MAPPING A MAP: FACTUM ARTE AT THE SALA BOLOGNA

Adam Lowe, 2011

Related Project: Sala Bologna, The Vatican Palace

Some reflections on copies in the Vatican

When Factum Arte embarked on the recording of the Sala Bologna in the spring of 2011, the team was repeatedly confronted with diverse manifestations of copying that linked our efforts to this historically pervasive phenomenon and gave us new conceptual insights into the multiple dimensions of our own process. As we walked past the back of the apse of Basilica di San Pietro, for example, we noticed the newly carved, five-meter tall figures of San Marón and Santa Rafaela made by the Spanish sculptor Marco Augusto Dueñas. The figures, produced in Carrara marble from smaller clay models, were unveiled in January 2010 by Pope Benedict XVI. When the figures were transferred from clay to marble and from small to large, their character changed. In the act of enlargement, they have become copies of themselves.

Once inside the Vatican Museums, the route we took to the Sala Bologna through the museum corridors and the Apostolic Palace was lined with other types of copies – of classical figures and objects from the natural world – some are all we know of lost originals, some are originals that involved moulding and casting in their fabrication, some are unique while others can be seen in many collections, some are faithful reproductions, others more liberal deviations from their points of departure. The word "copy," in fact, denotes a multitude of intentions and is not necessarily derogatory. Etymologically, it derives from the Latin *copia*, or copiousness, a concept central to Renaissance rhetoric and artistic invention that describes a positive and creative source of abundance and fertility. It is only the modern age that has come to regard copiousness and the promiscuous creativity of copying with suspicion, even derision.

Roman copies of the Greek ideal are numerous within the Vatican and include such well-known masterpieces as the Apollo Belvedere, thought to be a Hadrianic copy of a Greek sculpture from the 4th century BC (Winckelmann celebrated this sculpture as the example of the Greek aesthetic ideal but by 1969 Kenneth Clark observes that it is forgotten by all except tour guides). It is generally assumed that the celebrated and oft-replicated Laocoön is a copy of a bronze original, although its biography is not completely clear. After its rediscovery in 1506, Raphael oversaw an informal contest to decide on the position of the missing limbs, which were then carved and added, only to be removed and replaced in the 1950's.

In the Cortile della Pigna – home to an enormous bronze pinecone – a different kind of sculptural transformation has taken place. The process of bronze casting is capable of producing multiple copies, but it is likely that the Pigna was always a unique piece. It was made in the 1st century CE using the lost-wax casting process. Originally from the temple of Isis in Campo Martius, the pinecone was moved to the Basilica of St Pietro in the 8th century and transferred to its current location in 1608 on the instructions of Pope Paul V. The centre of the Cortile della Pigna is currently occupied by an equally vast, modern bronze sculpture, Arnaldo Pomodoro's *Sphere within Sphere*. This work is an edition and other copies can be seen in diverse parts of the world including Trinity College, Dublin, the Teheran Museum of Contemporary Art the United Nations, New York. It is

reassuring to see the Vatican Museums are still actively adding to the collection but this sculpture, like the pinecone, invites many questions. Why is it there? What will they look like in a few hundred years? Will time and their social history treat each copy differently? Will they generate further copies and prove as fertile as the pieces already mentioned?

Though all the copies mentioned so far are sculptural the most radical and innovative copies can be found in the Sala Bologna, the Galleria delle Carte Geografiche and the Terza Loggia in the form of maps. A map is always an attempt to copy the world we inhabit; In the Sala Bologna, the first of the great attempts within the Vatican to cartographically represent and order the world, Gregory XIII celebrated his native city. Together with the later maps in the Galleria delle Carte Geografiche and the Terza Loggia, these are representations of the world harnessed, mediated and contained. Everything has been mapped, from the local to the global, from the chorographic to the cosmographic, from the terrestrial to the celestial. Cartography offers a selective, mediated version of the world. Maps perform an act of intercession. Abraham Ortelius and Gerardus Mercator were both producing synoptic, global visions at exactly the same time in the Low Countries, but from unorthodox and potentially reformed religious positions. Their portable printed maps put mediation at the service of trade and earthly reward, but also endeavoured to capture what the English dramatist Christopher Marlowe, in his play *Tamburlaine* (1587-88), called "the wondrous architecture of the world."

Mapping a map

Factum Arte's work in the Sala Bologna was devoted to both capturing 'the wondrous architecture of the world' and cultivating an intimacy with the physical characteristics that give this unique room the specific qualities it has. Mapping old maps with new technologies (the work carried out by Factum Arte in the Sala Bologna) adds yet another dimension to the cognitive layering that separates the actual world from its representations. Renaissance technologies and skills, some based on the same principles of triangulation that we use today, mapped and flattened the city of Bologna onto the walls; three times using three different projections onto three different walls – a map, an image of a city and a view. The province of Bologna and the celestial chart on the west wall and ceiling are also complex acts of cartography, the latter a further example of what Marlowe's Tamburlaine sees as the desire to 'measure every wandering planet's course… climbing after knowledge infinite.'

Our task was to focus on the map of Bologna on the south wall and record it in sufficient detail to make a facsimile, an exact copy that will hang in Bologna. We were also asked to record the whole room at sufficient resolution to facilitate a detailed study for academic and conservation purposes and to provide the visual material for this publication. Factum Arte was approached to carry out this work by Francesco Ceccarelli, Nadja Aksamija and Roberto Terra who have been working to ensure the maps from the Sala Bologna are available for scholarly study. They had seen the facsimile of Veronese's *Wedding at Cana* commissioned by the Fondazione Giorgio Cini for the Palladian refectory on the island of San Giorgio Maggiore and realised that a similar approach could result in a recreation of the Sala Bologna. While the facsimile of the Veronese returned one of the world's great paintings to its original location and at the same time raised questions about authenticity and originality, the production of a facsimile of the Map of Bologna is primarily about access to a remarkable, yet immovable and fully inaccessible cartographic monument.

The Sala Bologna is situated in an area of the Vatican that is not open to visitors and as a result, the technical and conceptual aspects of both the walls and the ceiling have not received the critical attention they merit. Originality is rooted in the trajectory or career of objects and images; it is not

a fixed state of being, but a process that changes and deepens with time. For this process to happen the work of art needs to be seen and discussed. Its importance is revealed in an ability to reflect the changing ideas and values that condition both its appearance and the ways we respond to it. While the frescoes in the Sala Bologna have had an unusually coherent and discrete history, their relative obscurity has masked their importance. After more than a year of negotiation it has been decided the facsimile of the Map of Bologna will be installed in the entrance to the Museo della Città at the Palazzo Pepoli Vecchio in Bologna. This will make this cartographic work accessible to the general public and will become part of the career of this complex image.

A brief description of the room

The south wall of the Sala Bologna is dominated by a map of the city of Bologna; this is the largest known Renaissance city map. It shows the city in great detail, framed by the depictions of popes Gregory IX and Boniface VIII. On the west wall is the first cartographic image of the Bolognese territories, while the north wall presents a view of Bologna seen from San Michele in Bosco. The east wall is mostly undecorated, as it used to have three windows looking out over the city of Rome. The ceiling depicts the night sky and zodiacal constellations from the outer-celestial point of view. As a result, when Gregory XIII stood on his crest, a tailless heraldic dragon inlaid in marble in the centre of the floor, he was able to take in the view of Rome, while simultaneously being surrounded by different representations of Bologna that virtually transposed his hometown into an idealized city state. When he looked up at the stars he saw them from the point of view of God looking down. In this bold cartographic representation, the pope was able to envisage the divine, while simultaneously reflecting on earthly governance. The conceptual purity of the room's cartographic conceit seems to invite a dialogue with two of the great twentieth century artists, Marcel Duchamp and Marcel Broodthaers.

Thanks to the durable medium of fresco, the Sala Bologna has changed relatively little from the way it looked when Gregory XIII first saw it finished, but it has changed in significant ways. Most significantly, the view over Rome through the windows on the east wall is no longer possible. The centre of the west wall contains a large infill and the pattern on the dado moves in opposite directions either side of this repair, an indication that the infill covers what may once have been a door. The areas of restoration around the two doors that now exist at each end of the wall imply that these have been changed as well. Both the ceiling and the south wall have undergone stabilization and limited conservation, clearly visible in the detailed photographic data we gathered. Chalk marks that cover parts of the south wall are an indication that further restoration work in being considered or planned. Perhaps surprisingly for a room that has not been open to the public, it contains a great deal of graffiti both incised into the surface and written on the surface.

Technology and innovation

There is no detailed information on the exact mapmaking techniques used for the city map, but its scale is estimated at 1:392. This remarkable urban document is both a representation of reality and an aesthetic idealization of a modern city. The map shows a beautiful city with its system of streets, a planned density with open spaces painted green, public buildings and churches (with their roofs gilded) and a defensive wall. To achieve this representation, the mapmaker(s) has adopted various strategies. For example, the open and comfortable feel of the city (a rejection the chaotic character of medieval urban living) is a result of widening of some of the streets. This has the effect that the facades can be shown in greater detail but it also requires a cartographic distortion. The act of mapping the surface of a painting with modern technology is similar in many ways, but the aim is

to produce an accurate and detailed relief map of the surface (in the areas that have been 3D scanned) and a high-resolution photographic archive that is accurate in terms of colour and dimensions. The transformation from real city to flattened city requires rules and decisions. A detailed observation of the surface of the fresco reveals a great deal about these rules and decisions. It also provides information about technique, intentionality, accident and the complexity of physical things. Objectivity is crucial and we rely heavily on technology. Every attempt is made to limit and understand the transformations that are inherent in every act of mediation.

The recording of the world's heritage in two and three dimensions is time-consuming and can be expensive. It has not been commercially targeted by most of the companies producing specially designed hardware and software, as the profit margins are not sufficiently attractive. The battle for control of copyright of the data is also of concern to many institutions and has made the task of obtaining permissions more difficult. Factum Arte has been developing practical solutions to both of these problems. On the one hand, we work with the institutions to ensure that the copyright of the data stays under their control so it can be freely used for study and conservation (in this case all negotiations with the Vatican Museums were successfully carried out by Nadia Aksamija and Francesco Ceccarelli with Roversi Monaco). At the same time, we have built up a team of designers, engineers and software writers working to overcome the technical difficulties that are encountered in each new situation.

White Light scanning and Panoramic photography

The recording in the Sala Bologna was carried out under the supervision of Rosanna Di Pinto and Filippo Petrignani and lasted for four days. The limited access and the scale of the work that had to be undertaken resulted in the use of two different systems capable of recording a vast amount of information in a short period of time; Panoramic photography was selected over planar photography and we worked for the first time with a Dr Clauss panoramic head and a camera with a 600mm lens. Structured light scanning was chosen over laser scanning for recording the surface of the south wall. A Nub3D SIDIO scanner and two independent markers were used. Both recording systems were modified for the work in the Sala Bologna.

Panoramic Photography

For the Panoramic photography Grégoire Dupond (head of photographic recording at Factum Arte) worked closely with the technicians at Dr Clauss (in Zwoenitz, Germany) and assembled the optimum configuration for the task. The system was tested on the facsimile of the burial chamber of Tutankhamun that is currently in Factum Arte's workshop. Panoramic photography relies on a fixed point of view: the camera and lens rotate on this point (in rows and columns) by an angle value inferior to the angle value of the field of view of each photograph, to ensure the whole area to be photographed is covered. Having a fixed and precisely set up point of view allows for each photograph to be warped and positioned in space with mathematical precision on a projection plane scaled to the original plane that was photographed. As each photographed area is at a different distance from the camera autofocus is essential. Some of the areas being recorded have no clearly defined features so it was necessary to attach a laser pointer to the camera. This was triggered with the autofocus to provide a clearly defined target and ensure accurate focus. One photograph was taken every 6 seconds allowing the flash unit time to reload. A 'slave' flash unit was used to provide a regular light source. This consisted of a fast Elinchrom flash head with a lens assembly to focus the flash on a small area of the painting. The camera and the slave unit work in tandem illuminating the detail that is being photographed. Separating the camera unit and the flash unit made possible to

control light incidence on the walls and avoid hotspots by positioning the flash accordingly during capture. It also allowed to reduce overall light exposure as only the area covered by each photograph was receiving light. As the position of the flash unit is known each photographic exposure is adjusted to compensate for light distance variation.

While the theoretically optimum results allowed by the camera and lens can be achieved recording at 5.5meters at a resolution of about 600dpi, we chose to shoot from a 8m to achieve a resolution of 340dpi at 1:1. This decision both increased the speed of recording and increased the quality of the data in the corners where the distortion, or warping is at its greatest. Six thousand individual photographs were stitched together with sub-pixel accuracy, meaning that the dimensional precision can be trusted. In 4 working days we took over 6000 photographs, recorded 33 billion pixels and produced an archive of over 200GB of 16 bit RGB data.

Structured Light 3D scanning

For the 3D scanning we used a NUB 3D SIDIO structured light scanner and two markers. This system uses the conjunction of optical technology, 3D topometry and digital image processing to extract 3D coordinates from an object surface. This technique is known as structured white light triangulation. Three-dimensional information is acquired by analysing the deformation caused when lines are projected onto the surface of an object. A series of images is captured by an integrated camera in the measuring head and from these images SIDIO integrated technology calculates a co-ordinated x,y,z point cloud relating to the surface of the object.

Pedro Miró (director of scanning at Factum Arte) worked with Jorge Rodríguez Larena at Nub 3D to write and perfect a new software known as the Dali Module. When scanning with the SIDIO both point cloud information and colour information are recorded. For every measured spatial point an RGB value is given. This color (tone) is not valid as an accurate color reference but it gives a map reference for the colour data recorded with Dr Clauss system. In order to extract a high resolution image from the 3D data the Dali module was used. This piece of software allows us to export 3D data as high resolution TIFF files, in other words we can output the cloud point as an ordered grid of pixels in which the height is represent as a tone of grey (and we can also output the RGB value for each point as RGB TIFF file). These files are used as a reference to match the high resolution colour data - an operation that is essential in order to produce a meaningful facsimile.

A 5 Sq meter section of the south wall was recorded at a resolution of 300 microns. The recording resulted in an archive of 220 shots. Each shot covers an area of 350x240 mm. A cloud point of 211 million measured points was generated. It was aligned and processed using Innovmetric Poliwork v11.

Non-contact recording and 'digital restoration'.

All the recording carried out in the Sala Bologna is 'non-contact', which means that at no point were any of the walls touched. The recording systems used by Factum Arte meet the highest conservation standards, have been fully tested and do not require markers to be fixed to the walls. As the quality of the recording improves and computer memory and software is developed the possibilities for both study and the new field of 'digital restoration' increase dramatically. It has taken many years for non-contact conservation to become an important part of the preservation of cultural heritage – this approach to conservation places the emphasis on creating the right environment so that things do not decay. Digital restoration makes it possible to test certain ideas

and theories virtually before undertaking any intervention on the actual work. While this approach has only recently become possible in any meaningful way, it is already starting to exert its influence on both on academic research and museum display.

The West wall of the Sala Bologna contains a map of the Bolognese territory, a highly detailed and specific cartographic exercise. In the centre is the city of Bologna, recognizable not only by its leaning tower but as a detailed 'idea' of the city. Every other town on the map seems to have the same degree of detail. An interesting study could be carried out by integrating this map into Google Earth, correcting the projection and using the satellite zoom and street view to compare and analyse the differences between the territory then and now. The whole wall is covered with cracks, nail holes (from which tapestries have been hung), infills, scuffed surfaces (especially on the place names), re-painting and lacunae. All of this can be digitally retouched using other maps and historical documents as a guide. In order to demonstrate the potential of this approach we have already started to undertake some digital restoration on this wall. It is hoped that this use of the data will facilitate a meaningful study both of the mapping techniques and the province itself. It will certainly suggest new types of museum display that can both engage and educate the public in Bologna.

Summary

Digital technology is associated with an increase in virtuality. So, when we speak of "digital restoration" we tick many of the right boxes. But 'physical facsimiles' made from digital data are more problematic. Contrary to common presuppositions about the limitations and failings of facsimiles and copies, digital technology is introducing many new twists into the ways we think about, preserve and share works of art. The installation of the map of the city into the new museum in the Palazzo Pepoli Vecchio in Bologna will certainly bring the extraordinary achievement of sixteenth century Bolognese cartography to the attention of as wider public. Like many of the copies in the Vatican museums, it will hopefully have repercussions that will deepen our understanding and interest in this subject.

In the production of the facsimile for the museum we have to address the problems of the real world; detailed plans, lighting specifications, budgets and compromise. The map of Bologna has not only changed location it has changed function. It has become an object tailored to its location in the entrance to a new museum, adapted to its spatial and functional context in terms of size (only 66 % of the total south wall has been re-produced). The area that has been replicated aims to maintain exact correspondence to the original in terms of colour, texture and relief, but like all the copies that exist in the Vatican, small differences affect what we see and feel. The importance of the digital archive of objectively accurate colour and surface data is that any subjectivity that has entered the process will not pass unnoticed.

Like the map in the Sala Bologna, the work carried out by Factum Arte to record and make a facsimile should be judged by its degree of accuracy to reality. The map of Bologna is valued for its accuracy to the real morphology of the city; the facsimile will be judged on its similarity to the original fresco. Both can be considered (and used) as active, efficiently designed objects, capable of mobilizing complex networks by themselves and able to construct an idea of the city. Apart from asking if the object is similar to the original, the questions should be: Does it serve its new function well? Is it well or poorly replicated? Will it lead to new understandings and insights?

Technical information

Dimensions of the Sala Bologna: Length 14.88m, Width 9.14m, Height 6.7m at walls and 9.18m to ceiling. Square meter area of painted surface: Ceiling 140 sqm, Wall area 189.6 sqm, decorated area of floor 4sqm.

The Photographic recording

- 360 Panorama of the Sala Bologna: 1100 photographs, 11.25 GigaPixels, 75 dpi at 1:1 - 67GB
- South Wall: 3000 photographs, 11.6 GigaPixels, 342 dpi at 1:1 - 69GB
- West Wall: 1100 photographs, 3.8 GigaPixels, 150 dpi at 1:1 - 23GB
- North Wall: 180 photographs, 1.2 GigaPixels, 334 dpi at 1:1 - 7.3GB
- Ceiling: 532 photographs, 6.4 GigaPixels, 190 dpi at 1:1 - 31GB

Photographic equipment

Camera: Canon EOS 7D: 18 MegaPixels APS-C CMOS sensor 22.3x14.9mm (5184x3456). Lens: Canon EF 600/4 L IS. Diagonal angle of view for combination camera/lens: 2º 34', Total weight: 6180g.

Dr Clauss Panoramic System: Rodeon VR Head with automatic pan and tilt produced in Germany by Dr Clauss GmbH. The Dr Clauss system was used with an Elinchrom Zoom Flash on a separate 'slave' unit.

Computers: One desktop to control the Dr Clauss System (and camera) and one to check the image quality. Both were used in a gigabit closed network so quality control and immediate backup can be ensured. The computer used to check the data has a colour calibrated external NEC professional LCD2690WUXi2 Monitor. All files are 16 bit Adobe RGB.

An EOS5D II camera and a video recorder were also used to document the work.

A Kodak greyscale and colour bar was used. For accuracy during printing Factum Arte's colour sticks were used. This system relies on human skill and attention to the reflectivity and complexity of the colours.

3D scanning of the South Wall

- A 5 Sq meter section of the south wall was recorded at a resolution of 300 microns.
- Nub3D Sidio Pro structured light scanner
- Camera resolution 1.4 Megapíxels, recording speed 1,5 sec per shot. Average distance between measured points 0.075mm – 0.400 mm, accuracy of the measurement 0.006 mm. 2 Schneider lenses (f12 and f28) are used for different resolutions.

The system was used with 2 markers.

Other requirements: Calibration system consisting of 4 calibration boards (550,360,230 and 120mm) and a sensor calibration linear guide. A set of 3 Schneider polarizing filters, 3 Manfrotto tripods, Intel i7 PC computer with Microsoft Windows 7, Triple scanning software (v.2.11), PolyworksInnvometris software v.10.6, 17'' LCD screen, mouse and keyboard, backup HD 2.5"

Routing

5 triangulated meshed tiles were generated from the cloud point, each of 1 sq meter. Each file was exported as a Binary STL file.For the routing, each of the STL files was imported individually into ARTCAM V11. Two toolpaths were generated corresponding to a rough and a fine cut. The rough cut was done with a 6 mm ball nose bit with a step-over of 1mm. The fine cut was done with a 0.4 radius tip with a step-over of 100 microns. The average cutting time for each tile was 3-4 days. Each tile was routed into 5cm thick high-density polyueurethene Axon board. The 3 D data was routed on a Victor VC-1300.

Facsimile

The routed panels were then joined by hand to form a 1 meter strip running from the door to the wall on the west wall. This was then moulded in silicon and cast as a positive into a flexible printable gesso developed by Factum Arte for this work. All printing was done on Factum Arte purpose built flatbed pigment printer. At the time of writing the facsimile production is ongoing.

Factum Arte recording team (also involved in the facsimile production): Adam Lowe, (Director of Factum Arte), Gregoire Dupond, (Director photographic recording), Pedro Miró Infante, (Director of 3D recording), Miguel Guillen: (Video and co-ordination), and Gabriel Scarpa (Photographic recording).

The production of the Facsimile: Juan Carlos Arias (Director of the workshop), Rafa Gershenson Rachewsky (Director of printing), Carmen G. Figueras, Aniuska Martín, Mari Carmen Pascual, Christian Fernández Mirón, Sebastián Beyró, Silvia Rosende, Francisco Javier Barreno, Eduardo Corrales, Carlos Bayod Lucini, and José Manuel Pellón,

Interns: Pepe Gómez-Acebo, Dean Schreiber, Otto Lowe, Laura Heinonen, Joel Stevens.

With thanks to: Jerry Brotton, Nadja Aksamija, Grégoire Dupond, Pedro Miró and Carlos Bayod.