

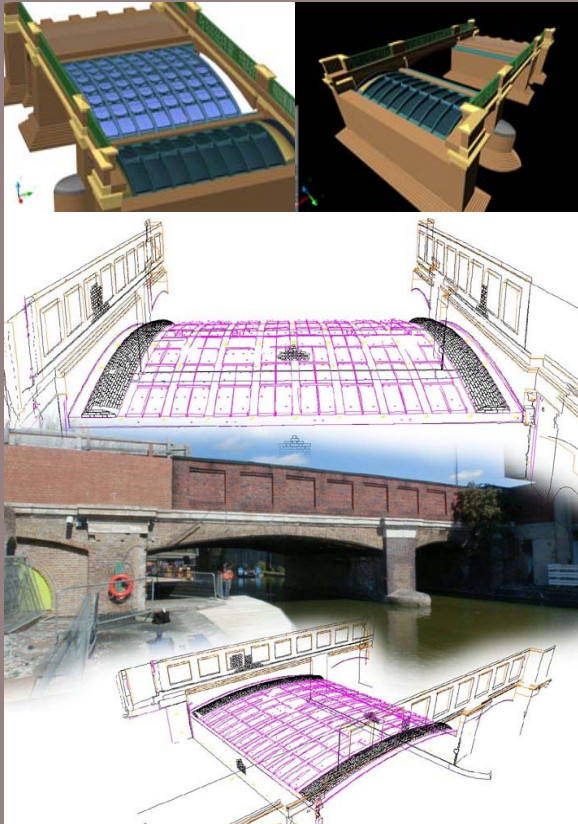
New dimensions on rock art recording

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Head of Geospatial Imaging
Imaging Graphics and Survey
Research Department, Conservation & Protection
English Heritage
Tanner Row
York



Why do we survey?



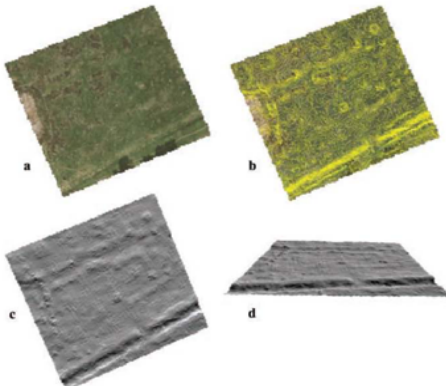
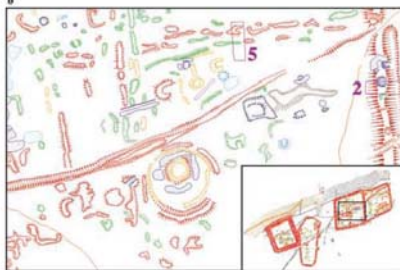
'Brunel's Bridge', Paddington, London

Photogrammetric line drawings provided accurate record of former canal bridge at Paddington Station, built to a design by British engineer, Isambard Kingdom Brunel, in 1838

To assist with understanding a monument or landscape through

- Architectural Recording

Why do we survey?



Cawthorne Roman Camps, North Yorkshire, NE England

Use of photogrammetry by aerial archaeologists to map landscape

To assist with understanding a monument or landscape through

- Architectural Recording
- Archaeological Recording

Why do we survey?

Prior to an Intervention

- Architectural Recording
- Archaeological Recording
- Condition survey reports

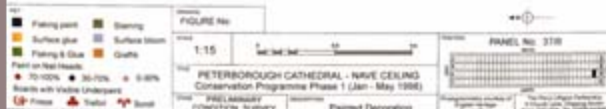
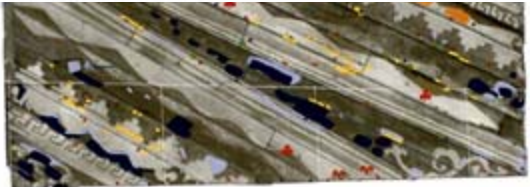

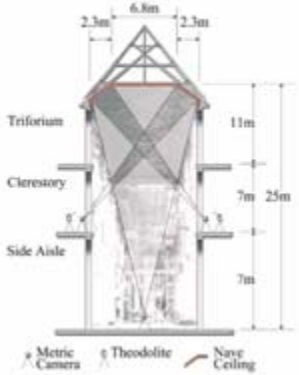
To enable each of the twenty-two stereo-models to be contained in an analytical stereoplotter or a digital photogrammetric workstation, a maximum of four control points per model was required because of the difficulty of placing plastic targets on the ceiling. It was decided to use points of detail, even though these would not provide the same clarity of pointing and hence level of accuracy as a target and would also take longer to observe. The wide platform at triforium level was used for surveying the control points in intervention, as it provided both an unobstructed view of the ceiling and reduced the need for any camera vertical angle observations (Fig. 54). To allow the measurements to be carried out efficiently, colour prisms were made from the stereophotography and marked up directly on site, as detail points were submitted. A total of eighty-five points of detail were coordinated. This meant that there were up to six points available per model. Normally, only four points per model are required as three extra control points helped moderate the reduced accuracy that was a consequence of using widely-detailed points.

5.5.2 Stereo-photography

The cathedral ceiling is 25m above ground-floor level. In order to acquire stereophotography of a suitable negative scale it was necessary for the English Heritage Maintenance Team to use either remote equipment or a camera with a telescopic lens. The use of remote equipment was rejected for two reasons. First, there was the physical difficulty of bringing a wall-mounting tower or hydraulic lift into the cathedral. Secondly, the photography had to make use of available light, since artificial methods would not have given adequate illumination over the whole ceiling. The long exposure times that would result from the use of remote equipment were also a problem, as it would not have been sufficiently stable. The decision was therefore taken to use a Zeiss UMK 30/1318 metric camera for the photography.

The 5m, V 7m format and 300mm lens of the UMK meant that the entire width of the ceiling could be covered in one photograph taken from the ground floor (see Fig. 54). The resulting negative scale of approximately 1:80 was sufficient to allow the production of drawings at 1:20 or even 1:10. The camera and tripod were mounted on a 'dolly' and wheeled down the centre of the nave, making possible a run of twenty-three photographs and thus twenty-two stereo-models (Fig. 55). In addition to this ground-based photography, stereo-images were taken from the triforium using a 5m, V 7m format WILD P31 metric camera with a

Figure 54 (Detail) A corner part of the nave ceiling.



Peterborough Cathedral, E England

Use of photogrammetry to aid condition assessment and conservation planning

IMAGING, GRAPHICS
AND SURVEY



ENGLISH HERITAGE

Why do we survey?

Basis for planning proposals

- Architectural Recording
- Archaeological Recording
- Condition survey reports
- Detailed design work



Courtesy Upper Cut Productions



Whitby Abbey, N Yorkshire NE England

Use of photogrammetry to aid building recording, structural analysis and design work for new EH visitor centre

Why do we survey?

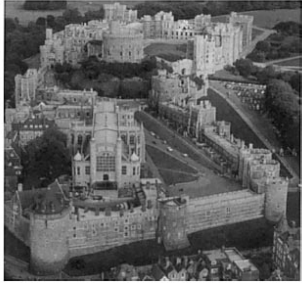


FIG. 1. Windsor Castle: a view of the present Castle looking east.

PRE-RESTORATION ANALYSIS OF THE FIRE DAMAGED AREAS

The fire on Friday, 20th November, 1992 destroyed a large section of the private and State Rooms in the north-east corner of the upper ward. The scale of the devastation is difficult even now to appreciate fully (Fig. 2).

Before the ashes had cooled, thought was being given to the reconstruction of the buildings which was to become the subject of a national and, at times, heated debate. Representatives from English Heritage were quickly on site to advise on the clearance of the buildings. Experience of previous fires at Hampton Court Palace in 1986 and Uppark House in 1989 had shown that if authentic restoration was to be carried out (that is to say the accurate reconstruction of damaged structures and decorative finishes using the original methods and where possible salvaged materials) then the fire debris had to be collected and sorted for the retrieval of structural and decorative materials. In this case, salvage also included items of furniture and sculpture.

The first priority for fabric recording was the rapid assessment of the damaged timber structures. Demolition of damaged roof structures began almost immediately.



FIG. 2. An illustration of some of the damage caused by the fire in St. George's Hall.

Windsor Castle, SE England

New & archived photography, both from the Royal Household's own collection and the National Monuments Record (NMR), used within post-fire restoration

Providing an Archive

- Architectural Recording
- Archaeological Recording
- Condition survey reports
- Detailed design work
- Archival and ante-disaster purposes

Why do we survey?



Greatstone Listening Devices,
West Sussex, S England

Acoustic mirror technology - forerunner
to radar. 3D virtual model created in
2005 using a combination of
photogrammetry and laser scanning

To assist site interpretation and presentation

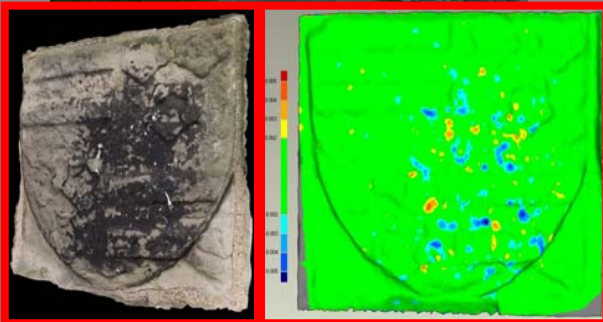
- Architectural Recording
- Archaeological Recording
- Prior to an Intervention
- To assist detailed design work
- Archival and ante-disaster purposes
- Presentational images and 3D models

Why do we survey?



To assist monitoring of historic fabric

- Architectural Recording
- Archaeological Recording
- Prior to an Intervention
- To assist detailed design work
- Archival and ante-disaster purposes
- Presentational images and 3D models
- Monitoring and decay mapping



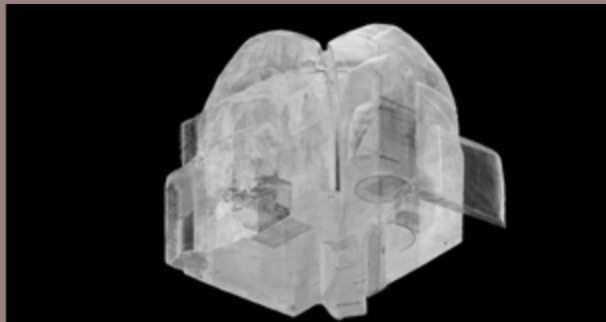
Hylton Castle, Sunderland, NE England

Digital Imagery & laser scanning
acquired in 2008 & 2009 to enable
decay monitoring of heraldic shields

Why do we survey?



Courtesy Andrew Beardsley, Oakes Surveys



Longthorpe Tower, Peterborough,
E England

Laser scanning and digital imagery
acquired in 2009 to aid art-historical
reassessment of 14th century wall
paintings within their architectural,
artistic and social context

To assist analysis of historic fabric

- Architectural Recording
- Archaeological Recording
- Prior to an Intervention
- To assist detailed design work
- Archival and ante-disaster purposes
- Presentational images and 3D models
- Monitoring and decay mapping
- **Analytical recording and interpretation of painted detail**

What survey techniques are available for recording?



‘Direct’ or ‘Active’

(non image based - selection at the point of capture)

Hand Survey/Drawing

Theodolite/REDM Survey

GPS (**G**lobal **P**ositioning System)

Laser Scanning



Laser Scanning

Close range

Triangulation & Structured light



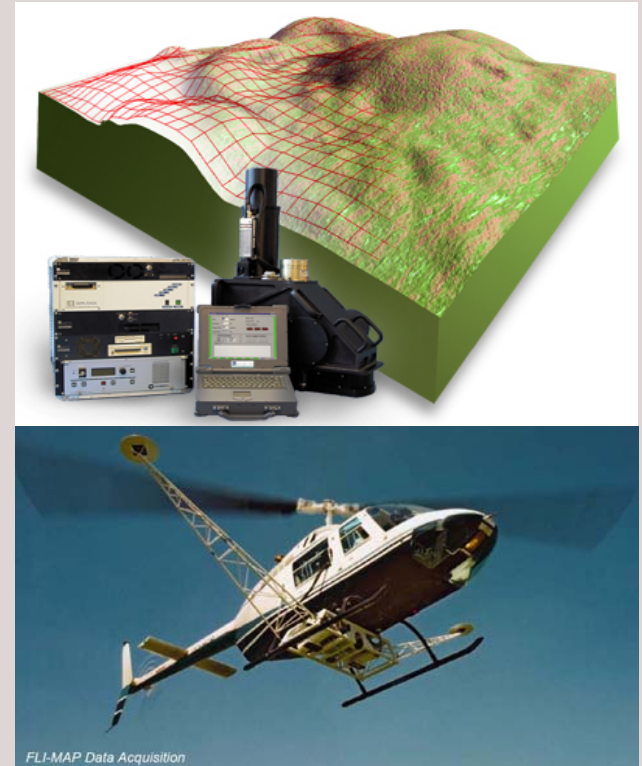
Terrestrial

Time of flight (pulse) & phase difference



Airborne

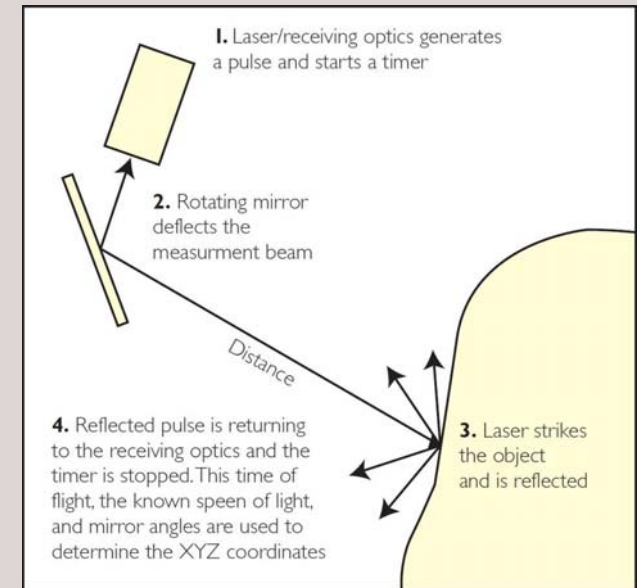
LiDAR



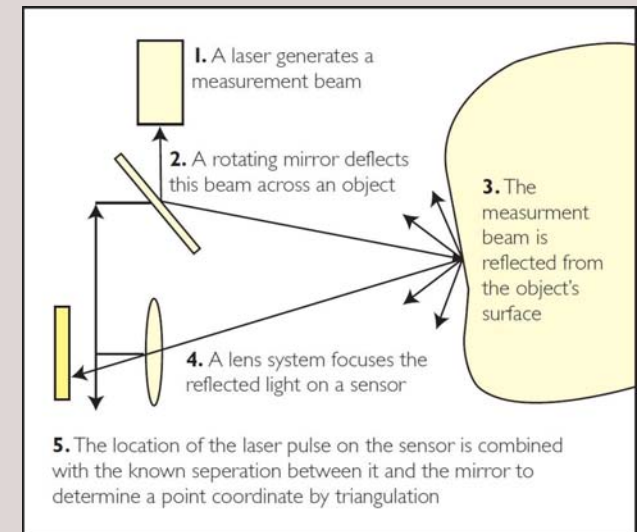
Laser Scanning – how does it work?



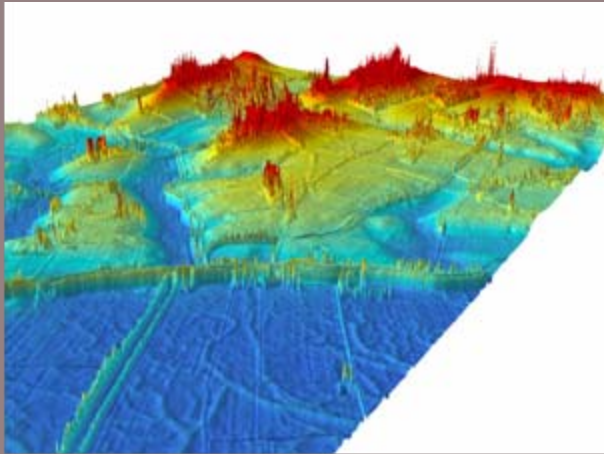
Time-of-flight' & Phase-based



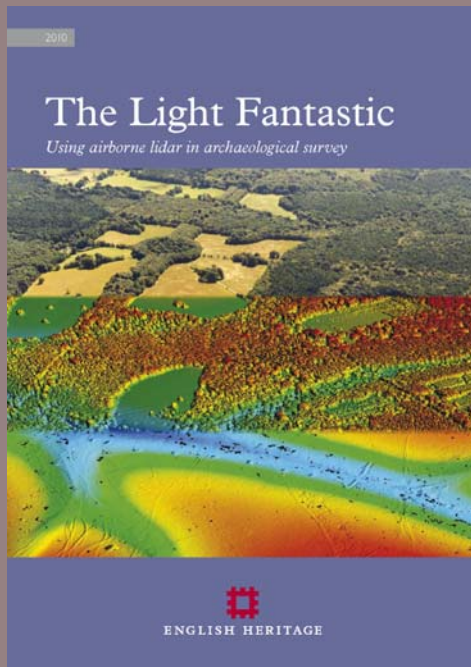
Triangulation and structured light



Laser Scanning – how might it be used?

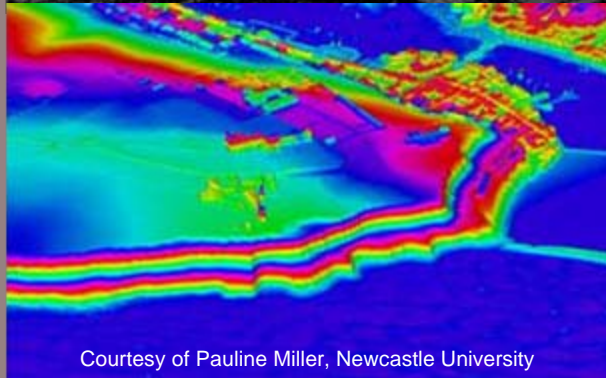
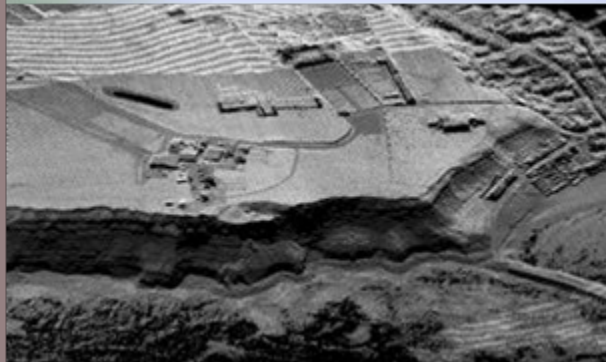
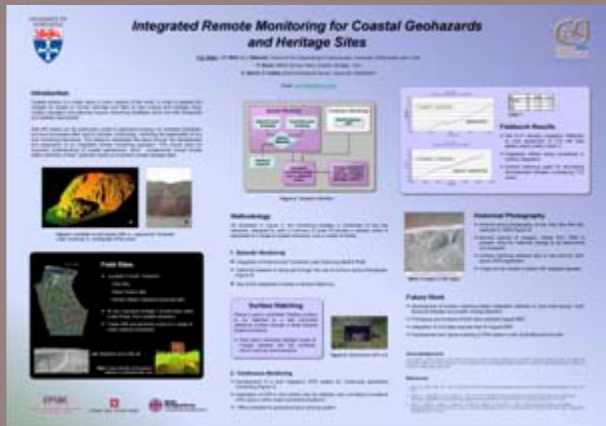


- Assist landscape mapping & interpretation



Laser Scanning – how might it be used?

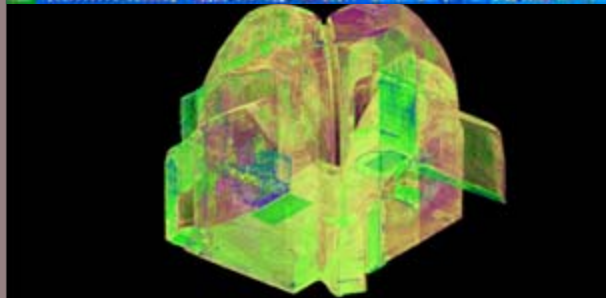
- Assist landscape mapping & interpretation
- Aid coastal survey & monitoring



Courtesy of Pauline Miller, Newcastle University

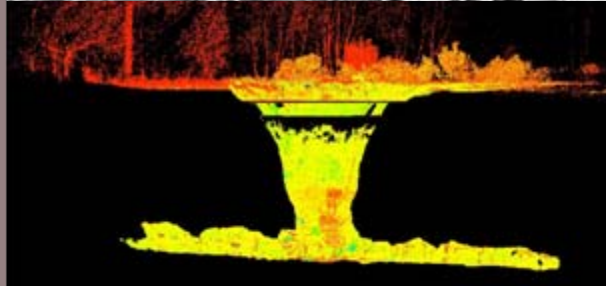
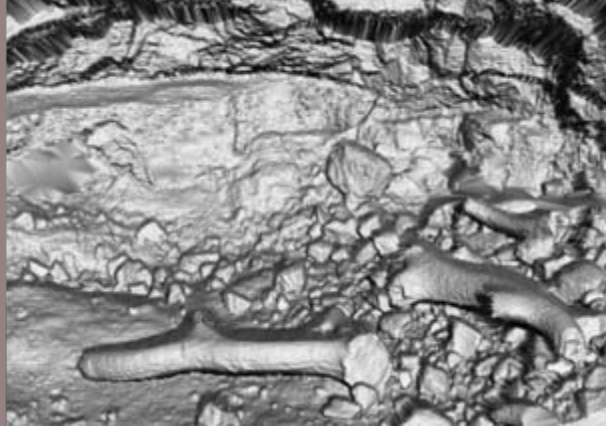
Laser Scanning – how might it be used?

- Assist landscape mapping & interpretation
- Aid coastal survey & monitoring
- Assist Building recording, analysis & interpretation



Laser Scanning – how might it be used?

- Assist landscape mapping & interpretation
- Aid coastal survey & monitoring
- Assist Building recording, analysis & interpretation
- Assist Archaeological recording & presentation

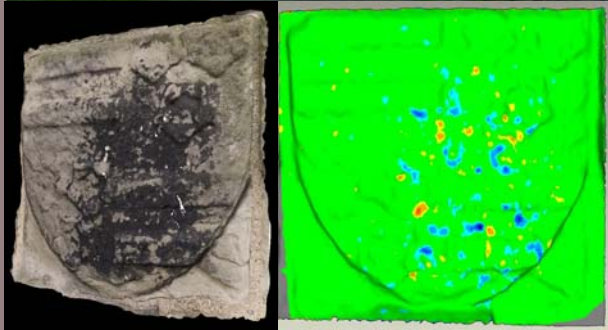


Grimes Graves Neolithic Flint Mine, Norfolk

Laser Scanning – how might it be used?



- Assist landscape mapping & interpretation
- Aid coastal survey & monitoring
- Assist Building recording, analysis & interpretation
- Assist Archaeological recording & presentation
- Aid monitoring of historic fabric & decay mapping



Laser Scanning – how might it be used?



Ketley Crag Rock Shelter, Northumberland

- Assist landscape mapping & interpretation
- Aid coastal survey & monitoring
- Assist Building recording, analysis & interpretation
- Assist Archaeological recording & presentation
- Aid monitoring of historic fabric & decay mapping
- Aid rock-art recording



Laser Scanning – how was it used within NADRAP?

Ketley Crag Rock Shelter



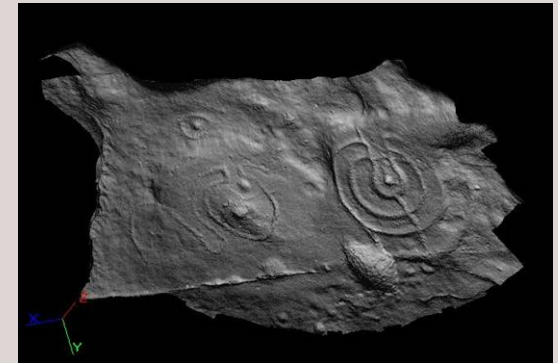
This site is unique but has great display potential - possibly through a museum replica or 3D visualisation

Cotherstone



The impact of lichen coverage could be assessed

Huntersheugh



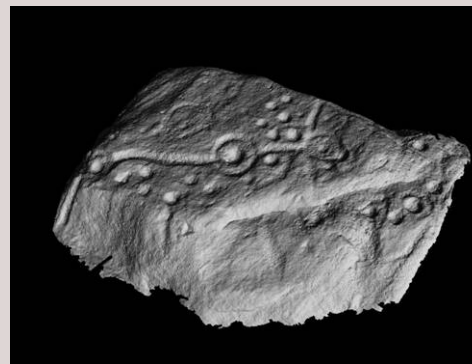
Need to capture the fresh and fragile markings which had been uncovered following excavation

Chatton Park Hill



The impact of physical and chemical erosion could be assessed

How Gill



Opportunity to measure turf encroachment



Image courtesy of Tertia Barnett

What survey techniques are available for recording?



‘Indirect’ or ‘Passive’
(*image based – mass data capture*)

Rectified Photography

Panoramic Imaging

Photogrammetry

3D Laser Scanning



Photogrammetry

“The art and science of obtaining reliable measurement by means of images”

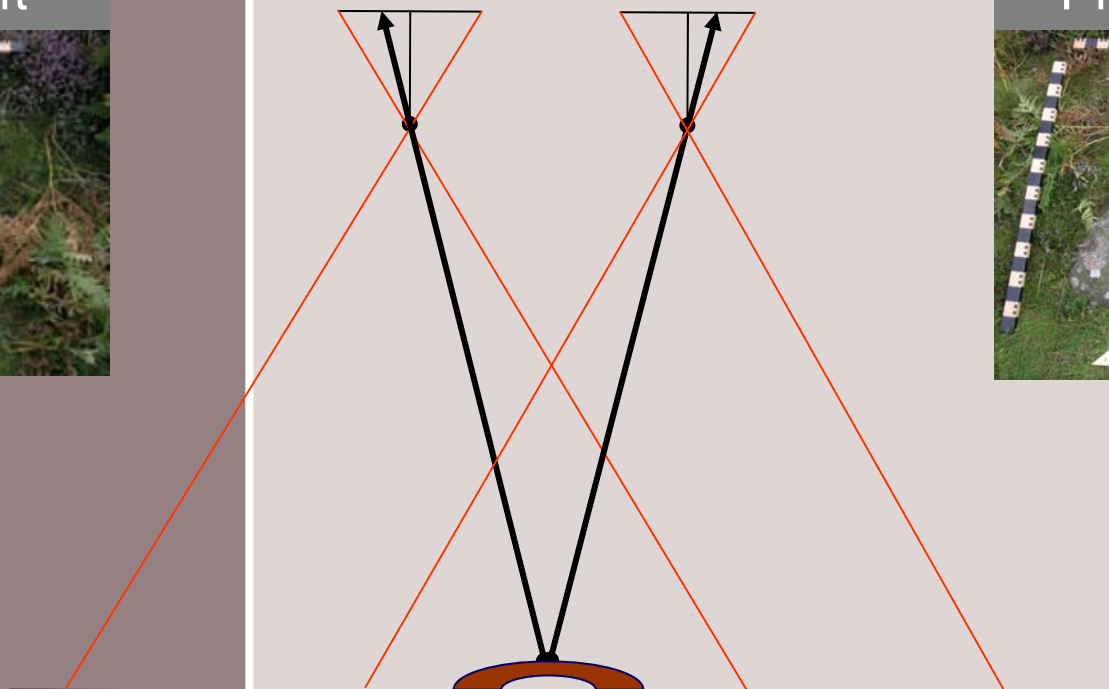
(RSPSoc, 2004)

Photogrammetry - stereo-photography

Photo 1 - left



Photo 2 - right

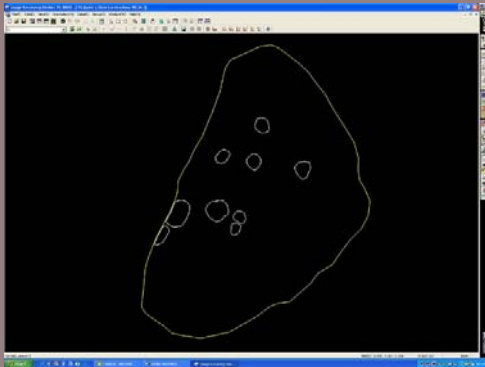


Stereo-pair



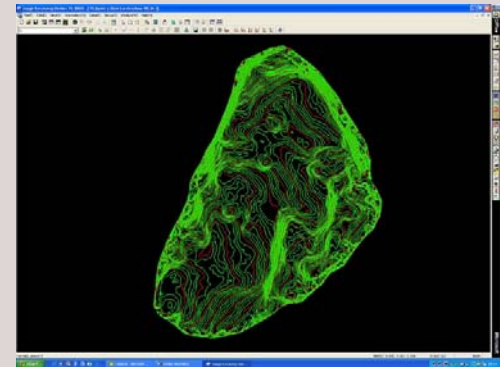
Photogrammetry - stereo-photography

Drawings

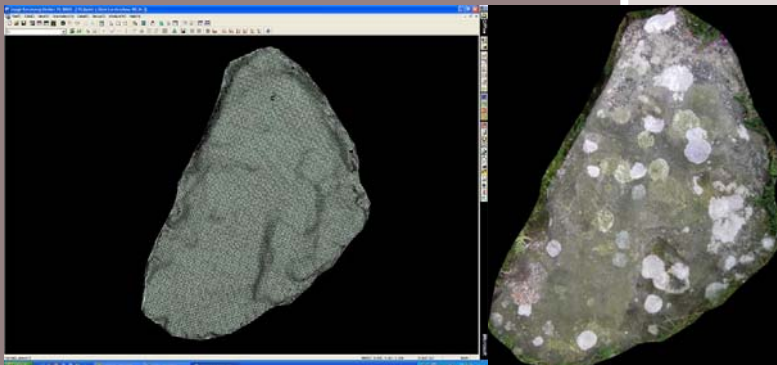


Stereo-photography –
the '*building-block*' for
photogrammetric
outputs

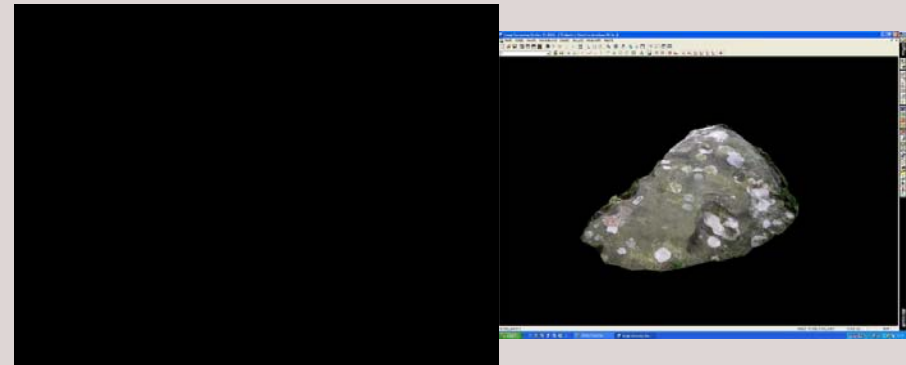
Contour Plots



Surface Models/Orthophotographs

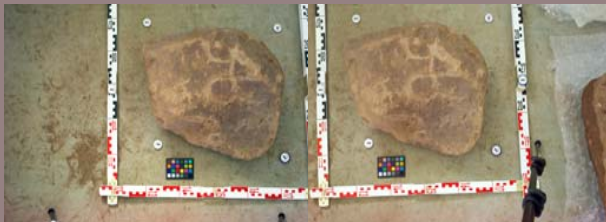


Animations & 3D Models



Photogrammetry – cameras & software

Digital Image Acquisition

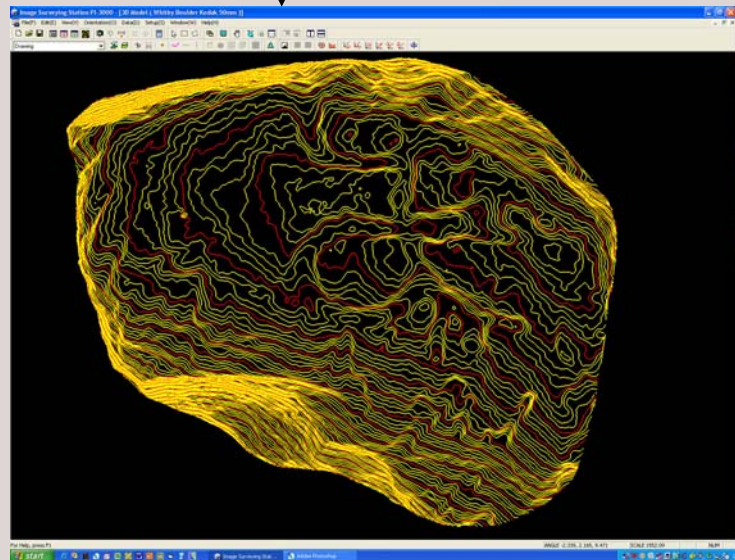
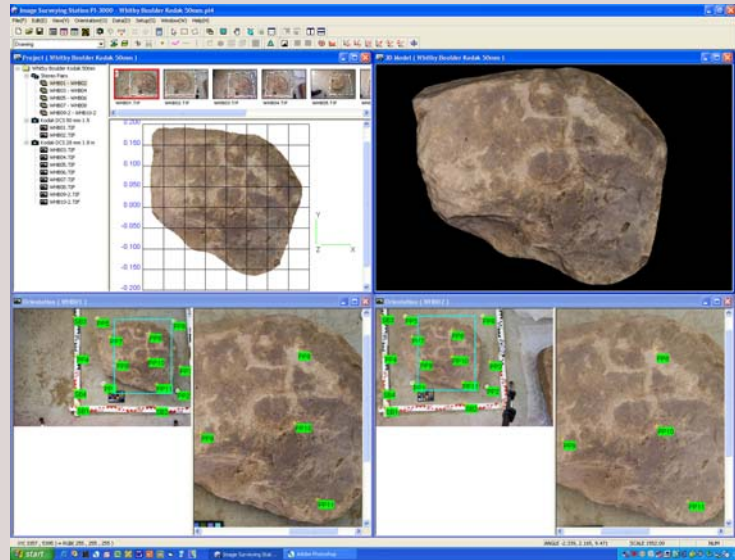


We now use Digital SLR cameras calibrated at set focus distances

Nikon D300 – 12MP

Kodak DCS ProSLR – 14MP

Canon EOS 1Ds & 5D – 22MP



Topcon ImageMaster
Photo
low-cost photogrammetry
software

Textured 3D surface
model
'Carved boulder from Whitby
Abbey



Photogrammetry – 3D cameras



St Breock's Monolith, Bodmin, SW England

Prehistoric standing stone of Middle to Late Bronze Age (2000 – 600BC)



Textured 3D surface model

Ortho-rectified image

We now use Digital SLR cameras calibrated at set focus distances

Nikon D300 – 12MP

Kodak DCS ProSLR – 14MP

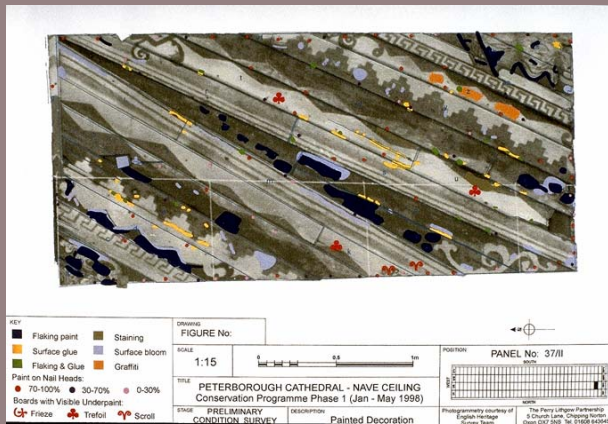
Canon EOS 1Ds & 5D – 22MP

Fuji W1 3D Compact – 10MP

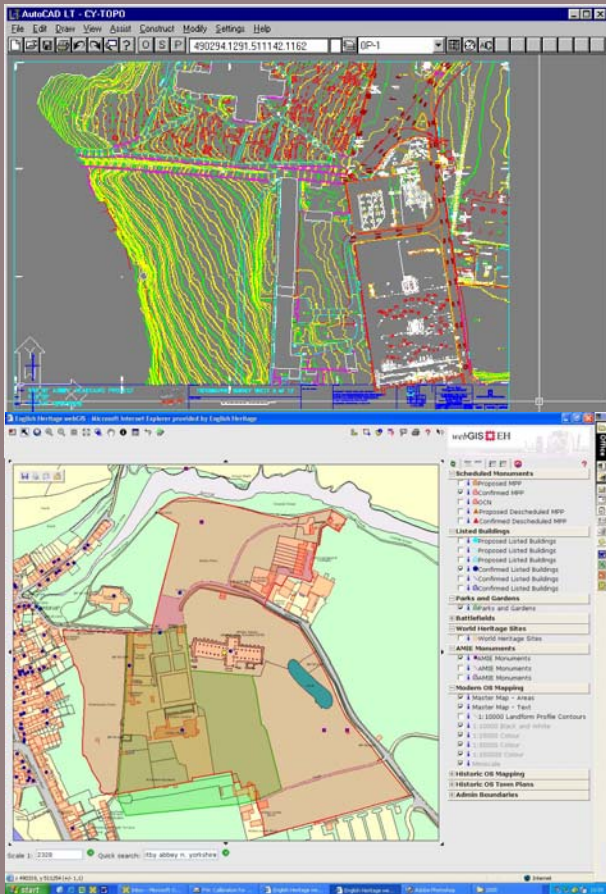
@£400, **world's first 3D camera!**

Photogrammetry – how might it be used?

- Prior to an Intervention - conservation plans & condition surveys

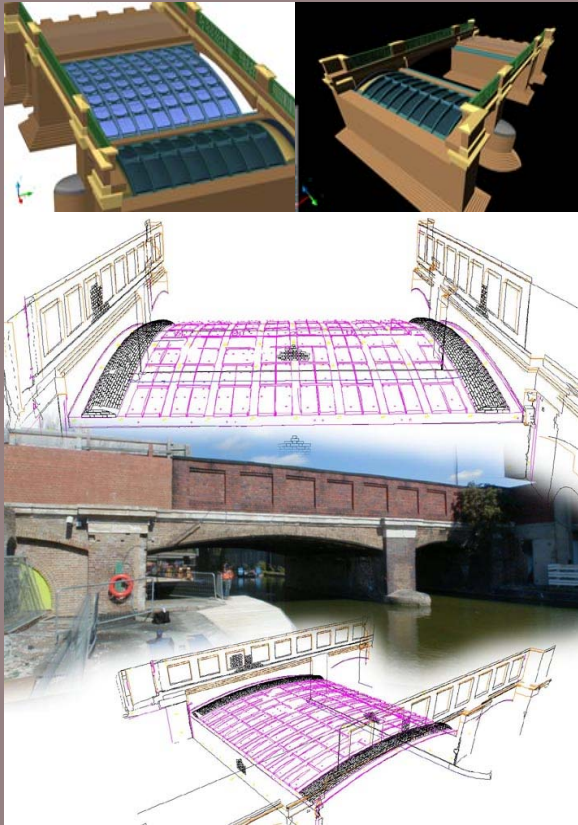


Photogrammetry – how might it be used?



- Prior to an Intervention
- Assist analysis - base GIS data

Photogrammetry – how might it be used?



- Prior to an Intervention
- Assist analysis – building recording

Photogrammetry – how might it be used?



- Prior to an Intervention
- Assist analysis
- Assist site interpretation & presentation

Photogrammetry – how might it be used?



- Prior to an Intervention
- Assist analysis
- Assist site interpretation & presentation
- Assist conservation management – decay monitoring

Photogrammetry – how might it be used?

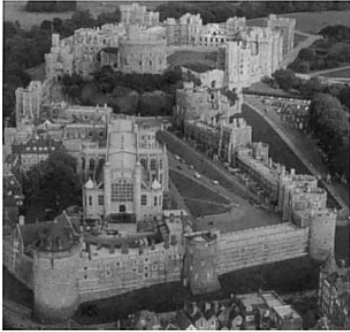


FIG. 1. Windsor Castle: a view of the present Castle looking east.

Windsor Castle

New & archived photography, both from the Royal Household's own collection and the National Monuments Record (NMR), used within post-fire restoration – as featured in Photogrammetric Record article October 1995

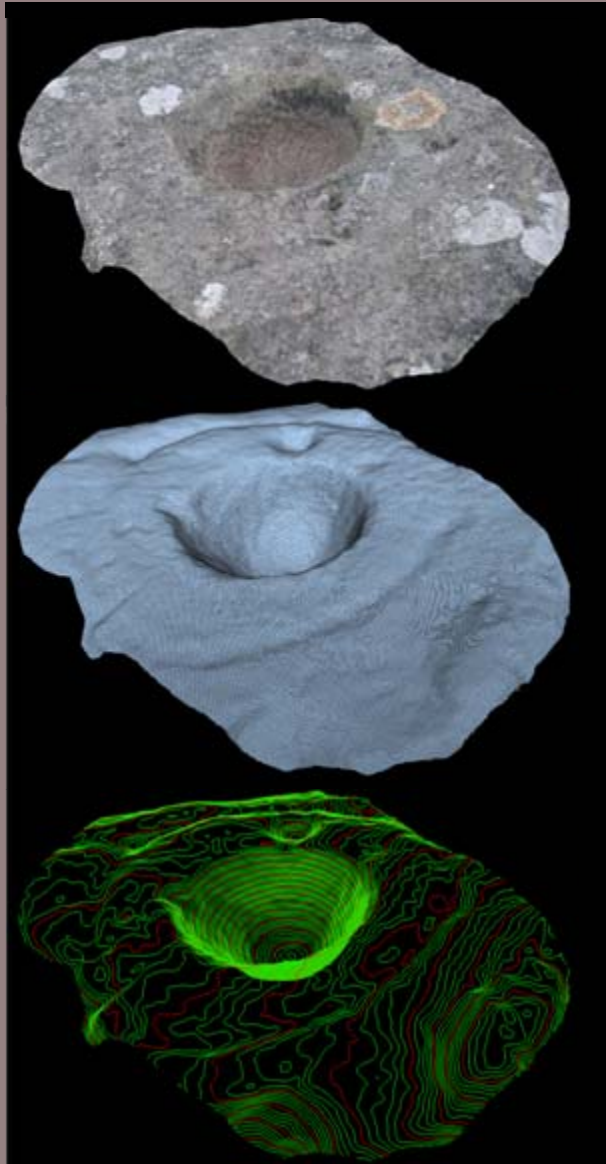


FIG. 2. An illustration of some of the damage caused by the fire in St. George's Hall.

226

- Prior to an Intervention
- Assist analysis
- Assist site interpretation & presentation
- Assist conservation management
- Contribute to the archive & provide ante-disaster material

Photogrammetry – how might it be used?



- Prior to an Intervention
- Assist analysis
- Assist site interpretation & presentation
- Assist conservation management
- Contribute to the archive & provide ante-disaster material
- Aid rock art recording



Recording Prehistoric Rock Art – traditional approaches

- In UK rock art has traditionally been recorded using two dimensional techniques:
 - Conventional & digital photography - **easiest & most convenient way, excellent results, but need right lighting conditions to pick out detail**



Images courtesy of Richard Stroud

Recording Prehistoric Rock Art – traditional approaches



Drawing by Stan Beckensall (Late 20th Century)



Image courtesy of Tertia Barnett, RCAHMS

- In UK rock art has traditionally been recorded using two dimensional techniques:
 - Conventional & digital photography
 - Drawing the stone and its' motifs - **effective, but subjective and dependant on the skills of the artist**

Recording Prehistoric Rock Art – traditional approaches



Image courtesy of Stan Beckensall

- In UK rock art has traditionally been recorded using two dimensional techniques:
 - Conventional & digital photography
 - Drawing the stone and its' motifs
- Rubbing - enables you to feel the features, but subjective and a skill to produce good results

Recording Prehistoric Rock Art – traditional approaches



Images courtesy of Tertia Barnett, RCAHMS



- In UK rock art has traditionally been recorded using two dimensional techniques:
 - Conventional & digital photography
 - Drawing the stone and its' motifs
 - Rubbing
- Such techniques are limited in terms of level of detail, three dimensionality and objectivity of captured data
- Neither technique is capable of accurately and non-intrusively recording the three dimensional form of the host rock surface
- Can constrain in-depth examination and condition assessment of the carvings/host rock, which can in turn mislead our interpretations



Photogrammetry – how was it used within NADRAP?

Application of Photogrammetry

- Following initial training the project volunteers acquired their own stereo-photography using calibrated Nikon 5400 digital camera's



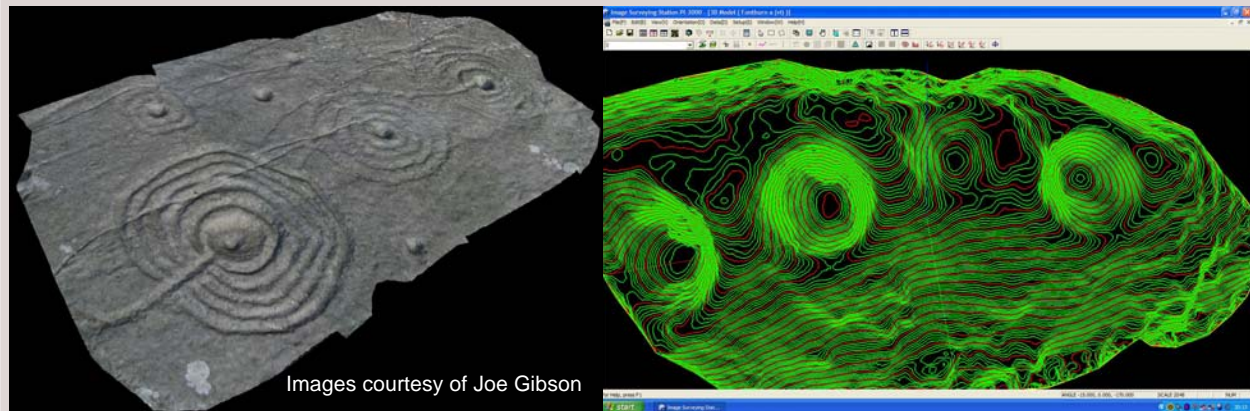
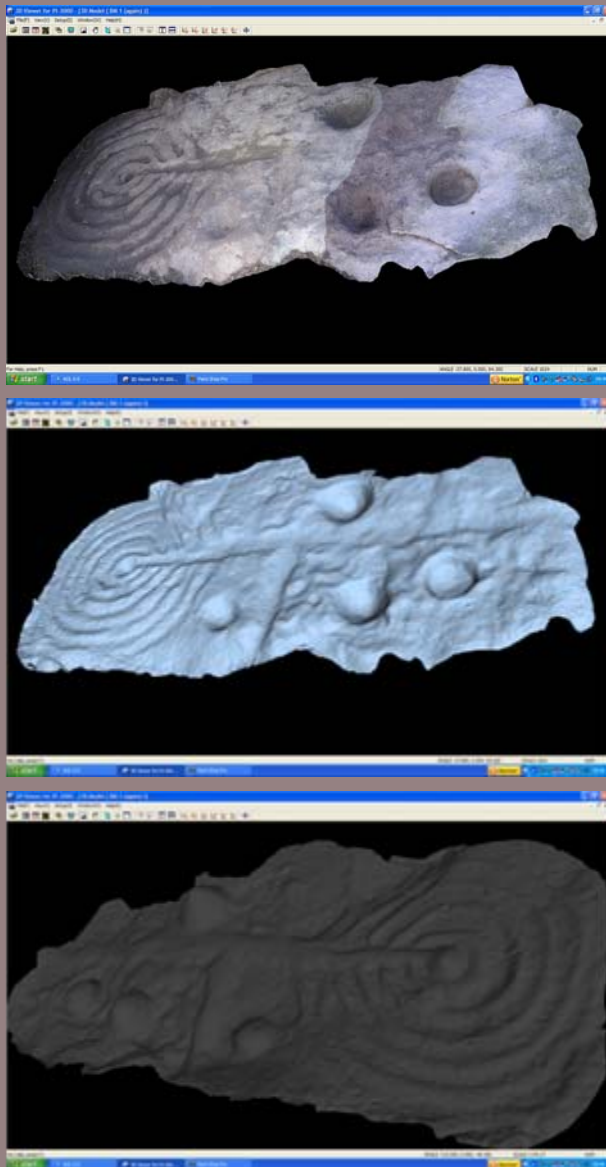
Images courtesy of Tertia Barnett



Photogrammetry – how was it used within NADRAP?

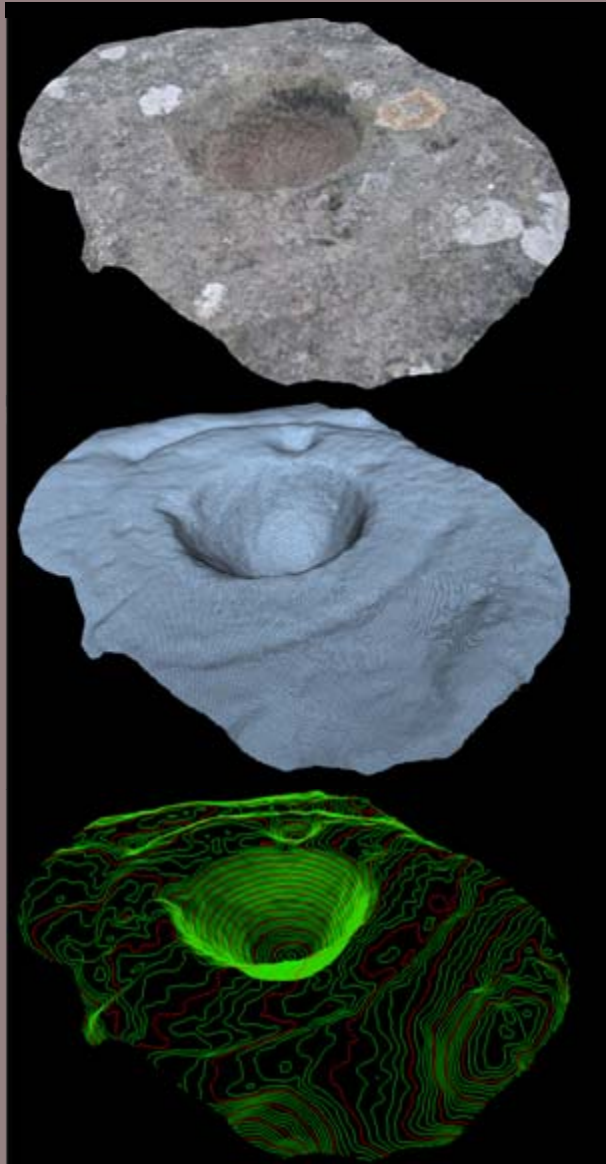
Application of Photogrammetry

- Following initial training the project volunteers acquired their own stereo-photography using calibrated Nikon 5400 digital camera's
- Used Topcon's PI-3000 'Image Surveying Station' software to process their own imagery and provide:
 - 3D surface models – textured, untextured and reversed (aids interpretation)
 - Orthophotographs (scaled images)
 - Contour plots



Images courtesy of Joe Gibson

Photogrammetry – the pros & cons



Advantages

- Assists interpretation of motifs
- Measurement ability to inform conservation
- 3D model & surface capabilities
- Accuracy of derived 3D surface appropriate for most carvings ($\pm 2-5\text{mm}$)
- Excellent results from off-the-shelf cameras
- Portability of equipment
- Non invasive technique
- Archival capability of stereo-photography & derived data

Disadvantages

- Cost of software – ImageMaster Photo approx £2500
- Need appropriate lighting conditions
- Need to minimise effect of shadows
- Camera calibration required at various focus ranges
- Individual ability to control camera & acquire suitable image
- Time element in processing large rock art panels
- Cannot easily deal with superimposition of carvings

Additional techniques - PTM



PTM (Polynomial Texture Mapping)

- The capture of a single image that at pixel level represents the reflection of light off an object as opposed to just its depiction in (RGB) colour
- Uses 'off-the-shelf' consumer-grade camera and a portable flash or spot-light source
- A 'virtual hemisphere' is formed around the object by rotating the light at fixed intervals round a stationary camera position
- Multiple images merged together in free open-source software to create single image with freely adjustable 'virtual' illumination

Currently restricted to two-dimensional output but 3D being explored



Thank you for listening.....and any questions?

- The recording of rock-art has traditionally been tackled using two-dimensional approaches such as drawing and photography
- The power of the image as a documentary resource is well understood.....
-but the power of the image to supply accurate and reliable three dimensional information using photogrammetry is less well known, particularly at a lower cost
- New survey tools, such as laser scanning, can provide rapid three dimensional coverage of carved surfaces.....
-but require detailed consideration of all related factors, not only cost and time, to ensure appropriate and consistent data is generated
-and, like PTM, there is always another new survey technique 'just around the corner'!