

A REPORTER AT LARGE NOVEMBER 28, 2016 ISSUE

THE FACTORY OF FAKES

How a workshop uses digital technology to craft perfect copies of imperilled art.

By Daniel Zalewski

The Factum Arte warehouse, in Madrid, is filled with copies of treasured art works, including a facsimile of an Assyrian winged lion that once stood in Nimrud—a site, in Iraq, that has been largely destroyed by ISIS.

The Egyptian painters who decorated King Tut's burial chamber had to work quickly—the pharaoh died unexpectedly, at about the age of nineteen, and proper preparations had not been made. Plaster was applied to lumpy limestone walls. On the chamber's western wall, twelve baboons with an identical design are arrayed in a grid, and various slip-ups suggest haste: one of the baboons is missing a black outline around its penis. When the entrance to the chamber was sealed, some thirty-five hundred years ago, the baboons, along with the gods and goddesses depicted in other panels, were expected to maintain their poses for eternity. This wasn't an entirely naïve hope. Tutankhamun was interred in the Valley of the Kings, the vast network of tombs in the hills outside Luxor, four hundred miles south of Cairo. The air in the valley is bone-dry, and pigment applied to a plastered wall in a lightless, undisturbed chamber should decay little over the centuries. When the British archeologist Howard Carter unsealed the burial vault, in 1923, turning the obscure Tutankhamun into the modern icon of ancient Egypt, the yellow walls remained dazzlingly intact. The Egyptians had made only one mistake: they had closed the tomb before the paint, or Tut's mummy, had dried, and bacteria had fed on the moisture, imposing a leopard pattern of brown dots on the yellow background. The room is known as the House of Gold.

Since then, tens of millions of tourists have crowded inside the living-room-size chamber, exuding a swampy mist of breath and sweat, which has caused the plaster to expand and contract. Bahaa AbdelGaber, an Egyptian antiquities official, told me recently that the temperature inside the Luxor tombs sometimes exceeds a hundred and twenty degrees. "Oh, the smell on a busy day!" he said.

In 2009, a team of conservators from the Getty Conservation Institute, in California, visited Tut's tomb and determined that some painted areas had become dangerously loosened. The conservators cleaned portions of the walls and applied adhesives to

flaking paint, in an effort to forestall pictorial losses. Reversibility is a prime rule of modern conservation, and, according to the latest scholarly thinking, these physical interventions were safe.

Recently, I visited Luxor. For the past several years, terrorism and political tumult have devastated Egypt's tourist economy. Going into the Valley of the Kings felt like sneaking into the Metropolitan Museum in the middle of the night: I had the place to myself, but the privilege was discomfiting. Before 2011, when tourism in Egypt was at its peak, a thousand people a day visited Tut's tomb. Now, in a parking lot the size of a football field, a lonely bus baked in the sun. Tram cars that convey tourists up the inclines between tombs had been abandoned near the ticket kiosk, coiled together like snakes. The Valley of the Kings looks like an elegant quarry; as I approached the tombs, it was so quiet that I heard the skittering of every pebble dislodged by my shoes.

To my eye, the Getty's touch-ups looked nimble. Freed of desert grime, the marigold pigment saturated my field of vision. But, as with plastic surgery, some treatments don't hold up well over time. Lori Wong, a Getty conservator who has worked in the tomb, is a model of circumspection, and she told me that the Getty was "really cautious" when making interventions. But the scientific understanding of how treatment materials affect art works keeps changing. For example, a 2013 study suggests that the adhesive Paraloid B-72, which previous conservators applied to the wall paintings in Tut's tomb, can cause "chromatic variations" in surface pigments. Other research has suggested that the adhesive isn't fully reversible: getting rid of it can dislodge paint. In the end, every physical alteration is a risk. Too often, the main reason to restore a treasured art work is to remedy a botched restoration. Wong said that she has removed patches of B-72 that had left "a shiny surface," as well as "a fair amount of surface drips" caused by old repainting efforts.

I have seen what Tut's tomb looked like before conservation work began. Dust had settled on protrusions in the walls, and, though these areas were a bit distracting, they allowed the murals to double as relief maps, underscoring the fact that the walls had been chiselled by hand. More troubling were the bacterial splotches. The goddess Nut, stylishly attired in a white dress with a red belt, appeared to have a five-o'clock shadow.

When this detail leaped out at me, I was not standing in the real tomb. I was inside a full-sized replica that has been installed on a gravelly hillside about a mile east of Tutankhamun's resting place. The facsimile had been made by digitally recording the tomb, in 2009, with a fleet of scanners, for seven weeks. Nut and her companions were immortalized at actual size, and at a resolution of up to eight hundred dots per inch. After the data sets from the scans were stitched together on a computer screen, the quilt of 0s and 1s was returned to physical form. The process eerily echoed that of making a fresco. First came the walls. A recording of their topography, capturing every bulbous paint drip, was rendered in 3-D by a computer-numerical-control milling machine, which produced two hundred and forty panels of high-density polyurethane. The panels, which mimicked the uneven surface of the original walls, were fitted together. The ersatz walls were then wrapped with a flexible "skin," of a gesso-like material, bearing a lush ink-jet printout of the frescoes. Mummified walls: a nice Egyptian touch.

The man who led the facsimile project, a proudly dishevelled Englishman named Adam Lowe, was admiring the fake walls alongside me. Lowe prefers to call them "rematerialized" walls. He whispered, "Amazing—it looks just like the real thing, doesn't it?" He is fifty-seven years old, and looks like what Paul McCartney might look like had McCartney never undergone restoration. Lowe, a former painter, who, in the nineteen-eighties, became obsessed with printmaking, runs Factum Arte, a "digital mediation" workshop that is based in Madrid. It took two years for Lowe and several dozen technicians to remake the Tutankhamun walls—considerably longer than the ancient Egyptians took to produce them. Perfecting the digital printout, he told me, had involved hundreds of hours of analog assessment: thousands of paint samples were mixed by hand, in Luxor, to match the tones in the original tomb, then compared with ink-jet outputs. Factum modified an enormous Epson printer so that it could make repeated passes over the gesso-like skin in perfect registration, allowing for fine tweaks.

Two versions of a medieval Christ: a computer-milled wooden facsimile (right) and a 3-D-printed model.

As I examined the facsimile, I was prepared to summon my inner Walter Benjamin and bemoan the mechanical reproduction's lack of an "aura." But there were no Disneyfied abominations: the baboons, with their playful upturned tails, looked as mischievous, mold-mottled, and ancient as the originals. I could make out the spot where, in a long brushstroke outlining a baboon's crest, the artist had just begun to run out of paint. In their brutal objectivity, the 2009 scans had recorded beauty and blemish alike. "That's printed dust," Lowe joked, pointing at a baboon that had been painted on a particularly bumpy area. "It's not something that will just *come off*." The only thing that was perceptibly modern was the absence of a musty odor. Lowe

noted that the room's sound wasn't right, either. He hopes to enlist engineers to record the "acoustic signature" of Tutankhamun's tomb, so that he can re-create it inside the facsimile.

Factum began operations in 1998, when it was becoming clear that 3-D printing was a revolutionary tool. The workshop has made millions of dollars by fabricating sculptures for artists—Anish Kapoor, Maya Lin, Marc Quinn—who sometimes require technological assistance to realize their visions. Lowe appears to spend nearly all his profits on fanciful-seeming projects that, in aggregate, mount a serious case that the facsimile can play a central role in art conservation. In order to raise funds for his preservation projects, he established a nonprofit wing, the Factum Foundation.

A digitally recorded copy, Lowe argues, can be both a lode of "forensically accurate information" and a vehicle for provoking a "deep emotional response." Because an art work can be scanned without physical contact, the facsimile process makes traditional conservation efforts—from repainting to varnishing—seem like an exalted form of graffiti. A facsimile also allows the public to see objects that are nearly impossible to approach in person: Factum has recorded and reassembled everything from a Renaissance painting outside the Pope's bedroom to rock carvings on a remote plateau in Chad. Lowe has a boyish indifference to danger, and colleagues must constantly dissuade him from, say, driving into Libya with a scanner in the trunk.

Factum made its reputation in 2007, with a replica of Paolo Veronese's monumental painting "The Wedding at Cana," which Napoleon presented to a new museum, the Louvre, after ripping it off the wall of a refectory in Venice in 1797. The painting's place in the refectory, which was designed by Palladio, had never been filled; Lowe installed his copy in the exact spot. Factum's noninvasive protocol, in which their scanner's lasers captured every whorled brushstroke without touching the canvas, was in stark contrast to the Louvre's restoration of the painting, in the nineteen-nineties, during which it accidentally fell onto some scaffolding and was gored in five places.

The Tutankhamun reproduction, which is about sixty square metres, expanded on the ambition of the "Cana" project, and it is the most heralded digital facsimile yet made. (*National Geographic* called it "a replica fit for a king.") Lowe believes that Factum's work transcends the taint of chicanery and cheesiness which traditionally has been associated with copies. The goal, after all, is not deception. "It's verisimilitude, not falsity," Lowe said. "What we're trying to do is to actually study something close enough that we can remake it." Factum's scanning technology allows recorded objects to be viewed at a zoom of five hundred per cent. "You can study many art works *more deeply* with the data we're recording," Lowe went on. Closeup photographs are helpful, he conceded, but wouldn't an academic learn even more by handling one of his replicas? How many art historians have felt the heft of a Brancusi bird?

Factum's Web site contains dozens of treatises questioning the aesthetic assumptions behind our disdain for fakes. Lowe proclaims that his workshop seeks to "redefine the relationship between the original and the copy." He told me, "We have this weird obsession with the original, as though it were static and immortal, even though we know that, like everything else, it journeys through time. We know this every time we look in the mirror! But why is it that we engage in these efforts to try to keep an art object looking the same, especially when those efforts so often fail?" Is seeing "The Wedding at Cana" in the Louvre—where it occupies the same noisy salon as the "Mona Lisa"—a richer experience than seeing the facsimile in the painting's original location? When Italians witnessed the unveiling of the Veronese replica, in the creamily lit space where the artist intended his masterpiece to be seen, many of them wept. Bruno Latour, the French theorist, championed the "Cana" project, and he and Lowe later wrote an essay about it, in which they referred to a "migration of the aura" from original to copy.

Some scholars remain wary. Sybille Ebert-Schifferer, of the Max Planck Institute for Art History, in Rome, told me that the "Cana" installation is valuable, because it makes Palladio's refectory "aesthetically complete." But she warned that a visitor "will not learn anything about the original painting," adding, "A painting is not just made of the surface, but of a multitude of layers and changing pigments which are part of its individuality and that of its creator. It has not only an iconography but also its own material personality. It is a horrifying vision to imagine that we could be faced with a horde of never-aging clones."

But clones have their advantages. AbdelGaber, the antiquities official, told me that tourists in Luxor are typically allowed to view the actual Tut tomb for about "ten to fifteen minutes." Many Egyptologists expect that Tutankhamun's resting place, like many others in the Valley of the Kings, will one day be closed to tourists, in order to save it from destruction. But they can pant as long as they like inside the fake tomb, which is built beneath the same scalding sun, and set at the same angle.

Lowe pointed out a few divergences between Tutankhamun's tomb and his reconstruction of it. Most notably, the facsimile contains a "virtual restoration" of a printed panel that used to be part of the south wall. Howard Carter largely destroyed that wall when he broke into the sealed room. A boulder-size fragment, now missing, was photographed, in black-and-white, soon after Carter's discovery. Factum technicians scanned the photograph, then colorized it and added relief, by extrapolating from topographical data extracted from similar areas in the tomb. Placing the missing panel inside the replica led Lowe to notice that its surface was far less deteriorated—visual proof that tourism is rapidly damaging the surviving walls.

If the joy of studying a masterpiece is, as Nabokov put it, "to fondle the details," lingering inside the facsimile is unquestionably superior to being herded through the original tomb by a guide. Lowe has signed an agreement with the Egyptian government to place at least two other tomb facsimiles near his Tutankhamun replica, creating an Uncanny Valley of the Kings.

The Tut replica cost more than six hundred thousand dollars to produce. Factum paid for almost all of it. In 2014, the facsimile was presented to the nation of Egypt, as a gift. In theory, Lowe's data could be rematerialized anywhere. In practice, Lowe said, he could build the tomb facsimiles only in Luxor. The Egyptian government holds the copyright on the data, and would consider it cultural theft—and an assault on its tourism industry—if someone installed tomb facsimiles in London or Dubai. "We'd have another Elgin Marbles kind of drama," Lowe joked.

It took two years for Lowe and several dozen technicians to remake the Tutankhamun walls—considerably longer than the ancient Egyptians took to produce them. The facsimile of the tomb was installed in Luxor, Egypt, in the spring of 2014.

AbdelGaber told me that his country is grateful to Factum. "When we make a replica, we can protect something very fragile—that's good for Egypt and for culture," he said, adding, with a laugh, "The Russian people! They go inside the tombs and touch the color. We've talked about it with their Ambassador. But, with only one or two guards, you can't watch all the tourists."

By educating visitors about their impact, Lowe argues, tourism can "become a positive force in the preservation of the past." He is training Egyptians in his scanning methods, and he plans to set up, in Luxor, a digital-fabrication studio modelled on the glass-blowing workshops in Murano. Lowe can't be sure how long the materials in his Tutankhamun facsimile will last, but his data sets have no expiration date. The 2009 recording could be rematerialized a hundred years from now—and at an even higher resolution, because current printing technology is not refined enough to harness all the data in the scans. The data could also play a role in preservation: comparing the 2009 scan with a future one would pinpoint the tomb's rate of decay.

Although you must fly to Luxor to go inside Lowe's tomb, the high-resolution images have been posted on Factum's Web site. They are hypnotically detailed, and if you scroll through the data on an iPad it seems as if you were touching the walls. When the screen frames a tiny portion of the wall, you notice how varied in intensity the color washes are, and how every square inch is spiderwebbed with cracks. Life-size copies of ancient sites have been made before: you can walk through fake versions of the Lascaux and Altamira caves. But these replicas, Lowe points out, are "painted by hand." Such facsimiles, which record only the details that the copyists notice, have no scholarly value. Few Vermeer scholars study forgeries of Vermeer paintings. A high-resolution digital scan, Lowe notes, captures details that may not yet have been appreciated as significant. Indeed, the topographic map of Tutankhamun's chamber has already led an Egyptologist to a radical theory.

After combing through the grayscale images, Nicholas Reeves, an English scholar, detected several ridges that had escaped notice for a century—the ornate paintings had provided too much distraction. The ridges were rectilinear and seemed to outline doorways. One such shape was on the western wall, underneath two of the baboons; another was on the right-hand side of the north wall. The doorways, Reeves surmised, must have been filled in before the walls were painted. Was something hidden behind them? He felt confident that there was. One day in early 2015, he called Lowe and said, "If I'm right, I think it's going to change my life and yours."

Lowe checked the scans, and he panicked. One of the lines was so long and straight that he worried it was a "digital artifact"—the result of two scanning sets being fused improperly. But, as a review of the data and a subsequent visit to the tomb confirmed, the ridges were real.

Reeves shared with Lowe a monograph that he had prepared. The tomb of Queen Nefertiti, one of the most celebrated Egyptian royals, has never been found. Many scholars suspect that her mummy is hidden in the Valley of the Kings, which, despite its name, contains the tombs of various nobles as well. The Egyptologist Zahi Hawass, who is known for flashy projects—for a TV special, he placed Tut's mummy in a CAT scanner—has searched for her tomb, without success. Nefertiti was the chief wife of Akhenaten, and is thought to have died about a decade before Tutankhamun. When Carter discovered Tut's burial chamber, Reeves noted, he was surprised to find many tribute objects depicting a royal woman—among them a statue of a pharaoh, with breasts, standing atop a leopard. Some scholars believe that Nefertiti assumed control of the Egyptian empire at the end of Akhenaten's reign.

Reeves told Lowe that Tutankhamun, having died before a tomb was ready for him, might have been squeezed into the entrance of a deeper tomb. Did one of the sealed doorways lead to Nefertiti's burial chamber? In November, 2015, preliminary thermal imaging detected that the area inside the rectangular outline on the north wall was "different in its temperature than the other parts" of the wall—suggesting that there was a space behind the area. The news made the front page of the *Times*. The Egyptian government announced plans to follow up with ground-penetrating radar.

As we examined the replica's north wall, Lowe pointed out the ridges that Reeves had identified. "See the black shape and the feather above the table?" he said. "That would be the top of the door. And then you can see the line going down just behind the length of this figure of Osiris." I asked him if he would be embarrassed if the hidden space turned out to be as big a dud as Al Capone's vault. "No," he said. "It's a victory, no matter what." Factum's facsimiles could not be trivialized as high-tech stunts. The intense scrutiny of digital data could open doors.

Factum Arte occupies a compound of skylighted, paint-splattered warehouses in the eastern part of Madrid. When I visited, last December, new sculptures and fake old ones mingled promiscuously on the workshop floor. Three busts had been made from a scan of the head of the performance artist Marina Abramović, her eyes closed in willed ecstasy. Huddled in a corner were resin replicas of three marble Biblical figures by the Renaissance master Jacopo della Quercia. (The originals are perched high on the façade of an Italian basilica.) "Factum is a place of atemporal creativity," Lowe said later. "People always say, 'Isn't it difficult working with contemporary artists and working with, say, Caravaggio?' The answer is no. They're *exactly* the same. The only difference is that Caravaggio is dead."

Lowe, who was giving me a tour of the workshop, explained that the della Quercia replicas had been made with a 3-D printer—a device that expels pixel-size globules of synthetic resin, which harden and amass into a complex shape. "That's one way to make a 3-D object," he said. "We generally prefer using C.N.C.s"—computer-numerical-control milling machines, which carve into a block of material. For large objects, this process is more accurate. "With current technology, subtracting is better than adding," he said. Across the room, a hulking milling machine was applying rotary cutters to a slab of high-density polyurethane, which, Lowe said, "is the material that will hold the finest information." (Stone cannot be cut as precisely.) The machine's robotic head darted a few inches above its plastic target, lunging at the surface like a fencer.

"Pillows for sleeping on are downstairs. These are all for screaming into."

Resin replicas have a telltale sheen, so to reproduce antique sculptures the protocol at Factum includes a step that is more 1816 than 2016: the digital data set is rematerialized using a C.N.C., and then a mold and a cast are made. Factum has rendered facsimiles in everything from plaster to bronze. In a nook that resembled a messy kitchen, an Argentinean employee, a trained sculptor named Sebas Beyro, was preparing to make a cast by kneading a "dough" of *scagliola*—plaster tinted to imitate stone. The mold was made from a scan of the hindquarters of a colossal alabaster statue that once stood in the ancient Assyrian capital of Nimrud: a winged lion with a man's gently smiling face, dating from the ninth century B.C. Factum was reconstructing the creature, an Assyrian deity, in sections. A few milling machines on the market are large enough to produce a single resin mold of a ten-foot-tall sculpture, but they are not accurate enough for Factum's purposes. Beyro planned to mask the joints between the sections with wisps of plaster—the sole human touch on an object that had a resolution of three hundred microns.

Beyro was tinting his dough brownish gray, so that the plaster would match the hue of the original lion, which is in the British Museum. Lowe prizes objective data, but he also believes in the artist's eye. In his view, most computer-generated creations require "craft skills" in order to be fully convincing. Recently, his workshop explored methods for giving facsimile sculptures an ancient-looking patina, including, he said, "burying them in a pit filled with yogurt and dog shit."

Lowe has a fine-arts degree from the Ruskin School of Art, at Oxford University, but he is happy to stand apart from fusty academic conservationists. He sees himself as closer in spirit to Hollywood directors like James Cameron, who freely combine cutting-edge and traditional methods in order to achieve visionary ends.

Universities are becoming attuned to the promise of digital restoration; Columbia University, which offers a master's degree in historic preservation, recently hired Lowe to teach a course in its conservation lab. But Factum isn't likely to lose its lead anytime soon. Because of all the Kapoors that Lowe fabricates, he can invest hundreds of thousands of euros a year in experimental technology—something that few academics can do.

The winged-lion replica, which was nearly complete, loomed over the workshop. I touched its front paws, and the plaster surface felt craggy, echoing the eroded surface of the original, which stood, for nearly three millennia, on the site of a palace in Nimrud, in what is now Iraq. In April, 2015, soldiers from ISIS besieged what remained of the Nimrud site. After a few days of hacking and bulldozing, they released a video of the entire archeological site being blown up. They also took a cruel photograph of a winged lion similar to the one being fashioned in Madrid: a militant was obliterating its smile with a drill.

The British Museum wasn't the only Western institution that owned precious objects from Nimrud. Many treasures were spirited out of Iraq during the nineteenth century, the heyday of imperialist archeology. After the Iraq War began, Lowe contacted curators at five museums that own pieces from the throne room of the Assyrian king Ashurnasirpal II and secured permission to replicate them. The British Museum's lion was scanned, at night, in the course of five weeks. (Recording at a resolution of three hundred microns takes time.) Lowe's initial plan was to help Iraqi curators partly "reassemble" the throne room in a library in Mosul. Facsimiles of the winged lion, and of reliefs depicting a lion hunt, were completed in 2014. High-density polyurethane is expensive, so the milling alone cost four hundred thousand euros. "We got them all through Turkey, through Kurdistan, through Erbil, down through Iraq into Mosul," Lowe said. Then ISIS ransacked the library. The facsimiles were likely destroyed.

Fortunately, Factum saved its molds. "The beauty is that we can send another set," he said. The winged lion being finished by Beyro, then, could be a replacement for a replacement.

Now that ISIS had laid waste to all of Nimrud, Lowe had conceived an even bolder proposal. He told me that Boris Johnson, the British foreign minister, had announced plans to help reassemble the Nimrud fragments remaining from the recent destruction, following the model of the Acropolis, in Athens. This struck Lowe as foolish nostalgia—fetishizing stone shrapnel that was likely too ruined to conjure the monuments' beauty. A smarter way to honor Nimrud's past, he told me, would be to "scan *all* the known fragments"—he gestured to a wall that held copies of Nimrud friezes that are in the Pergamon Museum, in Berlin—"and have copies erected on the site." He planned to start a campaign to promote his idea, presenting his latest lion to potential donors as a proof of concept.

As Lowe contemplated the digital restoration of Nimrud, he noted that even the British Museum's lion was substantially changed from its initial state. It originally had colored paint on its surface, but after it arrived in London, in the eighteen-fifties, British curators made a plaster cast of it, and the color was peeled off in the molding process. "An original, you see, is *never* an original, once it goes through time," Lowe said.

He is confident that Factum's facsimile technology is without parallel. Though he welcomes competition, he can be withering about rivals, especially the Institute for Digital Archaeology, an upstart founded, in 2012, by Roger Michel, an American. Michel is an unconventional arts professional; he is an assistant district attorney in Massachusetts, who has, as Lowe puts it, a "talent for publicity." Last year, the I.D.A. made headlines, and the cover of *Newsweek*, after it erected, in Trafalgar Square, a marble replica of a triumphal Roman arch in Palmyra, Syria—another icon destroyed by ISIS. A 3-D model was produced, Michel says, by collating dozens of photographs that archeologists and tourists had taken before the terrorists descended. Lowe went to London to examine the arch, and felt that it was a sloppy stunt. "For starters, it is *one-third* the original size!" he fumed. (According to Michel, a one-to-one facsimile would have been too heavy to display in Trafalgar Square.) Moreover, Lowe said, the facsimile was inaccurate: "If you look at the arch, there are these beautiful Corinthian columns on it, and on the finial it looks like there's an artichoke on it. You can just tell that one of the people making it was, like, 'That's too hard right there,' and simplified the shape! It's *appalling*." Recently, Michel and Lowe appeared on a panel at Columbia. Michel said that he made his arch to "redress a sense of loss" felt by Syrians, and he complained that Western scholars were "very fetishistic" about high-

resolution data. Lowe noted icily that Nicholas Reeves's Tutankhamun discoveries would not have been possible "without the data being submillimetric."

Lowe agrees with Michel about one thing: locals should be enlisted to digitally record cultural-heritage sites, as a safeguard against iconoclasm or accidental damage. Although Lowe is fond of his lasers, sophisticated digital replicas of monuments can now be generated with S.L.R. cameras—if thousands of shots are taken from every possible angle, in consistent light. This method, called photogrammetry, "is really about to take off, and replace 3-D scanning as the state of the art for facsimiles," Lowe said. "The algorithms have gotten so much better." The latest technology can achieve a resolution of a hundred microns, which is what the typical human eye can discern at reading distance. "If you can get the same quality data and object by using photographs, not lasers, the recording process is cheaper and a lot faster."

A milling machine, with a six-axis robotic arm, carves into a piece of contemporary art. "With current technology, subtracting is better than adding," Lowe said.

Lowe has initiated a project to demonstrate how to do proper photogrammetry of a historic site. Next year, he plans to fly a drone equipped with a camera over some sandstone tombs in Petra Archeological Park, in Jordan, and compile data for "exquisite, one-to-one" facsimiles. "The recording will be done by a small group of Jordanians," Lowe said. "And this scan, unlike some, will actually be *worth* keeping for posterity."

We climbed some stairs and Lowe led me into a small chamber that houses Factum's most prized invention: the Lucida scanner. Photogrammetry is deft at capturing sculptural form, but it is less suited to recording the glossy surface of Old Master paintings—the glare caused by a flash results in errors. Lowe said that it took Factum more than a decade to solve the problem. The Lucida was invented by Manuel Franquelo, a Spanish painter, who helped Lowe found Factum. A laser pointer projects onto a painting a vertical red beam, which becomes slightly crooked wherever the surface isn't flat. The laser pointer is flanked by two video cameras, and a topographic map is generated. Both cameras capture underexposed images and overexposed ones, an arrangement that helps insure that no detail is lost. A metal support bar affixed to a trolley allows the laser to follow a level path a few inches from the painting's surface. The system can record the shiniest of substances, including the gold leaf on a Byzantine halo. The National Gallery in London bought a Lucida, for twenty thousand pounds, and has begun scanning its permanent collection with it. The Prado used a Lucida to scan Goya's "black paintings," including "Saturn Devouring His Son."

The Lucida is easy to pack on a plane, and Lowe has been travelling around the world with one in order to record the sixteen scattered panels of the Polittico Griffoni—an altarpiece, completed in 1473, that once decorated the Basilica of San Petronio, in Bologna. The work, painted primarily by Francesco della Cossa, was dismantled in 1725 and its components were sold off. "I think that if the altarpiece could again be seen all together it would finally be recognized as one of the great achievements of the Renaissance," Lowe told me.

A printout of Lowe's favorite panel, depicting St. George, was on his office desk. It had not yet been framed, and I could see white gesso around the edges of the printout. "Slightly more work needed on the face," Lowe pronounced. "I still don't *believe* it." As sophisticated as facsimile printouts have become, they remain flawed in one key respect: printers deploy ink, not oil paint, let alone other materials, like walnut oil, that artists such as Rembrandt swirled into their brushes. A painting's texture and shine are connected to its physical makeup, and until 3-D printers can squirt simulations of the varied materials that were originally applied to a canvas, the surface reflectivity of a digital facsimile will be suspiciously uniform. Lowe disguises this problem as much as he can by employing a classic optical trick—he coats his printouts in Old Master varnish. (The St. George replica shone warmly when I placed it under Lowe's desk lamp.) This final barrier to authenticity may soon be conquered. For the Griffoni project, Factum is conducting some experiments with a Dutch company, Océ, which is at the frontier of 3-D printing. Researchers there have created a printer that uses special inks that mimic the reflective qualities of oil and lacquer and lead. Such a printer, guided by data about a painting's chemistry, could yield the ultimate fake.

In 2018, Factum plans to mount an exhibition of a re-created Polittico Griffoni, which, Lowe hopes, will travel among all the museums that own panels. Over the centuries, most of the panels have been extensively restored through repainting, some of them clumsily, so they will clash when joined together: in the central panel, which is at the National Gallery in London, the sky has a teal cast, but it looks marine blue in the two flanking panels, which are at the Pinacoteca di Brera, in Milan. Lowe is considering presenting two versions of the altarpiece—"one with the pieces as they look now, and one with each panel digitally restored, so that they harmonize into one image."

Such a project might be his strongest challenge yet to the idea of physical restoration. If you can create a replica that effectively relays a curator's hypothesis about what an art work once looked like, why make possibly damaging physical alterations to the original? The Art Institute of Chicago has experimented with a similar approach. In 2005, it displayed a "digital rejuvenation" of Seurat's Pointillist masterpiece "A Sunday on La Grande Jatte," many of whose pigments, such as zinc yellow, have browned with age. A large printout of the color-adjusted image was presented next to the painting, which has not been restored. Lowe's proposition is thornier: will museums want their doctored Griffoni panels subjected to a merciless critique? "It's an idea that may have to remain inside my head," Lowe said.

Even if every prominent museum bought a Lucida scanner, digital restoration is hardly going to make Lowe rich. Fortunately, getting rich is not one of his goals. He has what a colleague calls a "karmic business model"—London galleries seem to make fresh fabrication commissions whenever his conservation projects leave him in debt. In order to pay for his lavish facsimiles, Lowe has radically streamlined his life. He drives a rotting old Saab, and for the past two years he hasn't even had a permanent place to live—he is always off scanning in France or Chad, anyway, so when funds ran low he didn't mind giving up the apartment he rented in Madrid. By that point, his all-consuming commitment to Factum had prompted his first wife to leave him; Lowe told me, with sympathy, that "she wanted a tranquil life, full of holidays and nice things, and she wasn't going to get it." His son, Otto, who is twenty-seven, has been more willing to be sucked into the Factum vortex: he helps run the nonprofit foundation.

Earlier this year, Lowe married a British architect, Charlotte Skene Catling, in Venice, on the island where the "Wedding at Cana" replica resides. A constant traveller herself, she finds his wanderings romantic. In December, 2015, they spent what Skene Catling called a "holiday" in Dagestan, where Lowe scanned medieval Muslim tombstones. The U.S. State Department strongly advises against travel there, given the prevalence of Islamist extremism. When I asked the couple if the trip had been nerve-wracking, they scoffed, in unison, "It was *fine*."

When Skene Catling, who works out of London, is visiting Lowe in Madrid, they sleep in the Factum warehouse, which has beds in a few rooms. I peeked into one of them. The wall above the bed's headboard was covered with a welter of color printouts depicting closeups of Caravaggio paintings. If the painter were still alive, you'd think that Lowe was stalking him.

"Set the alarm for 2020."

Factum has scanned three of the Baroque artist's paintings, whose extreme contrasts between light and dark are difficult to capture with ordinary photography. The paintings, which depict the life of St. Matthew, are at the Church of San Luigi dei Francesi, in Rome. The replicas have been installed at a research center in the Lombardy town that gave the artist his name. The scans, archived on Factum's Web site, contain six gigabytes of data each. A few test printouts of the Caravaggios now decorate a salon in the Madrid workshop, giving it the air of a Mafia safe house filled with stolen masterpieces.

One of Caravaggio's most celebrated works, the "Nativity with St. Francis and St. Lawrence," was, in fact, stolen by the Mob from a chapel in Palermo, the Oratory of San Lorenzo, in 1969. The painting depicts the two saints and a few other figures clustered around Mary; her face has the spotlighted glamour of a Hollywood head shot. Nobody is sure what happened to the "Nativity" canvas, although the favored local story is that it was rolled up and stashed in a Sicilian barn, where it was destroyed by rats and pigs. After the theft, a blurry photograph of the "Nativity" was hung in the chapel in its place.

A few years ago, Lowe decided that he would try to restore the chapel's aura, by creating what he called a "performance of the Caravaggio, with me as the conductor." He digitally combined details from multiple photographs of the "Nativity," including black-and-white images, to create the "most complete data set possible." (Anna Paola Ferrara, a Factum employee who worked on the project, calls the resulting image "a Frankenstein.") Lowe marshalled what he had learned from making the other Caravaggio facsimiles to mimic the topography created by the artist's thick, quick brushstrokes. Using the giant Epson, he printed out the "rebuilt" composition, then showed it to an Italian art historian. In response to his comments, Lowe and two colleagues acted like old-school restorers, making touch-ups with a brush. To integrate these tweaks, he scanned the altered fake and made another 3-D print. The historian made yet more critiques, and six more printouts were produced before the work was deemed ready for display. The project, which cost a hundred thousand euros, was paid for by Sky TV, the European cable channel, which made a documentary about the painting's theft.

At the end of my Madrid visit, I flew with Lowe to Palermo, to attend the unveiling. Just before 11 A.M., we entered the chapel through a courtyard graced by a solitary orange tree; overripe fruit had fallen off and rolled into the corners. The courtyard was

crowded with European journalists: the President of Italy, Sergio Mattarella, and the mayor of Palermo were coming to see the new “Nativity.”

The chapel is a Baroque folly, its white stucco walls decorated with putti spanking and kissing one another. Just as Veronese’s “Wedding at Cana” dominated the spare refectory in Venice, Lowe said, Caravaggio’s work was the “only colored image in a chapel that’s essentially bone white.” He said of the “Nativity,” “Losing it throws off the entire scheme of the chapel.”

Inside, Lowe’s creation was hidden behind a curtain. He told me that, after examining closeups of the three scanned Caravaggios on computer screens, he had divined some of the Baroque master’s secrets. Caravaggio typically painted his figures with brushstrokes that were perpendicular to those he used for his dark backgrounds; the subtle friction caused a feathering of the surface, lending the figures a gauzy luminosity. As Lowe put it, “Caravaggio grounded his canvas specifically so that he’d break down the edges while he painted.” When Lowe made his touch-ups, he imitated this practice. With the original object missing, he said, such artisanal impositions could not be avoided; at least they were based in rigorous digital analysis of Caravaggio’s style.

The curtain itself had a playful trompe-l’oeil effect: it had been digitally printed with an image of the rectangle of flaked paint which had been exposed by the theft. Soon after the President arrived, a bell rang, and the curtain fell to the floor, revealing the new “Nativity.” The hundred or so people gathered in the chapel applauded. In the decade since the Veronese facsimile had been completed, a cultural shift had taken place: instead of crying, the Italians began feverishly taking cell-phone pictures of the facsimile and posting them on social media. A lunette window near the ceiling splashed the canvas with light at an angle similar to that of the implicit light source in Caravaggio’s composition. The shimmer felt integral to the work, and it highlighted the many bumps, folds, and varnish cracks on the printout, producing the illusion of an antique provenance.

Lowe came over and appraised his work. “The texture of the background has this manky surface at the bottom,” he said, with satisfaction. The facsimile needed to look like it was painted in the seventeenth century, with gravity taking its toll. I asked him how he knew that his colors were accurate. “Caravaggio has a relatively limited palette,” he said. “And so the reds—from the work we did in San Luigi dei Francesi, we have exact color matching.”

President Mattarella smiled before the “Nativity” and got his picture taken. He made a brief statement, in which he called the theft a “desecration” and noted that Factum “allows us not to fix what happened but to rediscover the effect and the emotions that Caravaggio’s work created in this oratory.”

Lowe acknowledged that the “Nativity” project was new territory for Factum. It was a speculative act—an educated guess about an art work’s original condition. Then again, so is a traditional restoration. Lowe’s speculation, however, had not been imposed on the original. As we left the chapel, he told me, “In my dreams, I hope that the people who stole this painting will feel the power that is generated when many people focus on the importance of an object, and the importance of its place, and that tomorrow morning, rolled up outside the chapel, the original painting will be left.”

Meanwhile, Lowe was planning a furtive operation of his own. Before the Factum “Nativity” was sent to Palermo, he noticed a few details that still made him unhappy. A new iteration was being prepared, and Lowe promised that, one day in the coming months, “we’re going to replace it and see if anyone notices.” He paused and smiled. “We’re basically going to steal our own painting.”

The Lucida scanner is easy to operate, but it’s hard to carry, in pieces, down the steps of an ancient Egyptian tomb. Many parts aren’t heavy—the component containing the lasers and the cameras is the size of a laptop—but the trolley base bears an unnerving similarity to a toboggan, and the stairs to the tomb we were entering, that of Seti I, were steep. The tomb is the longest and the deepest in the Valley of the Kings. “Here we go,” Lowe said, as we descended with four others from the surface to a metal security gate, whose turnkey code system evoked a Cold War submarine. Lowe had been in Luxor for several days, and, though he hadn’t bothered with a hat or sunscreen, his skin remained pale. He is the kind of heedless traveller who somehow avoids the food poisoning that befalls his companions.

SEPTEMBER 7, 2015

We were accompanied by an Egyptian official, who unlocked the gate. As we walked into the shadows, a wave of chill hit us. Lowe was exhilarated. He had been waiting to scan the Seti tomb for years. “We were meant to go and record it in 2009,” he

had told me. “But, when we got there, Zahi Hawass was removing debris from a long passage at the bottom of the tomb. He didn’t find anything, but he filled the whole tomb with dust! He said, ‘All right, you’re here with all the equipment, you can go and do Tut.’ But I was disappointed. Because Seti is a large, important tomb that desperately needs recording. And Tut is a famous tomb, but it is *not* one of the most important.” This twist of fate, he admitted, had turned out to be “the biggest gift in the world from the pharaonic gods.” The global fascination with Tut—and the subsequent excitement about the possible hidden tomb of Nefertiti—had given Factum a level of prominence that a scan of the Seti tomb, however valuable, would not have provided.

Throughout the aughts, Lowe kept asking to record the Seti tomb, but he met resistance from Egyptian officials, who found Lowe’s proposal either bizarre or suspicious. “But I’m fucking stubborn,” he said. “I’m like a terrier that bites into something and I just don’t let go.” The modern city of Luxor is across the Nile from the Valley of the Kings. He had so many meetings with local bureaucrats that the canopied ferry he hired to shuttle him across the river was christened the Adam Boat.

In May, Lowe began scanning the Seti tomb, with the understanding that he would also be training Egyptians in the art of making facsimiles. Aliaa Ismail, a twenty-five-year-old native of Cairo, had been working in Madrid for eighteen months, mastering the Lucida scanner, and she was ready to lead a team of Egyptians. Lowe had been recruiting locals for the cause, including Abdu Ghaba, a Jack-of-all-trades who had helped machine a set of bespoke screws for the Lucida after a batch got lost on the journey from Spain. He was now carrying some of our equipment, with pointed ease. “I can make a scanner if I watch you do it,” he told Lowe at one point. “I am a fast learner. Things that slide exactly on metal—I can do that!”

The scanning was going to require five Lucidas, if the work was to be completed within five years. Compared with Tut’s burial chamber, Seti I’s tomb, which was once the most gloriously decorated in the Valley of the Kings, has fifty times the amount of painted surface. It was discovered not by an archeologist but by a circus strongman from Padua, the Great Belzoni, when he was treasure hunting in the Valley of the Kings. In 1817, he found an opening in a hillside, and, inside, a stairway. The tomb descended more than four hundred feet. There were ten connected chambers. Tens of thousands of hieroglyphs, carved in bas-relief and painted with vivid colors, covered the walls of nine of them. In the other room, Belzoni saw thousands of preliminary drawings—red outlines that had been corrected, in black, by a master artisan. Exhaustion had apparently set in: this was the first Egyptian tomb to feature decoration on every wall, a style that became the pharaonic standard.

It was a fitting tribute to Seti I, a commanding pharaoh who had built one of ancient Egypt’s architectural glories: the Great Hypostyle Hall, in the temple of Karnak. The tomb, Belzoni wrote in his journal, appeared “as if just finished on the day we entered it.” He added, “The paintings became more perfect as we advanced farther into the interior. They retain their gloss, or a kind of varnish over the colors, which had a beautiful effect.” As Belzoni explored the space with torches, he discovered that paintbrushes still littered the floor.

The tomb is no longer in superb condition. After Belzoni discovered it, flash floods turned its lower chambers into a swimming pool, causing many of the bas-reliefs to crack. During the next century, Egyptologists hacked into the walls to remove panels, which allowed groundwater to seep in. Others made “wet-paper squeezes”—applying moist paper to the surface to create a colored print. Throughout the tomb, I saw ghost traces of these souvenirs: Rothko rectangles where the paint is less intense. Huge chunks of a celestial painting on a ceiling—the stars aligned as rigidly as those on the American flag—have fallen off. In the late eighties, conditions were deemed so dangerous that the tomb was closed to the public.

One chamber of bas-reliefs so impressed Belzoni that he named it the Room of Beauties. “When standing in the center of this chamber, the traveller is surrounded by an assembly of Egyptian gods and goddesses,” he wrote. The stairway leading into the chamber was flanked by two panels depicting the same scene: Hathor, the goddess of the underworld, welcoming Seti into her domain. The panels are now separated, one residing in the Louvre and one in a Florence museum. As we walked down the steps, Lowe gave a damage report: “The panels no longer look alike, and they also look nothing like the rest of the tomb. The Louvre color background has become beige, which is not a color you see in any tomb in the Valley of the Kings.”

Belzoni wanted fame and money for his trouble. He lugged Seti’s alabaster sarcophagus out of the tomb and sold it to the architect and collector Sir John Soane, in London. He also made wax impressions of the walls of the Room of Beauties—removing paint in the process—and commissioned plaster casts of its bas-reliefs. An exhibition of the assembled replicas opened near Piccadilly Circus, in London, in 1821. The show was a sensation, making Belzoni rich. He died two years later, of dysentery, while trying to find the source of the Niger River.

Lowe wasn't going to make a profit from his tomb replicas, but they were a calling card for his technology. After setting up a Lucida in the tomb, he was going to Abu Dhabi, to meet curators at the Louvre's new outpost there, which will occasionally display masterpieces borrowed from Paris. Why not scan and replicate every object on loan? Doing so would allow the curators in Abu Dhabi to assemble a twenty-first-century version of the Victoria and Albert Museum's Casts Courts—a grand nineteenth-century project to display plaster replicas of the world's best sculptures, including Michelangelo's David. Some of the reproductions in the V. & A. collection are of sculptures that have been destroyed.

The cost of scanning and rematerializing the Seti I tomb will likely approach twenty million dollars. The Factum team will use the Lucidas for eye-level bas-reliefs and photogrammetry for the ceiling. "Seti has probably got three thousand square metres in decorated wall," Lowe said. Setting up a workshop in Egypt would help the project proceed more quickly, and funnel money into the local community.

We set the equipment down in the Room of Beauties. The metal hitting the floor produced a sinister echo. There is rudimentary lighting in the tomb, but the electricity is spotty, and there are sporadic blackouts. Lowe showed me around, pointing to a panel of Horus which retained deep reds and blues. "It is the most naturalistic thing of extraordinary power," he said. He noted all the damage: "*That's been stolen. That's been taken.*" For the Seti replica, Lowe planned to scan and incorporate the many fragments that had been hacked off since Belzoni's day. "Egyptologists from Basel have identified hundreds of fragments that are missing from the original tomb," he said. "Recently, at the Griffith"—an Egyptology institute in Oxford—"they tracked down a few more."

"I don't know what's wrong, but, if you open and close the hood like this, it looks like your car is talking."

AUGUST 25, 2008

The Room of Beauties still earned its name, but it looked deeply scarred. "You can see a lot of big squeezes here," Lowe said. "It's very lacking in color." There was some recent damage, too, in an adjoining chamber. In the nineties, the American Research Center in Cairo had undertaken a test restoration of a panel depicting Horus, the god of the living, introducing Seti I to Osiris, the god of the dead. The colors didn't match the surrounding ancient pigments, and some touch-ups were already decaying. "Here, where this is all peeling off the wall, is acrylic paint," Lowe said, shaking his head.

Egyptian officials, Lowe said, had given the go-ahead to Factum's proposal to scan a third tomb, that of Queen Nefertari. To celebrate the start of the Seti project, Lowe had arranged for a party to be held just outside the Tutankhamun replica. Musicians played electric ouds while several dozen guests sipped chilled hibiscus tea with sugar sediment at the bottom of the cups. In a speech in Arabic, Ismail, the Egyptian Factum employee, said that the scanning project would "change the way we see ancient monuments," adding, "Adam scanned the first tomb. We will all do the second tomb. The third will be done by Egyptians."

Inside the Seti tomb, we descended to the chamber with the celestial fresco. The lapis lazuli on the ceiling and the golden paint on the walls reminded me of a Byzantine church. In a corner, there was a pile of rubbish from the nineteen-twenties. "Those are flashbulbs used by Harry Burton, who took the first photographs of the tomb," Lowe said.

I asked Lowe about the ongoing investigation into Tutankhamun's burial chamber. Since November of 2015, Egyptian officials had approved more tests, and the results had been ambiguous. A Japanese radar technician, Hirokatsu Watanabe, assessed the walls using ground-penetrating radar, and he concluded that "organic and metallic substances" lay behind the north wall. Watanabe's test, however, couldn't give a clear sense of how much metallic material there was. It could be a few broken tools, or a heap of Nefertiti treasures. Zahi Hawass, perhaps out of competitiveness, dismissed Watanabe's findings, saying, "Radar is not scientific."

In March, the National Geographic Society sent over two American experts in ground-penetrating radar, who publicly cast doubt that there was any hidden chamber at all. The society, however, also submitted the data to an Englishman, George Ballard, who runs an international firm that conducts forensic structural investigations. Word spread in Luxor that Ballard concurred with Watanabe's more optimistic assessment.

Egyptian officials began discussing whether to drill a very small hole behind the north wall, from an unpainted nook adjoining the burial chamber, and peek in with a fibre-optic camera. Any incursions would have to be meticulous: scientists now have the technology to study the chemistry of air that's been locked inside a sealed tomb, and, if anyone allowed precious data to seep

out, it would be a scandal. Nicholas Reeves told me he hopes that a hole will eventually be opened, but he appreciates the caution: “You can’t start drilling the tomb like a Swiss cheese. You want to be sure.”

In the Seti tomb, Lowe told me that a conclusive answer to the mystery did not seem imminent. After the crash of an EgyptAir plane, in May, even fewer tourists were planning trips to Luxor. The Supreme Council of Antiquities would likely not move forward until touristic fears had subsided.

Ghaba, the handyman, began assembling the Lucida. A second scanner would be set up in the summer, Lowe said, and in the fall a Factum photogrammetry specialist would begin work on the celestial ceiling. Ismail and a Spanish colleague, Carlos Bayod, were about to spend several months in what amounted to an underground kiln watching a laser stripe inch across a wall. I asked Bayod, who has supervised dozens of scans with the Lucida, if the prospect daunted him. “No,” he said. “It gives you time in front of the painting—time to appreciate.” In an age of crowded museums, digitization afforded an increasingly rare experience: private communion with a work of art.

When the Great Belzoni entered Seti’s tomb, its resplendence could not make up for one major disappointment. There were no treasures except for the sarcophagus. “Seti I was a more famous pharaoh than Tut,” Lowe told me. “Very few of his funerary objects have ever been found. We’d know at this point, I think, if they had been found.” That is, they would have shown up on the black market, if not in museum collections. “So this means that they could possibly be *hidden* somewhere,” he went on. “And that’s why this scan is especially important. With the Tut, we weren’t even looking to find extra chambers. But the Egyptian authorities wanted us to scan Seti I precisely because a lot of people speculate that there are additional chambers.” Before we began climbing the steep steps back to the surface, leaving the Lucida scanner entombed in the Room of Beauties, I stared at the walls with suspicious eyes. But I was overwhelmed by all the ancient color. ♦

Daniel Zalewski is the magazine’s features director. He has contributed profiles of Werner Herzog, Ian McEwan, and others.

This article appears in other versions of the November 28, 2016, issue, with the headline “The Factory of Fakes.”