

# Replicating Tutankhamun's Tomb

AE looks at how a Spanish company, Factum Arte, is using the very latest technology to create a facsimile of Tutankhamun's tomb, as one of the ways of helping to preserve the original tomb.



The recording in high resolution of Tutankhamun's well known but small tomb, and the production of an exact copy of it, is part of a major initiative by the Egyptian Supreme Council of Antiquities (SCA). Its aim is to preserve the fragile tombs in the Valley of the Kings, while making important tombs that are either closed or in need of closure accessible to the general public and to scholars.

Visitor pressure on the tombs, in the Royal Valley in particular, has been causing increasing concern as, almost inevitably, some damage to the tombs has occurred, and is likely to continue to take place. This damage is caused by direct contact with the tomb walls – by people touching them or accidentally brushing against them – and, more importantly, by the introduction of moisture and by temperature changes, which alter the environment in the tomb. This is disastrous for the painted decoration and has resulted in the temporary closure of some tombs to allow them to 'rest'. Some are occasionally closed for routine conservation work. The tombs of King Sety I and of Queen Nefertari, two of the best known in the Luxor

area, have also been affected by other natural problems that mean their opening to the general public in the future is most probably out of the question.

The facsimile project has been launched by the General Secretary of the SCA, 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.

The project is ambitious: the SCA has granted permission for the recording and facsimile production of the tombs of Sety I in the Valley of the Kings (which is justly famous for its fine reliefs, but which has been closed to the public since the late 1980s), of Queen Nefertari, Great Royal Wife of Rameses II, in the Valley of the Queens (which has for many years been closed to the general public and open only with special permission) and of Tutankhamun, which is one of the smallest yet most visited tombs in the Valley of the Kings.

All the recording of Tutankhamun's tomb has now been completed. Work on the processing of the data is being finalised and work is almost complete on the facsimile of

the burial chamber and the sarcophagus of Tutankhamun.

Dr. Hawass has commissioned a feasibility study to identify the ideal location for a new visitor centre where the facsimiles will be displayed. One possible site is on the West Bank of the Nile at Luxor near the recently restored and re-opened Carter House at the entrance to the Valley of the Kings.

It is estimated that over half a million visitors a year could 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 as a whole.

It's a simple idea that demonstrates how inspired leadership, innovative uses of technology and careful management can result in the sustainable preservation of this important site.

The making of the facsimile tombs was the result of a great deal of consultation and discussion. Final agreement followed a successful feasibility study carried out by Factum Arte in 2002. The project is 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.

Factum Arte had already produced a superb facsimile of the burial chamber of the Tomb of Thutmose III, which has been on display in Europe, and which was also displayed at a special exhibition in Edinburgh (see the August/September 2005 issue of *AE*, number 31.) This facsimile alone has to date been seen by a remarkable two million visitors, many of whom would not easily have been able to see the original tomb in the Valley of the Kings.

Detailed funding plans are now being



finalised between the SCA, Factum Arte, The Foundation for Digital Technology in Conservation and the Society of Friends of the Royal Tombs of Egypt. Over 95% of the initial funding has been provided by the Foundation for Digital Technology in Conservation and Factum Arte. This will provide for the creation of the facsimile of the

burial chamber of Tutankhamun and the sarcophagus, and an interactive archive of digital data that will be stored in the SCA's Documentation Centre in Cairo and will enable the entire burial chamber to be studied and monitored in great depth. Work on the tomb of Nefertari is scheduled to begin as funding becomes available. The detailed planning has already started.

The work on the tomb of Sety I will start when ongoing excavation work in the tomb exploring the corridor that runs from the burial chamber has been completed. (This work has been reported in previous issues of *AE*.)

The unprecedented resolution of the recording processes and the substantial surface area of the tombs (Sety I in particular has approx 2,500 square metres of relief polychrome surface) means that the recording work will take several years.

Work on the production of the replicas is currently in progress at Factum Arte's workshops in Madrid.

The stages of the work in making the facsimile tombs are:

1. The digital recording in three dimensions using a laser scanner (at a resolution of 100 microns) and a white light scanning system (with resolutions of between 200 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 Sety I, Nefertari, and Tutankhamun.
2. The creation of an exact facsimile of each tomb.
3. The establishment of an exhibition built around the facsimiles of each tomb that will be permanently installed on the West



OPPOSITE PAGE

A view of the facsimile tomb being assembled in Factum Arte's workshop in Madrid.

THIS PAGE

TOP: The west wall in the Tomb of Tutankhamun. Photo: courtesy of the SCA.

ABOVE: A detail of the facsimile of part of the north wall of the tomb.

Bank. A copy of Tutankhamun's tomb will also be installed at Susan Mubarak Children's Museum in Cairo.

4. 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.

5. The copyright of the all 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 managed by the Supreme Council of Antiquities, which will enable more work of this kind to be done in Egypt in the future.

All this work is 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. The 3D recording is being done at a resolution of 100 microns with 100,000,000 independently-measured points per square metre. A colour photographic system has been developed with low level cold lights to record the painted surfaces at 1:1 (actual size) at 600 - 800 dpi (dots per inch). The entire tombs of Sety I and Nefertari will be recorded along with the burial chamber and sarcophagus from the tomb of Tutankhamun.

A special feature of the project, in connection with the Tomb of Sety I, will be the ability for the re-integration of all the fragments removed from the original tomb in the nineteenth century. (Fragments of the tomb are scattered around various museums. For example, a well known scene of Sety with the goddess Hathor is now in the Louvre in Paris and a corresponding fragment in the Museum of Archaeology in Florence.)

The team working in the Tomb of Tutankhamun is led by Adam Lowe, who is the Head of Mission and Director of Factum Arte. The team also includes the laser-scanning experts, photographers and conservators, as the protection of the tombs during this work is important. The team also works closely with members of the Egyptian SCA.

Each of the three tombs presents specific recording challenges. Tutankhamun's tomb is small and the sarcophagus and sarcophagus lid, which is not on the sarcophagus but lying nearby, reduce the available working space in the burial chamber. The distance between the sarcophagus and the wall is about a metre and a quarter at the narrowest point.

In the case of Tutankhamun's tomb, the only one of the three tombs open, work was carried out without interrupting the normal flow of visitors. On a busy day



ABOVE: Factum Arte's laser scanner recording the surface of the east wall of the Tomb of Tutankhamun.

OPPOSITE PAGE:

TOP: Gregoire Dupont using Factum Arte's photographic system to record the east wall of the tomb.

BELOW: The north wall of the facsimile tomb in the workshops of Factum Arte in Madrid.



approximately one thousand people can enter the tomb and this huge number has a dramatic effect on the temperature and humidity in the space. The heat and humidity is one of the greatest threats to the tomb and one of the main reasons for the initiation of the project in the first place. 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, something many of them may not have realised before.

### Laser Scanning

Using a 'SETI' low intensity red light laser 3D scanner at a resolution of 100 microns, it took fourteen days to record both small ends of the king's red quartzite sarcophagus, about two square metres of the east section of the north wall and one and half square meters of the east wall. This involved over seventy individual scans. Much of the time was spent handling and setting up the equipment inside the confined space of the tomb. Safety is always first priority and the team took all necessary steps to ensure that the tomb, the team members and the equipment were protected. At no point was the surface of the fragile paintwork touched.

A NUB 3D white light 3D scanner, with a resolution of 200 to 700 microns was used over a thirty-two day period to record the whole of the tomb. Over one thousand three hundred scan shots were necessary to cover the surface-scanned.

The data captured by the laser scanners records the surface of the wall and enables an exact 3D copy to be made, accurate to the finest detail. Even brush strokes of the painted decoration are recorded by this technique along with any variations in the surface.

### Photography

Some photographic work was done using a 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.

A Canon EOS5DII camera with a 100mm or 180mm lens, 1:1 at 600-800 dpi, was used over a twenty-one day period, mounted on a special computer-controlled three axis machine (the same one used for the SETI 3D scanner).





It was then used for a further eighteen days mounted onto a one-axis computer-controlled machine specially designed for use in the cramped spaces of the tomb. This system was designed especially by Factum Arte for this work and was made and shipped to Luxor.

Over eight thousand individual shots, resulting in sixteen thousand files, were necessary to cover the whole of the tomb, with approximately one hundred shots taken for each square metre. The resolution of these photographs is between 600 and 800 dpi at 1:1.



In the making of the facsimile, all the digital images are printed and transferred onto an exact replica of the surface of the wall produced using a special milling machine. This mix of surface and colour results in a faithful copy of the wall in its current condition. When illuminated with the same lights that are used in the tomb the facsimile is almost indistinguishable from the original.

### Work-Monitoring and Colour-Recording in the Tomb

Factum Arte's conservator, Naoko Fukumaru, monitored the team and the equipment paying special attention to the safety of the tomb. She is also in charge of the accurate colour matching using Factum Arte's labour-intensive but highly accurate non-contact system based on direct colour comparisons – an essential part in the production of their facsimiles.

TOP: Colour matching using the colour samples, compared by eye to the original red quartzite sarcophagus.

LEFT: Some of the range of colour samples used during work on recording the tomb.

#### OPPOSITE PAGE

TOP: One of the corners of the facsimile sarcophagus after routing at a resolution of 300 microns.

BOTTOM LEFT: Factum Arte's routing machine cutting a section of the east wall at a resolution of 200 microns.

BOTTOM RIGHT: The colour being transferred to the walls using PaperGel transfer material.



Over five hundred different colour samples were created on paper sticks (*see opposite*) and compared to colours on the walls. Matching colours (a process done by eye as this has proved to be more accurate than optical measuring systems when working on complex and varied colour surfaces) would then be noted and located precisely. Naoko also took macro photographs of these specific locations and recorded other important characteristics of the surface.

### Making the Facsimile

The final work involves using the scanned information to produce three-dimensional copies. The accurate 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 52x52 cm takes approximately seventy-eight 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 detail of the surface that results in a convincing facsimile.

The milled facsimile is made in a medium-density polyurethane board – this is then assembled, moulded and cast in a resin. The tomb walls are made as large sections which are then covered with the high resolution images using a flexible transfer material developed by the Spanish company PaperGel. The flexible transfer material means it is possible to get the colour in perfect registration with the relief of the surface.

Once the data and all the images have been recorded and the moulds for the sections of wall made, it is of course then possible to make more than one copy of parts, or all, of the tombs.

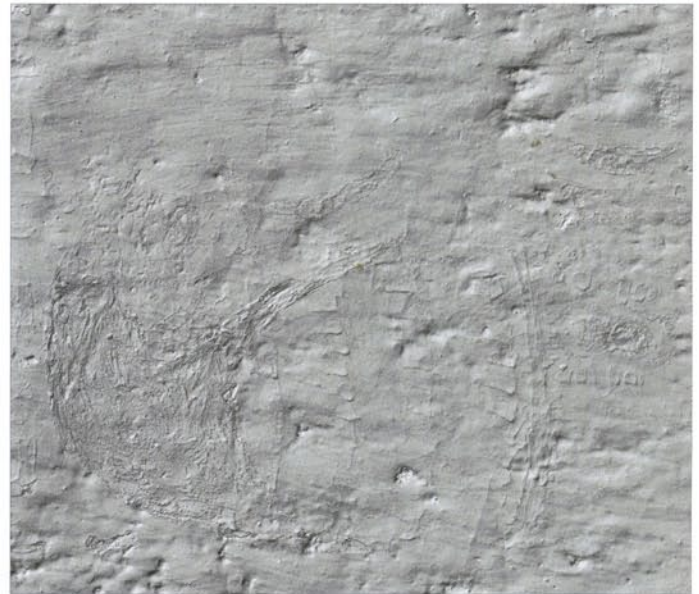
In the case of the Tomb of Tutankhamun two copies are to be made.

The first one is being shipped to Egypt at the end of this year and will be installed in the new Susan Mubarak Children's Museum at Heliopolis in Cairo, which is scheduled to open in January 2011.

The second facsimile will be the one installed in Luxor near the Carter House. Work on this site is due to start very soon, but no date has yet been given for the facsimile or when the work is due to be completed.

I was fortunate to be able to visit the facsimile of Thutmose III's tomb when it was in Edinburgh, just a week after seeing the real tomb in the Valley of the Kings. The quality of the facsimile was remarkable and, strange to say perhaps, it was possible to see *more* of the detail on





the facsimile than in the real tomb. Not only can the facsimile tombs be better lit, but the tomb decoration can be seen clearly as they are not behind a layer of glass. And, most importantly, certainly in the case of Edinburgh in winter, there was no problem with heat and humidity. In

facsimile tombs in Egypt, even the environment can be controlled for the comfort of visitors.

I might have been among those to argue that only the original tombs should be open and that visitors or experts would not want to see a copy, but, having seen one exam-

ABOVE (from left to right across both pages):

1. The high-resolution photo of the head of Tutankhamun's mummy from the east wall; 2. The 3D data recording the surface of the sample part of the wall; 3. The routed facsimile produced from the data in 2.
4. The colour transferred onto the routed section (before colour correction).

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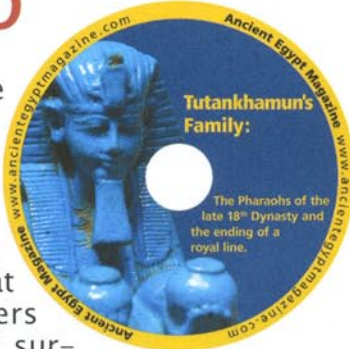
The DVD free with this issue of the magazine looks at the immediate family of Tutankhamun and in particular at those members where their bodies survive and which have recently been the subject of DNA testing.

To play the DVD you will need Microsoft Powerpoint, which is installed on most computers.

Simply insert the DVD then click on "View" and "Slide Show" and the disc will play automatically.

If you do not have Powerpoint on your computer a free Powerpoint Player can be downloaded from

<http://www.microsoft.com/downloads/en/details.aspx?FamilyID=048dc840-14e1-467d-8dca-19d2a8fd7485&displaylang=en>



**Tutankhamun's Family:**  
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ple and also a presentation in London a few years ago given by Factum Arte, where some demonstration panels from the Tomb of Sety I were shown, I am now a complete convert and think the idea is superb and that it *does* work.

If access to the original tombs is no longer possible then making of facsimile tombs is the only way that visitors and experts alike can see them in their entirety and appreciate the space of the tomb, rather than just seeing illustrations of isolated scenes in books.

Even if the original Tutankhamun tomb is kept open, visitor numbers do need to be controlled in the future, and the opportunity to see such a good copy is far better than not seeing the tomb at all.

I will look forward to being able to visit all three facsimile tombs in the future.

**R.P.**

Editor of *AE*.

The author would like to thank Adam Lowe, of Factum Arte for his help in putting this article together. Unless otherwise stated, all images are courtesy of Factum Arte and were taken by Alicia Guirao, and Gregoire Dupond. For more information about Factum Arte, see: [www.factum-arte.com/eng/conservacion/tutankhamun/tutankhamun\\_en.asp](http://www.factum-arte.com/eng/conservacion/tutankhamun/tutankhamun_en.asp)

For more information on the Society of Friends of the Royal Tombs of Egypt see [www.sfrte.ch](http://www.sfrte.ch)



ABOVE: A composite image of all the walls in the tomb. The whole of the tomb was recorded as 1:1 at a resolution of 700 dpi.

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