



FACTUM ARTE'S WORK IN THE TOMBS OF TUTANKHAMUN, NEFERTARI AND SETI I

MARCH - MAY 2009
FOR THE SUPREME COUNCIL OF ANTIQUITIES

AND THE PRODUCTION OF A FACSIMILE OF
THE BURIAL CHAMBER OF TUTANKHAMUN FOR
THE SUSANNE MUBARAK CHILDREN'S MUSEUM, CAIRO.

FACTUM ARTE’S WORK IN THE TOMBS OF TUTANKHAMUN, NEFERTARI AND SETI I

The High resolution recording and production of exact facsimiles of the most endangered tombs is part of a major initiative by the Supreme Council of Antiquities to preserve the Theban Necropolis while making important tombs that are either closed or in need of closure accessible to the public and to scholars.

The Supreme Council of Antiquities has granted permission for the recording and facsimile production of the tombs of Seti I (closed to the public since the late 1980’s), Nefertari (closed to the general public but still visited by special appointment) and Tutankhamun.

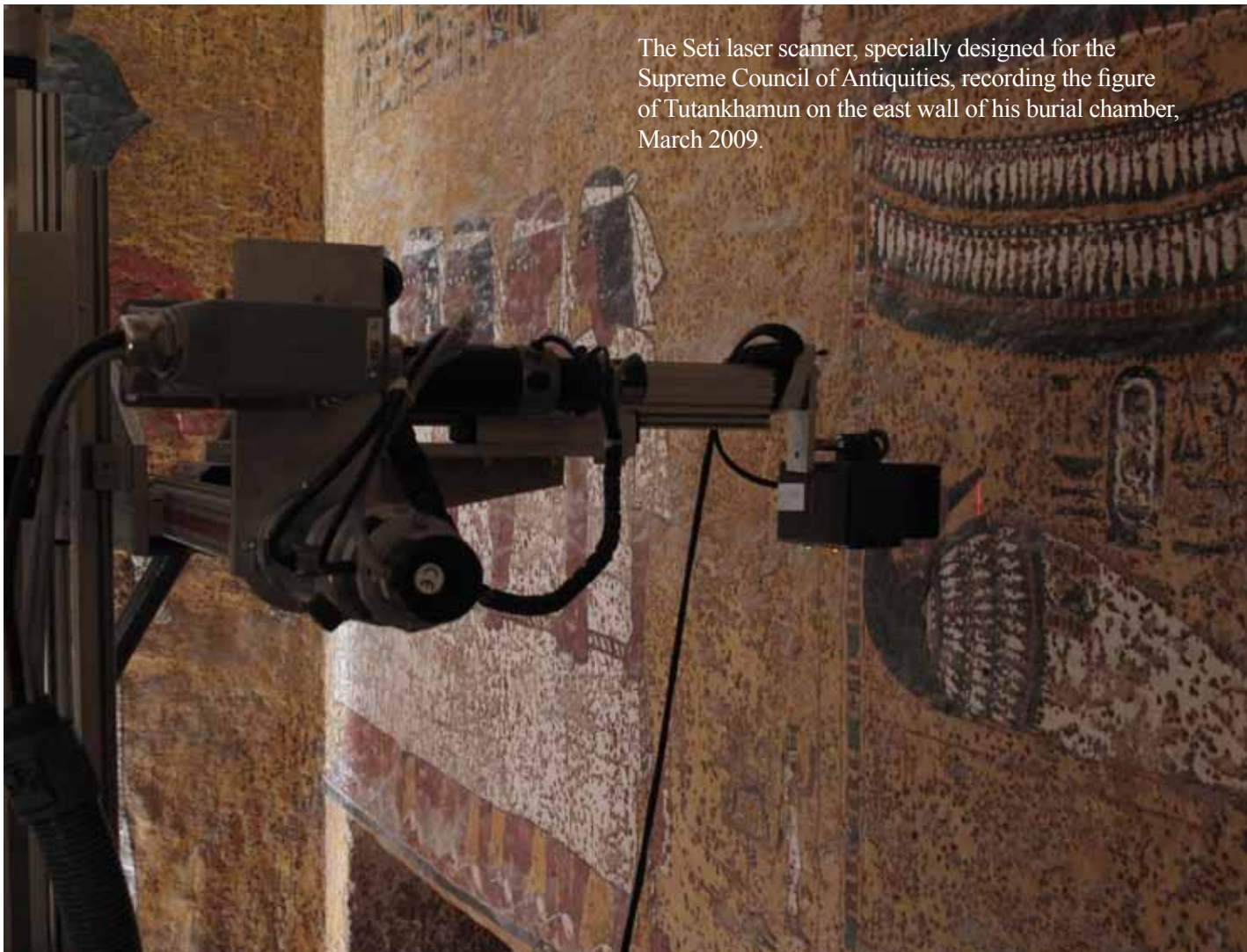
The project has been launched by Dr Zahi Hawass in collaboration with the University of Basel, The Friends of the Royal tombs of Egypt, the Foundation for Digital Technology in Conservation and Factum Arte.

All the recording of the tomb of Tutankhamun has now been completed. Work on the processing of the data is now underway and work on the facsimile of the burial chamber and sarcophagus of Tutankhamun will be completed in time for the opening of the Susanne Mubarak Children’s Museum in January 2010.

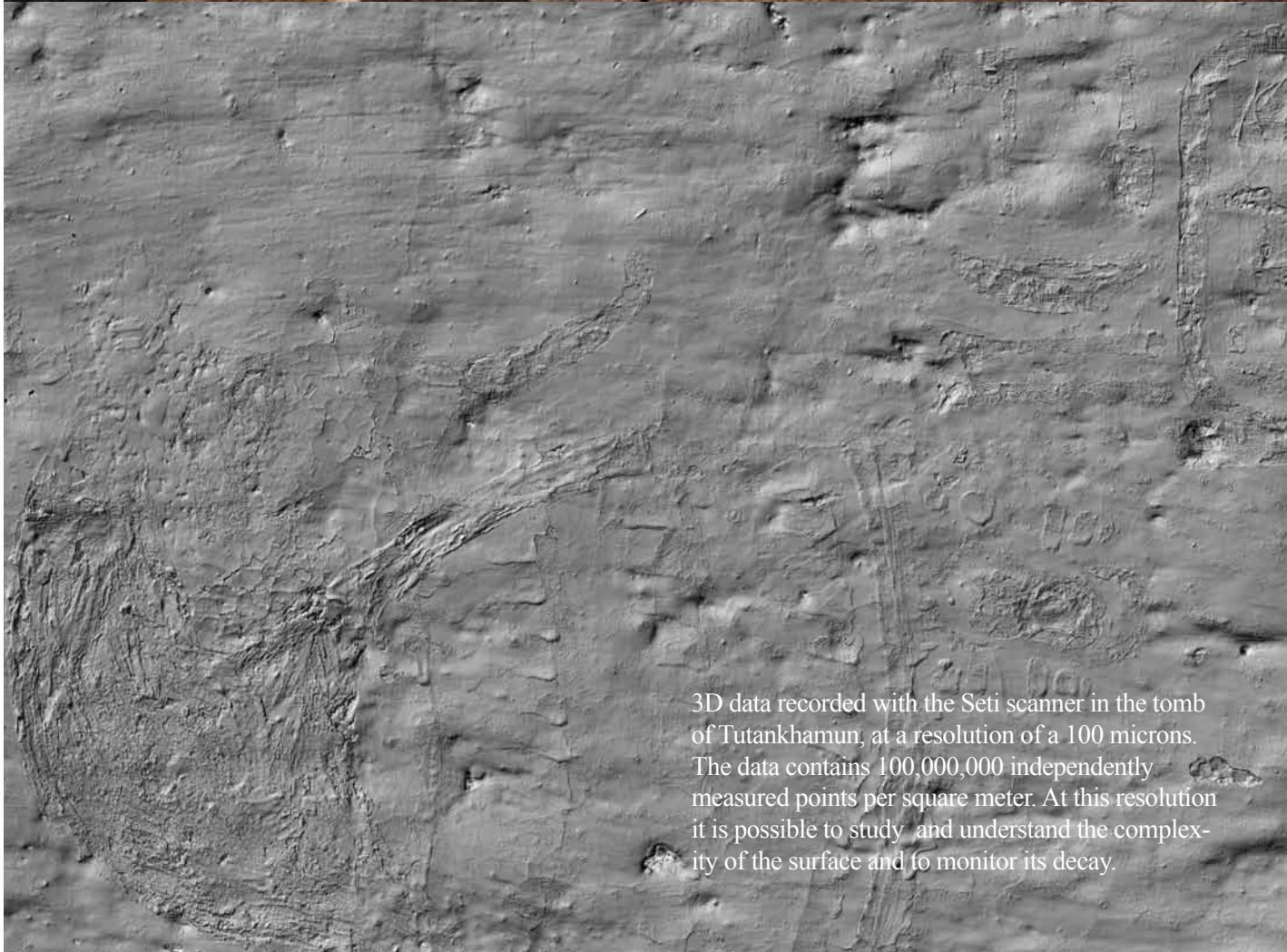
Dr Zahi Hawass has identified a site near Carter House at the entrance to the Valley of the Kings to install the facsimiles and a full feasibility study has been commissioned. It is estimated that over 500,000 visitors a year will visit the site and that the paying visitors to the facsimiles (and related exhibitions focused on the biography of each tomb) will provide revenue that can be used to ensure the long term preservation of the Theban Necropolis.



Factum Arte’s Pedro Miró and Gregoire Dupond working in the tomb, March-May 2009



The Seti laser scanner, specially designed for the Supreme Council of Antiquities, recording the figure of Tutankhamun on the east wall of his burial chamber, March 2009.



3D data recorded with the Seti scanner in the tomb of Tutankhamun, at a resolution of a 100 microns. The data contains 100,000,000 independently measured points per square meter. At this resolution it is possible to study and understand the complexity of the surface and to monitor its decay.

THE IMPORTANCE OF THE WORK

The proposal to carry out a detailed documentation of the complete tombs of Seti I, Nefertari and Tutankhamun and the production of accurate facsimiles has been approved by the Supreme Council of Antiquities following a successful feasibility study carried out by Factum Arte in 2002. The project is being directed by the University of Basel and the work managed and undertaken by Factum Arte, Madrid, in conjunction with Erik

Hornung, Emeritus Professor of Egyptology at the University of Basel, and Theodor Abt, president of the Friends of the Royal Tombs of Egypt.

Detailed funding plans are now being finalised between the Supreme Council of Antiquities, Factum Arte and The Foundation for Digital Technology in Conservation. The initial funding has been raised and work started on 16th March 2009. Recording work in the Tomb of Tutankhamun was completed on the 6th May. Work will begin in the Tomb of Nefertari in October 2009 after careful planning has been completed. Work in Seti I will begin when the excavation work in the tunnel has been completed (estimate 2011). The unprecedented resolution of the recording processes and the substantial surface area of the tombs (Seti I has approx 2500 square meters of relief polychrome surface) will require several years to record. The fabrication of the exact facsimiles will begin at Factum Arte's workshops in Madrid in the autumn of 2009 after all the data has been processed and prepared.

THE SUPREME COUNCIL OF ANTIQUITIES HAS APPROVED THE FOLLOWING WORK

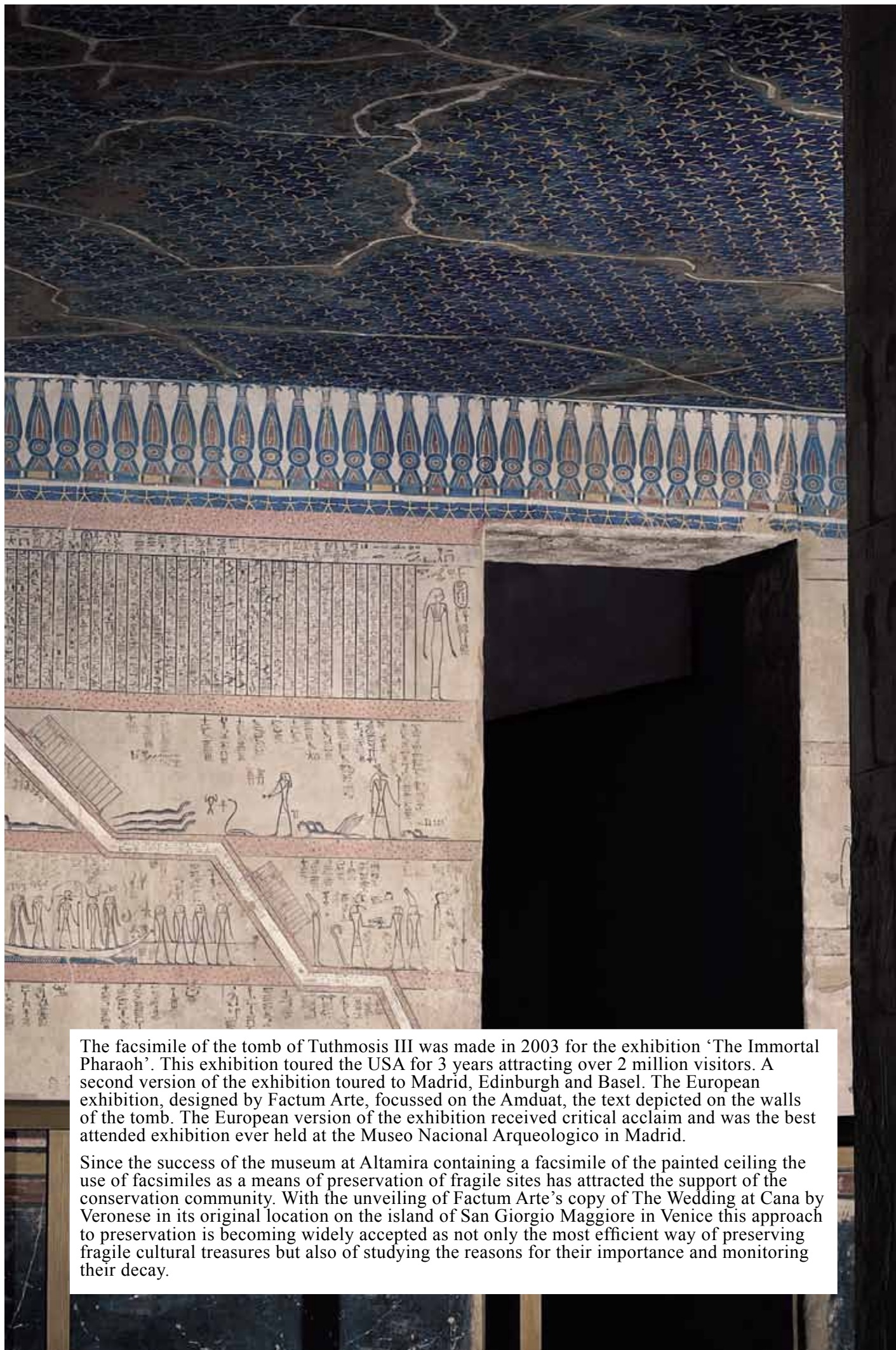
- *The digital recording in three dimensions (at a resolution of between 100 and 700 microns) and colour recording (1:1 digital photographs at a resolution of 600 - 800 DPI) of all of the decorated surfaces within the tombs of SETI I, NEFERTARI and TUTANKHAMUN.
- *The creation of an exact facsimile of each tomb.
- *An exhibition built around the facsimiles that will be permanently installed on the West Bank.
- *The creation of a digital archive consisting of all the high-resolution data recorded during the documentation of the tomb. This archive will be essential for monitoring the future condition of the tombs.
- *The copyright of the data will belong to the Supreme Council of Antiquities.
- *A significant transfer of technology and training will also result in a permanent laser scanning unit within the Supreme Council of Antiquities.

This will result in the highest resolution large-scale facsimile project ever undertaken. It will set new standards for the use of facsimiles in conservation. New 3D scanning systems have been developed specifically for use in the tombs and a new generation of scanner is now in production. The 3D recording is being done at a resolution of 100 microns with 100,000,000 independently measured points per sq meter. A colour photographic system has been developed with low level cold lights to record the painted surfaces at 1:1 at 600 - 800 DPI. The aim is to record the entire tombs of Seti I and Nefertari along with the burial chamber and sarcophagus from the tomb of Tutankhamun.

Technology at the service of conservation and preservation.

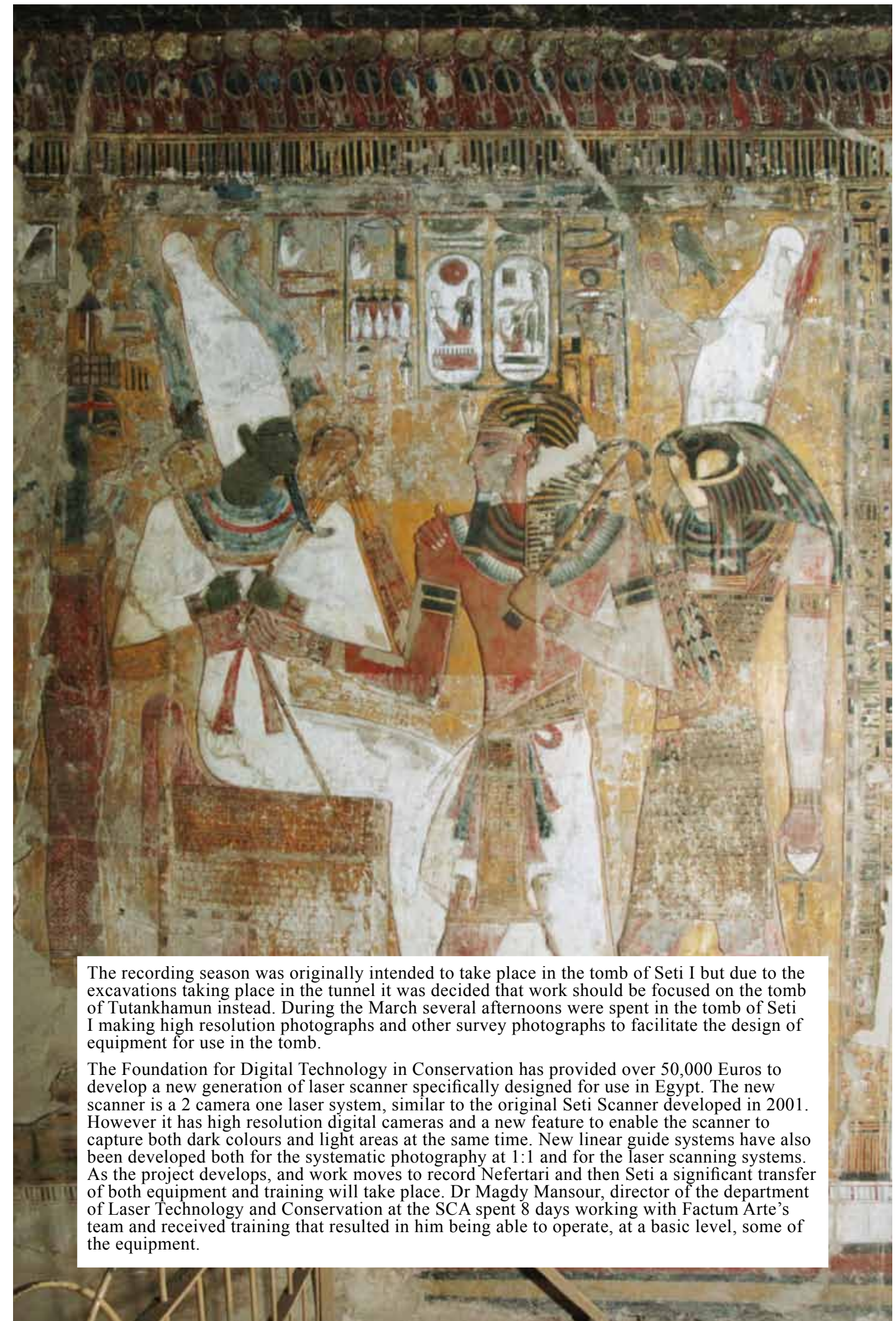
The use of new technologies to record and reveal the complex histories of these tombs has already proved very popular with the public. The aim is to turn this public interest into a force assisting in the protection of the tombs. It is anticipated that the facsimiles will receive at least 500,000 paying visitors a year. A facsimile of the tomb of Tuthmosis III was made by Factum Arte in 2002 and has now been visited by over 2 million people. A touring exhibition based around the facsimile of Nefertari is being planned by the Antikenmuseum Basel for 2013.

The production of the facsimile of tomb of Seti I is the most ambitious part of the project not only due to its scale but also because it will re-integrate all the fragments removed in the C19th. Most of these fragments are now in museums in Europe and the USA. An exhibition relating to each tomb will focus on its biography and will reveal the reasons for their continued importance and relevance.



The facsimile of the tomb of Tutankhamun was made in 2003 for the exhibition 'The Immortal Pharaoh'. This exhibition toured the USA for 3 years attracting over 2 million visitors. A second version of the exhibition toured to Madrid, Edinburgh and Basel. The European exhibition, designed by Factum Arte, focussed on the Amduat, the text depicted on the walls of the tomb. The European version of the exhibition received critical acclaim and was the best attended exhibition ever held at the Museo Nacional Arqueológico in Madrid.

Since the success of the museum at Altamira containing a facsimile of the painted ceiling the use of facsimiles as a means of preservation of fragile sites has attracted the support of the conservation community. With the unveiling of Factum Arte's copy of The Wedding at Cana by Veronese in its original location on the island of San Giorgio Maggiore in Venice this approach to preservation is becoming widely accepted as not only the most efficient way of preserving fragile cultural treasures but also of studying the reasons for their importance and monitoring their decay.



The recording season was originally intended to take place in the tomb of Seti I but due to the excavations taking place in the tunnel it was decided that work should be focused on the tomb of Tutankhamun instead. During the March several afternoons were spent in the tomb of Seti I making high resolution photographs and other survey photographs to facilitate the design of equipment for use in the tomb.

The Foundation for Digital Technology in Conservation has provided over 50,000 Euros to develop a new generation of laser scanner specifically designed for use in Egypt. The new scanner is a 2 camera one laser system, similar to the original Seti Scanner developed in 2001. However it has high resolution digital cameras and a new feature to enable the scanner to capture both dark colours and light areas at the same time. New linear guide systems have also been developed both for the systematic photography at 1:1 and for the laser scanning systems. As the project develops, and work moves to record Nefertari and then Seti a significant transfer of both equipment and training will take place. Dr Magdy Mansour, director of the department of Laser Technology and Conservation at the SCA spent 8 days working with Factum Arte's team and received training that resulted in him being able to operate, at a basic level, some of the equipment.

REPORT ON THE WORK COMPLETED IN THE TOMB OF TUTANKHAMUN.

SEASON MARCH -MAY 2009

Supreme Council of Antiquities
University of Basel
Factum-Arte, Madrid

The Foundation for Digital Technology in Conservation.
Erik Hornung, Emeritus Professor of Egyptology at the University of Basel
Theodor Abt, president of the Friends of the Royal Tombs of Egypt

The work is being managed and undertaken by Factum Arte, Madrid.
All work is being carried out in co-operation with the Department of Laser Technology and Conservation at the SCA and a transfer of equipment and training will take place throughout the project.

The Team working in the Tomb of Tutankhamun consisted of :
Adam Lowe - Head of Mission and Director of Factum Arte
Grégoire Dupond - Acting head of mission (when Adam Lowe was not present)
and Head of Photography and technical development at Factum Arte.
Pedro Miro - Head of 3D scanning at Factum Arte
Piers Wardle - Laser Scanning and Photography
Naoko Fukumaru - Chief Conservator at Factum Arte
Alicia Guirao - Photography and documentation
Mohammed Khalil - SCA Inspector
Magdy Mansour - SCA Department of Laser Technology and Conservation

Financed by Factum Arte, the Foundation for Digital Technology in Conservation and the Friends of the Royal Tombs of Egypt.
The Swiss Ambassador, Charles-Edouard Held, provided a guarantee that enabled the equipment to clear customs.

It is important to note that each tomb presents specific recording challenges. Tutankhamun’s tomb is small and the sarcophagus and sarcophagus lid reduce the available working space with the distance between the sarcophagus and the wall of 126 cm at the narrowest point. Work was carried out without interrupting the normal flow of visitors. Throughout the recording work the tomb remained open to the public. On busy days approximately 1000 people visit the tomb. The visitor numbers have a dramatic effect on the temperature and humidity in the space. Most visitors showed a great interest in the work that was being carried out and many expressed concern that their presence had a destructive impact on the preservation of the tombs.



One of Harry Burton’s photographs taken soon after the discovery of the tomb of Tutankhamun. The section on the left is no longer in the tomb. Once its exact location has been identified it will be recorded and reintegrated into the facsimile. Photograph from the Griffith Institute, Oxford



The lorry arriving at Marsam Hotel, Gourni on Friday 13th March. It had taken 12 days to clear everything through customs in Cairo. The customs clearance was finally made possible by a guarentee underwrit-ten by the Swiss Embassy. After leaving Cairo the lorry was involved in a crash 200 km south of Cairo and all the boxes had to be moved to a new lorry.



Loading the boxes onto a tractor and trailer to move them to the Valley of the Kings.



The boxes arriving in the Valley of the Kings escorted by Adam Lowe and Alicia Guirao on the left and Gregoire Dupond on the right.



Unloading the boxes into storage in KV3. Due to the space limitations in Tutankhamun most of the equipment, that was specially designed for use in the tomb of Seti I, had to be stored in KV3 and moved into the tomb as it was required.



Loading the Seti laser scanner into the truck at Marsam hotel after extensive testing to ensure no damage had occurred during transport.



The Seti scanning frame being lifted into the tomb of Tutankhamun after the sarcophagus lid had been covered with a wooden structure to protect it during the work.

RECORDING EQUIPMENT USED IN THE TOMB:

“SETI” low intensity red light laser 3D scanner. Resolution of 100 microns

This equipment was used for 14 days to record both ends of the sarcophagus and about 2 square meters of the east section of the north wall and 1.5 square meters of the east wall. There are over 70 individual scans.

The time spent scanning relatively small areas was due in part to handling and setup of the equipment inside the confined space of the tomb. Safety was our first priority and we took all necessary steps to ensure that the tomb, the team and the equipment were protected. It was decided to stop using that equipment when recording became difficult in tight spaces.

This equipment was handled by Grégoire Dupond and Piers Wardle.

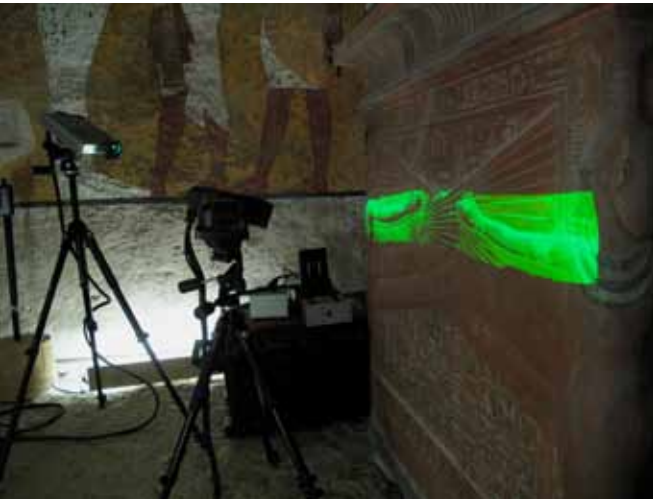


The Seti Laser scanner mounted onto the linear guide frame that was specially designed for use in the tomb of Seti I. This is a scanning system designed to record painted surface with shallow relief. A new generation scanning head is currently in production.

NUB 3D white light 3D scanner. Resolution of 250 to 700 microns

This equipment was used for 32 days to record the whole of the tomb.
Over 1300 scan shots were necessary to cover the surface scanned.

This equipment was handled by Pedro Miro.



Nub 3D structured light scanner recording the west side of the sarcophagus.



Pedro Miró working with the Nub 3D structured light scanning system to record the South Wall. The data being recorded appears on the monitor allowing an initial check to be made during recording.

Phase One H25 digital back on a Hasselblad MF camera with an 80mm lens.1:1 at 800 dpi

This equipment was used for the first few days in the tomb to do a survey of different parts of the tomb and to record the seals in the treasury. This equipment was handled by Alicia Guirao.

A Canon EOS5DII with a 100 mm or 180mm lens. 1:1 at 600-800 dpi

This equipment was used for 21 days.

For the first 3 days the camera was used on a computer controlled 3 axis machine (the same one used for the SETI 3D scanner - see previous page).

It was then used for 18 days mounted onto a 1 axis computer controlled machine specially designed for use in the cramped spaces of the tomb. This system was designed by Factum Arte, made and shipped to Luxor.

Over 8000 individual shots resulting in 16000 files were necessary to cover the whole of the tomb, with approximately 100 shots per square meter. The resolution of these photographs is between 600 – 800 DPI at 1:1. This equipment was handled by Grégoire Dupond, Piers Wardle and Naoko Fukumaru.



Due to space restrictions in the tomb a new linear guide structure was made, tested and used for the majority of the photographic recording.

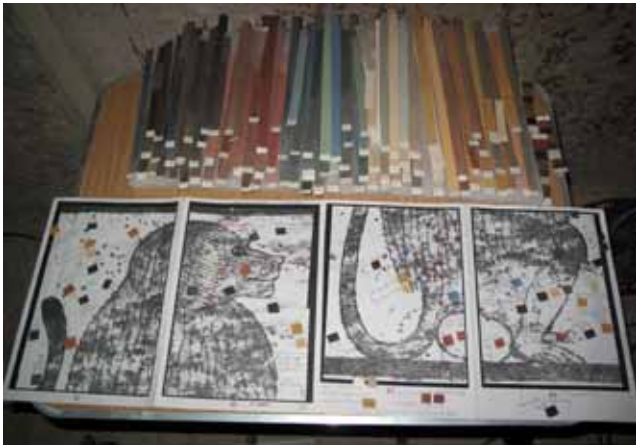


The specially designed photographic system recording the walls of the tomb of Tutankhamun in March 2009. Operated by Gregoire Dupond.

Work Monitoring and Colour Recording in the Tomb:

Factum Arte’s conservator, Naoko Fukumaru was monitoring the team and the equipment, paying special attention to safety of the tomb. She also was in charge of taking colour samples that are an important part in the production of the facsimiles. In order to produce a facsimile that has accurate colours it is necessary to be able to compare the colours of the original with the colours of the facsimile.

Over 150 different colour samples were created on paper sticks and compared to colours on the walls. Matching colours are noted and located precisely. Over 500 different sticks were recorded. Naoko Fukumaru also took macro photographs of these specific locations and recorded other important characteristics of the surface.



The system used to ensure accurate colour matching during the production of the facsimile involves specially prepared colour sticks that are matched to the exact tone and brilliance of the colour on the wall.



Naoko Fukumaru, Factum Arte’s conservator carrying out colour matching on the North wall.



Routing the 3D data at a resolution of 100 microns to produce the exact relief of a section of the east wall of the burial chamber of Tutankhamun.

The precision milling of the surface in three dimensions ensures objective accuracy and results in an exact facsimile. This is the most expensive and time consuming part of the production process. When cutting at the highest resolution each section of 52 x 52 cm takes approximately 78 hours to machine. Once the surface has been milled it is then moulded, cast printed and finished by hand. It is this level of obsession with the details of the surface that results in a convincing facsimile.



All of the photographs were taken during the routing and before all the dust had been removed.

Top: Routing a panel measuring 38 x 52cm.

Middle: A detail of the centre of the panel around the beard of the figure of Tutankhamun. From 3D data of this resolution it is possible to understand how the paint is cracking and to locate the most pronounced microbacteria growing on the surface

Bottom: A detail of the head-dress of Tutankhamun showing the relief and brush marks in the areas of blue/green paint.



Top: A photograph of one of the seals taken during the recording in the tomb of Tutankhamun. The coloured area in the centre is collaged from three different seals and is the first stage of a physical reconstruction of one of the seals.

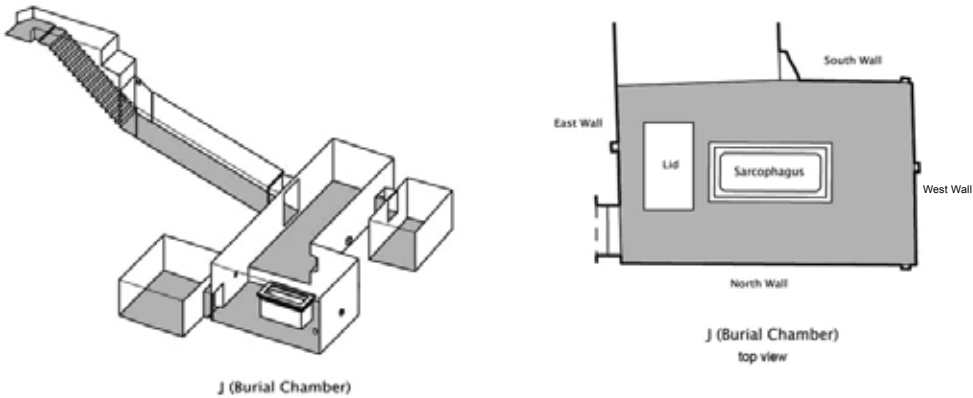
Below: A photograph of one of the broken seals in the tomb.



Accurate colour matching and detailed observations of the surface characteristics of the walls of the tomb and surface of the Sarcophagus are an essential part of the work carried out by Facrum Arte. Without this data it is impossible to make a facsimile that has the character fo the original tomb in its current condition.

TUTANKHAMUN NUB3D STRUCTURED LIGHT SCANNING

FROM 9TH MARCH - 4TH OF MAY 2009.
KV 62, VALLEY OF THE KINGS, WEST BANK, LUXOR, EGYPT
PREPARED BY PEDRO MIRO



*Plans taken from Theban Mapping Project

Scanning equipment
Nub 3D, triple system. version 1.2 (windows 2000 version)

Site Location
Latitude: 25.44 N
Longitude: 32.36 E
Elevation: 170.55 msl
North: 99,572.277
East: 94,069.638

Measurements of the Burial Chamber
Average height: 3.64 m
Average width: 4.11 m
Maximum width: 6.35 m
Total area scanned: 63.18 sq. m

SCANNING J
In March and April Factum Arte carried out a 3D survey of the burial chamber of Tutankhamun (KV 62).
The first day of scanning with the Nub3D system was the 14th of March and the last the 29th of April. The parts of the chamber scanned during this period were the following:

- South Wall: 14th - 18th March
- West Wall: 18th - 23th March
- North Wall: 26th March - 2nd April
- East Wall: 4 - 5th April
- Seal sample (small fragment of a seal from the treasure room) 7th April
- Sarcophagus North side: 13 - 18th April
- Sarcophagus East side: 19 - 21st April
- Sarcophagus South side: 21 - 25 th April
- Sarcophagus West side: 26 - 27th April
- Sarcophagus top Lid: 28th April
- South West section from the ceiling - 29 th April

Ordered by scanning dates
Check map above for visual reference

RESOLUTION AND EXPOSURE

The scanning resolution varies for the different objects scanned. The three resolutions used in the tomb are: 700 microns, 400 microns and 200 microns.

Objects scanned at 700 microns are:

- South Wall
- West Wall
- North Wall
- East Wall
- South West section from the ceiling

Objects scanned at 400 microns are:

- Top and bottom rim from the North side of the Sarcophagus
- Top and bottom rim from the East side of the Sarcophagus
- Top and bottom rim from the South side of the Sarcophagus
- Top and bottom rim from the West side of the Sarcophagus
- Sarcophagus lid

Objects scanned at 200 microns are:

- Seal sample (small fragment of sealing wall assumed to be from the treasure room)
- Main Sarcophagus North side
- Main Sarcophagus East side
- Main Sarcophagus South side
- Main Sarcophagus West side

The exposure settings used for most of the tomb (at all resolutions):

- Multi exposure
1st exposure 33 - 2nd exposure 133 - Markers were launched on the 2nd exposure

MEASUREMENTS AND SCANNED AREA

Walls

North wall	6,35x3,64 m	23,11 sq m
South wall	2,88x3,64 m	10,48 sq m
West wall	4,11x3,64 m	14,96 sq m
East wall	4,02x3,64 m	14,63 sq m
TOTAL AREA	63,18 sq m	

Sarcophagus

North side	2,36x1,5 m	3,54 sq m
South side	2,36x1,5 m	3,54 sq m
West side	1,03x1,5 m	1,55 sq m
East side	1,03x1,5 m	1,55 sq m
Top Lid	1,30x2,65 m	3,45 sq m
TOTAL AREA	13,63 sq m	

Extras

Seal	0,13x0,08 m	0,0104 sq m
SW Ceiling	1,36x2,50 m	3,40 sq m

The average scanning speed under optimal circumstances is:

- 700 microns: Average of 5.6 sq meters/day (1.6 sq meters per 2 hour per session).
- 400 microns: Average of 3.5 sq meters/day
- 200 microns: Average of 1,30 sq meter/day

The walls were finished in 24 days (2,63 sq meters a day). The average optimal scanning speed is 5.6 sq meters that means due to different kinds of problems over different days the average was reduced down to 2.63 sq meters.
But for example the East wall was done in 2 days - at 7,3 sq meters/day.

FILE SYSTEM AND NAMING

The Nub3D scanner works with TRIPLE v1.2 that generates TRI format files. Each file corresponds to a session. In each session between 20 and 30 shots are made (depending on the resolution)

From the TRIPLE (.tri) we export each of the individual shots into PIF format (This is the file format is used by PolyWorks 10). Each PDF files contains a cloud point corresponding to the area of each shot. It also includes black and white image data from the shot.

From PolyWorks 10 we import the PIF files into polyworks projects. Each project has PWK extension and can only be opened in Polyworks.

A correlative session number gives the files names and each file is held in a folder named with as the object scanned. For example: /Wall E/session 1.tri or /sarcofago/side E/session 1.tri

DIRECTORY STRUCTURE

The Data is contained in external HD under a folder called **Tutankhamun 3D**

In this folder there is another folder called **White light scanner**. This folder contains all the data generated with the Nub3D white light system. Under that folder we can find:

- Original TRI files
- PIF files
- Polyworks files
- Testing files

Original TRI files folder 49, 74 Gb

contains the TRIPLE session files. Size 49, 74 Gb and contains these folders:

- ceiling
- lid
- Sarcofagus
 - Side E
 - Side W
 - Side N
 - Side S
- Seals
- Wall E
- Wall W
- Wall N
- Wall S

PIF files Folder 12 GB

Contains the exported images of each session they are kept following the same folder structure as Original TRI files folder. This folder will contain all the pif files

Polyworks files Folder 4, 68 Gb
Contains the polyworks project files for each object. The walls and the sides of the sarcophagus are considered different objects.

Testing files Folder 482 Mb
Contains test files made during the scanning process.

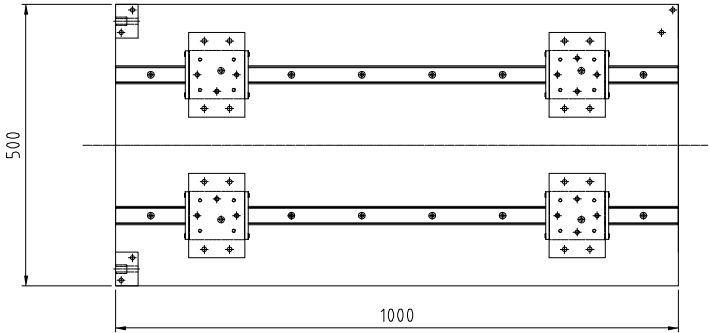
Another folder will be included as:
STL files folder which will contain the STL files generated from the aligned images.

HD BACKUP
At this moment there are 3 copies of the White light scanning folder in 3 external HD plus a working copy in Factum Arte’s office. This last one will become the source archive that will be added to as the files are prepared for routing and printing. One copy of the Data was delivered to Dr Mostafa Wazery by Gregoire Dupond on Thursday 7th May along with a provisional report.

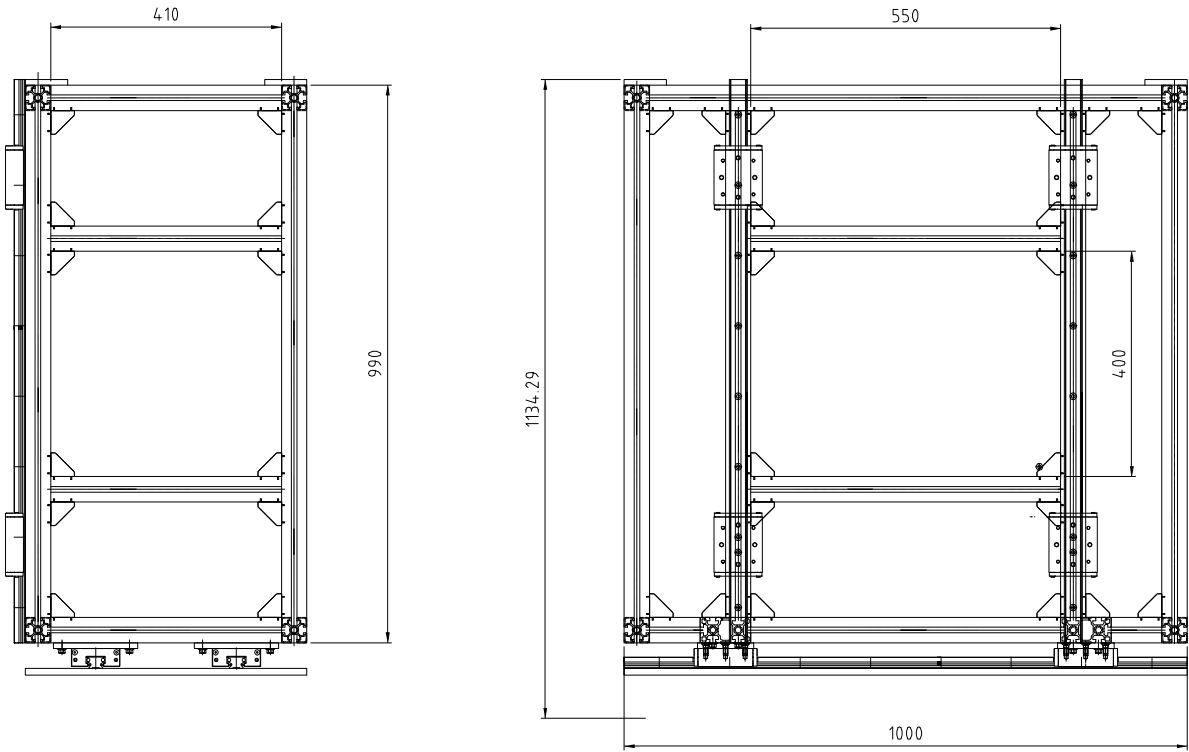
This data will be supplied to the SCA when it has been assembled.

DESIGN FOR LINEAR GUIDE SYSTEM TO HOLD
THE SETI SCANNER AND THE CAMERA WITH LIGHTS

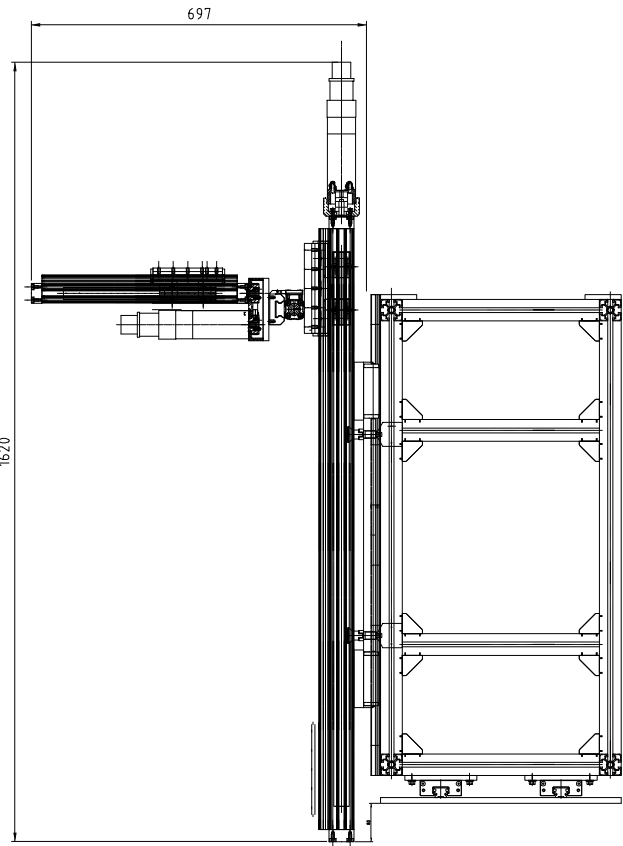
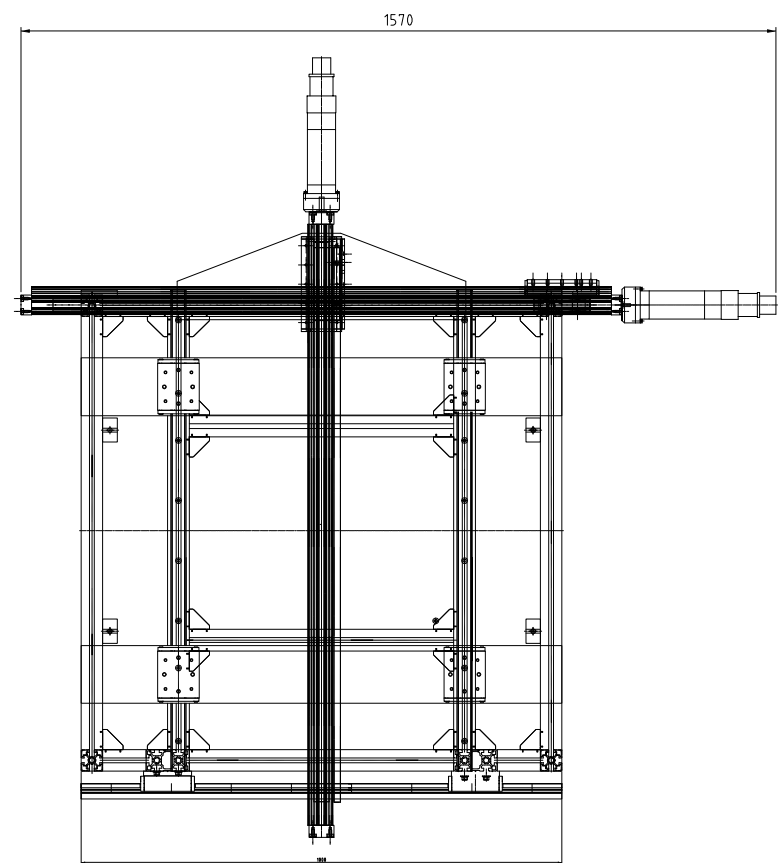
BASE PLATE WITH TRACKS



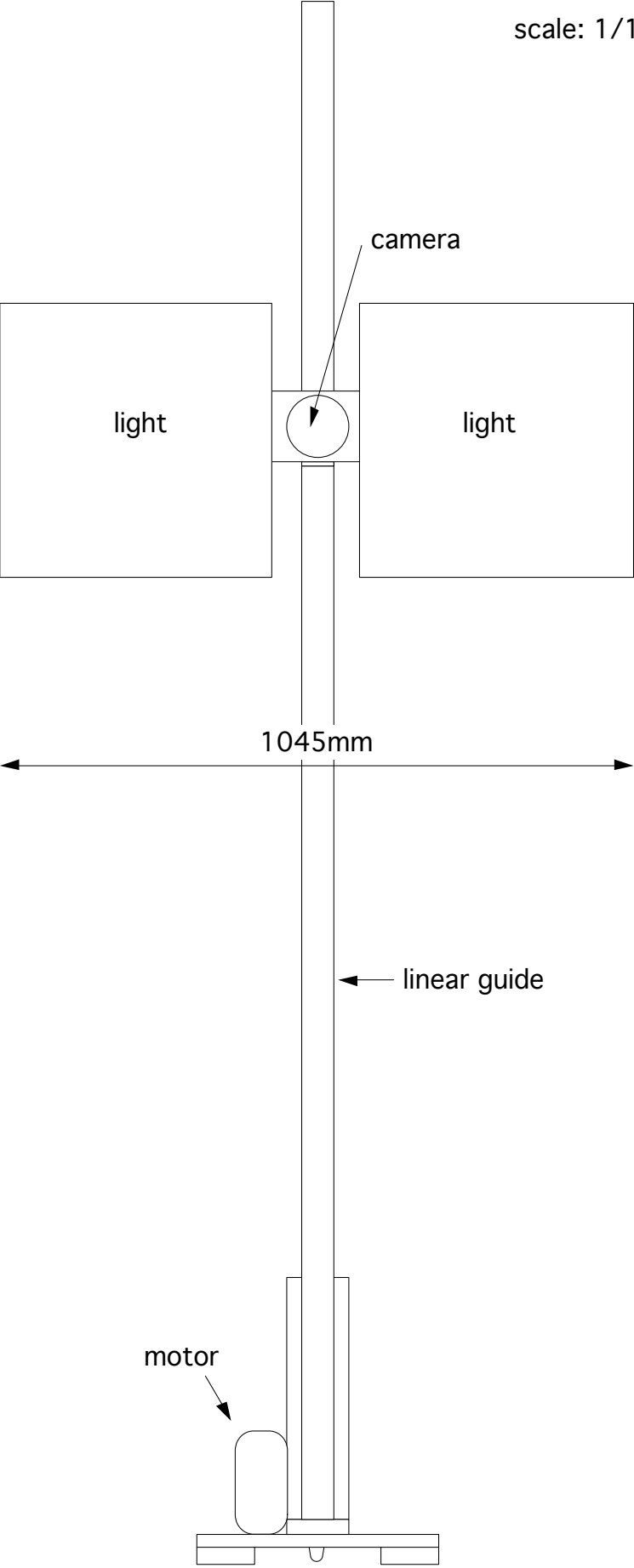
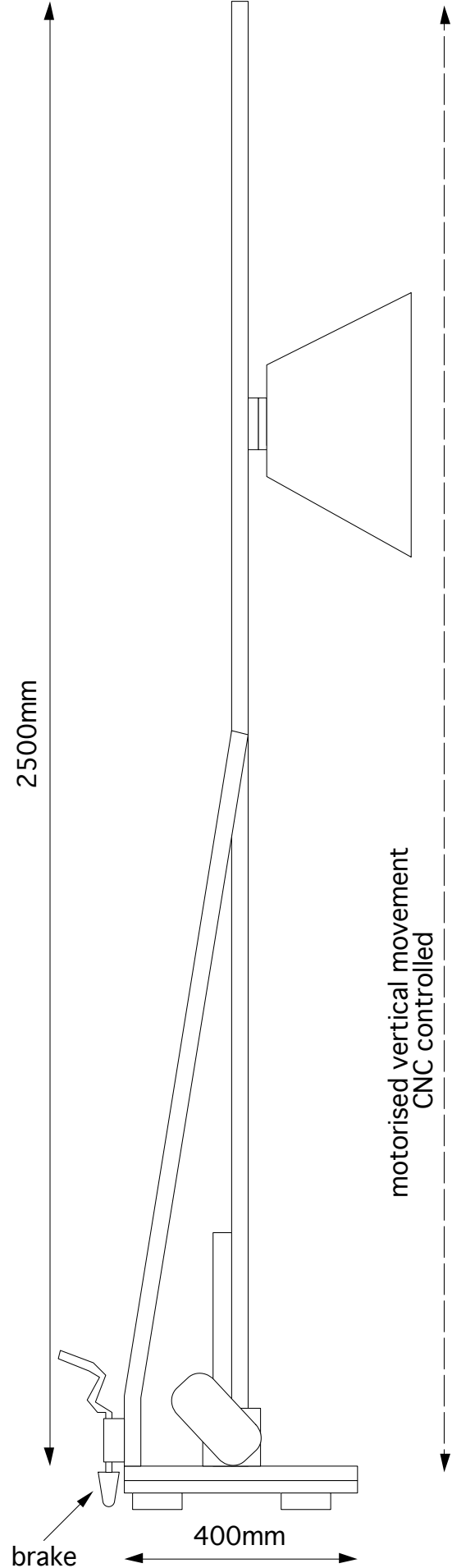
BASE MODULE



LINEAR GUIDES



DESIGN FOR LINEAR GUIDE SYSTEM TO HOLD THE SETI SCANNER AND THE CAMERA WITH LIGHTS



scale: 1/10

manual horizontal movement on base plate
(base plate is same as other system using precision rails)

**COLOUR RECORDING AND CONDITION REPORT OF
THE TOMB OF TUTANKHAMUN (KV62)**

PREPARED BY NAOKO FUKUMARU

All comments are based on visual observation of the surface of the tomb. At no point was the surface touched or any chemical or destructive analysis carried out. The aim of the study is to understand the character of the surface and the reasons it looks as it does. This is not a report for conservation purposes.

The surface of bedrock was probably prepared with hand-axes, hammers and chisels. Tool marks are visible underneath of the plaster layers or brick holes. Photo: 4617, 4618 south wall, brick holes: 5543 north wall, 5545 south wall, 5547 west wall, 5548 east wall.

The walls were coated with a few layers of plaster (thickness of 1-8 mm) for smoothing the bedrock before application of the priming coat and painted decoration. Photo: 4619, 4620 left bottom of west (monkey) wall, 5537 two layers of plaster on south wall, 5538~5540 three layers of plaster on north wall.

Plaster contains many small bubbles. Photo: 4910.

Some areas of painted plaster have been detached from the bedrock. Photo: 4617, 4618 south wall, 5542 north wall, 5597 east wall.

Coarser plaster was used on some areas. Photo: 5536 south wall, 4632 a brick hole on south wall 4630, 4631 west wall .

Plaster was coated with bright white priming paint on the north and west walls. Photo: 4626, 4672 west wall, 4692 north wall.

Some areas of paints have been detached from the plaster. Photo: 5807, 5817, 5818, 4924 east wall.

Yellow paint was applied on the plaster without white priming paint on the south and east (book of the dead) walls. This is probably due to the lack of pigment or time. This indicates that the painting work was begun from the north and west then south and east walls. Photo: 4627 south wall, 5549 east wall.

White priming coat is visible where yellow paint was lost. Photo: 4656 bottom second monkey on the west wall, 4628, 4667 north wall.

There are tool marks on the plaster. This indicates that plaster was applied by trowel. Photo: 4682, 4683 north wall, 4918, 5572, 5573 north wall.

Hand marks on plaster? Photo: 4696, 4697 south wall, 4698, 4699 west wall.

There are strong brush strokes on pale blue/green paint on the apron of the Tutankhamen on the north wall. The thickest paint area is discoloured to dark brown. Brown discolouration is also visible on the pale blue/green on the east wall and on the apron of the Tutankhamen on the south wall. Blue pigment is probably Egyptian blue pigment (calcium copper silicate) that tends to discolour to dark brown due to deterioration of synthetic blue and green copper pigments. Photo: 4684, 4685 south wall, 5626, 5627 east wall, 5628 north wall

Baboons on the west wall were painted: 1.plaster 2.white priming coat 3.yellow paint 4.red under drawing 5.red face 6.blue 7.white hair 8.black lines Photo: 4657.

Baboons have different variety of colours blue, green and green brown. The original pigment probably applied was blue and not green. The secondary green products resulted from the alteration of the glass by weathering. Photo: 5785~5791, 5812~5816.

Bowls on north wall were painted; 1.plaster 2.white priming coat 3.yellow paint 4.light red under drawing 5.white paint 6.red outlines line Photo: 4915, 4916.

Leopard on the north wall was painted; 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 Photo: 4917.

Lights red under drawings are visible on the yellow paint. Photo: 4658~4660, 4662, 4663, 4895 west wall, 4661 south wall, 4664, 4666 north wall 4900, 4901 leopard on north wall.

There is mistake of black vertical line on the chequered pattern on the upper left section of the west wall. This black line is visible underneath of yellow paint. Photo: 4687.

Black outline of the penis on middle left baboon is missing. Photo: 4694, 4695.

The red rectangle was drawn middle of the black stick on the north wall. Photo: 5569.

There are many light and dark brown spots of microorganism or bacteria. They are visible on the limestone wall and on the wall paintings due to moisture. Small amounts of moisture came from the ancient offerings placed in the tomb such as vegetation, and also from the plaster on which the decoration was painted, which may not have been fully dry when the tomb was sealed. The black spots are resulting stains on the paintings. Photo: 5550, 5551 east wall, 5552 north wall.

Microorganism tends to grow light red under drawing. Photo: 4651~4653 west wall.

Microorganism tends to grow in the cracks. Photo: 4690~4692.

Microorganism tends to attack fibres within the paint or plaster. It is probably some kind of vegetable fibres, which was also observed in the tomb of Nefertari. Photo: 4928, 5561, 5564 north wall.

Microorganism tends to grow in line on white paint. Photo: 5555~5557 north wall.

According to photos that were taken in 1922-32, microorganism was already existed when the tomb was discovered. Photo: 6580~6582.

There is trace of microorganism removal on the north wall. Photo: 6545, 6546, 6579.

There is wax residue about 7cm x 13cm on the south wall. Yellow paint is abraded due to hash removal of the wax. Photo: 4624, 4625.

There are drippings of original yellow paint. Photo: 4633, 4634 bottom left of west wall, 4678 west wall.

The skirt of white paint was painted over the red painted legs. Photo: 4693 Tut on north wall, 5577, 5578 north wall.

Sandals were painted over the red painted feet and red colour is visible on the Sandals on the south wall and red colour is not visible on the north wall due to the thickness of the white paint. Photo: 4890, 4891 south wall, 5574, 5575 north wall.

Brush strokes are visible at the table on the north wall. Photo: 5570, 5571.

There are splash of retouching paint on the original paint. It is probably imitation of microorganism spots. Photo: 4638, 4639, 4641, 4648 north wall, 4882, 4883 south wall, 5613~5615 east wall.

There are numerous injection holes on the cracks. Photo: 4644, 4645 north wall, 4904 leopard north wall, 4906-4909, 4914, 5568 north wall, 4646 west wall, 4626 east wall.

Restoration fills have no texture and have imitation of microorganism. This indicates that microorganism was already on the wall painting when restoration work was done. Photo: 4640, 4643 north wall, 4881 middle left monkey on west wall, 4670~4675 north wall, 4676 4888, 4889 south wall, 4893, 4894 west wall, 4911~4913 north wall, 5612 east wall.

There is white residue of consolidation. Photo: 4647 north wall, 4668 Tut north wall.

White consolidation residue is over the microorganisms. Photo: 5558~5560, 5564, 5565 north wall.

There are drippings from consolidation darkening the paint. Photo: 4648, 5562, 5563 north wall, 4654 west wall, 4655 south wall.

There is a drop of glossy resin on the paw of leopard. Photo: 5810, 5811.

The wall painting has numerous cracks. There is no structural damage to the chambers. Photo: 4902~4904, 4926.

Some of the cracks have been consolidated and darken the paint. Photo: 4884, 4886 south wall, 4887 west wall.

Some original paints are flaking and exposed yellow paint. Left side of the photo is restoration fill and retouching. Brown retouching is covering the original paint. Photo: 4920 east wall.

Some area of the painting surface had been abraded and paint is lost. Photo: 4669 foot of Nut on north wall.

There are scratches from previous restoration. Photo: 5580 the leg of Qinai on the north wall.

There are several dents on the wall painting on the west wall. Photo: 6548, 6549.

Black, blue and green paints tend to get micro-cracks and to detach from the plaster especially on the east and west walls. Photo: 4635, 4636 Comparison with red paint. Photo: 4637 bottom left west wall, 5688~5692 detached paints, 5807, 5817, 5818 blue on east wall.

The paints on the east wall are thicker, shiny, cracking, flaking and missing. It seems shiny varnish was applied over matt paint (photo 5625) and microorganism has no gloss burnish. It is also possible that different binders

were used for different colours and lack of binder. The binder of the painting is probably gum arabic or gelatin. Gum arabic was (and is still, today) available in and around Luxor. The surface of the east wall is rougher than the other walls. Photo: 4924 black paint, 4921~4923, 5601, 5602, 5605, 5606, 5622~5624 red paint, 5623, 5624 yellow paint, 5603, 5604 green paint, 5619~5621 white paint, 4919 rough surface.

There is a rectangle shaped paint loss on the east wall. This was probably due to loss of black paint. There is trace of black paint around the paint loss. This black paint is on the microorganism although microorganism is on the exposed plaster. Photo: 5607~5611, 5616, 5617.

There is a large amount of fill on the east wall. Photo: 4925.

There is a light black arrow under the feet of Tutankhamen on north wall. It seems microorganisms are growing over the arrow. Photo: 4688, 4689, 4691.

There is graffiti of “PEP” on cloth of the Qinai on the north wall. Photo: 4905.

There are strips of tape on the northeast corner of the wall. Photo: 4927 northeast.

There is cement like material on the wall painting. Photo: 5566, 5567.

Cement like material is on the microorganism. This indicates that cement was applied later period. Photo: 6551.

SARCOPHAGUS

It is decorated with figures of four godness, Isis, Nephthys, Neith, and Selket, carved in high relief on the corners, with their wings outspread to protect the body of Tut. Hieroglyphs of religious text, religious scenes and protective Wadjet eye are also engraved on the sarcophagus.

The sarcophagus is carved from a single block of red quartzite supported at each corner upon a block of alabaster.

The rim of the sarcophagus has trace of gold decoration. Underneath of gold has dark brown paint or size. Brush strokes are visible northeast rim. Photo: 4896, 4897 southwest corner, 4898, 4899 southeast corner, 5553, 5554 north east corner, 5656~5659 north, 5658 brush strokes.

The hieroglyphs and deities were decorated with yellow paint. There are paddles of dried yellow paint below the rim decoration. Photo: 5660~5664, 5670 north, 5671 south, paddle of paint on south side 5673~5676, 5679 south.

Black, dark blue and pale green/blue paints were used to decorate deities. Photo: 5668, 5669 north, 5682, 5685 south, 5683, 5684 black.

Binder of paints was discoloured to dark brown due to aging of resin. Photo: 5686, 5687.

There is dark brown/black stain along the hieroglyphs text on side of sarcophagus. Photo: 5677, 5678.

There are splashes of plaster or white paint on the northeast of the sarcophagus. Photo: 5665, 5666.

There is abraded surface at the hair of goodness on southwest corner. Photo: 5681.

The lid is made of red granite and cracked across the center. Photo: 2916, 2902, 2907.

The surface of the lid has numerous abrasions. Photo: 2887.

Three sides of the lid have been painted (colour stick no. TR 17 & 18) and the paint layer is visible around the small losses. [Photo](#): 2908.

There is purple stain on the lid. [Photo](#): 6519.

Some areas of hieroglyph have a trace of yellow paint. [Photo](#): 2911.

Hieroglyph has layer of dust (colour stick no. TW15). [Photo](#): 2892.

The colour of red granite is mixture of Pink, beige and black. [Photo](#): 2900.

Pink: colour stick no. TR 14 & 15, Beige: TW 1, 13 & 21, Black: TBI 9 & 17.

The surface of the granite has been polished (gloss colour stick C). [Photo](#): 2898.

Colour recording was carried using more than 500 colour sticks, which was made with Golden acrylic paints. 102 colour sticks were matched to the wall paintings, sarcophagus and the lid. Three gloss samples were used to match the shine of surface. Gloss samples were made with Winsor and Newton gloss varnish. Over 831 points (389 on north wall, 112 on south wall, 72 on east wall, 103 on west wall) were measured using colour and gloss sticks. [Photo](#): 6354~6362 north wall, 6352, 6353 south wall, 6348~6351 west wall, 6363, 6364 east wall, 6371 colour strips, 2764, 2766, 2809 during working

Please see attached photography contact sheets.



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IMG_4618.jpg



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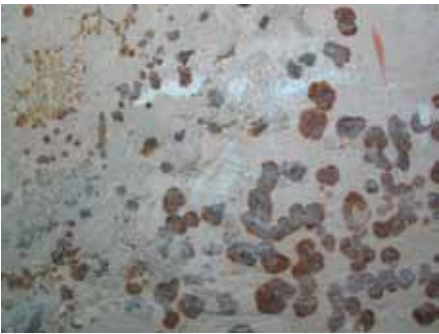
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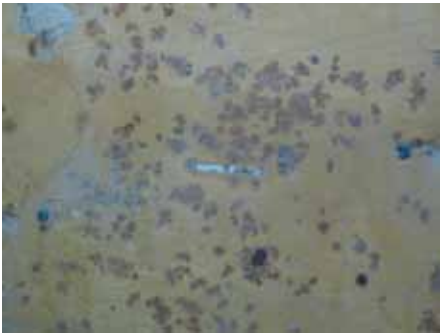
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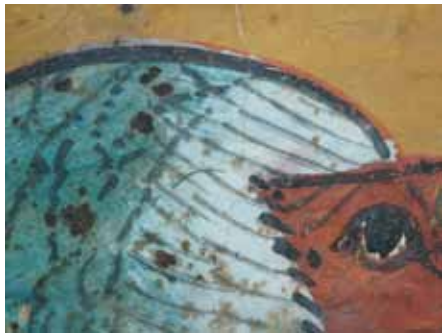
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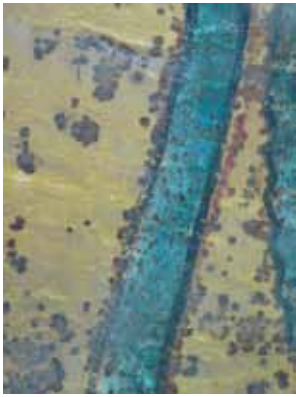
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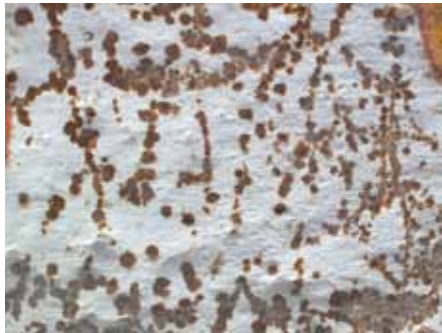
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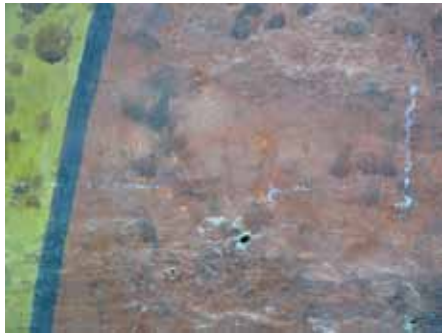
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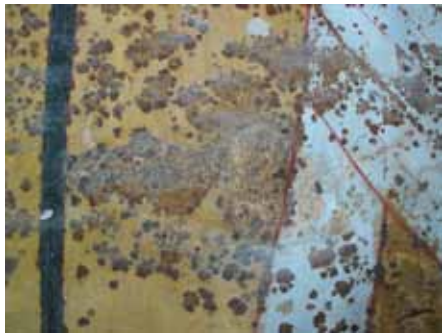
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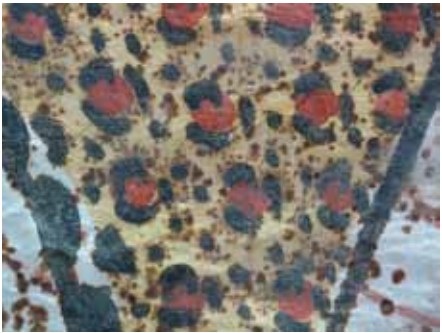
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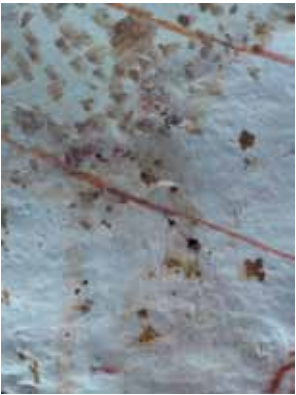
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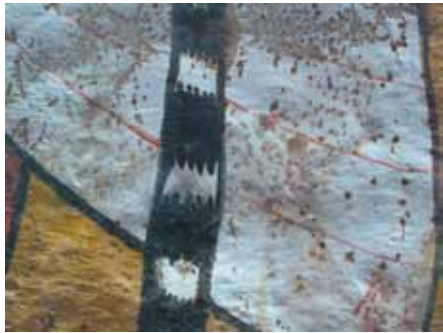
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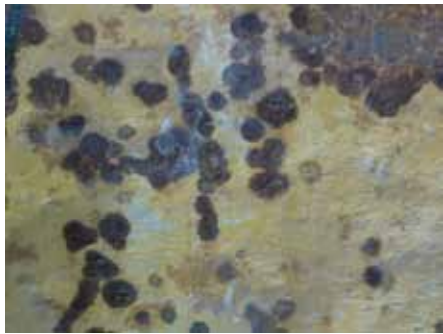
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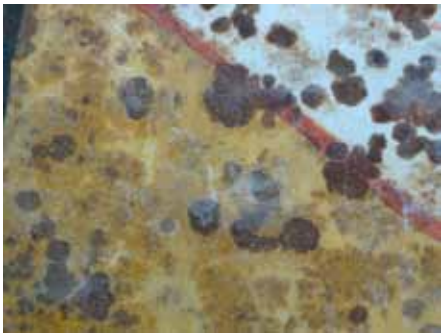
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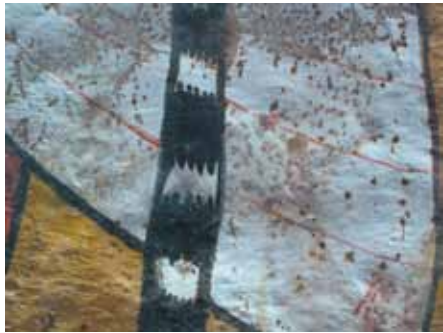
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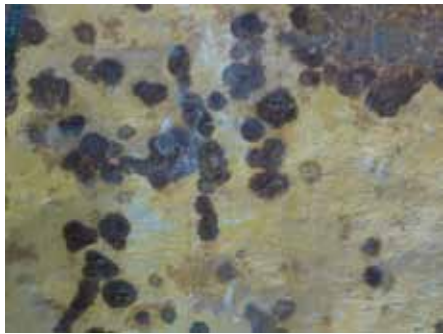
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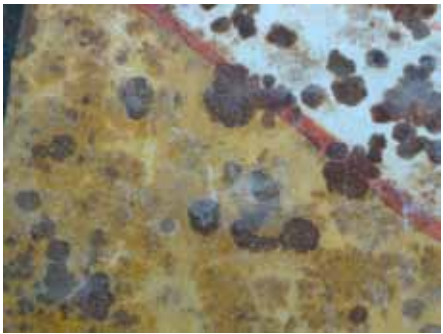
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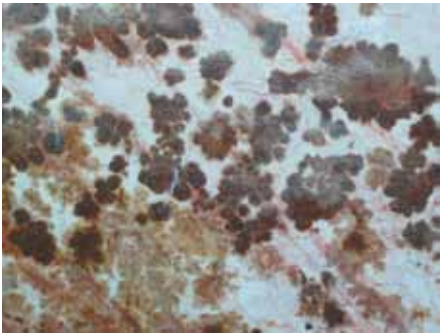
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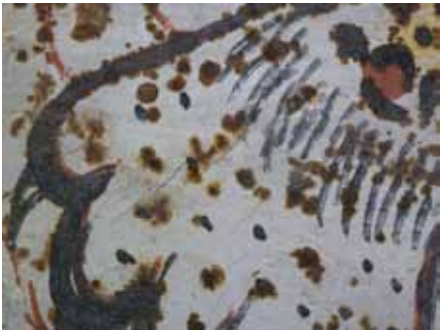
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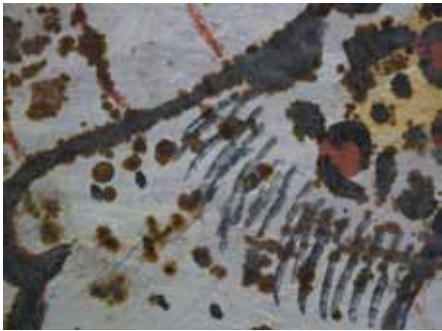
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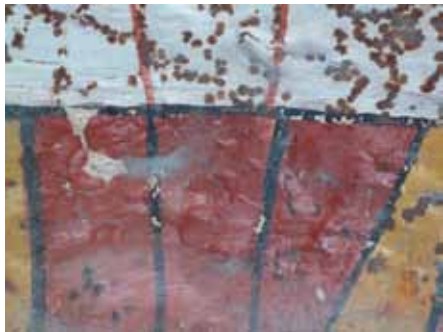
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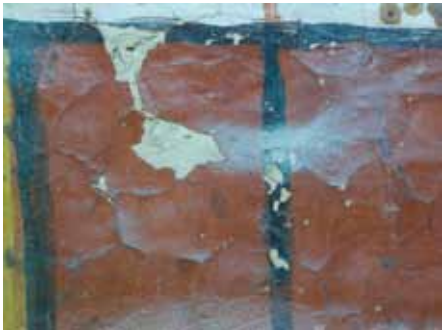
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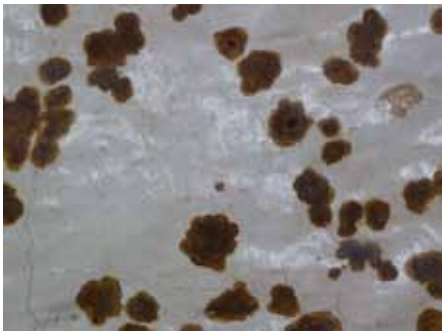
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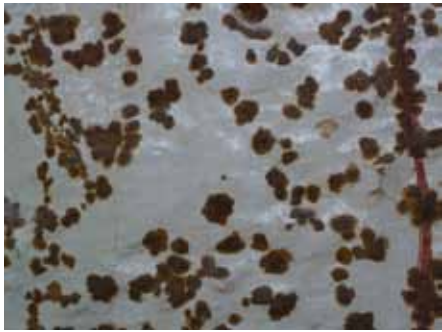
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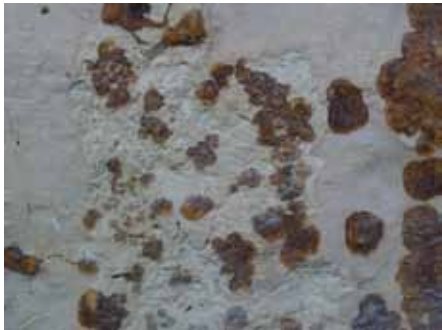
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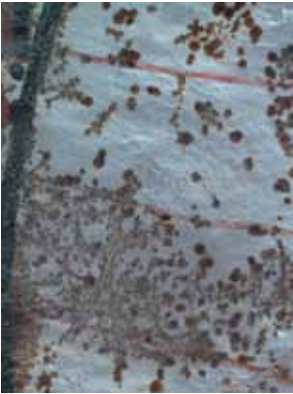
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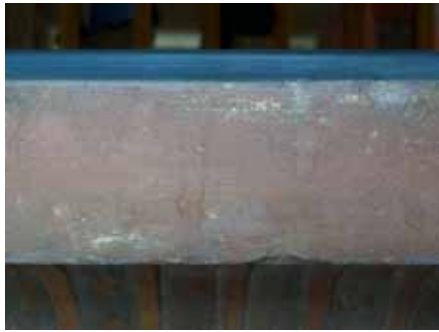
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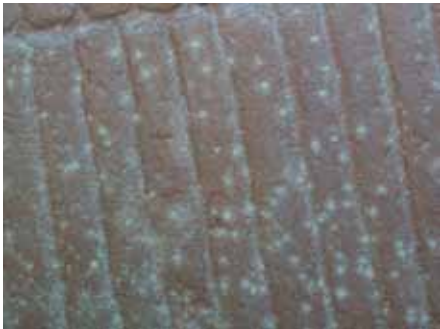
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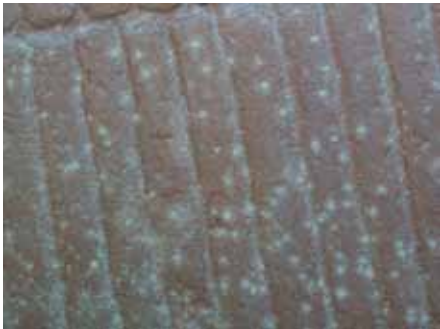
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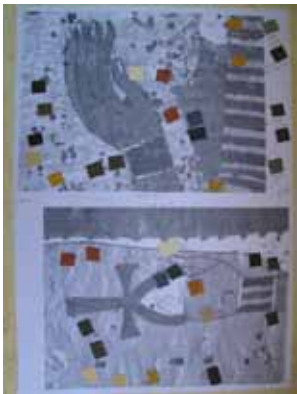
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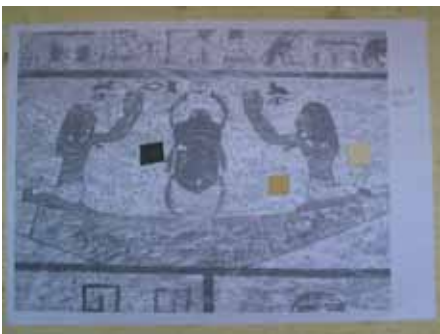
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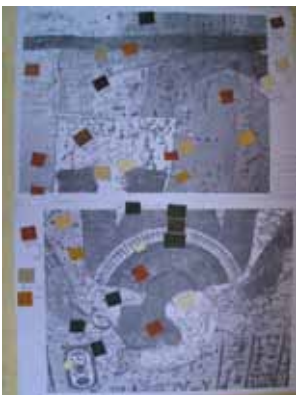
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PHOTOGRAPHY IN TUTANKHAMUN

PREPARED BY GRÉGOIRE DUPOND

The photographic equipment was used for 21 days for high resolution macro photography.
3 days this was used on a computer controlled 3 axis machine (the same one used for the SETI 3D scanner).
The following 18 days using a 1 axis computer controlled machine, simpler and taking much less space, that was designed and shipped to Luxor specifically for Tutankhamun’s Tomb.
Over 8000 individual shots resulting in 16000 files were necessary to cover the whole of the tomb, with approximately 100 shots per square meter.
This equipment was handled by Grégoire Dupond, Piers Wardle and Naoko Fukumaru.

March 12th to 18th:

First photographic survey of all small existing damages on the walls.
Using a 21 MegaPixels Canon EOS5DII with a 24-105mm zoom lens or a 100 mm or 180mm lens.

March 19th:

Begin testing with 3D Seti scanner on the Seti frame.
This work begins every day, or every time the machine is moved, by a calibration.

March 21st to 22nd:

First test shooting at high resolution on the East wall
Attach the camera equipment to the Seti frame with two low power cold UV free lights housed in light boxes on each side of the camera to light the wall. As the lights are moving with the camera, the duration of illumination of the wall is reduced to a minimum.
The 21 MegaPixels Canon EOS5DII was used with a 100 mm macro lens at a distance of 80cm.
183 shots at high resolution were made on the 21st, 85 on the 22nd. Setting up camera and lights to the specificity of Tutankhamun’s walls were the aim of these 2 days.

March 23rd to 23th:

The photographic equipment is removed from the frame and replaced by the 3D Seti scanner.
100 microns high resolution 3D scanning is done on the same area that was photographed on 21st and 22nd.

March 24th to 26th:

The Seti frame is turned 180° toward the sarcophagus so we can 3D scan at 100 microns the East side of the Sarcofagus, using the same equipment.

March 28th to 31st:

The Seti frame is turned 90° clockwise towards the North Wall.
Approximately 1.5 square meters of the North Wall on the east part of it are scanned at 100 microns.
6 3D scans were done to cover that area, with rescans to capture missing data, especially in the dark areas (black painted lines).

April 1st to 5th:

The Seti frame was moved on the West part of the Tomb to scan the other side of the Sarcophagus with same equipment, at 100 microns.
9 3D scans were done to cover that side of the Sarcophagus.

April 7th to 11th:

On the 7th the Seti frame was turned 180° toward the West wall and 3D scanning equipment removed and replaced by photographic equipment set up on March 21st and 22nd.

On the 7th afternoon 8th and 9th a section of the baboons were shot at high resolution.
7th: 124 photography shots at 800dpi
8th: 432 photography shots
9th: 381 photography shots
11th: 336 photography shots

In total 1273 shots were made using the Seti frame on a section of the baboons wall.

April 11th:

It was then decided to stop using the Seti frame and therefore the Seti scanner, as the limited space in the Tomb was not allowing us to work efficiently with maximum security.
The Seti frame was removed from the tomb by SCA personnel on that afternoon.

April 12th and 13th:

A new equipment that was designed for use in Tutankhamun’s tomb was sent from UK to Luxor to replace the Seti frame. This equipment used for photography was set up during these 2 days. This new equipment consists of a vertical CNC controlled guide of 250cm than can hold 10kg of equipment (camera plus lens plus lights is under 5kg). This equipment is on a base equipped with carriages that can slide smoothly on rails attached to heavy aluminium base plates that we already had for the Seti frame. An extension would allow us to reach to top of the walls.
The equipment was first set up on the South wall were we decided to begin shooting.

April 13th to 15th:

Photography shooting of the South wall at 800dpi.
13th: 656 photography shots
14th: 811 photography shots
15th: 276 photography shots with extension

In total 1743 shots were made using the new lightweight equipment to cover the South Wall.

April 16th to 21st:

Photography shooting of the West wall at 800dpi.
16th: 461 photography shots
18th: 150 photography shots with extension
19th: 183 photography shots (138 with extension)
21st: 73 photography shots

In total 867 shots were made using the new lightweight equipment to cover the remaining of what was already shot on April 7th to 11th (1273).
So In total 1273+867=2140 photography shots at 800dpi to cover the West Wall.

April 21st to 28th:

On April 21st the photographic equipment was set up for the North wall
Photographic shooting of the North wall at 800dpi.
21st: 298 photography shots
22nd: 644 photography shots
23rd: 179 photography shots with extension
24th: 133 photography shots with extension
26th: 360 photography shots
27th: 234 photography shots with extension
28th: 103 photography shots

In total 1951 shots were made using the new lightweight equipment to cover the North Wall.

Also on the 28th, 251 photographic shots were made to cover missing areas in South West corner on South wall as well as South West corner on West wall.

April 29th to May 2nd:

On April 29th the photographic equipment was set up for the East wall.

Photography shooting of the East wall at 800dpi.

April 29th: 171 photography shots

April 30th: 515 photography shots

May 2nd: 302 photography shots

In total 988 shots were made using the new lightweight equipment to cover the East Wall.

Also on April 29th as the lid of the Sarcophagus was uncovered (uncovered April 27th) we made 33 photography shots of detail of the lid.

The lid was covered again on 29th right after our shooting.

May 4th:

300 photographs were made of details, the floor and the sarcophagus at a lower resolution (around 300dpi).

Also between 25th and 30th of April photographs of the ceiling and other details (doorway, bottom of walls unreachable by photographic machine etc) were made by Naoko Fukumaru using a Canon G10 and a tripod. About 500 photos were taken in total.

The total surface photographed at a resolution of 600 to 800dpi is 65 square meters for the walls and 10 square meters for the sarcophagus. This represents over 16000 files for a total of 300GB of data.



The camera and lights mounted onto the specially made linear guide recording the West Wall.



Setting up the camera system and checking the computer connections that control the camera.



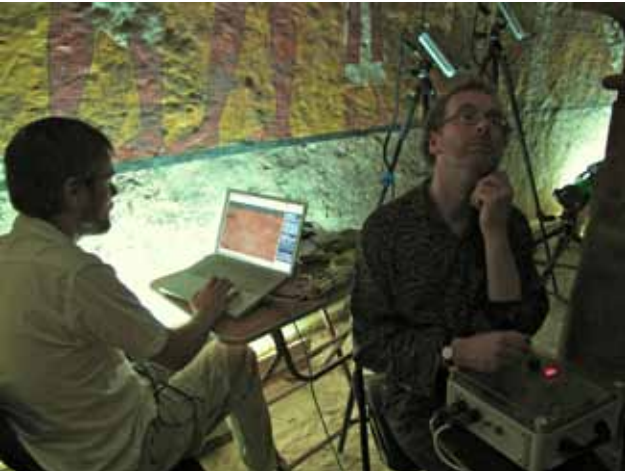
The camera system with the modified reflectors (taped to the back of each light) during the final checks.



The photographic system recording the East Wall.



Checking the emergency stop controls on the Seti scanner. These types of testing are always done with the camera or scanner away from the walls.



Gregoire Dupond operating the camera and Piers Wardle controlling the positioning of the camera.

THE FOUNDATION FOR DIGITAL TECHNOLOGY IN CONSERVATION

The Foundation is dedicated to the use of high-resolution digital recording and exact facsimiles as part of a coherent approach to the preservation of major heritage sites.

Advances in digital technology have rapidly and radically changed our understanding and appreciation of our shared cultural heritage. The conservation and preservation communities have realised the importance of high-resolution digital recording and this data is starting to be integrated into professional protocols. Central to this shift of attitude is a fundamental reappraisal of the role of exact facsimiles both installed in their original location and used in touring exhibitions.

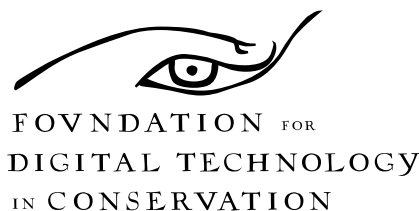
The aim of the foundation is to show that the way we understand the ‘original’ object is part of a dynamic process and not a fixed state of being. When this is successfully presented, works of art reveal their relevance as their complex biographies inform the present. If developed in the right spirit, this shift can be used to turn cultural tourism into a pro-active force assisting in the preservation of important monuments and works of art. The aim of the Foundation is to ensure that future generations can inherit the past in a condition where it can be studied in depth and emotionally engaged with.

The central aim of the foundation will be to create a pool of funds generated from donations, exhibitions and other sources that can be used to seed a variety of projects in parts of the world where the application of technology is limited but where the preservation of cultural heritage is most needed.

Factum Arte has been working with museums and artists for many years focusing on the way mediation and transformation condition the appearance of the physical object. The idea behind the foundation has grown out of many years of working in high-resolution documentation and the realisation that a lack of communication and understanding is hampering the application of technology in conservation.

The aims of the Foundation for Digital Technology in Conservation are:

- * To ensure that research and development into recording and display technologies can be carried out without compromise thereby demonstrating and establishing the importance of high resolution documentation for monitoring, study and dissemination of the world’s cultural heritage.
- * To fund the development of recording systems designed especially for use with cultural heritage. Equal attention will be paid to two dimensional recording systems, multi-spectral photography and three dimensional (3D) recording systems.
- * To facilitate an understanding of the transformations and mediations involved in all forms of recording and output. This will be done through both academic papers and general interest publications.
- * To reduce the costs of both hardware and software and ensure that high resolution recording systems, along with technical support and training, are available in the parts of the world where they are most needed.
- * To carry out meaningful comparative studies between different recording systems and to make the results available to the conservation community.
- * To clarify the role of physical facsimiles in conservation and to establish a code of good practice.
- * To develop archiving and display systems as a user-friendly interface for high resolution data.
- * To establish originality as a process and not a state of being and to prepare exhibitions that develop the biography of both objects and sites.
- * To help fund projects of cultural importance that cannot finance themselves.



FACTUM ARTE

In the eight years since Factum Arte was set up it has established a considerable reputation both for the quality of its work and for its desire to make technology work for the interests of art and cultural heritage.

Factum Arte has already used its 3D and photographic recording equipment in the Valley of the Kings and in the British Museum (London), the Pergamon (Berlin), the Staatliche Kunstsammlungen (Dresden), the Museum of Archaeology (Madrid), the Biblioteca Nacional (Madrid), the Calcografía Nacional (Madrid), the Museo del Prado (Madrid), the Musée du Louvre, The Brera Museum (Milan) and many other museums.

Completed projects include:

- * The facsimile of the Tomb of Thutmosis III. This facsimile toured the USA and Europe from 2003 until 2007.
- * The recording of the Beato Primero for the Biblioteca Nacional (Madrid). This work set new benchmarks for the recording and preservation of rare manuscripts.
- * The facsimile of Veronese’s Wedding at Cana. This facsimile caused a media sensation when it was installed in Palladio’s refectory on San Giorgio Maggiore in Venice and led to a re-evaluation of the use of facsimiles in conservation
- * The facsimile of Leonardo’s Last Supper attracted large crowds when it was shown in Milan as part of a collaboration with Peter Greenaway. A permanent home is now being proposed in Milan and an exhibition is being developed for the Expo in Milan in 2015.
- * The scanning and production of a facsimile of all known fragments from the Eastern end of the Throne room of Ashurnasirpal II, Nimrud, for the purposes of an exhibition.

Other projects can be viewed on Factum Arte’s website: **www.factum-arte.com**

A major project for the town of Caravaggio has recently been announced to the Italian press. The Fondazione Giorgio Cini and Factum Arte will start an ambitious project to establish a research centre in the town of Caravaggio containing a high resolution digital archive of all of the paintings of Michelangelo Merisi (Caravaggio). The research centre will be in the C16th church of St John the Baptist. The aim is to facilitate an in-depth study and appreciation of this great artist’s work.

This is a unique project from many points of view. Despite a growing awareness that high-resolution digital documentation is now essential for the study, conservation and monitoring of art works, a project of this size, focused on the work of a single artist and combining research with the development of new technologies, has yet to be realised. In addition to the high-resolution recordings of the paintings, a complete history of the state of conservation of each work will be compiled together with a detailed reconstruction of its biography. This information will form the basis of a digital archive, which will eventually be accessible online.

EXHIBITIONS

The intelligence and style of Factum Arte’s exhibition design and desire to communicate complex ideas had been repeatedly praised by both the academic community and the general public.

Exhibitions include:

- * Las Horas Oscuras del Sol, Madrid – this exhibition broke all attendance records for an exhibition at the Museo Arqueológico Nacional, Madrid.
 - * Immortal Pharaoh, Edinburgh.
 - * In Pharaohs Grab, Basel – This exhibition transformed the space in the Antikenmuseum and was critically acclaimed.
 - * John Martin – with the Calcografía Nacional Madrid – Voted one of the 5 best exhibitions in Spain in 2006 by El Mundo.
 - * Editing Originality – Galería Betty Guereta Madrid.
 - * Il Miracolo di Cana – L’Originalità della ri-produzione – In collaboration with Fondazione Giorgio Cini, Venice.
- Factum is currently working with the Grand Palais, Paris on a major exhibition ‘Originality and the Crisis of representation’ which is scheduled to open in November 2011.

FACTUM arte

