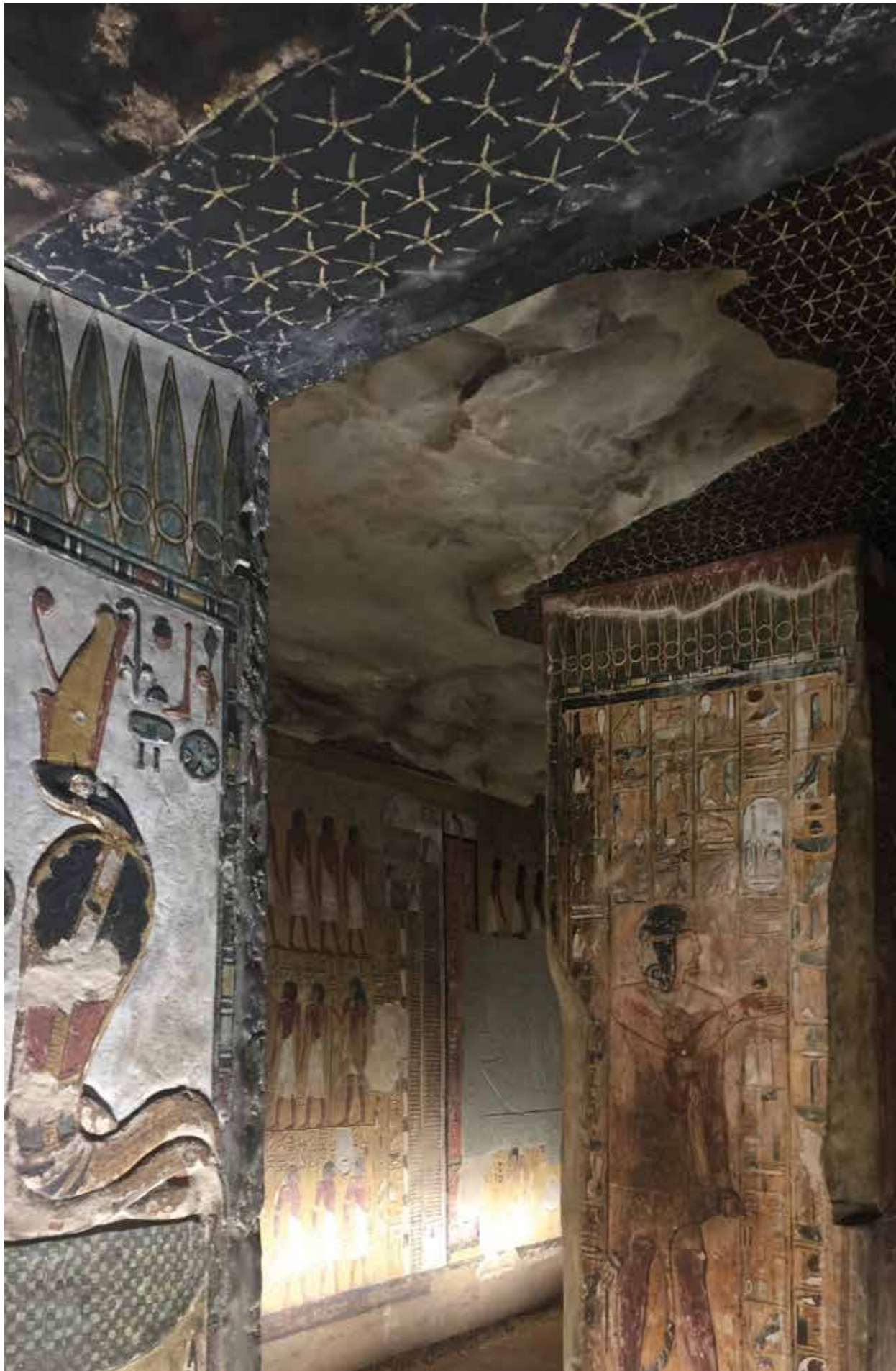
The “original” Teschen Table, now in the Musée du Louvre, symbolises the intersection between art, design, politics, diplomacy and the natural sciences in the 18<sup>th</sup> century. It commemorates a largely forgotten, yet highly important treaty in the history of international relations: the Treaty of Teschen. The treaty represents one of the defining moments in the evolution of European co-operation, establishing the principle of collective security that underpins many of our international institutions today, from the United Nations to NATO.

Created by Johann-Christian Neuber, using diverse and highly skilled craftsmen working in Dresden, the Teschen Table was presented as a gift by the Duke of Saxony to the French ambassador, the Baron Louis Auguste de Breteuil, in 1780 in return for his work to secure the treaty. It is an opulent table covered with 128 semi-precious stones sourced in Saxony, evidencing the growing interest in geology and alluding to the Duchy’s mineral wealth and prestige. The polished stones are inset with Meissen porcelain medallions by Johann Eleazar Zeissig, depicting allegorical celebrations of peace. The table top is also encrusted with floral designs in coloured glass and precious stone. It is an object that carries many narratives.

In 2015, the table was sold by the Marquis de Breteuil to the Musée du Louvre. As part of the conditions of sale it was agreed that one facsimile could be made to ensure the table’s continued presence in the Chateau de Breteuil. Factum Arte recorded the table using 3D scanning and composite photography supported by measured and written notations – an objective recording that made it possible, by merging digital technologies with established craft skills, to produce a facsimile that was almost identical to the original when compared side by side.

The facsimile now resides in the Chateau de Breteuil, one of France’s most visited tourist attractions. The emotional and historical impact of this copy in its original setting compliments the aesthetic impact of the original table in its new home.

The research into the processes to record and remake the table acted as a focus. Another table by Neuber has emerged suffering from war damage. From the skill set developed to remake the Teschen Table it has been possible to carry out a detailed study of the destroyed top and to re-imagine it as it was. As it always has, the past comes to life through the lens of the present.



A text by Adam Lowe & Charlotte Skene Catling,  
Published in *Domus* magazine, *Mediation over Time* articles, April 2018.

“The rest is silence.”  
Hamlet’s last words. William Shakespeare, *Hamlet*, Act 5, Scene 2

The ambient acoustics of a rock-cut tomb invisibly define its space. A tomb, when sealed, protects the most profound silence for eternity. This silence is not “nothing”, but an active absence of human sound and a living audience. The tombs in the Valley of the Kings are incised with a funerary narrative known as the Book of Gates, which leads the deceased through the underworld. The journey corresponds to the passage of the sun through the night, from death to rebirth. Upon dying, the pharaoh loses the senses that define him as human – hearing among them. Noise, like the buzzing of bees, overcomes defined sounds. The Book of Gates acts as a guide from senselessness to a re-attuned state that comprehends all the information in white noise.

The tombs are now filled with the buzzing of thousands of people. They bring essential income to locals, but also lead to inevitable destruction and decay. Thanks to written records and detailed watercolours, we know that the tomb of Seti I was in near perfect condition when it was discovered in October 1817. Then the great Egyptologists descended and in just a few years the tomb was reduced to a ghost of itself. In the name of preservation, large fragments were removed to the new museums that were appearing throughout Europe. Surfaces were “squeezed” and stripped of colour. Souvenirs were hacked out and carried off. Over the last 17 years, the tomb has been recorded using non-contact technologies and remade with an assortment of 3D output systems. The facsimile, by Factum Foundation, has an extraordinary presence. It looks and feels identical to its source, but all the senses need to be convinced.

Technology has made many things possible, but there is still more to do and subtle refinements are ongoing. The heat and humidity generated by thousands of tourists has to be replicated; smell, a musty mixture of time and stale body odour, must be introduced. The facsimile also needs to sound the same, with its silence reverberating with the same inaudible intensity of the tomb.

“Noise” has another meaning and significance in digital recording. In 2001 the technology did not exist to record the “flesh eating” alabaster sarcophagus from the tomb of Seti I, now in Sir John Soane’s Museum. The laser light of the scanner penetrated the transparent alabaster and the digital “noise” generated overwhelmed the information collected. In 2014, using just a 35mm camera, and the latest and most elegant photogrammetry software, the extraordinary RealityCapture 3D model was created consisting of 2.7 billion polygons. This digitisation also contains the colour of the alabaster, stained by London’s 19<sup>th</sup>-century smog, and the minute carvings that narrate the complete Book of Gates. But re-materialising all this complexity had to wait until the development of Océ’s remarkable elevated printing technology, along with the ingenious use of Global Mapper topographic software to separate the surface detail from the general form. The facsimile of Seti I’s sarcophagus is unprecedented in terms of recording technology, software application and output method. Facsimiles can help us understand more about the thoughts of people living 3,300 years ago than the original objects as they continue to decay. All things change over time, carrying with them the evidence of their unpredictable biographies. The tomb and sarcophagus of Seti I remained silent for more than three millennia. Now, although scarred by preservation attempts and mass tourism, they still allow future generations to understand the extraordinary insights of pharaonic philosophy. For the ancient Egyptians, the “buzzing of bees” contains more information than the living can comprehend. “Buzzing” has stood the test of time. Is tweeting ephemeral?



A text by Adam Lowe & Charlotte Skene Catling,  
Published in *Domus* magazine, *Mediation over Time* articles, May 2018.

“Between the conception and the creation  
between the emotion and the response  
falls the shadow.”

Thomas Stearns Eliot, *The Hollow Men*, 1925

And on the Sixth Day, God created... the Shamir...! This tiny creature appears in several Jewish sacred texts, including the Talmud, as one of the ten miraculous creations of day six of the Hexameron. The Shamir was a worm, the size of a grain of barley, whose intense gaze could cut through even diamond, the hardest substance known to man. Such tremendous power needed to be both protected and contained, and for this God chose the Hoopoe bird, which – with the caution worthy of a nuclear launch code – sealed the minute but mighty worm into a lead box, the only material able to withstand its laser-like glare. The Shamir was kept safely encased, in the Garden of Eden, until required by Solomon as principle stonemason for his Temple. Since then, this curious but voracious creature seems to have gone quiet, but for the mysterious phenomenon of “vermiculated rustication”...

Rustication – the symbolic, sculpted transition from raw material to rarefied architectural composition takes many forms across a spectrum; from “Cyclopean”, coarse boulders hurled together with mythological strength where rock is carved to mimic a more primitive version of itself, to the geometrically pure “diamond- pointed”, the armour-plating of Renaissance architecture. Rustication is a built metaphor for the transforming process of construction, from its geological origins, hewn out of natural rock, through to its civilising refinement as it leaves the ground and rises into the sky.

All types are characterised and animated by the presence of shadow. Rustication adds actual and illusory depth to a facade. But none as powerfully as vermiculated – or “worm-eaten” – rustication where the depth is both literal and metaphoric.

This is architecture as *memento mori*, a portal to the Underworld, where the subterranean speaks to the subconscious, earthly Self.

Here, petrified organic traces and worm-eaten trails meander across the larger framework of stone courses and punctuate the overall facade. “Ruin” reveals a biographical narrative, manipulated into decorative pattern-making. These organic forms are a rich counterpoint to the blank stare and glazed slickness of much contemporary building, where the viewer’s gaze is bounced off the surface through reflection, locked out of any real engagement with impenetrable architecture.

Technology is allowing us to play once again with the idea of depth and to sculpt the shadows between conception and creation. Organic modelling and 3D scanning are the breeding ground for wind-eroded, maggot-eaten and exfoliating forms. The Computer Numerical Control machine (CNC) is the new “stone-eating worm” and can carve with a precision that would have mesmerised Grinling Gibbons. Laminar build systems can place impossibly thin layers of different materials on top of each other until a form emerges like Aphrodite from the sea foam.

These panels are the first of a series of new vermiculated rustications – geo-archaeological forms that will make up the facades of new architectures. Some are routed directly into limestone, marble or concrete; others are moulded and slip cast in clay from the originals.

Designed to hold earth and capture urban grime, these surfaces have an aesthetic that evolves as they generate their own life and miniature ecosystems. They are a 21<sup>st</sup>-century architectural Vanitas, speaking of life, death, dirt and time.

A text by Adam Lowe & Charlotte Skene Catling,  
Published in Domus magazine, *Mediation over Time* articles, July 2018.

“There is no art without Eros.”  
Max Frisch

In myth, the world began with Eros, the primordial god of love, emerging from Chaos. As a driving life force, and through irresistible longing, he “unnerves the limbs and overcomes the mind” (Hesiod, *Theogony*). Eros represents the battle between body and mind, and equally, their synthesis. Great art is a sensual piercing of the intellect, understood through desire. It sublimates and transforms, merging hardness and softness.

In 1708, the Saxon alchemist Johann Friedrich Böttger discovered the secret of hard-paste porcelain production in Europe – or “white gold”, as it was known – using pale kaolin clay and the feldspathic rock petuntse. Bone china is a soft-paste porcelain made with clay and the ash of cattle bones. In Limoges in the 1760s, producers found a large kaolin deposit and began making an imitation softpaste, mixing the white clay with powdered glass to dazzling effect and widespread yearning.

Delicate porcelain *gobelets à lait* (“milk goblets”) were developed by Sèvres to hold the milk-cure for the anxious, depressed and over-sexed, and to prevent “insane love”. These vessels, some deeply recessed into the socket of their saucers to prevent the quivering hands of delicate owners spilling the contents, became known as *trembleuses*; exquisite emblems of rarefied temperaments. Four porcelain *bol-seins* or *jatte-tetons* (“breast cups” or “nipple bowls”) were commissioned for Marie Antoinette’s dairy at Rambouillet in 1787. Rumoured to have been cast from her royal breast, the thought of the casting process gave a voyeuristic frisson. Each was delicately painted to mimic flushed living flesh, its erect nipple a deeper shade of pink. To drink, the milk-filled breast is lifted from its tripod base where it rests on the curved horns of three goats.

In 18<sup>th</sup>-century medical discourse, milk, a symbol of pastoral purity and feminine innocence, was put forward as a wholesome health cure for the elite ailments of the urban upper class. Diderot’s *Encyclopédie* included the essay *Lait* (“Milk”) as part of a new secular Enlightenment morality. But in recommending adult breastfeeding as a cure for gloom, the author saw there might be unavoidable erotic side effects; if “[adult men] can be cured by habitually lying with young and beautiful wet nurses, this salutary revolution might be due to the constant excitement of the venereal appetite.” 18<sup>th</sup>-century medical and architectural treatises were presented as thinly disguised erotic novellas to make their subjects more compelling. Milk was the treatment for the hypersexual “trembling” young girl described in Dr. Bienville’s medical tract *Nymphomania, or Treatise on the Uterine Furies* (1771), personally administered by the doctor, vaginally as well as orally. The aristocratic mania for milk and rural life, or a rarefied simulacrum of it, led to a whole genre of architectural contrivance: the *laiterie d’agrément* or “pleasure dairy”, little temples to health and the simple life. But Marie Antoinette’s Hameau and Rambouillet failed to project innocence: her pleasure dairies became infamous as rendezvous for degenerate, incestuous sex, and were part of her downfall.

Pauline Bonaparte was still growing up when Marie Antoinette lost her head. Napoleon’s sister became known for her beauty – specifically, her beautiful breasts – and her promiscuity. When her second husband Camillo Borghese commissioned an allegorical portrait from Antonio Canova, Pauline rejected the artist’s suggestion to portray her as a chaste, robed Diana, and chose the seductive *Venus Victrix* instead, with an allusion to the Borghese family’s mythical descent from Venus, via Aeneas, founder of Rome. But Pauline evidently also enjoyed the scandalised response to her topless portrait and the speculation of her posing naked; she even invited Canova to immortalise her breasts as casts.

Casting the soft tissue of a breast and the dynamic nature of a nipple in plaster without deformation takes great skill, as Pauline’s breast at the Museo Napoleonico in Rome demonstrates. This is a natural breast, subtle and observed. Silicon casting now captures subtlety more easily, and there are echoes of Canova’s sculptural practice in today’s aesthetic surgery through mark-ups, augmentation and removal. Canova used a *machinetta di punta* (“pointing machine”) to translate his plaster originals into marble. Marking the plaster with metal pins, identical points were exactly located using the *machinetta*, and drilled into the marble block, to specific depths at pre-determined angles.



© Andrea Avezzi. Courtesy of La Biennale di Venezia

The stone was carved away to reveal the original form, and the surface then worked to a skin-like finish in the final transformation from liquid to hard plaster, to point cloud, to marble.

The reclining marble of Pauline, now at Villa Borghese, was scanned and photographed by Factum Arte in 2016, working with glass master Giberto Arrivabene. She was stereo-lithographically printed in tanks of liquid resin, moulded and cast to make a wax positive. The opaque marble original was translated into glass through lost-wax casting. Like pouring a bowl of milk into water, the glass figure has the mysterious complexity of a moving cloud. She seems to dissolve into the sensual suggestion of an idea. From the light glancing off the waxed surface of the life-sized marble original, to the light swelling inside her miniaturised glass body, an ethereal life force is made visible.

The life force vs. the death wish: Eros vs. Thanatos. In the whisper of a guillotine blade, Marie Antoinette loses her head. Thanatos triumphs, and Eros is momentarily returned to Chaos, only to re-emerge, like the glass Pauline, in another form.

A text by Adam Lowe & Charlotte Skene Catling,  
Published in *Domus* magazine, *Mediation over Time* articles, September 2018.

“To put a city in a book, to put the world on one sheet of paper -  
maps are the most condensed humanized spaces of all...”

*Eccentric Spaces*, Robert Harbison, 2000

In cartography, contour lines join points of equal distance from a given level to describe form. In our digital age the means of transforming the real world into a representation of itself have multiplied and cartography has emerged as a realistic language; a hybrid concoction of measurements, signs and graphic notations from which we create mental constructions to see places we know well, imagine places we have never visited and grasp places that exist only in the imagination. Topographic information used to be extracted from painstaking measurements taken by romantic and eccentric figures. Today it is derived from using the speed of light to define distance or ‘feature mapping’ composite photographs to generate form. The evidence of the hand is now mediated by the tools it chooses from a digital palette. These are predetermined by elegant and inventive algorithms written by invisible digital artisans.



An equivalent of these artisans is found in 12<sup>th</sup> century Sicily in the cartographers who worked in the court of Roger II with the Muslim scholar al-Sharif al-Idrisi to produce an extraordinary world map. Al-Idrisi’s legendary book, the *Kitāb nuzhat al-mushtāq fī ikhtirāq al-āfāq* (*The Book of the Journey for He Who Longs to Penetrate the Horizons*), is the evidence of their collective genius.

The mountains in al-Idrisi’s masterpiece don’t have contours; they have shape and colour. They sit in an unmarked background with graphic notations and handwritten script. Cartographic clarity is based on many types of sign to draw quantities, evidence and narratives into the map. It functions both as image and information. Al-Idrisi and his team gathered information from travellers passing through the ports of multicultural Sicily over a period of about fifteen years, cross-checking it, measuring distances and striving to produce a clear and useful representation of the world – useful for trading both knowledge and materials. The stories on the map include narratives of whales and turtles ‘twenty arms long’ with thousands of eggs in their bellies, exotic places inhabited by serpents whose gaze was deadly, lavish clothes and valuable stones.

Each selected element is carefully delineated and brought into focus while the multitude lies unfocused in the bokeh of our imagination. The restless nature of perception prevents stasis. The mix of thoughts and actions, trade and veneration, mystery and narrative merge to produce a dynamic and constantly changing terrain of act and fiction.

The map itself was engraved onto a silver tray, two meters in diameter, which was lost in a shipwreck soon after its completion. The Ottoman copy in the Bodleian Library, Oxford, survived.

The digital artisans working to recreate this great map form a team with diverse skills and perceptions. Collectively they determine the limits of our cartographic imagination and define the contours that control the CNC engraving tools and the laminar building systems used to rematerialize our world in physical form. Borges would have delighted in the new families of materials that can be fused by heat and light or carved with a precision that previously required a perverse array of manual skills. Electricity is the king in this hybrid, alchemical world as liquids transform into solids, metals emerge from powder and stone is reduced to dust.

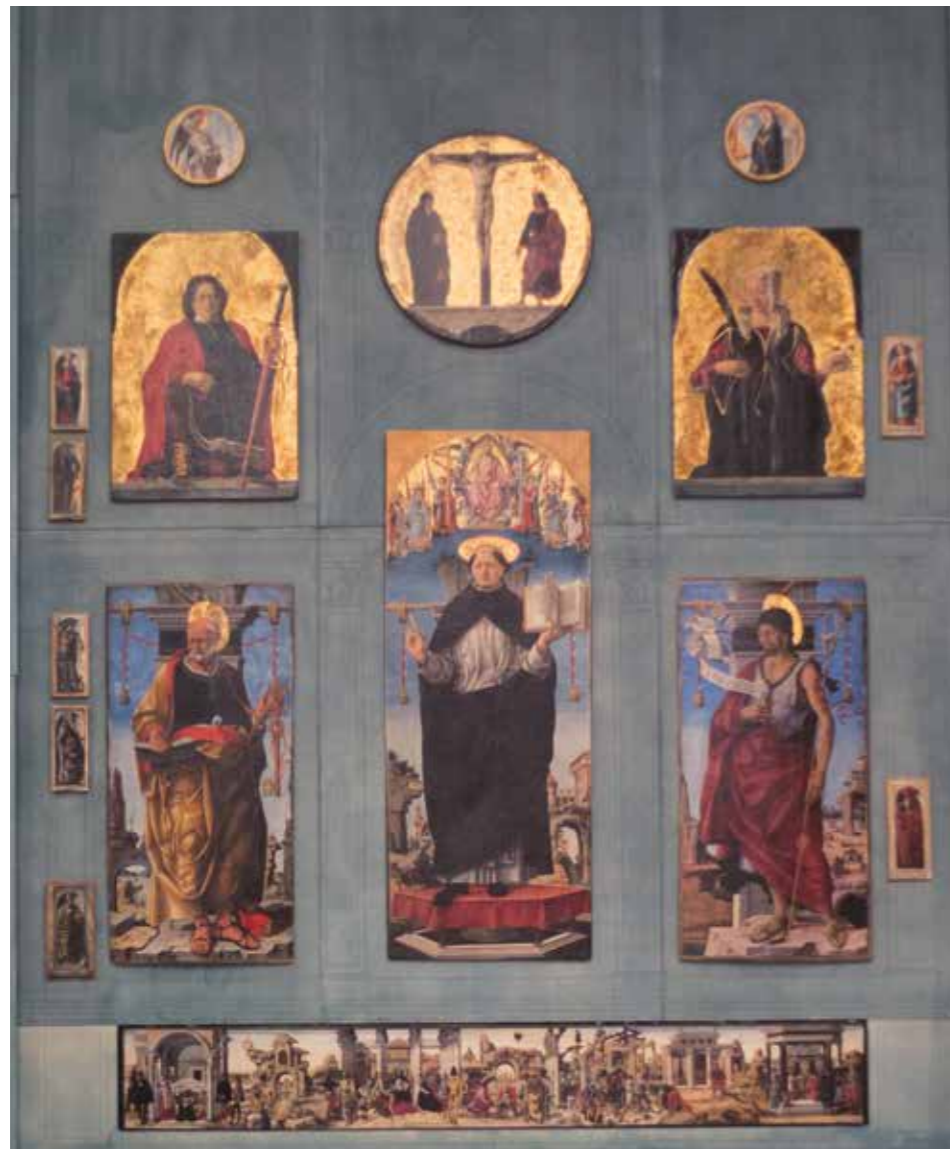
But as much as it strives to take physical form, the digital remains an electrical stimulus. It is a bit noisy, but with care it is a signal that can be controlled. As a visualisation it exists in a nebulous space dependent on light and a surface to receive the light. In this spectral form it can hover as virtual, augmented and mixed realities that we can experience and interact with.

J.R.R. Tolkien inhabited the imaginary space of Middle-earth but made it real by producing detailed maps complete with contours and ordnance survey notations. These great works are currently on show at the Bodleian Library in Oxford (*Tolkien: Maker of Middle-earth*, until 28<sup>th</sup> October 2018). At the centre of the display is a model of Middle-earth merging the virtual and the physical. A relief map with illumination from above and below gives the sensation of looking through Tolkien’s eyes and thinking his thoughts. Craftsmanship and technology have merged. His thoughts have taken a physical form, merging illusion with reality.

In this period of ‘post truth’, subjectivity and objectivity become liminal and fluid. But the wonder of art is that it occupies a place where the muse still resides, a place where objects are celebrated as complex subjects that reward any amount of study. They reveal the truth to those who look for it, and aesthetic pleasure to those who find it.

A text by Adam Lowe & Charlotte Skene Catling,  
Published in Domus magazine, *Mediation over Time* articles, October 2018.

"To thine own self be true"  
*Hamlet*, Act-1, Scene-III, 78-82.  
William Shakespeare



The 'Vera Icona' was the original and ultimate self-portrait: an image made without the imperfections of human hand and mind, a direct imprint of 'Him Self'. Once unique, the 'mandylion' spawned many copies that sought to capture the truth within the image: the unchanging eternal truth of the Son of God, made in the image of God himself.

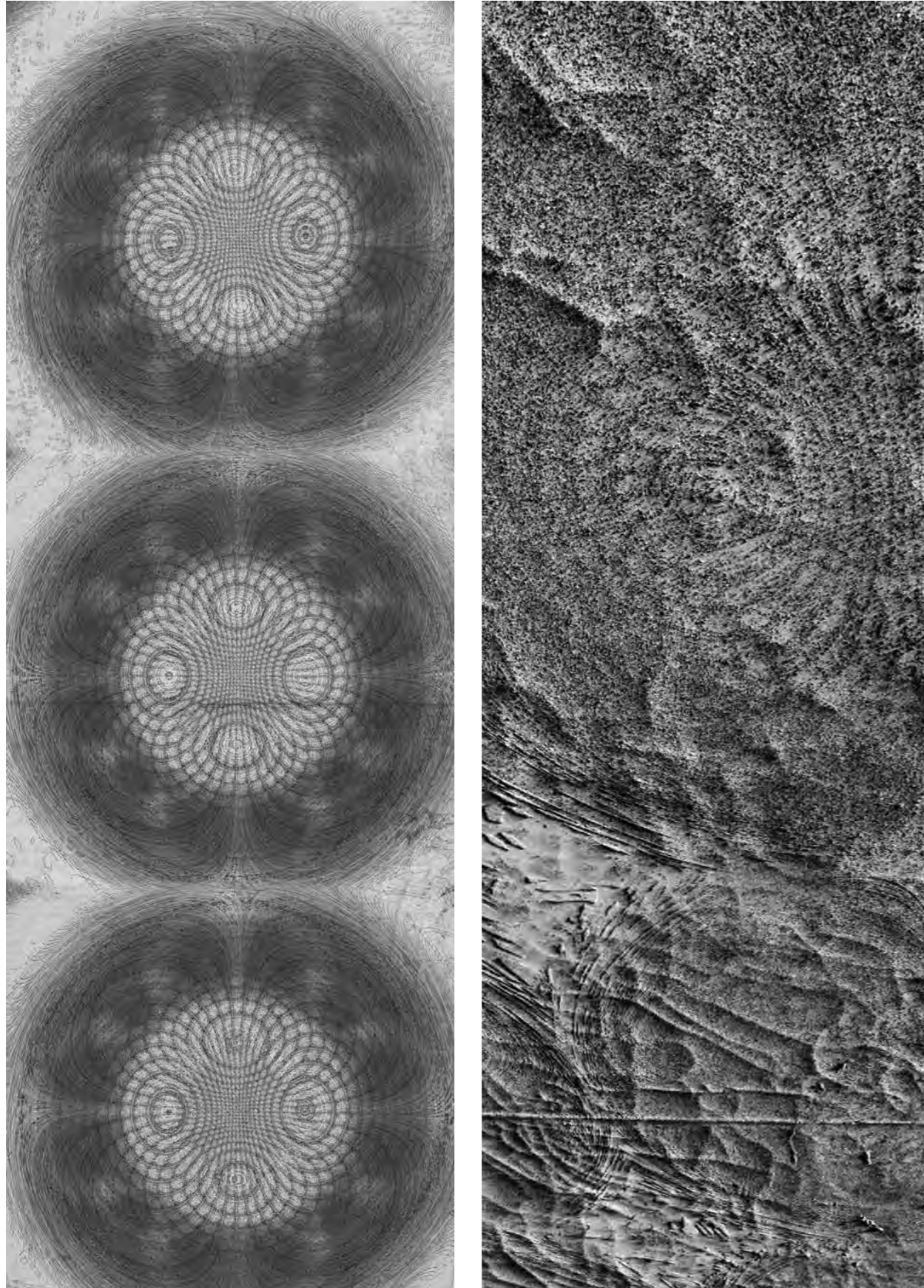
Today's 'selfies' are shameless and ubiquitous, each an ephemeral trace of a moment, often used for constructing stories around the 'self' that stray far from the 'truth'. Each year in the Musée du Louvre, the Mona Lisa, the most famous and photographed painting in the world, is surrounded by millions of people. Many turn their backs to the painting as they use their phones to record themselves with the celebrity in her bullet-proof, glass case. During this act, they face the Louvre's former greatest attraction, Veronese's vast *Wedding at Cana*, the counter-reformation masterpiece depicting the complexity of life, narrative, myth and intrigue. The *Wedding at Cana* was recently featured in the *Apeshit* video by Beyoncé and JAY-Z, an art-historical fly-through which has already been turned into a Louvre tour, attracting a new generation to the museum. Hopefully some of these visitors will see the painting they are facing and ask the question, 'where did this come from...?'

Veronese painted the *Wedding* onto the canvas-covered end wall of Palladio's refectory on the island of San Giorgio Maggiore in Venice. At its original site, it filled the wall in dialogue with, and as an extension to, the surrounding architecture. It was a focus for meditation and reflection, slowly delivering its complex message to the monks who ate there. Windows either side provided light, and each day at a different time the shadows in the room align with the illusion in the painting. Napoleon's soldiers cut the painting into strips when they ripped it from the wall. At the Louvre, what can be glimpsed through the crowds is an extensively restored and altered painting hanging in a heavy gold frame, at the wrong height, between two doors, illuminated by diffuse light from above. Factum Arte's facsimile, which puts the painting back into its intended refectory location within the *Fondazione Giorgio Cini*, questions the very notion of 'originality', and suggests a new one, based on experience.

The fate of the great Bolognese polyptych, the *Polittico Griffoni*, painted in 1471-2 by Francesco del Cossa and Ercole de' Roberti, is another demonstration of how facsimiles can create experiences capable of reuniting the viewer with the original intentions and power of a work of art. The *Polittico Griffoni* was removed from the Griffoni chapel in the Church of San Petronio in 1725 when the chapel was re-dedicated to the Aldrovandi family. The panels were taken out of their gold surround, separated and sold. Today, sixteen parts of the altarpiece are dispersed between the National Gallery in London, the National Gallery of Art in Washington, the Vatican Museum, the Brera in Milan, Museo di Villa Cagnola in Gazzada, Museum Boijmans van Beuningen in Rotterdam, the Musée du Louvre in Paris, Collezione Vittorio Cini in Venice and Pinacoteca Nazionale, Ferrara. Each panel reveals how it has been cared for, preserved and restored since its removal. The gilded altarpiece and some panels are still missing. A schematic drawing of half the complete object still exists in Bologna. The facsimile of all the known panels has been returned to the Church of San Petronio, prompting new interest in the complete work.

In the *Polittico Griffoni's* fragmentary form, the panels as individuals contain great beauty. But the complete polyptych has a visual coherence as it rises from the temporal and perspectival world depicted in the predella to the gilded otherworldliness of the upper panels. Only together do they articulate their message.

Works of art are fundamentally about communication. A facsimile is an iteration, indistinguishable in scale, colour and surface to the naked eye under museum conditions. It is a technologically objective replication generating forensic evidence that allows a profound understanding of the dynamic process of originality. Is this today's 'true image'?



A text by Adam Lowe & Charlotte Skene Catling,  
Published in *Domus* magazine, *Mediation over Time* articles, November 2018.

Where eldest Night  
And Chaos, ancestors of Nature, hold  
Eternal anarchy amidst the noise  
*Paradise Lost*, Line 879. John Milton 1667-79

In myth, Chaos is the void. This unfathomable origin of everything gives birth to Erebus and Nyx, darkness and night.

Robert Fludd uses a black square as a simple but conceptually radical depiction of the absence that preceded Creation in his *Utriusque Cosmi* of 1617. At each edge of the square, the words '*Et sic in infinitum*' extend a limitless blackness to create the perfect metaphysical context out of which the universe could unfold. In '*Paradise Lost*', John Milton followed Fludd in reversing the mythological order so that darkness and 'eldest Night' came first. For Milton darkness was accompanied by silence. Chaos – 'eternal anarchy' – writhed to a soundtrack of noise.

As well as cacophony or disturbance, 'noise' is used to describe meaningless or irrelevant data picked up at the same time as desired input. Radio transmitters emit an incoherent hiss until tuned into particular frequencies – omitting all others – to produce recognisable sound. In the digital world of 3D scanning, 'speckle noise', generated as light waves, are reflected with uneven intensity from complex surfaces and has to be filtered out to allow clarity and legibility. Noise becomes visible as a freckled field through which the content emerges, like a galaxy from a star-filled night sky.

For Ovid, when he wrote '*The Origin of the Cosmos*', Chaos was more of a philosophical concept than a mythological deity. He described it as 'congested in a shapeless heap', a 'rude and undeveloped mass' ... and again, suggesting noise, with 'discordant elements confused'. Anyone involved in making things will recognise the creative process that pulls chaos into something meaningful, transforming the apparently random into order, drawing harmony from discord. In a brilliant act of imaginative creativity, Fludd illustrates Creation itself. After the black square, he depicts the profound and unimaginable as a series of concentric, monochrome images: a storyboard of Genesis that verges on abstraction. Darkness is overthrown first with the concept, then the Word. With '*Fiat Lux*', the void is pierced with light.

As mysteriously as order emerges from Chaos, a recent 'digital accident' hints at the vast unknown and invisible that surrounds us. The Lucida Laser Scanner, designed by Manuel Franquelo and made in conjunction with the engineering team in Factum, was used to make a 3D and colour recording of Goya's vast *Maria Louisa on Horseback* of 1799 at the Museo del Prado, Madrid. Its surface is encrusted with paint – thicker and more active around the horse and sitter, but heavily cracked and undulating around the stretcher bars. The whole painting, over three metres tall, moves almost imperceptibly in the museum air-conditioning and the turbulence caused by visitors. This subtle motion was picked up as noise in the data produced by the laser scanner. Clusters of vertical parallel lines, 2.5cm high, and of varying widths, could be seen in the output. To remove them, a special algorithm was written that could identify their characteristics and separate them from the surface relief of the painting. The Lucida scanner captured sections of the canvas that measure 48 by 48 cm, with an overlap on each side so that they can be accurately tiled together. During the operation of data processing, and reconciling the outcome with the painting surface, there was a software clash that produced an unexpected artifact: a moiré or interference pattern that resembles sacred geometry, or a figure produced by an harmonograph. Curiously they also recall Fludd's centrally focused representations of the divine formation of the cosmos where light radiates from a centre into darkness: a geometric pattern as iconic symbol.

Chaos and noise represent 'full potential', where the creative act is one of selection, reduction and focus to reveal what is already there: the 'essence'. Rather than additive, it is a process of removal. By implication, the filter of art allows a glimpse of the divine. Through creation, we have Paradise Regained.



A text by Adam Lowe & Charlotte Skene Catling,  
Published in *Domus* magazine, *Mediation over Time* articles, December 2018.

"Remember me, remember me, but ah!  
Forget my fate.  
Remember me, but ah! Forget my fate"  
*Dido's Lament, or 'When I am Laid in Earth'*  
From *Dido and Aeneas* by Henry Purcell,  
libretto by Nahum Tate, 1689

These are Dido's words as her lover, Aeneas, departs by boat from Carthage. With the smoke rising from her funeral pyre, she sends an ephemeral sign to him that she has killed herself. Purcell's heartbreaking aria captures our human longing to be remembered, with our simultaneous need to manipulate that memory.



This is the last of ten short pieces written for *Domus* this year, each focused on the complex relationship between the past and the present, and why the material evidence of our history is so critically important. The first was a reflection on Idrimi, refugee King of Alalakh, whose autobiographical statue was decapitated in an attempt to control the power of his image and send his memory to oblivion. But through physical remains, Idrimi is remembered while his assailant is long forgotten.

Iconoclastic attacks on works of art are ubiquitous through time, tracking contemporary machinations. In ancient Egyptian sites iconoclasm reveals the zealotry of the early Christians who asserted their beliefs by hacking out the original subtle carvings, especially faces; they record the negligence of the Salle Copts who subsisted inside the great temples; they chart the cultural arrogance of the European visitors who incised, 'squeezed' and graffitied their way through the 19th century... and they bear the scars of today's global obsession with Pharaonic culture. Mass tourism exploits these extraordinary achievements by traipsing millions of sweat- and heat-emitting people through tombs designed to last – unopened - for eternity.

But how much has already been lost through war, decay and displacement? These are ongoing threats. Dido was the legendary Queen of Carthage, a town newly settled by refugees from Tyre. In nearby Sidon, Phoenician 'anthropoid sarcophagi' were discovered, having evolved from Egyptian funerary monuments with Greek influence. The most magnificent collection is found in the National Museum of Beirut, located on the notorious Green Line that divided East from West Beirut during the bloody Lebanese civil war of 1975 to 1990. With great foresight and ingenuity, Maurice Chebab, the Director of Antiquities, hid his smaller objects behind false walls and enveloped his sarcophagi in concrete tombs where they stood, saving them from bullets and shelling, and the snipers and militia who occupied the building. The collection of 31 sarcophagi are beautifully carved from white marble, their bodies perfect simplifications of earlier Egyptian mummies, but each with a perfectly unique face - a portrait - as if the soul of the occupant somehow rose through the marble, emerging as a tangible and recognisable presence. Here and there are further human details; hair curls, a headdress, toes that seem to grip, an arm; a hand holding a flower between delicate finger and thumb that have escaped death to rest on the smooth abstraction of the stone encasement.

Iconophilia can be as damaging as iconophobia; at the Ptolemaic 'Crocodile' Temple of Kom Ombo near Aswan, the distinct faces of a series of healing figures have been almost completely eroded through the tactile worship of fervent believers seeking cures, fertility or physical health. The meteor on the corner of the Kabbah - set into its silver frame following iconoclastic attack by the Christians - is now a black recess caused by repeated touch. Richard Burton claimed the blackness was the visual evidence that the stone absorbs human sin.

We live in a period of extreme division between rich and poor. The vast differences in wealth, global movement and political systems seem to be calling for a radical overhaul. So too do our current notions of 'leisure' and 'culture', and the way the former has subsumed the latter. Our desire for luxury is coupled with a cult of 'the self' that takes many forms of worship: from pampering, auto-analysis and psychobabble, to dietary fads and obsessive exercise. In this climate, our fragile sense of identity is masked in hedonistic disguise, through anti-aging treatments and stem cell technologies...for those who can afford it. We are in a daily process of fashioning our own image to be remembered by, and through it we are turning into living reproductions of ourselves. We want to be seen, but we want to control the image. How will we be remembered as a culture in the future? Perhaps our own bodies will be the material evidence that reveals our current concerns.

Wealth is needed to build empires, but individuals and civilisations are never remembered simply for being rich. Money is only memorable through what it's able to generate, instigate and create. Memory is a collective force that can be shaped but never owned. Cultural artefacts offer a profound way for humans to communicate, vaulting over time, different philosophies and religions, education and perceptions. Collectively they provide a vast pool of information from which new thoughts can emerge to influence us both emotionally and intellectually. These objects need to be engaged with in order to question, re-set and realign where we are today. By looking closely at the past, we can refocus a vision for the future. Through our memory, we can shape our fate.

Up: detail of the Temple of Kom Ombo, which stands on the promontory of the homonymous town in Egypt, on the west bank of the Nile. It was built during the Ptolemaic period.

Bottom: Phoenician anthropoid sarcophagi conserved at the National Museum of Beirut.

Re-creation of al-Idrisi's world map engraved in silver using CNC milling.

A SELECTION OF PROJECTS CARRIED OUT BY FACTUM FOUNDATION AND FACTUM ARTE SHOWING THE DIVERSITY OF FABRICATION, RECORDING AND TRAINING INITIATIVES





Lucida 3D Laser Scanner 2001 - ongoing

The Lucida 3D Laser Scanner is a close-range, non-contact laser recording system that captures dimensionally accurate high-resolution surface texture data for low-relief surfaces such as paintings or bas-reliefs. The Lucida, along with its hardware and software, were designed, built and developed by Spanish artist and engineer Manuel Franquelo and artists, conservators and engineers at Factum Arte, with logistical support from Factum Foundation.



Replica 360 Recto/Verso Recording System 2015 - ongoing

The Replica revolving table scanner was designed by Adam Lowe and Dwight Perry and built by the team at Factum Arte for the Fondazione Giorgio Cini and EPFL. It was designed specifically to record the Cini's collection of one million photographs. It is a high-resolution image capture system that records front and back of a document at the same time.



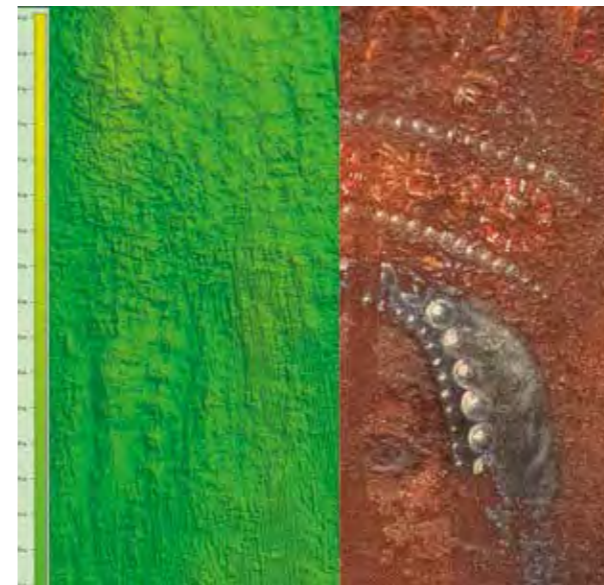
Book Scanner 2016 - ongoing

Designed by Enrique Esteban this manuscript recording system, captures, downloads and corrects the image. It has been in use at the State archives in Daghestan for over a year and can be controlled by remote access from Madrid. It has been designed to record fragile manuscripts without damaging the binding.



Portable Book Scanner 2017- ongoing

Portable Book Scanner: Keep the first sentence and add: The scanner is lightweight, easy to assemble, and fast, whilst maintaining a standard manuscript imaging quality of minimum 300 dpi. It can be transported in normal camera bags and one custom-made case.



RTI computational photographic method 2018 - ongoing

Since 2017, Factum Arte has been developing a new surface scanning system for materialization of high quality facsimiles based on Reflectance Transformation Imaging. This work has been led by Jorge Cano and Enrique Esteban (Engineering Department at Factum Foundation). In recent months Adam Weigert and Abhijit Dhanda (Carleton University) have significantly added to the innovation integrating 3D data from photogrammetry, RTI and photometric stereo.



Small Object Scanner 2018 - ongoing

A photogrammetric system with a revolving table and multiple programmable camera positions. This photogrammetric system has been developed by Matt Marshall in Factum.



Photogrammetry 3D recording with a camera 2016 - ongoing

Increasingly photogrammetry is emerging as an important tool in the 3D recording of sites and objects. Multiple camera positions allow an object to be recorded in three dimensions. If done correctly this method can produce high-resolution data. Factum Arte is working closely with Capturing Reality to improve their Reality Capture software. In recent months Adam Weigert and Abhijit Dhanda (Carleton University) have significantly added to the speed of the research into both hardware and software developments.

Recording, facsimile and digital restoration of the largest map of the renaissance in the Vatican. The work was done for the Museum of the City of Bologna in collaboration with Dr. Nadja Aksamija and Francesco Ceccarelli.



Non-contact digital restoration

- Top: Colour recording from the wall of the Sala Bologna.
- Middle: Digital restoration of the landscape and reconstruction of the centre of Bologna.
- Bottom: Digital restoration of the toponyms



3D Recording and production of a facsimile of all known fragments of the Throne room of Ashurnasirpal II. Two Lamassu from the British Museum recorded by Factum Arte. In early 2014 plaster casts of the works recorded were donated to the Ashurbanipal Library project in Mosul. These were destroyed during the occupation of Mosul by Islamic State. In a collaborative initiative between the British Museum, the Rijksmuseum van Oudheden and Factum Foundation, the Lamassu will be delivered by the Spanish Ministry of Defense to the University of Mosul.



© Rijksmuseum van Oudheden

Plans are now being finalised with the Spanish military to ship the facsimiles of the Lamassu to Mosul and install them permanently in Mosul University.

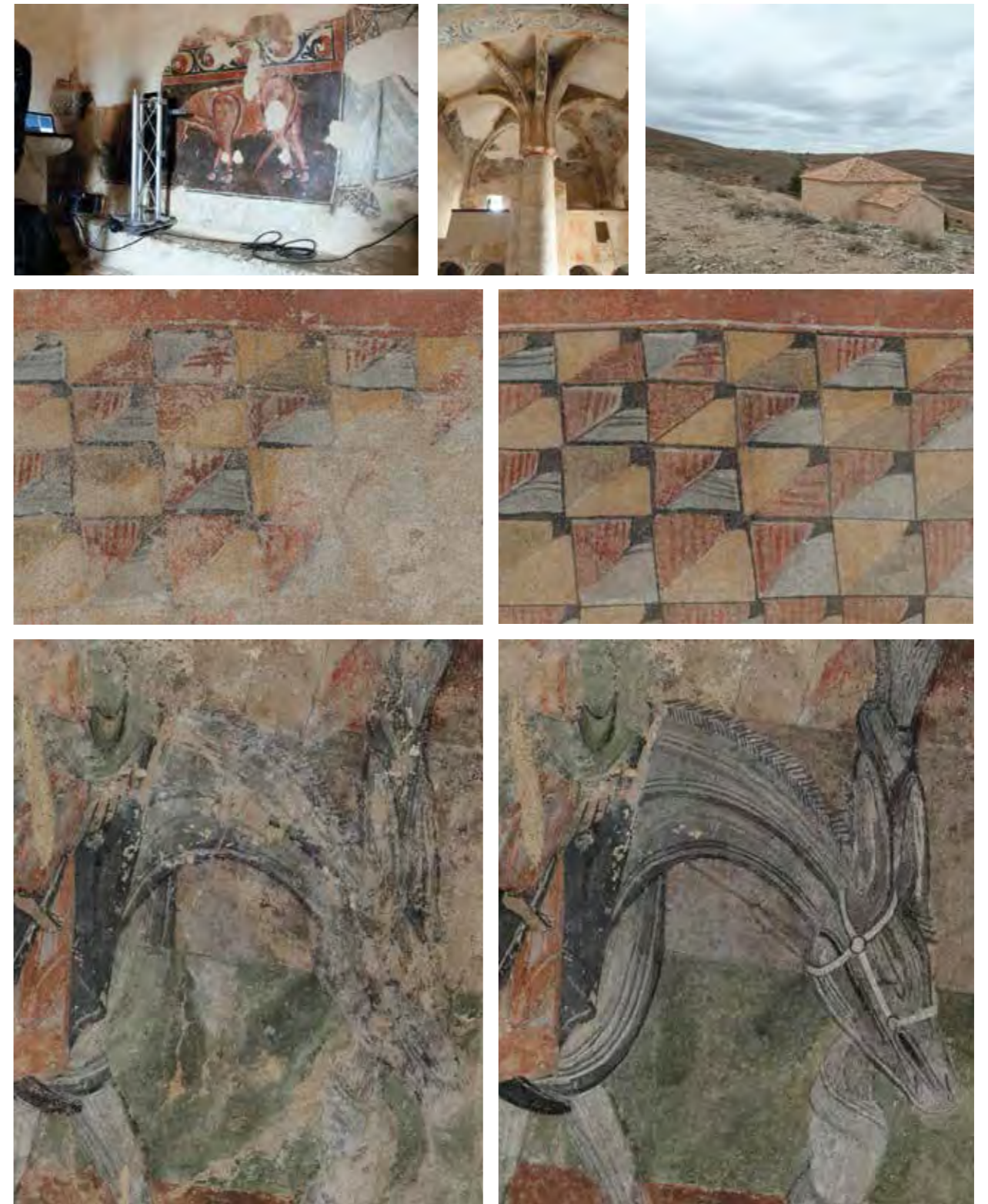
All 16 panels of the Polittico Griffoni have been recorded at high-resolution. A facsimile was donated to the Church of San Petronio in October 2017 in time for the Pope's visit. The altarpiece, painted in 1472 by Francesco del Cossa and Ercole De' Robert, formed the central part of the Griffoni Chapel. It was removed in 1725 and split up. It is now housed in nine different museums in North America and Europe. An exhibition of both the original panels and the complete facsimile will take place in Palazzo Fava, Bologna in March 2020.



3D recording and facsimile production of the romanesque capitols in the cloister of the Cathedral at Tudela. The capitols are crumbling to sand. The cause has been attributed to restoration works carried out in the 1950's.



Recording and digital restoration of the frescos from the Hermitage of San Baudelio. A significant part of the decorative cycle in this Mozarab chapel was removed in 1922, restored in London and shipped to New York. In 2013, the Factum Foundation started a project to virtually restore the wall paintings. In 2016 the chapel was scanned and photographically documented as part of a research project with students from Columbia University. The 3 panels in the Cloisters Museum, New York, were also recorded.



3D and colour recording and production of the facsimile of Tutankhamun's Burial Chamber. The replica is installed next to Howard Carter's house at the entrance to the Valley of the Kings, Luxor. This facsimile was produced as part of the Theban Necropolis Preservation Initiative, carried out with the University of Basel and the Ministry of Antiquities. The digital data also offers new opportunities for study.

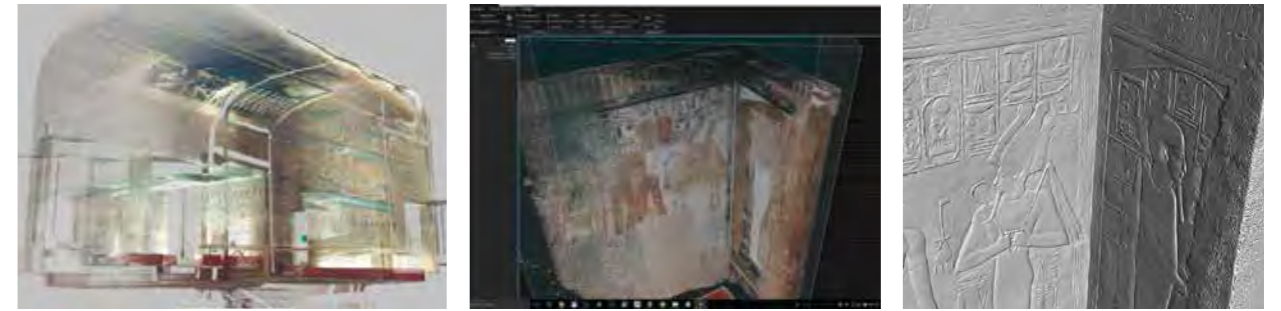


The replica of the Tomb of Tutankhamun is now housed in an underground building next to Howard Carter's house at the entrance to the Valley of the Kings. It was designed by Tarek Waly (Waly Centre for Architecture and Heritage) and built by local craftsmen. It opened to the public in 2014.



Following the successful installation of the facsimile of the burial chamber of Tutankhamun, the Factum Foundation and the University of Basel, in conjunction with the Ministry of Antiquities, has been recording the tomb of Seti I and training local operators to 3D scan and process the data. The transfer of skills and technologies is a central part of Factum Foundation's work.

An exhibition *Scanning Seti – The Regeneration of a Pharaonic Tomb* (October 2017 to May 2018) was based around the facsimile of 2 rooms in the tomb of Seti I. The work of the TNPI is ongoing and received the patronage of the Egyptian National Commission for UNESCO in 2019.





Stoppelaere house was built in 1951 by the Egyptian architect Hassan Fathy for Alexander Stoppelaere, chief restorer of the department of Antiquities at this time. The Waly Centre for Architecture and Heritage, carried out a complete restoration in order to rehabilitate the building and convert it for use as the 3D scanning, Archiving and Training Centre. It was opened in February 2014 by Irina Bokova, Secretary General of UNESCO, and the Minister of Antiquities Khaled El-Anany.



A laser scan of the facsimile of the alabaster sarcophagus of Seti I was attempted in 2001. Due to the translucent nature of the alabaster it failed. The recording was successfully completed in 2016 using photogrammetry. The production of the facsimile was carried out using a variety of software applications and innovative elevated printing technology developed by Océ in Holland. The facsimile has been exhibited in Basel and Oslo and will be given to Egypt. This recording work marked the start of the work to record all the tomb's scattered elements. The intention is to record and re-integrate all the fragments to make the facsimile more complete than the original in its existing state.



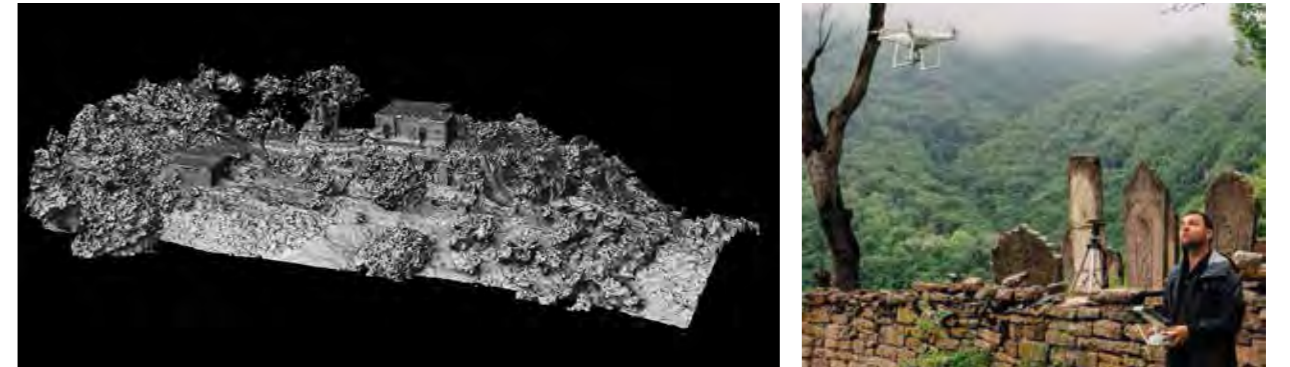
8.10 SETI I SCATTERED FRAGMENTS, 2016 - ongoing

Fragments from the tomb of Seti I have now been recorded in MFA (Boston), Museum of Archaeology (Bologna), British Museum (London), Musée du Louvre (Paris), Archaeological Museum (Florence), Sir John Soane's Museum (London), Pergamon (Berlin) and in private collections.



8.11 MOSQUE AND MAUSOLEUM AT KALA-KOREYSH, Daghestan, 2015

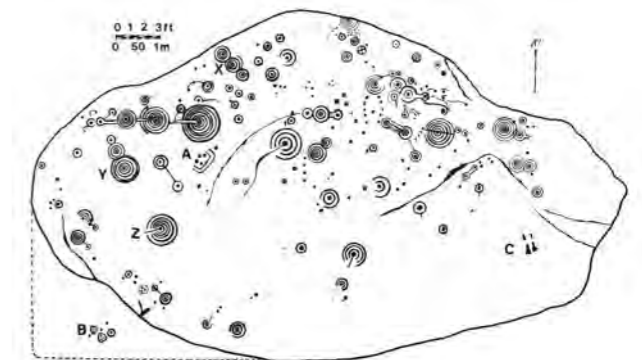
3D and colour recording was used to create a digital archive for preservation and dissemination of the gravestones in the Mausoleum at Kala-Koreysh. The project was also used to train people from Daghestan in the use of 3D scanning and photography technologies. A drone was used to record the topography of the remote site where the mausoleum and mosque are located. This was the first collaboration with the Peri Foundation and an exhibition, *Written in Stone*, was shown at the Hermitage, St Petersburg and the V&A, London as part of the ReACH initiative. One of the gravestones has been donated to the V&A and forms part of the new permanent display in the recently restored cast courts.



Photogrammetric recording of the Stela to Esarhaddon and five other stele at Nahr El Kalb offered a chance to develop the collaboration with APSAD and the Ministry in Lebanon. This low cost, highly portable, non-contact method of recording 3D is of great importance for the preservation of vulnerable sites. As the software for processing 3D photographic information improves, this technique has rapidly established itself as the most important recording system when funding is limited and the transportation of fragile equipment is not possible. The physical rematerialisation of the Stela of Esarhaddon from the 3D data is useful to study the inscription on the stone, evaluate the level of decay and to assist in the epigraphic study of the text.



3D recording of the Cochno Stone is a good example of the role high-resolution recording can play in revealing the importance of vulnerable works of art. The stone, in a suburb of Glasgow is the most important group of rock carved inscriptions in the UK. It was buried in 1964 to protect it from vandalism and has since faded from memory and both public and academic attention. This project was a collaboration between Factum Foundation, the University of Glasgow Archaeology Department, Richard Salmon Restoration and Elemental Films, and has generated a renewed interest in the stone and its markings. It has also revived a sense of local pride. A test recording took place in 2015 and the full excavation and recording of the stone took place in 2016.



8.14 BORGHERINI CHAPEL, Rome, 2017

The recreation of the Borgherini chapel, a collaboration between Michelangelo and Sebastiano del Piombo was made for the exhibition *Michelangelo and Sebastiano* at the National Gallery, London, 2017. The role of facsimiles in museum display is changing as the public demand to understand more about the works on show. The facsimile was exhibited in a room with three drawings by Sebastiano and three by Michelangelo. The nature of their collaboration was focused by the presence of the accurate facsimile which showed not only the scale and importance of the composition but also revealed that the upper parts (painted in 1516) were made using the 'true fresco' method while the Flagellation (1524) was an innovative mix of oil paint onto the treated wall.

Display technologies are the subject of a vast amount of investment. Virtual, mixed and augmented realities will play increasingly important roles in life and entertainment but an important fact is often overlooked. To make an exact facsimile you need to record high-resolution data. You can optimise and decimate this data for use with screen based applications. But you cannot increase the resolution of screen-based data to make a facsimile.

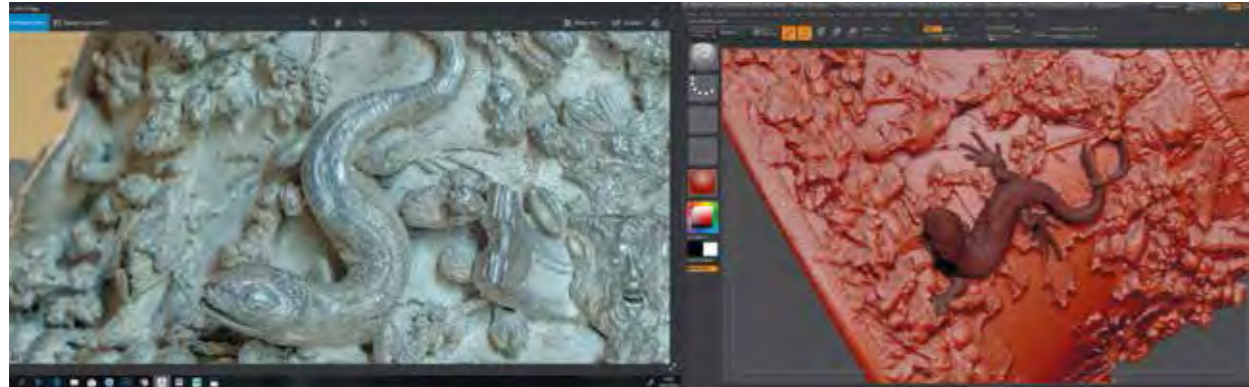


8.15 FERAPONTOV MONASTERY, Northern Russia, 2017 - ongoing

Following the collaboration with the Peri Foundation in Daghestan recording important Islamic sites and manuscripts, it was agreed that the collaboration would focus on significant Christian and Jewish heritage in Russia. The frescoes at the Cathedral of the Nativity of the Virgin painted by Dionisy in 1502 were selected as a site of great significance that could benefit from digital recording in colour and 3D. The Ferapontov Monastery is a UNESCO world heritage site. It was painted in about six months by Dionisy and a team of icon painters who created a complete environment with fully decorated walls and ceilings and a vast Iconostasis which has since been dismantled. The entire cathedral was recorded and some panels of the Iconostasis were also recorded. The data is now being processed and will be made freely available at high-resolution. The aim is to communicate the importance of sites like Ferapontov while assisting in its long-term preservation. The third part of the collaboration with Peri Foundation has resulted in the recording of the Gintsburg archive of Judaica and Hebraica. In a collaboration between the Russian State archive and the Israel Library digital copies of all the manuscripts will be available at high-resolution in Jerusalem.



Factum Foundation is involved in an ongoing collaboration with Strawberry Hill House in London, the great gothic revival building designed by the aesthete, connoisseur and collector Horace Walpole. The building was fully restored with a Heritage Lottery Fund grant but the contents had been sold off in the 19<sup>th</sup> century. The latest additions to the objects that have been made as facsimiles are the Jamnitzer bell (part of the Rothschild bequest to the British Museum) and A facsimile of a painting of the Waldegrave girls by Joshua Reynolds in the National Gallery in Edinburgh. All the facsimiles formed part of the exhibition *Lost Treasures of Strawberry Hill*, (2018).



Top: Facsimile of a portrait by Allen Ramsay of Walpole's nieces, in the Gallery at Strawberry Hill.  
Bottom: The Lucida 3D Scanner recording Joshua Reynolds's *The Ladies Waldegrave*.

An interactive 3D map of Middle-earth is part of the touring exhibition *Tolkien: Maker of Middle-Earth*. The map was made from Tolkien's drawings and the written descriptions in his books. It has both back projection and front projection and is an example of the way technology can transform exhibition design. Occupying a central position in the exhibition, the looped video display lasts 10 minutes and is able to orient the visitor and connect them to Middle-earth. The main sites and journeys are traced on or under the surface creating the feeling that you are seeing this great fictional landscape through Tolkien's eyes.



In 2017 a team from People's Palace Projects and Factum Foundation travelled to Ipatse to work with Takuma Kuikuro, a well know film-maker and artist. The idea was to take technologies that could extend Takuma's practice and introduce new display technologies in an attempt to communicate the importance of indigenous culture. 3D LiDAR, photogrammetry, drone recording and ambisonic recording were carried out as Takuma and other members of the tribe started to realise the potential that technology can provide. This visit was followed up in September 2018 with the complete recording of the sacred caves at Kamukuwaká that contain the creation myths of the Wauja. On arrival we discovered that the rock-cut inscriptions have been dramatically defaced. The data captured from this trip was combined with photographic documentation dating from before the attack to produce an entire 3D recreation of the cave. The Wauja have been working with the team in Factum to ensure the digital recreation is perfect and that the petroglyphs are correct. The digital restoration was completed and the data materialised through a 3 axis CNC machine milling directly onto medium density polyurethane at a resolution of 200 microns. The high-resolution details from the digital restoration were integrated manually onto the surface, before the application of an acrylic resin. The physical reconstruction is now complete and all resources are focused on fundraising to send the cave to Brazil.



8.19 QUT PAINTINGS, ASIR, Saudi Arabia, 2017 - ongoing

Asir is a mountainous region in the south of Saudi Arabia near the border with Yemen. It is famous for the colourful geometric paintings by the women of the region. These works, up to two hundred years old are being lost at an alarming rate as the houses are torn down or renovated. In collaboration with Art Jameel, Factum Foundation sent a team to record the most significant remaining examples and to understand how to revive the tradition amongst the local women. An archive of composite photography was assembled in five different sites. This is being processed and digitally restored and a pattern book is being prepared. This will be supplied as a training tool to the community of painters in Rijal Alma that is being trained by Fatima and Ali Mughawi. In 2017, after the recording, UNESCO listed the Qut paintings as examples of important intangible heritage.



8.20 RECORDING AL BALAD, JEDDAH, Saudi Arabia, 2017

A pilot project carried out with Art Jameel and the house of Traditional Arts to train and apply photogrammetry to the preservation of the historic centre of Jeddah, Al Balad. Architectural details were recorded with photogrammetry while whole buildings were recorded using a LiDAR scanner. The training demonstrated that a 'learning by doing' approach can result in a rapid transfer of skills. This needs to be maintained and supported but is very effective. A trip to scan rock cut inscriptions in Al-Ula took place in September/October 2018. As a result of the success of this second training session a Centre for Digital Recording will be opened in Al-Ula and a third training session will take place in October /November 2019.



**Factum Foundation for Digital Technology in Conservation & The Frontline Club Charitable Trust (UK Charity No. 1111898)**

“I have been watching their [Factum Arte/Factum Foundation’s] work develop for nearly a decade. I am now convinced it is the most important thing happening in 21<sup>st</sup>-century art - because it can quite literally save civilization”.

Jonathan Jones, *The Guardian*, February 2017

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Introduction

Aims of the project and overall framework

**Factum Foundation** is embarking on an innovative new venture with the **Frontline Club Charitable Trust**, that will become the model for training and transferring skills to people who can assist in safeguarding heritage in conflict zones through the application of high-resolution recording technologies. This proposal focuses on the cultural heritage sites across the MENA (Middle East and North Africa) region that are either under direct threat or suffering indirectly from the side effects of conflict in the region.

These unique sites, buildings and artifacts will be captured for posterity by a network of local specialists trained in non-contact, 3D and composite colour recording technologies, in a model designed for social and economic sustainability and exponential growth. The goal is the transfer of skills and equipment to be used for high-resolution documentation of cultural heritage and digital preservation in at-risk or post-conflict scenarios. Once the data is collected from the in-depth study, relocation or making informed decisions on restoration or reconstruction becomes easier and can be fully considered.

The Factum - Frontline collaboration will train independent freelance photojournalists in photogrammetry and composite photography. In turn, they will train carefully selected local teams. The skills and characteristics required for reporting in challenging situations overlap to a large degree with those of digital preservation: ability in photography, knowledge of regional languages and culture, adaptability and courage, negotiating permission and access and understanding how to work effectively, sensitively and sensibly in difficult environments. Furthermore, journalists stationed in specific regions are often flexibly employed as freelancers, with sporadic bursts of intensive work followed by quieter periods when they are in need of additional income. Therefore, undertaking conservation training alongside their photojournalist work represents a highly complementary means of supporting the important work they are doing as reporters. This will result in cost-effective training for local preservation groups.

The safety of all those involved and trust building will be paramount. The staff of Factum - Frontline will adhere to a strict policy of neutrality regarding local conflicts and are prohibited to engage in covert activities of any kind.

The project will be co-ordinated by Otto Lowe in Factum Foundation Madrid who will report to the managers of Factum Foundation and Frontline Club. He will be responsible for selecting and training photojournalists, managing the support team and devising ‘process-based’ training programmes. Otto will ensure that the data is captured at the highest resolution possible, securely archived, owned by and remains accessible to those who care for the artefacts or sites.

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The first Factum-Frontline project in Mosul

The first project of the Factum - Frontline Collaboration will take place in Mosul, Iraq in late 2019, in collaboration with Dr. Ali Aljuboori of the University of Mosul Archaeology Department.

Dr. Aljuboori was instrumental in leading the Ashurbanipal Library Project, an initiative to create a cuneiform study library within Mosul University. The Ashurbanipal Library building and its collection of plaster casts were extensively damaged by fire and vandalism in 2016. The university is now restoring and refitting the building. This project will serve as a pilot and provide a proof of concept that Factum - Frontline’s plan for knowledge and equipment transfer can be successfully implemented.



Destruction of the city of Mosul by the Islamic State.



One of 3 sites in Libya's Acacus Mountains World Heritage Site irreparably damaged with spray paint.



Ali Aljuboori is involved in many of the international research projects and partnerships that have resumed since the recent reopening of the University of Mosul. He has identified four graduates from Mosul University Archaeology department with photographic and computer skills. Their training will be in both the technique of high-resolution photogrammetry, composite photography and other non-contact recordings of cultural heritage. These first four graduates will become the core of a team in Mosul and will be able to train others. They will be linked with the team who are working in Luxor and with Factum Foundation's core team in Madrid. Ongoing support is key to the success of this initiative.

The first Factum - Frontline photo-journalist to be trained and equipped in digital preservation is Luke Tchalenko, who has many years of experience in reporting in conflict situations. He will receive training in high-resolution photogrammetry at Factum Foundation's workshop in Madrid. This will also include training in airborne photogrammetric recording (Luke has already taken a course and received his drone pilot's licence, paid for by Factum Foundation). Luke Tchalenko will be used as the model to fix costing and to plan for future trainees. It is anticipated that he will be able to train the four graduates in basic photogrammetry and processing in about two weeks. He will then form part of Factum Foundation's 'remote support' team who will provide ongoing advice and support from Madrid or London to monitor the quality of the work that is being carried out and ensure it is securely archived. As more teams receive training and get to work throughout the MENA region, Factum will encourage lateral communication or visits to develop a community of practice that may also engage in dissemination and education where and when circumstances allow.

Once trained, the local team, working with the Archaeology Department under Ali Aljuboori's direction, will offer their skills to record in Mosul Museum, on-site in Nimrud and elsewhere in parts of the city in need of emergency documentation. Each member of the local team will be paid a salary to carry out the recording. They will be paid on a day rate equivalent to the salary they receive from the University. Their salary will be agreed for one year but the aim is to extend this on an annual basis if funding can be secured.

It is hoped that this initiative will foster a dialogue in a region riven with sectarianism and religious strife, and will nurture understanding and different perspectives at a time when reconstruction and a principled reconciliation are being negotiated. Core to the project is the recasting of local perceptions of value. Enabling local communities to change their relationship to their own history and cultural heritage, through deepening understanding and knowledge, while making them the direct guardians and beneficiaries of it.

These are vital forms of preservation and contribute to rebuilding the diverse social fabrics that have been torn apart by conflicts and decades of oppression.

The aim is that Factum Foundation, the Frontline Club and local partners will work with the other organisations and individuals to make the Mosul project a successful pilot. Our goal is to provide the high-resolution 3D and composite photographic recording to supplement the important work they are doing. All work will be dependent on permission from the State Board for Culture and Heritage in Iraq.



One of the two Lamassu from the throne room in the Palace of Ashurnasirpal II in Nimrud that is now in the British Museum, London. The two facsimiles made by Factum Arte will be delivered to Iraq by the Spanish Ministry of Defense and installed in the University of Mosul.

In October 2018, Factum Foundation, Fondazione Giorgio Cini, and the Digital Humanities Laboratory of Ecole Polytechnique Fédérale de Lausanne (DHLAB-EPFL) launched ARCHiVe - Analysis and Recording of Cultural Heritage in Venice, a new initiative dedicated to the use, study and transmission of cultural heritage through digital technologies.

The 1000 square meter headquarters, located on the Venetian island of San Giorgio Maggiore, include a workshop and educational space dedicated to research for technology in the digital preservation of cultural heritage and archives.



Fondazione Giorgio Cini, photograph by Matteo De Fina.



Top: The Lucida 3D scanner, recording the surface of Veronese's diptych.  
Bottom: Veronese's diptych, *Prophets Ezekiel and Isaiah*. Courtesy of Gallerie dell'Accademia, Venezia.

ARCHiVe is primarily funded and supported by The Helen Hamlyn Trust.

Each of the institutions fueling this initiative brings a unique skill set to the recording and analysing of cultural heritage. The Fondazione Cini is a leading centre of academic research complete with extraordinary archives and collections, providing an incredible infrastructure for ARCHiVe. Factum Foundation's digital technologies' specialists bring experience, creativity and innovation in the training and transfer of technologies as well as in the development of data capturing systems. Whereas, EPFL's Digital Humanities Lab is perfectly equipped to analyse and extract meaning from the data collected thanks to the intelligent computer vision software it developed in the previous years.

The three partners share the belief that digital conservation is leading to a deeper understanding of works of art and cultural heritage. Hence, it is an epoch-shaping opportunity bound to have a big impact on both research and education. Within this vision, research independence is a key value for guaranteeing the unconditioned progress of science and scholarship and the availability of the results of free and unrestricted research for the benefit of society.

Implementation:

ARCHiVe is operating through four different, yet complementary strands:

1) It promotes the **high-resolution 3D and colour recording** of key artifacts and sites in order to facilitate their preservation, study and dissemination.

Understanding the right technology for the right task is critical in every project. While, currently, the core skills are high-resolution photogrammetry, composite photography (colour, X-Ray, infrared, ultraviolet) and the Lucida 3D laser scanner, an engineering workshop is responsible of the adaptation of existing equipment and development of new technologies, such as RTI and photometric stereo, to best fit the needs of art and cultural heritage under all their forms. This will eventually allow ARCHiVe to systematically obtain the highest possible quality of data.



Top: The Replica Scanner in action. The creation of this recording system by Factum Foundation for EPFL led to the creation of ARCHiVe at the Fondazione Giorgio Cini.  
 Middle: Rashmi Gajare, the first intern working on optical character recognition (OCR) results in the recording of the Alain Danielou collection of Sanskrit manuscripts on Indian music.  
 Bottom: Helen Hamlyn meeting the ARCHiVe team in May 2019. A generous donation from her Foundation made the creation of this innovative centre possible.



Mario Costa, student from the Master of Digital Architecture who have interned at ARCHiVe in Venice and Factum Foundation in Madrid, carrying out the 3D laser scanning of the cherry-wood printing blocks of the 16th-century "Mappa Turchesca".

2) It supports the **development and application of Intelligent Computer-Vision Software**. In fact, as the algorithms get more precise and the data becomes freely available, new technologies are redefining the relationship between the past and the present and are opening up new epistemological and methodological perspectives for art-historical research into cultural heritage.

3) Furthermore, generating vast amounts of data comes with the responsibility of storing it and ensuring future generations have access to it. Therefore, investigating **long-term storage solutions for digital archives** is another fundamentally important mission for ARCHiVe. The centre works on ensuring safe and secure digital systems to migrate, store in multiple locations, access and use various types of data without expensive proprietary software. But it also focuses on the storage of digital data in physical form capable of withstanding extended periods of time without electricity.

4) Finally, ARCHiVe focuses on **transferring skills and technologies** through specialised training programmes. This approach ensures local guardianship and has the potential to generate income at a local level. These training programmes take a step further compared to any other classical educational programmes as they are a hub gathering people from many different boards such as the growing community of electronic engineers, software writers, IT specialists, archivists, cataloguers, conservators and students from a wide range of disciplines.

The centre bases its training programme on a practical 'learning by doing approach', thus allowing the participants to acquire an intricate knowledge of fieldwork practice. Theory and practice are oriented to carry out actual projects of Cultural Heritage digitisation.



© Carlotta Luke

Bell tuning, 1991.

### 9.3 The Whitechapel Bell Foundry

Factum Foundation and the United Kingdom Historic Building Preservation Trust are working together to save the Whitechapel Bell Foundry. Bells have been cast in Whitechapel since the thirteenth-century and the Whitechapel Bell Foundry was formed as a company in the reign of Queen Elizabeth I. It is an important part of Britain's manufacturing heritage that occupies a site which has been continuously casting metal since 1739 and should continue to transform metal into bells. The Whitechapel Bell Foundry is far too important to lose.

We have a clear vision about how this can be done that will attract attention around the world. We are currently fighting proposals to allow a change of use to a boutique hotel. If we succeed it will be a great example of what can be achieved when culture is valued and technology is applied.

The best use of this internationally important site and building is through its ongoing function as a foundry but in a radically revitalised way fit for the 21st century as supported by Factum Foundation: one of the world's leading foundations promoting craft skills including foundry work. This is financially viable and, above all, appropriate.

UKHBPT made an offer to acquire the foundry at fair market value, for the purpose of continuing a foundry business on the site, to the previous owners in March 2017. They are still willing to enter into negotiations with the developer on the same basis.

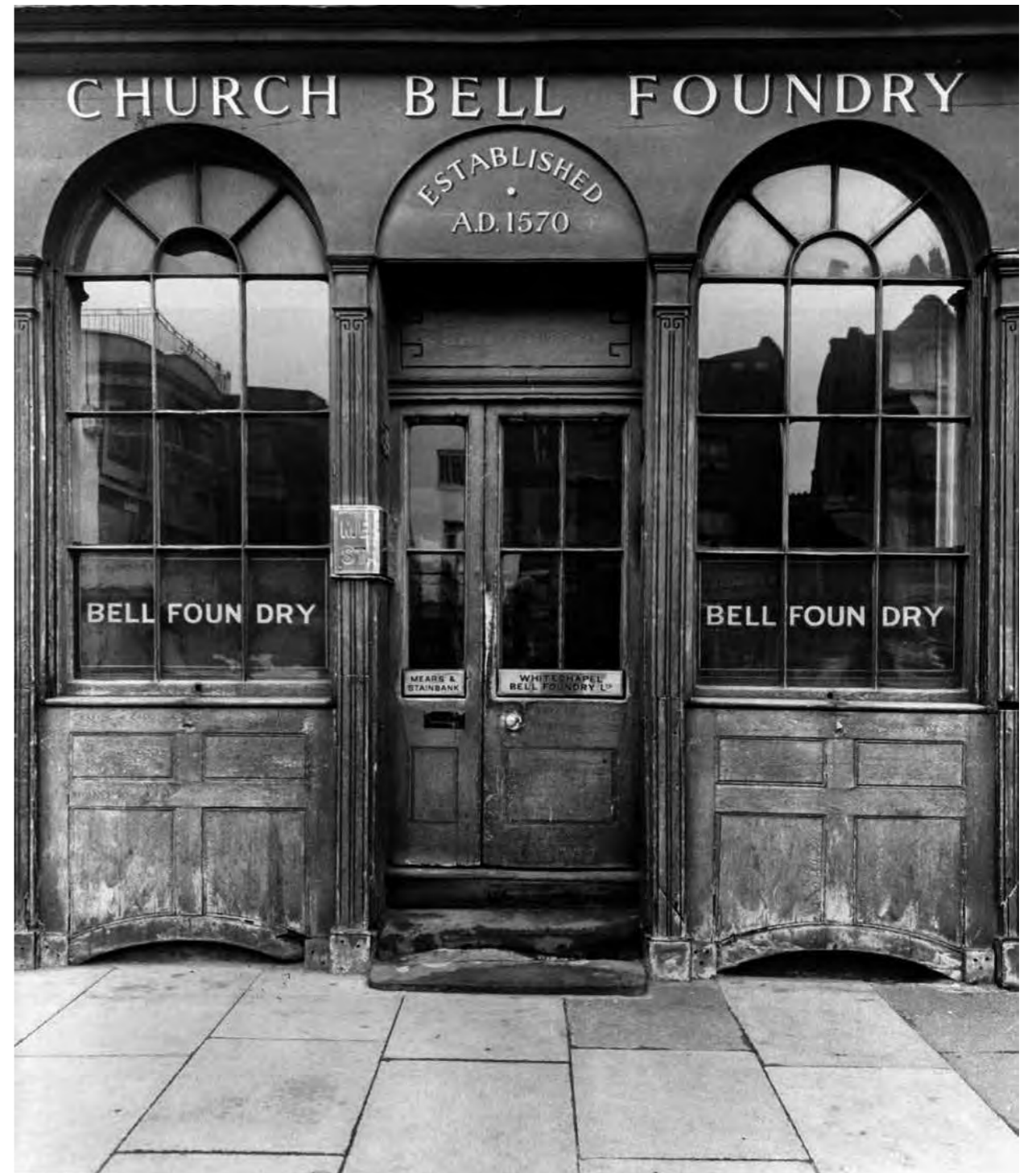
Heritage buildings are about much more than just the physical structures; a fundamental aspect is about the uses that go on within them.

"The Foundry at Whitechapel is world-famous for casting bells since the reign of Elizabeth I. It is the UK's oldest continuous manufacturing business and one of our finest cultural and heritage assets. The Trust's proposal to retain it as a working foundry, in a revitalised way suitable for the 21st century, will retain and create important creative skills vital to the future of the UK economy. It is a proposal I fully support.

Apart from the cultural and heritage loss to the nation should this site be redeveloped as the current private owner intends, his proposal would do little for the residents of Whitechapel. Instead, as the Trust proposes, we need to retain a business that keeps and creates valuable skilled manufacturing jobs. It will also be an exciting new visitor destination for London.

Bells, including some of the world's most famous bells, have been made on this site since 1571. London should never countenance the loss of such an iconic national and international business."

John McDonnell, *Shadow Chancellor of the Exchequer*.



Entrance to the Whitechapel Bell Foundry shown here in 1976.





Severely damaged monoliths scattered in a yam field at Nkunkundah, Nnam land.



#### 9.4 The Bakor Monoliths. Heritage under threat in eastern Nigeria

Over the past three years, Factum Foundation has collaborated with the Trust for African Rock Art (TARA) and the University of Calabar (UNICAL) on a project aimed at documenting, conserving and raising awareness about the Bakor monoliths, also known as the 'Cross-River' or 'Ikom' monoliths, and locally referred to as 'akwanshi' or 'atal'. As a part of this endeavour, Factum Foundation is developing an exhibition on the subject of the monoliths and their preservation, based around a series of facsimiles of examples now in international collections, that will be returned to their original sites following a tour of Nigerian museums. The Bakor monoliths take their name from a group of linguistically and ethnically related communities ('clans') in an area of approximately 350 square miles in the Middle Cross River region in which they are exclusively found. The word 'Bakor' means 'come and take', a name that was chosen as a collective title because the phrase is identical in the languages of each of the original eight clans that make up the Bakor people.

The monoliths are primarily basalt or limestone that has been naturally shaped in nearby riverbeds and range from around 40 cm up to 3m in size. The natural forms of the rock are embellished by carvings of facial features, beards, decorative markings (probably indicating scarification), protruding navels, etc., which distinguish each as an ancestral clan leader. The age of the monoliths remains the subject of speculation, particularly in the absence of proper archaeological investigation. It seems probable that the tradition developed over a number of centuries, gradually falling out of practice in the period of British colonial influence. This must, however, have occurred some time before direct engagement as the earliest account of the area that references the monoliths, Charles Partridge's *Cross River Natives* (1905), demonstrates that the inhabitants had already lost the custom of producing them.<sup>1</sup> The situation of cultural disconnect today has been exacerbated by the strong influence of Pentecostal Christianity in Nigeria, which associates the monoliths with 'juju'.

#### Preservation issues: damage and theft

An extensive survey of the monoliths was commissioned by the National Museum in Lagos and was carried out by Philip Allison, formerly of the Nigerian Forestry Department, over a period of two months in 1961 and 1962. These findings were eventually published in 1968 in the only book entirely dedicated to the subject of the monoliths.<sup>2</sup> Allison's survey put the number of carved stones at 300. In the course of three periods of fieldwork, of about one month in total, Factum Foundation, TARA and UNICAL visited all the major sites documented by Allison and, in addition, identified a handful of others not yet recorded. The condition of the monoliths and their sites vary greatly: the greatest threat to their preservation comes from forest clearance and subsequent farming activity, in particular slash and burn methods which heat up the stone, causing it to crack as it cools.

Allison's survey has proved an invaluable resource in addressing the other chief problem that the monoliths have faced: theft. It has enabled the identification of monoliths in international museum collections as well as a number of private galleries. Research indicates that the monoliths were predominantly stolen from the sites in the 1970s, following the crisis of the Biafra Civil War, and smuggled over the nearby border with Cameroon before entering the antiquities market. The threat of theft continues to be a problem today, with one community claiming that a monolith had been stolen from them as recently as 2009. The issue of theft has contributed to the inclusion of the monoliths on ICOM's Red List of West African cultural objects at risk. In addition, the critical condition of the Bakor monoliths has led to their being listed on the World Monuments Fund's 'World Monuments Watch' (inscribed in 2008) and UNESCO's tentative list of World Heritage sites.

In Fall 2020, an exhibition at the British Museum will coincide with the 50th anniversary of the adoption by the UNESCO of the Convention on the Means of Prohibiting and Preventing the Illicit Import, Export and Transfer of Ownership of Cultural Property.

Factum Foundation will produce five 1:1 facsimiles of monoliths recorded in four different international collections: the Metropolitan Museum of Art, New York, the Musée Quai Branly, Paris, the Israel Museum, Jerusalem, and Galerie Didier Claes, Brussels. These will be exhibited alongside reproductions of Philip Allison's photographs of the monoliths, now held in the Bodleian Library, Oxford, as well as other visual material generated in the course of the fieldwork. In addition, a film addressing the issues around preservation is currently in production. Should the permissions be secured, the exhibition could feature two more facsimiles of the monoliths: one from the collection of Pierre Darteville and another belonging to the British Museum.

The project has received support from the US Ambassador's Fund for Cultural Preservation. This covered the costs of the third period of fieldwork in April 2019. Following the display at the British Museum a touring exhibition will start at the University of Calabar and tour to local villages. This exhibition and the related training project has been generously supported by the Carène Foundation who are also supporting the production of 1:1 facsimiles.

The exhibition will be curated by a team with representatives from the British Museum and each of the project partners: Ferdinand Saumarez Smith from Factum Foundation for Digital Technology in Conservation, David Coulson from the Trust for African Rock Art and Dr. Abu Solomon Edet from University of Calabar. Further support will be provided by Dr. Frank Enor and Dr. Ivor Miller from the University of Calabar.



The top half of NT4 in the Metropolitan Museum of Art, NY.



The base of NT4 pictured on site in October 2016.



The two halves of NT4 digitally reunited.

Factum Foundation has ongoing partnerships with the following institutions:

Art Jameel, Jeddah  
 Book Works, London  
 Capturing Reality, Bratislava  
 Dust and Scratches, London  
 École Polytechnique Fédérale de Lausanne  
 Esfinge, Madrid  
 Fademesa, Madrid  
 ICONEM, Paris  
 Materialise, Leuven  
 Océ - A Canon Company, Venlo  
 Open Care, Milan  
 PIQL, Oslo  
 Royal Commission of Al-Ula, Riyadh  
 Think to Thing, Toronto

We have also collaborated and continue to collaborate with many other institutions on specific projects and series of projects:

#### **Belgium**

Koninklijk Museum voor Schone Kunsten Antwerpen (KSMKA).

#### **Brazil**

People's Palace Projects, Associação Indígena Kuikuro do Alto Xingú, Spectaculo.

#### **Chad**

Ministry of Culture, Ministry of Tourism.

#### **Egypt**

Ministry of Antiquities.

#### **France**

Musée du Louvre, Musée Cluny, Musée Jacquemart Andre, Bibliothèque Nationale de Bordeaux.

#### **Germany**

Alte Pinakothek Munich.

#### **Greece**

Benaki Museum.

#### **Iraq**

University of Mosul.

#### **Italy**

Genus Bononiae, Vatican Museums, Villa Borghese, Pinacoteca Nazionale in Ferrara, Basilica of San Petronio in Bologna, Fondazione Giorgio Cini, Pinacoteca Ambrosiana, Pinacoteca di Brera, San Luigi dei Francesi Rome, Villa Cagnola, Cenacolo Vinciano, Oratorio of San Lorenzo, Lo Spasimo, Palermo, National Archaeological Museum of Florence, Archaeological Museum of Bologna, Palazzo Grimani in Venice, Venetian Heritage, Museo Civico and Palazzo Sturm in Bassano del Grappa, Canova Museum Possagno, Association of Italian Banks - ABI.

#### **Kingdom of Saudi Arabia**

MISK Foundation, Royal Commission of Al-Ula.

#### **Lebanon**

Association pour la protection des sites et anciennes demeures au Liban (APSAD), Arab Image Foundation, Ministry of Culture.

#### **Netherlands**

Rijksmuseum van Oudheden, Leiden, Rijksmuseum Twenthe, Mauritshuis.

#### **Nigeria**

University of Calabar, The Trust for African Rock (TARA).

#### **Norway**

Norsk Folkemuseum, Henie Onstad Kunstsenter, Oslo, Architectural Department of the University of Oslo.

#### **Russia**

Peri Foundation, Kala-Koreysh, Institute of History, Archeology and Ethnography of the Dagestan Scientific Center of the Russian Academy of Sciences (IHAE DSC RAS), Monastery of Ferapontov, Tretyakov Gallery, Museum Sanctuary and Ethnographic Complex Dag-Aul Museum.

#### **Spain**

Museo Nacional del Prado, Fundación Amigos Museo del Prado, Museo Cerralbo, Museo Sorolla, Hermita de San Baudelio de Berlanga, Ayuntamiento de Barrado, La Casa Árabe, Casa de Pilatos, Fundación Casa Ducal de Medinaceli, Consejo Superior de Investigaciones Científicas (and CSIC: Proyecto Djehuty), Museo de Colecciones Reales, Palacio del Capricho, Calcografía Nacional, Real Academia de Bellas Artes de San Fernando, Cabildo de Gran Canaria, Real Santuario

Insular de Nuestra Señora de las Nieves, Biblioteca Nacional, Museo Arqueológico Nacional, Real Fábrica de Tapices, Museo Bilbao Bellas Arte, Real Armería - Patrimonio Nacional, Real Academia de la Historia, Instituto Andaluz de Patrimonio Histórico, Comunidad Valenciana, Generalitat Valenciana, Catedral de Mejorada del Campo, Fundación Banco Santander.

#### **Switzerland**

Universität Basel.

#### **US**

National Gallery Washington, Columbia University, Museum of Fine Arts Boston, Metropolitan Museum, MoMA, the Cleveland Museum of Art.

#### **UAE**

The Museum of Al Ain, Musée du Louvre Abu Dhabi, Department of Culture and Tourism Abu Dhabi, Juma al Majid Centre for Arts and Heritage, Dubai.

#### **UK**

Victoria and Albert Museum, British Museum, National Gallery, Sir John Soane's Museum, Ashmolean Museum, Bodleian Library, Griffiths Institute, Waddesdon Manor, Royal Academy, Strawberry Hill House, Houghton Hall, The Rothschild Foundation, Helen Hamlyn Trust, The Frontline Club, Auckland Castle, Art UK, Scottish National Gallery, United Kingdom Historic Building Preservation Trust.

Photographs courtesy of Factum Foundation / Oak Taylor Smith, Adam Lowe, Otto Lowe, Luke Tchalenko, Ferdinand Saumerez Smith, Gabriel Scarpa, Charlotte Skene Catling.



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