3D Laser Scan Survey of Stonehenge, Wiltshire.

By Andrew J Dodson & Cory D Hope.

Image provided by Paul Backhouse, English Heritage IGS.

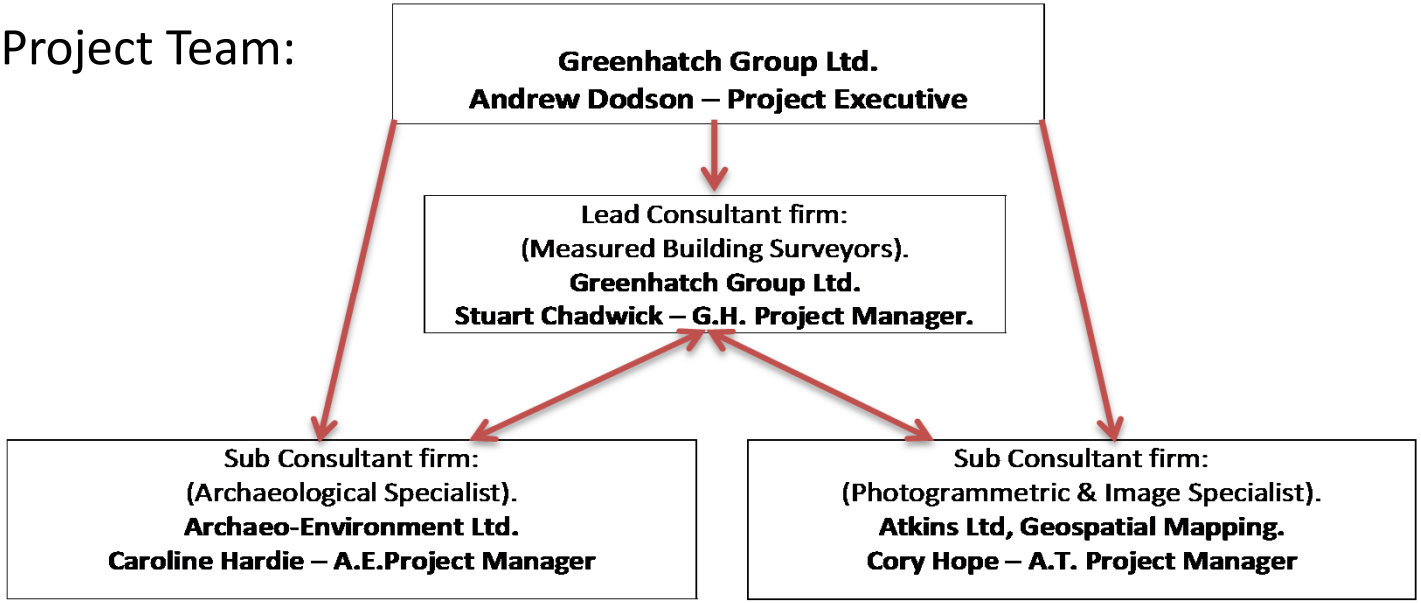
Prepared by: Andrew J Dodson
The Greenhatch Group Ltd.

ENGLISH HERITAGE

greenhatch group

3D Laser Scan Survey of Stonehenge, Wiltshire.

The Project Team:



- The Greenhatch Group: Laser Scanning & Building Surveying Specialists.
  Project managers for the task.
  Undertaking engineering and scanning elements of the project.

- Atkins Ltd Geospatial Mapping: Photogrammetric & Image Specialists.
  Capturing high resolution mono images of each stone face.
  Capturing high resolution stereo images at high level.

- Archaeo-Environment: Archaeological Interpretation Specialists.
  Providing initial guidance prior to survey.
  Providing an assessment of any features that become evident from the survey data that may warrant further investigation.

greenhatch group

3D Laser Scan Survey of Stonehenge, Wiltshire.

Resources Used:

Leica Geosystems

TS30

Smart Pole

C10

Pulse Target

ZF Zoller+Fröhlich

5006i

5010

M-Cam

Phase Target

Software Used:

Leica Geosystems — **Leica Cyclone**
3D Point Cloud Processing Software

Leica Geosystems — **Leica TruView & Cyclone PUBLISHER**
Free, Easy Viewing & Measuring of Point Clouds

geomagic

pointools
performance point cloud software

PhotoModeler®

LSS DTM Software from McCarthyTaylor

greenhatch group

English Heritage: The Survey Brief.

Proposed application of laser scanning within AS&I project

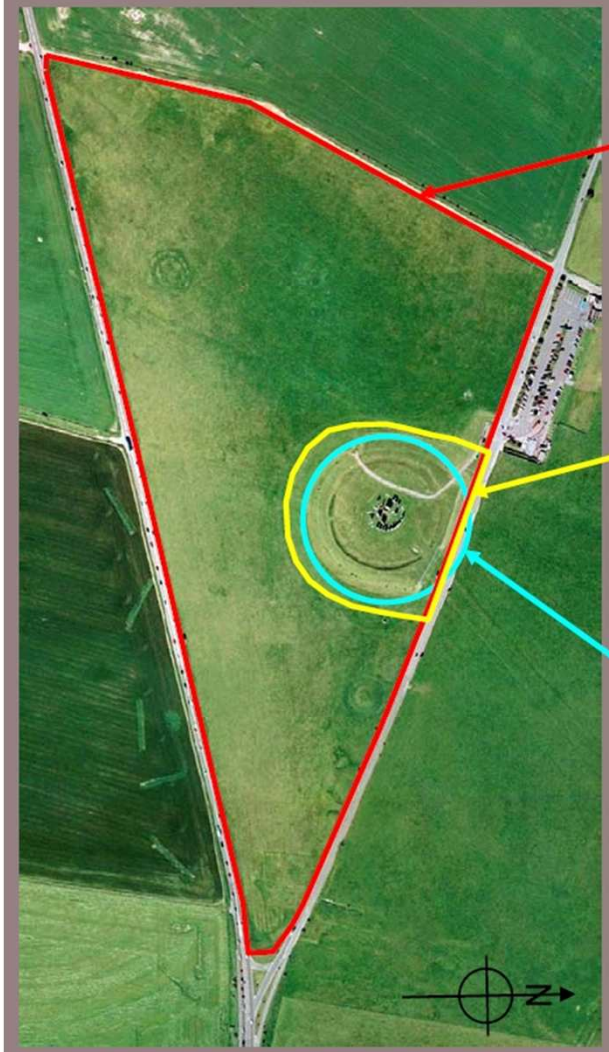


Image supplied through Pan Government Agreement (PGA)

- This will hopefully cover the following:
  - Landscape within the 'triangle' up to the surrounding boundary fence – using terrestrial laser scanners to capture a point-spacing (resolution) of at least 10cm
  - The stone circle and landscape immediately surrounding it including the road-side verge on the northern side of the boundary fence, up to the southern edge of the road carriageway (A344) – using terrestrial laser scanners to capture a point-spacing of at least 2cm for the landscape and up to 1mm for the standing stones themselves
  - The stones, both standing and fallen - using close-range and/or high-resolution terrestrial scanners to capture as many visible faces of the stones at a point-spacing of at least 0.5mm

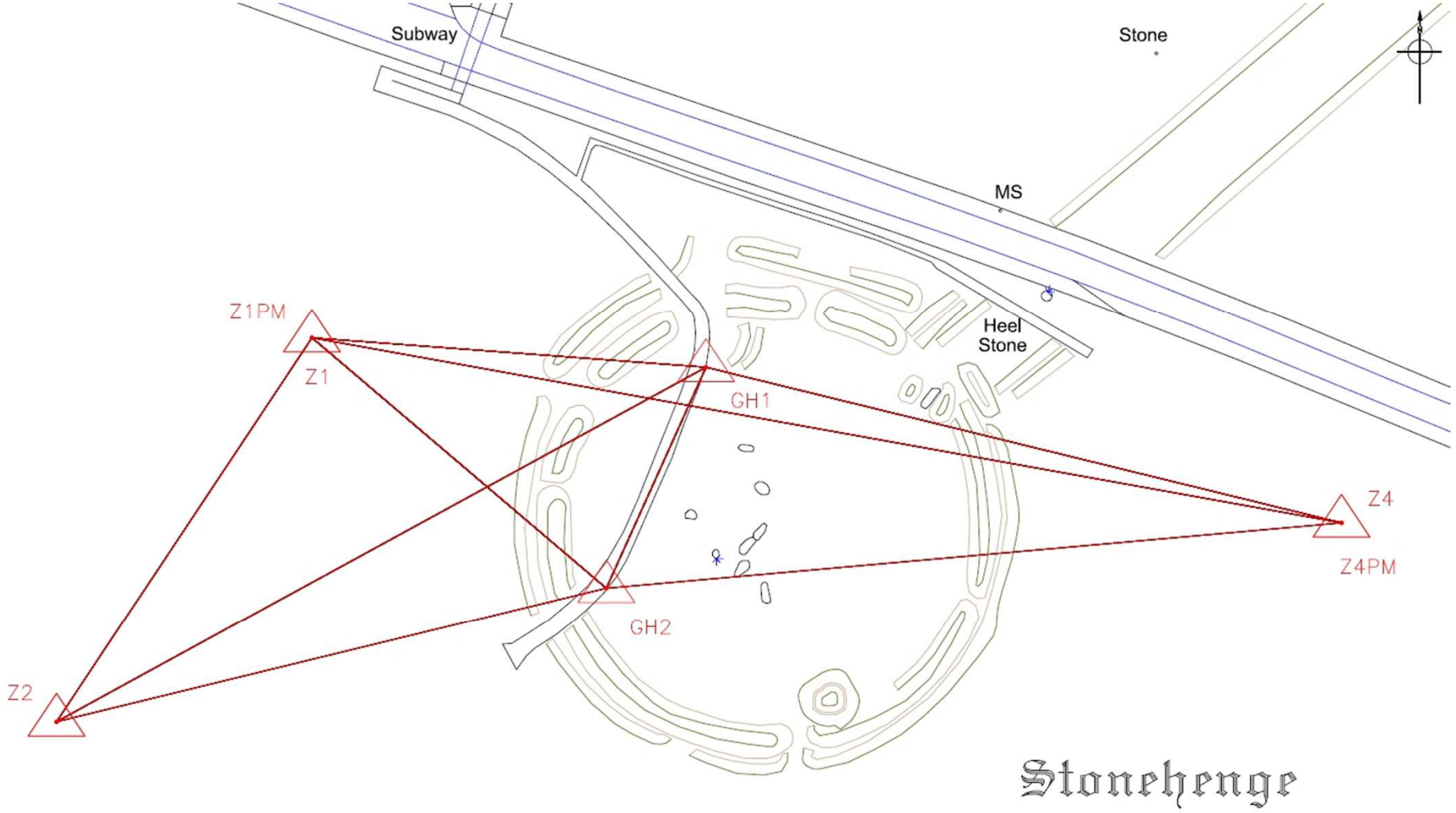
IMAGING, GRAPHICS AND SURVEY

ENGLISH HERITAGE

Stage 1: Survey Control & Field Target Co-ordination.

- Undertaken utilising a 0.5 second, high accuracy, peizo drive, TS30 Total Station offered by Leica.
- A closed loop, twin face, survey traverse was established, incorporating the existing survey control.
- Repeated sets of angles were recorded from each control point, enhanced by the peizo drive system.

Traverse diagram provided for the Stonehenge project.



Stonehenge Down

LSS DTM Software from McCarthyTaylor

greenhatch group

Example of survey control and field target recoding.

Image provided by James Davies, English Heritage IGS.

- The precise field targets are rotated to be observed by the TS30 Total Station using REDM.
- The accurate co-ordination of the field targets is undertaken using a reflectorless twin face method of recording, to ensure that high levels of accuracy are maintained.

LSS DTM Software from McCarthyTaylor

greenhatch group

ENGLISH HERITAGE

Document Ref: 15462_Traverse Adjustment

Traverse Adjustment

SITE:	Stonehenge	Traverse Route :	Z1-Z1

TRAVERSE ADJUSTMENT

Meaned Data :-

Station	Easting (m)	Northing (m)	Level (m)	Angle (dms)	Distance (m)	Level Diff (m)
Z1	1000.000	1000.000	100.000	113 23 10		
					103.911	1.252
Z2PM	942.524	913.433	101.252	47 35 39		
					292.581	-4.984
Z4PM	1231.643	958.314	96.268	19 01 28		
					235.397	3.728
Z1PM	999.966	1000.002	99.996	113 23 01		
					103.880	1.262
Z2	942.504	913.462	101.258	47 35 45		
					292.630	-4.983
Z4	1231.674	958.331	96.276	19 00 59		
					235.390	3.727
Z1	1000.001	1000.000	100.002			
Stored	1000.000	1000.000	100.000			
Misclosure	0.001	0.000	0.002	0 00 02		

After angular misclosure adjustment :-

Station	Easting (m)	Northing (m)	Level (m)	Angle (dms)	Distance (m)	Level Diff (m)
Z1	1000.000	1000.000	100.000	113 23 10		
					103.911	1.252
Z2PM	942.524	913.433	101.252	47 35 38		
					292.581	-4.984
Z4PM	1231.643	958.315	96.268	19 01 28		
					235.397	3.728
Z1PM	999.966	1000.002	99.996	113 23 01		
					103.880	1.262
Z2	942.504	913.461	101.258	47 35 45		
					292.630	-4.983
Z4	1231.674	958.332	96.276	19 00 58		
					235.390	3.727
Z1	1000.001	1000.000	100.002			
Stored	1000.000	1000.000	100.000			
Misclosure	0.001	0.000	0.002	0 00 00		

Length of traverse 1263.789
Accuracy, 1 in 1605176

Bowditch adjusted Data :-

Station	Easting (m)	Northing (m)	Level (m)	Angle (dms)	Distance (m)	Level Diff (m)
Z1	1000.000	1000.000	100.000	113 23 10		
					103.910	1.251
Z2PM	942.524	913.433	101.251	47 35 38		
					292.581	-4.984
Z4PM	1231.642	958.315	96.267	19 01 28		
					235.397	3.728
Z1PM	999.966	1000.002	99.995	113 23 01		
					103.880	1.262

Stored	1000.000	1000.000	100.000	
Misclosure	0.001	0.000	0.002	0 00 00

Length of traverse 1263.789
Accuracy, 1 in 1605176

LSS DTM Software from McCarthyTaylor

greenhatch group

SURVEYOR:	CHECKED BY:	DATE OF SURVEY:
Gary Radmore	Andrew Dodson	21-28/02/2011

Survey by: Greenhatch Group Ltd, Rowan House, Duffield Road, Little Eaton, Derby, DE21 5DR
Tele: 01332 830 044 Fax: 01332 830 055 E-mail: admin@greenhatch-group.co.uk

For: © English Heritage, 37 Tanner Row, York, YO1 6WP
Tele: 01904 60 1901 Fax: 01904 60 1999 E-mail: Survey.Team@english-heritage.org.uk

ENGLISH HERITAGE

Document Ref: 15462_Target Listings

Target Listings

SITE:	Stonehenge	Week 3 Targets 07-13/03/2011

Target	Easting	Northing	Level
TPS1	412225.507	142178.158	102.917
TPS2	412233.134	142175.106	102.826
TPS3	412227.400	142186.930	102.924
TPS4	412236.562	142180.295	102.802
TPS5	412242.666	142172.186	102.692
TPS6	412245.424	142183.858	102.930
TPS7	412249.801	142172.058	102.563
TPS8	412257.950	142175.325	102.432
TPS9	412253.436	142182.542	102.846
TPS10	412264.305	142177.672	102.236
TPS11	412255.588	142186.545	102.770
TPS12	412262.251	142188.870	102.485
TPS13	412270.662	142184.021	102.126
TPS14	412263.577	142196.095	102.466
TPS15	412268.978	142195.309	102.194
TPS16	412261.800	142189.094	102.492
TPS17	412270.794	142187.368	102.120
TPS18	412263.862	142196.296	102.467
TPS19	412272.004	142197.330	102.053
TPS20	412269.421	142204.076	102.116
TPS21	412261.781	142203.614	102.443
TPS22	412263.721	142211.618	102.261
TPS23	412258.350	142207.899	102.546
TPS24	412257.014	142216.549	102.363
TPS25	412254.265	142211.143	102.607
TPS26	412251.522	142220.379	102.380
TPS27	412249.256	142213.746	102.540
TPS28	412243.475	142212.013	102.619
TPS29	412244.171	142220.507	102.417
TPS30	412249.276	142203.572	102.631
TPS31	412244.038	142205.932	102.674
TPS32	412254.618	142205.951	102.709
TPS33	412258.777	142199.917	102.507
TPS34	412252.528	142200.999	102.624
TPS35	412237.924	142191.877	102.754
TPS36	412229.285	142187.350	102.898
TPS37	412230.809	142193.164	102.816
TPS38	412226.221	142183.697	102.974
TPS39	412236.894	142185.182	102.764
TPS40	412224.652	142191.081	103.017
TPS41	412249.071	142185.175	102.919
TPS42	412252.878	142181.798	102.821
TPS43	412256.080	142183.161	102.784
TPS45	412251.029	142187.866	102.838
TPS46	412255.980	142188.881	102.724
TPS47	412257.833	142187.768	102.708
TPS48	412255.986	142195.293	102.530
TPS49	412259.939	142195.734	102.480
TPS50	412255.289	142199.125	102.533

Target	Easting	Northing	Level
TPS51	412256.113	142204.107	102.645
TPS52	412250.718	142201.773	102.654
TPS53	412249.573	142207.474	102.671
TPS54	412232.882	142206.720	102.832
TPS56	412228.807	142200.708	102.827
TPS57	412230.128	142212.900	102.832
TPS58	412225.123	142203.200	102.976
TPS59	412238.722	142218.777	102.661
TPS60	412234.007	142196.703	102.844
TPS61	412230.023	142187.814	102.870
TPS62	412223.984	142190.812	103.033
TPS63	412236.402	142189.271	102.797
TPS64	412314.006	142243.001	100.957
TPS65	412297.085	142245.186	100.942
TPS66	412314.589	142237.042	100.668
TPS67	412304.181	142241.472	100.845
TPS68	412296.689	142249.049	101.106
TPS69	412297.330	142246.089	100.951
TPS70	412247.499	142196.532	102.627
TPS71	412248.927	142191.185	102.748
TPS73	412256.136	142194.552	102.524
TPS74	412258.449	142198.153	102.479
TPS75	412248.312	142205.108	102.620
TPS76	412245.446	142190.097	102.800
TPS78	412251.374	142186.851	102.862
TPS79	412250.725	142194.134	102.663
TPS80	412247.499	142196.533	102.626
TPS81	412242.304	142185.650	102.854
TPS82	412245.772	142191.977	102.730
TPS84	412249.371	142191.210	102.752
TPS85	412283.878	142165.772	102.204
TPS86	412278.003	142172.890	101.889
TPS87	412291.288	142179.463	102.050
TPS88	412282.786	142180.730	101.871
TPS89	412296.665	142168.941	101.385
TPS90	412278.456	142215.664	101.856
TPS91	412284.284	142219.354	102.161
TPS92	412285.320	142228.430	101.637
TPS93	412279.988	142231.030	101.601
TPS94	412277.307	142224.198	102.025
TPS95	412201.315	142215.147	103.778
TPS96	412217.871	142220.623	102.893
TPS97	412211.229	142203.763	103.201
TPS98	412208.459	142225.288	103.553
TPS99	412199.756	142207.604	103.793
TPS101	412242.838	142186.560	102.867
TPS102	412244.448	142196.136	102.690
TPS103	412256.020	142194.550	102.524
TPS104	412252.343	142197.450	102.609

LSS DTM Software from McCarthyTaylor

greenhatch group

SURVEYOR:	CHECKED BY:	DATE OF SURVEY:
Gary Radmore	Andrew Dodson	21-28/02/2011

Survey by: Greenhatch Group Ltd, Rowan House, Duffield Road, Little Eaton, Derby, DE21 5DR
Tele: 01332 830 044 Fax: 01332 830 055 E-mail: admin@greenhatch-group.co.uk

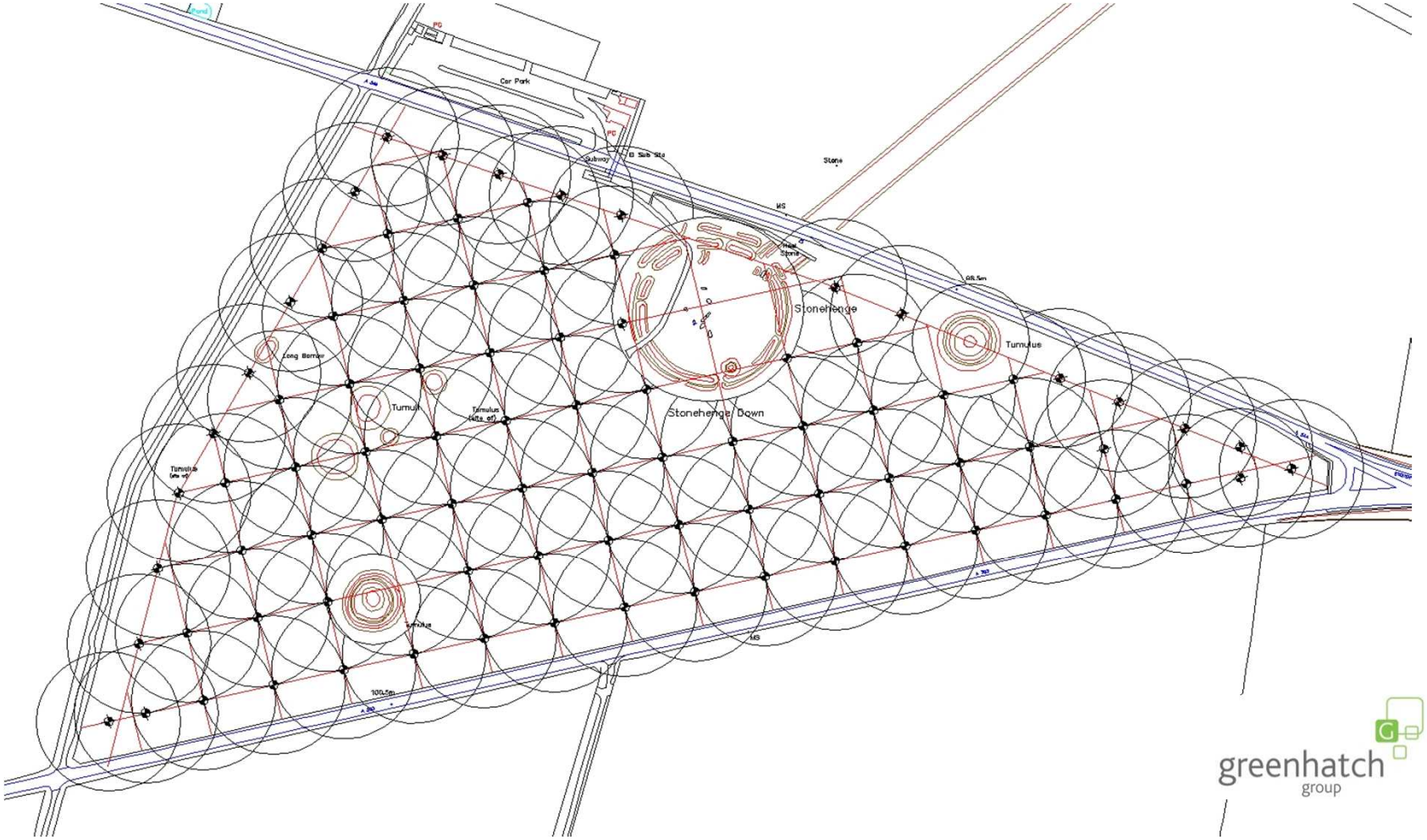
For: © English Heritage, 37 Tanner Row, York, YO1 6WP
Tele: 01904 60 1901 Fax: 01904 60 1999 E-mail: Survey.Team@english-heritage.org.uk

Stage 2: Survey of triangle landscape at 100mm point resolution.

- Undertaken utilising a Leica C10, pulse based, long range laser scanner.
- Provides high quality survey grade scan data at a range of up to 300m.
- Records laser scan data at rate of 50,000 points/sec.
- On board high accuracy field target selection & registration system perfectly suited to the extensive landscape environment to be surveyed.

greenhatch group

Initial desktop study to ensure confident data coverage to the site.



- The 1.2 km site presented challenges in confidently providing comprehensive 3D data coverage.
- Scan tests highlighted a 100mm point spacing at 50m range, would provide the best resolution.
- A 50m intersection grid was therefore established across the site in desktop form.
- Intersection co-ordinates (Ordnance Survey) were then set out in the field using GPS and TPS.
- Additional “Freestyle” laser scan positions undertaken to any pronounced archaeological features.

Image provided by James Davies, English Heritage IGS.

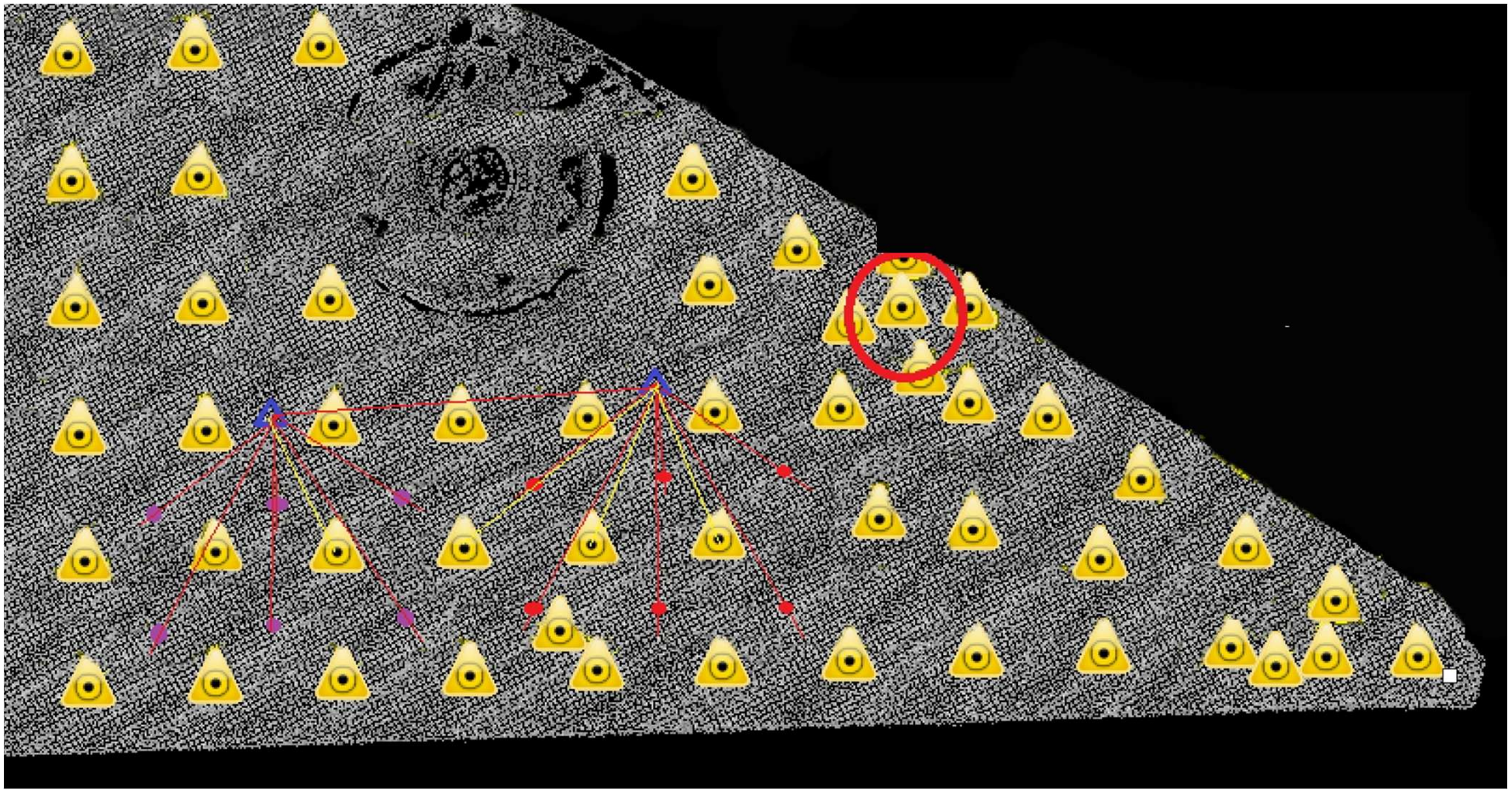
Leica C10, long range laser scanner, used to survey the triangle landscape.

greenhatch group

Additional “freestyle” scan locations undertaken around significant archaeological features.

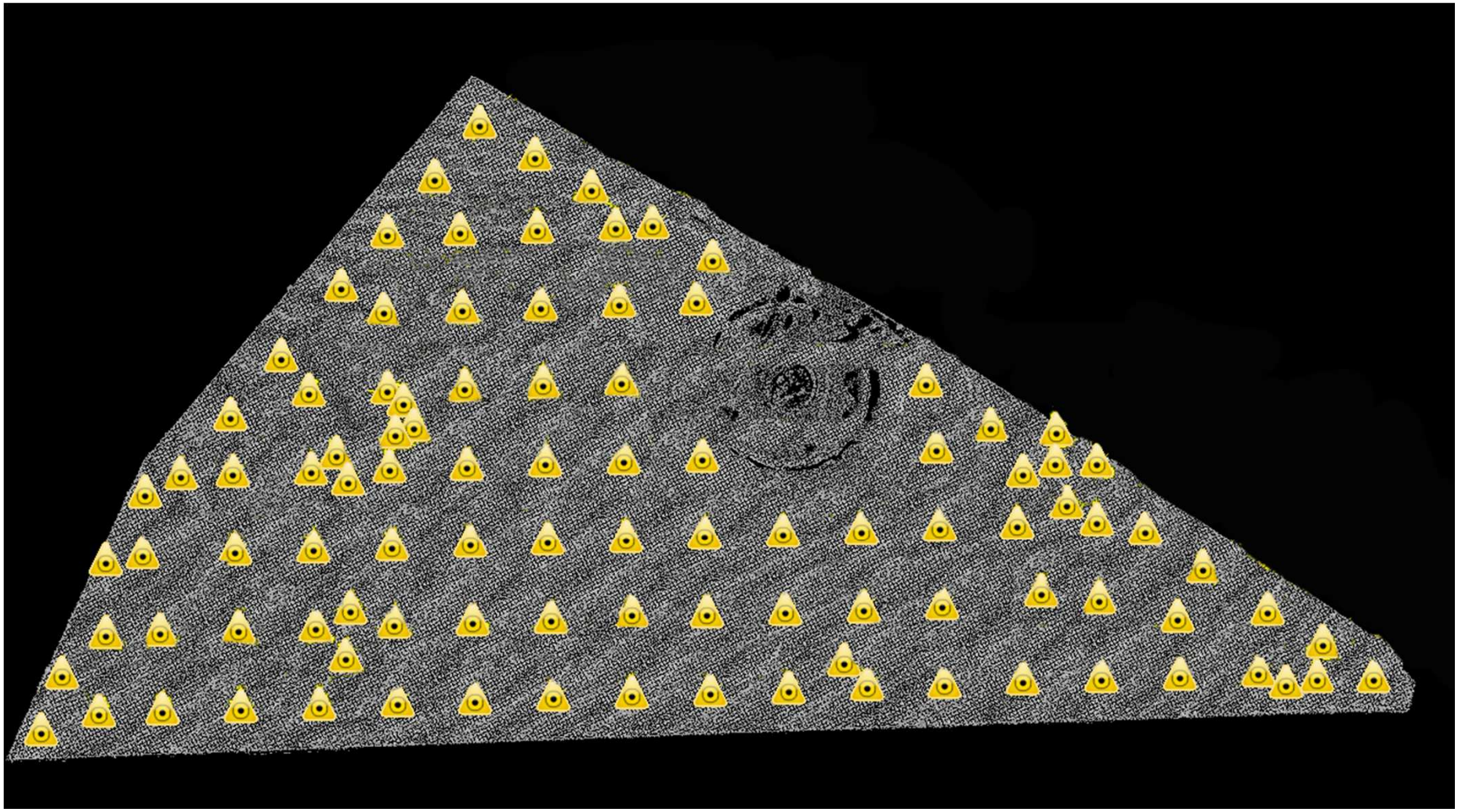
greenhatch group

Example of field target location strategy and co-ordination by total station.



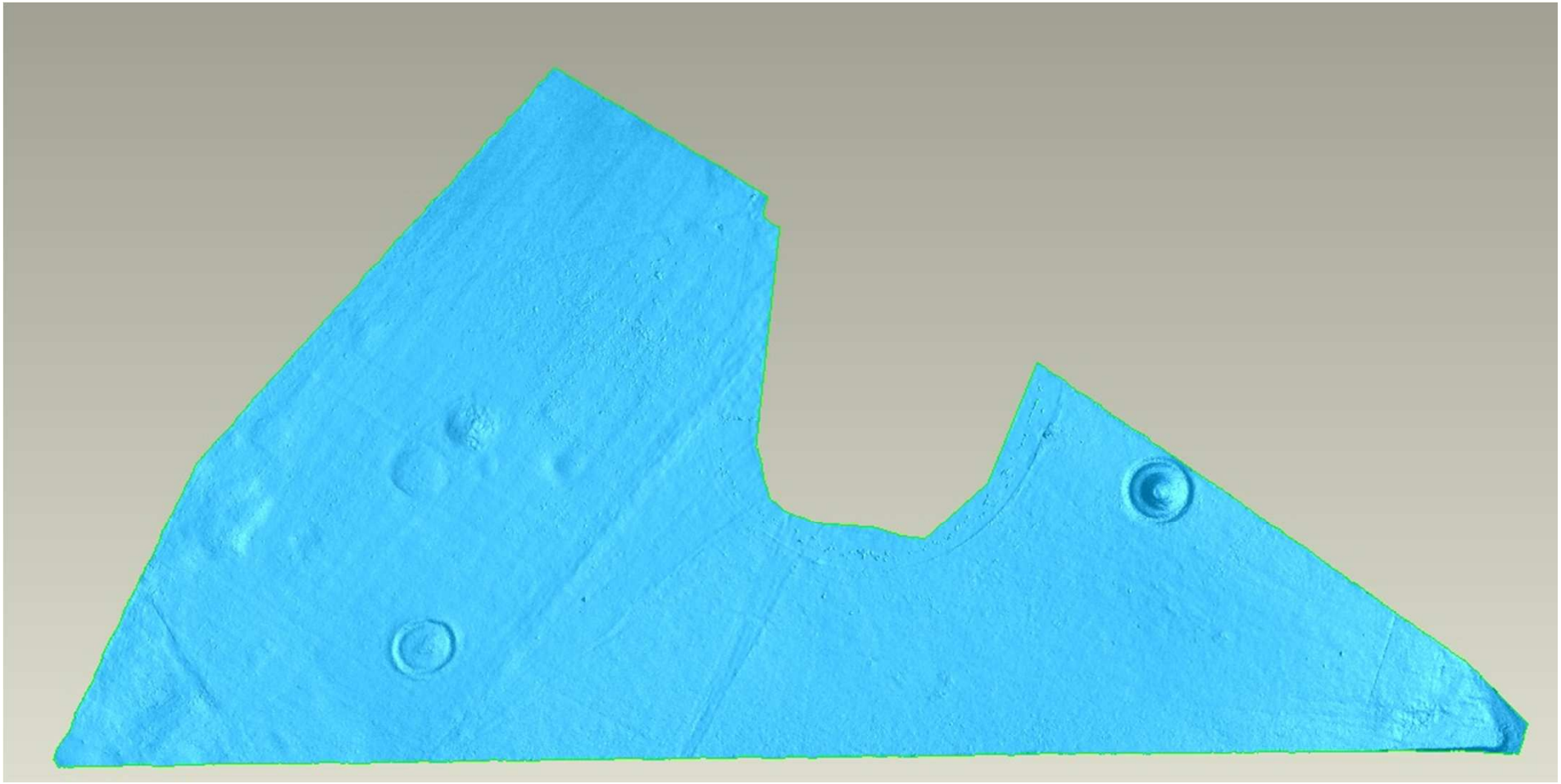
- 6 no field targets were used one site, being positioned in a 50m square around each scan position.
- The TS30 total station would be traversed around the site setting out scan positions and also locating field targets at the same time (all using twin face recording methods).
- Additional targets (4 No per scan) were regularly spaced around each additional “freestyle” position.

Image highlighting the location of all scan positions in Cyclone software.



- This image highlights all the scan registration positions captured on site for the 100mm triangle landscape and also demonstrates how successfully complete coverage has been achieved.
- Due to the amount of regular overlap and recorded point density, the actual resolution available is 50mm.

Resultant meshed model created from point cloud data using Geomagic software.



- Meshed model surface of the triangle landscape using a point cloud resolution filtered to 100mm.
- Data processed in sections and merged together due to file sizes (1 GB in total, post filter).

geomagic

greenhatch group

Stage 3: Survey of the bank & ditch landscape at 20mm point resolution.

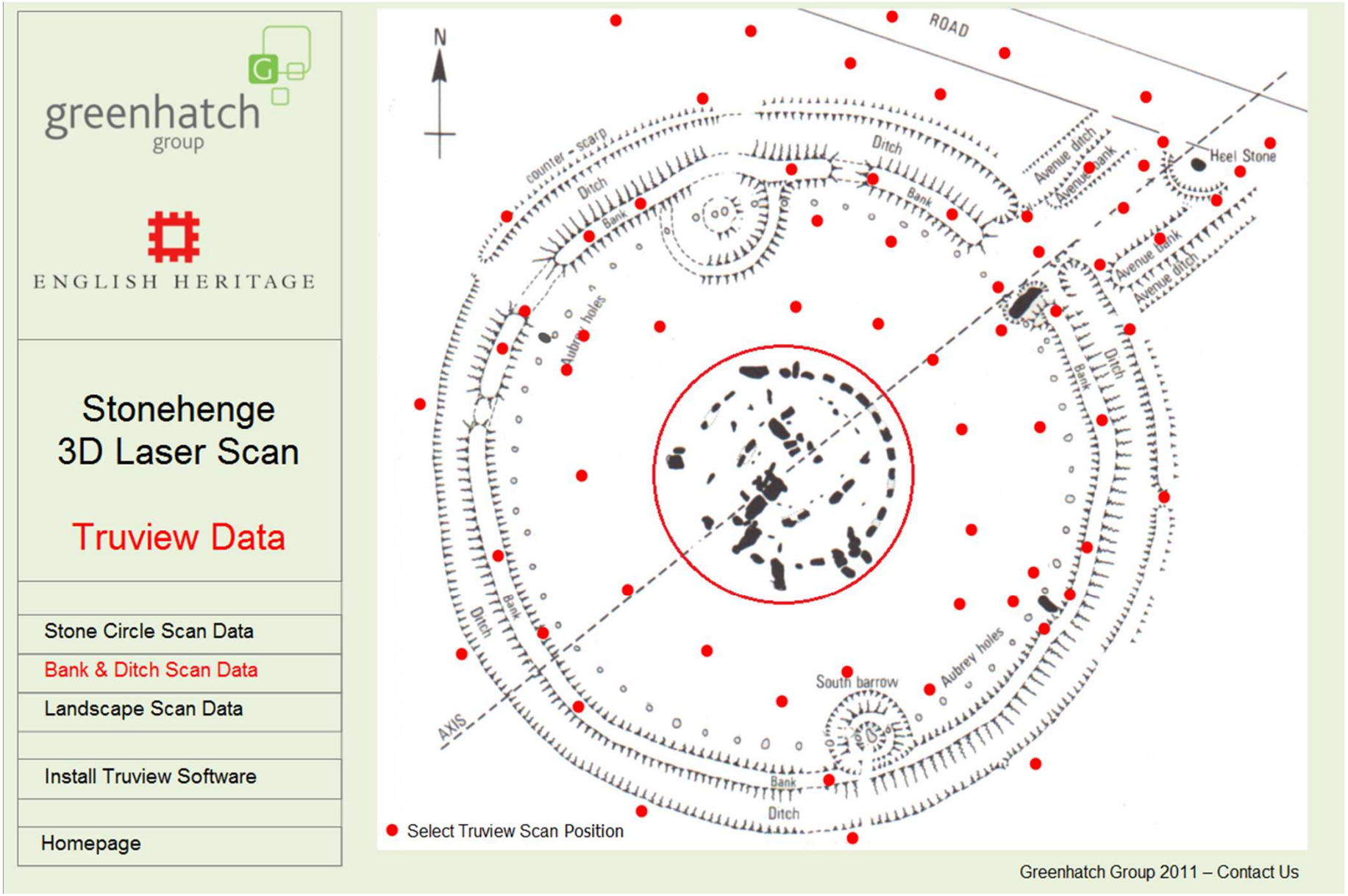
- Undertaken utilising the same Leica C10, pulse based, long range laser scanner.
- Resolution settings increased from 100mm to 20mm increments.
- “Freestyle” laser scan positions situated in suitable positions around the bank & ditch landscape.

greenhatch group

Image provided by James Davies, English Heritage IGS.

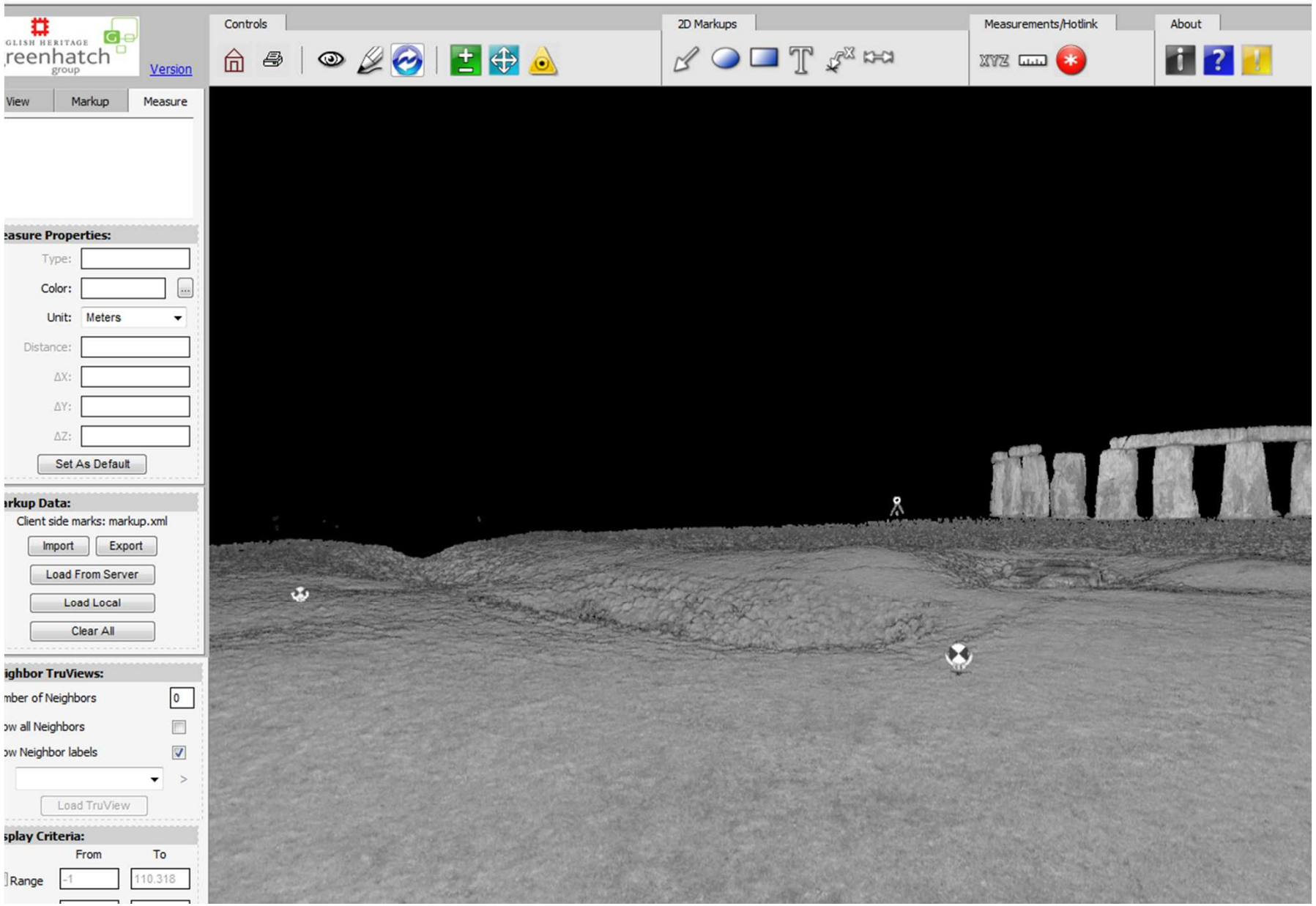
The use of the Leica C10 Laser Scanner around the bank & ditch landscape in conjunction with the Leica TS30, high accuracy total station, co-ordinating the scan field targets.

greenhatch group



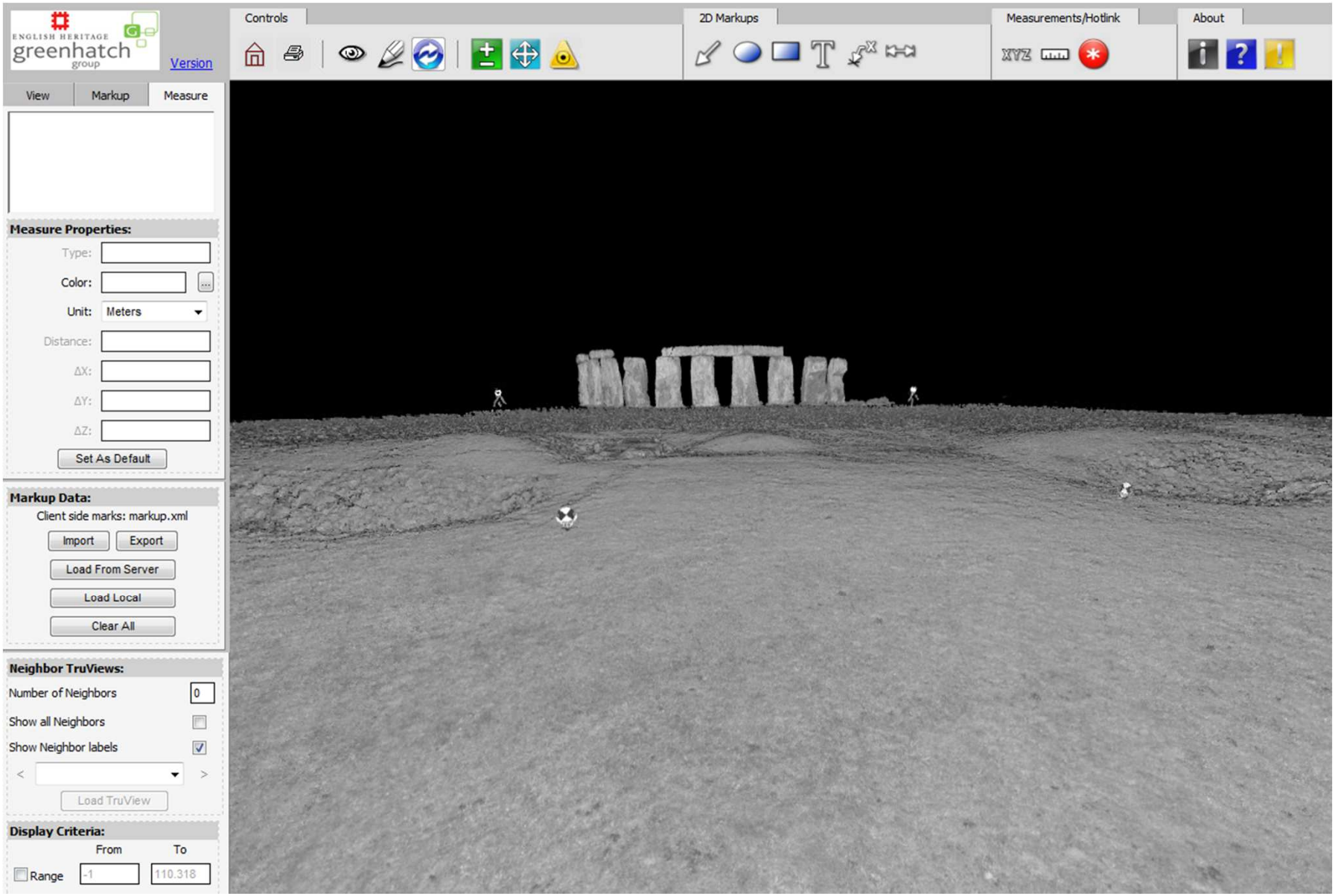
- Laser scan positions for 20mm bank & ditch landscape, highlighted within Leica “Truview” software.
- Leica Truview software allows interactive viewing of each individual laser scan position.

Leica TruView & Cyclone PUBLISHER
Free, Easy Viewing & Measuring of Point Clouds



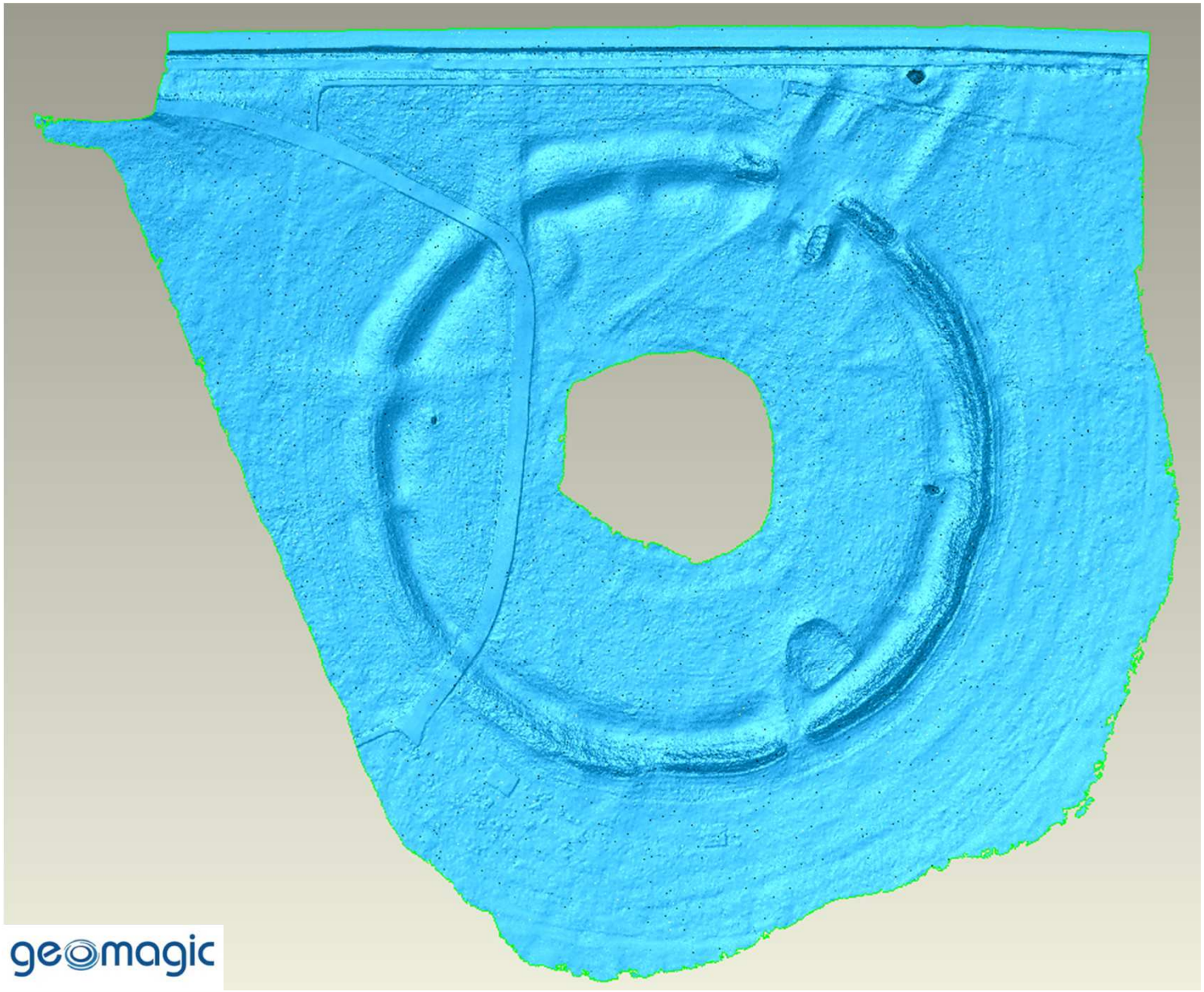
- Leica " Truview" portal, highlighting 20mm point cloud resolution of bank & ditch.

Leica TruView & Cyclone PUBLISHER
Free, Easy Viewing & Measuring of Point Clouds



- Leica “ Truview” portal, highlighting 20mm point cloud resolution of bank & ditch.

Leica Geosystems **Leica TruView & Cyclone PUBLISHER**
Free, Easy Viewing & Measuring of Point Clouds



- Meshed model surface of the bank & ditch landscape highlighted using a point cloud resolution filtered to 20mm, although an actual resolution of 10mm was possible.
- Data processed in sections and merged together due to file sizes (1.3GB).

greenhatch group

Stage 4: Survey of stone circle at 1mm point resolution.

- Undertaken utilising the Z+F 5006h, high speed, short range laser scanner.
- Typically records laser scan data at rate of 500,000 points/sec.
- Can provide high resolution, 1mm phased based data at 7.5m with a further range of up to 50m.
- Used in conjunction with a Z+F M-Cam (motorised camera) system.
- On board camera provides calibrated colourised point cloud data in a fully automated form.

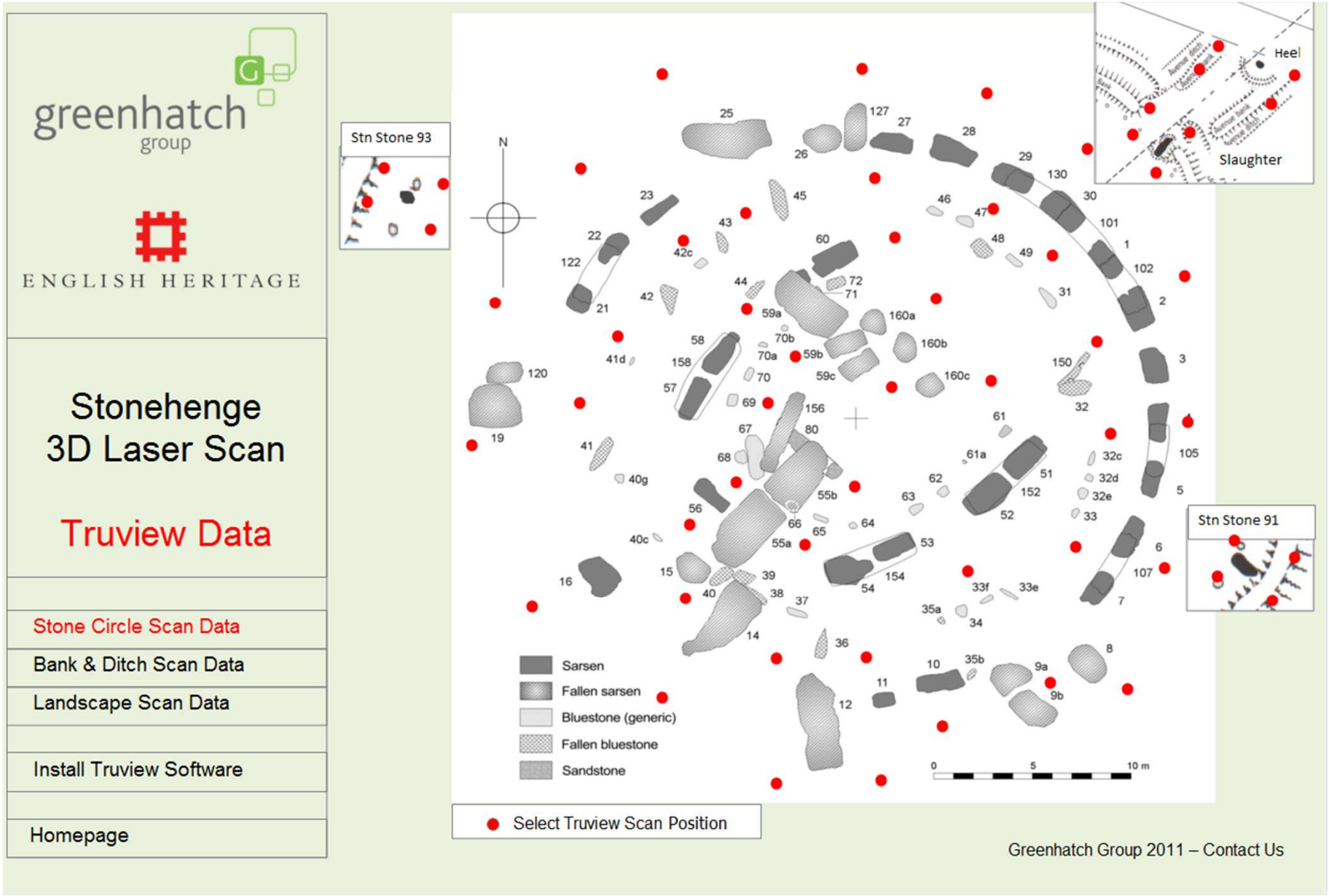
greenhatch group

The use of the Z+F 5006h high speed laser scanner with on board M-Cam system.

greenhatch group

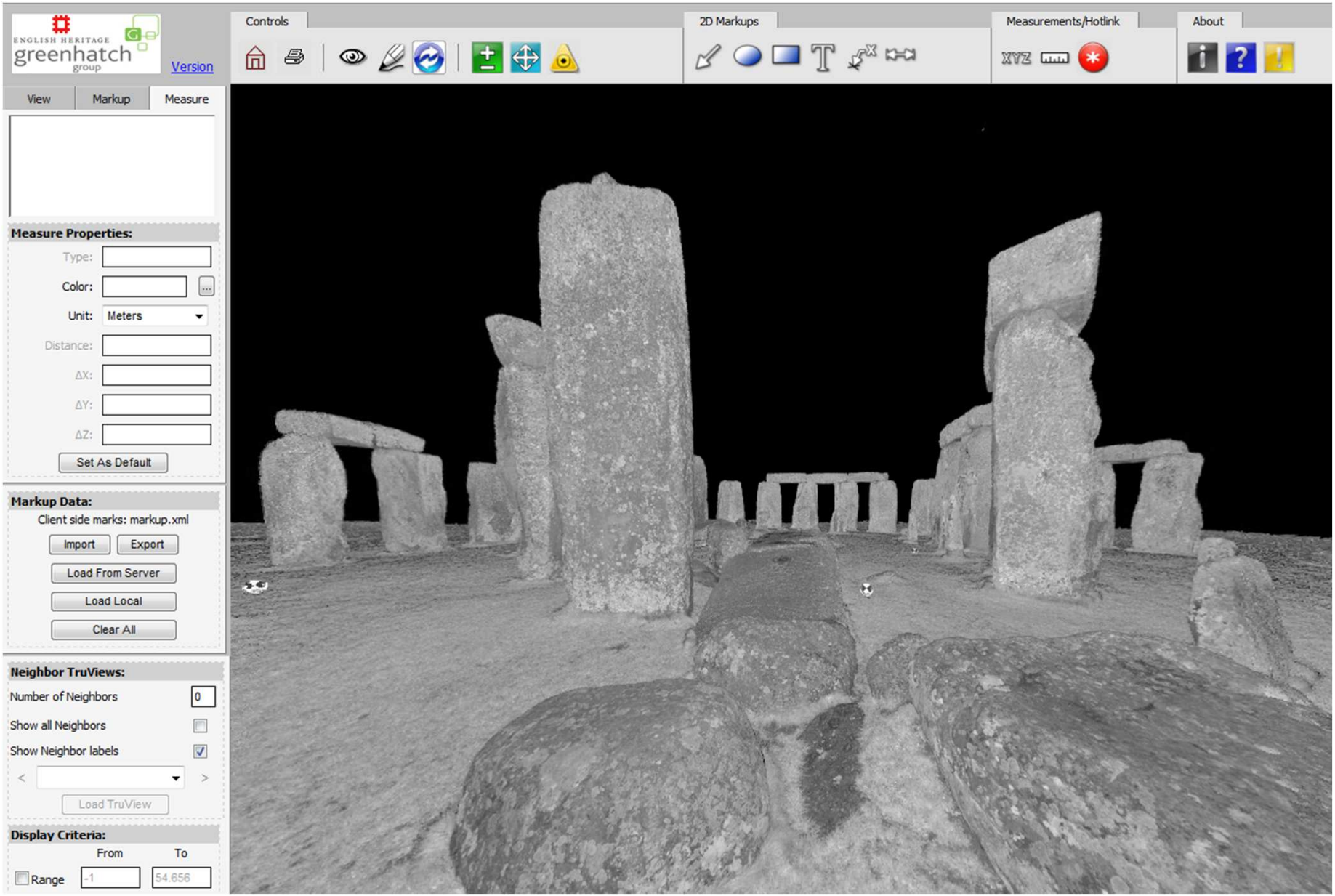
The use of the Z+F 5006h Laser Scanner around the perimeter of the stone circle in conjunction with the Leica TS30, high accuracy total station, co-ordinating the scan field targets.

greenhatch group



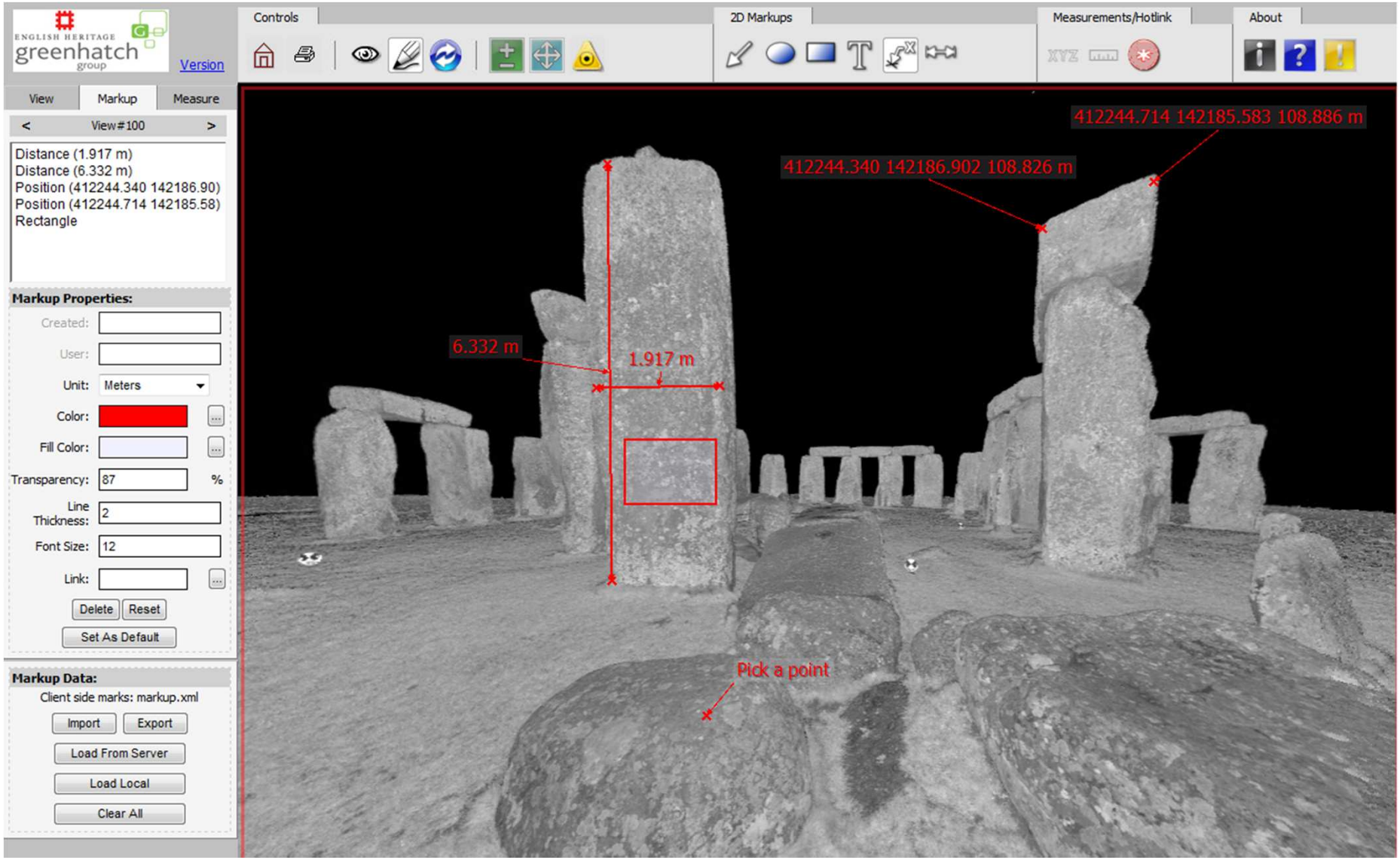
- Physical laser scan positions for the 1mm resolution survey to the individual stones on the site.
- Highlighted within the Leica “Truview” software which interactive viewing of each scan position.

Leica TruView & Cyclone PUBLISHER
Free, Easy Viewing & Measuring of Point Clouds



- Leica “ Truview” portal, highlighting a 1mm point cloud resolution of the inner stone circle.

Leica Geosystems **Leica TruView & Cyclone PUBLISHER**
Free, Easy Viewing & Measuring of Point Clouds



- Leica " Truview" portal, highlighting a 1mm point cloud resolution with additional functionality.
- Software provides interactive ability to measure on screen, highlight areas of interest and print as a PDF.

Leica Geosystems **Leica TruView & Cyclone PUBLISHER**
Free, Easy Viewing & Measuring of Point Clouds

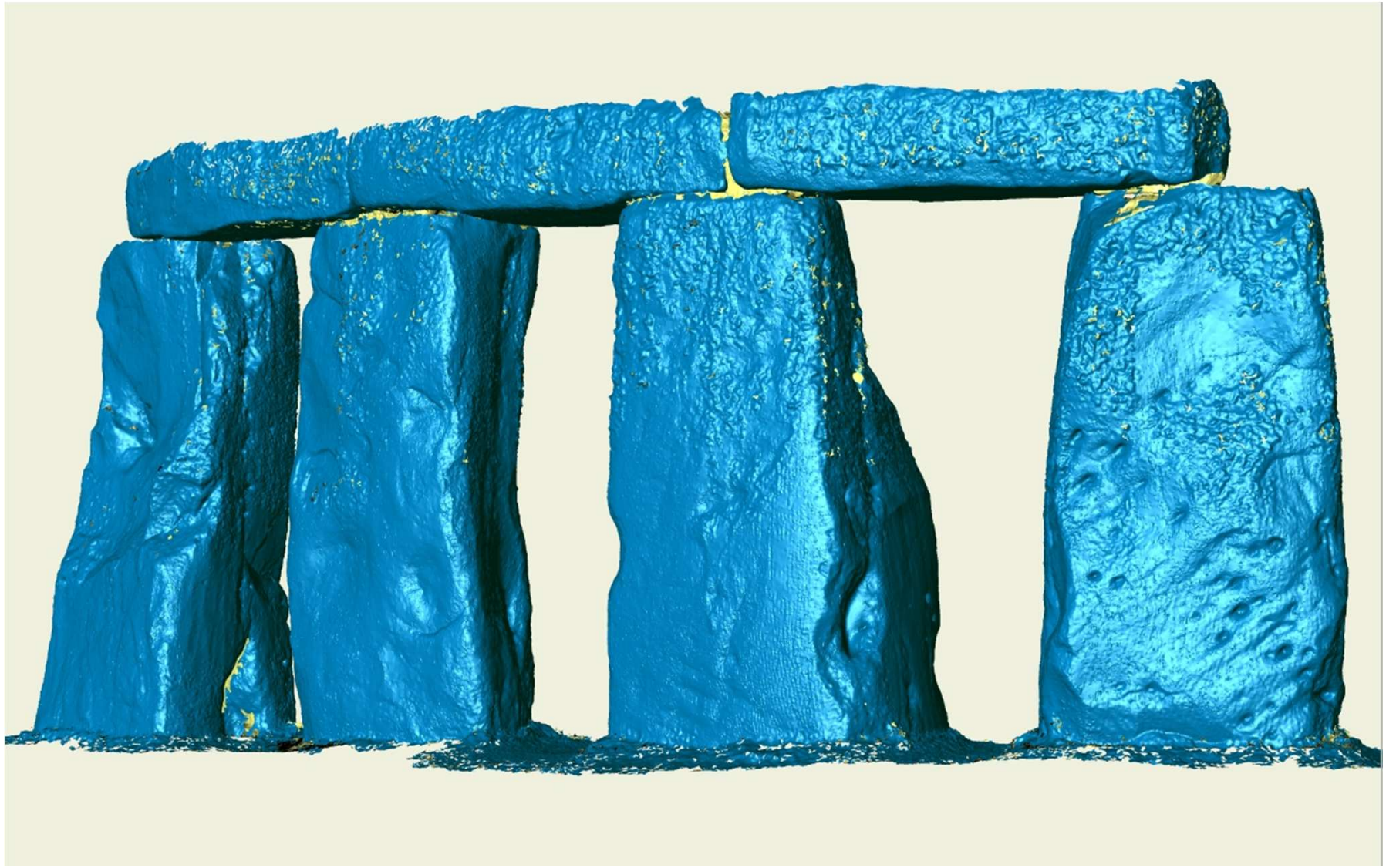
Example of the final colourised, 1mm resolution “3D point cloud” model.

Example of the final colourised 1mm resolution point cloud model.

Example of a selection of stones in colourised point cloud form, prepared for initial mesh modelling.

pointools
performance point cloud software

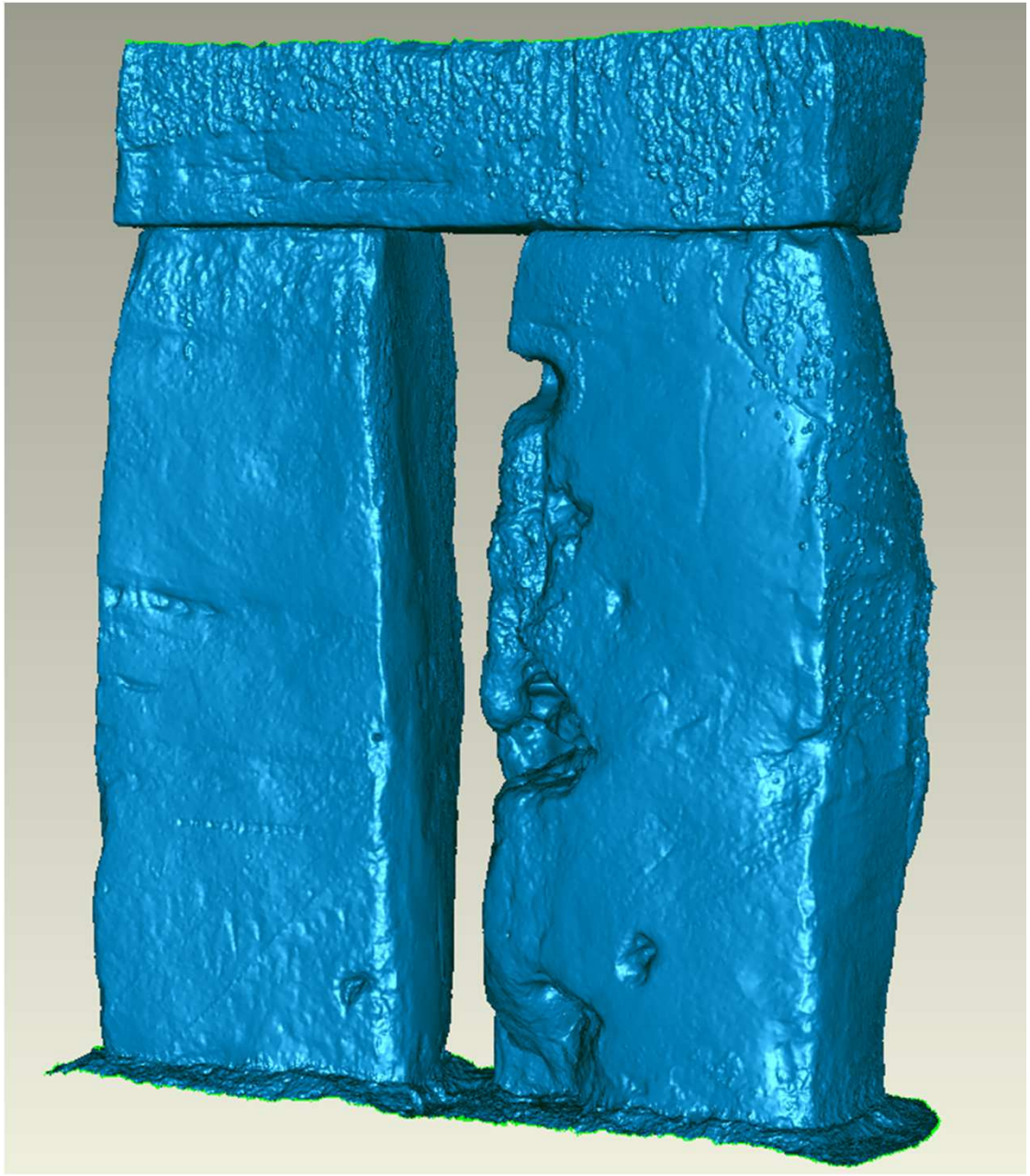
greenhatch
group



Example of initial mesh modelling of point cloud data using Geomagic software.

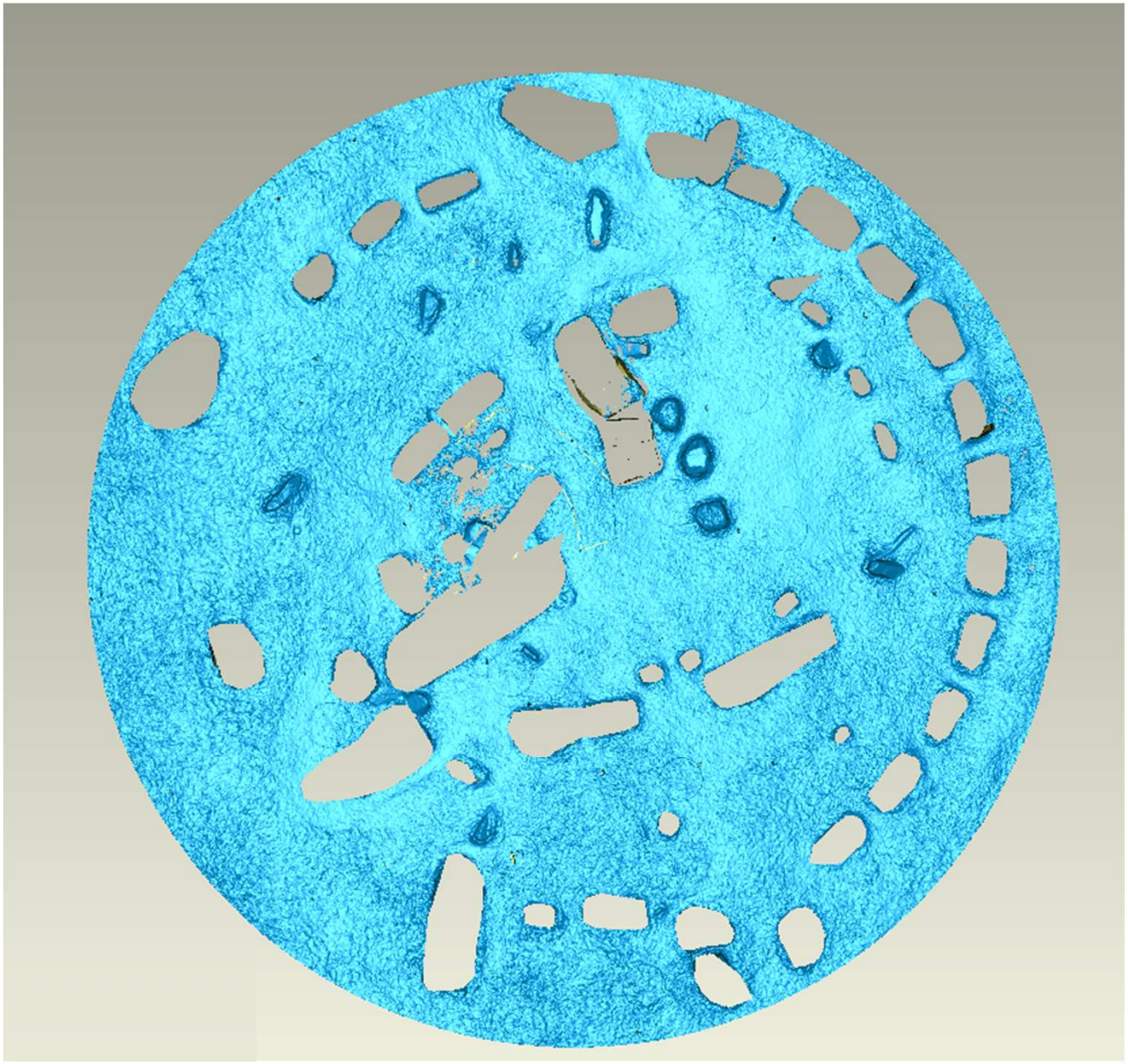
geomagic

greenhatch group



Example of a 1mm resolution meshed model surface to stones 53 & 54, prepared for evaluation.

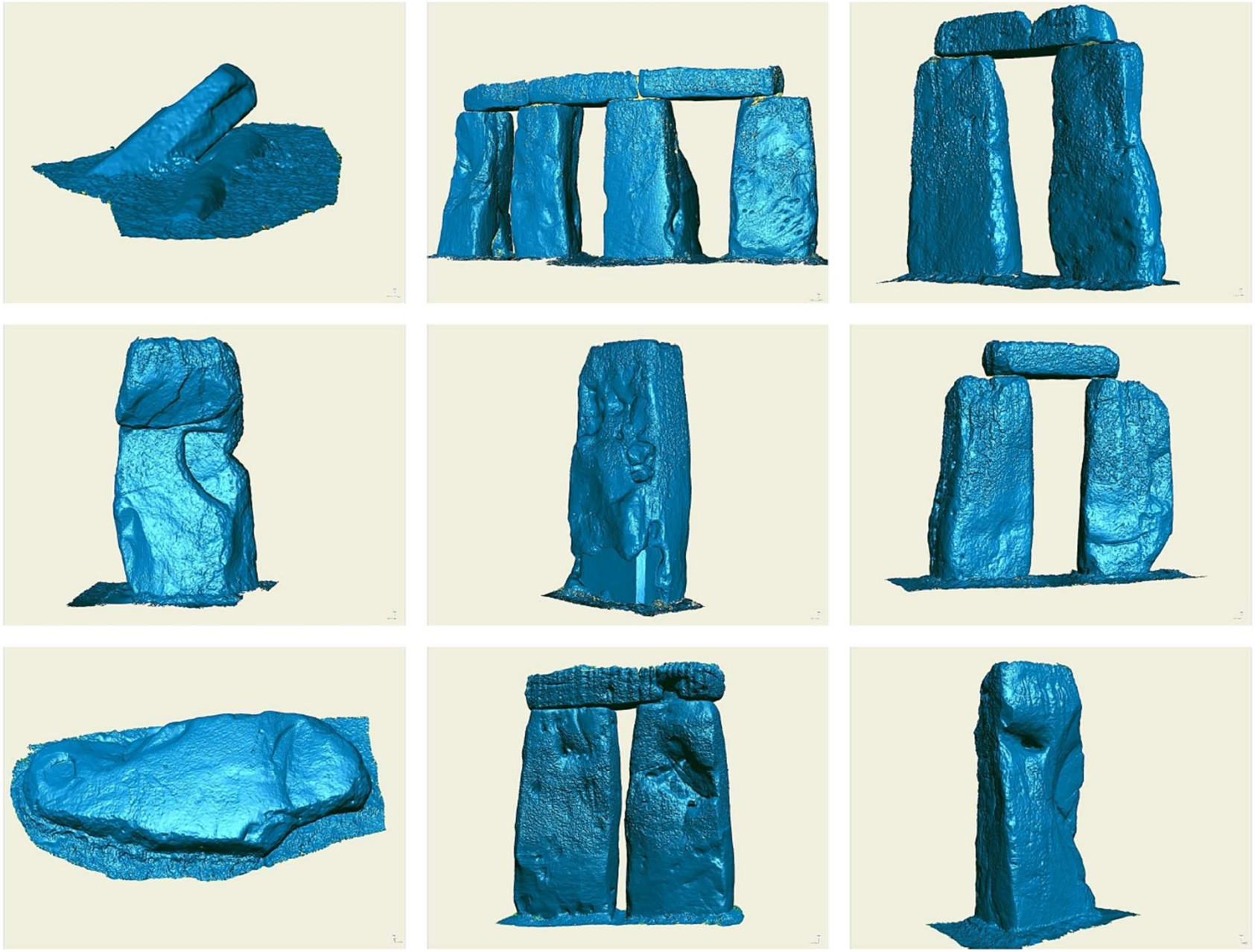
Example of a meshed model surface to stones 53 & 54, with colourised point cloud data overlay.



Example of the meshed model, topographical surface of the Stone Circle.

geomagic

greenhatch group



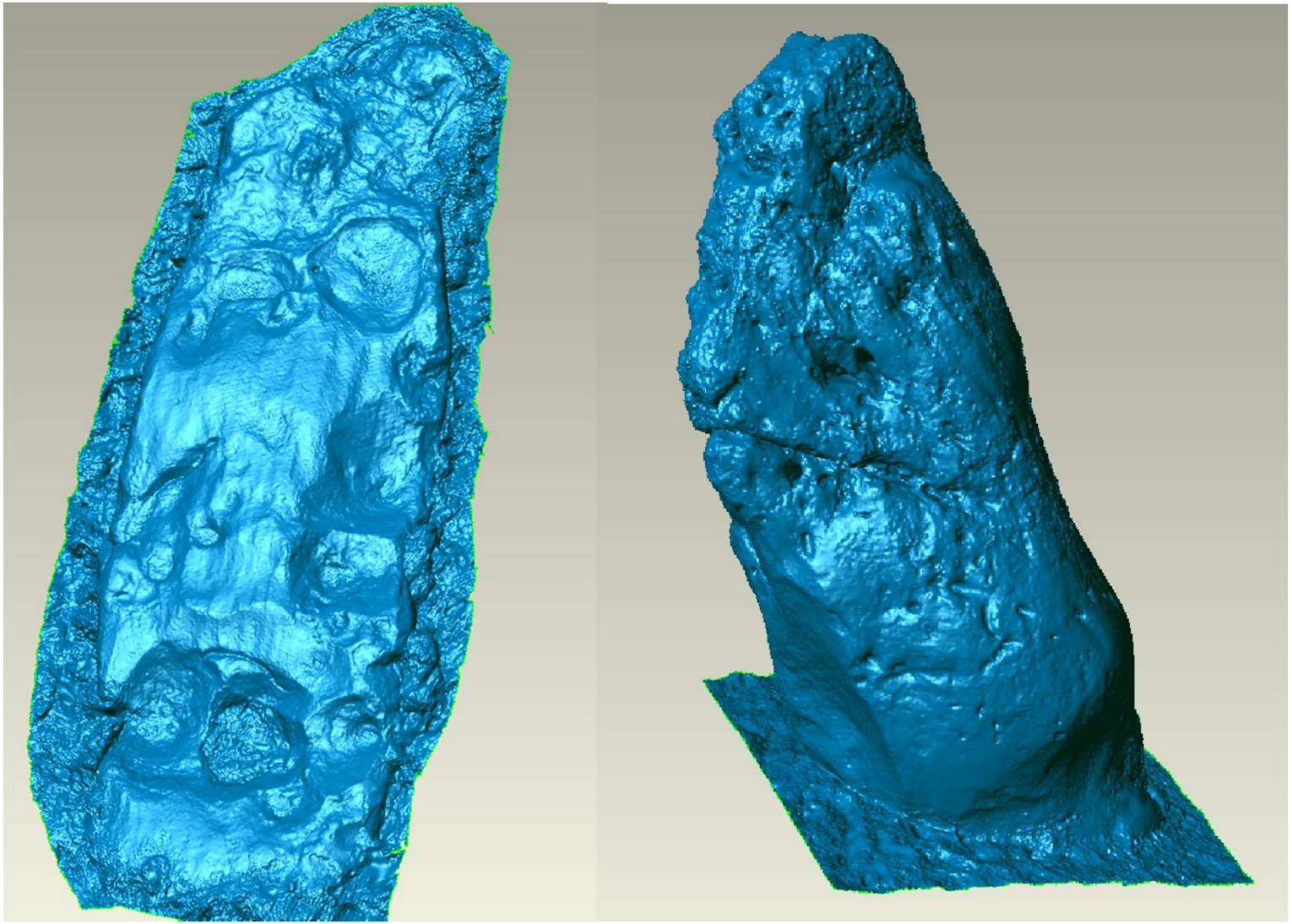
Examples of the 1mm meshed models issued for initial archaeological analysis and also for integration into the stone circle ground surface model.

geomagic

greenhatch group

Slaughter Stone

Heel Stone



- Examples of 1mm individual stone meshed models, typically using 30 > 50 Million points.
- Each file was exported into Geomagic as an ascii file, typically 1.5 GB in size.
- Each Geomagic meshed model needed to be limited to 10 Million triangles to aid visibility.

geomagic

greenhatch group

Stage 5: Survey of individual stone faces at 0.5mm point resolution.

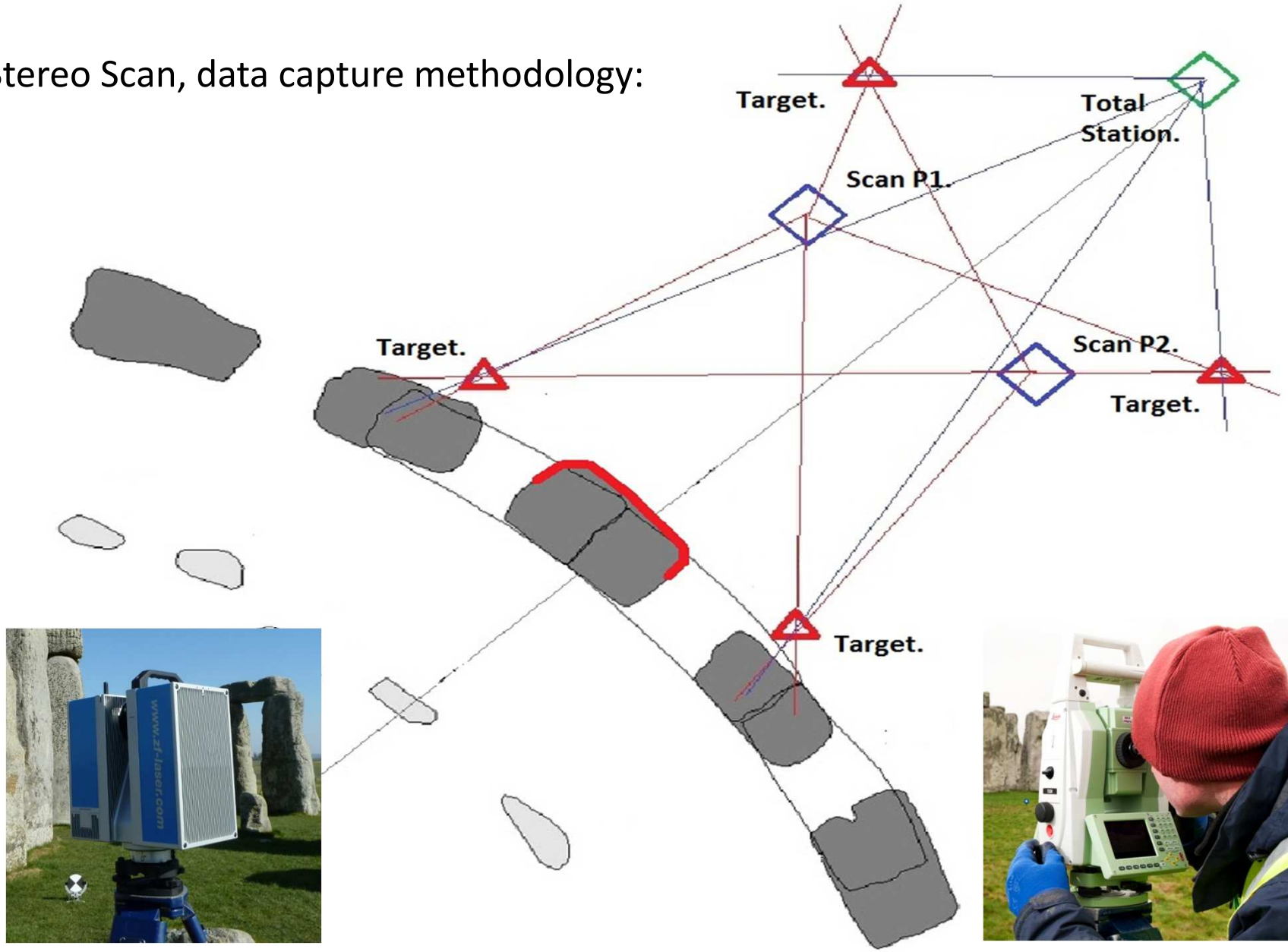
- Undertaken utilising the newly released, Z+F Imager 5010, ultra high speed laser scanner.
- Can provide **exceptional quality, high resolution**, sub-mm **data** at 7.5m, with an extended range of **up to 190m**.
- Can record laser scan data at rate of up to 1,000,000 points/sec if required.
- **Availability to multi capture specific scene selections, thus reducing file sizes.**
- **Availability to increase the quality of data recorded by reducing the speed of capture.**
- Additional Mono Imagery of each stone face captured by a Canon 7D 18MP DSLR with a 10-22mm Lens.

greenhatch group

Use of the newly released, Z+F imager 5010, high resolution laser scanner, working around the outer face of the stone circle, in conjunction with a TS30 Total Station, recording each field target by twin face REDM methods.

greenhatch group

Stereo Scan, data capture methodology:



An illustration of the stereo scan & static field target methodology used on site to create the accurate 0.5mm “depth of field” point cloud data recorded per individual stone face.

greenhatch group

Use of the Z+F imager 5010, high resolution laser scanner within the stone circle.

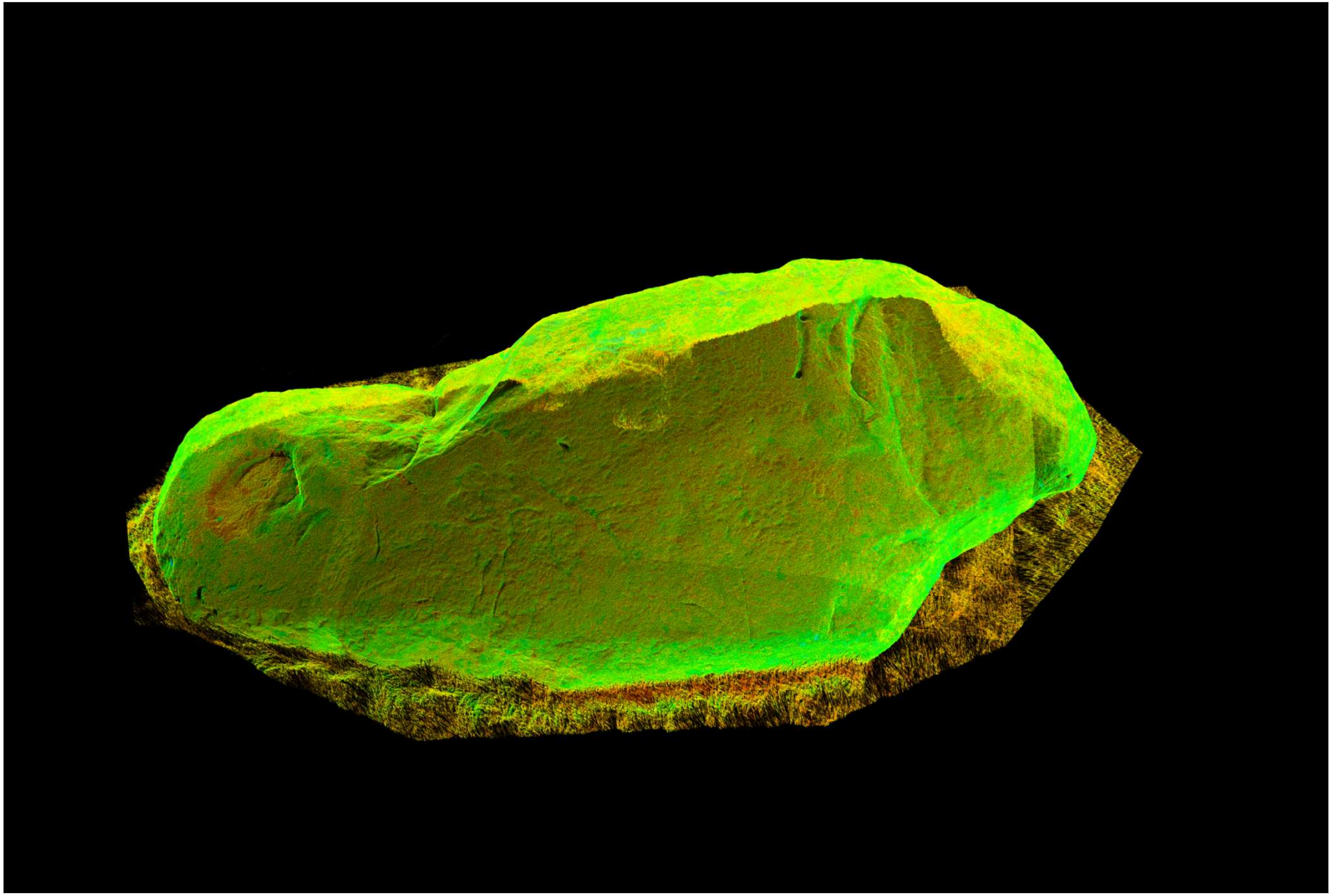
greenhatch group

Example of high level laser scan coverage to the stone circle using an extendable tripod.

greenhatch group

Example of low level laser scan coverage using a reduced height tripod.

greenhatch group



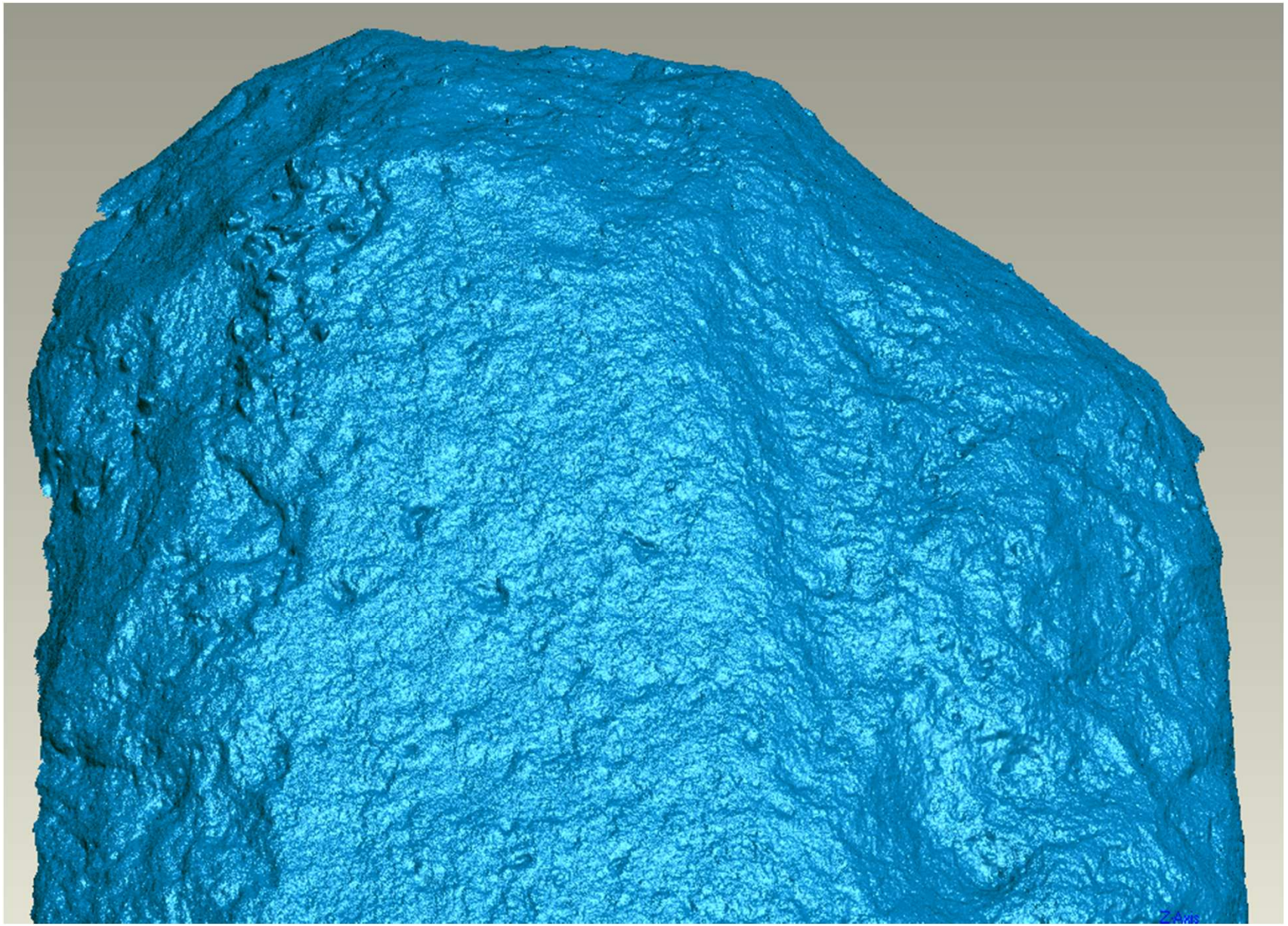
Example of 0.5mm resolution, high quality, point cloud data available for Stone No 25, for future analysis.

Leica Geosystems

Leica Cyclone

3D Point Cloud Processing Software

greenhatch group



- An example of the 0.5mm resolution point data available in meshed modelled form.
- File sizes severely limited to a maximum of 10 million triangles.
- Each single face was exported in ascii format with a typical file size of 8 GB.

geomagic

greenhatch group

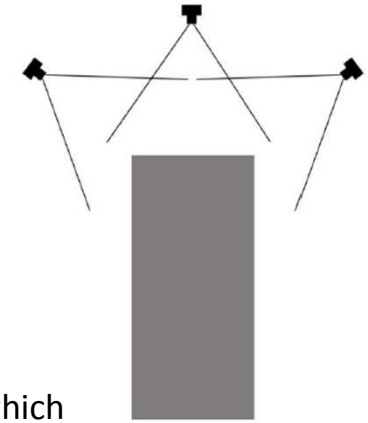
- An example of the modelled data with a high resolution mono image draped over.
- Total archived ascii data set for all stone faces was 500 GB.
- Data captured will however, enable further analysis and higher levels of 3D presentation in the future.

geomagic

greenhatch group

Stage 6: High Level Digital Photogrammetry.

(Provided by Atkins Ltd - Geospatial Mapping).



- Undertaken utilising the high level access “Jimmy Jib” portable boom which is commonly used in the film industry, having a 12m height range and great portability.
- Use of a high resolution Nikon D3x 24.5 MP DSLR camera with focus locked, mounted on the boom in a fully automated form.
- Camera calibrated using PhotoModeler software, prior to the photogrammetric survey.

greenhatch group

Image provided by James Davies, English Heritage IGS.

The use of the “Jimmy Jib” portable boom with high resolution camera attachment.

greenhatch group

Images provided by James Davies, English Heritage IGS

The use of the “Jimmy Jib” boom, highlighting image capture and camera mount manipulation.

Photogrammetric process methodology.

Image provided by James Davies, English Heritage IGS.

- The use of the “Jimmy Jib” portable boom, enabled high quality overlapping digital photography to be captured to the tops of each stone lintel .
- Images were taken at a maximum distance of 2.5m resulting in a pixel size of 0.007m, thus enabling a realistic DSM of 1mm to be achieved.
- Each image captured, was then used on site at a later date to allow feature point coordinates to be observed by Total Station REDM techniques.

greenhatch group

An example of the digital photography taken from the high level access boom.

PhotoModeler®

greenhatch group

An example of imagery acquired suitable for use with digital photogrammetry processing.

PhotoModeler®

greenhatch group

An example highlighting the recording of “feature point coordinates” to the stone lintels for use in the processing and orientation of the digital photogrammetry data.

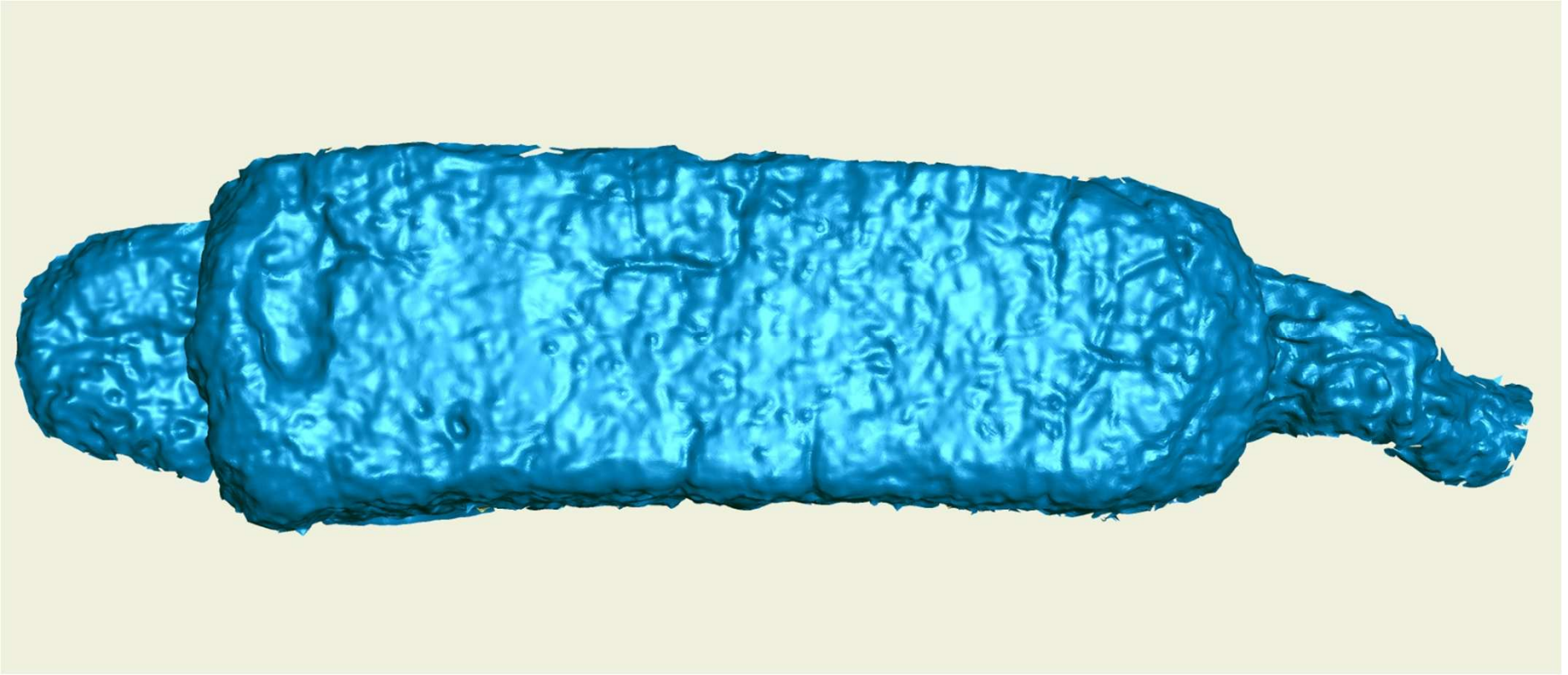
PhotoModeler®

greenhatch group

An example of the 1mm resolution, colourised point data available from the resultant digital photogrammetry process, for the upper Stone Lintel No 105.

PhotoModeler®

greenhatch group



An example of the 1mm meshed modelled form of the stone lintel.

geomagic

greenhatch group

An example of the colourised, meshed modelled form of the stone lintel.

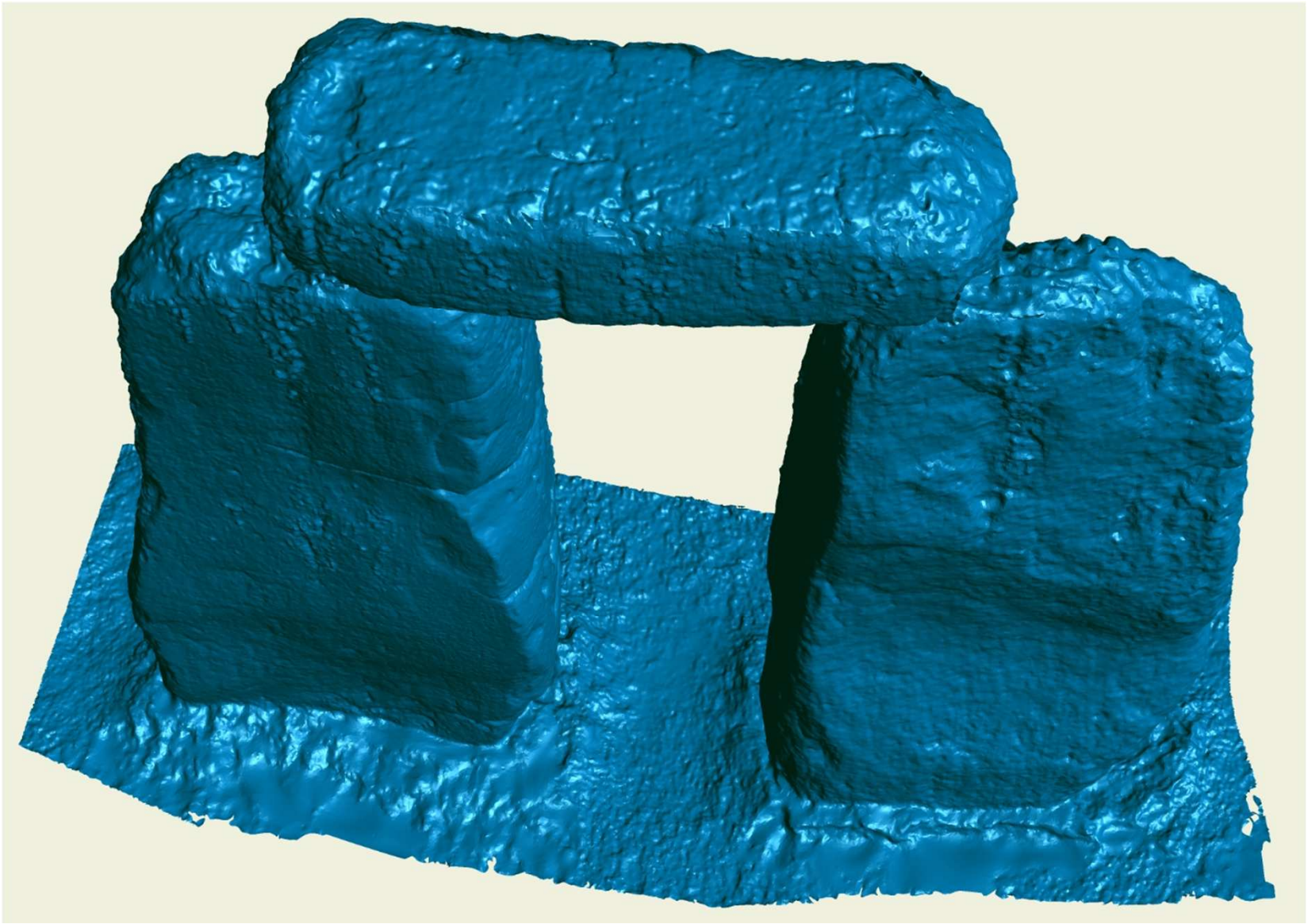
geomagic

greenhatch group

A further example of the colourised, meshed modelled form of the Stone Lintel No 105.

geomagic

greenhatch group



An example of the succesfully completed meshed model for Stones 4, 5 & 105, using both 3D laser Scanning and also Digital Photogrammetry processes.

geomagic

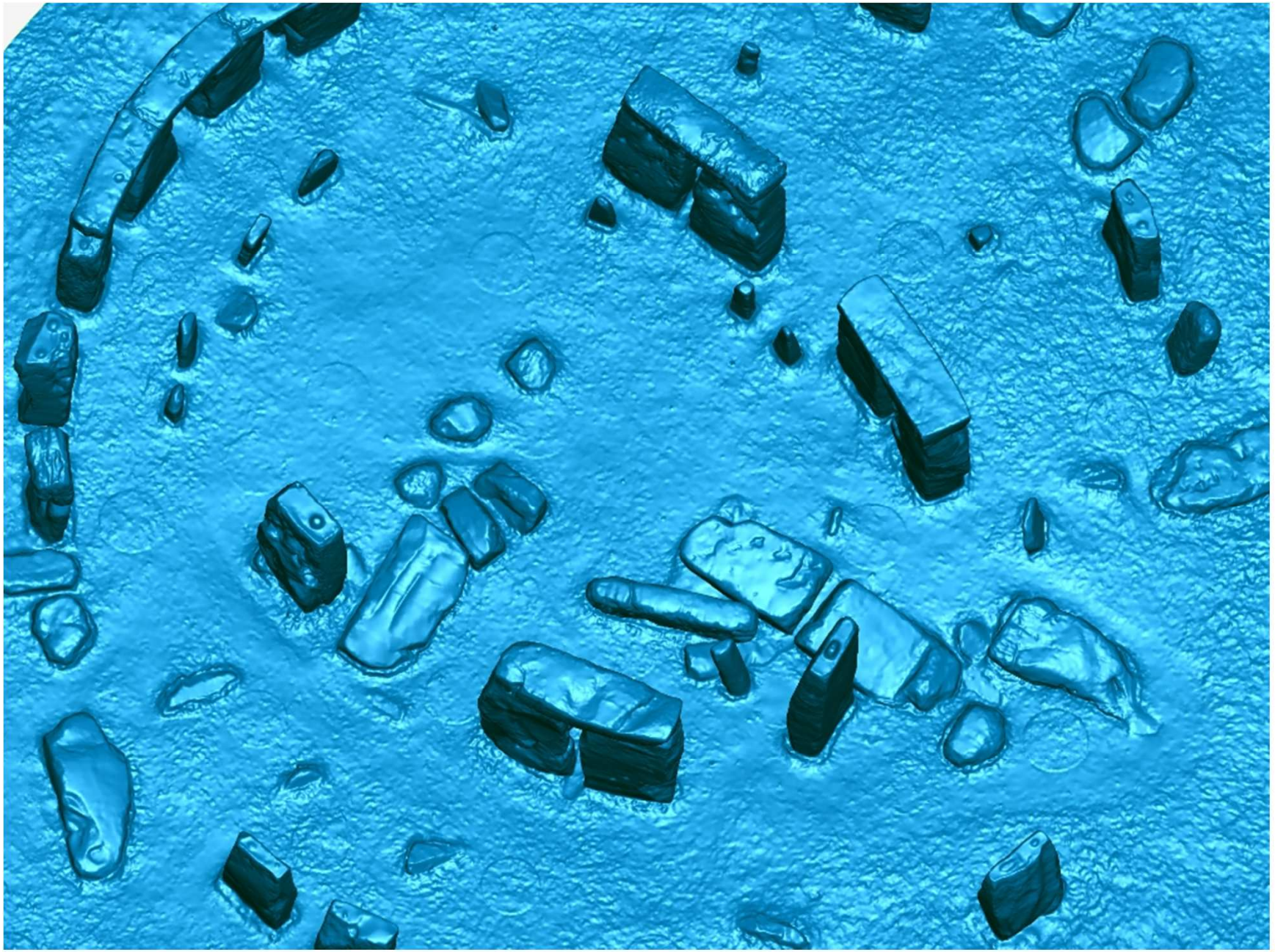
greenhatch group

An example of the completed colourised, meshed model for Stones 4, 5 & 105.

geomagic

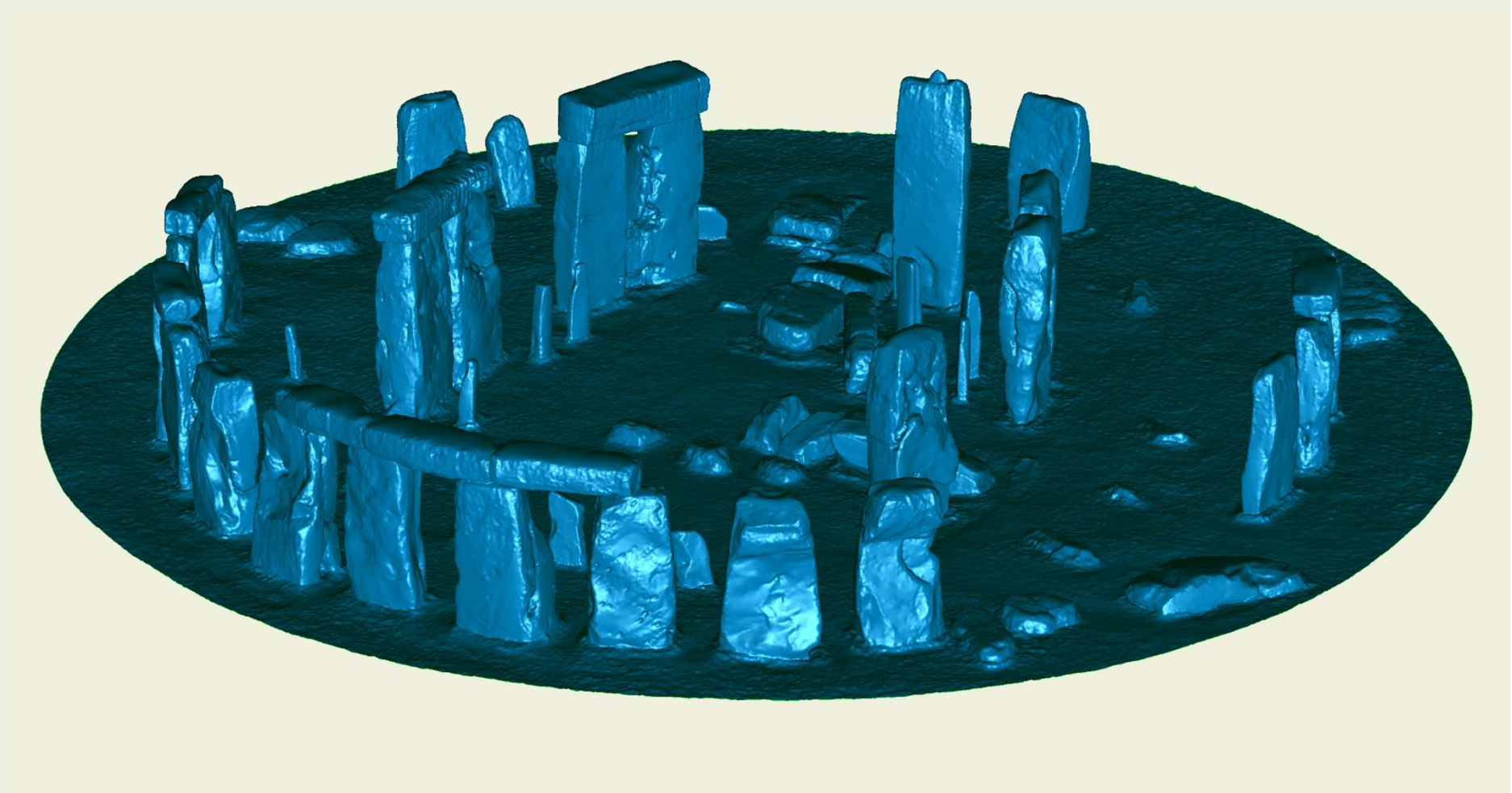
greenhatch group

An example highlighting the successful integration of laser scan and digital photogrammetry data, represented in full colour.



An example highlighting the surface detail evident to the upper stone faces.

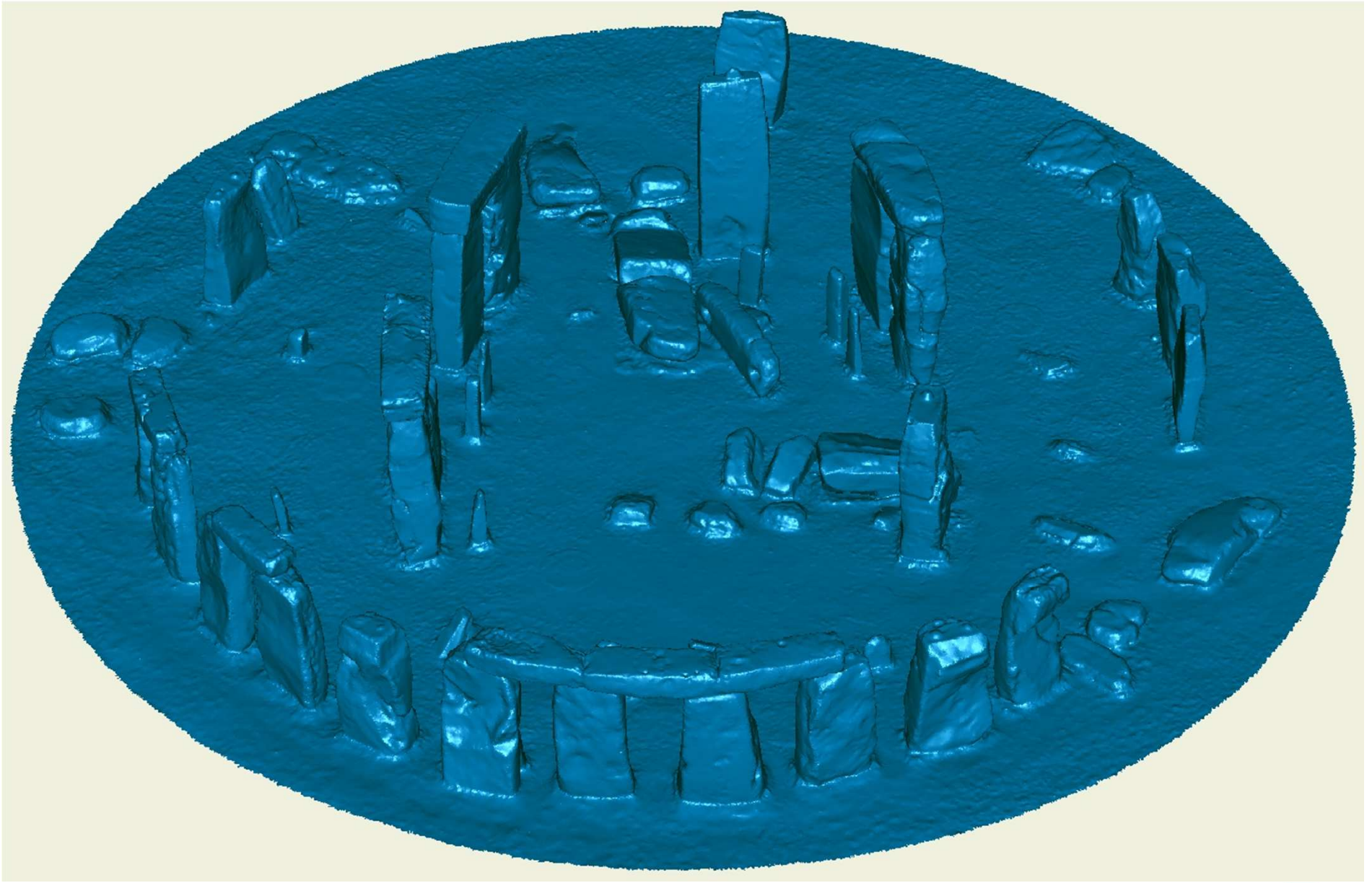
A meshed model representation of the entire Stone Circle.



- Decimation levels needed to be reduced to 10% of the actual data available to enable modelling.
- From the 3 Billion points initially captured, data was decimated to a final file size of 600 MB to allow visibility and regeneration of the final meshed model.

geomagic

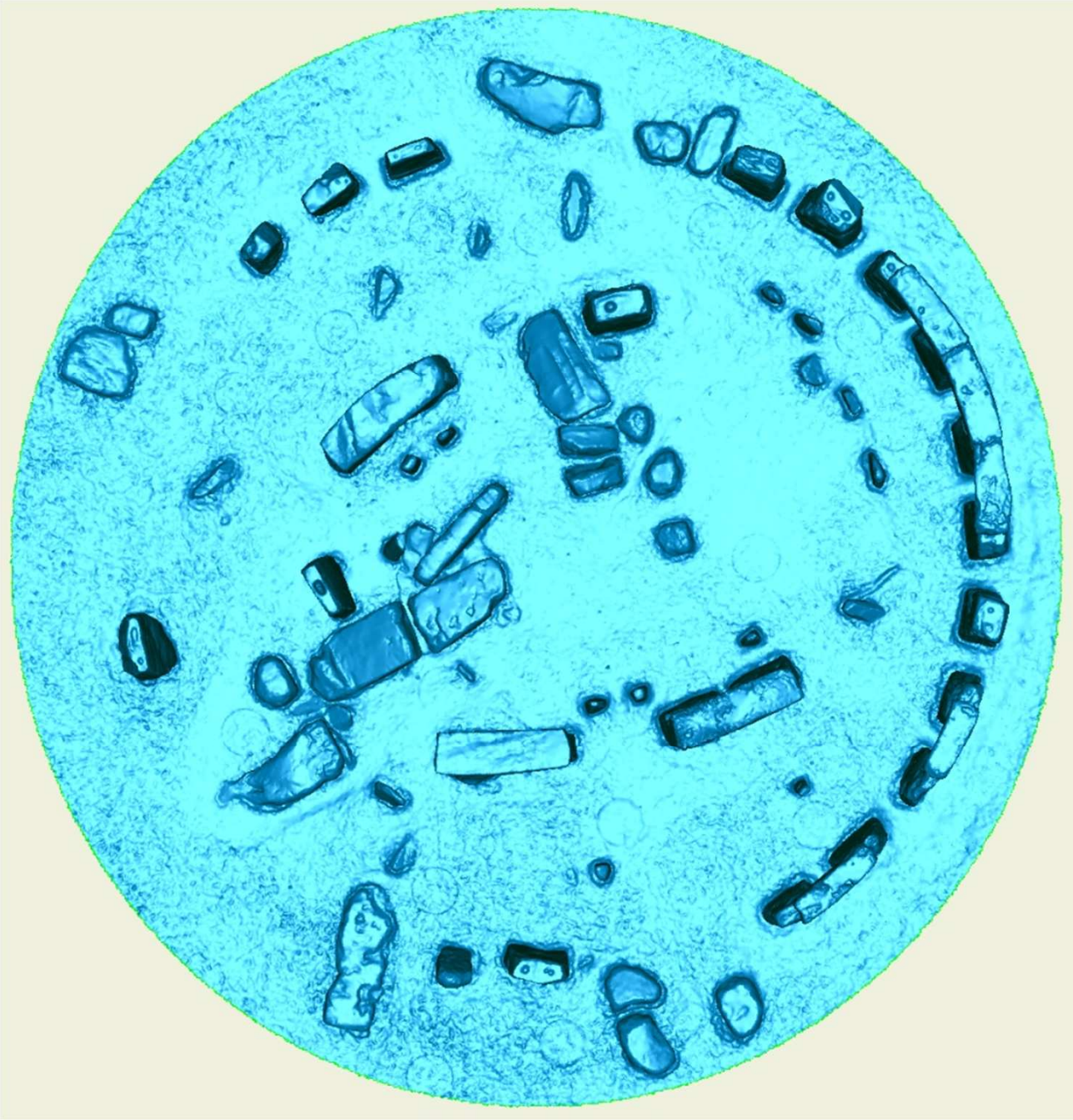
greenhatch group



geomagic

greenhatch group

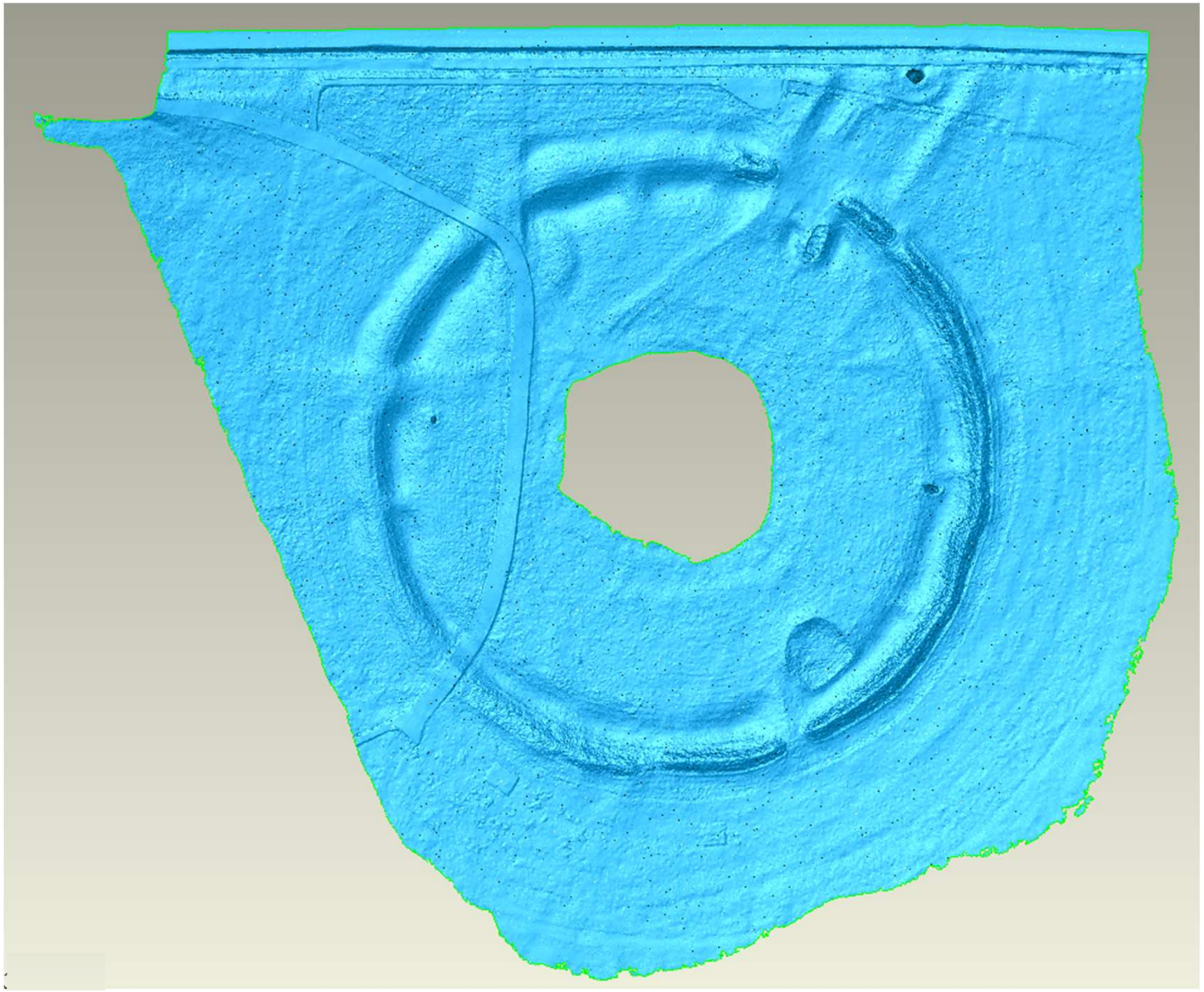
i. Stone Circle, 3D Laser Scan Meshed Model.



geomagic

greenhatch group

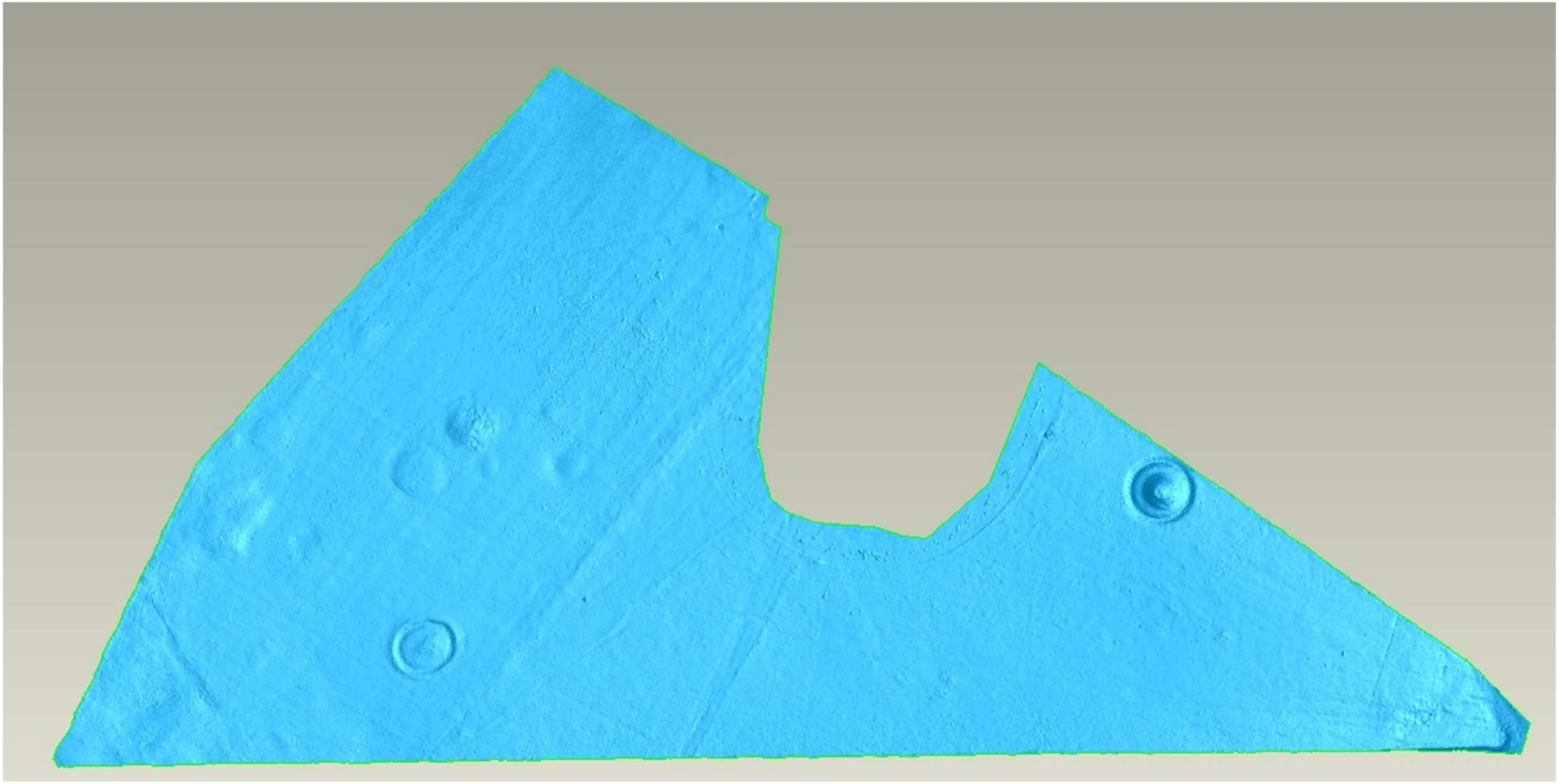
ii. Bank & Ditch, 3D Laser Scan Meshed Model.



geomagic

greenhatch group

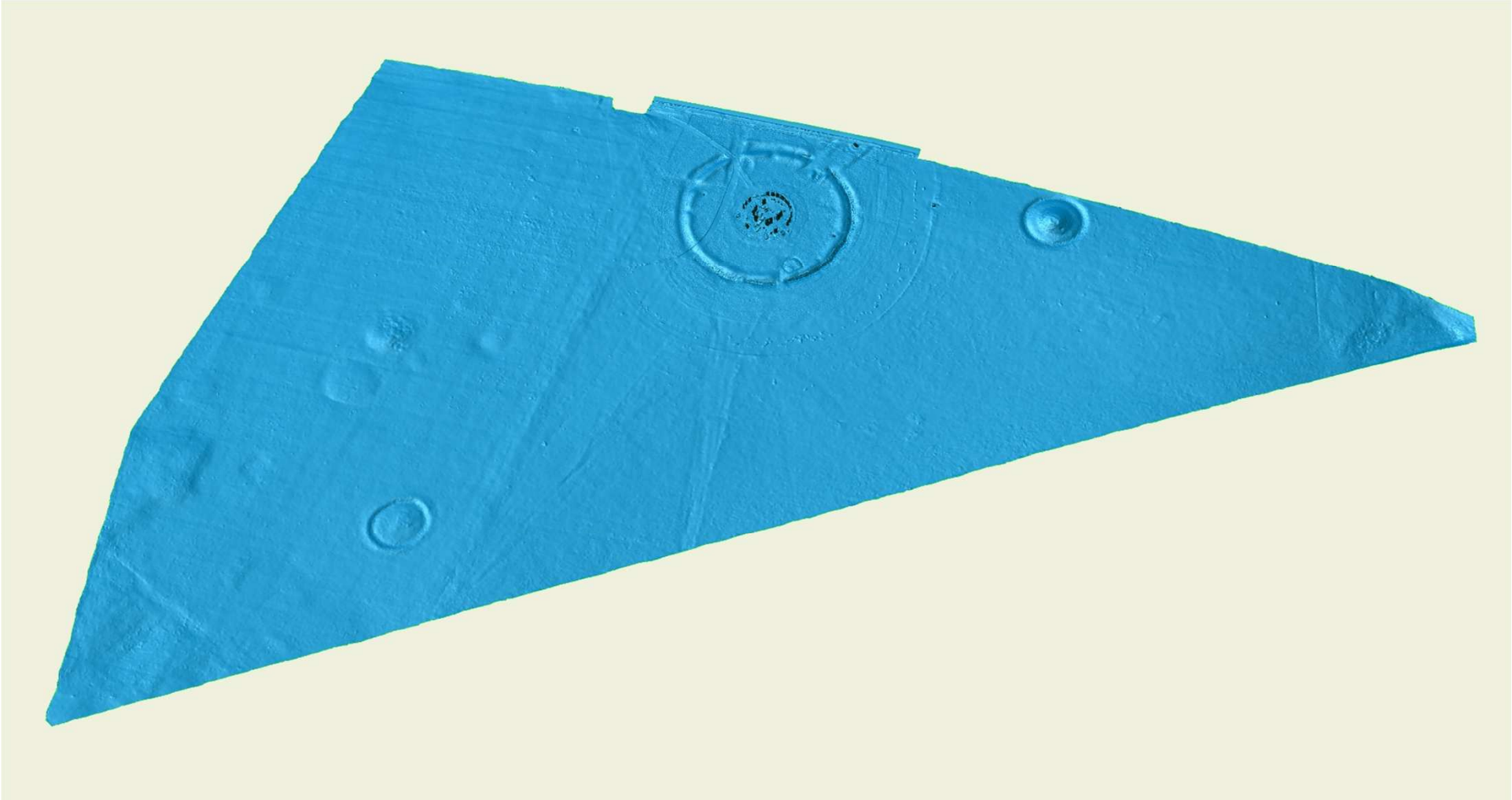
iii. Triangle Landscape, 3D Laser Scan Meshed Model.



geomagic

greenhatch group

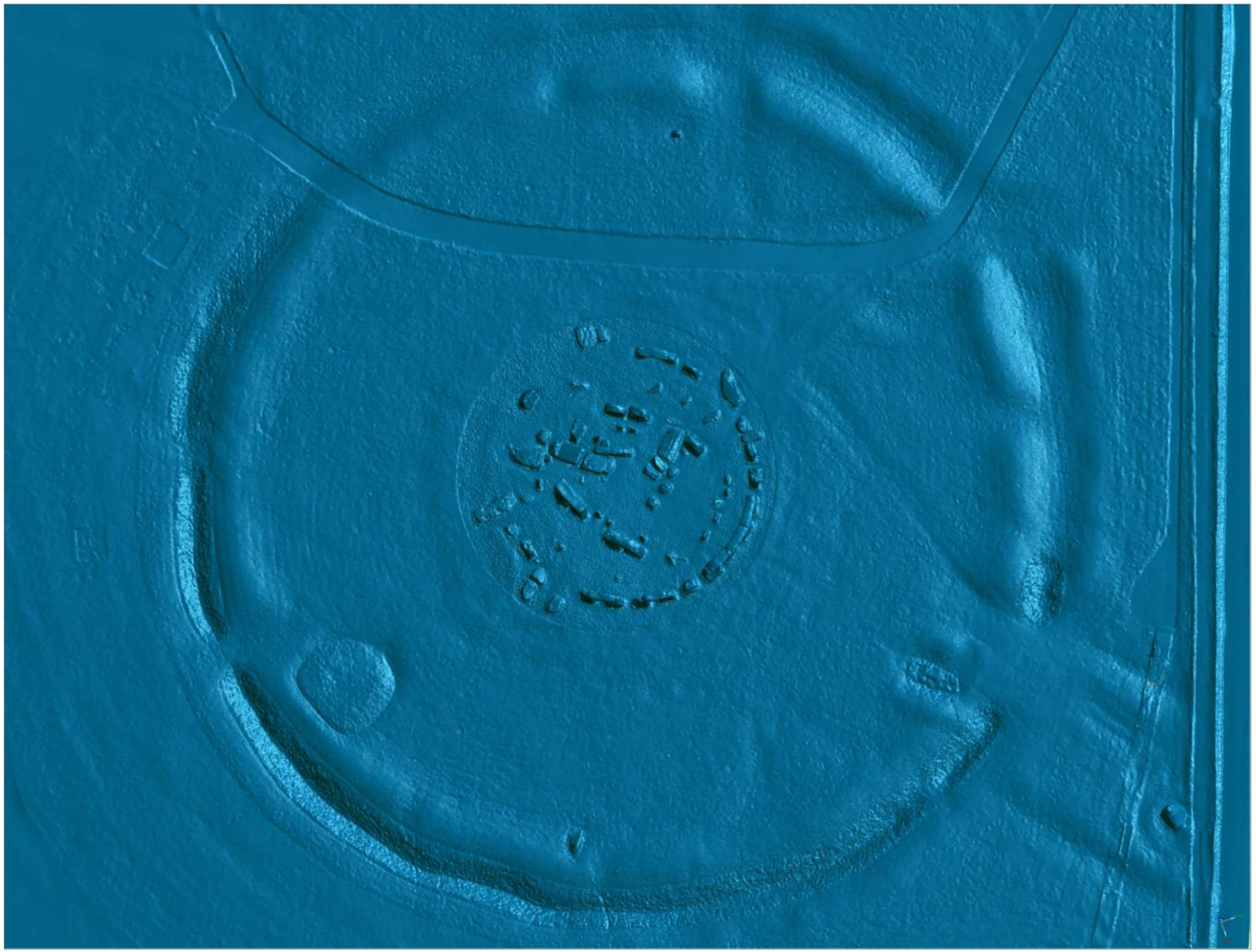
iv. Entire Stonehenge Site, 3D Laser Scan Meshed Model.



- Landscape Triangle, point density, decimation required: 50% of the data available.
- Bank & Ditch, point density, decimation required: 25% of the data available.
- Stone Circle, point density, decimation required: 10% of the data available.
- Total file size limited to 1.5 GB to aid visibility and regeneration of final model.

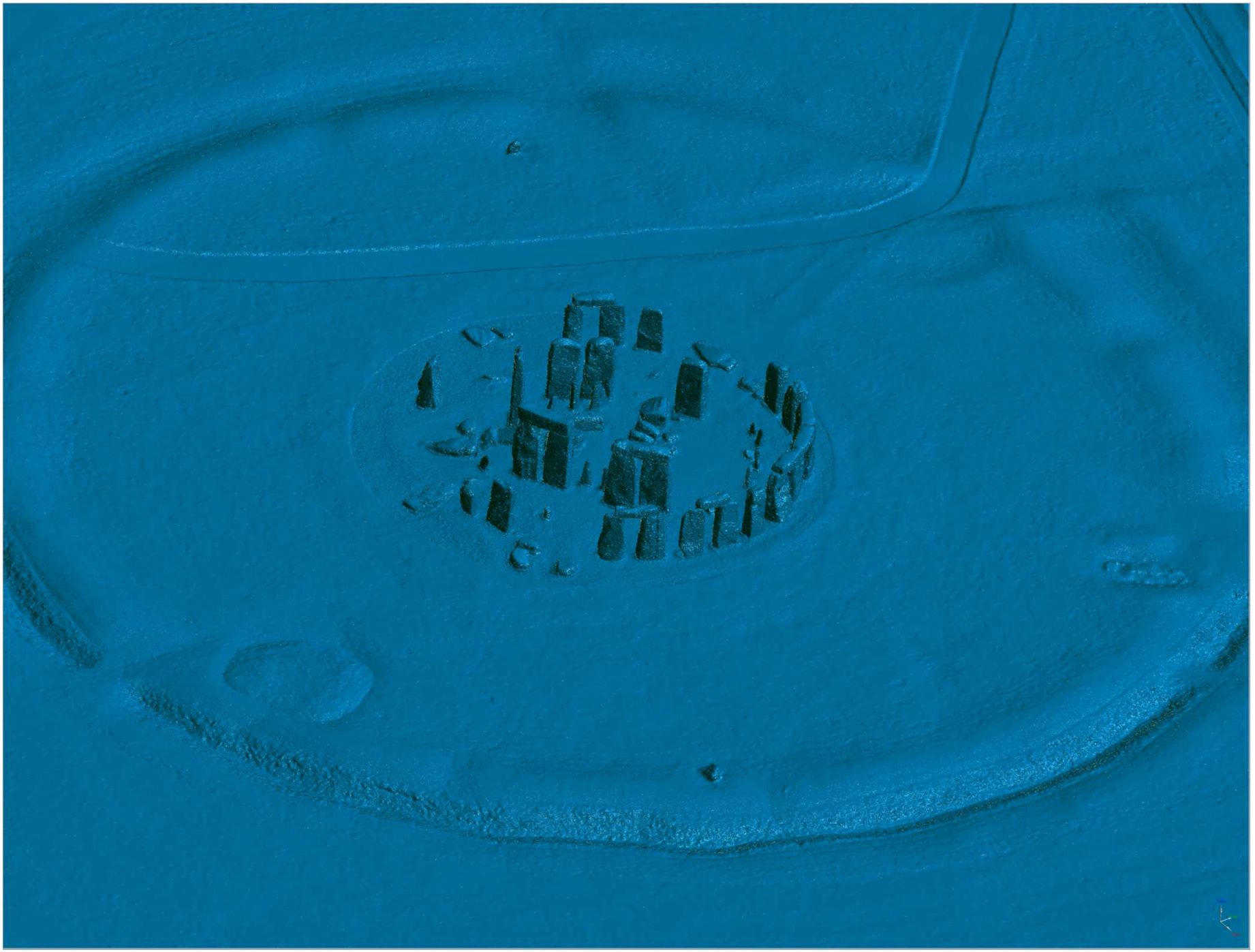
greenhatch group

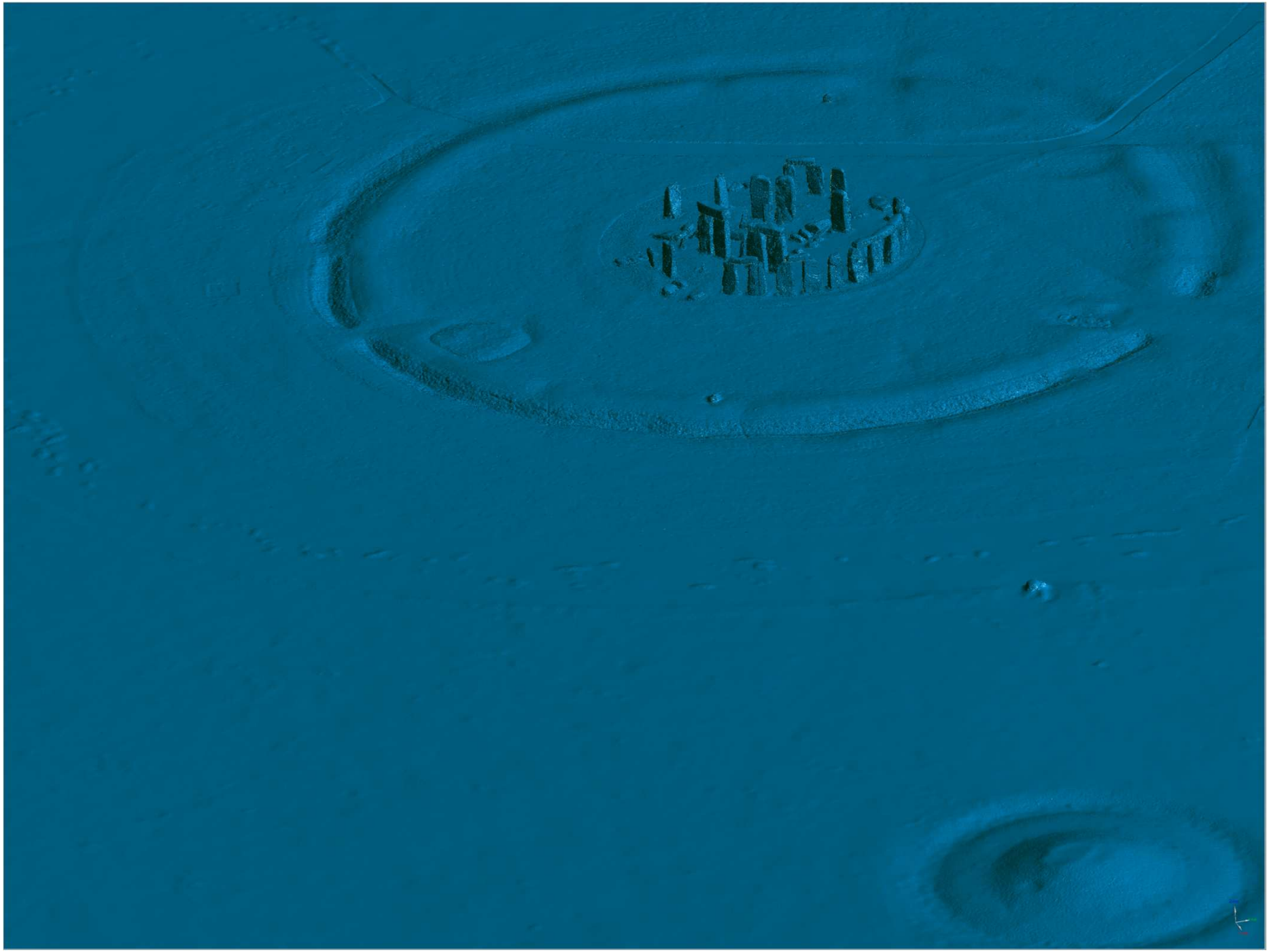
Example illustrations of Stonehenge Triangle Landscape, mesh model.

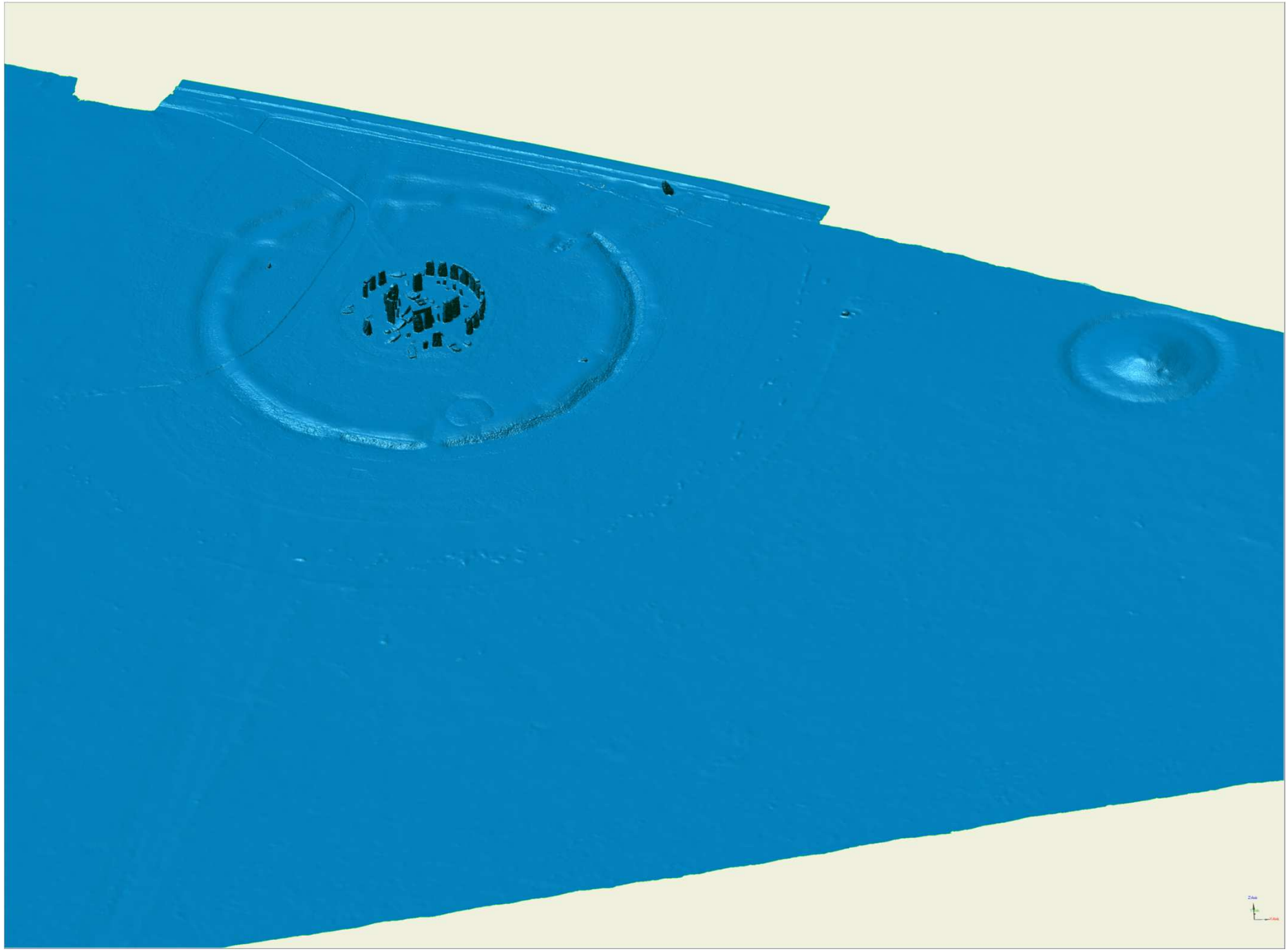


geomagic

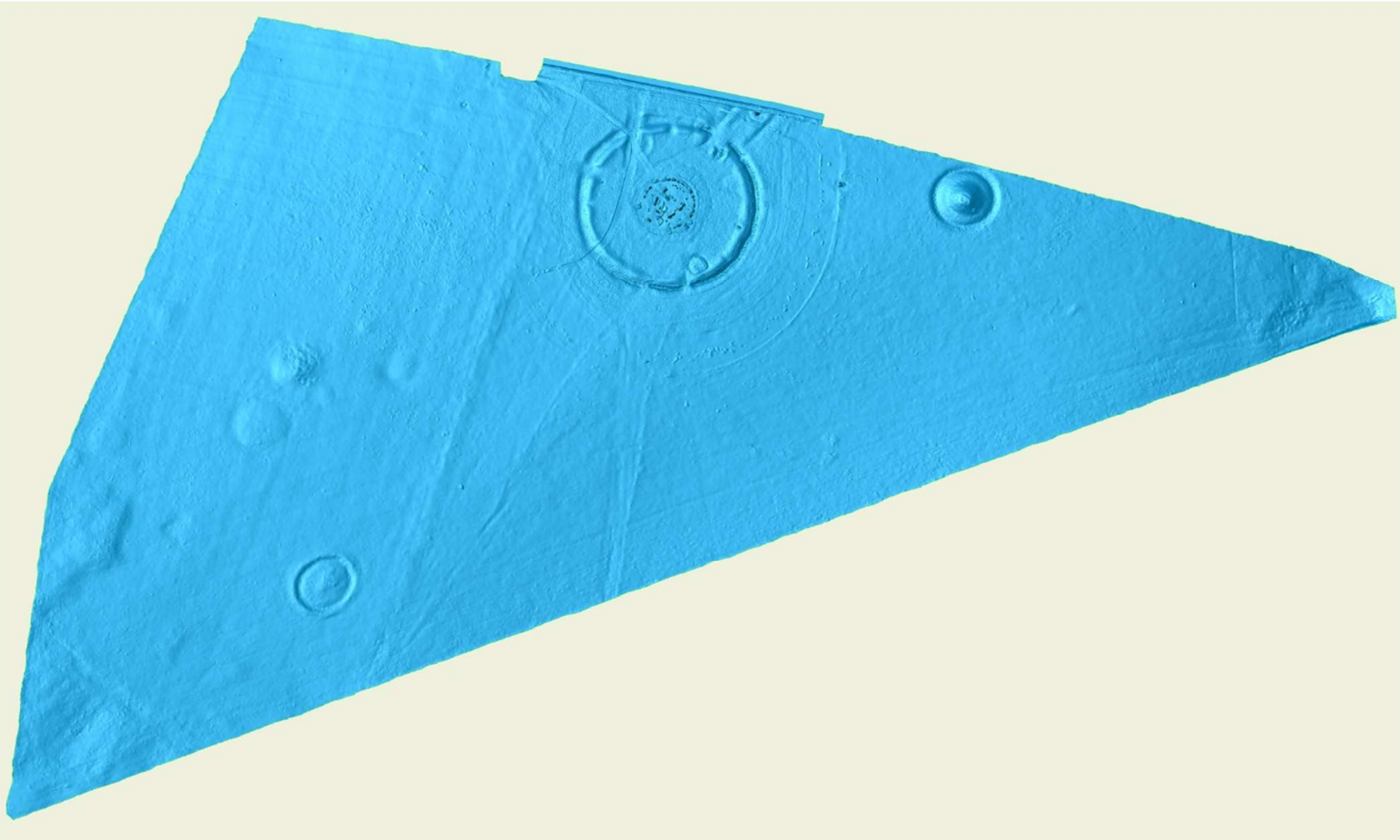
greenhatch group







Triangle Landscape, 3D Laser Scan Meshed Model.

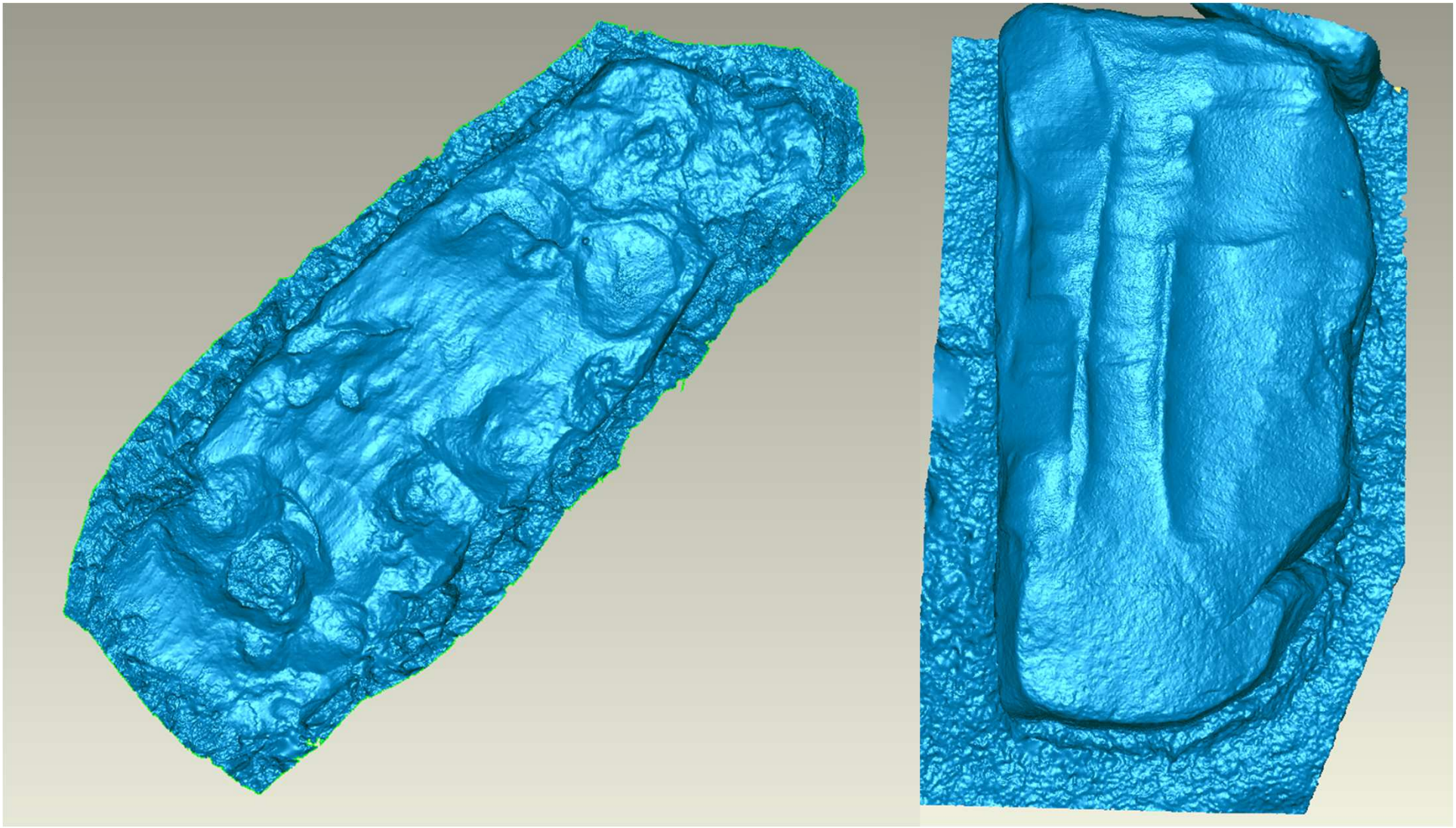


All meshed data files issued in varying levels of decimation from 0%>25%>50%>75%.

Total archival data set issued to English Heritage: In excess of 800 GB (1 Terabyte).

greenhatch group

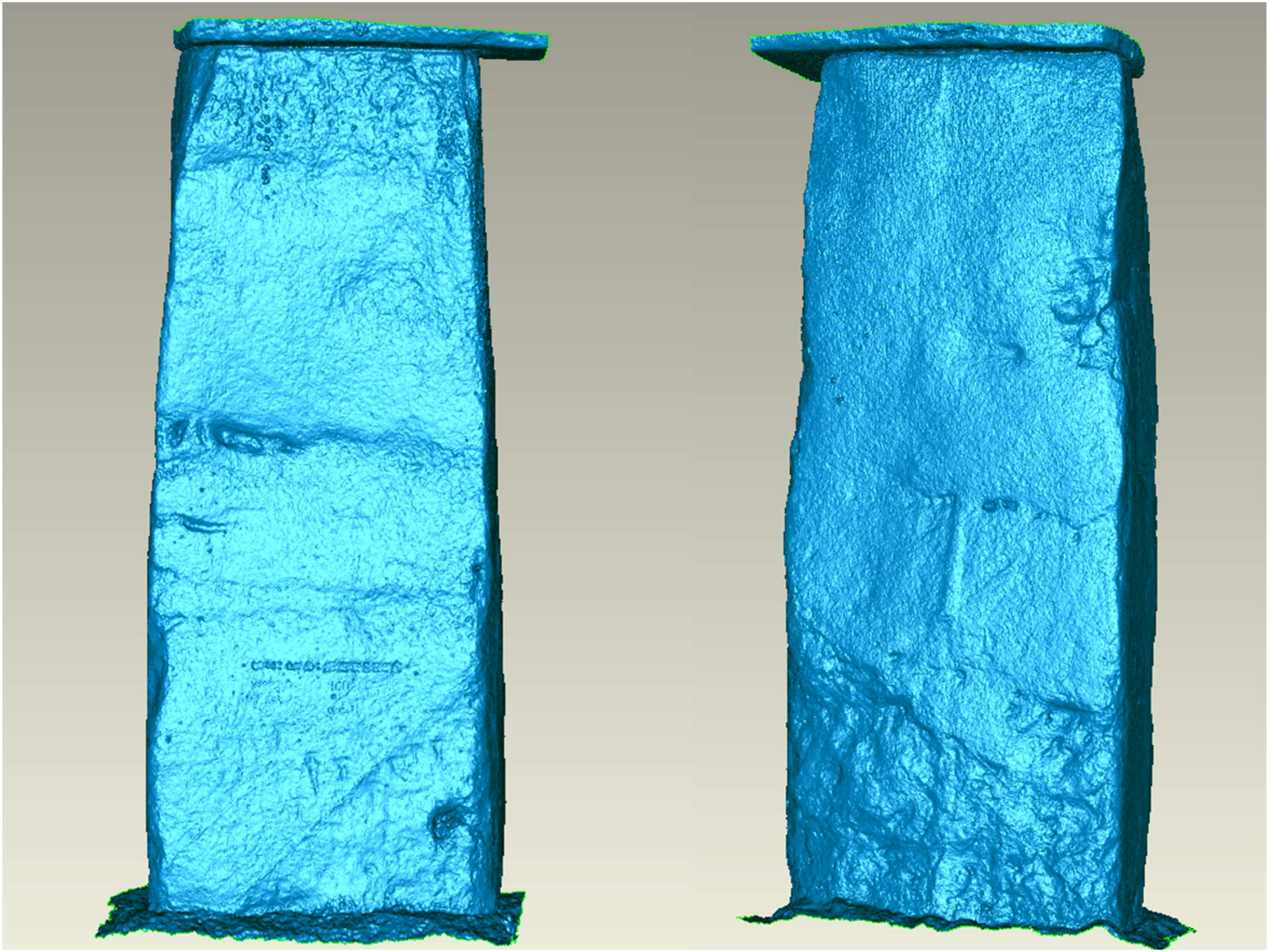
Examples of 1mm meshed models used for Archaeological Interpretation.

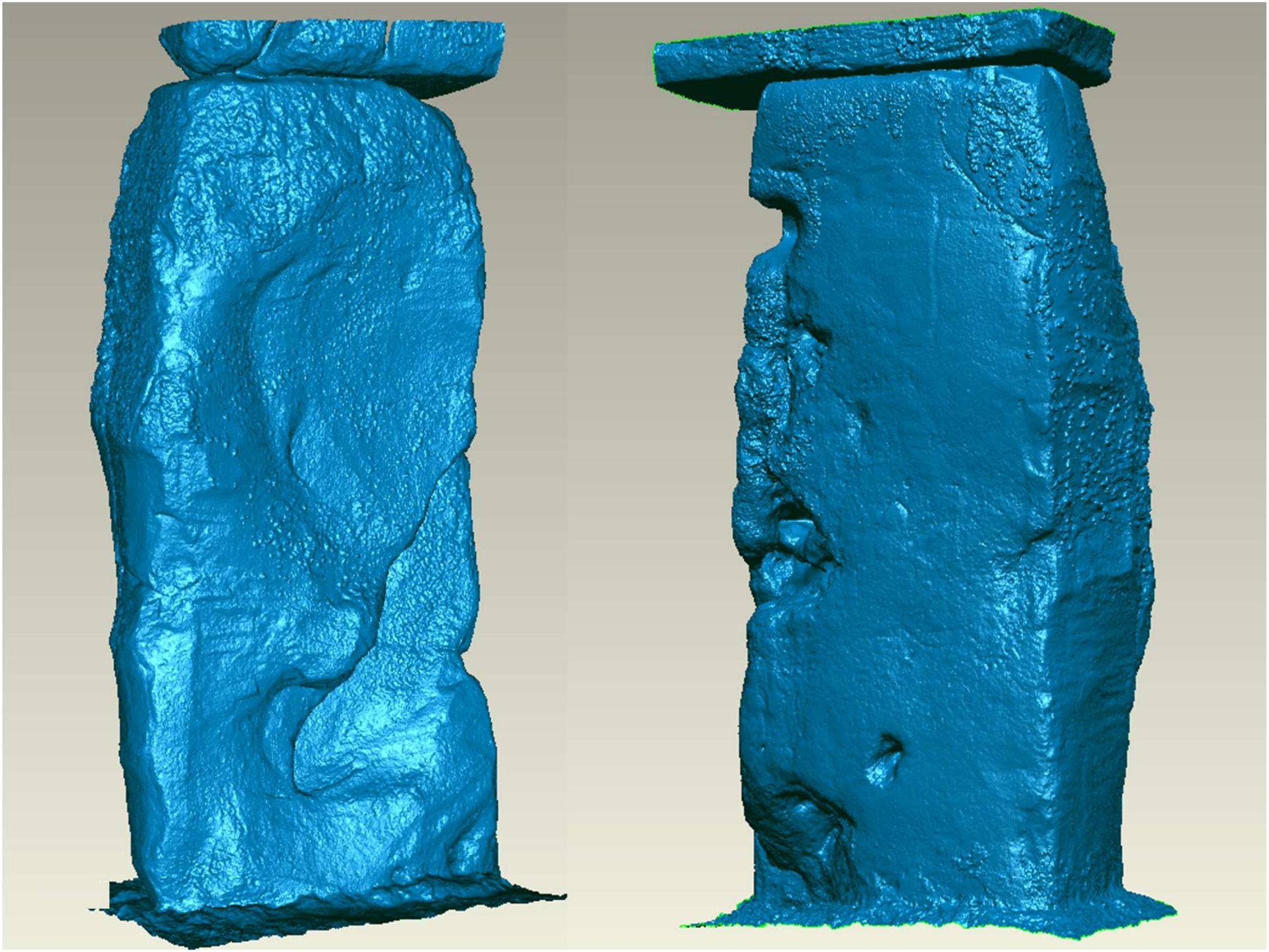


Whilst investigations into the graphiti evident within the stones are still on-going, the 1mm meshed models have helped to understand in more detail, the methodology and processes undertaken for the smoothing and surface preparation of the stones.

geomagic

greenhatch group





Example illustrations of Stonehenge Stone Circle, mesh model.

Summary:

- By utilising the very latest survey technology in conjunction with approved survey and point cloud registration techniques, data sets have been delivered to English Heritage that are of a very high quality with exceptional levels of inherent accuracy.
- Due to the in-depth site methodologies planned and taken place on site, the level of data coverage and point density achieved exceeds the requirements stipulated in the original brief by as much as 50%.
- The project has successfully provided a benchmark for the monuments current condition, allowing future management to monitor and analyse any changes over time. Survey data provided will also inform future interpretations providing accurate data for subsequent reconstruction drawings, plan, maps and 3D visualisations.
- The project will also further work towards the World Heritage Sites' management plan and research framework, by contributing towards the research of modelling the environment and analysing landscape change.

greenhatch group

Acknowledgements i:

Image provided by James Davies, English Heritage IGS.

English Heritage IGS: For support, guidance and provision of professional site photography.

The Leica Geosystems: For providing the free use of a TS30 Total Station for the entire project.
For providing the use of a C10 Laser Scanner and on site support.
For providing the use of additional software support during the project.

ENGLISH HERITAGE

greenhatch group

Acknowledgements ii:

Image provided by James Davies, English Heritage IGS.

Z+F UK Ltd: For enabling the use and hire of the only imager 5010 available in the U.K.
For providing the 5006i and M-cam solution, also used on the project.
For providing on site support.

Building on the success of the Stonehenge Project, the Greenhatch Group are also now proud to announce the purchase of the first Imager 5010 and M-Cam solution from Zoller + Frohlich for use within the Heritage sector.

greenhatch group

3D Laser Scan Survey of Stonehenge, Wiltshire.

Image provided by Paul Backhouse, English Heritage IGS.

Thank you for watching.

ENGLISH HERITAGE

greenhatch group