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The Sussex Declaration

Technical report for Add Mss 8981

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Technical report of scientific analysis held at the British Library 1-3 August 2017 of Add Mss 8981 (The Sussex Declaration) in collaboration with Harvard University, West Sussex Record Office and the Library of Congress. This report covers technical details and specifications of multi-spectral imaging and digital microscopy.

Multi-spectral Imaging

Multi-spectral imaging at the British Library utilises a *Megavision Cultural Heritage EV Imaging System*. The EV camera includes *MegaVision's* Monochrome E7 50-megapixel back, computer controlled shutter and aperture, and custom hyperspectral parfocal lens, which is responsive over the entire range of silicon sensitivity. The *MegaVision* system uses narrow-band LED illumination, which subjects the Sussex Declaration to only the required light energy to expose the sensitive unfiltered monochrome sensor. Images are captured over fourteen spectral bands from the near ultra-violet (UV, 365 nm) to the near infra-red (IR, 1050 nm).

MegaVision's Photoshoot digital image capture software controls all aspects of capture as well as controlling a colour wheel which allows additional light modifications such as filtration to isolate fluorescence in concert with UV illumination. Two filter wheels were used in the image capture sequence; [red, green, blue] and [UV pass, UV block, orange]. All areas were imaged with a programmed sequence of forty-two images including seven in the visible spectrum, one ultra-violet, six infra-red, ten filter wheel, seven visible spectrum raking left, seven visible spectrum raking right, one UV raking right, one UV raking left, one IR raking left and one IR raking right. Details of the complete sequence and corresponding legend can be found in the accompanying file '*MSI legend.xlsx*' (see *Figure 1*).

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Figure 1: MSI legend.xlsx

Stitching and Blending with PTGui

PTGui is a panorama photo stitching program for *Windows* and *Mac OS X*. It features its own stitching and blending engine along with compatibility to Panorama Tools. The Sussex Declaration was imaged in nine sections on both the verso and recto to achieve over 600 ppi resolution. These images were digitally stitched using *PTGui* to generate single images of the entire Sussex Declaration for each of the forty-two images captured in the sequence. One set of nine images was uploaded into *PTGui e.g. Figure 2*.



Figure 2: Nine component images of the recto side used in the final stitch.

A combination of automatic and manual control points was applied to overlapping areas in adjacent images (*Figure 3*). The control point distance indicates how well a control point pair aligns in the panorama. When the distance is zero, the two control point pairs overlap exactly. Once sufficient control points populate the images the project is initialised and optimised which minimises the distance of each control point pair. Once stitched and blended (*Figure 4*), a full size montage is output. This project is then saved as a template which can be batch applied to each of the forty-two images in the sequence resulting in a fully stitched montage of the Sussex Declaration at every light and filter combination.





Figure 3: PTGui screen capture showing control points.

Figure 4: PTGui screen capture showing stitch template.

This same process of stitching, blending and applying the aligned template to all images was employed on the verso side of the Sussex Declaration (*Figure 5*).



Add Mss 8981 Verso T1_PSC_MLblendMR.tif



Add Mss 8981 Verso C1_PSC_MlblendMR.tif





Add Mss 8981 Verso T2_PSC_MlblendMR.tif Add Mss 8981 Verso T3_PSC_MlblendMR.tif



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Add Mss 8981 Verso B2_PSC_MlblendMR.tif Add Mss 8981 Verso B3_PSC_MlblendMR.tif

Add Mss 8981 Verso B1ii_PSC_MlblendMR.tif

Figure 5: Nine component images of the verso side used in the final stitch

Post-Processing and Composite Images

Five further images were generated using combinations of those forty-two captured: Add Mss 8981 *Recto PSC Panorama.tif* is a full colour image combining the seven greyscale images captured in the visible spectrum under both lights (Figure 6), Add Mss 8981 Recto PSC_ML Panorama.tif is a raking colour image combining the seven greyscale images captured in the visible spectrum under the left light panel, Add Mss 8981 Recto PSC_MR Panorama.tif is a raking colour image combining the seven greyscale images captured in the visible spectrum under the right light panel, Add Mss 8981Recto B1_PSC_MLblendMR_Panorama.tif is a blend of raking lights left and right, and Add Mss 8981 *Recto+UVCompositeR15G17B19.tif* is an ultra-violet colour image combining the three images captured in the ultra-violet spectrum in combination with the RGB colour filter wheel (Figure 7).

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B1+MB470LB_002.tif



Add Mss 8981 Recto B1+MB590AM_005.tif



Add Mss 8981 Recto B1_PSC.tif



Add Mss 8981 Recto B1+MB505CN_003.tif



Add Mss 8981 Recto B1+MB627RD_006.tif

Figure 6: Digitally combining the seven visible spectrum greyscale images results in a true colour image.



Add Mss 8981 Verso Erasure+WBUVR25_015.tif



Add Mss 8981 Verso Erasure+WBUVG58_017.tif



Add Mss 8981 Verso Erasure+WBUVB47_019.tif



Add Mss 8981 Verso Erasure+UVCompositeR15G1 7B19.tif

Figure 7: Digitally combining the three images of a UV light with the RGB filter results in a UV colour composite image.

High Resolution Areas of Interest

Four areas of interest were identified for MSI capture at a higher resolution of over 1000 ppi (*Figures 8-11*). These include the erasure over the main title on both the recto and verso, the central tear on the verso, and the visible stain on the verso. The same forty-two image sequence was run on these areas and the resulting images processed as previously described.

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Figure 8: Add Mss 8981 Recto Erasure.tif



Figure 10: Add Mss 8981 Verso Erasure.tif



Figure 9: Add Mss 8981 Verso Centre.tif



Figure 11: Add Mss 8981 Verso Stain.tif

Digital camera technical specifications:

- Digital Back: MegaVision 50 megapixel E7 Monochrome, rotates to any angle
- Camera Body: rail and bellows, 13 cm travel, standards fixed co-axial to optical axis, rear standard focusing.
- Lens: MegaVision's unique 120mm f4.5 hyperspectral; Parfocal with execllent sensitivity from 350 to 1,000 nm.
- Shutter: Copal-0, 7 leaf, 1/60 to 60 seconds, computer controlled and powered via USB, rated for over 1 million exposures.

- Dynamic Range: 12 bits per channel: 14bit ACD
- File Size/wavelength: 100 Mbyte/channel at 16 bits, 50 Mbyte/channel at 8 bits.
- Capture Rate: One image frame per 2 seconds, subject to illumination constraints.
- CCD Array: 8176 x 6132 pixels, 6.0 micron pixel size.
- Equivalent Film Speed: Adjustable; 100, 200, & 400 ISO.
- Connectivity: Gigabit Ethernet.
- Software: Photoshoot[™] Operating System: Windows 7.
- Colour filter wheel.

Digital Microscopy

Magnified areas of the Sussex Declaration were captured *in situ* using a *Keyence VHX 2000* E series stand-alone digital microscope. This system comprises a high-resolution camera (54-megapixel 3CCD) attached to a compact, high-performance zoom lens that allows images to be captured at magnifications ranging from ×20 to ×200 with a large depth of field. The microscope was used with illumination provided from the lens unit, using a dimmable 12 V, 100 W lamp that has a colour temperature of 3100 K at maximum light intensity. The large size of the Sussex Declaration rendered the motorized XY stage (measuring only 171 × 168 mm) redundant and therefore the Keyence free-angle observation system which allows the lens unit to be inclined or rotated was not employed. The lens was attached to a standard size copy-stand which was manually adjusted to vary the focal range and focus on areas of interest. This enabled imaging of the surface without unnecessary handling.

The Sussex Declaration was placed on a bespoke sheet of black foam and situated under the lens on the copy-stand. No fibres were removed from the Sussex Declaration for examination by visible microscopy. Regions of interest on both the recto and verso of the Sussex Declaration were identified at which to produce images so that an overall understanding could be provided of ink, parchment, stains, damage, erasures, and any other significant observable features as individual components of the entire Sussex Declaration, as well as to observe their relationship to each other.

To acquire images with a wide contrast range, the microscope was set to capture in High Dynamic Range mode. In this mode a number of colour images are automatically captured at various shutter speeds, thereby increasing the range of different lightness levels that can be obtained. This mode generates images with the equivalent of a 16-bit depth from the series of 8-bit colour images captured by the camera, providing detailed images of the Sussex Declaration even in those areas that appear to show poor contrast.

A visual map of the recto and verso locations can be found in the files '*West Sussex Add Ms 8981* - *Microscopy Locations Recto.tif*' (*Figure 12*) and '*West Sussex Add Ms 8981* - *Microscopy Locations Verso.tif*' (*Figure 13*). Sixty-two images were captured on the recto and thirty-seven on the verso. Details of the locations and corresponding legend can be found in the accompanying file '*Microscopy locations and descriptions.xlsx*' (*Figure 14*) which contains two tabs for the recto and verso respectively.





Figure 12: Add Ms 8981 - Microscopy LocationsFigure 13: Add Ms 8981 - Microscopy LocationsRecto.tifVerso.tif

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6	170801_AddMss8981_Recto-5-x50	5	50		dge damage (bottom	right)		
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Figure 14: Microscopy locations and descriptions.xlsx