Location: Stove room at Museo Cerralbo, Madrid

Author: Anonymous

Dated: 18th century

Measurements: 283 x 437 cm

Materials: Wool and silk

Description: Tapestry fragment with a central composition consisting in two birds (a macaw and a peacock), framed with a traditional verdure decoration of plants, flowers and trees aligned to the vanishing point, with a landscape of mountains and a stream in the distance.
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1. THE TAPESTRY AT THE CERRALBO MUSEUM

The Cerralbo Museum was originally a palace, built in the 19th century by the Marquis of Cerralbo, established as both a family residence and a gallery in which to exhibit their collection.

The Marquis donated his palace, along with its collections, to Patrimonio Nacional. Due to poor conditions, some pieces had to be removed from their original location within the palace. This was the case for this verdure tapestry which could be found hanging as a curtain ‘in order to create a dark and romantic atmosphere’.

The Instituto del Patrimonio Cultural de España commissioned Factum Arte to make a facsimile that would hang in the tapestry’s original location. The project was divided into five steps:

- Cleaning the original tapestry at the Real Fábrica de Tapices.
- High resolution recording of the tapestry. The return and archiving of the original piece.
- Digital restoration.
- Developing and testing a printing system on textiles with high definition colour matching.
- Printing and arranging the hanging system at the museum’s stove room.

The data obtained allowed Factum to investigate:

- Research based on historical and scientific information to determine the tapestry’s original colours and tonal range at the time of its production in the 18th century.
- Digital restoration of the tapestry’s tonal intensity.
2. MOVING THE TAPESTRY

The tapestry was packed at the Cerralbo Museum. It was hanging in a tight corridor, since its deteriorated state would not allow for it to be placed in the stove room, where it had hung during the Marquis of Cerralbo’s life.

The first step was to bring the tapestry to the Real Fábrica de Tapices, where it was cleaned by the conservation department in preparation for recording.
The tapestry was dismantled and folded. Photographic documentation was taken of the rolled up tapestry and its transfer process.
3. PHOTOGRAPHIC DOCUMENTATION BEFORE CLEANING PROCESS

Before the cleaning process, a detailed photographic documentation was done to record the tapestry prior to restoration. A written document was drawn up and observations related to the tapestry’s state were noted; these included old interventions, any detected damage and other important details relating to the tapestry’s conservation. Cartographic deterioration maps were drawn up from this information.

These maps were then broken down into 30 quadrants and numbered for easy identification.
3.1. General photographs of the tapestry prior to intervention

Cartographic photographs of detailed deterioration were taken and used as a visual guide to written documentation:

3.1.1. Front

As can be seen in the above photograph, the tapestry surface was dirty. It is also possible to observe warps and creases, which resulted from the dehydration of the fibres, as well as from previously restored patches where the silk had become powdered/sprayed.

3.1.2. Reverse/back

The reverse of the tapestry has a weaved lining of cellulose material, onto which a jute strap (or similar) has been sewn across the whole length in order to hang the tapestry.
A series of different fabrics were used either as a means to strengthen and reinforce the tapestry, or so that its basic re-stitching could be appreciated beneath the lining:

Removing the reinforcing layers of material prior to the tapestry’s cleaning.
4. CONDITION REPORT

- Dirt and soot covered the tapestry’s surface, a result of decay, which was accelerated by the original position of the tapestry near a fireplace.

- The tapestry has had its four borders cut off - its valances as well as its girdles. These elements of the tapestry were removed when it was converted into a drape for the Marquis of Cerralbo.

The creases were shrunk so that the surface of the tapestry could be observed. This type of deterioration was due to the dehydrated state of the fibres, caused by dust and other dirt residues.

Detail of the 1A and 5A quadrant showing the ripples that have appeared from the fibre shrinkage.

Details of the 2C and 1D quadrants; burns on the fabric.
- In addition to the damage along its perimeter, the tapestry also had two significant holes. The first hole had been covered by a patch from a previous restoration.

![Detail of the 1D quadrant - a patch that was added during a previous restoration.](image1)

The second hole, located near the bottom of the tapestry, had been substituted with a patch from a different tapestry with similar colour scheme.

![5D and 5E quadrants - displaying the patch originally belonging to another tapestry.](image2)

- Rough seams done by a previous restoration where the tapestry was coming apart.

![Details of the 3C and 3F quadrants - rough seams added by previous restoration.](image3)
- Old restoration of the patchwork showing the heavy discolouration of the patchwork.

2A and 3A; discoloration of the trunk's patchwork.

Detail of the 3B quadrant; silk patchwork.

5B; maroon coloured patches caused by oxidation.
- In general, the tapestry’s silk patches were significantly deteriorated, especially in lighter zones, where the filaments had almost completely decayed.

4B; depolymerised silk.

- Unstitched areas.

- Repairs.
5. TREATMENT

5.1. Removal of the tapestry’s linings, reinforcements and old restorations

Once the tapestry’s state had been documented, previous interventions were removed and a mechanical clean was undertaken on the obverse and reverse.

5.2. Cleaning

The cleaning process took place over a single day, in a specially designed area, at the Real Fabrica de Tapices. The tapestry was soaked in demineralised water and cleaned using ‘Saponin’, a pharmaceutical soap product.

The cleaning was conducted in the following steps:

- Application of the cleaning product.
- Manual suction with sponge on the front side of the tapestry, under controlled pH conditions.
- Soaked in several baths of demineralised water.
- Drying of the tapestry.
- Air dried on a rack.
6. COLOUR DIGITALISATION

6.1. Preparation of the tapestry for photography

Once the fabric had been cleaned, and temporarily fixed with pins onto a flat support, the tapestry was digitally recorded from the front and back.

High resolution documentation of the tapestry was carried out through non-contact digital scanning. The techniques employed by the scanning team were completely unobtrusive and there was, at no point, any physical contact with the tapestry.
6.2. Introduction to the digitalisation system

Elinchom Studio focused flash and camera set up on a Clauss robotised head.

The system used by Factum Arte separates the light source from the recording equipment, eliminating any shadows in order to obtain large files and high quality images.

-Doctor Clauss panoramic photography:

The photographic recording was done using automated panoramic photography equipment, which consisted of a motorised panoramic head supporting a camera and lens, a computer to control the head, and archiving software for downloading and cataloguing the photographs.

The photographs were recorded in raw format in order to ensure maximum quality of the images. The camera took each photograph in auto-focus mode; the distance between the lens and the work of art was varied slightly for each angle a photograph was taken.

-Resolution

A unique 16 bit full resolution image of the recorded work was obtained through a process where the numerous photographs were stitched together. The accuracy of the stitching process is very high with an error average of under one pixel (usually 0.6 to 0.7 pixel).

- Independent illumination system

In collaboration with Doctor Clauss, Factum Arte developed a way of physically separating the flash system from the main camera unit whilst allowing them to work in tandem with each other. The advantage of this is that it allows for manipulation of the flash in order to minimise any trace of shadows or reflections. The flash used was a high speed Elinchom A3000, with a shutter speed of approximately 1/1950s.
7. COMPOSITE IMAGE STITCHING

“Stitching”, as its name implies, unifies or merges a series of high resolution images into one single photograph. A series of photographs are taken in identical resolution with a DSLR camera and large 600 mm lens, generating images close to 1 gigapixel (1,000,000 megapixels).

Graphic representation of the construction of an image mosaic.

Image ‘stitching’ is particularly common in the digitalisation and documentation of heritage and has been frequently cited in bibliographies of property registration documents since 1999.

‘Stitching’ is carried out in four steps:

1. Detection of specific features with algorithms, that describe the image through characteristics that are relative to its morphology.

2. Image comparison in order to specifically understand how two pairs of images overlap each other.

3. The register whereby two pairs of images are displaced until their common characteristics agree and relate with their coordinates.

4. Merging of images using blending routines in order for each pair of images to become a single image.
8. LUCIDA 3D SCANNER

The Lucida 3D Scanner scanned a section of the tapestry, approx. 0.52 m² on both sides of the tapestry which is digitalised in high resolution (100 micras (10,000 pixels/cm²).

Description of the Lucida 3D Scanner:

The scanner moves parallel to the work’s surface, in horizontal bands 2.6 cm wide x 48 cm high, synchronised to the two recording cameras that record one video frame every 100 microns (0.1 mm). This allows the generated 3D archives to have a resolution of 10,000 pixels per 2 cm² (or 100 million pixels per m²). When 20 bands have been recorded, a section of 48 x 48 cm will have been completed containing more than 23 million pixels of information on the relief.

The intensity of the laser can be increased or decreased and its software and hardware applications enable it to record dark and light shades, high gloss and even reflective materials like gold. The recorded data is dimensionally accurate and bears a close correspondence to the surface or the object being recorded. The scanning process is controlled from a portable computer through an intuitive and simple user interface. The depth of field is limited to 2.5 cm but a custom software application allows the user to select specific sections of the target for re-scanning if necessary. Re-scanned data can then be merged with the previous scan. The z axis is manually operated in order to ensure safe use and to avoid any accidental damage in case of a motor malfunction. All stitching is done using an innovative ‘switch’ between a rendered image and 3D co-ordinates. This approach allows the operation to be done with any standard image-stitching software. All files are saved as raw black and white video data ensuring that they can be processed at higher resolutions in the future as the technology develops. The proof of the quality of the data comes in the ability to output it in a physical form which can be compared to the original surface.
Digital file obtained from 3D scanning. Front of tapestry, 50 x 50 cm.
Digital file obtained from 3D scanning. Reverse of tapestry, 50 x 50 cm.
9. DIGITAL RESTORATION

Once the tapestry had been cleaned and documented, we proceeded to work on the tapestry’s digital restoration. One of the main advantages of this is that digital restoration is a non-invasive method of extracting or adding information and does not involve any physical contact with the original piece, thereby eliminating the risk of any potential damage occurring.

The digital restoration work flow is broken down into similar steps as those employed in traditional/manual textile restoration, as exemplified below:

- Material restoration:

  A. The application of neutral coloured fabric onto the reverse of the tapestry, which further contributes to the structure’s reinforcement.
  
  B. Chromatic reintegration: this consists in filling the tapestry’s gaps and highly deteriorated areas with matching fabric, in order to effectively camouflage the area.
  
  C. Introduction of texture: colour matching material is aligned with the original textile wefts.
  
  D. Structural restoration: colour, texture and the recovery of lost form.

- Digital restoration:

  AD. Gaps are filled with a layer of colour similar to its surrounding areas.
  
  BD. The textures taken from more intact and similarly coloured areas of the tapestry are then added to the patches.
  
  CD. Automatic pattern filling is then generated in areas within the piece where coherence has been lost. This method analyses the image’s content and automatically fills the section with a similar pattern. Though this is a good method for recovering lost data, it does not always guarantee continuity or adequate pattern generation in more complex works.

  Step 2: In case of a chromatic anomaly generated from automatic pattern filling, extra tweaking is done.
  
  DD. With the aid of a cloning tool, the tapestry’s pattern, or drawing, is re-designed paying great attention to detail.

In the end, due to certain circumstances related to the reproduction of the Cerralbo tapestry, it was not necessary to continue beyond point CD.
Photograph of the tapestry prior to digital restoration.

AD level of digital restoration.

BD level of digital restoration.
CD level of digital restoration, step 1.

CD level of digital restoration, step 2.

DD level of digital restoration.
10. PRINTING

10. 1. Choosing a support for printing

Different supports and materials were tested, particularly sublimation printing on polyester textile and UVI ink printing. However, conventional industrial materials seemed to present a large number of limitations in terms of colour and textile quality and they were therefore deemed inappropriate.

We then tried printing on a variety of different textiles using our own inkjet printer - these results weren’t satisfactory either, despite the definition and colour being good, the rigidity and plasticity of the acrylic primer resulted in a flat and implausible appearance.

We finally opted for a fabric that produced a similar texture to that of a handmade tapestry: ivory coloured Ottoman fabric, which is 80% polyester, and 20% cotton.
Having tested the various possibilities of printing with acrylic based primers, we continued to search for primers that were better suited for this kind of project. We started looking at companies specialising in transparent primers used for digital textile printing. We found that Lubrizol, a colourless, aqueous polymer base primer was the best suited as a dye in ink-jet printing.

This product was tested and showed good results; the fabric retained its full texture while the inks maintained their true colours.
10. 2. The printing process

We proceeded to adjust the colour settings on the printer, both manually and digitally. A series of different coloured fabric samples were taken by direct observation of the tapestry. These colour samples serve to act as a constant reference in the verification of digital colour settings, in order to ensure their similarity to the original tapestry’s colours throughout the restoration process.

The printing was undertaken on an Epson 11880 printer, modified by Factum to enable large scale printing.

- **Colour management:** it was necessary to first design an ICC colour profile to fit the support.

- **Preparing the digital image for printing:** the printing done on a non standard support resulted in behaviour atypical of the material. Thanks to specific software, we were able to detect some ‘out of range’ colours, particularly shades blue, that required specific adjustments.
-Final stage of the process: Due to its large size (280 x 438 cm), it was necessary to sew two fabrics together. The fabric was then placed on a frame in preparation for the application of the primer. After the application, it was dried at high temperature in order to cure the primer. The printing was done in two parts (top half and bottom half) as our printer is limited to a 440 x 150 cm printed surface at once. The perfect registration of the printed area was fundamental so the joint between the two halves was invisible. While half of the tapestry was being printed, we rolled the other half of the fabric into a lateral tube designed for the printer for large-scale formats. The printed textile was then cured at high temperature again in order to ensure optimum tint fixing.
11. COLOUR RECOVERY

Cerralbo Tapestry: Detail of the front of the C18th Verdure from high-resolution composite photograph take by Factum Arte after cleaning.
Flipped detail of the back of the tapestry after cleaning. The coloured yarns are significantly less faded than the front of the tapestry. Restorations, that may be only just visible are clear when seen from the back.
The front of the tapestry after digital restoration. All previous repairs were studied with the conservator from the Real Fábrica de Tapices and were undone or re-done virtually onto the high resolution file.
The front of the tapestry with the re-coloured threads based on the evidence extracted from the image of the back of the tapestry and close study of the dyes in the threads. Some of the decisions are objective, others subjective. The area around the eyes of the Macaw was extensively restored and reworked. Once the reworking was removed it was decided that the pale circle around the eye was not part of the original intention. Some brown refils in the reeds were also clearly faded retouches. The beauty of this approach is that it allows time for reflection before any action is imposed onto the actual tapestry.
Conservation and restoration by Factum Arte, under the technical supervision of Ana Schoebel from the Instituto de Patrimonio Cultural de España. This work was funded by the Spanish Ministry of Culture.

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