Historic England

The challenges encountered in using geospatial survey to digitally preserve the nations heritage

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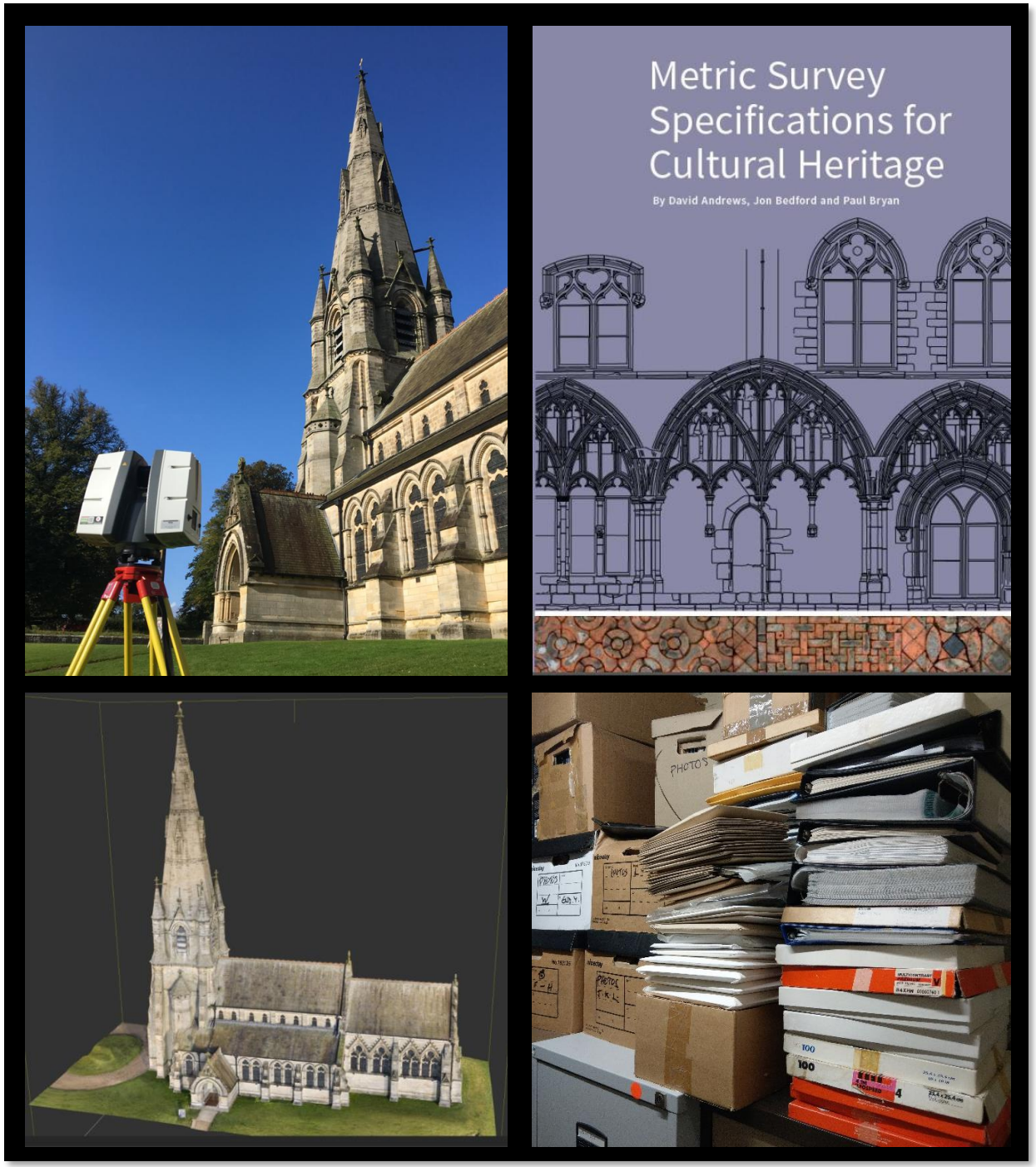

ARPAS-UK The UK Drone Association

GEO BUSINESS 2020 LONDON • UK 24 – 25 SEPT
• Exhibition
• Conference
• Seminars
• Workshops
• Networking

THE SURVEY ASSOCIATION AFFILIATE MEMBER

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Welcome

- On behalf of Historic England (HE) many thanks for registering and ‘virtually’ attending

- We would have met in our office in Tanner Row……..

- ……but thanks to Covid-19 (and Zoom) we’re now meeting online instead!

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Who am I?

- An FRICS chartered land surveyor with 40 years experience in surveying
- Studied surveying science and geography at the University of Newcastle upon Tyne from 1980-1982
- Worked in the commercial survey sector between 1982-1985 principally working in Iraq and Kuwait
- Joined English Heritage in 1985 as their field surveyor based in York
- Became Head of the EH Photogrammetric Unit in 1991 working principally in their London office
- Moved across to Historic England in 2015

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What do I do?

- I manage a team of five surveyors based in the York office that specialise in applying geospatial survey techniques to heritage
  - Jon Bedford
    Senior Geospatial Survey Analyst
  - David Andrews
    Geospatial Survey Analyst
  - Gary Young
    Geospatial Survey Analyst and lead drone pilot for team
  - Elizabeth Stephens
    *Geospatial Survey Technician Apprentice on 2 year apprenticeship with Historic England – **HE's first heritage apprentice** - and a qualified drone pilot*

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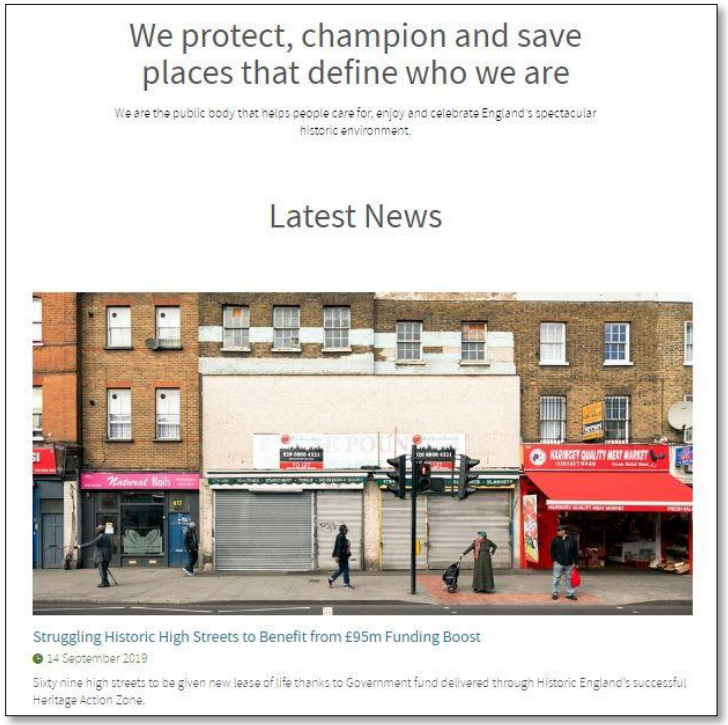
Who do I work for?

- I work for Historic England who are the public body that looks after England's historic environment

"*All aspects of the environment resulting from the interaction between people and places through time, including all surviving physical remains of past human activity, whether visible, buried or submerged and landscaped and planted or managed flora*"

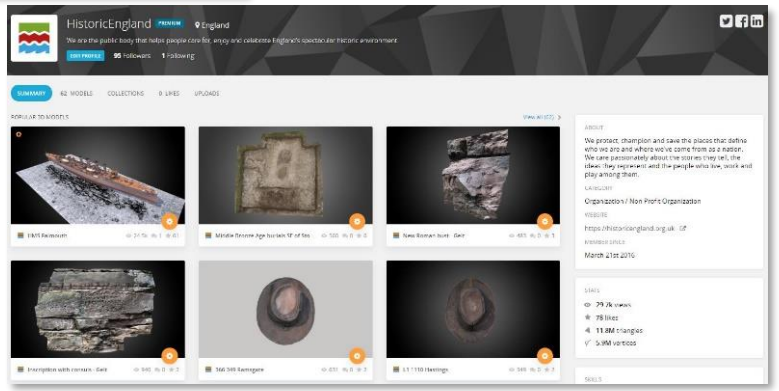
National Planning Framework, Dept. for Communities and Local Government, 2012



https://historicengland.org.uk

- We protect, champion and save places that define who we are

https://Sketchfab.com/HistoricEngland



- See our web and & Sketchfab sites

Historic England

What do we do?

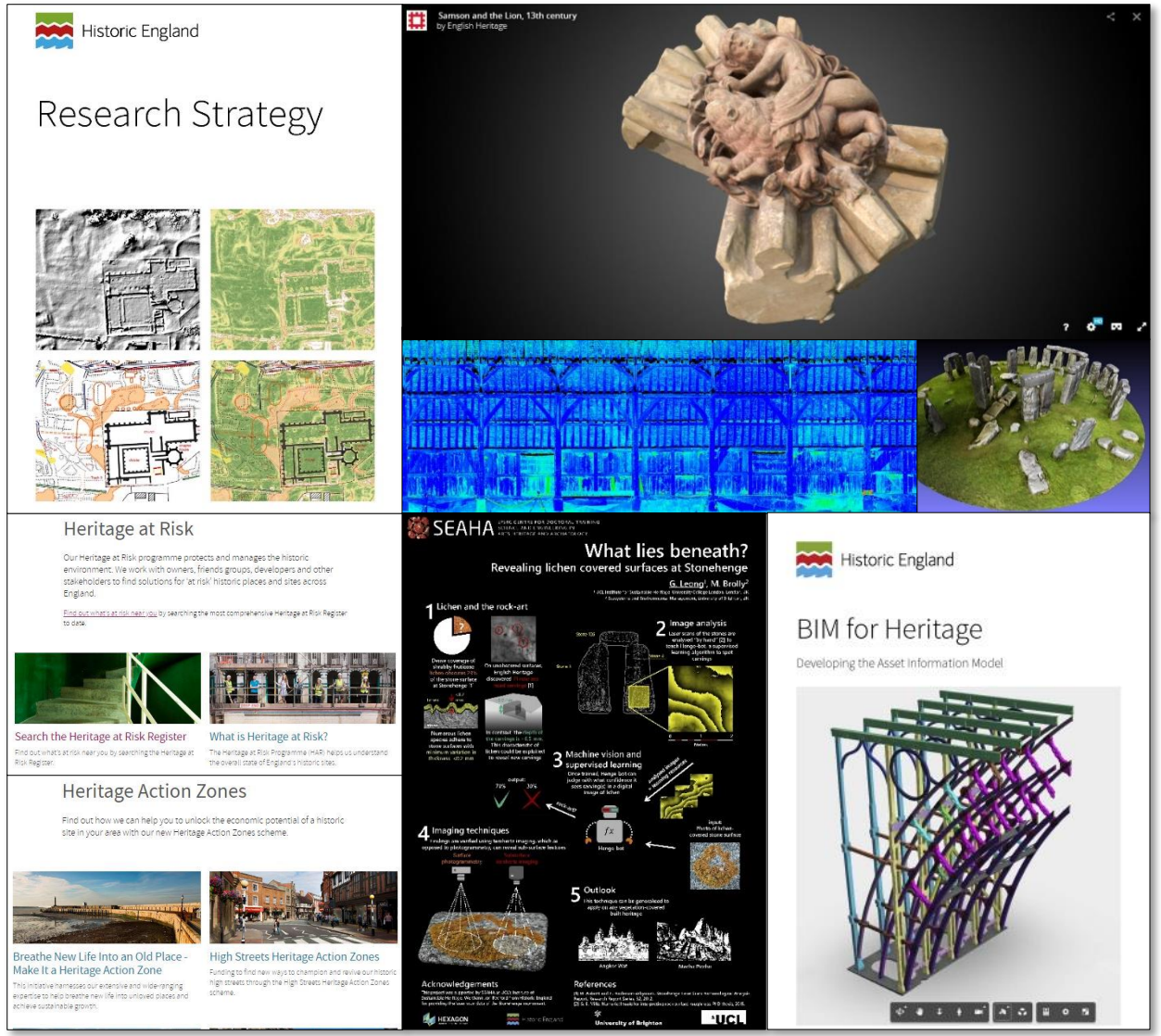
We advise on and undertake surveys for

- Historic England research projects
- Heritage at Risk (HAR)
- Heritage Action Zones (HAZ)

- English Heritage projects

- We undertake collaborative research with academic partners

- We produce technical guidance related to geospatial survey techniques



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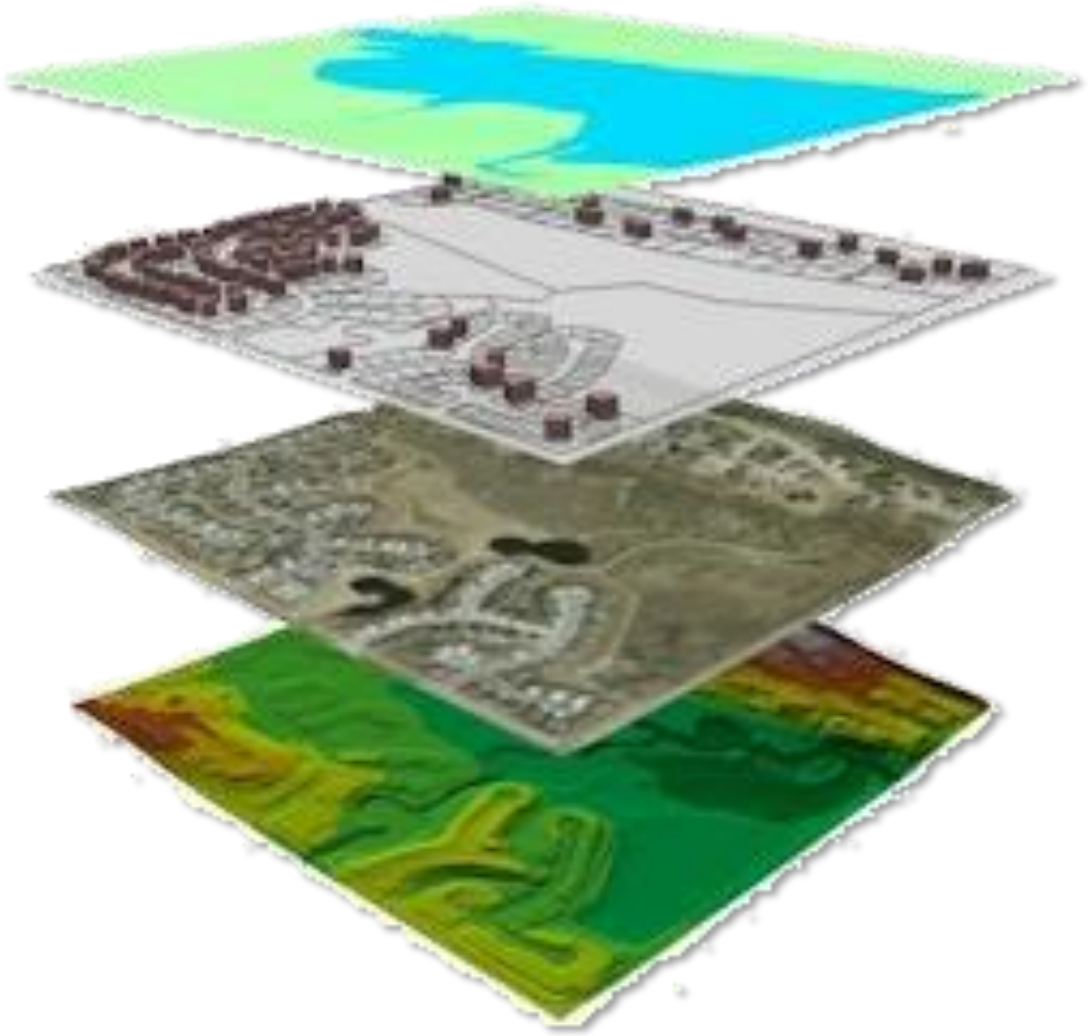
What are the challenges encountered in using ***geospatial survey*** to digitally preserve the nations heritage?

Geospatial Data

"*the availability of information relevant to* ***location***"



Geospatial Survey

"*The* ***technologies*** *used to extract geospatial information from remotely sensed imagery and other raster data types*"

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Challenge 1

Wide variety of geospatial survey technologies now available to heritage – *which should I choose?*

Direct techniques

- active

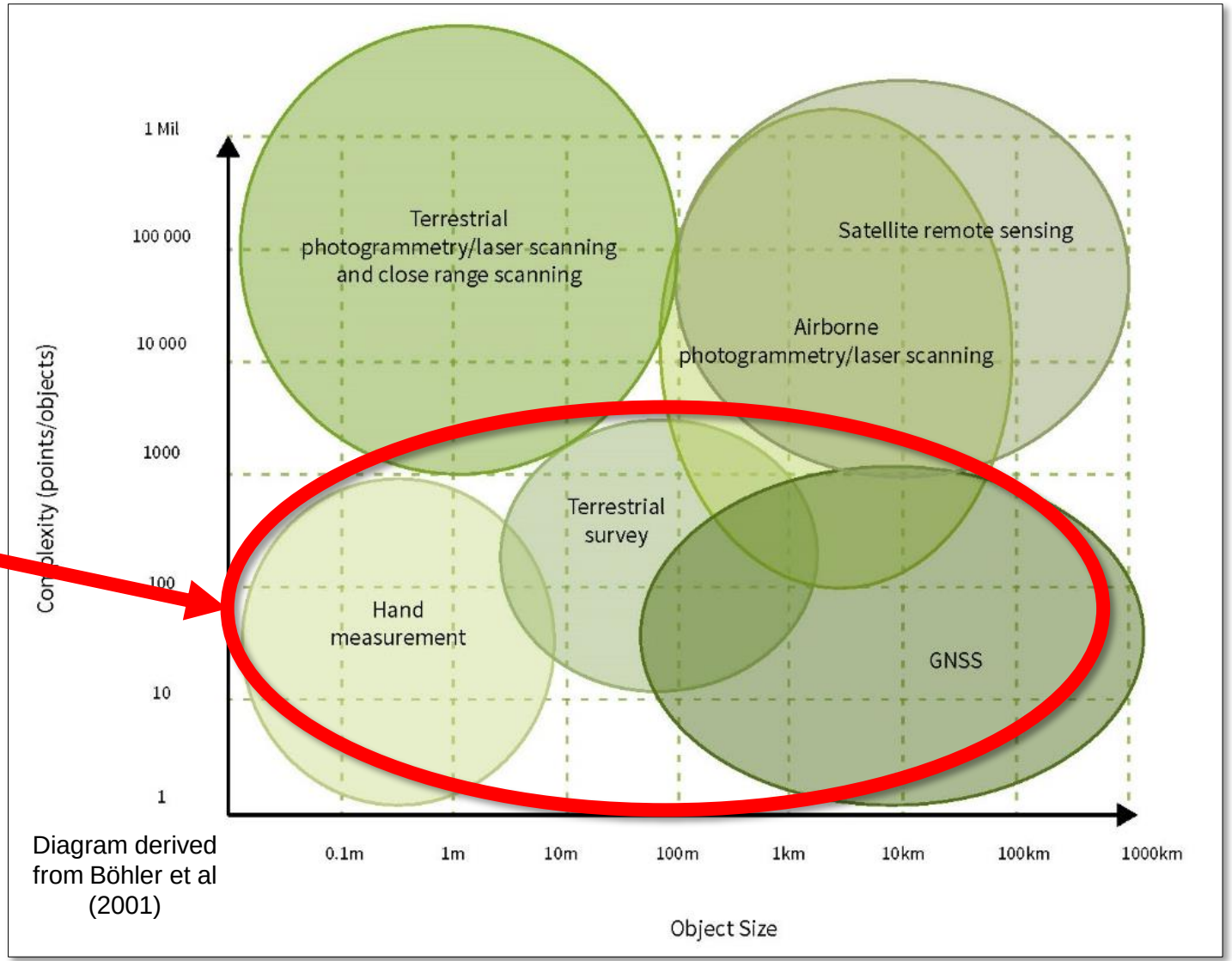

Diagram derived from Böhler et al (2001)

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Challenge 1

Wide variety of geospatial survey technologies now available to heritage – *which should I choose?*

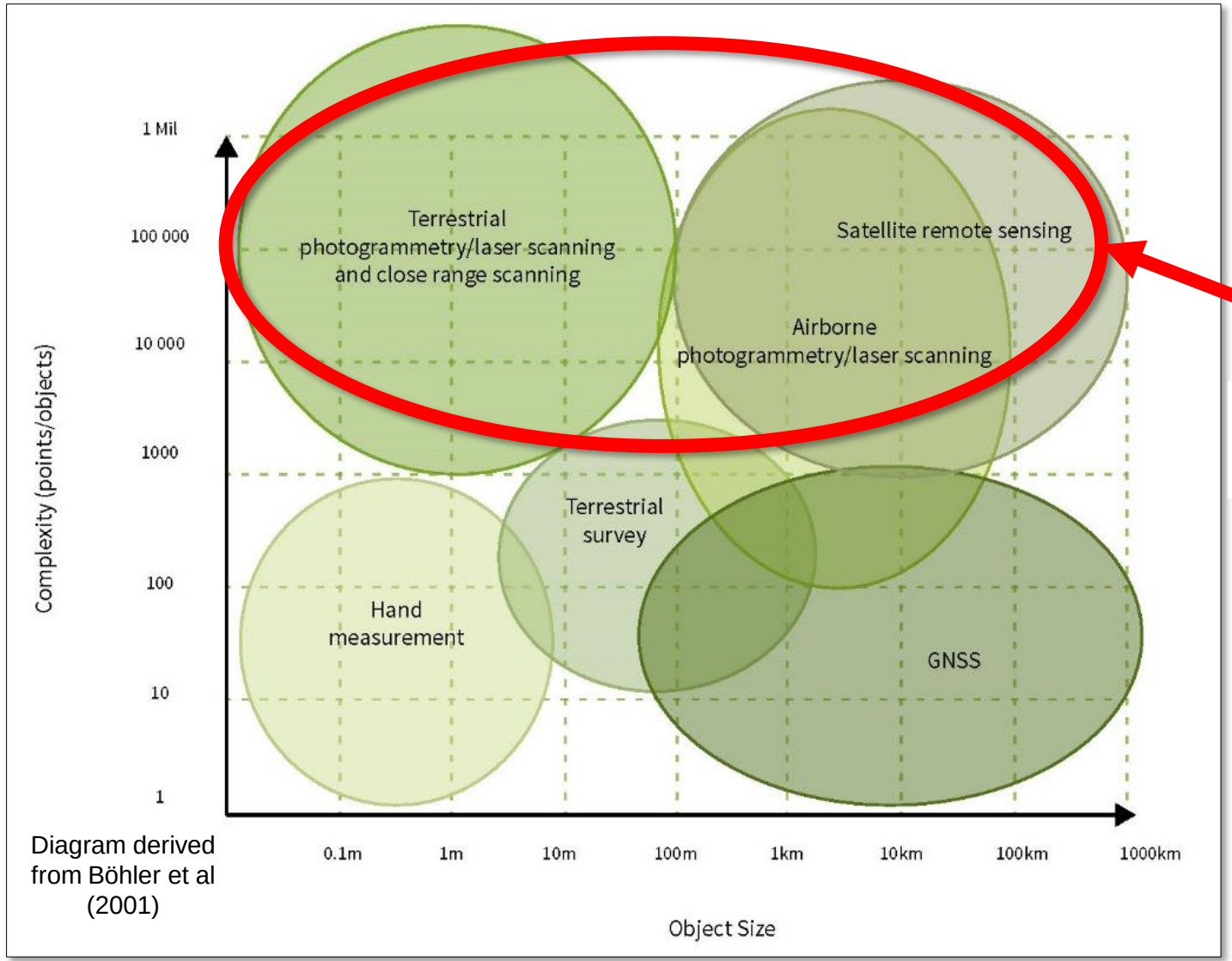

Diagram derived from Böhler et al (2001)

Indirect techniques - passive

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1. Wide variety of geospatial survey technologies now available to heritage

Photogrammetry

"The art, science and technology of determining size, shape and identification of objects by analysing terrestrial or aerial imagery"

Boardman 2016

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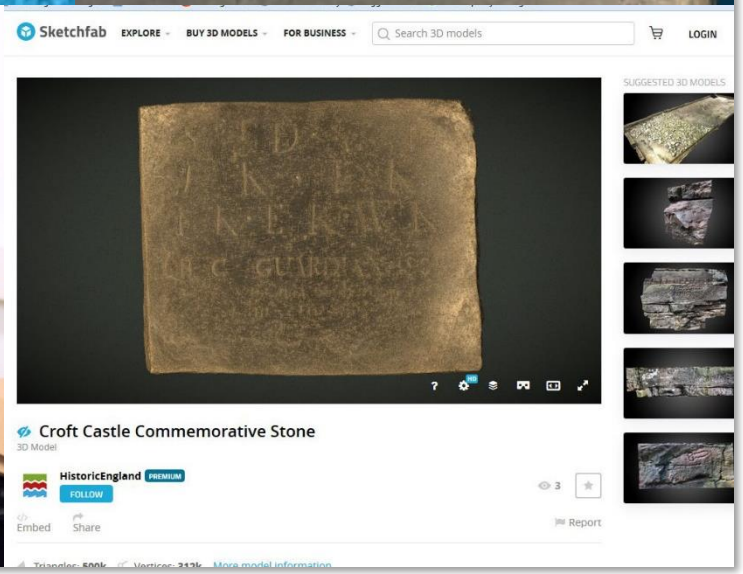
1. Wide variety of geospatial survey technologies now available to heritage

Photogrammetry

Advantages

- Applicable on all 2D and 3D surfaces
- Multi-image photography provides excellent archival record
- Modern approaches use ‘off-the-shelf’ cameras
- Can generate high-resolution 3D ‘point clouds’
- Structure from Motion (SfM) is low cost helping to make photogrammetry fashionable again



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1. Wide variety of geospatial survey technologies now available to heritage

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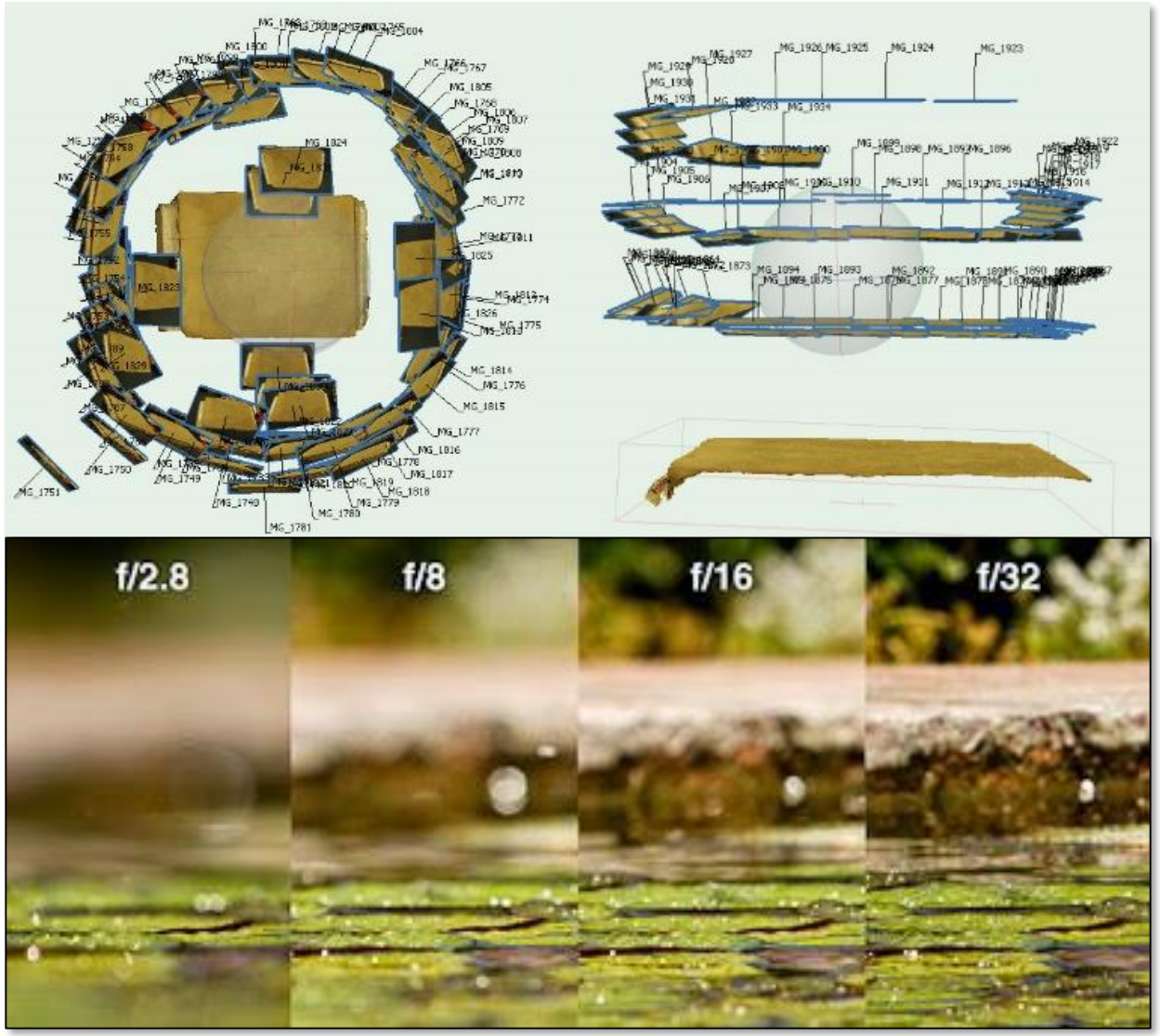
- Structure from Motion (SfM) is low cost helping to make photogrammetry fashionable again

Disadvantages

- Needs multi-overlap photography creating large image sets
- Pixel correlation requires good visible texture within imagery – not suited to plain, reflective or translucent surfaces
- Accurate data relies on suitable image arrangements & control networks – cannot rely on just the cameras GPS
- Black-box SfM software simplifies the photogrammetric processing - but ***Rubbish in = Rubbish out!***



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1. Wide variety of geospatial survey technologies now available to heritage

3D Laser Scanning

"Laser scanning is an active, fast and automatic acquisition technique using laser light for measuring, without any contact, and in a dense regular pattern, 3D coordinates of points on surfaces"

Grussenmeyer 2016

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1. Wide variety of geospatial survey technologies now available to heritage

3D Laser Scanning

Advantages

- Applicable on all 2D and 3D surfaces
- Extremely fast – over 1,000,000 pts per second
- Generates high resolution 3D point data '*in the field*'
- Mobile scanning solutions allow data capture '*on the move*'
- Modern scanners integrate 3D point data with imagery from other on-board sensors - RGB, 360° & thermal

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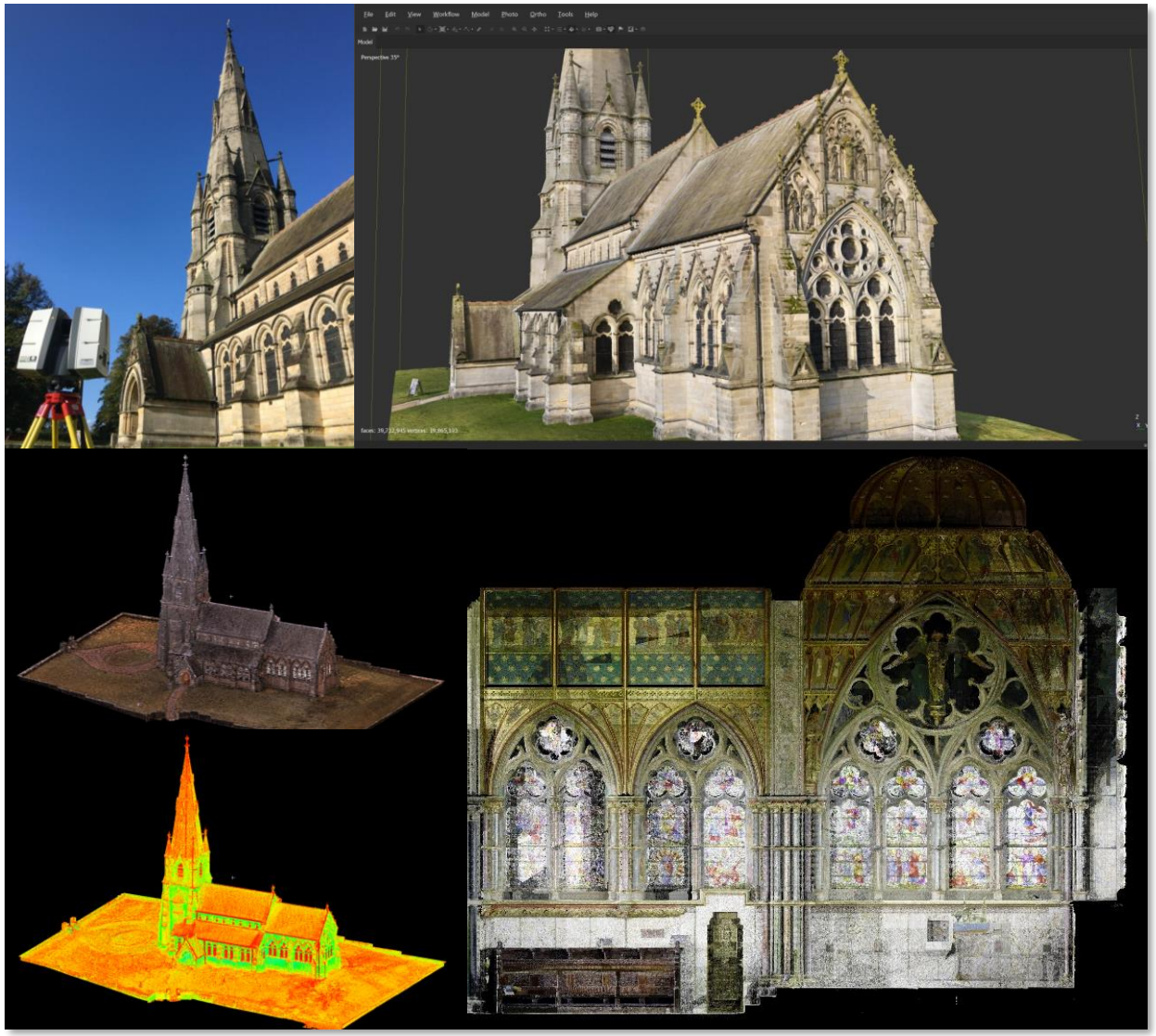
- Modern scanners integrate 3D point data with imagery from other on-board sensors - RGB, 360° & thermal

Disadvantages

- Generates extremely large data files often difficult to view without high-end computers and specialist viewing software
- Laser scanners are expensive - between £25K - £90K
- Sophisticated post-processing software needed to generate useable output
- Line drawings require manual digitisation – automated feature extraction still not working satisfactorily for heritage



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Challenge 2.

Applying geospatial survey technologies appropriately – *how do I ensure 'fit for purpose' data is generated*?

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2. Applying geospatial survey technologies appropriately

Use a specification

- Can be method or performance based
  - Performance based preferred to enable non-proprietary solutions to be considered and prevent commercial bias
  - Aids understanding of techniques
  - Helps manage client expectations
  - Drives development of techniques
  - Focuses on what a client actually needs….and not what's easiest for the contractor to supply
  - Aids accountability

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2. Applying geospatial survey technologies appropriately

Use a specification

- Can be method or performance based
- Considers the tolerances of the required datasets

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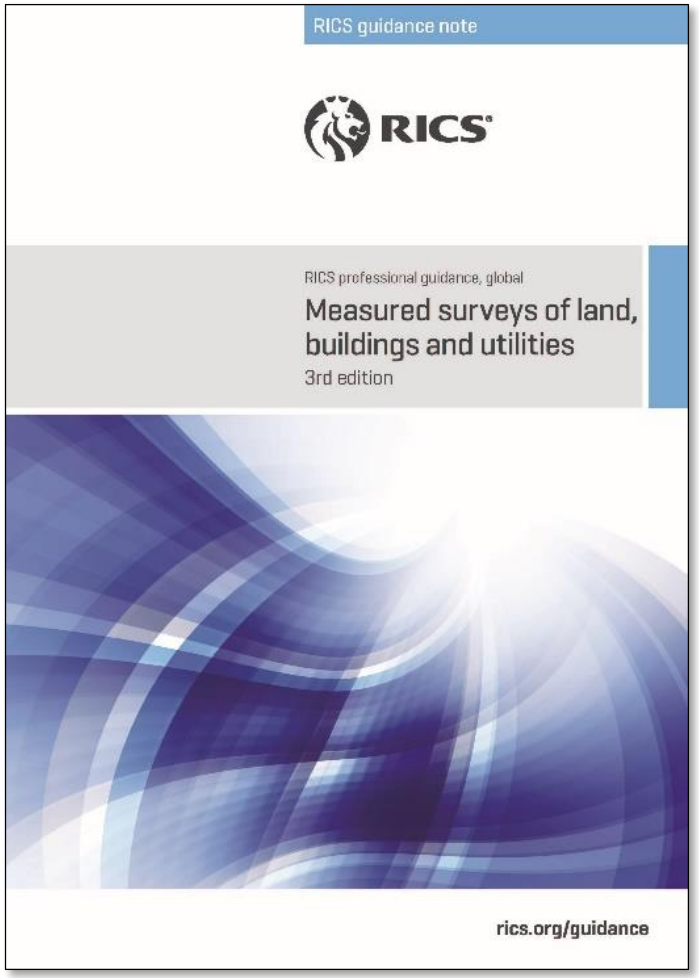
2. Applying geospatial survey technologies appropriately

Use a specification

- Can be method or performance based

- Considers the tolerances of the required datasets
  - RICS ‘Measured surveys of land, buildings and utilities’ 2014 3rd edition
  - Designed for use by land, engineering and measured building surveyors



http://www.rics.org/uk/knowledge/professional-guidance/guidance-notes/measured-surveys-of-land-buildings-and-utilities-3rd-edition/

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2. Applying geospatial survey technologies appropriately

Use a specification

- Can be method or performance based

- Considers the tolerances of the required datasets
  - RICS ‘Measured surveys of land, buildings and utilities’ 2014 3rd edition
  - Designed for use by land, engineering and measured building surveyors
  - Uses survey accuracy band that considers scale which dictates accuracy, resolution and detail

1:20

1:50

Survey detail accuracy band table

Plan accuracy (X,Y)			Height accuracy (Z)[1]					
Band	1 sigma	2 sigma	Band	Accuracy hard detail	Accuracy soft detail	Example survey types/uses[2]	Approximate legacy plot scale output required to achieve accuracy band[3]	Min size of feature shown true to scale (not symbolised)
A	+/- 2mm	+/- 4mm	A	+/- 2mm	N/A	Monitoring, high accuracy engineering setting out and fabrication surveys	1:5	4mm
B	+/- 4mm	+/- 8mm	B	+/- 4mm	N/A	Monitoring, high accuracy engineering and measured building surveys and setting out	1:10	5mm
C	+/- 5mm	+/- 10mm	C	+/- 5mm	N/A	Engineering surveying and setting out, high accuracy measured building surveying, heritage recording	1:20	10mm
D	+/- 10mm	+/- 20mm	D	+/- 10mm	+/- 25mm	Engineering surveying and setting out, measured building surveys, high accuracy topographic surveys, determined boundaries, area registration	1:50	20mm
E	+/- 25mm	+/- 50mm	E	+/- 10mm	+/- 50mm	Measured building surveys, topographic surveys, low accuracy setting out, net area	1:100	50mm

Plan accuracy (X,Y)			Height accuracy (Z)[1]					
Band	1 sigma	2 sigma	Band	Accuracy hard detail	Accuracy soft detail	Example survey types/uses[2]	Approximate legacy plot scale output required to achieve accuracy band[3]	Min size of feature shown true to scale (not symbolised)
C	+/- 5mm	+/- 10mm	C	+/- 5mm	N/A	Engineering surveying and setting out, high accuracy measured building surveying, heritage recording	1:20	10mm
D	+/- 10mm	+/- 20mm	D	+/- 10mm	+/- 25mm	Engineering surveying and setting out, measured building surveys, high accuracy topographic surveys, determined boundaries, area registration	1:50	20mm

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2. Applying geospatial survey technologies appropriately

Use a specification

- Can be method or performance based
- Considers the tolerances of the required datasets
- What products are required?

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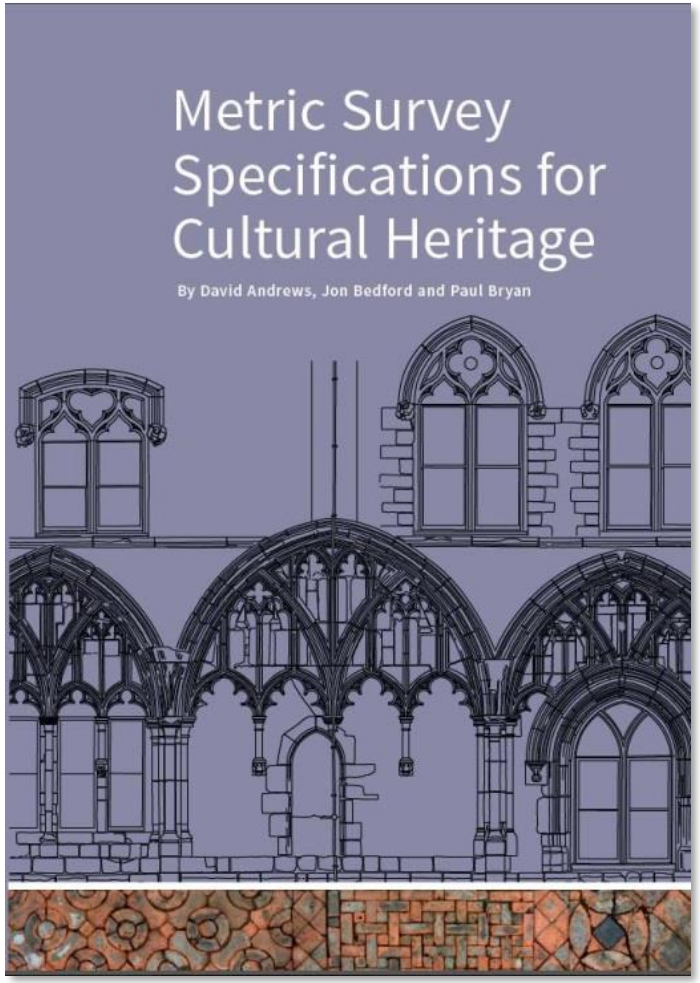
2. Applying geospatial survey technologies appropriately

Use a specification

- Can be method or performance based
- Considers the tolerances of the required datasets
- What products are required?
  - Historic England ‘Metric Survey Specifications for Cultural Heritage’, 2015, 3rd edition
  - Designed for heritage professionals who need to specify metric survey work and survey contractors who need to work to a heritage based specification
  - Includes sections on the format, presentation and provision of survey data generated as
    - Line drawings
    - Orthophotos
    - 3D models
    - Building Information Modelling (BIM) data



https://historicengland.org.uk/images-books/publications/metric-survey-specifications-cultural-heritage/

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2. Applying geospatial survey technologies appropriately

Use a specification

- Can be method or performance based
- Considers the tolerances of the required datasets
- What products are required?
- Considers archiving requirements
  - Data formats, metadata and retention policies

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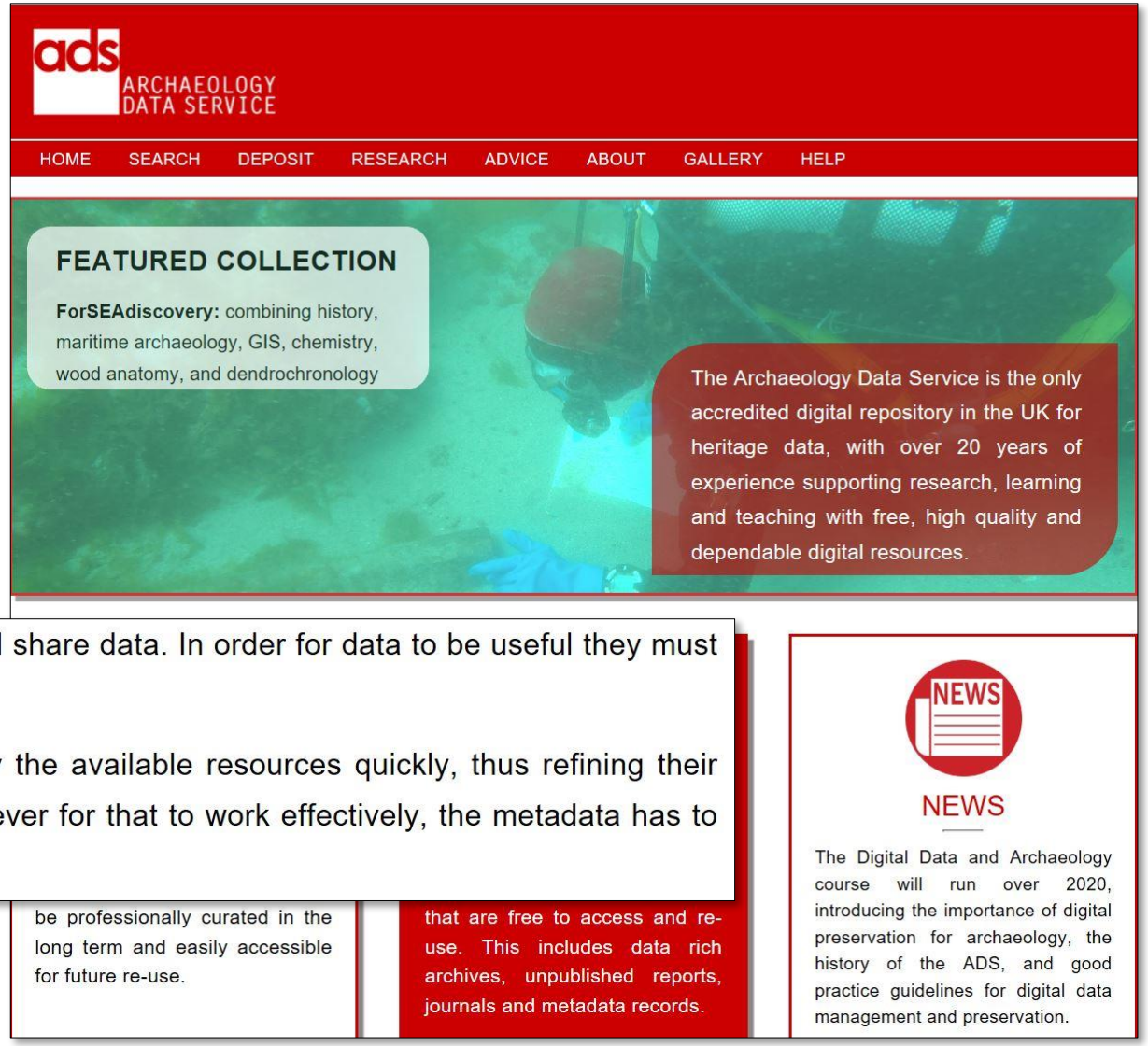

Metadata is data about data. Metadata makes it possible to discover and share data. In order for data to be useful they must be seen in context.

Good metadata, like a good library catalogue, helps readers to identify the available resources quickly, thus refining their research, and putting them in touch with the resources they need. However for that to work effectively, the metadata has to be implemented accurately and in a standard format.

https://archaeologydataservice.ac.uk/

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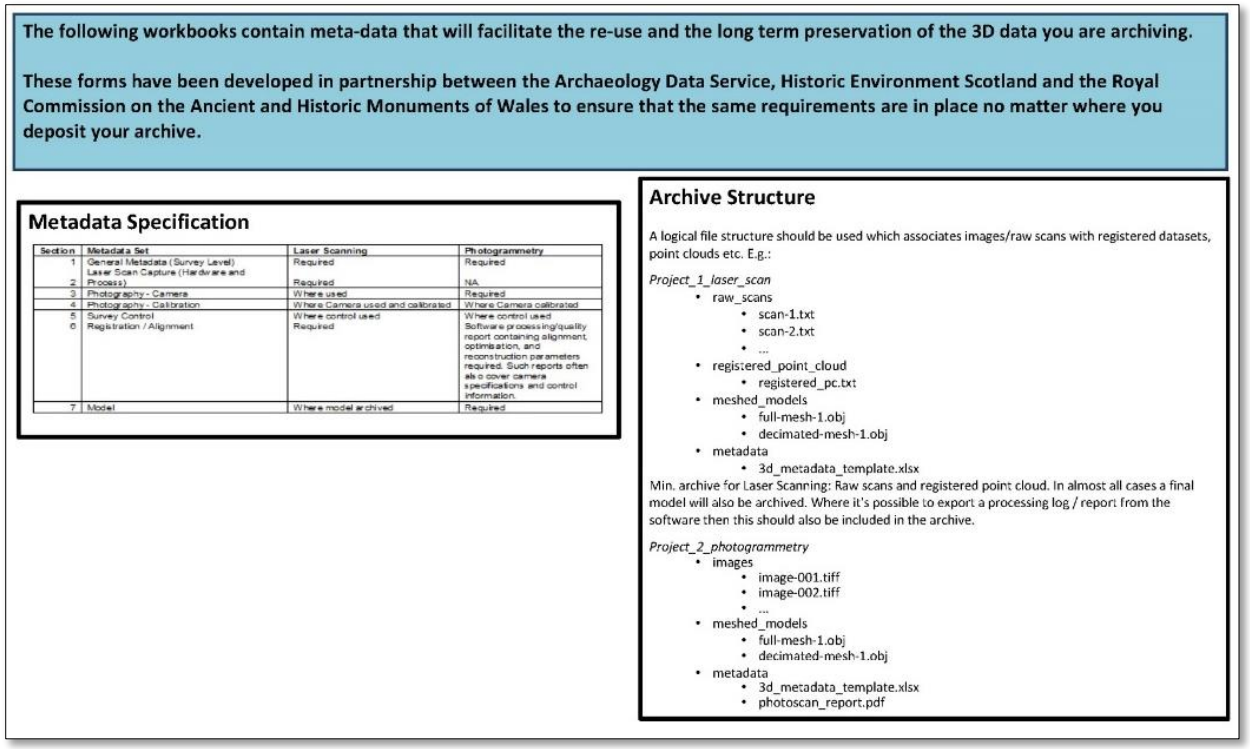
2. Applying geospatial survey technologies appropriately

Use a specification

- Can be method or performance based
- Considers the tolerances of the required datasets
- What products are required?
- Considers archiving requirements
  - Data formats, metadata and retention policies
  - Metadata specification for 3D data
    - Jointly produced by ADS, Historic Environment Scotland (HES), Royal Commission on the Ancient and Historic Monuments of Wales (RCAHMW) with input from Historic England (HE)



The following workbooks contain meta-data that will facilitate the re-use and the long term preservation of the 3D data you are archiving.

These forms have been developed in partnership between the Archaeology Data Service, Historic Environment Scotland and the Royal Commission on the Ancient and Historic Monuments of Wales to ensure that the same requirements are in place no matter where you deposit your archive.

Metadata Specification

Section	Metadata Set	Laser Scanning	Photogrammetry
1	General Metadata (Survey Level)	Required	Required
2	Laser Scan Capture (Hardware and Process)	Required	NA
3	Photography - Camera	Where used	Required
4	Photography - Calibration	Where Camera used and calibrated	Where Camera calibrated
5	Survey Control	Where control used	Where control used
6	Registration / Alignment	Required	Software processing/quality report containing alignment, optimisation, and reconstruction parameters required. Such reports often also cover camera specifications and control information.
7	Model	Where model archived	Required

Archive Structure

A logical file structure should be used which associates images/raw scans with registered datasets, point clouds etc. E.g.:

Project_1_laser_scan
- raw_scans
  - scan-1.txt
  - scan-2.txt
  - ...
- registered_point_cloud
  - registered_pc.txt
- meshed_models
  - full-mesh-1.obj
  - decimated-mesh-1.obj
- metadata
  - 3d_metadata_template.xlsx

Min. archive for Laser Scanning: Raw scans and registered point cloud. In almost all cases a final model will also be archived. Where it's possible to export a processing log / report from the software then this should also be included in the archive.

Project_2_photogrammetry
- images
  - image-001.tiff
  - image-002.tiff
  - ...
- meshed_models
  - full-mesh-1.obj
  - decimated-mesh-1.obj
- metadata
  - 3d_metadata_template.xlsx
  - photoscan_report.pdf

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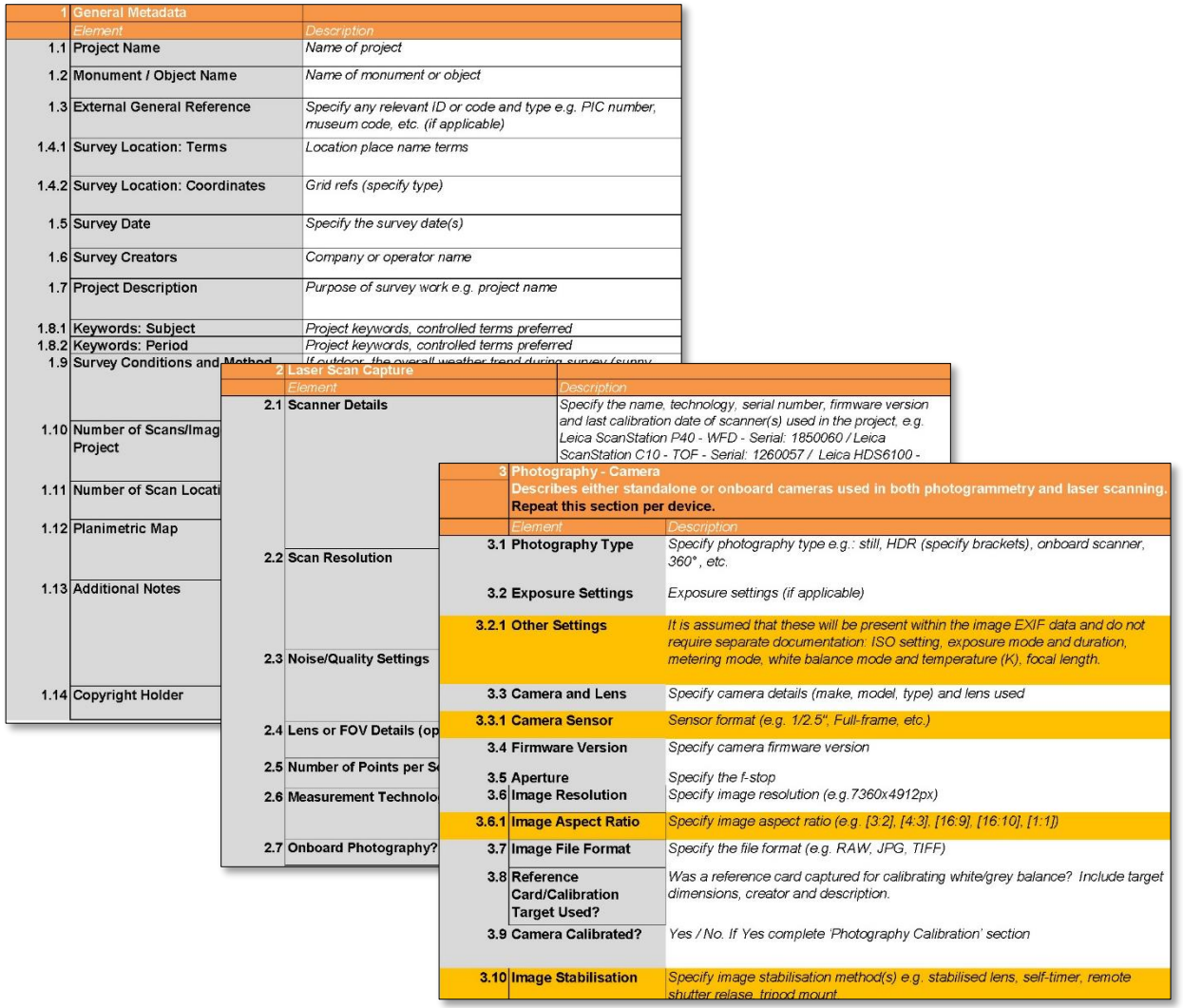
Use a specification

- Can be method or performance based
- Considers the tolerances of the required datasets
- What products are required?
- Considers archiving requirements
  - Data formats, metadata and retention policies
  - Metadata specification for 3D data
    - Jointly produced by ADS, Historic Environment Scotland (HES), Royal Commission on the Ancient and Historic Monuments of Wales (RCAHMW) with input from Historic England (HE)
    - Basis for metadata standard for 3D heritage survey
    - Proposed inclusion in new 4th edition of Metric Survey Specifications for Cultural Heritage



1	General Metadata	
	Element	*Description*
1.1	Project Name	*Name of project*
1.2	Monument / Object Name	*Name of monument or object*
1.3	External General Reference	*Specify any relevant ID or code and type e.g. PIC number, museum code, etc. (if applicable)*
1.4.1	Survey Location: Terms	*Location place name terms*
1.4.2	Survey Location: Coordinates	*Grid refs (specify type)*
1.5	Survey Date	*Specify the survey date(s)*
1.6	Survey Creators	*Company or operator name*
1.7	Project Description	*Purpose of survey work e.g. project name*
1.8.1	Keywords: Subject	*Project keywords, controlled terms preferred*
1.8.2	Keywords: Period	*Project keywords, controlled terms preferred*
1.9	Survey Conditions and Method	*If outdoor, the overall weather trend during survey (sunny*
1.10	Number of Scans/Imag Project	
1.11	Number of Scan Locati	
1.12	Planimetric Map	
1.13	Additional Notes	
1.14	Copyright Holder	

2	Laser Scan Capture	
	Element	*Description*
2.1	Scanner Details	*Specify the name, technology, serial number, firmware version and last calibration date of scanner(s) used in the project, e.g. Leica ScanStation P40 - WFD - Serial: 1850060 / Leica ScanStation C10 - TOF - Serial: 1260057 / Leica HDS6100 -*
2.2	Scan Resolution	
2.3	Noise/Quality Settings	
2.4	Lens or FOV Details (op	
2.5	Number of Points per S	
2.6	Measurement Technolo	
2.7	Onboard Photography?	

3	Photography - Camera Describes either standalone or onboard cameras used in both photogrammetry and laser scanning. Repeat this section per device.	
	Element	*Description*
3.1	Photography Type	*Specify photography type e.g.: still, HDR (specify brackets), onboard scanner, 360°, etc.*
3.2	Exposure Settings	*Exposure settings (if applicable)*
3.2.1	Other Settings	*It is assumed that these will be present within the image EXIF data and do not require separate documentation: ISO setting, exposure mode and duration, metering mode, white balance mode and temperature (K), focal length.*
3.3	Camera and Lens	*Specify camera details (make, model, type) and lens used*
3.3.1	Camera Sensor	*Sensor format (e.g. 1/2.5", Full-frame, etc.)*
3.4	Firmware Version	*Specify camera firmware version*
3.5	Aperture	*Specify the f-stop*
3.6	Image Resolution	*Specify image resolution (e.g.7360x4912px)*
3.6.1	Image Aspect Ratio	*Specify image aspect ratio (e.g. [3:2], [4:3], [16:9], [16:10], [1:1])*
3.7	Image File Format	*Specify the file format (e.g. RAW, JPG, TIFF)*
3.8	Reference Card/Calibration Target Used?	*Was a reference card captured for calibrating white/grey balance? Include target dimensions, creator and description.*
3.9	Camera Calibrated?	*Yes / No. If Yes complete 'Photography Calibration' section*
3.10	Image Stabilisation	*Specify image stabilisation method(s) e.g. stabilised lens, self-timer, remote shutter release, tripod mount*

Images courtesy of Kieron Niven, Archaeology Data Service (ADS)

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Challenge 3.

What level of geospatial survey represents digital preservation

– *raw, processed, both or none of them?*

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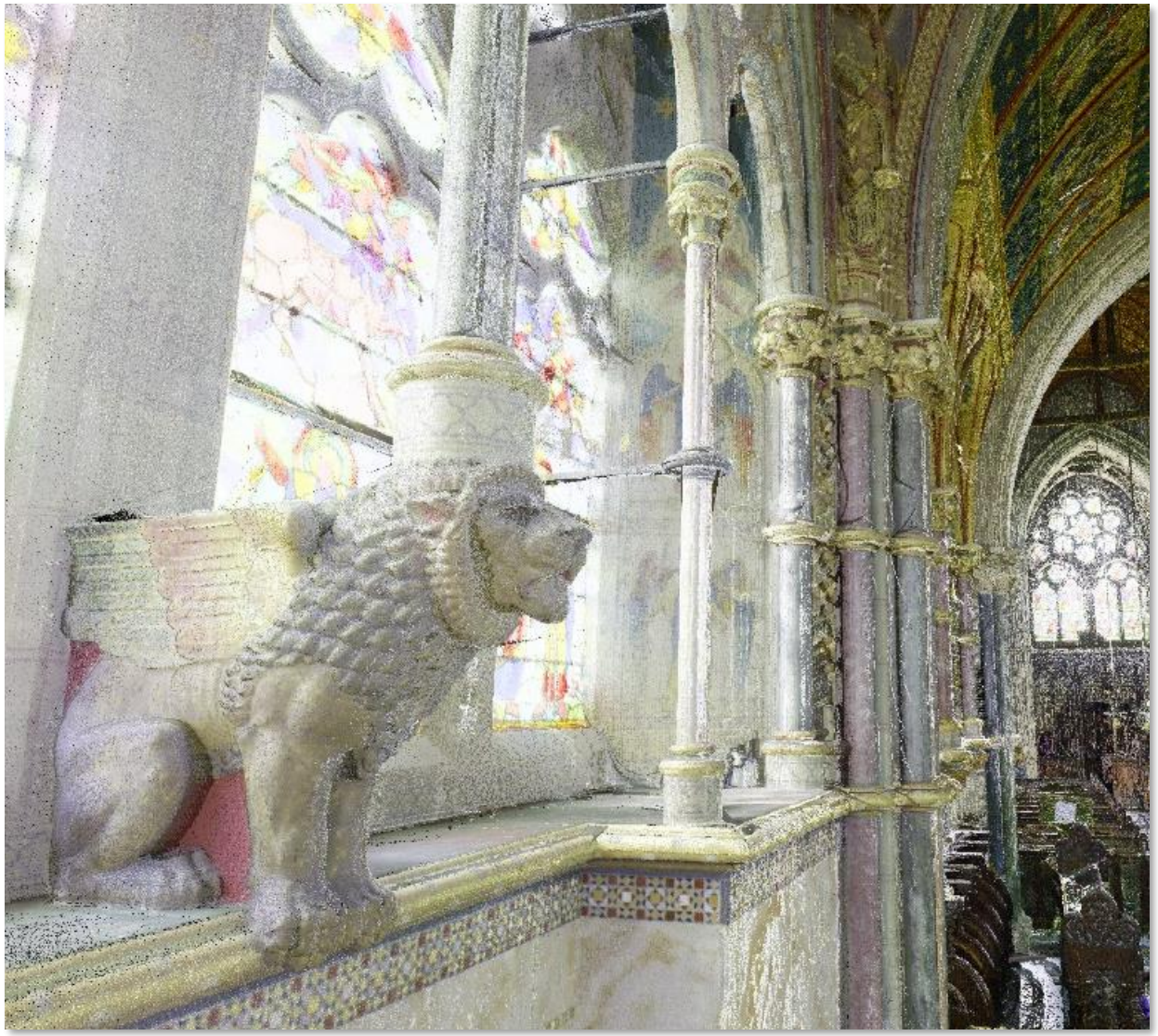
3. What level of geospatial survey represents digital preservation?

3D Laser Scanning - Raw data

- Raw data – proprietary & E57
  - Scanner point data - X, Y, Z, laser intensity & colourised by imagery captured by the scanner
  - Can be exported for archive – E57



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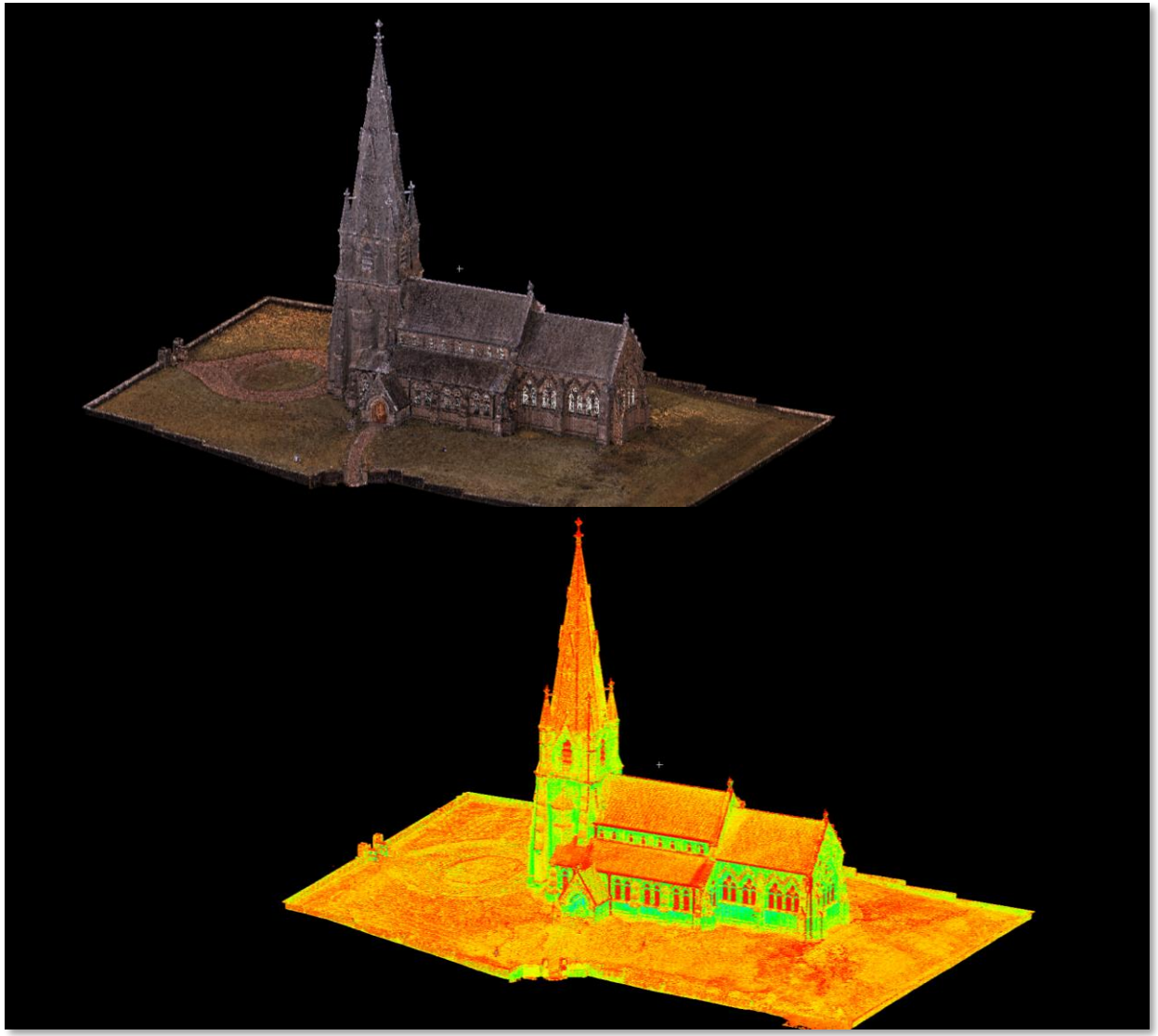
3. What level of geospatial survey represents digital preservation?

3D Laser Scanning - Processed data

- Raw data – proprietary & E57
  - Scanner point data - X, Y, Z, laser intensity & colourised by imagery captured by the scanner
  - Can be exported for archive – E57

- Processed data – proprietary & E57
  - Registered point cloud data
  - Colourised point cloud data



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3. What level of geospatial survey represents digital preservation?

3D Laser Scanning – Output data

- Raw data – proprietary & E57
  - Scanner point data - X, Y, Z, laser intensity & colourised by imagery captured by the scanner
  - Can be exported for archive – E57
- Processed data – proprietary & E57
  - Registered point cloud data
  - Colourised point cloud data
- Output – proprietary & non-proprietary
  - Ortho-rectified image – TIFF
  - Mesh model – OBJ
  - Visualisation – AVI, Jetstream and Sketchfab
  - BIM model – RVT & IFC

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3. What level of geospatial survey represents digital preservation?

Photogrammetry - Raw data

- Digital imagery – proprietary & TIFF
  - Camera RAW files – NEF & CR2
  - Exported as uncompressed TIFF
  - JPEG not used

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3. What level of geospatial survey represents digital preservation?

Photogrammetry - Processed data

- Digital imagery – proprietary & TIFF
  - Camera RAW files – NEF & CR2
  - Exported as uncompressed TIFF
  - JPEG not used

- Processed data – proprietary & E57
  - SfM processing files
  - Registration report - PDF

Historic England

3. What level of geospatial survey represents digital preservation?

Photogrammetry – Output data

- Digital imagery – proprietary & TIFF
  - Camera RAW files – NEF & CR2
  - Exported as uncompressed TIFF
  - JPEG not used

- Processed data – proprietary & E57
  - SfM processing files
  - Registration report - PDF

- Output – proprietary & non-proprietary
  - Ortho-rectified image – TIFF
  - Mesh model – OBJ
  - Visualisation – AVI, Jetstream and Sketchfab
  - BIM model – RVT & IFC

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Challenge 4.

How long should geospatial survey data be retained – *one year, seven years, indefinitely or not at all?*

- Geospatial survey data provides an important basis for:
  - Archaeological and Architectural analysis
  - Conservation planning
  - Condition monitoring
  - Site presentation
  - Online content
  - Building Information Modelling (BIM)
- Most surveys are product driven for a specific application so can all the data be deleted after one year once completed?

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4. How long should geospatial survey data be retained

- Geospatial survey data provides an important basis for:
  - Archaeological and Architectural analysis
  - Conservation planning
  - Condition monitoring
  - Site presentation
  - Online content
  - Building Information Modelling (BIM)
- Most surveys are product driven for a specific application so can all the data be deleted after one year once completed?
- HE's 'Metric Survey Specifications for Cultural Heritage' suggests being retained for a minimum of seven years
- The datasets of today do become the archive of tomorrow so should all geospatial survey data be retained indefinitely?
- ……or do we not need to retain modern datasets as it will be quick, easy and cheap to repeat surveys in the future?

1.7 Survey material supplied

1.7.1 Copyright

The copyright of all materials generated as part of the contract is to be transferred to the client unless stated otherwise in section 1.1.6.

1.7.2 Retention of survey documentation

On request the contractor shall make available to the client all materials used for the compilation of the required survey. This material must be retained by the contractor for a minimum of seven years.

As a minimum this material will include: field notes and/or diagrams generated while on site; the raw and processed data used for the final computation of control; and a working digital copy of the metric survey data that forms each survey drawing or model (including formatted 2-D and 'raw' 3-D data files). The precise digital format and file type of this archive will be specified in section 3.1. If during this period the contractor wishes to change the format of this data archive, they are to seek the client's permission.

Historic England

Many thanks for listening

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THE SURVEY ASSOCIATION AFFILIATE MEMBER

Challenge 1

Wide variety of geospatial survey technologies now available to heritage

– which should I choose?

Challenge 2

Applying geospatial survey technologies appropriately

– how do I ensure 'fit for purpose' data is generated?

Challenge 3

What level of geospatial survey represents digital preservation

– raw, processed, both or none of them?

Challenge 4

How long should geospatial survey data be retained

– one year, seven years, indefinitely or not at all?