Cotswold Archaeology

FIELDWORK SURVEY MANUAL
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Introduction

This manual aims to provide a definition of responsibilities, best practices and processes for Cotswold Archaeology employees undertaking fieldwork survey. It is divided into sections guiding the user through pre-survey planning, setting out, survey, use of photogrammetric techniques, levelling, and an overview of the post survey process. There are several appendices included that detail the comprehensive DRS codelist, quick survey guides for Global Positioning System (GPS) and Total Station Theodolite (TST), photogrammetry methodology and survey record sheets.

Affordable survey equipment, correctional GPS and 3G/4G/5G connectivity have made it possible for archaeological features and sites to be located far more accurately and quickly than ever before. Since 2008 Cotswold Archaeology has used Real Time Kinematic (RTK) GPS and TST equipment to map and locate sites and the features on those sites. Using File Transfer Protocol (FTP), survey data can be quickly sent back to any of our offices, processed and turned into site plans, which is a far cry from the days of badly located and crumpled site plans turning up months after a site has finished. However, with this technology and know-how comes a heightened expectation from clients and curators for high standards of survey. It is essential that all Cotswold Archaeology employees understand the requirement for accurate and consistent survey practices from Archaeologists to Project Leaders and Project Managers.

Those members of staff given the responsibility for survey preparation or capture must follow the guidance in this manual wherever possible, in order to capture a complete and accurate record of the archaeology, before leaving site. Although new and affordable survey technology increases efficiency, compared to the days of hand tapes and automatic levels, time and care must be taken when surveying as digital survey forms a vital part of the site archive.

All CA standards for accuracy, number of points and tolerances must be maintained, along with the proper use of CA survey protocols and methods. Any situation where these standards cannot be adhered to must be brought to the attention of the Geomatics Team and project manager immediately.

Useful Contacts

Cotswold Archaeology

Office	Name	Position	Tel	Mob	Email
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Sunbelt survey processing support

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Sunbelt support (if you experience issues with the GPS in the field)

01293 565 565

Section 1 Pre-Survey planning

WSI/trench location plan

The project manager will in the first instance contact the Geomatics Team to prepare a plan of the site. This will usually be in ArcGIS format, webmap and PDF, and will typically show the following:

- site boundary
- proposed limits of excavation/trenching/test pits
- previous archaeological works
- scheduled areas
- geophysical survey results
- proposed development
- additional information - lidar, historic maps, geological, topo data, aerial
- service information (provided by client, Linesearch or directly from service company) and safety buffers
- other constraints (public footpaths, spoil heaps, tree protection orders etc.)
- proposed compounds or fencing

The site plan will use background mapping appropriate to the scope of the WSI:

- OS Mastermapping for urban work (where scales less larger than 1:1250)
- OS Vector Mapping for rural work with mapping scales of 1:2500 – 1:10,000 are required
- Client basemapping where this is available and appropriate for use
- Freely available basemap for webmap (although this can be changed if necessary)

If additional information, such as lidar or georeferenced historic maps, is required please request this from the Geomatics Team.

If no service information has been provided, the Geomatics Team will put in a search on the Linesearch website to request any service information. The results of the search and subsequent actions taken will be shared with project leaders. The results of the search and all correspondence will be published to Deltek, and their results added to GIS.

Any services found to be crossing the site will be mapped and an appropriate safety buffer will be added to the plan.

- Underground services – 3m buffer
- Overhead services – 9m for wooden poles (up to 33kv), 15m buffer for larger metal pylons (275kv to 400kv)

The plan will be sent to the PM as a scaled PDF. If areas are required for excavation areas these can be provided by the Geomatics Team.

Once the trench location plan has been approved, the Project Manager should contact geomatics and request stakeout data for the approved trenches. The stakeout data will be saved in .csv format which can be downloaded via FTP onto the survey equipment. For a straight trench a single point is generated at each end of the trench centre line. For trenches of different shapes, coordinates will be

issued accordingly. A stakeout plan will be provided in PDF format to assist the surveyor with stakeout.

The trench location plan and stakeout plan will be saved in the WSI folder in the Geomatics folder and published to Deltek. Trench locations will be published on webmap. A copy of the stakeout file will be saved to the FTP folder so it can be accessed from site.

Equipment

It is essential that the correct survey equipment is used for the job. Considerations such as tree cover, built-up areas, accuracy specifications and telecoms (i.e. signal strength etc.) are all important and can have an impact on the efficient surveying of the site. If you are in any doubt, please consult the Geomatics Team before the project begins.

CA has its own pool of dedicated VIVA and Captivate GPS kits that can be booked to a project in the equipment tab of the *CA Fieldwork Programme*. This should be done by a member of the Geomatics Team or Fieldwork Manager. If there is no suitable survey kit available, the Project Manager *must* contact the Geomatics Team to book a hire kit. The Geomatics team have sole responsibility for managing hire and off-hire of survey equipment and maintaining the relationship with our external suppliers. It is the responsibility of the Project Leader to check the GPS allocation each week as this is subject to change. PLs should not assume a GPS has been booked for them so please check.

When booking out survey equipment in the programme please ensure the *project name* and *number* are included.

CA has 4 Camranger and Photomast kits for elevated photography. These also need to be booked in advance by project managers and added to the programme.

Survey equipment check lists

It is best practice to prepare an equipment list before going to site so that you don't forget anything. See below for an example of an equipment list for a Total Station survey.

Make sure that all the survey equipment is in working order – SD cards are in the instruments; all batteries are charged and that you have all the peripherals and mapping that you need. Batteries can be charged from the 24v power supplies in most modern welfare cabins, a power invertor is available if batteries need to be charged from CA vehicles. Also include stakes, nails, and a wax crayon stick for installing control points. Remember to fill in the daily survey sheet to record your work for Quality Assurance checking.

Total Station Survey

Standard Equipment required

1 Leica TCRP 1203 or equivalent

1 1 man kit - controller, controller plate, 360 prism.

Automatic level (dumpy)

Target sets - prisms, tribraches, mounts

1 Sectional staff (Timber/plastic)

PK Nails/Hilti Nails

1 GST20 tripod

1 Metal tripod for levelling

1 Pocket tape measure, stiff bladed if possible (min. 2m long)

Wooden Stakes

1 Yellow wax crayon stick

1 Detail Pole - make sure it has the correct adaptor to take a Leica prism

Special Equipment required

1 Mini prisms for burials

Personal Protective Equipment (PPE)

Standard - hard hat, steel toe cap boots, hi-vis jacket or vest, safety glasses, gloves

Survey equipment care

- GPS/TSTs should always be put away in the hard case when being transported. All poles and GPS boxes must be removed from vehicles at night.
- If your equipment gets wet during the day, ensure it is left out if the opened box to dry overnight. If the equipment or box gets dirty ensure this is cleaned off.
- If any damage or problems are noticed with the equipment, please contact the Geomatics Team.

GPS kit

Each GPS should come with a controller (handset), an antenna, a pole, a clamp, a pole holder base plate, 4 batteries, a SIM card, an SD card and charger. The box, antenna, pole and controller should all be labelled with the GPS number. If the label or any parts are missing, please contact the Geomatics Team.

TST kit

The TST kit should come with two hard cases, one TST, a radio handle, 4 batteries, at least one tribrach, at least one tripod, a controller, a detail pole, a 360 prism, a clamp, a pole holder base plate, a SD card, and a charger.

You may need to take the following: additional tribraches, tripods, prism set and dual strut bipod (for establishing control), survey nails, chalk, note pad, tape measures.

Hire equipment

- Hire kits need to be configured before use on site. Please contact the Geomatics Team if this is needed
- An on hire/off hire form will be completed for all hire equipment
- Project leaders must make sure when receiving or having survey equipment collected from site that a thorough record and check is made. We must have a collection or delivery note detailing all items collected/delivered so we can chase these up with our suppliers

Health and safety

- Surveyors must ensure the necessary PPE is worn as referenced in the CA Construction Phase Plan (CPP) and accompanying risk assessment.
- The surveyor must also ensure compliance with any existing health and safety risk assessments prepared by the client/principal contractor.
- If a risk assessment has not been completed this must be carried out before site work is started and reassessed once site reconnaissance has been undertaken.
- A copy of CASHE and other relevant health and Safety documents must be accessible on site and the surveyor must adhere to all CA H&S policies.
- Lone work should be avoided if possible but if this unavoidable then the surveyor must follow the CA safe system of work for lone working.

Reconnaissance

Reconnaissance should be carried out in advance of taking any instrument from its box. Time spent in this initial planning stage of any survey can save problems later. Control stations should be kept to a minimum and should be inter-visible where possible to allow sighting checks and should be positioned to maximum effect for the collection of survey detail.

Significant changes in elevation across the site should be noted and influence the amount of data you collect. For sites with a large variation in elevation more points will need to be taken to show this. PL might be asked to measure a grid of points across the site before the work commences – please check this PM before the work starts and inform Geomatics team.

Consider how the project will unfold before setting out. If there are identified areas of site which will take longer to complete, or are of a higher priority, then these should be set out first.

When carrying out an earthwork survey, reconnaissance is essential to enable a full identification of the features and their extents.

If the survey strategy is not suitable for what is found on site, then now is the time to highlightit.

Section 2 Setting out

Site Control

Control points (stations) are typically nails or wooden stakes that have been installed in the ground and positioned with GPS/TST. They are used in the following scenarios:

- when using a TST, control points are used as known points over which the instrument can be set up (see INSTALLING A CONTROL NETWORK FOR TST SURVEY),
- when using GPS, control points are used to take check measurements to confirm the accuracy of the instrument (see below),
- when using a level, control points are also used as height benchmarks from which you can use an automatic level to transfer heights (see SECTION 5 LEVELLING).

Important - Some projects have strict specifications from the client for setting up control on a site and taking a check point at the start and end of each survey job. We will be expected to demonstrate that we have set this control up and cross reference it throughout the project. If you have any concerns and questions, please contact the Geomatics Team.

Use either a PK survey nail or a wooden peg with a nail driven into the top to mark your station. A PK nail driven directly into tarmac is preferable to a wooden peg, as it is harder to dislodge.

If you are on a site where your station could be disturbed by plant, or the public then please create a cordon around the station.

Make sure to record the location of the control point (a sketch plan) and take a witness photograph showing general location of the station and another showing a close-up, so that the station can be easily relocated. Pass this information to Geomatics team. They will store this information and use it to compile a survey report if required.

If control points for GPS survey are required, for any subsequent survey carried out on site, a check point (one observation) must be taken on a minimum of 1 control point at the start and end of each survey job. These must be 2 different control points.

See APPENDIX 2 VIVA GPS GUIDE and APPENDIX 3 CAPTIVATE GPS GUIDE for full details on how to install control points.

Installing a Control Network for TST survey

When creating a series of control points for use with a TST, the surveyor will need to position a minimum of 2 points with a GPS. Please see APPENDIX 2 VIVA GPS GUIDE and APPENDIX 3 CAPTIVATE GPS GUIDE for details on how to set the control points.

Any additional stations that you need to add can be positioned by traversing the TST. Essentially a traverse is a repeated set of backsights and foresights which allow the TST to calculate where it is and where the next station is. On a site with 2 GPS stations a traverse would begin by setting the TST up over one station (B), taking a backsight to the other (A). Once this has been done the next step is to take a foresight onto the new station (C). Now that you have both your backsight and foresight you can move onto the next station and repeat the process (i.e. setup over C, backsight to B and foresight to new station D).

There is a TST App for controlling TST traverses, if you think that traversing will be required, make sure that geomatics team is aware that you require this App to be active on the controller *before* they rent the equipment.

You must always ensure that the traverse is closed on the point of origin (closed), or another known point (open). This is necessary to calculate the misclosure and distribute the errors evenly across the traverse.

The details of these foresights and backsights must be recorded on the Level sheet (see APPENDIX 7 RECORD SHEETS for a template).

Stakeout/setting out

Setting out points for areas of excavation can be done using a range of methods and instruments. Co-ordinates and plans will have been supplied by Geomatics before the project is due to start and most commonly a GPS instrument will be used to locate these co-ordinates when on site.

Stakeout/setting out with a GPS

When staking out with a survey instrument most of the time a GPS unit will be used. It is possible to set out using a TST, but when compared to GPS it is far more time consuming.

- You will need to take survey flags (sometimes wooden stakes, canes or road irons are used instead), masking tape, a permanent marker and a site plan with the trench locations marked on it.
- You will require a stakeout file prepared by the Geomatics Team. This can be downloaded from site via the FTP server or loaded onto the device prior to the stakeout.

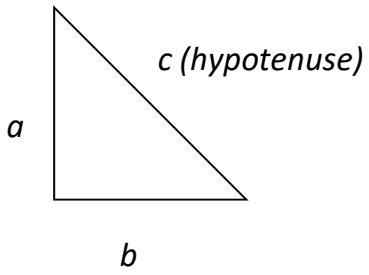
Once you have the stakeout file on the GPS, select the point you wish to stake out on the plan and select that point on the instrument. The GPS will then guide you to that point location.

You must always take a measurement on the stakeout point with the GPS or TST. Place a marker flag in the ground and write the trench number on the masking tape and attach it to the flag. Note on your site plan that this point has been set out and proceed onto the next point. Keep your annotated site plan safe as it provides a useful written record of progress for the Project Leader and a useful QA document for Geomatics.

For details on how to use our GPS's to set out a site and download stakeout data see APPENDIX 2 VIVA GPS GUIDE and APPENDIX 3 CAPTIVATE GPS GUIDE which contains full instructions.

Setting out grids with measuring tapes

A right-angled grid can be set out for the purposes of creating hand drawn plans by using metal grid pegs (with wooden/plastic cap), measuring tapes and Pythagoras theorem.



The Pythagorean Theorem

If *a* and *b* are the lengths of the legs of a right triangle and *c* is the length of the hypotenuse, then the sum of the squares of the lengths of the legs is equal to the square of the length of the hypotenuse.

$$a^2 + b^2 = c^2$$

Using this theorem, we can calculate the following:

- 5x5m grid the hypotenuse would be 7.07m
- 10 x 10m grid the hypotenuse would be 14.14m

The grid should start at 100E/50N and each grid peg labelled so that they can be correctly labelled on any plans and surveyed in later.

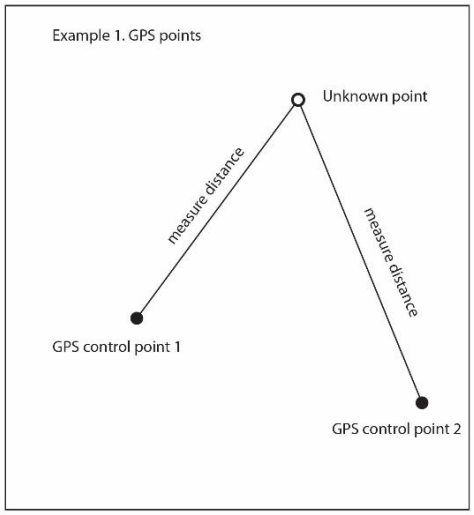
Locating points using triangulation

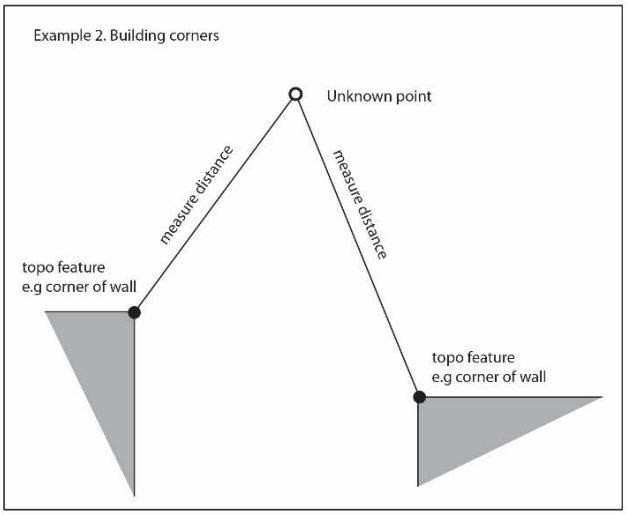
If you are unable to locate the site of an excavation, an archaeological feature, or a grid by surveying it with a GPS or TST, then it is possible to locate it using hand tapes and triangulation, although this method should only be used as a last resort.

The point can either be measured from known topographic features on your site (i.e. building corners, field boundaries) or known coordinated control points that have been surveyed e.g. if a site is under cover of a tree or building then points can be surveyed where the GPS *does* have signal and measurements taken from those points.

For each point you want to locate (e.g. for each grid peg or corner of trench) you must have a minimum of two measurements to two known points (See diagram below). This needs to be drawn up carefully and given to the Geomatics Team.

Once two measurements have been taken then the point can be triangulated and located on the OS grid.





Setting out fieldwalking transects using a GPS

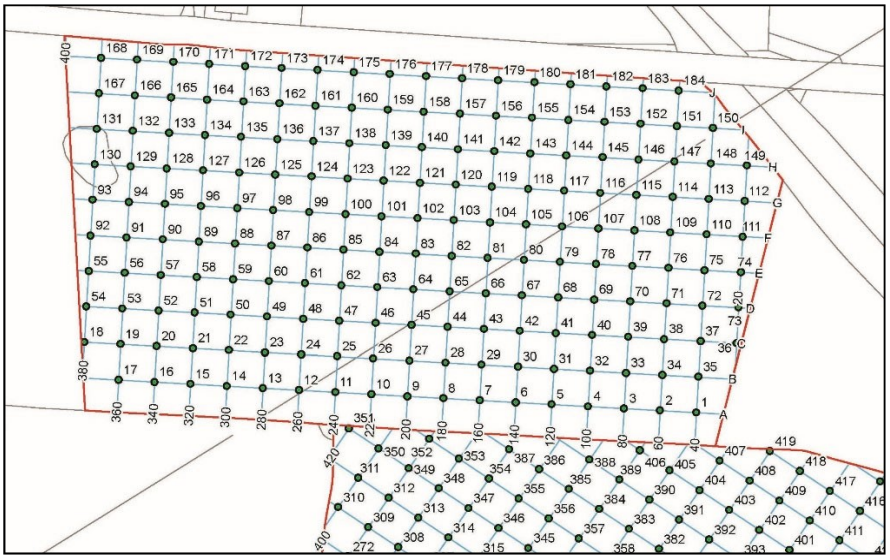
When staking out fieldwalking transects this should always be done with a GPS unit. This should rarely be a problem as by its nature this is usually carried out in open space with few impediments to GPS signal. Transects are usually spaced 10 or 20m apart.

You will need to take survey flags (sometimes wooden stakes, canes or road irons are used instead), masking tape, a permanent marker, and a site plan with the predefined transects marked on it.

You will require a stakeout file prepared by the Geomatics Team. This can be downloaded from site via the FTP server or loaded onto the device prior to the stakeout.

Select the transect point you wish to stake out on the plan and select that point on the instrument. The GPS will then guide you to that point location. Transects should be labelled by Field number, Transect and distance e.g. 1A10 (Field=1, Transect=A, distance=10m)

As mentioned before, see APPENDIX 2 VIVA GPS GUIDE and APPENDIX 3 CAPTIVATE GPS GUIDE for full instruction for stakeout procedures.



Section 3 Survey

Survey

CA has a dedicated pool of Leica GPS kits available for survey on sites. The Total Stations use the same operating systems as GPSs and essentially work the same way.

The Leica instruments work by attaching codes and attributes (i.e. context information) to survey points.

The attributes attached to the points contain specific data relating to contexts, section lines, sample points etc.; the instruments use these attributes to draw lines between the coded points to show polygons and linework when processed.

As mentioned in SECTION 2 SETTING OUT, there are specific instances when it will be necessary that permanent ground markers be setup on site. A minimum of two of these must be surveyed at the start and end of each survey job on the GPS or TST.

Daily survey sheets must be completed online for each survey job. The form is located at https://form.jotform.com/203215631820040

Survey quality

As the digital survey is the primary record of the site and has by and large replaced hand drawn plans, the requirement for quality survey is very important.

The GPS equipment is configured with a threshold of 0.05m for Three-Dimensional Coordinate Quality (3DCQ). Points measured should not exceed 0.05m. If your GPS is giving measurements over 0.05m then please wait until the GPS is receiving a better signal (satellite or internet data) or contact the Geomatics Team to arrange alternatives.

The Geomatics Team will check for survey gaps/disconnects and will feedback where there is a perceived lack of enough points to accurately record the shape of features and where post-ex survey has not been undertaken.

Additional points must be recorded, if deemed necessary, in order to produce an accurate representation of feature shapes at 1:50 scale (typically acceptable for routine ditches and pits/simple field systems etc.) and/or 1:20 for more complex or significant features that are likely to be published in detail (i.e. structures and other 'special features').

QA of survey data must be done in 'real time' when the team is still on site, such that features can be surveyed/re-surveyed appropriately before the chance to amend survey errors is lost. If additional geomatics resource is required, such as on-site editing, Project Managers or Project Leaders should relay this to the Geomatics Team.

Surveyors are encouraged to use the **map** screen on their GPS/TST to QA the integrity of the survey 'as they go', taking extra points as necessary to accurately record feature form for representation at an appropriate scale.

All archaeological features must be post-ex surveyed when excavated or cleaned up, even if they have already been pre-ex surveyed. This includes relationships between features if they can be determined, such as ditches, even if not fully excavated.

For sites where photogrammetry is being utilized, surveyors should be mindful that this is not a replacement for the survey but is a tool to enable additional detail to be captured and to aid analysis. Please ensure all features are surveyed to an adequate level of detail (especially structures).

Project leaders and surveyors should continue to ensure they thoroughly check all survey updates provided by the Geomatics Team and respond promptly to any queries on survey quality.

If you are working on a steep slope, then pick up more points to show differences in elevation.

Be sure when recording points that the detail pole is held vertically and as still as possible, use the levelling bubble on the staff to guide you in this.

Survey points spacing

It is difficult to prescribe a set amount of survey points for features as each should be judged individually, but it is possible to give an indication on the frequency that points should be taken on a feature. This way we can avoid taking too few or too many points.

These figures below should be taken as a guide only and it is up to the surveyor to adjust this dependent on how irregular or curved a feature is. If features are being surveyed as pre-ex then a minimum of points should be taken, however, when post-ex survey is being done enough points should be taken to allow site plans to be reproduced at 1:50, 1:20 or 1:10 without features looking 'pointy' or too angular, if in fact they are curved.

Pre-ex linear feature: c. 1 point every 2-3m on a straight; 0.5-1m if it curves or bulges

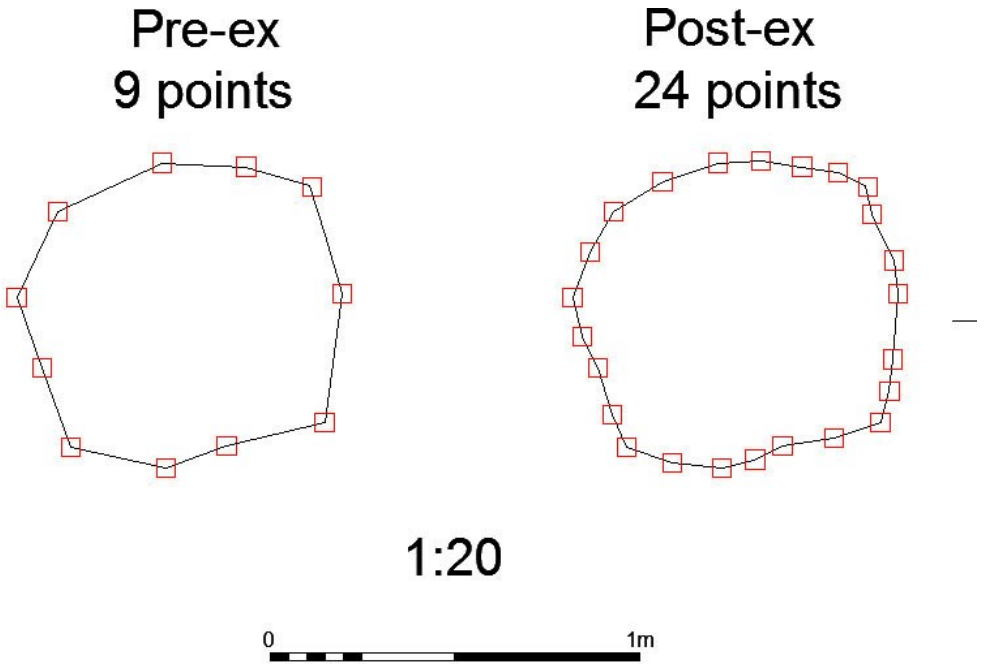
Pre-ex circular feature: c. 1 point every 0.2m

Post-ex linear feature: c. 1 point every 0.5m on a straight; 0.2m if it had a curve or bulge

Post-ex circular feature: one point every 0.1 m; 0.05m if irregular or sharply curving

Excavated intervention: Should match the number of points taken for the post-ex feature

Sections: Two points at either end, and on any change in angle



Codelist

All survey must be undertaken using the CA codelist. The latest version is DRS v2. The codelist should be loaded onto the survey instrument. If the codelist is not on the survey kit, then it can be downloaded from the FTP server (see APPENDIX 2 VIVA GPS GUIDE and APPENDIX 3 CAPTIVATE GPS GUIDE).

The codelist defines how features are surveyed. Details of attribute data required for each code are listed in APPENDIX 1 SURVEY CODE LIST. Typically, these attributes would ask for the context ID, the sur_type (i.e. Interpretation), and some comments (if applicable).

Code	Description	Type	Code	Description	Type
Burial_ply	Burial feature	Area	**Find_pt**	Registered artefacts	Point
Burial_sk_ln	Skeleton schematic plan	Line	**Intervention_ln**	Break of slope	Line
Burial_sk_pt	Skeleton level points	Point	**Intervention_ply**	Excavated interventions, base of feature, break of slopes	Area
Constraint_ln	Constraint line	Line	**Level_pt**	Spot height	Point
Constraint_ply	Constraint area	Area	**LOE_ply**	Limit of exc/ev	Area
Control_pt	Stations	Point	**Modern_ply**	Modern features	Area
Deposit_ply	Deposits and fills	Area	**Natural_ply**	Geological and natural features	Area
DP_pt	Drawing points	Point	**Section_ln**	Section lines	Line
Enviro_pt	Samples	Point	**Structural_ply**	Structures	Area
Feature_ply	Cuts, preex, furrows	Area	**Target_pt**	Photogrammetry targets	Point

Pre-ex survey

Once a site has been set out and stripped to the archaeological level a pre-ex survey may be required. This will help the Project Leader/Manager plan the excavation strategy by giving them a map of the site. This will also preserve the location of features in the event of flooding, or the project being stopped for any time. Pre-ex site plans are often required from our clients to get a sense of how much archaeology there is to deal with.

The essential components of the pre-excavation survey are the limit of excavation (LOE_ply) and the basic outlines of features that are exposed. If features are very clear and unlikely to change much (e.g. linears), once they have been excavated, it is worth spending more time and surveying with a bit more care so the survey can be used as post-ex survey. If this is the case use the relevant codes in the codelist. Pay attention to the points spacing (SURVEY POINTS SPACING). However, if some areas are very complicated or busy the rapid pre-ex should be used (e.g. for clusters of pits) so that it is made obvious that these areas will be resurveyed once they have been excavated (*Feature_ply, sur_type: rapid_preex*).

If the Project Leader requires any additional detail to be surveyed, they should guide the surveyor in this regard. Examples of additional detail may include modern services, buildings and disturbance, haul roads, geological/natural layers, furrows, and other constraints.

Ideally you would assign context numbers before you do the pre-ex survey but often this won't be the case, so arbitrary numbers can be used.

When surveying the LOE, take points along the edge of the trench at the base of the stripped area. Continue the line of points ending approximately 2m from the starting point. Once the survey is downloaded the final point will be joined to the starting point to form a closed polygon. If you survey beyond the starting point, then the final polygon ends up looking messy and needs further work to tidy it up. When you have finished the base of the LOE then survey the top LOE, use this method for both evaluations and excavations.

Due to the way the codes work, all survey features must be surveyed as closed polygons (except line and point codes) so make sure the surveyed feature starts and ends in the same place (or just before). When doing pre-ex survey try not to show any relationships as these will be determined once the features have been excavated.

Use the guidance in SURVEY POINTS SPACING section for point spacing.

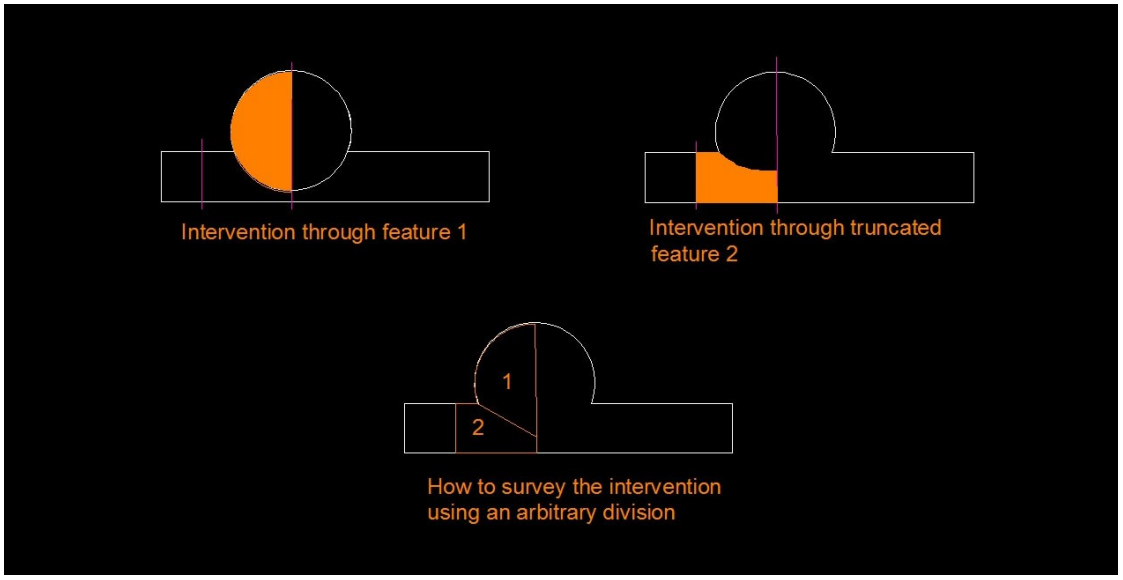
Guidance on use of our Leica instruments for surveying features can be found in APPENDIX 2 VIVA GPS GUIDE and APPENDIX 3 CAPTIVATE GPS GUIDE.

Post-ex survey

When a feature has been excavated and recorded post-ex survey is required. This can include the extent of the excavated intervention, an updated extent of the feature, the section line(s), any drawing point, geo-reference point, registered artefact point or environmental sample points etc.

Firstly, re-map the extent of each excavated feature to record any changes in plan now that it has been cleaned up and relationships between inter-cutting features defined. Use the correct cut number that has been assigned to the feature. Be sure to use the correct code and input the type now that the feature has an interpretation. In the case of a linear feature, survey at least 5 – 10m either side of the intervention and assign the cut number or survey the entire linear if only basic pre-ex survey has been done. See APPENDIX 1 SURVEY CODE LIST for a guide on which code to use.

Survey the extent of the intervention (i.e. excavated part) for the feature. If the intervention is through inter-cutting features then please survey a polygon representing each cut, in most cases it will not be possible to accurately survey the cut where it has been excavated, instead create an arbitrary boundary between the features for the purposes of survey. Please see below. For most complex interventions a hand plan should be created which can be digitised if more detail is required in the site plan or for illustration purposes. Do not survey in any overcut interventions (these can be surveyed as a sondage on the LOE code (if necessary). Do not survey the interventions without the cut.



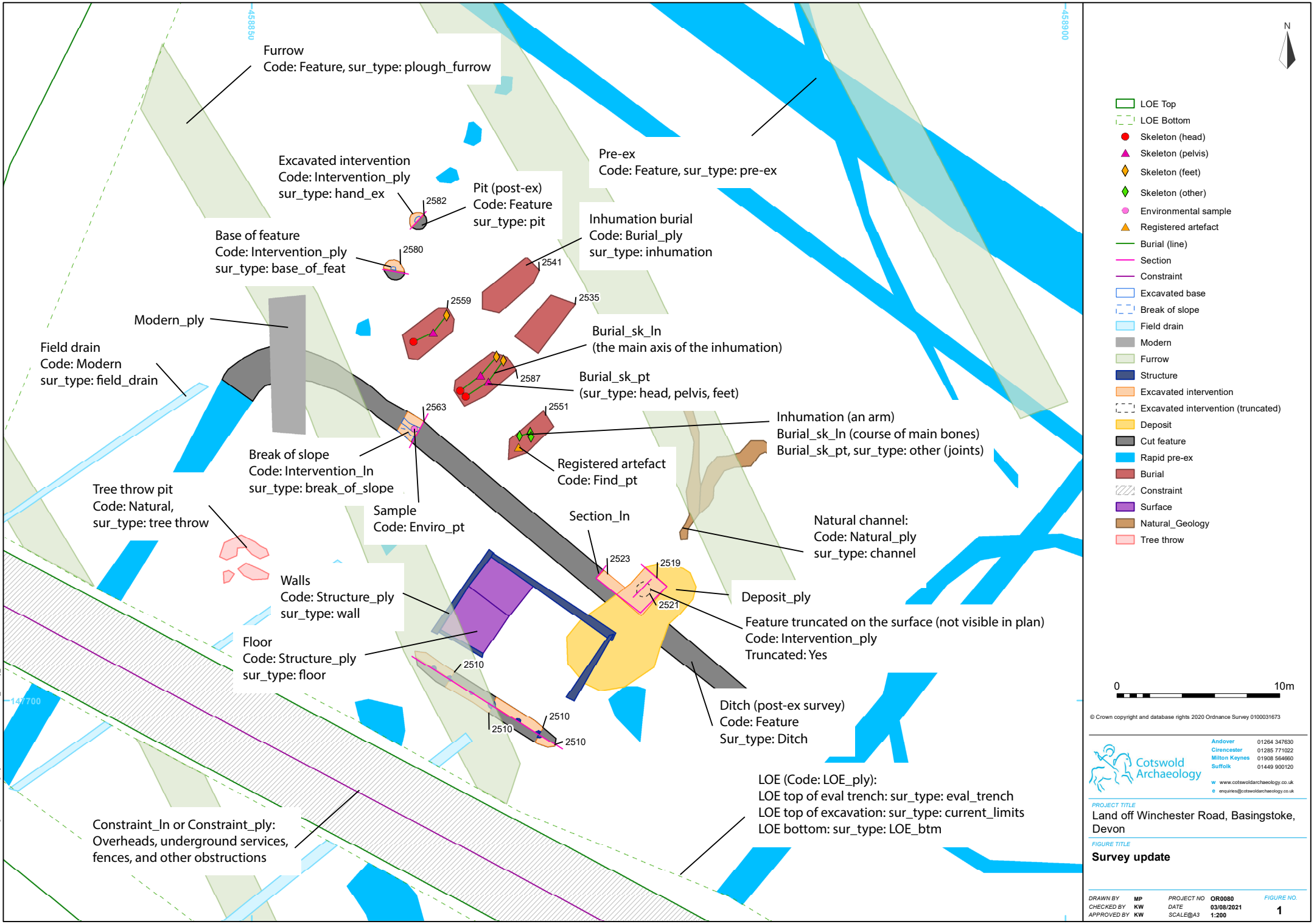
Make sure to survey any breaks of slope and base of intervention.

The profile of the feature (taking points on each change in slope) should be surveyed. The profile information can be used to calculate volumes of interventions as well as provide a cross check for section drawings (see section SECTION LINES)

Context number should be assigned to every intervention and excavated feature. It is a project leader's decision whether assign context numbers to unexcavated features or not.

For features that are only recorded in section (this might include cuts, deposits, and walls etc.), the position of the feature must still be recorded as an intervention and a feature – this can be done in a form of a narrow rectangle surveyed just under the section. This way the number can be labelled and queried in GIS.

Completely truncated features can be surveyed using the "truncated" attribute in the intervention code. This attribute defaults to 'No'. if 'Yes' is selected from the drop-down menu the feature will be dashed lined in GIS but will still have a label showing the context number.



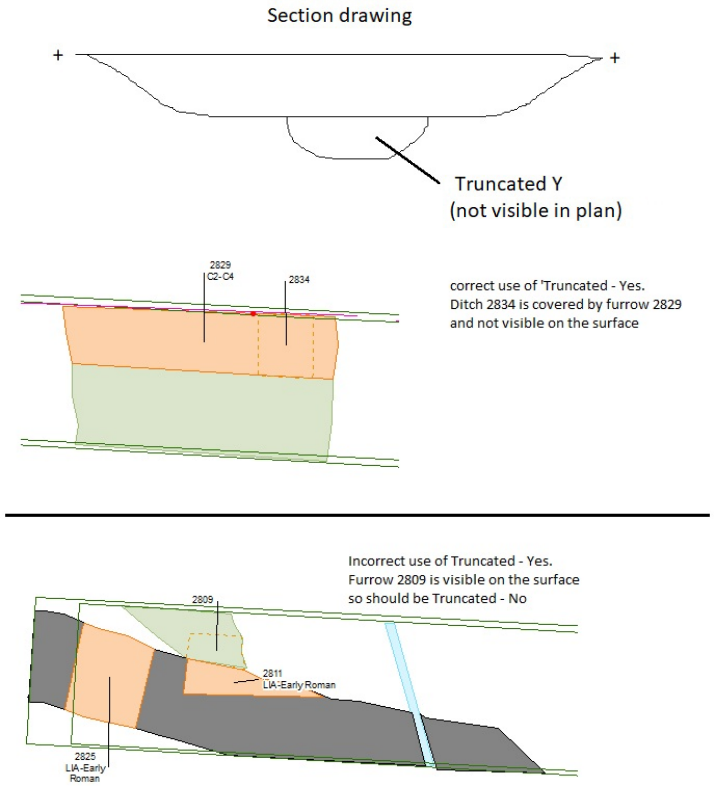
Cotswold Archaeology
Andover 01264 347630
Cirencester 01285 771022
Milton Keynes 01908 564660
Suffolk 01449 900120
w www.cotswoldarchaeology.co.uk
e enquiries@cotswoldarchaeology.co.uk

PROJECT TITLE
Land off Winchester Road, Basingstoke, Devon

FIGURE TITLE
Survey update

DRAWN BY	MP	PROJECT NO	OR0080	FIGURE NO.	
CHECKED BY	KW	DATE	03/08/2021		1
APPROVED BY	KW	SCALE@A3	1:200		

Document Path: P:\OR0080 - Digital Recording System DRS\GIS\OR0080_survey_master.mxd



Walls and structures should be surveyed at the top and bottom and at least one cross section/profile line surveyed. If stone by stone recording is required, photogrammetry or photo-rectification should be considered, see SECTION 4 PHOTOGRAMMETRY.

Section lines

When surveying section lines, start at the left-hand side as you face the section.

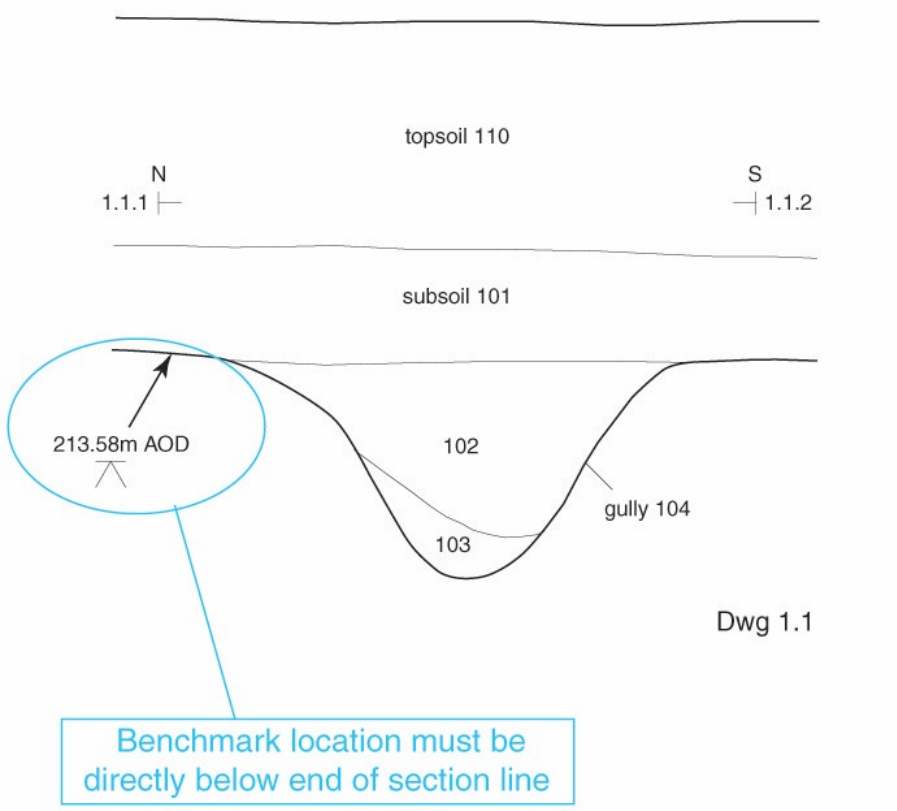
In the GPS survey screen re-number, your point ID to the Section Line number i.e. 102.1, 102.2, etc.

When surveying sections, take the GPS point **on the base** of the trench or excavation area below, not on the string line.

Ensure that the point of the GPS detail pole is at ground level and not stuck in the peg hole or soft ground.

Geomatics need this information to pass it to illustrators' team to annotate their section drawings with the AOD height.

Please see the drawing below showing how this relates to your section drawing with a height benchmark.



Spot heights

Spot heights are required at regular intervals across a site. It is possible to get heights from other surveyed features, but these are not always spread regularly across the site, so it is good practice to take spot heights as part of your survey.

Levels should always be taken at the base of LOE. This is particularly important for urban sites where this information is often required by clients or to inform volume calculations for costing work. If in doubt, speak to your Project Manager or the Geomatics Team on the specific requirements for your site.

Always include the context number if applicable, and enter in the location in relation to a feature (i.e. top, bottom) so that its position can be understood later.

If required, a detailed grid of spot levels should be taken, with a regular point interval enough to capture topographical details and reflect changes of level for particularly important features or areas.

Georeferencing points

Georeferencing points are points that allow us to locate information other than the survey. This could be drawing points for paper plans, grid pegs (*DP_pt* code) or photo georeference points (*Target_pt* code).

When surveying drawing points these points renumber the Point ID in a similar way to section lines. If the plan number is 101, then the drawing points should be re-numbered as 101.1 and 101.2. This must be reflected on the permatrace plan to allow the plan to be digitized correctly.

For grid pegs, the local grid coordinate must be entered in the ID field. The point ID doesn't need to be changed.

For full information on how to use the georeferencing code see APPENDIX 1 SURVEY CODE LIST.

Registered Artefact and environmental sample points

Survey points must be taken for all environmental sample locations (*Enviro_pt* code) and all registered artefacts (*Finds_pt* code), even if they are shown on paper plans, to record the information about their depth.

Hand plans

Although most sites are completely surveyed with a TST or GPS, there is still a case for hand plans. If an area is particularly complicated it may benefit from a hand drawn plan. The Project Leader may elect to set out a grid, as discussed in section 2, or just a simple two-point base line centred on the feature. In either case the drawing points must be surveyed with the drawing number recorded and drawn clearly on the drawing.

Even if a feature is hand drawn, a basic outline including a context number must still be surveyed along with all other information such as excavated interventions, section lines and any other post-ex detail as discussed above. It is critical that all contexts are recorded digitally by some means even if more detail is to be added later from hand drawn plans.

Burials

When surveying burials, the following elements must be surveyed:

- Burial_SK_Point – Point - levels taken on the skull, pelvis, and feet of each inhumation
- Burial_SK_line - Line - line from head -> feet (prone burials) or head -> pelvis -> knees -> feet (flexed burials)
- Burial_ply – Area – outline of the grave cut and/or coffin

CA standard practice is to take geo-referenced photos of all burials instead of drawing from hand measurements. A minimum of 6 georeference tags must be used per photograph. See SECTION 4 PHOTOGRAMMETRY for more details.

Volumetrics

The aim of volumetric recording is to calculate the quantity of artefacts and ecofacts per m^3 of features. The results can provide both intra site analysis (e.g. compare density of finds in discrete pits/ditches in enclosure A against enclosure B) and inter site comparisons (i.e. comparing one site with another). Please contact Geomatics team if you think you require this.

Section 4 Photogrammetry

Photogrammetry

Photogrammetry is the use of photography in surveying and mapping to ascertain measurements of and between objects. This process creates, as a minimum, detailed and scaled orthographic (two-dimensional) images, such as stone-by-stone detail of structures or skeletons.

CA standard practice is to use photogrammetry for all burials and any other complex feature/structures, which would benefit from the additional record or detail. For example, a cobbled surface would traditionally be hand drawn on site, stone-by-stone. Photogrammetry saves the time required to draw the structure on site, as well as creating a more accurate record.

There are two main photogrammetric methods CA uses – photo rectification and multi-image photogrammetry, otherwise known as Structure-from-Motion (SfM).

- Photo rectification outputs - orthographic images.
- Multi-image photogrammetry/SfM outputs - Digital Surface Models, volume calculations and scaled 3d models.

Photo rectification

A photograph is taken parallel to an object (typically a structure or skeleton). Using targets (or photo georeference points) located by a TST or GPS, the image can be transformed, or *rectified,* using GIS software. This is particularly useful for burials as the object can generally be captured in one or two images.

A detailed guide for carrying out photo rectification can be found in APPENDIX 6 PHOTOGRAMMETRY METHODOLOGY AND OPTIMAL CAMERA SETTINGS.

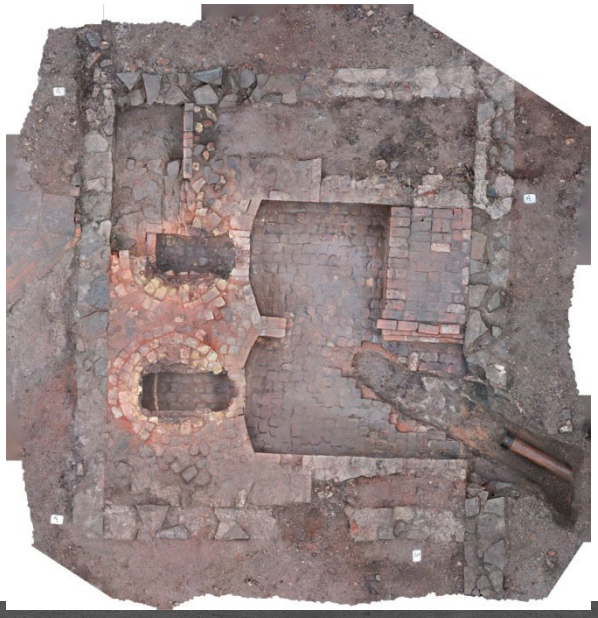
- **Pros** – Very quick to do for one object and quick to rectify, requires fewer photos thanstructure-in-motion
- **Cons** – Accuracy over a large area and matching images can produce poor results, only produces a 2d flat image, requires an elevated position for skeletons (e.g. camera pole or ladder)

Multi-image photogrammetry or Structure-in-motion

Overlapping images can be taken of an object or area. Using targets (or photo georeference points) located by a TST or GPS these images are be processed in Agisoft Photoscan software to produce a textured 3d model. This model can provide ortho images (2d images) and measurable 3d models.

A detailed guide for carrying out multi-image photogrammetry can be found in APPENDIX 6 PHOTOGRAMMETRY METHODOLOGY AND OPTIMAL CAMERA SETTINGS.

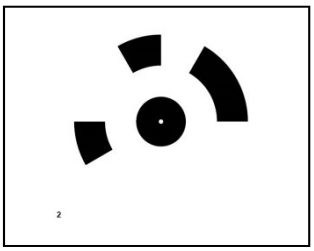
- **Pros** – preserves almost real-life model of the site, allows creation of very accurate ortho images over large areas, allows many different products such as 2d, 3d, heights, volumes, and marketing.
- **Cons** – images need to have 60 – 80% overlap required, relies on good imagery and specific training, processing takes more time, and the images require larger storage which has implications for the CA server.



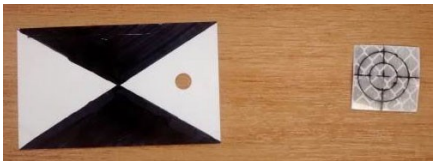
Equipment

To undertake a photogrammetric survey, you will need to consider taking some of the following equipment.

- Digital SLR camera – to produce high quality and accurate images. Please see APPENDIX 6 PHOTOGRAMMETRY METHODOLOGY AND OPTIMAL CAMERA SETTINGS for optimal settings
- Camera mounts
  - Aerial-cam - CA has 4 aerial-cam masts available, one in each office. These are ideal for photographing burials and surfaces for photo-rectification. These come as a kit with an extendable mast with guy ropes, motorised tilt head, camranger, wifi hub andaccessories
  - Monopods and tripods - there is an assortment of optional photo masts, bipods and tripods available from the Geomatics Team if needed
  - Step ladder - if you don't have access to an aerial mast this will be required for burials – don't use a wheelbarrow for obvious reasons!
- Targets – different targets are required depending on the method (see below). If you require any of these speak to the Geomatics Team.
  - Agisoft targets – These are specific to Agisoft Photoscan Pro and multi-image photogrammetry. They are recognised by the software and the configuration of the pattern means the target number is automatically calculated.



  - Holographic and black and white targets – These can be used for burials or other photogrammetry if nothing else is available. The number on the target relating to the GPS surveymust be clearly visible in the photographs.



  - Large black and white targets - These are used if a drone is being utilised for the purposes of aerial photo capture for photogrammetry. These ground control markers are clearly visible in the drone imagery and can enable the geolocating of any ortho images created from a drone survey
- Scale bar – it is always useful to add a scale bar to a part of the area you are photographing for photogrammetry as a reference line to check scaling etc. Make sure it does not obscure the object of the survey
- Drone/UAV – Drones/UAVs have become a great alternative, or supplement, to ground based photogrammetry. If a UAV is necessary, CA will appoint a qualified and experienced contractor with appropriate permissions from the Civil Aviation Authority. Survey will be undertaken using a suitable UAV which will capture images overlapped by 60-80% covering

the stripped areas of the site. A UAV survey can produce the following: a Georeferenced orthographic photo plan of site with maximum ground sampling distance of 2mm per pixel, Digital Surface Model with maximum error of +-0.05m, Volume calculations for topsoil and subsoil bunds. If you think a UAV flight is required for a site you are working on, first contact your manager who can discuss the requirements with the Geomatics Team. UAV flights start at £500 p/day.

Record keeping

It is crucial that the photographs that are used for any photogrammetry are clearly recorded in the site photo register. The range of photograph numbers should be clearly identified, along with the context numbers, feature labels or area ID relating to the photogrammetry.

The details of any photogrammetry should also be detailed on the photogrammetry sheet and the Geomatics Team should be notified.

The photos must be saved at the earliest opportunity to the server so the photogrammetry can be processed while the team is still on site. This should not be done in post-ex.

Section 5 Levelling

Establishing a TBM (Temporary benchmark)

Either use a Permanent Ground marker as your TBM or setup the TBM using the instructions for ground control markers in SITE CONTROL (see also APPENDIX 2 VIVA GPS GUIDE and APPENDIX 3 CAPTIVATE GPS GUIDE for detailed instructions).

Levelling run

If you are unable to survey in a TBM close to your site, you make need to perform a levelling run which transfers the height of a known point to your TBM.

1. First, set your automatic level up on its tripod and use the bubble to level the instrument.
2. Enter the value of your known point (GPS point or other point with a published height value) on the Level register sheet in the TBMs box.
3. Backsight onto the TBM and enter the value from the level staff onto your levels register in the Backsight column (BS). Add a note in your Remarks column to show where you have backsighted from i.e. TBM1
4. Take a foresight of roughly equal distance to the backsight and enter the value in the Foresight column (FS) on the next row down. Move your instrument, re-level it and repeat the process until you reach your TBM. When entering the values on your levelling sheet the FS to a point and the BS from the same point should be on the same row.
5. Continue your level run, using your TBM as a change point and include any other TBM's you want to install in your levelling run.
6. Return to your point of origin to close the levelling loop on your known point.

Once you have done this your levelling run is closed. Next it is necessary to check the accuracy of your levelling run. Due to errors and limitations of the instruments there may be a discrepancy, this is called a misclosure. To determine misclosure subtract the sum of the foresights from the sum of the backsights. If this value is greater than ± 20mm then repeat the levelling run.

Always use a prominent point to place your levelling staff on; if you can place the bottom of the staff on a point rather than a flat surface then you can confidently go back to that location if necessary, to retake the measurement. On hard standing look for the corner of a kerb, manhole etc. or use a change plate. On soft standing use either a change plate or push wooden grid peg into the ground until it is stable and place the staff on the top. This will increase the accuracy of your levelling run and will allow you to repeat measurements from known points at every stage.

For each change point enter the remark CP# in the remark column.

Please complete your levelling run data on a level register and calculate your final adjusted reduced levels. The Excel levelling sheet can be found in the Geomatics section of the project folder structure. A blank levels register can be found in the APPENDIX 7 RECORD SHEETS.

Taking levels on archaeological features

Taking levels on archaeological features is a simple procedure once the TBM is established. It should follow the below workflow.

1. First, set your automatic level up on its tripod and use the bubble to level the instrument.

2. Backsight onto the TBM and enter the value from the level staff onto your levels register in the backsight column (BS). Add a note in your Remarks column to show where you have backsighted to i.e. TBM1
3. Take intermediate levels on archaeological features
4. Take a foresight on any new TBMs you'd like to setup
5. Take a final backsight on your point of origin to check for any differences.

Ensure that your tripod is securely positioned as it may be there for a long period of time.

Close your levelling back onto your TBM at the end of the day and calculate misclosure to check that the instrument has not been moved.

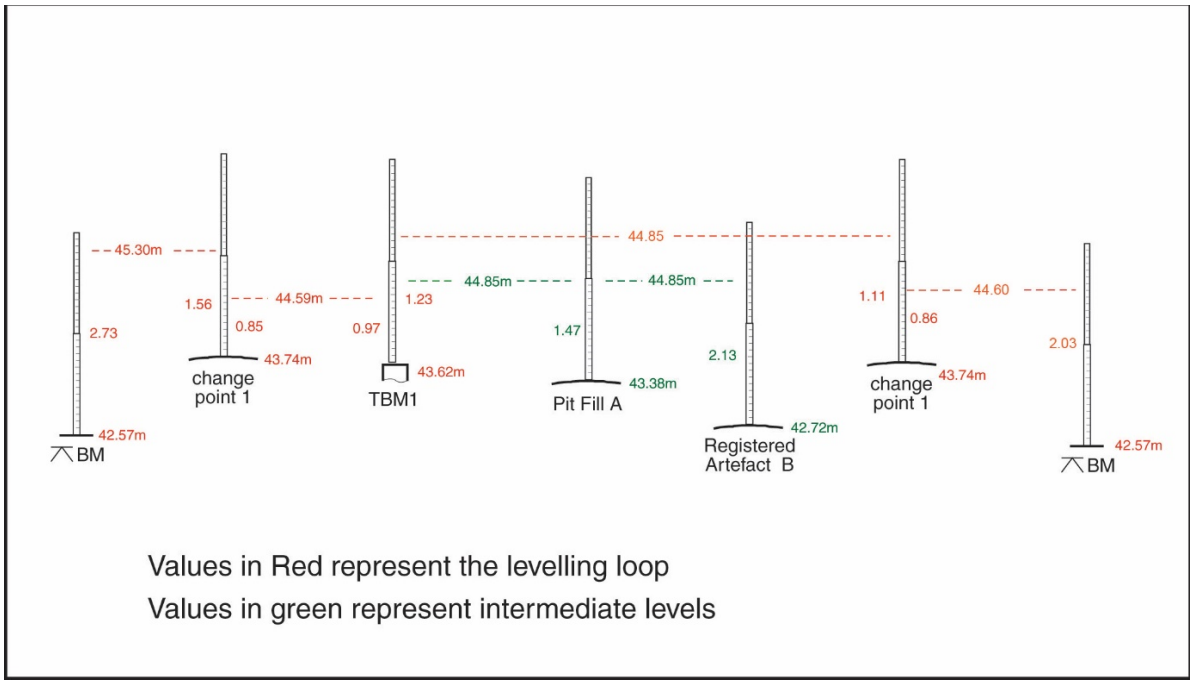
If you must move your instrument, then simply foresight onto a change point and then move the instrument to a more suitable location and backsight onto your change point. Again, once your survey is complete close the levelling run to your TBM and calculate the misclosure.

Calculate final adjusted reduced values.

Why is it necessary to go to these lengths? To make sure that we have a fully quality assured record of how we have calculated the heights of the archaeology.

Levelling Example

Below is an example of a simple levelling run to establish a TBM on site and to take a couple of spot heights while the instrument is set up. Overleaf is an example of a correctly filled out levels register for this run.



LEVELS REGISTER

Site Code:

Site sub-div:

Surveyor:

Date:

Site Benchmarks:

BM ID	BM Value

Level No:	Back sight:	Inter sight: (archaeology)	Fore sight:	Collimation (Inst. Height)	Reduced level:	Comments:
1	2.73			45.30		Bench Mark (42.57m)
2			1.56	45.30	43.74	CP 1
3	0.85			44.59		CP 1 (43.74m)
4			0.97	44.59	43.62	TBM 1
5	1.23			44.85		TBM 1 (43.62m)
6			1.11	44.85	43.74	CP 1
7	0.86			44.60		CP1 (43.74m)
8			2.03	44.60	42.57	Bench Mark
9	1.23			44.85		TBM 1 (43.62m)
10		1.47		44.85	43.38	Pit fill A
11		2.13		44.85	42.75	Registered Artefact B

Cotswold Archaeology

Sheet [ ] of [ ]

Sum BS	
Sum FS	
Misclosure	

CA/FRM/9

Section 6 Post- Survey

Data backup

Once a survey has been completed it is essential that the data is saved or transferred from the survey equipment memory as soon as possible. This should be done at the end of each day of survey without exception. The main methods used at CA to save or transfer data from survey equipment is to send the data remotely to the CA server (via an FTP connection), by saving the data to the server via an SD card or saving the data to a fieldwork laptop via an SD card.

Backing up data via FTP (File Transfer Protocol) Server

This is by far the most common method of saving data. The FTP server is located on the CA network and is dedicated to the transfer of survey job files and stakeout data. Connection to the server allows data to be transferred between office and Leica field controllers without the need for a laptop or PC. When using this method please be sure to only transfer the daily survey job from the instrument rather than the entire DBX folder.

In order to connect to the FTP server, it is not necessary to have the GPS antenna activated, or to be connected to Smartnet. All that is needed is the controller to be connected to the internet. See APPENDIX 2 VIVA GPS GUIDE and APPENDIX 3 CAPTIVATE GPS GUIDE for instructions on how to do this using a Leica GPS.

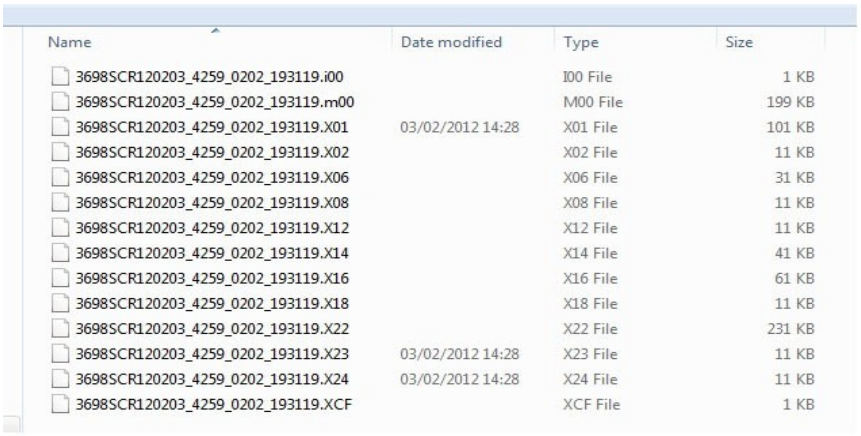
Once the data has been sent to the FTP server the Geomatics Team are able to process the data.

TST data cannot be sent back via FTP, as Total station controllers are not normally equipped with a mobile data SIM. The data from TST need to be downloaded using SD card reader.

Backing up data via SD card

Survey data on the GPS and TST is saved on the SD card or internal memory. If the survey is in the internal memory the survey job must be transferred to the SD card. Then the SD card can be inserted into a card reader and data copied either direct to the server or to a fieldwork laptop (provided this data is eventually backed up to the CA server regularly).

Survey data can be found on the SD card in the DBX folder, all the surveys that have been carried out using this instrument will be stored here. Each survey job dataset shows as a series of 14 files, each with the job name included; see below for an example.



Name	Date modified	Type	Size
3698SCR120203_4259_0202_193119.i00		I00 File	1 KB
3698SCR120203_4259_0202_193119.m00		M00 File	199 KB
3698SCR120203_4259_0202_193119.X01	03/02/2012 14:28	X01 File	101 KB
3698SCR120203_4259_0202_193119.X02		X02 File	11 KB
3698SCR120203_4259_0202_193119.X06		X06 File	31 KB
3698SCR120203_4259_0202_193119.X08		X08 File	11 KB
3698SCR120203_4259_0202_193119.X12		X12 File	11 KB
3698SCR120203_4259_0202_193119.X14		X14 File	41 KB
3698SCR120203_4259_0202_193119.X16		X16 File	61 KB
3698SCR120203_4259_0202_193119.X18		X18 File	11 KB
3698SCR120203_4259_0202_193119.X22		X22 File	231 KB
3698SCR120203_4259_0202_193119.X23	03/02/2012 14:28	X23 File	11 KB
3698SCR120203_4259_0202_193119.X24	03/02/2012 14:28	X24 File	11 KB
3698SCR120203_4259_0202_193119.XCF		XCF File	1 KB

All these files need to be copied and pasted to the correct project folder and subfolder:

Project\Geomatics\Survey\GPS\02_raw_survey_data. Make a folder with the survey job name and save the raw data there.

Do not delete the data from the SD card and do not try to process data directly from the SD card as this can sometimes cause the data to corrupt.

Total stations are not usually equipped with internet connectivity, so this is the only method of backing up the data. Please inform a member of the Geomatics Team if you have downloaded TST data to a project folder.

Survey processing and quality assurance

It is critical that a daily survey record sheet accompanies the survey data. The survey record sheet tells us important info like how many points were taken, which codelist was used and what pole height was used amongst other things.

The raw data is processed by a member of the Geomatics Team or an appropriately trained member of the field team.

The basic process involves importing the raw GPS data into Leica Infinity, where the following is checked – Pole height, Antenna type, Code list and Coordinate Quality.

At this point, levels for sections are exported as a table into the geomatics folder.

Next the data is exported as a shapefile for integration with GIS, and DRS.

Edits and survey updates

The survey will be edited as required by the Geomatics Team, however, any major changes or requirements for re-survey will be fed back to the Project Leader and Surveyor to be undertaken on site.

The survey will be added to the master survey drawing and sent out to all relevant parties as a Deltek link and a DRS webmap update, or a PDF (where necessary).

Digitising

Any site hand drawings should be passed onto the Geomatics Team to be digitised at the earliest opportunity.

Appendix 1 Survey code list

Codelist explanations

Use the table below to understand how each code from DRS codelist should be used.

There is a list after this table of common features and which code to use.

Code name	Geometry Type	Description of use and attributes
Burial_ply	Area	*This code should be used to survey contexts associated with burials, such as skeletons, graves, and cremations.* *Attributes:* *context_id = Context number,* *skel_id = Skeleton context id* *Sur_notes = any comments* *Sur_type = choice: burial, inhumation, cremation, coffin, vessel, animal*
Burial_sk_ln	Line	*Used to show the orientation of inhumations – for prone inhumations the first point should be measured at the head, and the second point on the feet. For flexed burials the first point should be on the head, the second on the pelvis, third on the knees and fourth on the feet.* *Attributes:* *Context_id = Context number* *Skel_id = Skeleton context id* *Sur_notes = any comments* *Sur_type = choice: complete, incomplete*
Burial_sk_pt	Point	*Points for level data on the head, pelvis and feet. This will provide level information for the head, pelvis and feet.* *Attributes:* *Context_id = Context number* *Skel_id = Skeleton context id* *Sur_notes = any comments* *Sur_type = choice: head, pelvis, feet, other (if other, specify in*

		sur_notes)
Constraint_ln	Line	*This code should be used for all constraints such as service exclusion areas,contamination and any other obstructions.* *Attributes:* *Sur_notes = any comments* *Sur_type = choice: constraint, service_live, service_dead, badger_sett, fence, barrier, safety_buffer, contamination, footpath, bridleway, ecological, tree, hedges, obstruction, other (if other, specify in sur_notes)*
Constraint_ply	Area	
Control_pt	Point	*This code should be used for control points on HS2 and TST stations.* *Attributes:* *Stn_id = Station/Control point ID* *Sur_notes = any comments* *Sur_type: HS2_control_point, station, other (if other, specify in sur_notes)*
Deposit_ply	Area	*This code should be used to survey all deposits, fills (only if specifically required), surfaces, dumps etc.* *Attributes:* *Context_id = Context number* *Sur_notes = any comments* *Sur_type = choice: deposit, fill, layer, surface, other (if other, specify in sur_notes)*
DP_pt	Point	*This code should be used for any points used to create plans, grids, etc.* ***not*** *sections* *Attributes:* *Draw_number = drawing number* *Sur_notes = any comments* *Sur_type = choice: plan, grid, other (if other, specify in sur_notes)*
Enviro_pt	Point	*This code should be used for recording the location of all environmental samples.* *Attributes:* *Enviro_id = Environmental sample number* *Sur_notes = any comments*

		Sur_type = choice: sample, bulk, monolith-bottom, auger_hole, other (if other, specify in sur_notes)
Feature_ply	Area	*This code should be used to survey all cut features, either excavated or not, **as well as** pre-ex **and** furrows.* *Attributes:* *Context_id = Context number* *Sur_notes = any comments* *Group_id = Feature id, if applicable* *Sur_type = choice: pre-ex, ditch, pit, gully, plough_furrow, unexcavated, posthole, stakehole, other (if other, specify in sur_notes)*
Find_pt	Point	*This code should be used for recording the location, type and material of registered artefacts. All registered artefacts should have a survey point. Don't worry if the type and material aren't certain as this can be amended later.* *Attributes:* *Find_id = unique registered find/small find number* *Material = choice: unspecified, flint, flint_burnt, pottery, wood, stone, bone, glass, metal, other (for all choices please specify in sur_notes)* *Sur_notes = any comments*
Intervention_ply	Area	*This code should be used to survey the top line of excavated interventions, **as well as** breaks of slopes and base of feature.* *Attributes:* *Context_id = Context number* *Sur_notes = any comments* *Sur_type = choice: hand_ex, machine_ex, base_of_feat, break_of_slope, undercut* *Truncated = Choice: yes/no (if a feature is invisible on plan because it was cut away by a feature above it, then the truncated is yes – this is **not** to be used to explain what cuts what); this attribute needs only to be filled in for the hand_ex/machine_ex, in other instances it can be left blank.*

Intervention_ln	Line	*This code should be used only to survey break of slope as a line.*
Level_pt	Point	*This code should be used for taking spot heights across the site, at thebase of LOE or on features.* *Attributes:* *Context_id = only if taken on a specific feature* *Sur_notes = any comments* *Sur_type = choice: spot_height, site_level, trench_level, feature, other (if other, specify in sur_notes)*
LOE_ply	Area	*This code should be used for the top and bottom of all limit of excavations, such as excavation areas, evaluation trenches and test pits.* *Attributes:* *Loe_id = trench number, area number, etc.* *Sur_notes = any comments* *Sur_type = choice: ex_current_limits (LOE top of excavation area), Ev_trench (LOE top of evaluation trench), Loe_btm (any LOE bottom), Test_pit, sondage, other (if other, specify in sur_notes)*
Modern_ply	Area	*This code should be used to survey any modern features, such as field drains, wheel ruts, etc.* *Attributes:* *Context_id = Context number* *Sur_notes = any comments* *Sur_type = choice: field_drain, wheel_rut, modern (if modern, specify in sur_notes)*
Natural_ply	Area	*This code should be used to survey any features which do not have been man-made, such as tree-throw pits, bioturbation, burrows, peculiar geology, etc.* *Attributes:* *Context_id = Context number* *Sur_notes = any comments* *Sur_type = choice: bioturbation, tree_throw, geology, palaeochannel, channel, animal_burrow, rooting, site_natural, other (if other, specify in sur_notes)*
Section_ln	Line	*This code should be used for surveying section lines.*

		Attributes: *Section_id = section number, as per drawing register* *Sur_notes = any comments* *Sur_type = choice: ground_level, string_level, transect, other (if other, specify in sur_notes)*
Structural_ply	Area	*This code should be used for all structural features such as walls, wells and hearths, etc. (lots of choices)* *Attributes:* *Context_id = Context number* *Sur_notes = any comments* *Material = choice: unspecified, cbm, earth, stone, timber* *Sur_type = choice: structure (if structure, specify in sur_notes), wall, floor, corn_dryer, road, oven, kiln, postpad, hearth, barrow, furnace, trackway, battery, burial_vault, cist, well, steps, fireplace, pier, roof_support*
Target_pt	Point	*This code should be used to survey photogrammetry targets.* *Attributes:* *Pgram_job = model number* *Sur_notes = any comments (such as description of the model)* *Target_id = target number*

Code quick reference

This is a list of common features and which CA code to use.

Feature type	Code
Skeleton	Burial_sk_ln, Burial_sk_pt,
Coffin	Burial_ply, sur_type: coffin
Cremation	Burial_ply, sur_type: cremation
Grave cut	Burial_ply, sur_type: burial
Pre_ex	Feature_ply, sur_type: pre-ex
Ditch	Feature_ply, sur_type: ditch
Gully	Feature_ply, sur_type: gully
Pit	Feature_ply, sur_type: pit
Posthole	Feature_ply, sur_type: posthole
Ridge and furrow	Feature_ply, sur_type: ridge_furrow (specify which in sur_notes if necessary)
Structural cut	Feature_ply, sur_type: other
Structure	Structural_ply, sur_type: structure
Wall	Structural_ply, sur_type: wall
Well	Structural_ply, sur_type: well
Oven	Structural_ply, sur_type: oven
Floor	Structural_ply, sur_type: floor
Timber	Structural_ply, material: timber, sur_type: structure (specify in sur_notes)
Palaeochannel	Natural_ply, sur_type: palaeochannel
Colluvium	Natural_ply, sur_type: other (specify in sur_notes)
Buried soil	Natural_ply, sur_type: other (specify in sur_notes)
Bioturbation	Natural_ply, sur_type: bioturbation
Tree-throw pit	Natural_ply, sur_type: tree_throw
Service	Constraint_ln, sur_type: service_live or service_dead
Manhole	Constraint_ply, sur_type: other (specify in sur_notes)
Fence	Constraint_ply, sur_type: fence
Hedge	Constraint_ply, sur_type: hedges
Section line	Section_ln
Top of excavation area	LOE_ply, sur_type: ex_current_limits
Top of evaluation trench	LOE_ply, sur_type: ev_trench
Top of watching brief area	LOE_ply, sur_type: other (specify in sur_notes)
Bottom of area or trench	LOE_ply, sur_type: loe_btm
Station	Control_pt
Drawing point for plan	DP_pt, sur_type: plan
Photo georeference	Target_pt
Spot height	Level_pt, sur_type: spot_height
Registered artefact	Find_pt
Environmental sample	Enviro_pt

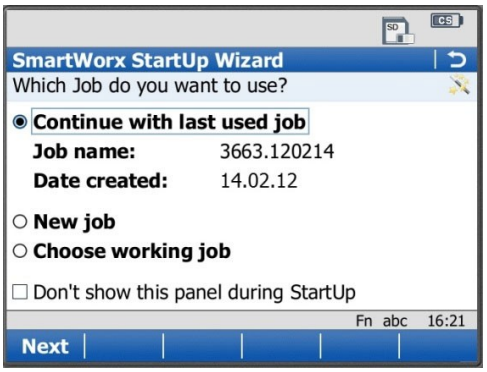
Appendix 2 Viva GPS guide

Equipment Setup Procedure

1. The contents of the GPS kit are detailed in section 1.2.2
2. Mount the controller bracket onto the staff sliding it up from the bottom to a comfortable height towards the top of the staff.
3. Mount the antenna onto the screw head on the staff and extend the staff to its full 2.0m height. Two spring loaded studs will pop into holes in the staff to lock it at its maximum height.
4. Mount the controller onto its bracket and screw to the pole. To take the controller off the bracket, push the centrally located red slide left all the way.
5. Switch the antenna on; hold the button down for a few seconds. The series of small lights will display on the antenna. Once the controller is switched on the middle light should turn blue as the Bluetooth connection is established.
6. Switch on the controller using the red power button.

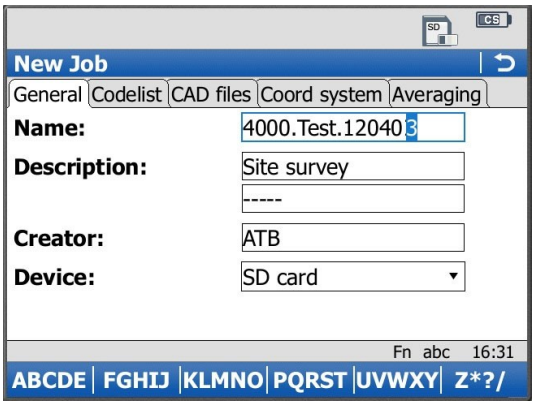
Job Creation

The Viva automatically opens a Start-up Wizard when the controller is switched on that guides you through the job creation process.



The options are as shown above, if you already have a job then use this shortcut to skip the job creation process. If not, then chose New Job and press F1 [NEXT].

The New Job screen looks like this:



Alternatively, from Main Menu select “Jobs & Data”, select working job and Select “New Job”

You should include the name of the project and the date written backwards (e.g. **survey job** AN0025_190725; **stakeout job:** AN0025_stk), a description of the job (e.g. mapping, stakeout), the person creating the job (just initials are fine) and you need to make sure that the job is stored to the SD card by using the drop down. Check other pages by clicking “Page” or F6 button:

- In Coordinate system tab, make sure OSGB(15) is selected
- In Codelist, make sure DRS_V2 is selected

Once these are confirmed press “Store” or F1 button. This will take you through to the main menu screen.

Connecting controller to the antenna

This can only be done while in the stakeout or survey app.

- Press the green “FN” button on the left of the keypad and then press “Connect” in the bottom right of the screen
- To begin with you will see a cartwheel symbol in the top left of the screen. When the GPS is fully connected this will change to a crosshair/plus symbol (+). Once this symbol appears you can begin your work

Accessing FTP server

From Main Menu select “User” (Option 4), “Tools & Utilities” (Option 4), and “FTP data transfer”

Make sure the following details are entered:

Host / IP address = **83.218.135.157**

TCP/ IP Port = **21**

User ID = **GPS**

Password = **Password01**

And press “Connect” or F1 button.

Uploading job to the server

Select “SD card” or F4

Go to \DBX and press **Enter** button (**not OK** or **Transfer**)

Find your job and press “Transfer” or F1 button.
Once it is complete, press “Page” or F5 button and check that the job is in the “Office” page.

Downloading stakeout data

Press “Page” or F5 to enter “Office” (FTP)

Go to \stakeout and press **Enter** button (**not OK** or **Transfer**)

Find your job and press “Transfer” or F1 button.

Stakeout job

Please keep stakeout job separated from any surveying.

1. Create a new job
2. Download stakeout data from FTP
3. Once transfer is complete return to Main Menu and select “Jobs & Data” (Option 2) → Select “Import Data” (Option 7) → Select “Import ASCII Data” (Option 1)
   From File = The file you just transferred
   To Job = The job you created
   Select “OK”
4. From Main Menu select “Go To Work” (Option 1) → Select “Stakeout” (Option 2) → Control Job = The job you created in Section 1; Select “OK”
5. Connect controller to the antenna
6. The Point ID will immediately set itself to the last point in the job (e.g. if you have 21 trenches then the Point ID will set to 21B and work in descending order from there); you can enter the drop-down menu next to Point ID and select points manually if you prefer
7. Follow the arrow on the screen to your point. Once you are within 0.5m of your point the screen will change to a crosshair. Get your GPS to within 0.05m of the center of this crosshair remembering to keep the staff straight. Once you are positioned accurately select “Meas” in the bottom left of the screen. The point will be stored, and the Point ID will immediately change to the next highest point on the list

Surveying

1. Create a new job
2. Select “Go To Work” from Main Menu (Option 1) → “Survey” (Option 1)
3. Connect controller to the antenna
4. Make sure Point ID is set to GPS0001, and pay attention not to duplicate the number at any stage during the surveying. The numbers will change automatically.

IF YOU REPEAT A POINT ID NUMBER WITHIN THE SAME JOB THE GPS WILL ATTEMPT TO AVERAGE OUT THE DUPLICATE POINTS WHICH MAY AFFECT YOUR SURVEY

5. Choose the correct code and fill in the attributes before you take the points. Over the last point of your area, click F7 (close all lines and areas) or go to Favourites (star button) and choose "Close all lines and areas". A yellow ribbon with such information will appear on the bottom. It will mean that the areas are closed and a new one can be started.
6. **When surveying lines**, make sure you change the Point ID to match the line ID (e.g. for section line 143, the first point to measure lies on the left-hand side of the section as one faces it. This first point will have Point ID 143.1. The second will have 143.2, etc.

   Remember to change to Point ID back to the last used+1 when you've finished. To check what was the last point's ID, click "Areas and points" icon on the top of the screen

You can review your work by selecting the "Map" tab at the top of the screen. There are navigational icons on the right-hand side. There is also a cog icon, which allows you to customize the map display.

Installing Control Points

1. In your survey screen change your point id to the station name i.e. STN01, and the Code to Control; fill in the attributes
2. Go to the user menu [Fn] and into the QUALITY CONTROL menu. Then select F3 (PARAM). Change the 'Number of Obs' to 180, then hit continue twice to return to your survey screen.
3. Setup your instrument directly over the station ensuring that it is level, if a bipod is available, please use it and press occupy. It will take a point every second for 3 minutes, then average out the measurements resulting in a very accurate position.
4. Repeat the process using the same point name after a minimum of 20 minutes break since the first observation. This will give us another set of positions which may differ slightly from the first due to the different satellite constellation overhead. Again, the instrument will average all the measurements taken resulting in a highly accurate control point.
5. Please remember to change the point occupation settings back to 1 obs when you have finished installing the control points.

Daily Survey sheets

Daily survey sheets need to be sent at the end of every job. They are done digitally through the form on the website. It is also possible to install an app for it.

Link to form: https://form.jotform.com/203215631820040

Link to App: https://eu.jotform.com/app/203281441149349

Troubleshooting

1. Problem: there is nothing on the map.
   Solution: check in the job properties that the coordinate system is set to OSGB(15)

2. Problem: I can't get an accurate lock.
   Solutions:
   a. If the crosshair/plus icon (+) doesn't appear or keeps disappearing then try to identify whether the problem is phone signal or satellite coverage.
      i. If you have very low numbers under the G and Σ this indicates that few satellites are communicating with the antenna
      ii. If the lightning bolt icon is static and not getting larger/smaller the problem is lack of phone data signal.
   b. For Satellites
      i. Check the Bluetooth – is the middle light on the antenna blue? If not then turn the antenna off and on again. If still not then change antenna battery. If still not then from the main menu go to "instrument," "GPS settings," "Antenna heights" and make sure that the rover antenna is set to GS08 pole, GS08plus pole or GS12 pole (depending on which model of GPS you have). Press "OK"
      ii. Note that working close to tall buildings or trees, especially to the south, will cause problems.
      iii. Check the satellite coverage - Press the star button then select "Satellite tracking" the GPS page lists which satellites are in the sky above you, any satellites with an elevation below 30° will not connect to your antenna.
      iv. Page across to skyplot for a graphic to show the location of satellites. NB you will need at least 5 online satellites to get an accurate position.
      v. If you have insufficient satellites you will need to try again later in the day; I would recommend checking hourly to see the coverage.
   c. For Phone signal - try reconnecting
      i. Press the green "Fn" key and select "Disconnect"
      ii. Press the "Fn" key again and select "Connect"
   d. If this doesn't work then turn the whole system off and on again
   e. If neither of these work then you can change the SIM card
      i. See section 11 for instructions
      ii. You must contact a member of the Geomatics team when you change the SIM card
3. Problem: I forgot to close a line/area.

Solution: Press F7 or Favourites button and choose “Close all lines and areas” to close all the lines

4. Problem: I accidentally took a wrong point.
   Solution: Select the Line/Area icon in the top right of the screen. In the Points Tab select the point which you accidentally took. Select “Delete” in the bottom left of the screen and select “OK”.

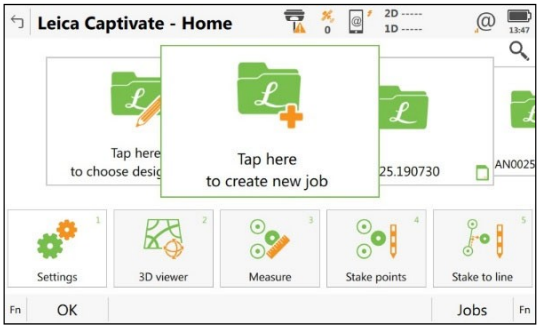
Appendix 3 Captivate GPS guide

Equipment Setup Procedure

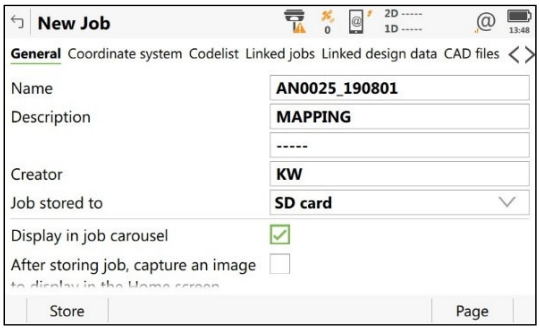
1. The contents of the GPS kit are detailed in section 1.2.2
2. Mount the controller bracket onto the staff sliding it up from the bottom to a comfortable height towards the top of the staff.
3. Mount the antenna onto the screw head on the staff and extend the staff to its full 2.0m height while pushing the metal button on the staff handle.
4. Mount the controller onto its bracket and screw to the pole. To take the controller off the bracket, push the centrally located red slide left all the way.
5. Switch the antenna on; hold the button down for a few seconds. The series of small lights will display on the antenna. Once the controller is switched on the middle light should turn blue as the Bluetooth connection is established.
6. Switch on the controller using the red power button.

Job creation

On the home screen tap the option '*tap here to create new job*'



The new job screen looks like this:



You should include the name of the project and the date written backwards (e.g. **survey job** AN0025_190725; **stakeout job:** AN0025_stk), a description of the job (e.g. mapping, stakeout), the person creating the job (just initials are fine) and you need to make sure that the job is stored to the SD card by using the drop down. Check other pages by clicking "Page" or F6 button:

- In Coordinate system tab, make sure OSGB(15) is selected
- In Codelist, make sure DRS_V2 is selected

Once these are confirmed press "Store" or F1 button. Your job will appear in the carousel on the main screen.

Connecting controller to the antenna

To connect the GPS controller to the antenna, tap the symbol that looks like a mobile phone (located on top right of the screen) and choose the '*start RTK stream'* option.

Once connected, tap the symbol that says 2D and 1D so it shows the 3D quality and the pole height. Make sure the 3D shows a number below 0.05 before proceeding to survey.

Once antenna and controller are connected, you will see two messages mentioning NTRC and SmartNet. Accept both.

Accessing FTP server

On the home screen, navigate to settings – tools – FTP data transfer – connect.

Make sure the following details are entered -

Host / IP address = **83.218.135.157**

TCP/ IP Port = **21**

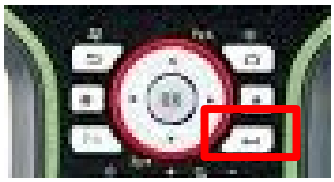
User ID = **GPS**

Password = **Password01**

And press “Connect” or F1 button.

Uploading job to the server

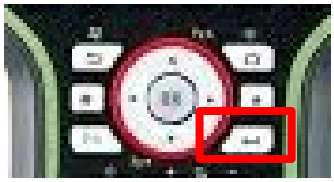
1. Select “SD card” or F4
2. Go to \DBX and press **Enter** button (**not OK** or **Transfer**)



3. Find your job and press “Transfer” or F1 button.
4. Once it is complete, press “Page” or F5 button and check that the job is in the “Office” page.

Downloading stakeout data

1. Press “Page” or F5 to enter “Office” (FTP)
2. Go to \stakeout and press **Enter** button (**not OK** or **Transfer**)

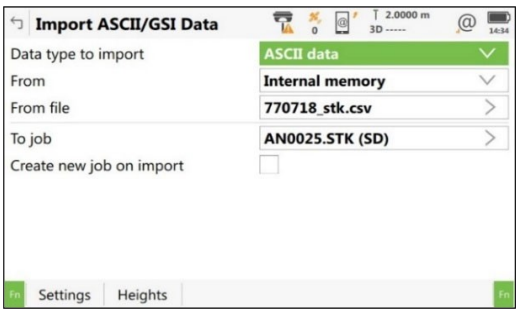


3. Find your job and press “Transfer” or F1 button.

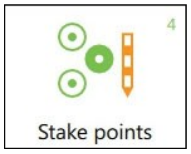
Stakeout job

Please keep stakeout job separated from any surveying.

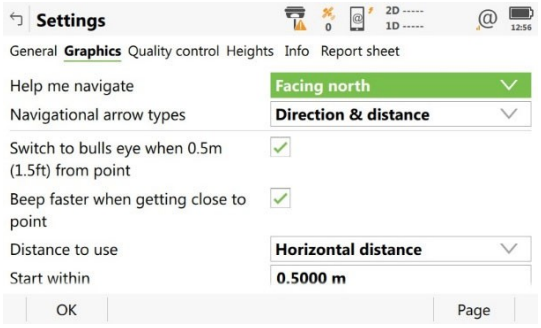
1. Create a new job
2. Download stakeout data from FTP
3. Once transfer is complete return to Main Menu
4. Tap on the job name and choose Import data → ASCII data → from internal memory
   From File = The file you just transferred
   To Job = The job you created



5. Select ‘stake points’.



6. Connect the controller to the antenna.
7. Choose desired point from the drop-down menu and follow the arrows on the map.
8. You can change the look of the map by pressing the FN button and going to Settings

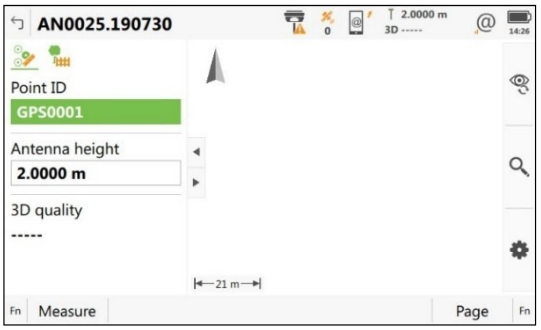


Surveying

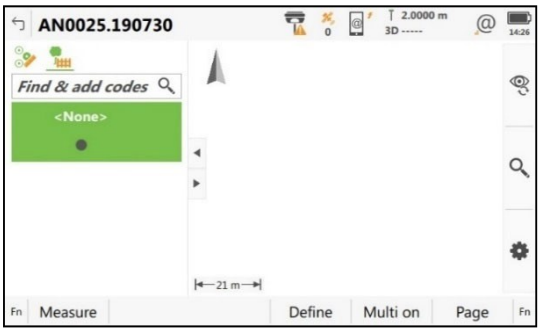
1. Create a new job
2. Select “Measure”

3. On the left hand of the screen there will be two tabs – one depicting some points and a ruler (points tab), the other a picket fence and tree (codes tab).

The points tab is where you go to change the GS number to section line/geo ref numbers.



The tree and picket fence tab are your code list.



1. Make sure your GS number is set to GS0001 and pay attention not to duplicate the number at any stage during the surveying. The numbers will change automatically.

IF YOU REPEAT A POINT ID NUMBER WITHIN THE SAME JOB THE GPS WILL ATTEMPT TO AVERAGE OUT THE DUPLICATE POINTS WHICH MAY AFFECT YOUR SURVEY

1. Surveying areas: choose the code from the drop down list, and click "Measure" (or F1 button or OK button). A pop up window will ask for some attributes. An icon underneath the code will change to indicate an opened line: 

When finished, click on the icon and change it to "Close line": 

2. Surveying section lines: choose the Section_ln code from the dropdown. Go to points tab and change the Point ID. Measure the section line. When finished, don't close the line. You just need to add a new one with a plus button: 

Don't forget to change the point ID back afterwards. You can access the point list by clicking on the job name at the top-left of the screen.

3. Surveying points: choose the code from the list and click the little notepad next to the code: 

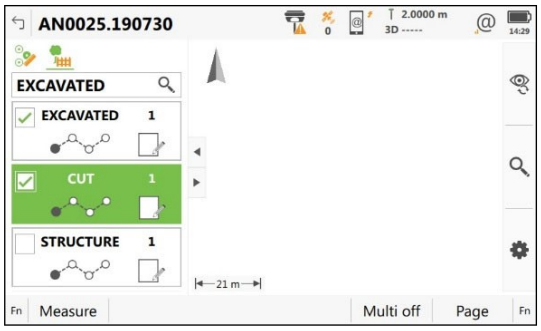
   Fill in the attributes. Press "Measure" (or F1 button or OK button).

Advanced surveying – using multi-coding

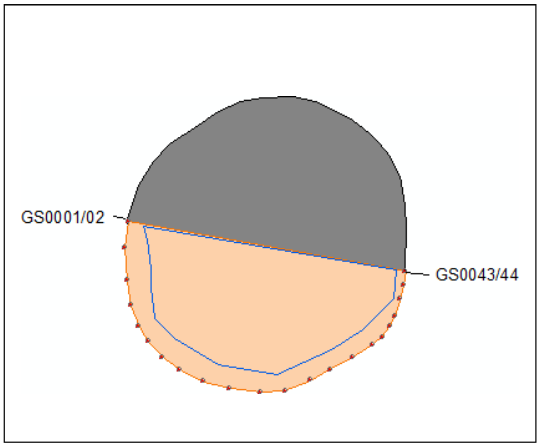
Like the VIVA, where you can survey areas together, with the Captivate you can survey two codes at the same time. This is particularly useful when doing post-ex survey of features. It is a more advanced surveying technique, so only use it once you are confident surveying and with using the Captivate.

1. Start your survey at a point where you will remember where you started (level with the section line point is sometimes a good location). At the bottom of the screen there will be an option for 'multi-on'.

2. Select this. Highlight both the codes you want to survey (e.g. cut and excavated) by making sure they are ticked.



3. Take your first point and it will then ask for the attribute details for both codes – clickstore.
4. Continue surveying the excavated area (using the example above – from GS0001/02 – GS00043/44) – it will then store both points, one for cut and one for excavated, at the same time.



5. Before surveying your last point (e.g. GS0043/44), you will need to let the GPS know you need to close the line. To do this you will need to turn 'multi off'. Highlight the excavated code on your list and close the line.
6. Turn 'multi on' back on and make sure both 'cut' and 'excavated' are both ticked. Survey your last point for excavated and it will close only the excavated polygon.
7. Turn 'multi off' – select 'cut' in your survey list and continue surveying the rest of the feature – remember to close the 'cut' line at the end of the feature.

Installing Control Points

1. In your survey screen change your point id to the station name i.e. STN01, and the Code to Control; fill in the attributes
2. Go to the Main menu. Go to "Settings" → "Point storage" → "GS Quality Control"
   Select: Stop measurement based on" → Positions
   Set number of positions to 180
3. Setup your instrument directly over the station ensuring that it is level, if a bipod is available, please use it and press occupy. It will take a point every second for 3 minutes, then average out the measurements resulting in a very accurate position.
4. Repeat the process using the same point name after a minimum of 20 minutes break since the first observation. This will give us another set of positions which may differ slightly from the first due to the different satellite constellation overhead. Again, the instrument will average all the measurements taken resulting in a highly accurate control point.

5. Please remember to change the point occupation settings back to the previous settings when you have finished installing the control points.

Daily Survey Sheet

Daily survey sheets need to be sent at the end of every job. They are done digitally through the form on the website. It is also possible to install an app for it.

Link to form: https://form.jotform.com/203215631820040

Link to App: https://eu.jotform.com/app/203281441149349

Troubleshooting

1. Problem: there are too many codes on the code list
   Solution: click Fn and you can clear one of them or all of them
2. Problem: there is a point that needs deleting
   Solution: click on the name of the job in top left corner and you can delete it from there
3. Problem: there is nothing on the map.
   Solution: check in the job properties that the coordinate system is set to OSGB(15)

Areas (need to be closed):

Burial_ply

Constraint_ply

Deposit_ply

Feature_ply

Intervention_ply

LOE_ply

Modern_ply

Natural_ply

Structural_ply

Lines and points (not to be closed):

Burial_sk_ln

Burial_sk_pt

Constraint_ln

Control_pt

DP_pt

Enviro_pt

Find_pt

Intervention_ln

Level_pt

Section_ln

Target_pt

Appendix 4 Viva TST guide

Appendix 5 Captivate TST guide

Setup

To set up the TST Captivate you will first need to be able to identify at least two (one station and one backsight) station points - three station points (one station and two backsights) would be better. Each station needs to be positioned at least five plus meters apart from each other. You need a GPS to obtain their coordinates.

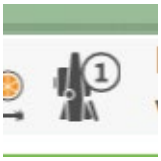
1. You will need to use the GPS that is connected the FTP to take and store the points (see APPENDIX 3 CAPTIVATE GPS GUIDE for detailed instructions).
    - Create a new job on the GPS and call it 'JobCode_Stations' i.e. SU0000_Stations
    - Go to Survey
    - Choose on 'control' on the codelists.
    - Call your stations 'TSN01' TSN02' and so on.
2. Before taking any of the station points use the GPS to see where the best location is on site for these stations to be.
    - Make sure the station is as close it can be to the site as possible (while still being within 0.05m accuracy)
    - **ALL** Stations must be able to get a clean line of sight between each other.
    - If your site has bad signal and cannot fix a station point accurately you may have to traverse the TST into the area of the site (see below).
    - Additionally, if your site is split into two or if there are obstructions that require TST to be moved, make sure you get enough stations to cover the entire site.
    - If you can try to keep the TST over one of the stations.
3. Once you have an area where you have good signal, place a wooden stake into the ground with a Mag Nail in the top of the Stake.
4. Place the point of the GPS pole into the divert in the middle of the nail and then take your station point with your GPS.
5. You will need to take not of the Easting, Northing and Height of each of your Station points, either take a photo of each or note on a piece of paper as this will be important later in the setup stage.

Setting up TST – levelling

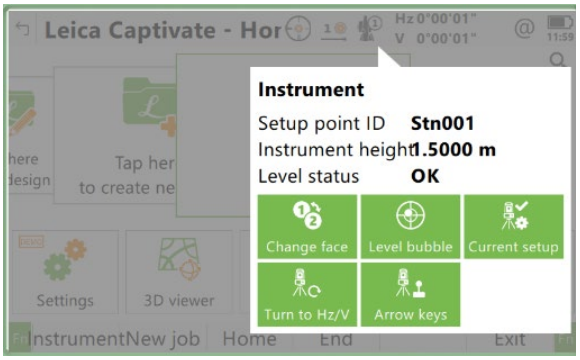
This section concerns identifying and positioning the station points, and getting their XYZ data.

1. Set the tripod up over one of your fixed 'Stations' that you have staked into the ground. This should be located on your main station point.
2. Attach the TST to the tripod as close the center of the tripod as you can and turn the TST on but NOT the controller.
3. Maneuver the Tripod as level as you can by adjustive the feet and height of each leg, until the bubble is inside the circle.

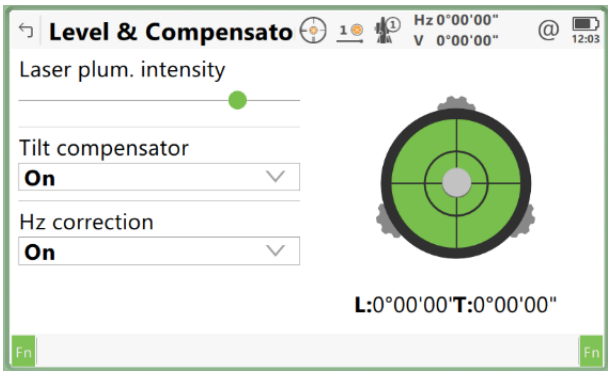
This is the what the screen on the TST will look like when you turn the machine on:

4. Click on the side profile of the TST on the top row 

This screen will appear. Click on the Level Bubble. This will aid you in getting the tripod and TST level:



5. Click on “Level Bubble”. You will see a laser coming from the machine straight down. Make sure the laser is close to the Nail in the stake. If the laser is not near the nail, move the tripod or TST on the Tripod to get the laser as close as you can to the center of the nail (you do not need to be dead accurate as you will have to still level the machine).
6. Once the laser is close to the nail, use the dials near the base of the TST and follow the instruction to adjust in very small increments (this is very sensitive). You will want to get as close to L:0°00’00’T: 0°00’00” with it not exceeding L:0°00’09’T: 0°00’09”:



Re check the laser is still pointing into the direct center of the nail. If not, maneuver the TST on the tripod so it is close and relevel.

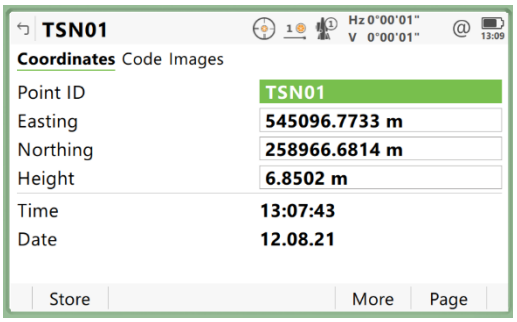
The TST is now levelled up properly. Next step is to position it within OSGB grid, using the X, Y, and Z data from the surveyed station points.

Setting up TST – positioning with known points

This section concerns using the points set up previously to position the TST within three dimensional grid.

1. Click on the 'Setup' Button on the home screen
2. Choose between the available options:
    - known backsight (if you only have two control stations)
    - multiple backsights (if you were able to set up more than two control stations).
3. Choose Setup Point:
   Setup point from: Job
   Job: either choose an existing one, or create a new one (see JOB CREATION section)
   Point ID: this is where you need the XYZ data (eastings, northings, heights) from the station points set up earlier

   You will need to manually need to add each of these into the job. It should look like this:



   Click store. Repeat for each point you have taken with the GPS. (The first point you choose should be the point that the TST is stationed over).

   The Set orientation should be set on your second point so TSN02.

4. You will now need a second person to stand over the backsight with the prism. Once the person is ready, click the prism icon at the top of the screen:

   Click on 'PowerSearch' and wait till the TST connects to the prism at the top of the staff.
5. Once connected you will need to press the Distance button at the bottom of the page.
    - You will need to make a note of the Difference in horizontal
    - Make sure the staff is up straight!
6. Once a difference in horizontal distance has been recorded down, press the 'Set' button.

   You will most likely get a warning message, saying that "it has exceeded 0.0250m as long as you are below … (Insert the difference) you are fine", so click yes.

Your machine has now been set up and is ready to start surveying using a normal Captivate controller (see SURVEYING section above for details). Make sure you create a new job for the survey.

You may lose sight with the TST at times - if that happens just navigate to the 'PowerSearch' button on your TST and this will find you.

Traversing

Sometimes you may be on a site that you may have to traverse to different stations to enable you to survey the entire site. If you can use one of the GPS points as your base station, then follow the instruction above to set up more stations. Make sure you choose the correct stations as your setup station and your backsight.

If you must traverse into areas where you cannot get a GPS signal you have to use TST to take a new point. Once its position is recorded, treat it as one of the station points.

Appendix 6 Photogrammetry methodology and optimal camera settings

Multi-image photogrammetry methodology

The process of capturing the photographs is simple as long as a few rules are observed. Remember, these are going to form the basis for constructing the model, if the photos are terrible the model will also be terrible.

Conditions

Make sure that the subject is evenly lit with no large shadows or that lighting conditions won't change during photography. Any shadows may cause holes in the model where the software cannot find common points to match on the photograph.

Ensure that there is enough light to avoid any blurriness in the photos. If the light levels are too low your camera shake will become more obvious in your photographs and will show as irregularities in the texture of the model. A tripod and monopod is available from geomatics if required.

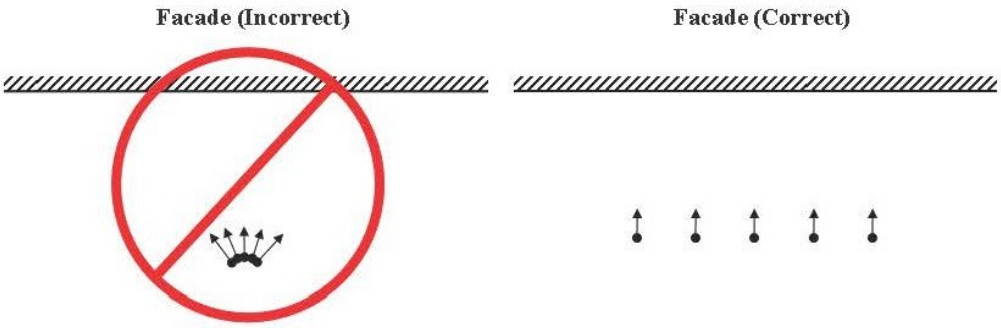
Ensure that the subject will not move, be knocked or altered in any way during photography. Again, this will make it difficult for the software to find common points to stitch the photos together and may create gaps.

Photography guidelines

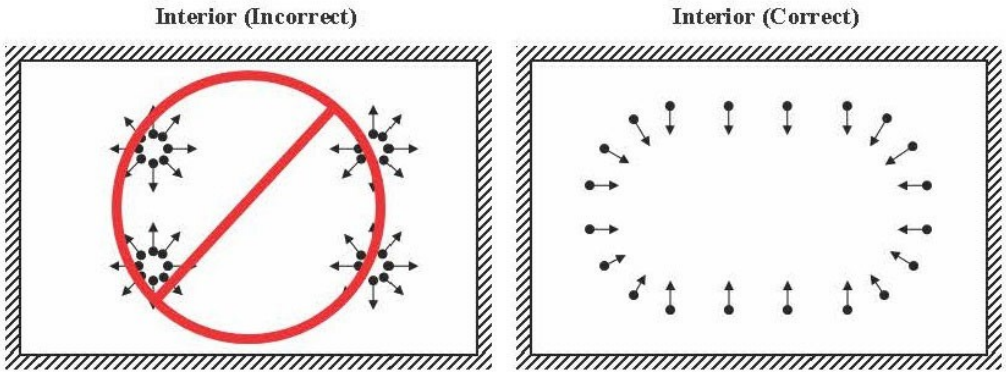
- Use a digital SLR camera, the standard SLRs provided to CA Project Officers will suffice for this.
- Avoid wide angle, fisheye or macro lenses. The standard lens on most of the CA SLR cameras will be fine to use.
- All photographs should be taken whilst completely zoomed out (i.e. using a fixed focal length).
- You do not need to get the entire subject into the frame, rather aim to systematically take sections ofthe subject.
- Try to get the part of the subject being photographed to fill the frame (without zooming in), photos can also be taken in portrait orientation if easier.
- There should be a 50-60% overlap between adjacent photographs.
- Once downloaded on to the server none of the photos should be modified in any way.

Where to take the photographs from

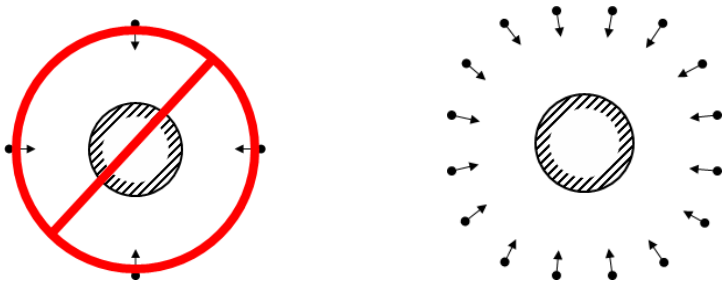
If photographing a flat wall, start at one end of the wall, face the wall at 90° and take the picture. Then move one step along the wall and take another. Repeat until the entire length of the wall has been photographed. This should give you the desired overlap. If the full height of the wall doesn't fit into the frame, take shots which overlap vertically until the top of the wall is reached.



If photographing a room, begin in one corner of the room facing towards the centre then take the photograph. Take one step to the side and take another photograph. Repeat until the entire room has been covered.



If photographing an individual object, or the external faces of a structure, work your way around the subject always keeping at a 90° angle to it.



Capturing extra detail

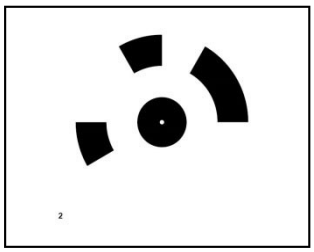
If the subject you are photographing contains recesses, such as doors, windows or archways, try to photograph the inside of these, maintaining a 50-60% overlap with the surrounding photographs. This can also be applied to corners of walls and anything protruding from a surface, such as buttresses, so all faces can be captured.

If there is a particularly detailed part of the subject, such as a specific worked stone block in a wall, this can be photographed using the same method close-up which should bring out more of the detailin the final model.

Using scaling targets within the photographs

To scale the mode, specific targets (Agisoft targets) can be used within the photos which can be detected by the software. These will have to be printed out and laminated for use on site. The usual black and white tags can be used in their place but may give a less accurate scale and cannot be automatically detected so may take longer to process.

The targets are quite large so avoid obstructing parts of the subject with them. Even if the model is to be used for a wall elevation, the targets can be placed on the ground and fixed into place with nails. If they feature in at least two photos, they can be placed wherever is appropriate.



Agisoft target

The targets will need to be surveyed so they can be put into CAD and the distance measured between them. This can be done using a hand tape and noted down but is far less accurate. From these known distances we can then scale the model.

Placement of Agisoft targets around the subject to be photographed

Quantity of photographs required

The number of photos required depends on the complexity of the subject and the amount of detail required on the model, whilst it if preferable to capture more photographs than needed, do keep in mind the amount of server space they will take up. If the photographs are taken sequentially around the subject, it should avoid the need for unnecessary random shots.

The model on the previous page was created using the 44 photographs shown, taken in an overlapping sequence with extra photos taken to capture the inside of the alcoves and the corners at the end of the wall. The photos also include the targets so the model can be scaled so elevations and plans can then be made from it.

Photo rectification methodology

Another method of creating plans and elevations from photographs is through rectified photography. This requires the photographer to produce shots which are as parallel as possible to the subject, whether straight on to a wall elevation or looking vertically down to a floor surface. This requires fewer photos than producing a 3D model as the overlap required is minimal.

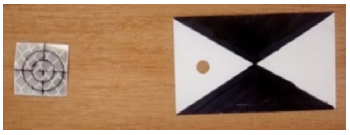
CA currently uses rectified photography to record plan views of skeletons, surfaces and structures and to produce wall elevations. The method uses survey data to stretch (rectify) the photograph to give an accurate scaled representation of what the wall/floor/skeleton would look like from directly above. This can then be used to create digitised plans of the features where required.

Cleaning the area

Ensure that whatever you want to appear in the photo can be seen clearly. If the photo is to be digitised, the digitiser needs to see what they are drawing, and they may not necessarily have worked on the site or seen the features photographed.

Placing the tags

Place a minimum of 6 markers within the boundaries of your photograph. If using adhesive holographic targets, stick them to the top of a clean 6-inch nail driven into the ground or wall face. If using black and white targets secure them with a 2-inch nail through the center of the cross.



Holographic and black and white targets

The targets do not need to be set out in a measured grid; this is no longer necessary due to the quality of instruments and software that we have. Place them so that they are visible, well-spaced and can beaccessed by the survey detail pole.

For larger subjects such as building foundations a well-spaced grid of points gives a better rectification result (e.g. 10 points across a 5m x 5m area).

Taking the photograph

It is advisable to take the photograph before surveying the targets. Try to reduce any obliqueness to the subject as possible. Any obliqueness will increase the amount that the software must warp the image which can lead to inaccuracies. If the photo is too oblique, it will be unusable.

To get extra height for the photograph an aerial mast can be used in conjunction with the appropriate Safe System Of Work. There are also tripods and a monopod available if extra stability is required.

Surveying the tags

The tags can be surveyed using the Target_pt code on the GPS or TST. It can be useful to number the tags. This will make it easier to select the appropriate tags to rectify from if they cannot be easilylocated via the surrounding features. To help you keep track of which target you should be surveying next set the point ID to 'JPEG No'.1 (e.g. 1234.1). Remember to survey the extent of the feature as well.

A detail pole can be used to survey tags placed on the ground, however reflectorless survey with a TST will avoid the tags being accidentally moved during survey. Reflectorless survey is also ideal for surveying tags placed on wall elevations.

Examples

Bad - Too oblique

Good - Rectifiable!

Bad - Too oblique

Good - Rectifiable!

Optimal settings for Photogrammetry Work

Image

- Image needs to be sharp and in focus – always check your images when finishing a survey session.
- *Aperture* is the size of the opening in the lens when a picture is taken and is measured in 'f-stops'. Aperture affects your *Depth of Field* (DOF) or the amount of your shot that will be in focus. The smaller the f/number, the smaller the area in focus. A small number like f/2 means small area in focus through the f/numbers to f/22 (and higher) which means large area in focus. For the purposes of photogrammetric work, the optimal setting is between f/8 and f/11.
- Avoid high ISO settings if possible, to reduce noise – never go above 800 if possible
- Use the fastest shutter speeds possible – 1/125 is optimal.
- Disable VR/IS (Vibration Reduction/Image Stabilization) systems – leaving this enabled will distort your accuracy.
- NEVER heavily post-process – no cropping or non-linear adjustments

Subject

- If any point is not visible in at least **2 images**, it cannot be modelled. More is usually better than less. Historic England recommends that any point should be visible in 9 images.
- Take shots at corners
- Avoid heavy shadows – the flatter the light, the better. Similarly, avoid over-exposed subject area.
- Never crop images, and never apply post-processing 'improvements'
- Always remember that even bad inputs can produce a 3D model, but your accuracy will be compromised.

Appendix 7 Record sheets

- Level recording sheet
- Photogrammetry sheet
- Photogrammetry register
  (for the sites with lots of orthophotos and models)
- On/off hire form

LEVELS REGISTER

Site Code:

Site sub-div:

Surveyor:

Date:

Site Benchmarks:

BM ID	BM Value

Level No:	Back sight:	Inter sight: (archaeology)	Fore sight:	Collimation (Inst. Height)	Reduced level:	Comments:

Cotswold Archaeology

Sheet [ ] of [ ]

Sum BS [ ]

Sum FS [ ]

Misclosure [ ]

CA/FRM/9

PHOTOGRAMMETRY SKETCH SHEET

SITE CODE:	**DATE:**
SITE NAME:	**CONTEXT/GROUP NO:**
SKETCH:	**PHOTOGRAPHER:**

NORTH ARROW (APPROX):

PHOTO NUMBERS:	**STORAGE LOCATION FOR PHOTOS (IF KNOWN):**
REFERENCE TARGET IDs:	
FURTHER COMMENTS:	

Cotswold Archaeology

PHOTOGRAMMETRY REGISTER

Site code:	Site name:

Model No	Structure/ Context No	Description	Trench/Area	Name	Date

Sheet		of	

GPS On hire/Off hire Form

Cotswold Archaeology

GPS VNR no/TST serial No		Hire Company	
		PO Number	

On hire Report

On hire date		Initials		Office	

Checklist	Tick	Notes
Check delivery note against all equipment parts		
Check conditon of all equipment parts		
Added to programme		
Configuration *(see G:\Geomatics\Manuals and Documents\Survey\Configuring GPS or TST kit)*		
Enabled FTP		
Point occupation settings		
Stop parameters		
Survey screen		
Codelist loaded		
Map screen config		

Any other comments/notes:

Off hire Report

Off hire date		Initials		Office	

Checklist	Tick	Notes
Copy all jobs from internal memory and SD card to server		
Delete FTP details		
Add offhire date to program		
Check conditon of all equipment parts		
Check all parts of equipment returned *(incl pole, batteries and charger)*		

Any other comments/notes:

Please return this form to the geomatics team