

Arundel Tomb & Gundulf's Door Architectural Laser Scan, Rochester Cathedral

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on behalf of: Keevill Heritage Ltd

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1. Background

- 1.1 In September 2012, Graham Keevill of Keevill Heritage Ltd on behalf of Rochester Cathedral Chapter, requested a quote for a laser-scan recording of architectural elements of Rochester Cathedral in advance of minor building work and in preparation for a new scheme of public display.
- 1.2 The scans were requested for the permanent record, virtual display and potential replication of a wooden Norman door, known as Gundulf's door, and for the permanent record and virtual display of a large indent bronze grave slab behind the main altar, known as the Arundul Indent, covering the grave of Sir William and Agnes Arundel, dating to c.1401.
- 1.3 This report details the laser scanning of these two features, using NextEngine triangulation-type laser scanners. This report and the survey it records follow the requirements for such documents and activities laid out by English Heritage in Bryan *et al.* (2009) *Metric Survey Specifications for Cultural Heritage*; and Jones (2011) *3D Laser Scanning for Heritage (second edition)*.

2. Field Methodology

2.1 Scanning Equipment

Scanning was undertaken using two NextEngine portable laser scanners utilising a triangulation based method of data collection, where each unit passes a series of laser lines across the features to be scanned and records points based upon the deviation of this line from an expected norm. Scan data is collected through the proprietary software ScanStudio HD Pro, designed specifically for use with the NextEngine hardware. The specification of these systems is as follows:

NextEngine Laser Scan Survey	
Survey Method:	Triangulation
Max. Point Density:	248 points/sq.mm
Min. Triangle Size:	0.064mm
Survey Point Density:	7 points/sq.mm
Survey Min. Triangle Size:	0.4mm
Accuracy:	+/- 0.38mm
Registration (mesh combination):	Surface Matching (MeshLab)
Control Software:	ScanStudio HD Pro (proprietary)
Mesh Manipulation:	MeshLab
Texturing and Rendering:	3D StudioMAX

2.2 Ancillary Equipment

In order to successfully complete the survey, two heavy duty tripods for the positioning of the scanners were utilised, as will a small mobile platform suitable for indoor work.

2.3 Staffing

The survey was undertaken by Dr Ben Edwards (Director, AS&C, and Manchester Metropolitan University) and Dr Andrew Wilson (Director, AS&C, and Bangor University).

- 2.4 *Point Density and Measurement Precision*
In the absence of a written specification detailing the scale of resulting data or the expected minimum feature size present at either of the two locations in the Cathedral, the following standards were used. Data was collected at a resolution of 7 points per sq. mm, producing an average triangle size (distance between vertices) of 0.4mm.
- 2.5 The final detail level of the two scans was as follows:
Arundel Tomb: 1088264 vertices, 1919502 faces
Gundulf's Door: 467502 vertices, 930406 faces
- 2.6 *Survey Control*
As the purpose of the survey was to create a digital record of features within a structure whose location is well known and will not be subject to change, a local coordinate system was adopted to orientate the scan data in 3D space. This utilised a 3D x,y,z grid whose origin was always to the lower-left extremity of the scanned feature.
- 2.7 Targets were not used to orientate the scans or to add spatial information. The known location of the scanned features meant that geospatial target recording was not required, and the registration process (below) did not require the use of targets.

3. Post-Processing

- 3.1 *Registration*
Registration is the term used to describe the orientation and combination of overlapping scan data-sets, created through the multiple passes required to scan large objects such as those targeted here. In this case, registration was undertaken in the programme MeshLab, following export from ScanStudio HD Pro (see above 2.1). The registration and orientation of the various scans was undertaken automatically using texture and surface matching algorithms, and therefore did not require the use of target points.
- 3.2 Following mesh combination, simplification and processing in MeshLab, models were textured in 3D StudioMax using the spatially referenced digital images collected by the laser scanners during scanning. Data was exported in the file formats required by archive standards and the client (see below).

4. Data Delivery, Reporting & Archiving

4.1 Data Delivery

In accordance with English Heritage standards (Bryan *et al.* 2009, section 7.4) and the verbal request of the client, data is provided to the client in the following formats (see digital appendix delivered with this report):

- ASCII (x,y,z) for archiving – both pre-processed and post-processed data will be provided in this format.
- textured VRML for web-based reproduction
- textured *.obj format at full-detail for later reproduction/graphical display
- textured 3D printing format if required by **subsequent request** of the client.

4.2 Project Metadata

The following metadata on the project will be supplied with the report:

- filename(s) of the raw data used in the registration
- date of capture (month and year)
- scanning system(s) used
- company name
- monument name
- monument number (if known)
- survey number
- total number of points
- description of registration method

4.3 A PDF version of this final report has been supplied to the following parties:

Keevill Heritage Ltd

Rochester Cathedral Chapter

Kent Historic Environment Record

4.4 Digital copies of the report, photographs, drawings and any surveys will be deposited to form part of the local HER and NMR.

5. Results

5.1 The survey was highly successful in recording the complexity and detail of surface features on both the Arundel tomb and Gundulf's door. The laser-scanning method successfully recorded both the grain of the wood on the door surface, and the roughness/texture of the surface of the tomb – particularly those areas where metalwork appeared to have been removed (G. Keevil pers. comm.).

5.2 Figures 1 & 2 display scaled orthophotographic projections of the scans for record purposes, whilst figures 3 to 5 and 6 to 8 show rendered and unrendered models of the tomb and the door, respectively. The untextured models are particularly useful for displaying the quality of the mesh, as they focus upon detail areas of the features.

**Rochester Cathedral:
Arundel Tomb**

Scaled orthophoto of the Arundel Tomb,
Rochester Cathedral, vertical aspect.

1m



Figure 1: Orthographic projection of the Arundel tomb

<p>Rochester Cathedral: Gundulf's Door</p>	<p>Scaled orthophoto of Gundulf's Door, Rochester Cathedral, looking south.</p>	<p>1m</p>
 An orthographic projection of a large, dark wooden door with a semi-circular top. The door is heavily reinforced with a complex network of dark metal bands and rings, forming a series of overlapping circles and triangles across its surface. Two large, dark metal hinges are visible on the right side of the door. The wood shows signs of age and wear.		

Figure 2: Orthographic projection of Gundulf's door



Figure 3: Textured model of the Arundel tomb, looking west

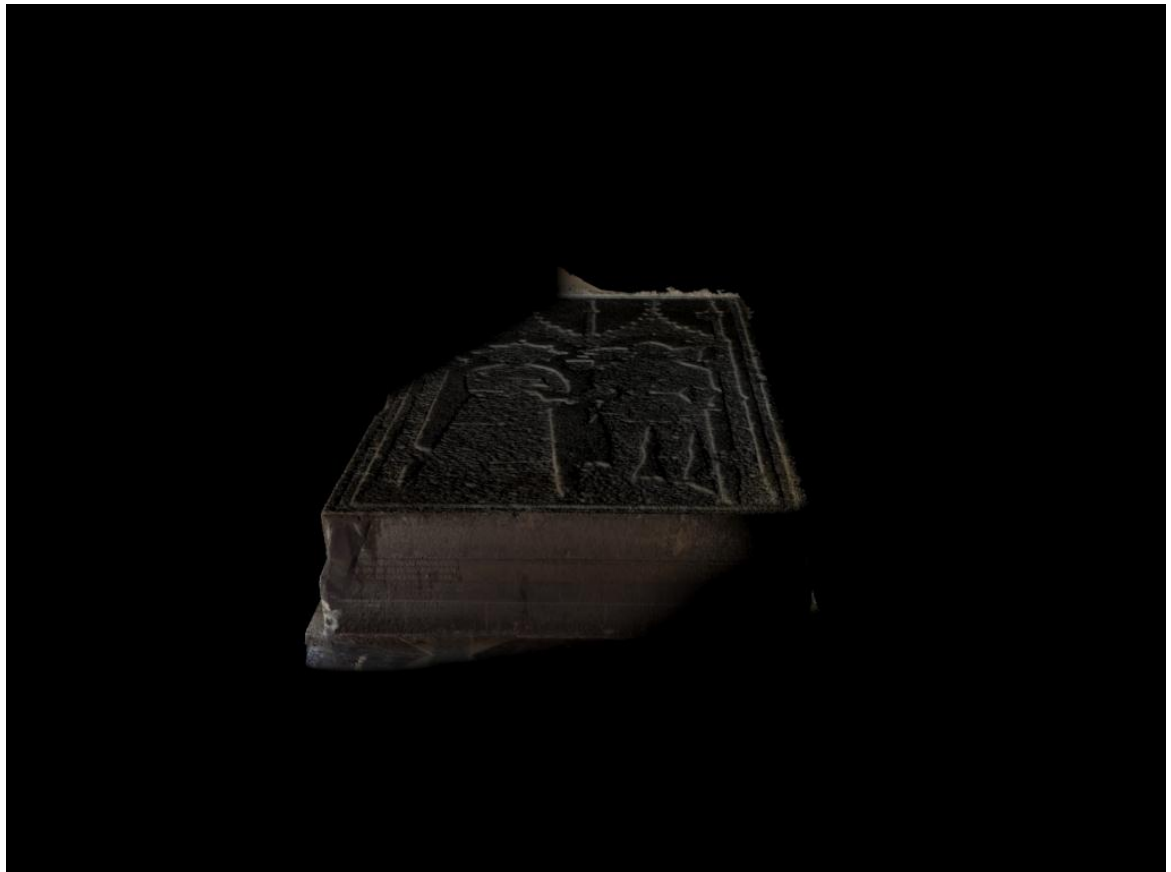


Figure 4: Textured models of the Arundel tomb, looking west, with dynamic lighting

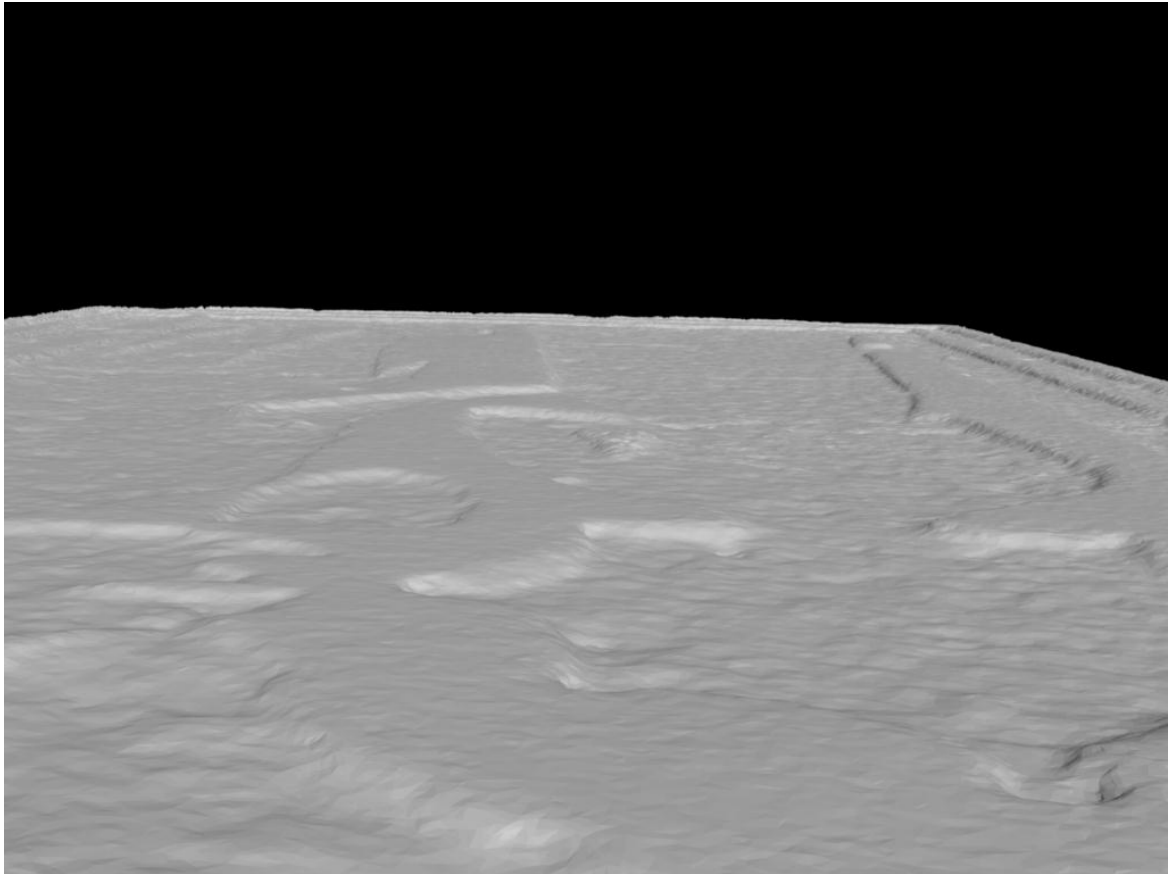


Figure 5: Untextured model of the Arundel tomb, looking east, showing the level of surface detail



Figure 6: Textured model of Gundulf's door, looking south



Figure 7: Textured model of Gundulf's door, top-left perspective

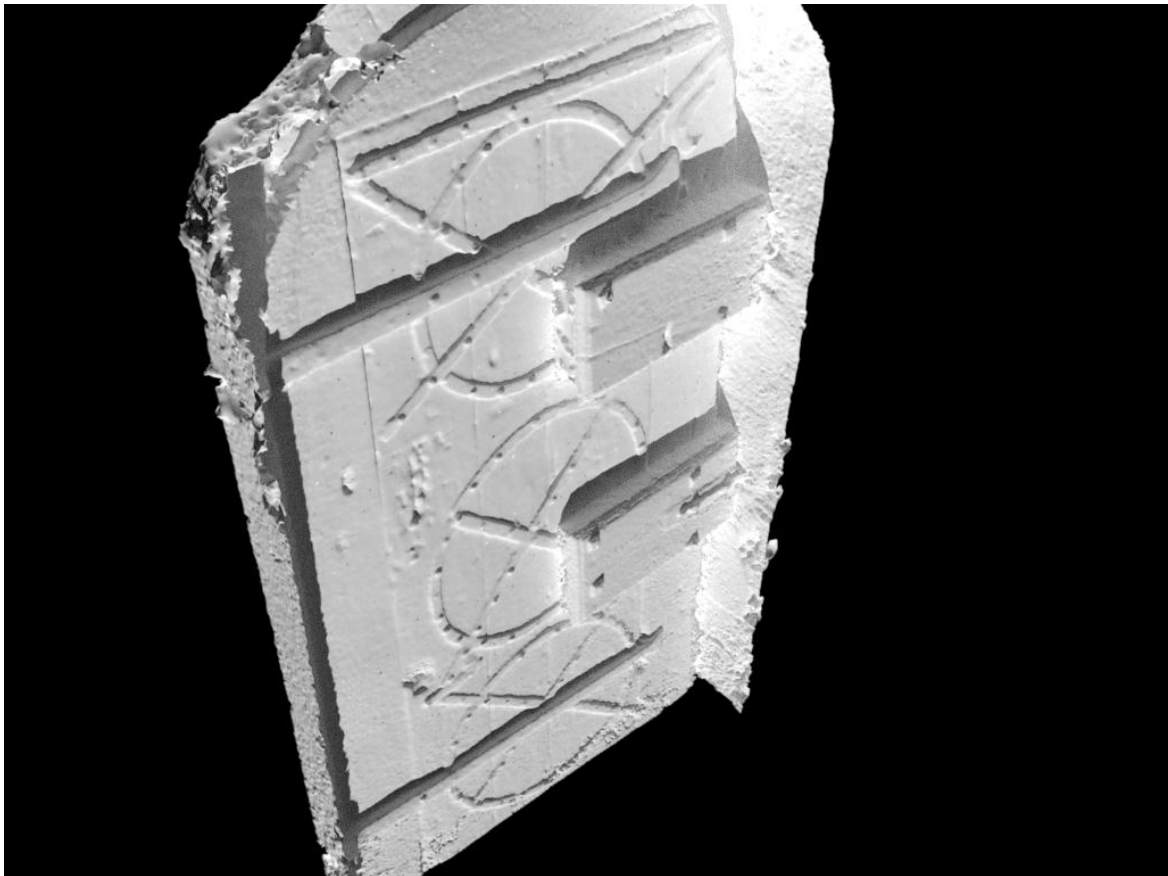


Figure 8: Untextured model of Gundulf's door, showing level of surface detail, top-left perspective

6. References

Bryan, P., Blake, B. & Bedford, J. 2009. *Metric Survey Specifications for Cultural Heritage* (Swindon, English Heritage).

Jones, D.M. 2011. *3D Laser Scanning for Heritage (second edition)* (Swindon, English Heritage).