

The Photogrammetry Archive

Jenny Ryder: ADS 27/08/2013

Background

The following document is intended to give a summary of the contents of the Topcon project folders and to provide further information as to the structure and creation of the photogrammetry aspect of the Silbury Hill Conservation Project digital archive; a summary of the metadata associated with the Topcon projects and a summary of the work involved in creating the photogrammetry archive.

The main aims of this document are:

- To explain the process in creating the photogrammetric record at Silbury Hill.
- To review the contents of the Topcon PI3000 sub-project folders.
- To summarize the metadata that has been created.
- To highlight any issues or points of note (see the appendices as well as the main text).

Contents

1. The Photogrammetry process
2. The Topcon PI3000 projects
3. The Photogrammetry archive metadata
4. Appendices
 - 4.1: Notes on Photogrammetry from 2007/2008
 - 4.2: Digitizing the 2D ortho-printouts vs. digitizing in Topcon 3000.
 - 4.3: Digitizing notes (2008)
 - 4.4 An assessment of the photogrammetry output from inside the tunnels in Silbury Hill (Eddie Lyons 19/11/2008)

1. The Photogrammetry process

With regards to the photogrammetric recording of the deposits which form Silbury Hill, the main aspects that were recorded were the re-excavated tunnels within the hill. There were stereo pair photographs taken of the summit excavations and the

hillside scar deposits, and these were subsequently processed in Topcon PI3000 in the same manner as the tunnel stereo pairs, but this was largely for practice; it was the tunnel sections that the photogrammetric recording was principally used for.

Recording in the tunnels:

The tunnel sections were recorded 'bay' by 'bay': the bays were the roughly 1 metre wide section between each 1960s tunnel support. Each tunnel was given a site subdivision (SSD) identifier: 5 for the Main (north to south) tunnel; 8 for the west lateral tunnel (running east to west branching from the main tunnel's west elevation at around bay) and 9 for the east lateral tunnel (running east to west branching from the main tunnel's east elevation at around bay).

SSDs 6 and 7 refer to the summit excavation and the hillside scar respectively.

The 1960s tunnel supports, bay by bay were marked with survey points, surveyed and stereo pair photographs were taken, a standard of 4 images per bay, one pair for the top half and one pair for the bottom half. The photographs were taken principally by the site Supervisor Duncan Stirk who also undertook the majority of the surveying. (Some of the photographs were also taken by other members of the temporary site staff and some of the survey was done by Tom Cromwell).

Issues:

The quality of the images varied due to the poor lighting conditions within the tunnel (though strip lighting was used to try and create as consistent a light level as possible throughout the tunnel recording process).

The surveying of the bays also had issues as it was discovered a fair way into the tunnel that the marked survey points were moving, sometimes around 10cm over the course of a day. This was caused by the tunnel supports themselves shifting, as the 1960s backfill was excavated, and due to the voids that had opened up in the hill, the tunnel supports were under increased pressure from hill material and collapsed hill material above and the supports started to sink and bend under the weight, shifting the deposits between them as well. The movement of the survey points made it difficult to tie in the stereo pairs from one day's recording to the next and many of the bays had to be resurveyed two or three times. This will probably go quite far in

explaining the issues Eddie Lyons (EH Graphics team) had when trying to use the photogrammetry projects to create effective visualisation/presentation graphics (see Appendix 4.4)

There was also the added difficulty of limited space, which became more and more of an issue the further into the hill the work progressed. Also, the hill was continuously shifting and the tunnels collapsing in places where voids were appearing above the tunnels. The 1960s supports, therefore, had to be reinforced with new support arches meaning that the photographs had to be taken from further away and with some of the supports in shot obscuring the view of the deposits.

Processing the images:

The processing of the images was done in the on-site office by Susanne Geck and Jenny Ryder with support from Paul Bryan and the photogrammetry team.

Renaming the files:

The images were downloaded and renamed according to their location, for example: 661_537Ebr.tif the name here indicates the following information:

- Characters 1-3: the site code; in this case, 661 identifying the file as belonging to the Silbury Hill conservation project.
- ‘_’ divides the site code from the rest of the spatial information.
- Character 5: the Site Sub-Division (SSD); in this case, 5 indicates the main tunnel.
- Characters 6 & 7: the bay (more specific area within the SSD); in this case 37 indicates bay 37.
- Character 8: a letter indicating, within the tunnels, which elevation the image is displaying, in this case ‘E’ represents the East elevation.
- Character 9: a letter indicating more specifically which area of the bay is shown, in this case ‘b’ indicates that it is the bottom half of the bay.
- Character 10: a letter (either l or r) indicating whether the image is the left or right image of the stereo pair.

The file name in the example shown therefore indicates that the image is the right-hand image taken of the bottom half of the East elevation, bay 37 of the Main tunnel.

Topcon PI3000

Importing/registering the data

Once the images were renamed in order to be descriptive and consistent, a new project was created in Topcon PI3000, usually with the photographs from a few bays at a time.

The ground control points were imported (these were .csv versions of the survey files), the image files were registered and the camera data was added (the camera calibration had been set using the associated Topcon PI-Calib).

Image Orientation

This stage verifies the angles and position of the camera in order to create a stereoscopic pair. The relevant left and right images of the stereo pairs are selected and registered and the pairs were identified in the software by combining their previous names into one hyphenated name. The relevant stereo pair was then selected and viewed in the orientation screen, the control points (survey points) were then located by clicking, using a target icon, on the exact point on each image where the survey point was marked. Extra points were also marked where parts of the image were identical in order to try and get as accurate an orientation as possible (pass points). The points were then 'measured' by the software and Topcon issues an 'OK' status to all points that were within an acceptable margin of error.

Automatic Surface Measurement

An outline (polyline) was drawn using the mouse around the area to be measured (in the Silbury tunnels, this was as much of the visible tunnel sections as possible, leaving out the tunnel supports). A breakline can be used to distinguish where there is a discontinuous surface, e.g., the tunnel supports were separate to the section and would have distorted the image, however, there was not usually much time to do more than the outline as the printed ortho-images were needed for work in the tunnels (see orthoimage section of this process). Once this was finished and the tool selected, the Topcon program measured the surface and created a TIN. The result could be seen in the Model screen.

Ortho-image

Again, this was done automatically using the Topcon PI3000 software, once the texture had been mapped onto the required TIN, an ortho-image could be created. An ortho-image was created in order for the archaeologists within the tunnel to create accurate section drawings using the printed ortho-image instead of manually drawing a section drawing in the traditional method using permatrace—a task that was thought to be more difficult and time consuming given the uneven nature of the tunnel sections, the length of the tunnel and the fact that it was revealed and shored up as the team progressed further into the tunnel. An ortho-image is different to a normal unrectified image, in that it has been adjusted for topographic relief and is therefore a more accurate representation of true distances. The Silbury ortho-images were printed at 1:5 scale and given to the archaeologists to take back to the tunnels and draw on the printout the lines between the different contexts, to be digitised as part of the post-excavation process.

Issues

As the lighting issues, tunnel collapses and need for more tunnel supports and shoring increased, the printed ortho-images became less helpful as the quality of the stereo pairs and therefore of the TINs and surface mapping degenerated. The archaeologists within the tunnel resorted to drawing the sections by traditional methods, in conjunction with the ortho-image printouts where possible.

The need to create the ortho-images each day for the archaeologists also meant that the processing of the photographs was done on a more hurried ad-hoc basis as the emphasis was on quickly creating the ortho-image and not of creating a high quality 3D surface, this could have been achieved through greater use of breaklines and more pass points as well as more checking and accepting less of a margin of error. The intention was that the ortho-image was the main product for the site works and then the 3D surface would be concentrated on in the post-excavation process in order to create a sophisticated, accurate and visually impressive 3D representation of all of the Silbury tunnels. This stage was not completed, however, and the products of the Topcon projects remain fragmented and unpolished.

Again, this is probably part of the cause of the problems encountered by Eddie Lyons of the EH graphics team (see Appendix 4.4 for his comments).

Digitising the sections

Once the fieldwork was completed, Jenny Ryder and Duncan Stirk continued to work on the tunnel sections, digitising the contextual information recorded by the archaeologists in the tunnel onto the Topcon 3D images. (There was debate about whether the digitising should be done in AutoCAD or Topcon see Appendix 4.2) This was completed to a satisfactory state in that a digital section drawing was created, but the 3D images themselves were not improved during this process, so the entirety of the Topcon PI3000 projects have been retained as there is no definitive finished product, just the digitised sections created from the unpolished 3D images.

2. The Topcon PI3000 projects at present (2013)

The digital archive has now been sorted, with the unnecessary or duplicate files weeded out and the retained files fully documented. The raw image files renamed to a more consistent and descriptive naming convention and sorted into a more logical folder structure. The Topcon Projects-which are essentially a process stage rather than either raw data or a finished product, have been retained as they are, with no movement or renaming of files in order to maintain their integrity.

It is hoped that these projects can be revisited and re-processed in order to create a more polished, accurate and consistent finished product.

The contents of the archive relating to the Photogrammetry work (excluding the Topcon projects) are as follows:

- 1,123 Photogrammetry Photos: 4 ortho-images; 10 calibration images;
- 1,109 Topcon images (i.e. the stereo pair photographs);
- 84 Digitised Topcon Projects (AutoCAD)-mainly the tunnel elevations;
- 121 survey files (though not all points relate to the photogrammetry work).

The contents of the Topcon Projects folders: most of these files were created internally by the Topcon software as part of the processing of the images to create a 3D surface.

The Topcon file types, in order of frequency, are as follows:

File type	File Count	Description
.imc	1115	Image Coordinates file-This file is internally generated by the Topcon PI3000 software.
.bmp	1052	This file is an image internally generated by the Topcon PI3000 software-manipulated versions of the stereo pair tiffs
.ext	1045	This file is internally generated by the Topcon PI3000 software.
.jpg	971	Generally these are the surface files created internally by the Topcon software (though a few of the original stereo pair images were jpegs as well.
.tif	834	Stereo pair images, these are duplicates of those saved separately in the EH Archive. 11 of these tiffs are part of the metadata
.rel	534	This file is internally generated by the Topcon PI3000 software.
.TIF	245	Stereo pair image
.ste	230	This file is internally generated by the Topcon PI3000 software. It contains data relevant to the stereo pairs.
.STE	220	This file is internally generated by the Topcon PI3000 software. It contains data relevant to the stereo pairs.
.txt	153	Generally the 'bundleresult.txt' files, internally generated by the Topcon PI3000 software, it is a key file for identifying how Topcon processed the information as it contains the relevant survey, camera calibration and image data for each particular sub-project
.cmr	85	The main camera calibration file used in the Topcon projects for the tunnel, Also saved elsewhere in the ADS archive.
.cs\$	83	This file is internally generated by the Topcon PI3000 software.
.dx\$	83	This file is internally generated by the Topcon PI3000 software.
.he\$	83	This file is internally generated by the Topcon PI3000 software.
.le\$	83	This file is internally generated by the Topcon PI3000 software.
.ti\$	83	This file is internally generated by the Topcon PI3000 software.
.pi4	81	Project file-the main file used to view the Topcon project-in this case the Main tunnel, East elevation, bays 01 to 03
.bm\$	78	This file is internally generated by the Topcon PI3000 software.
.bm\$w	78	This file is internally generated by the Topcon PI3000 software.
.or\$	78	This file is internally generated by the Topcon PI3000 software.
.JPG	27	Copies of stereo pair images (created by Topcon generally)
.IMC	10	Image Coordinates file-This file is internally generated by the Topcon PI3000 software.
.wrl	9	This file is internally generated by the Topcon PI3000 software - a general file for recording TIN and texture data.
.ort	7	This file is internally generated by the Topcon PI3000 software. (ortho-image)

.xls	5	These are the metadata spreadsheets.
.bmpw	4	This file is internally generated by the Topcon PI3000 software.
.BM\$	4	This file is internally generated by the Topcon PI3000 software.
.jpgw	3	This file is internally generated by the Topcon PI3000 software.
.pdf	3	Working images of ortho-images and points.
.dxf	3	This file is internally generated by the Topcon PI3000 software.
.CSV	3	Survey file used by the Topcon PI3000 software to locate images using target points, it is also saved elsewhere in the ADS archive.
.CV\$	3	This file is internally generated by the Topcon PI3000 software.
.DX\$	3	This file is internally generated by the Topcon PI3000 software.
.DXF	3	This file is internally generated by the Topcon PI3000 software.
.HE\$	3	This file is internally generated by the Topcon PI3000 software.
.LE\$	3	This file is internally generated by the Topcon PI3000 software.
.ORT	3	This file is internally generated by the Topcon PI3000 software.
.PI4	3	Project file-the main file used to view the Topcon project
.TI\$	3	This file is internally generated by the Topcon PI3000 software.
.TXT	3	Positional information file internally generated by the Topcon PI3000 software.
.dwg	2	test working drawings
.OR\$	2	This file is internally generated by the Topcon PI3000 software.
.tin	1	This file is internally generated by the Topcon PI3000 software. It is a Triangulated Irregular Network-a series of triangles that map a surface.
.BMP	1	This file is internally generated by the Topcon PI3000 software.
.csv	1	Survey file used by the Topcon PI3000 software to locate images using target points, also saved elsewhere in the ADS archive.
.bak	1	This file is internally generated by the Topcon PI3000 software.
Totals	47 file types	7327 files (85.4 GB)

3. The Photogrammetry archive metadata

The files also had to be fully documented in order that they remain as accessible as possible in the future, where possible all documentation was created according to the recommendations of the ADS and the *Guides to good Practice*(ADS and EH)

The documentation created during the archive preparation process for the photogrammetry files are as follows:

Topcon Projects (16 files):

- 11 tiff files-scanned images of plans of the survey points used to undertake the photogrammetry, (these were created during the archiving process using the stereo pair photographs)

- 3 excel spreadsheets-information pertaining to the different file types using the ADS templates. These are: Camera data; Image data; and survey data.
- Excel spreadsheet-file level-effectively an index of the Topcon project files
- Excel spreadsheet-project relationships: in addition to the ADS suggested templates, I have created a file relationship spreadsheet as so many of the photogrammetry files relate to each other. This basically states what image files were used with what survey files to create which project which was then digitised into AutoCAD.

The ADS standard metadata requirements for photogrammetry files are to provide information regarding: cameras, images, survey points (or reference/datum metadata), and the 3D models. Using the headings suggested on the ADS website (Guides to Good Practice section) the necessary documentation was created, as shown in the example tables below:

Camera Metadata

Camera Specifics	Camera Calibration File Name	Date of Calibration	Array dimensions in pixels	Array dimensions in mm	Focal Length and principal point	Lens Distortions	Affine distortions	Calibration Quality Values
Kodak DCS ProSLR/n 20mm lens f/22 1.2m focus	Pr661_2007_CameraCalibrationKodakDCSPro220mm1point2mfocus_Archive_v01.cmr	April 05, 2007	4500x3000	Unknown	Focal length: 19.968598mm; Xp Value: 17.489608mm; Yp Value: 11.670264mm	K1 Value: 2.807488 e-004 K2 Value: 4.943745 e-007; P1 Value: -9.526905e-006; P2 Value: -1.577939e-005	N/A	N/A

Calibration Quality Values	Calibration Adjustment Report	Number of images used for calibration	Calibration target description	Calibration Image file names	Original Camera calibration file name	Original Image file names.
N/A	Pr661_2007_CameraCalibrationKodakDCSPro220mm1point2mfocus_Archive_v01.cmr (?)	5	Topcon PI-Calib's Calibration sheet printed onto a board. The sheet contains rows of equally spaced dots, with five dots marked by squares. These mark a centre point and four periphery points. On the pattern of the Calibration Sheet, there are 5 squares.	Pr661_2007_Image-CameraCalibration-01_Archive_v01.jpg	Kodak DCSPRO2 20mm 1.2m focus.cmr	1.JPG

This is just an example, taken from file: Pr661_2012_Metadata-PhotogrammetryCameras_Archive_v01.xls; the data was entered into Microsoft Excel and contains 12 rows of data. Where the entry states N/A, I have been unable to find the relevant data. In addition to the ADS required fields, new file names have been added for the images and camera calibrations where they have also been saved elsewhere in the archive.

Image Metadata

Project Name	Number of Images used in project	Plan sketch File Name	Camera Calibration File Name	Image File Name (in Topcon Project folder)	Textural Description of location and orientation
914Eface	4	Pr661_2012_Drawing-PhotogramPointPlan-Diagram4_Archive_v01	Kodak DCSPro2 20mm 1.2m focus.cmr	661_914facebl4327.tif	Site Sub-Division 9: East Lateral Tunnel; Tunnel Face; bay 14

Format conversions	New image file name (saved separately in EH Archive)	Notes
converted from the raw 'DCR' format to TIFF using Adobe Photoshop CS2	Pr661_2007_TopconImage-9-14-Face-BL_Archive_v01.tif	Shows northern vertical part of support ring 13, 6 point labels and ID card reading "Silbury Hill 661 9:13 TERMINAL"

This is just an example, taken from file: Pr661_2012_Metadata-PhotogrammetryImages_Archive_v01.xls; the data was entered into Microsoft Excel and contains 1,191 rows of data. Where the entry states N/A, I have been unable to find the relevant data. In addition to the ADS required fields, new file names have been added for the images where they have also been saved elsewhere in the archive. In order to fill the 'Notes' field and make sure that the 'Textural Description' field was correct, this involved manually opening each image and entering the relevant data.

Reference/datum Metadata

Actual Point ID (as shown in photographs)	Source and Datum	x-coordinates	y-coord	z-coord	xyz covariance matrix	Textual description of location
493	Leica TCRM1203 Total Station. All positional data is referenced to the Ordnance Survey National Grid (OSGB36)	410001.698	168516.656	158.539	N/A	Possibly behind the shoring in around bay 56 in the Main tunnel, East elevation? Not visible in the photos.

Image with control point location indicated	Point ID as recorded in the survey files	Survey file name	Notes	Geometric constraints on reference features or control	Coordinate system
Pr661_2012_Drawing- PhotogramPointPlan- Diagram2- Sheet2_Archive_v01	PT493	Pr661_2007_SurveyData -0507_Archive_v01.csv	Not seen in the photos.	N/A	OSGB36

This is just an example, taken from file: Pr661_2012_Metadata-PhotogrammetrySurveyPoints_Archive_v01.xls; the data was entered into Microsoft Excel and contains 1,346 rows of data. Where the entry states N/A, I have been unable to find the relevant data, or it is not applicable. In addition to the ADS required fields, new file names have been added for the images where they have also been saved elsewhere in the archive. As with the Image Metadata, creating this table required looking at the images to see where the survey points were marked in order to check the co-ordinates and make sure that the plan sketches were accurate.

Model Metadata

In order to try and create the Model Metadata, a series of meetings/discussions were held with Paul Bryan to discuss where the information might be found, or if it could be generated if it didn't already exist in the archive.

The fields the ADS guidelines ask for are as follows:

- Name and version of the software;
- RMSE values;
- Constraints on object points;

For each point:

- Point type;
- XYZ priori and a priori;
- Covariance matrix a priori;
- Image coordinates and residuals;

For each image:

- Exterior orientation

N.B. Here the bundle.txt file found in each Topcon project and created automatically by the Topcon software is key. After meeting with Paul Bryan of the EH Photogrammetry team, it was established that these files contain all of the key information for re-use. The model metadata suggested by the Guides to Good Practice was not appropriate for the Silbury files as much of the information needed was either irrelevant to the Topcon software or could be found in the bundle.txt files anyway.

For the user of the Silbury photogrammetry archive, the bundle.txt file is essential.

In addition to the above tables, a spreadsheet detailing the relationships between the Topcon project folders, the images, survey files and detailing both the original names and the new names given as part of the archiving process was also created. An example row from this spreadsheet is shown below:

Photogrammetry Project folder name	Survey file (s) (original name)	New survey file name	Camera file	New camera file name
9Faceredone	661laterals3110_CSV	Pr661_2007_Survey Data-3110b_Archive_v01.csv	Kodak DCSPRO2 20mm 1.2m focus.cmr	Pr661_2007_CameraCalibration-KodakDCSPRO220mm1point2mfocus_Archive_v01.cmr

Original image name	New Topcon image name	Digitised Topcon Drawing original name	New Digitised Topcon Drawing name
661_9faceEI4491.TIF	Pr661_2007_TopconImage-9-Face-EL_Archive_v01.tif	N/A	N/A

Example from file: Pr661_2012_Metadata-

PhotogrammetryProjectRelationships_Archive_v01.xls

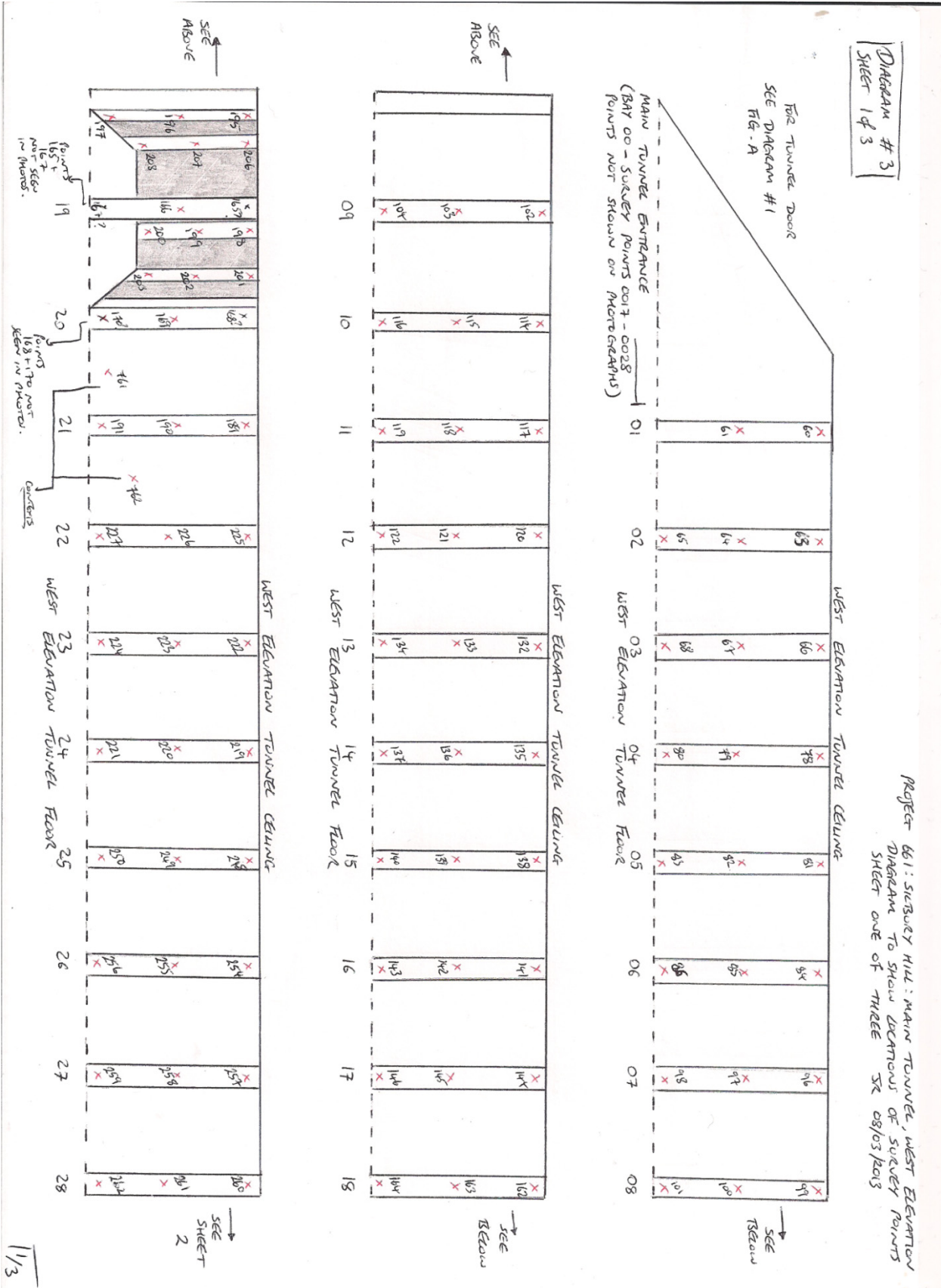
The creation of the Point and Image Metadata also required giving a textual description of locations and a plan of the locations of the survey points, for the images. The location is suggested in the file name, as shown earlier in this document, but in order to tie together the bay locations and the survey points, and ensure that the locations were correct, it was necessary to create an annotated plan from scratch.

The following 7 diagrams have been created:

- Pr661_2012_Drawing-PhotogramPointPlan-Diagram1_Archive_v01
- Pr661_2012_Drawing-PhotogramPointPlan-Diagram2-Sheet1_Archive_v01
- Pr661_2012_Drawing-PhotogramPointPlan-Diagram2-Sheet2_Archive_v01
- Pr661_2012_Drawing-PhotogramPointPlan-Diagram2-Sheet3_Archive_v01
- Pr661_2012_Drawing-PhotogramPointPlan-Diagram3-Sheet1_Archive_v01
- Pr661_2012_Drawing-PhotogramPointPlan-Diagram3-Sheet2_Archive_v01
- Pr661_2012_Drawing-PhotogramPointPlan-Diagram3-Sheet3_Archive_v01
- Pr661_2012_Drawing-PhotogramPointPlan-Diagram4_Archive_v01

- Pr661_2012_Drawing-PhotogramPointPlan-Diagram5_Archive_v01
- Pr661_2012_Drawing-PhotogramPointPlan-Diagram6_Archive_v01
- Pr661_2012_Drawing-PhotogramPointPlan-Diagram7_Archive_v01

An example (diagram 3, sheet 1) is shown below:



The documenting of the photogrammetry projects took 6 weeks in total; this is due to the fact that the process could not be automated or tasks done as batch processes. For documentation, the data has been entered into the spreadsheets manually whilst checking against the images and survey data simultaneously. This proved necessary because various issues with the data were highlighted as the work progressed:

- The names given to the survey points in reality and in the survey files were slightly different;
- Some of the survey points had been mis-named;
- In some cases, the same point ID had been given to different survey locations (e.g. duplicates between the summit excavations and the tunnel works;
- Some points were not marked in the photos;
- There was no master plan that was effective in showing the locations of all of the survey points and images;
- The tunnel supports during the site works were shifting (sometimes by around 10cm/day) which meant that some points were surveyed several times with different results, showing the movement of the hill. I have endeavoured to document each different point location used in the Topcon projects, which should go a long way to explaining why some of the sub-projects may not match with others.

In addition, and perhaps more than any other aspect of the digital archive, the photogrammetry data has required detailed specialist output in order to understand both the structure and function of the individual files within the Topcon system.

4. Appendix

Appendix 4.1: Notes on Photogrammetry from 2007/2008

Photogrammetry Notes

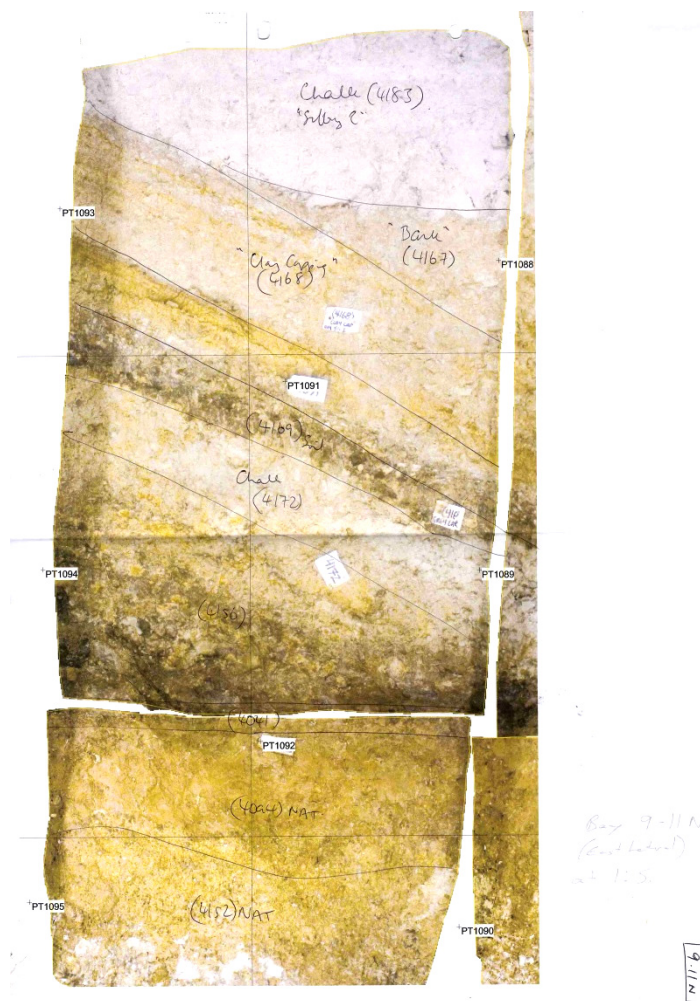
The following short notes were saved as 'Readme' txt files as the project progressed on site. As I am now preparing the files for archiving, I have combined these notes as they may prove useful should anyone revisit the Photogrammetry work. (JR 20/03/2012)

- Topcon Project 573E575E could do with a lot more work; the ortho-images are patchy due to fixing together various images because of the many obstructions to the tunnel sides. The 3D image is a mess, I will try and rectify this if I have time later, but it may be beyond my skills. (I'm only a beginner!) JR 25/09/2007
- 661_905Ntr4411 should actually be 661_905Ntr4412 (JR 30/11/2007)
- RE summit projects: I don't think these projects are very useful, they were all used as part of my training rather than as an actual part of the recording process. (JR 21.11.07)
- 9Facedone has not been digitised to date, 914Eface is the digitised version. JR 04/02/2008
- 562656WREADME.txt Though the images are saved into the project folder and appear to have been processed, the registered pairs for bay 565E do not appear in the project itself, however there is a 3-D version and an orthoimage for this bay. (JR 29/11/2007)
- 500PortalwestREADME.txt For some reason, this is wrongly named, the project is actually the West elevation, not the North, but cannot rename it at this stage. (JR 29/11/2007)
- 579WREADME.txt Although the images for 578W were copied into this project, there were too many obstacles for me to create a decent orthoimage and so the project was renamed to 579W. (JR 29/11/2007)
- 581WTomREADME.txt This project has not been completed successfully for reasons that remain unclear. (JR 30/11/2007)
- 582WTomv2README.txt This project has only partially been completed successfully, for reasons that remain unclear. (JR 30/11/2007)
- 569572Wread me.txt This project needs a lot of work, the lighting and focus are not great and the ortho-images are quite patch-worky due to using different images in order to get the least obstructed view of the elevation.
- 569572Wread me.txt The survey data for this project is titled 6611409A.csv in the TARGETS folder. JR 18/09/2007

Appendix 4.2: Digitizing the 2D ortho-printouts vs. digitizing in Topcon 3000.

The following document lists the advantages and disadvantages of digitising in AutoCAD versus digitising in Topcon. As I understand it, one of the main reasons for importing images into AutoCAD rather than digitising straight into Topcon was due to the belief that only half of the printed ortho-images were marked up, since all of the images have been marked up, it is possible to digitise in Topcon and use both section drawings on permatrace and the printed images as reference to get as accurate a digital version as possible.

NB: Due to the nature of recording in the tunnel, the marked-up ortho-printouts are not always the most accurate versions as they are not really measured drawings, so whether digitising in AutoCAD or Topcon, it may be necessary to change the positions of lines, where they clearly do not reflect the true stratigraphy e.g.:



In the soil layer (4169), the layer above chalk layer, (4172), the interface lines are clearly in the wrong place. This is more accurate in the permatrace

section, it seems as though the accuracy of the permatrace versus the printed images differs from bay to bay, which might make for quite a piecemeal section if done in AutoCAD.

AutoCAD Ortho-print Digitizing

- Pro- It may be quicker to do the very difficult bays? This is unclear. *After trying one of the darker bays in Topcon, it seems as if Topcon may be easier as the images are clearer.*

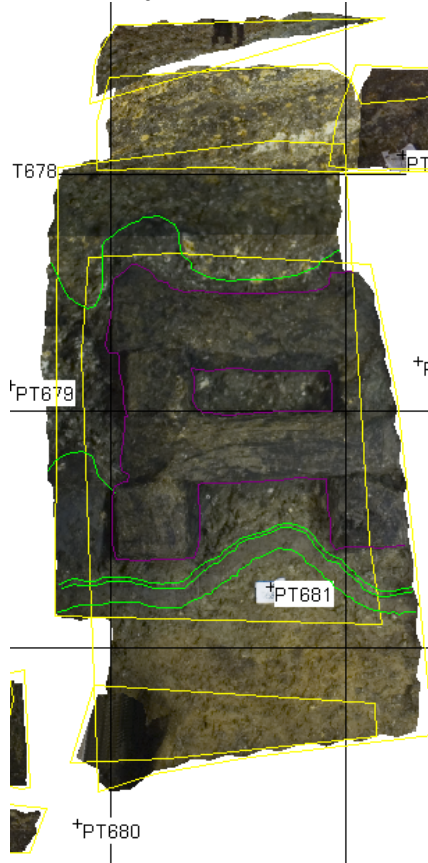


Image in Topcon

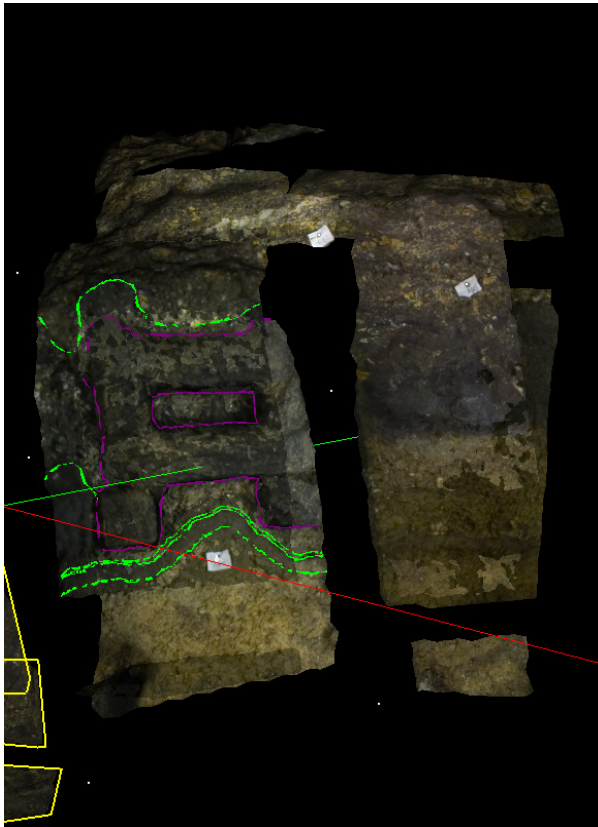


Scanned image

- Pro- It will be easier to add the more accurate section drawing information as it can be overlaid.
- Con- The interpretive lines drawn on the printouts are fairly inaccurate due to poor printouts where some strat is not clear. They were often annotated in low light, and there was no way to measure on the printouts. (The section drawings are more accurate) The source of the interpretive data is therefore the least accurate of the 3 possible sources.
- Con- There are problems with how and where the 2D images that we produce are fixed. We might be able to produce a cheap and cheerful elevation that is floating in space, but otherwise the huge variation in how far the control points are away from the strat. means that it will be

very inaccurate. What is the inaccurate and unfixed elevation to be used for?

- Presumably there will be a need for a 3D projection at some time. If this is produced by projecting our 2D elevation onto the 3D shape, we are magnifying once again the errors. Better to do the 3D projection in Topcon to start with.

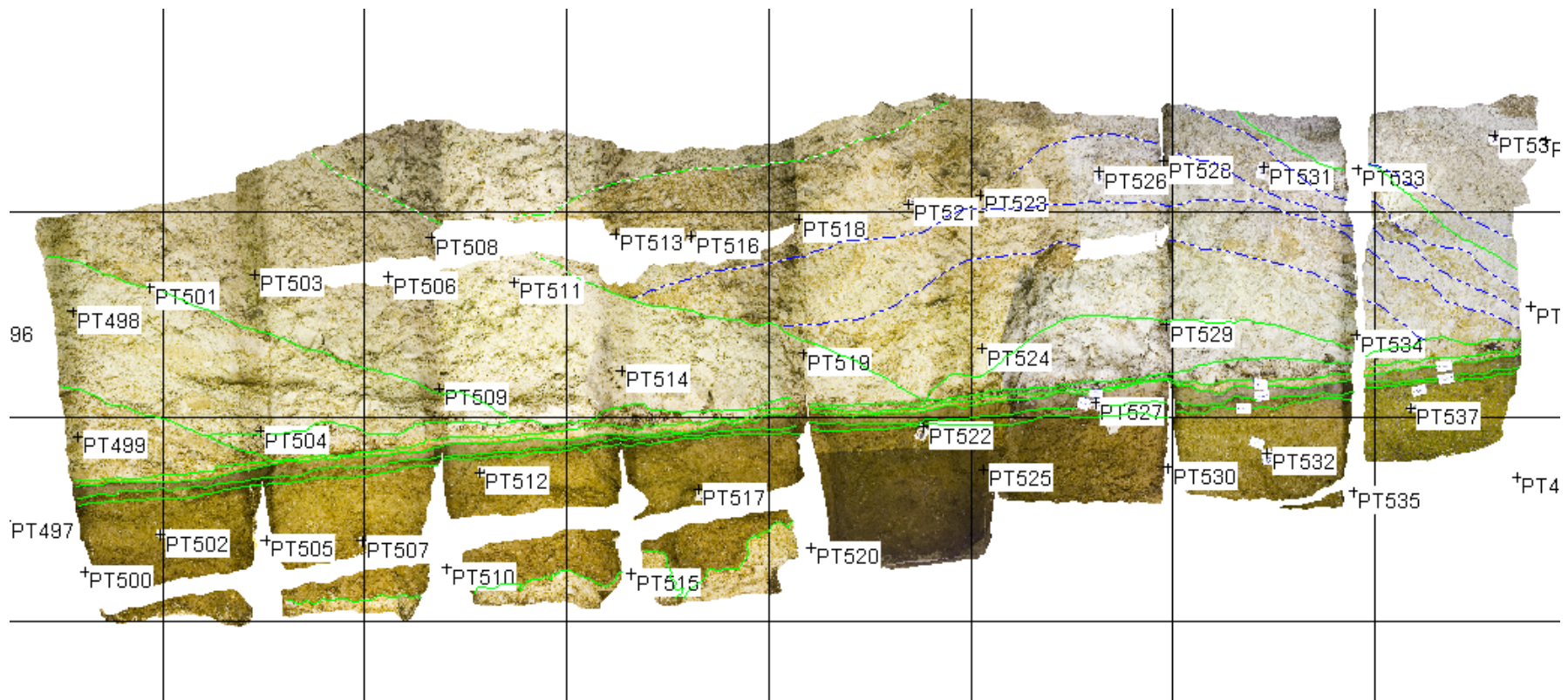


Same bay as above, in the 3D screen.

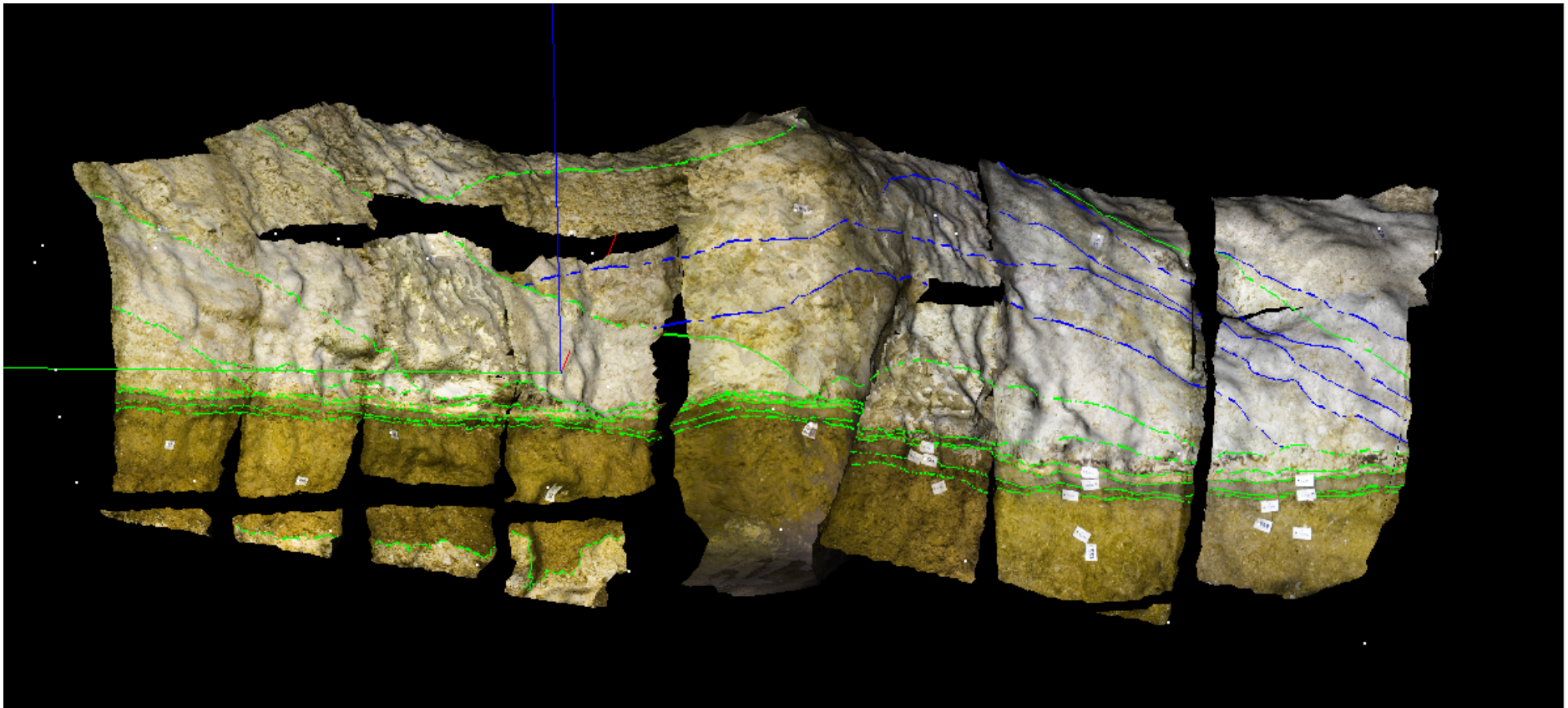
Topcon 3000 Digitizing

- Con- It is more difficult to incorporate the section drawing info in areas where the photos are not clear. *Having tried a problem area, the images are clearer in Topcon.*
- Con- Stretch errors have not yet been corrected by Paul Bryan's team. This ideally should be done before the definitive 3D model is done. *A lot of the distortion on the printouts are due to the image being stretched to make the photo 2D, in the 3D in Topcon, there is not the stretching, however, there are some issues with the supports being in the way in the 3D version, this does not prevent the image from being digitised, though.*

- Con- We currently only have one computer with Topcon software on it. *Depending on the method, Jenny could work in Topcon, and then transfer the digitised 3D model to AutoCAD, which can then be worked on by Duncan.*
- Con-There are a couple of bays that have not been processed in Topcon, but will have section drawings.
- Pro- errors are minimized as the strat is more visible on screen in the Topcon software than on the ortho printouts.
- Pro- A 2D projection in ACAD is easy to produce from the 3D Topcon model.
- Pro- A lot of the bays have already been digitized in Topcon on site, and this did not take long. Jenny estimates that it may actually be quicker than digitizing the ortho printouts. These were not done on the very difficult bays, *a few test projects suggests that overall, Topcon is the quicker way to go, even on the more difficult bays.*



Bays already digitised in Topcon showing context and tip lines.



Same bays as above in the 3D screen.

- Pro- The digitizing will only have to be done once rather than a rough version first, followed by a better version later.

Appendix 4.3: Digitizing notes (written as the post-excavation section digitizing process was undertaken Jenny Ryder and Duncan Stirk 01-02/2008)

EAST LATERAL

903N-910N

on the section drawings and printed ortho-images, the organic layer: 4100 peters out, but then a layer above the old ground surface (4041), which looks like orangey iron-panning is marked as 4100, I have not added this to the digitised versions as it is not the same layer and D.S. indicated that the iron-panning layers were not contexted towards the end anyway.

In bay 9.08N, I have added a line where 4156 ends just beneath the chalk nodule layer (4182), this line was not drawn on the sections originally.

The section drawing for bay 9.10N was labelled incorrectly and included a band of material that didn't appear to exist, so I have digitised the version as annotated on the orthoimage printout.

901S902S

Cut in bay 901S the line of the cut towards the top may need to be dotted as in the drawings, division between 4156 and 4157 is unclear due to slumping material and colour differences.

903S910S

Problems with 4182, this number seems to have been assigned to two different deposits, one a very chalky deposit, one a darker deposit, they're also in different places stratigraphically. I have given the darker material the number (4184) and have annotated the sections accordingly. I have dotted this in as it may just be a darker version of 4156, part of the primary turf mound. I have also written a context sheet explaining this further.

Digitizing notes

EAST LATERAL

903N-910N

on the section drawings and printed ortho-images, the organic layer: 4100 peters out, but then a layer above the old ground surface (4041), which looks like orangey iron-panning is marked as 4100, I have not added this to the digitised versions as it is not the same layer and D.S. indicated that the iron-panning layers were not contexted towards the end anyway.

In bay 9.08N, I have added a line where 4156 ends just beneath the chalk nodule layer (4182), this line was not drawn on the sections originally.

The section drawing for bay 9.10N was labelled incorrectly and included a band of material that didn't appear to exist, so I have digitised the version as annotated on the orthoimage printout.

901S902S

Cut in bay 901S the line of the cut towards the top may need to be dotted as in the drawings, division between 4156 and 4157 is unclear due to slumping material and colour differences.

903S910S

Problems with 4182, this number seems to have been assigned to two different deposits, one a very chalky deposit, one a darker deposit, they're also in different places stratigraphically. I have given the darker material the number (4184) and have annotated the sections accordingly. I have dotted this in as it may just be a darker version of 4156, part of the primary turf mound. I have also written a context sheet explaining this further.

Appendix 4.4: An assessment of the photogrammetry output from inside the tunnels in Silbury Hill (Eddie Lyons 19/11/2008)

Note: This document was created by Eddie Lyons who worked for the English Heritage graphics team, noting various issues with the photogrammetry data, as a response to his comments there are a couple of things that he was not aware of:

- *The survey points were moving due to pressure from collapsed hill material, with conditions for survey and photography within the hill degenerating towards the centre.*
- *Also, the projects created were done, by the end of the project, by temporary site staff who were trained in using Topcon PI3000 only so far as necessary to produce the ortho-images needed by the archaeologists within the tunnel.*
- *It was not the intention to have a completely finished, polished 3D representation of the tunnel by the end of the site works, that was always going to be done post-excavation, perhaps by Paul Bryan's team, though that has not yet happened, it is hoped that the archive may still be revisited and a complete end product achieved from the saved data.*

It may be that there was a response to this document, but I have not found it anywhere in the archive. I have kept these comments here as they tie in with the issues and comments raised in the previous appendices.

(Jenny Ryder Digital Archivist for the ADS, 2012-13 and Supervisor for Photogrammetry and Digital Data for the latter part of the Silbury Conservation Project, 2007)

The archaeological recording of stratigraphy inside the tunnels at Silbury Hill in 2007 was conducted photogrammetrically using Topcon PI3000 software. The control points used in the photogrammetry were provided by Total Station Theodolite (TST). The work was done by site staff (archaeologists) on short-term contract.

There were three tunnels: the main tunnel, and the east and west lateral tunnels. Each tunnel was regarded as a Site Sub-Division (SSD); the main tunnel was SSD 5, the west lateral was SSD8, and the east lateral was SSD9. Each tunnel was divided into "bays", defined as the spaces between the metal tunnel supports dating from the Atkinson excavation in the late 1960s. Each bay was numbered sequentially from the start of each tunnel. The stratigraphy was recorded photographically within each successive bay on both sides of the tunnel, either east or west for the main tunnel,

and north or south for the laterals. Each bay was distinguished by its SSD number, its bay number, and which side of the tunnel it was on; for example, the two sides of the tenth bay in the main tunnel were 510W and 510E.

The photogrammetry was divided into a number of "projects". Each project equated to one or more neighbouring bays on one side of a tunnel. Control points for the photogrammetry were placed on the metal tunnel supports supplemented by additional points on the tunnel face. Overlapping photographs provided left-hand and right-hand views for stereo plotting in Topcon PI3000, and also provided overlap coverage for the top part and bottom part of each bay.

The results of the Topcon projects are kept in the Silbury Hill project folder on the network in Fort Cumberland. They can be viewed individually using Topcon viewer software (not installed for everyone in the Fort). Otherwise they are accessible only with the original Topcon processing software, which is not currently installed on any computer in Fort Cumberland. Furthermore, this software is useable only with a hardware lock (dongle), the whereabouts of which are currently uncertain. (Hugh to confirm.)

All of the raw image files and the processed files are present in the project folder. The output includes a text file for each photogrammetry project named BundleResults.txt. These files include parameters for all of the control points, calculated points, camera, individual image files and stereo image pairs used in each project. However, some of the projects are missing this vital BundleResults.txt file (these are listed below).

In addition to the being output in Topcon format, each photogrammetry project was also exported in AutoCAD drawing file format. These AutoCAD files included surface meshes (as 3Dface objects), outlines of stereo image coverage, points (control points), and outlines of the stratigraphy, all as three-dimensional data. For the Silbury Hill Assessment Report and the Updated Project Design, these data were reprocessed in AutoCAD to 2D and combined to provide more traditional section drawings of the stratigraphy in the tunnel sides. At the time (early 2008) it was apparent that there were some discrepancies in the data, but consideration of this was left until a later time so that project deadlines could be met.

Aside from the production of illustrations, the 3D stratigraphic data are also required for analysis. This includes the three-dimensional reconstruction of Silbury Hill at various stages of development for output as DEMs for analysis in GIS.

Because of the discrepancies noted in the photogrammetry results in early 2008, it was necessary to assess their significance. The control point data were extracted from the individual BundleResults.txt files in each photogrammetry project folder and imported into a new AutoCAD drawing file (Tunnel Photogrammetry Control Points.dwg), and separated as point groups on individual layers. The layer name includes the photogrammetry project name (e.g. Point group 526W-530W).

What is immediately apparent are gaps in the data, which occur where the BundleResults.txt files are missing from the individual photogrammetry project folders. This reduces the overall ability to analyse the complete set of control points,

and to identify individual discrepancies. Nonetheless, the existing data allow many discrepancies to be identified.

The photogrammetry projects which are missing their BundleResults.txt files are:

547W-554W
574W-575W
576W-577W
579W
504E-510E
511E-516E
517E-519E
579E-580E

To fill in these gaps the control points were extracted from the relevant AutoCAD files. This at least provides a complete set of the control points used, although other data about the image parameters, stereo pair parameters, etc., are still missing.

The next most obvious results are the gross discrepancies between neighbouring point groups.

[[[Point groups displaced laterally]]]

[[[Gross differences in Z between neighbouring point groups]]]

Also apparent in the data are point groups that appear somewhat incoherent.

The overall quality and reliability of the photogrammetry output is further brought into question by a number of Readme.txt files included in the photogrammetry project folders. These make it clear that the operators left some photogrammetry projects unfinished, and that they had problems with others. These include:

569W-572W
578W
579W
581W
582W
562E-565E
573E-575E

Crucially, most of these problem projects are in the innermost part of the main tunnel, covering the stratigraphy for the earliest stages of the Hill.

This analysis of the photogrammetry control points has considered only the data at the output end of the process. It has not considered the control data used at the input end. Since the control points used as input data should be taken directly from the TST survey data it needs to be determined whether the survey data also displays the same discrepancies that the output data do. This will tell us whether the discrepancies originate at the surveying stage, or whether they are a result of the processing in Topcon. If the latter, then the most likely explanation is down to

operator error. This raises the question of whether these staff were sufficiently qualified or skilled to undertake the work.

[[[Photogrammetry work not completed - insufficient checking of the work - who's responsibility?]]] E.Lyons 2008