TheoLt

Quick start &

Hardware guide:

Tablet PC

(Fujitsu-Siemens ST 5011d/ST5031)

&

Total Station

(Leica TCR405)

About this document

This training manual was prepared by Bill Blake and Imogen Grundon for the development of survey skills in using TheoLt in Archaeology. It is to be used in conjunction with the manufacturers guidance on the use of the software and equipment. It is solely for the application described. The Authors accept no liability for the misuse of equipment or misuse of data acquired using it.

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Aims of this guide

This guide provides the practical information needed to operate TheoLt as a mapping tool and the basic operation of the tablet pc and total station.

The use of real-time CAD as a survey tool requires knowledge of 3 systems which are used concurrently: Total station, TheoLt and AutoCAD. This guide shows how the 3 systems work together and how users can achieve specific survey outcomes. The specifics of TheoLt are covered in the installed help *TheoLt Release 6 user guide. pdf* The AutoCAD advice in this guide is supplementary to the help supplied by Autodesk in the installed AutoCAD product.

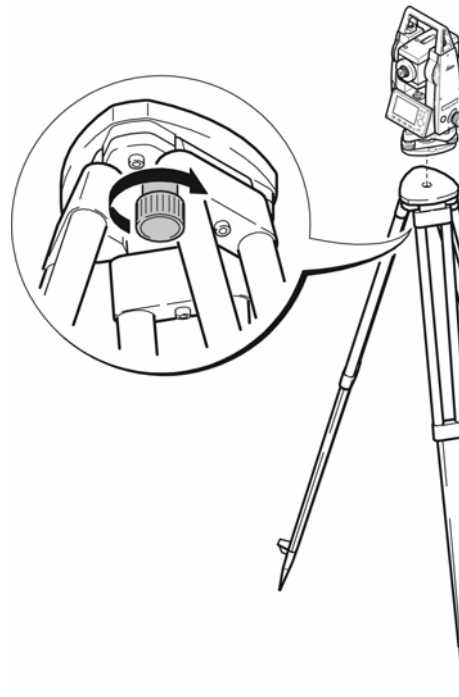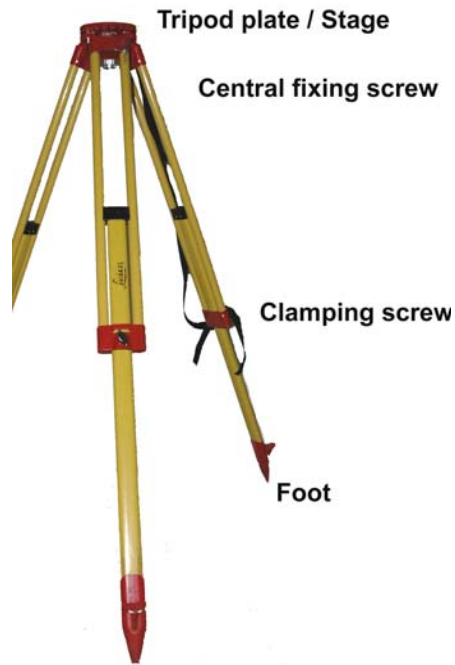*Bill Blake & Imogen Grundon*
Cambridge
28.03.08

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TCR 405 - Accessory list

1   **Data cable**

2   **Tribrach:** laser plummet type

3   **Charger shoe**. Check the battery is properly seated in the shoe when charging

4   **Adjustment tools**

5   **Spare battery GEB 111** the small battery is only good for about an hour of reflectorless work.

6   **Battery GEB 121**
2 of these batteries (4hours each) will do a good day's work.

7   **Mains adapter**. Care should be taken over the cable; it is easily broken by winding tightly.

8   **Pole tip:** this is often stored fixed to the mini prism (11)

9   **Lens hood and dust cover**. The dust cover should be secured with a tie in windy conditions

10   **Manual & software** .The CD contains pdf versions of the manuals and basic software for coding.

11   **Mini prism**. The prism is either a 18mm or zero offset

12   **TCR/Total station/EDM:** always place in the case with the battery cover up

13   **Detail pole**: in 4 sections when fitted together with the tip and prism attached you have a target height of 1.3m.

Centring & levelling up TCR400 Total station

Select a confortable height to set up your Total Station

Tripod plate / Stage

Central fixing screw

Clamping screw

Foot

1.Take the tripod, keep its legs together and loosen the clamping screws, let the legs drop out as you pull the stage up to your chin and re-tighten the clamping screws.

2. Spread the legs open to form a stable shape. Place the feet so that they won't slip. Place the tripod approximately over the point, placing your foot over the point and moving the tripod over your foot can help. Sight the point on the ground through the hole in the tripod stage and moving the whole assembly by rotation of 2 feet about the 3rd, line the centre of the stage up with the point.

3. Place the instrument carefully on the tripod. Check the tripod is stable, the stage roughly level and the plummet is over the point.

4. Secure the instrument tribrach to the tripod with the central fixing screw. The screw should be tightened firmly.

5. Drive the plummet to the centre of the mark with the tribrach foot-screws. Use 2 of the foot screws by turning your thumbs out or in together [but never turning them in the same direction] to move the plummet onto the point. The 3rd screw will provide the motion to move at right angles to the first movement.

6. With the plummet centred on the point the instrument is now levelled by adjustment of the tripod legs. Working on each leg in turn, slacken off the clamping screw and slide the leg to bring the instrument bubble in line with its centre circle. Re-tighten the clamping screw securely before adjusting the next. Measure and record the height of the instrument.

Centring & levelling up: key points to remember

- When a total station needs to be set up over a marked point on the ground, the foot-screws on the instrument are used to centre over the mark. Levelling up is done with the tripod leg clamp screws.

- Eye the tripod roughly over the point. Put your foot over the mark and place the open tripod over it.

- Before you start check the tribrach foot-screws are at the middle of their runs- there is a mark to show this.

- Kick in the feet of the tripod if you are on soft ground and fit the tablet bracket etc. BEFORE making fine adjustments.

- CENTRE the tribrach over the point with the FOOT-SCREWS

- Always work 2 screws and then 1 screw don't skip from one to another!
  When you turn two foot-screws move your thumbs in or out from each other- never turn them the same way!
  Watch the centre mark to see which way to move it!

- It's easy to drive the centre mark to the point with the foot-screws.
  Do this BEFORE YOU LEVEL UP!

- Level up the bubble with the TRIPOD leg adjuster clamp screws. By lengthening and shortening each leg in turn you will rotate the centred axis of the setup about the mark. Use your thumb to hold the weight as you slide the leg, you will be able to have millimetre control that way

- When complete the setup procedure must achieve 3 things which are essential for measurements to work. If these conditions are not met the work will be imprecise and beyond repair!

  1. STABLE AND SAFE, clear from wet, dust, wind and traffic (foot, goats, vehicle or otherwise!) Make sure the instrument is clamped to the tribrach. Keep the tablet in the shade and never point the telescope into the sun

  2. VERTICALLY CENTERED OVER THE POINT. If it's not over the mark don't use it!

  3. HORIZONTALLY LEVEL. Keep an eye on the bubble, it will move off centre over time. Use the foot screws to bring it back to level but don't forget if you adjust the level you will need to check the centring. Small adjustments can be made by carefully unscrewing the central mounting and sliding the tribrach back over the mark.

Tablet PC - accessory list

All of the components are vital. The loss or damage of any one part will render surveying operations in TheoLt impossible. Note that the Fuji needs a serial adapter (2) to connect it to the EDM with the TCR cable (1). The outfit includes 3 batteries and an off-unit charger (3). It is essential to have a minimum of 2 x 9 cell batteries (4). Charged for each day's work, they deliver about 31/2 hours each. The smaller 6 cell battery (5) is an emergency spare giving about 2 hours.
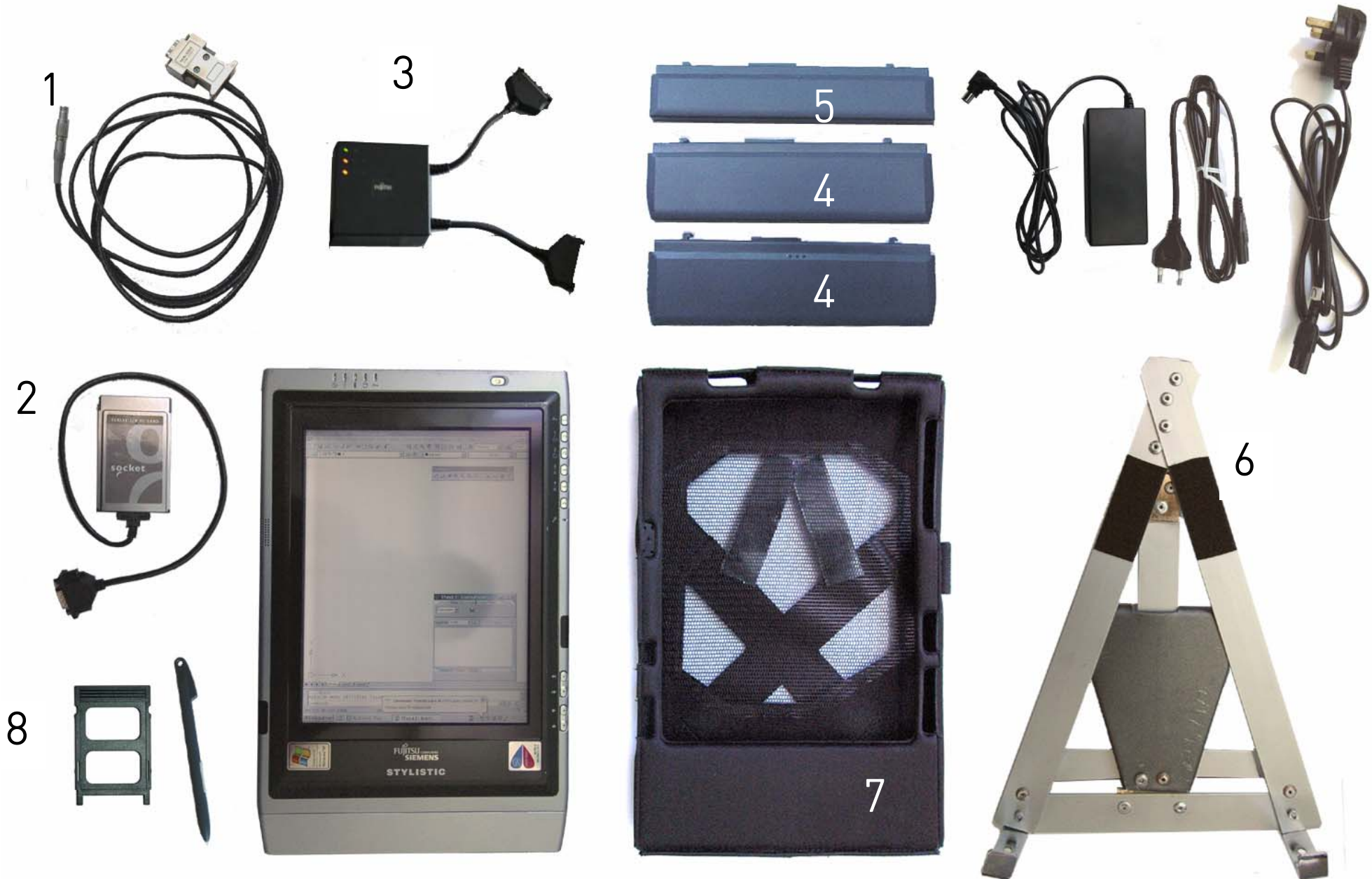
Inserting the serial adapter PCMCIA card

The PCMCIA port is on the top of the tablet and should be plugged with the insert to keep it clear of dirt at all times when not in use. The serial adapter card should be fitted as shown. Do not force the card into the slot under any circumstances. If it will not fit the slot the card should be examined for damage or dirt. The tablet is set up to hibernate on use of the power switch. This is a great time saver but if the serial adapter card is removed and not replaced before restarting a session software conflict can occur. This card is a ruggedised one but it is still vulnerable to damage. Treat it with care and protect it from being bent or contaminated with moisture, salt or dirt. Always replace the blanking plate (8) when the serial card is removed, to protect the slot from damage.

Connecting the TCR cable

The TCR data cable is plugged into the 9-pin serial adapter. At the tablet end the pins are delicate. Take care not to force them. The Lemo connector plugs into the TCR. It can be a tight fit so care is needed to ensure the connector is properly aligned.

The Lemo connector

The connector is aligned by matching the red dot on the instrument com port and the red dot on the connector collar. To remove the connector, slide the collar back to retract the locking tabs and then pull it out.

Make & break connection

When moving the TCR from station to station, you will need to disconnect the tablet. The safest method is to unplug either the 9-pin connector or the Lemo - unplugging the PCMCIA card from the tablet is likely to cause problems and expose the card slot to unwanted contamination from dust.

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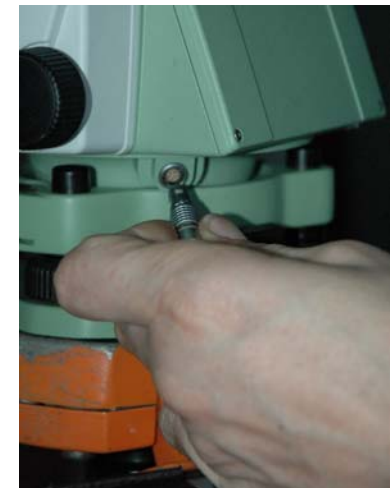
Fitting the bracket

The bracket (item 6 on p7) is designed for use with a survey tripod. It will fit both Wild and Zeiss pattern tripods. The spring steel clip must be fully engaged into the accessory slot on the tripod head and the strut correctly slotted home to form a secure platform for the tablet. The bump case (item 7 on p7) is supplied with Velcro patches for additional security: they will need to be pressed home.

Care should be taken to avoid upsetting the instrument level when mounting and de-mounting the bracket.

The bracket is designed for use with the tablet in its bump-case: it will be a loose fit if the case is not used.

Once the tablet PC is mounted to the tripod and connected to the TCR the instrument should be re-levelled and centred as fitting the tablet often causes a slight dislevelment!

Using the instrument: navigating the menus

The TCR 400 series uses a 5 key menu navigation system. The navigation key will allow scrolling between menu options; the page key will allow selection of pages within menus. There is some variation in the menu layout depending on the year of instrument manufacture.
In addition to the front panel keys a configurable trigger key (the' banana' button) on the side panel of the instrument can be set to measure and record (the 'all' function in the measure screen).
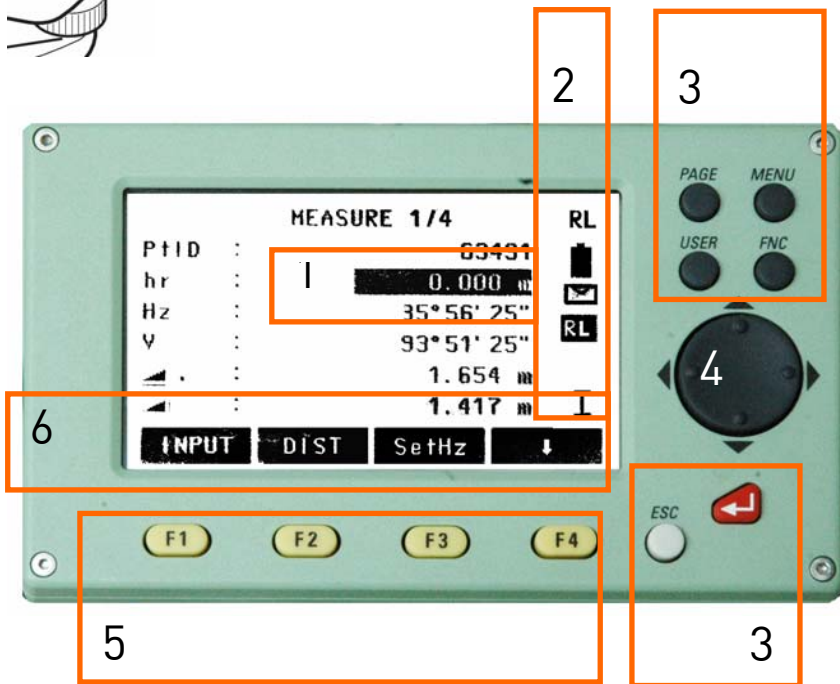
1	Selected field		Indicates the field of user or measured input
2	Status symbols		Indicates measurement mode (IR or RL), battery state and menu options
3	Fixed keys	Page	Scrolls to next page when dialogue consists of several pages
		Menu	Accesses programs and settings
		User	Customisable with function from the func menu
		Func	Quick access to measurement support functions
		Enter	Sets selected option
		Esc	Returns to previous screen
4	Navigation key	Menu navigation, focus scrolling and option selection
5	Function keys	Assigned to variable functions displayed on the softkey bar
6	Softkey bar	Functions available on current screen

IR and RL modes

IR = infra-red and RL = reflector-less. IR mode requires a reflector or prism (Item 11 on p4) to work.

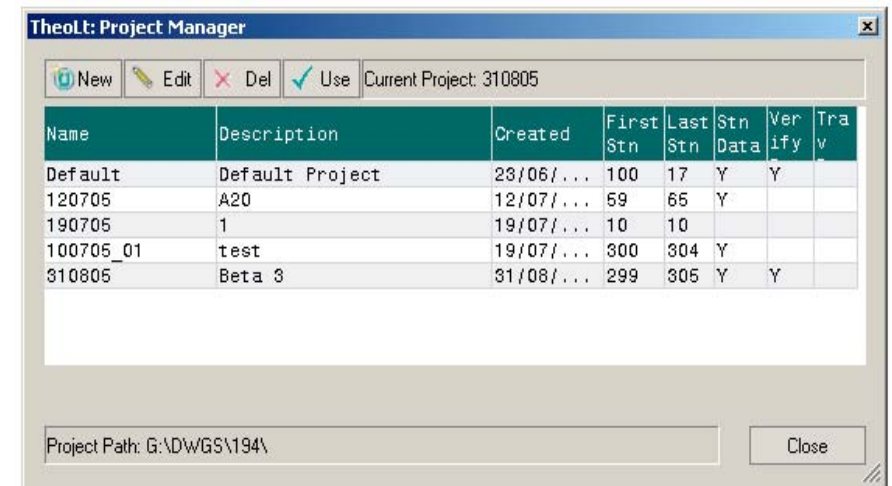RL uses zero (it is set by default when RL is selected)

Check that the prism offset (in the instrument EDM settings menu) is set to 18mm or zero when using the mini-prism. This is important when selecting the EDM mode to IR as the prism selected MUST have the correct offset.

Using TheoLt: key concepts

1. TheoLt is the link between the instrument and the drawing in AutoCAD

2. New site = new project

3. New set up =new orientation

4. Record instrument and target heights and check they are entered correctly

5. Save the drawing file in the project folder

6. Use the IR mode for ground lines: the detail pole will help improve the sight lines

7. Always work with a levelled instrument- if it is disleveled re-centre the instrument, correct the level and retake the orientation.

8. Keep equipment clean and dry. Always close the instrument case when it is not in use: keeping the case clean will protect the instrument.

9. Work from the whole to the part : trace the longest lines first especially when working with the prism

AutoCAD tips for surveying with TheoLt

1. Use *veiwports* to see the whole and the part.

2. Use *plan world* to check the orientation has worked ok

3. Use layers to separate work by day, station, and surveyor.

4. Freeze off layers you don't need : it is always worth the time taken to get a clear view of where you are working

5. 3D views will let you keep a check on heights

6. Don't panic- TheoLt will always plot in the draw tab: if you can see the data from the instrument in the command line- provided you have a *line* command to catch the points!

7. Remember you can zoom in on detail and draw with a *polyline* snapped through the measured points to get smoother lines if needed.

8. Watch out for *filedia* it will need to be reset to 1 from time to time: use the customised 'F' button to re-set it when the *saveas* dialog fails.

9. Remember to open your AutoCAD drawing before you open TheoLt: you won't be able to map anything without a drawing open!

TheoLt: Project Manager

New | Edit | Del | Use | Current Project: 310805

Name	Description	Created	First Stn	Last Stn	Stn Data	Ver ify	Tra v
Default	Default Project	23/06/...	100	17	Y	Y	
120705	A20	12/07/...	59	65	Y		
190705	1	19/07/...	10	10			
100705_01	test	19/07/...	300	304	Y		
310805	Beta 3	31/08/...	299	305	Y	Y	

Project Path: G:\DWGS\194\   Close

If you start operations by using the project tab you can pick the project in which all the survey data will be written. It is a useful habit to use this as the stations can be picked by number in the orientation dialogues. When you save the AutoCAD drawing if you use *saveas* you can place it in the project folder. Get to know where the project folder is: its root will be set by your system administrator.
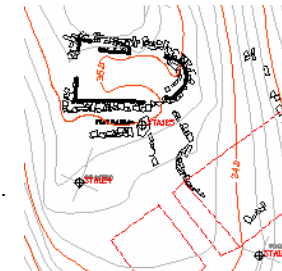
Surveying with TheoLt: basic procedure

1 Prepare drawing

Open **AutoCAD** and have the drawing you want to add to current.

Check the drawing to make sure your position agrees with it: know 'where you are' in the drawing. Identify the stations you will be using both on the ground and in the drawing.

2 Set up instrument

Set up your instrument, centre it and level it. Measure and record the height of instrument from the ground (not the top of the peg) to the instrument centre mark. Connect the tablet to the instrument and check the instrument level again. Make sure the tablet bag and instrument cases are closed after use to prevent dirt getting in.

An orientation is required before points can be measured so open **TheoLt**.

3 Orientate

Send a point to TheoLt and the orientation panel will be prompted. Enter the occupied and reference positions, the instrument and target heights, take the shot, check it and accept the orientation.
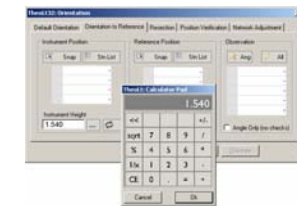
4 Survey

Check TheoLt is in the draw tab with the transparent tool set, select an AutoCAD layer, select the line tool and off you go!

Saving the drawing saves the work.

Use the control tab and follow the on screen prompts following measurement to set out more stations as required.

Orientation principles

Surveying can only work with an orientation. Unless you can place yourself (and your instrument) at a known point on the map and determine a fixed direction from which measurements can be made you cannot survey!. TheoLt offers 2 methods for achieving orientation on moving the instrument to occupy a new point.

Known positions must be marked. A station point should be recoverable and therefore it is marked by a nail, peg, pencil or scratch mark. It is essential the same point can be found and identified WHITH CERTAINTY .If a mark is to be left for future use it should be of adequate permanence. Do not use any mark for survey unless you are confident it is identified as a survey point with verified co-ordinates!

On moving the instrument to a new position there are 2 methods of achieving orientation; both require 2 clearly identifiable marked points. If the 2 points are inter-visible *orientation to reference* is possible if the 2 points can be seen from a 3rd *resection* is possible.

Resection is the solution of triangles to determine an unknown position by measurement to 2 (or more) known positions a new instrument position can be added to the survey.

Instrument heights are crucial. If a station is occupied with an incorrect height of instrument entered a false height value will be transferred to every point measured form it. Always measure and record the height of the instrument once you have levelled it.

The station peg is on the right, with the yellow cap. To the left is a 'trench' peg. The station peg should not be used for taping and stringing so is therefore undisturbed.

Target heights are crucial. Always check that the height of the target is correct, particularly after orientation when the reference target height can be carried forward and when switching to reflector less modes when a target height of zero is required.

Levelling and centring the instrument correctly is vital, follow the procedure on p5. Do not take measurements until the instrument is in a fit state to do so!

Moving the instrument. How orientation works
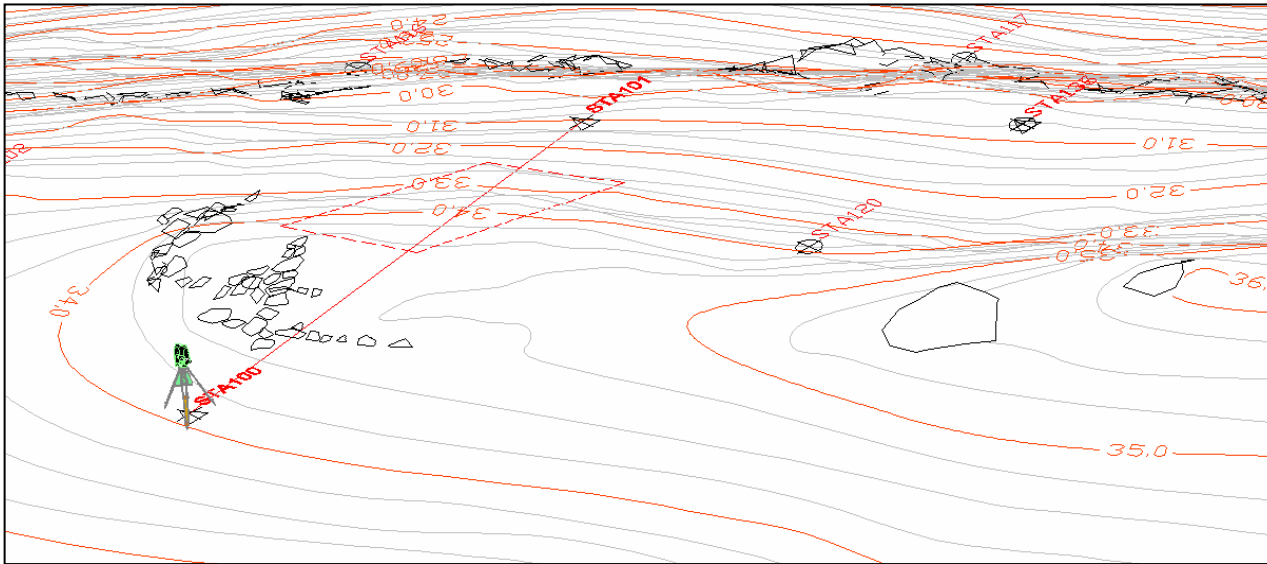
**Orientation to reference= Occupying 2 known points**:

Orientation to reference requires the Identification of the position of occupation and position of reference on the ground and on the survey drawing. By measuring the angles and distance between 2 known points on the survey orientation is achieved.
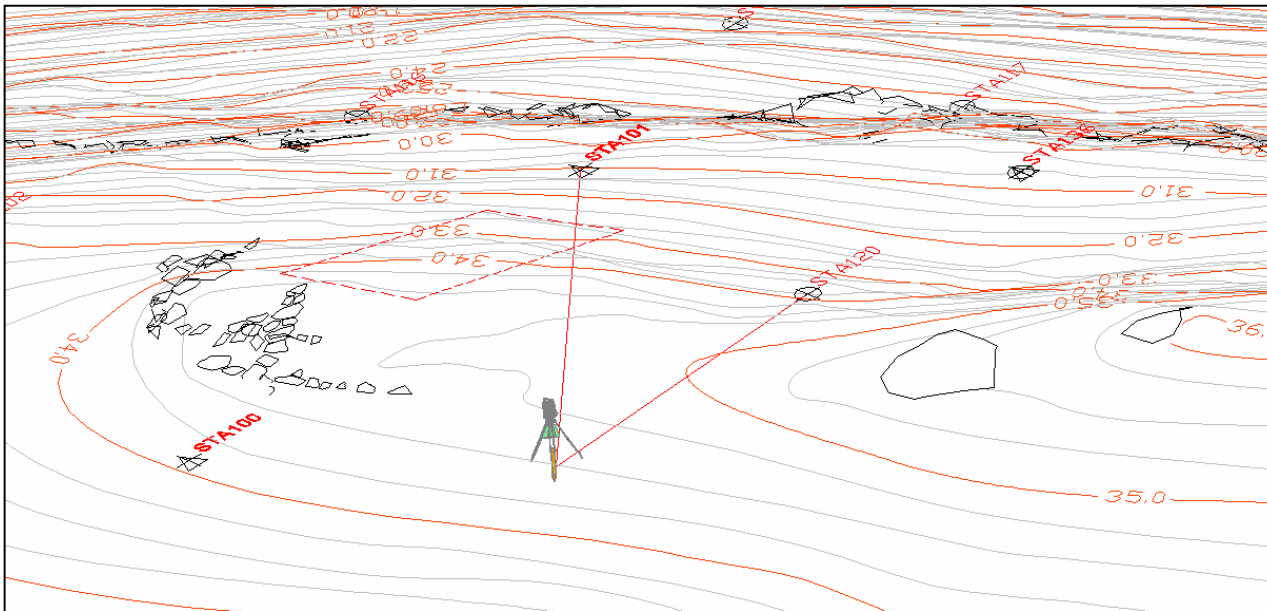
Resection= Occupying an unknown point:

To resolve the occupied position measurement to a minimum of 2 identified positions of reference is required. Resection allows you to set out a stations where you want to be provided you have lines of sight to 2 other stations or reference positions. If the geometry of the resection is poor it will be indicated in the position verify table: often the remedy for poor results is to move the instrument to a better position with improved geometry (i.e.: less steep angles or less variation in distances: the triangle you are solving should be 'well conditioned')

Orientation options in TheoLt
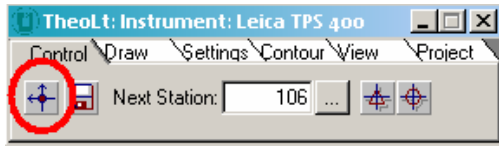
Default orientation (includes reuse last orientation)

The default orientation is designed for starting a survey job at an arbitrary value for the 1st station; it should not be used once a survey job is underway. The option does include a useful *restore last orientation* function which will reuse the last orientation at a set up where the instrument has not been moved but an AutoCAD session has been restarted (such as after a lunch break) . No values need to be input to use this function

Orientation to reference

Orient to reference will allow you to set up over a known point and sight to another, the measurement results will indicate the accuracy of the observation compared to the CAD data. The heights of instrument and target must be entered (see example on p17)

Resection

Resection is the quickest way to position the instrument without 'setting out' a new station. Always check the result in *position verification* as solutions are possible based on selecting the wrong reference stations!

Position verification

A running check on the precision of the orientation is kept in the position verify table. Check the table to make sure the precision of the survey in on track. Don't forget there is a known mismatch between GPS measured points and EDM measurements.

Network Adjustment (do not use!)

The control on the Keros site is a mix of GPS and EDM points which should not be adjusted as a contiguous network!

Procedure in the field: Orientation: 1.Selecting the stations

Pick the station you are on here. You can pick it off the drawing using the snap option or select it from the station list held in the project file.

The station list is updated as you add stations to the project: check the number against the drawing to make sure you select the right ones.

If you have 2 points on your survey with known positions (marked in AutoCAD with station symbols) you can use *orientation to reference* to align your work with the survey. Set up the instrument over one point and a prism over the other, select the control tab and then open the orientation panel, select the orient to reference tab and enter the station details need for the observation to record the orientation.

If you have the co-ordinate values for the stations they can be added using the 'new' option from the 'Stn List' option next to snap. The stations will be added to the project station list.

Enter the height of instrument here. You can use the popup keypad.

If you want to start a new drawing and add stations to the stn list (for example as a sub survey) you can insert the required stations into the current drawing using the *Insert stn/insert ref* option. You can also update the stn list by keying in the station co-ordinates with the 'new' option and then insert them into the drawing if you need to.

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Procedure in the field: Orientation: 2. Height of instrument

The height of the instrument **is crucial to the precision of the survey process.** Once the instrument is centred over the mark and levelled, the height is measured form the centre mark on the instrument to the ground height of the station marker. **Consistency in how this measurement is archived is important,**
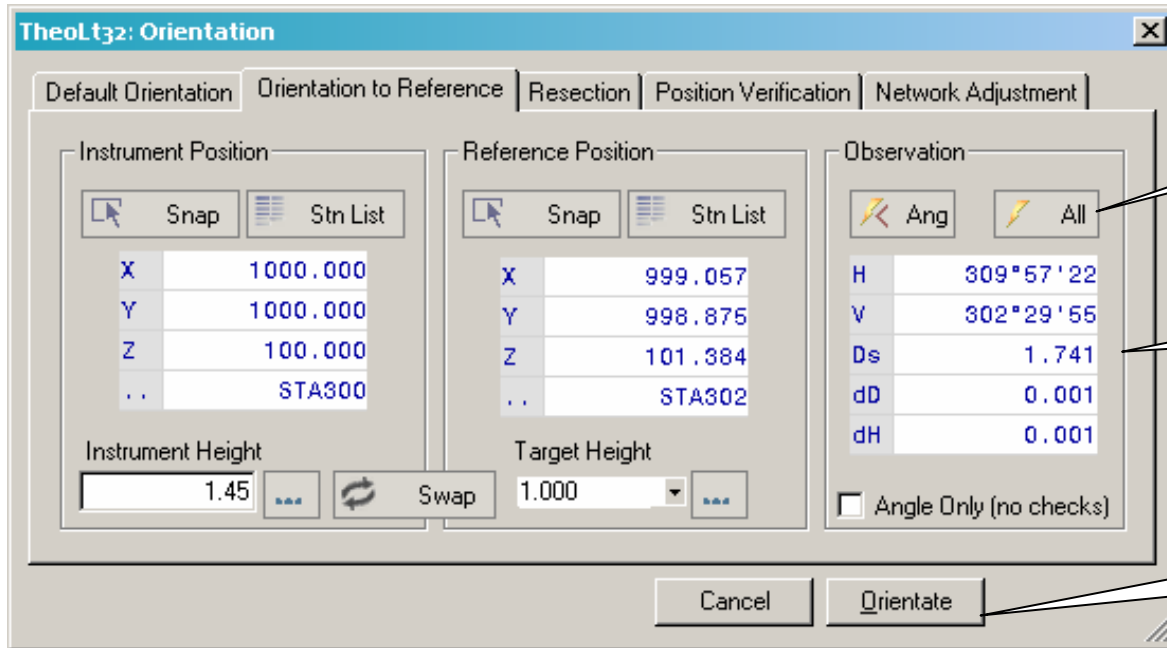
Every time the instrument is set up the height must be taken and entered in the correct field in the orientation dialogue.

The practice on the Keros project is to centre over the mark and record the height to the GROUND at the mark. With a bit of practice the height of instrument can be taken single handed, but it is easier if one person holds the tape end to the ground point and the other takes the measurement at the instrument centre-mark. TheoLt computes and plots the height of all points measured from an orientation based on the height of the instrument, Change the height and you need a new orientation
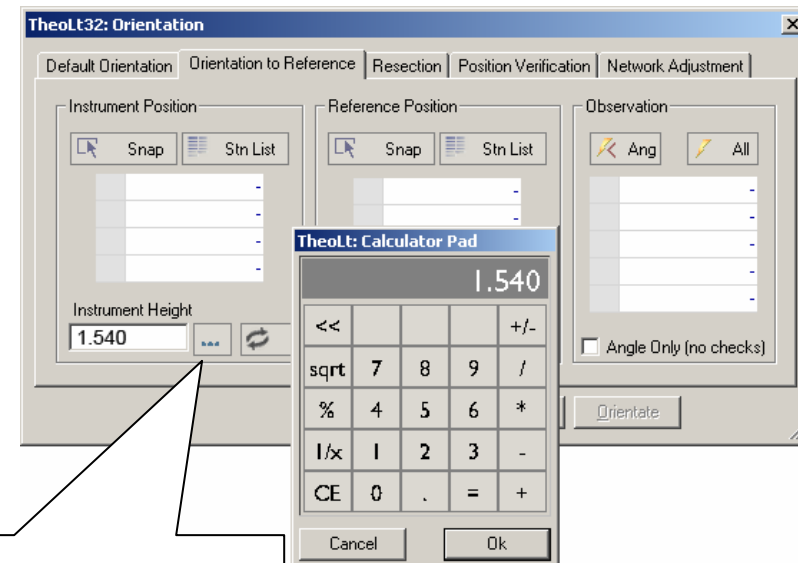
The popup keypad for entry of the Instrument height is brought up from the extra options button.

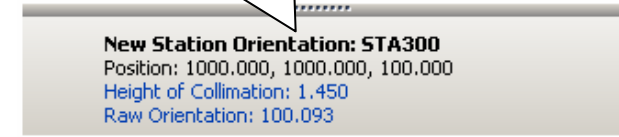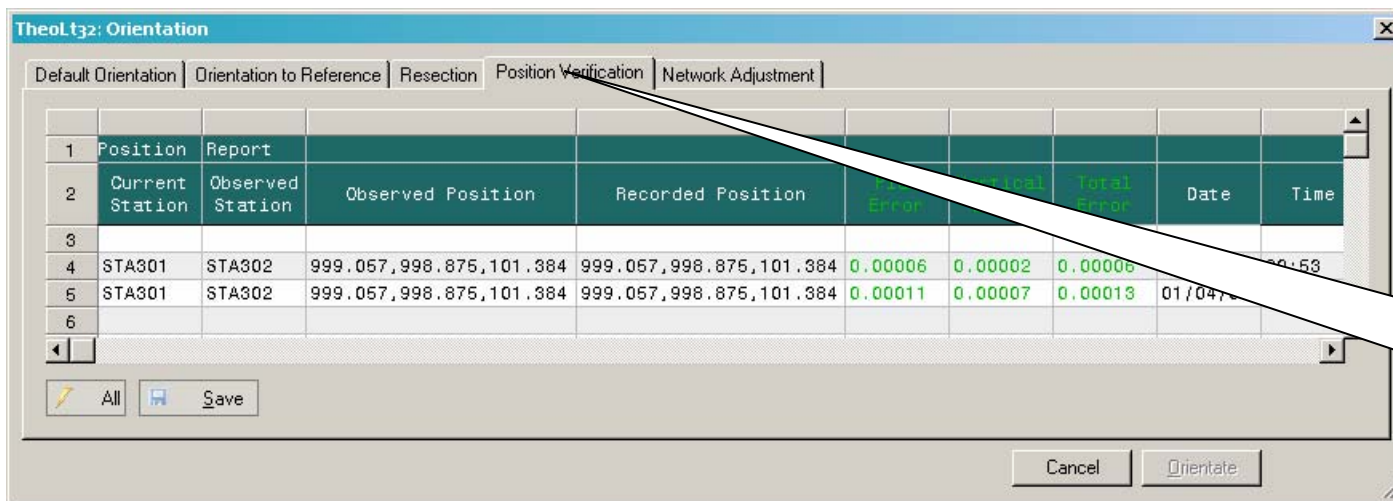## Procedure in the field: Orientation: 3. Check the results

TheoLt32: Orientation

Tabs: Default Orientation | **Orientation to Reference** | Resection | Position Verification | Network Adjustment

Instrument Position

Snap | Stn List

X	1000.000
Y	1000.000
Z	100.000
..	STA300

Instrument Height: 1.45

Swap

Reference Position

Snap | Stn List

X	999.057
Y	998.875
Z	101.384
..	STA302

Target Height: 1.000

Observation

Ang | All

H	309°57'22
V	302°29'55
Ds	1.741
dD	0.001
dH	0.001

☐ Angle Only (no checks)

Cancel | Orientate

With the 2 points identified, point the TCR at the reference target and take the orientation shot: the observation result is displayed in the H V Ds panel

The difference between the CAD positions and the measured position is shown as both the distance and height displacement (dD and dH) the values are shown in metres.

When you are happy the observation is good the orientate button will store the result and apply it to the data sent to AutoCAD.

Applying the orientation prompts the orientation the popup panel to confirm it.

New Station Orientation: STA300
Position: 1000.000, 1000.000, 100.000
Height of Collimation: 1.450
Raw Orientation: 100.093

Further confirmation of the orientation result can be obtained by using the position verification tab; take a shot to the reference target and the result is displayed: it can be logged to a file if desired.

TheoLt32: Orientation

Tabs: Default Orientation | Orientation to Reference | Resection | **Position Verification** | Network Adjustment

	Position	Report	Observed Position	Recorded Position	Horizontal Error	Vertical Error	Total Error	Date	Time
1	Position	Report							
2	Current Station	Observed Station	Observed Position	Recorded Position				Date	Time
3									
4	STA301	STA302	999.057,998.875,101.384	999.057,998.875,101.384	0.00006	0.00002	0.00006		0:53
5	STA301	STA302	999.057,998.875,101.384	999.057,998.875,101.384	0.00011	0.00007	0.00013	01/04/	
6									

All | Save

Cancel | Orientate

Procedure in the field: Measuring points using a prism

When using the instrument in IR mode, the height of the prism above the point of measurement needs to be corrected for.

Observations to the prism require the use of a **target height** in TheoLt to make sure the measured point is recorded at the ground height. **REMEMBER the target height is set with the tick button to confirm it!**
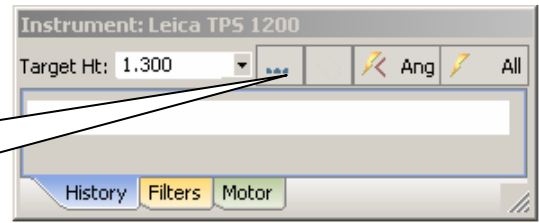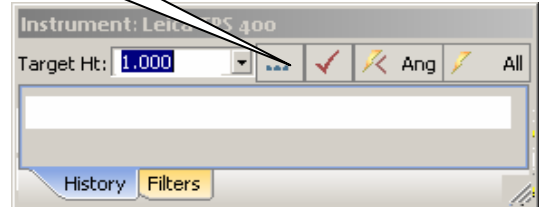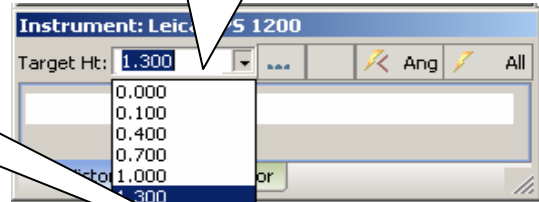
The height is entered in the instrument panel in TheoLt. The red tick indicates that the height of target is not set. Click on the symbol to set the height.

The last used heights are stored for reuse. Zero is always available for RL mode.

The prism bubble must be centred so that the pole is vertically over the point of measurement.

The height of target with a single section of pole and tip is **0.4m**

When the height of the target prism has been entered, the red tick will disappear
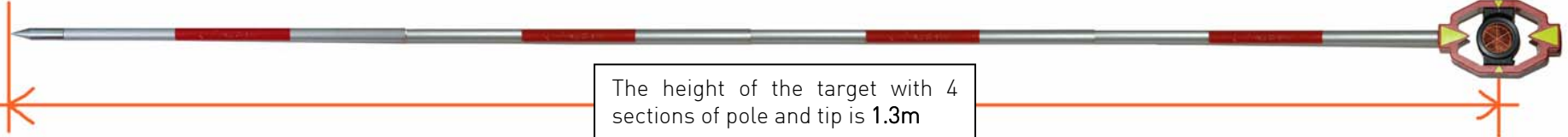
The height of the target with 4 sections of pole and tip is **1.3m**

Procedure in the field: Drawing in AutoCAD as you measure
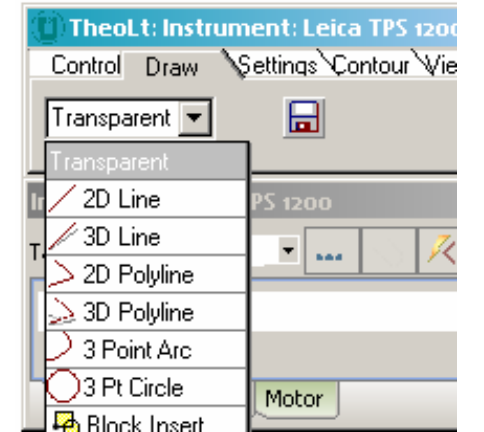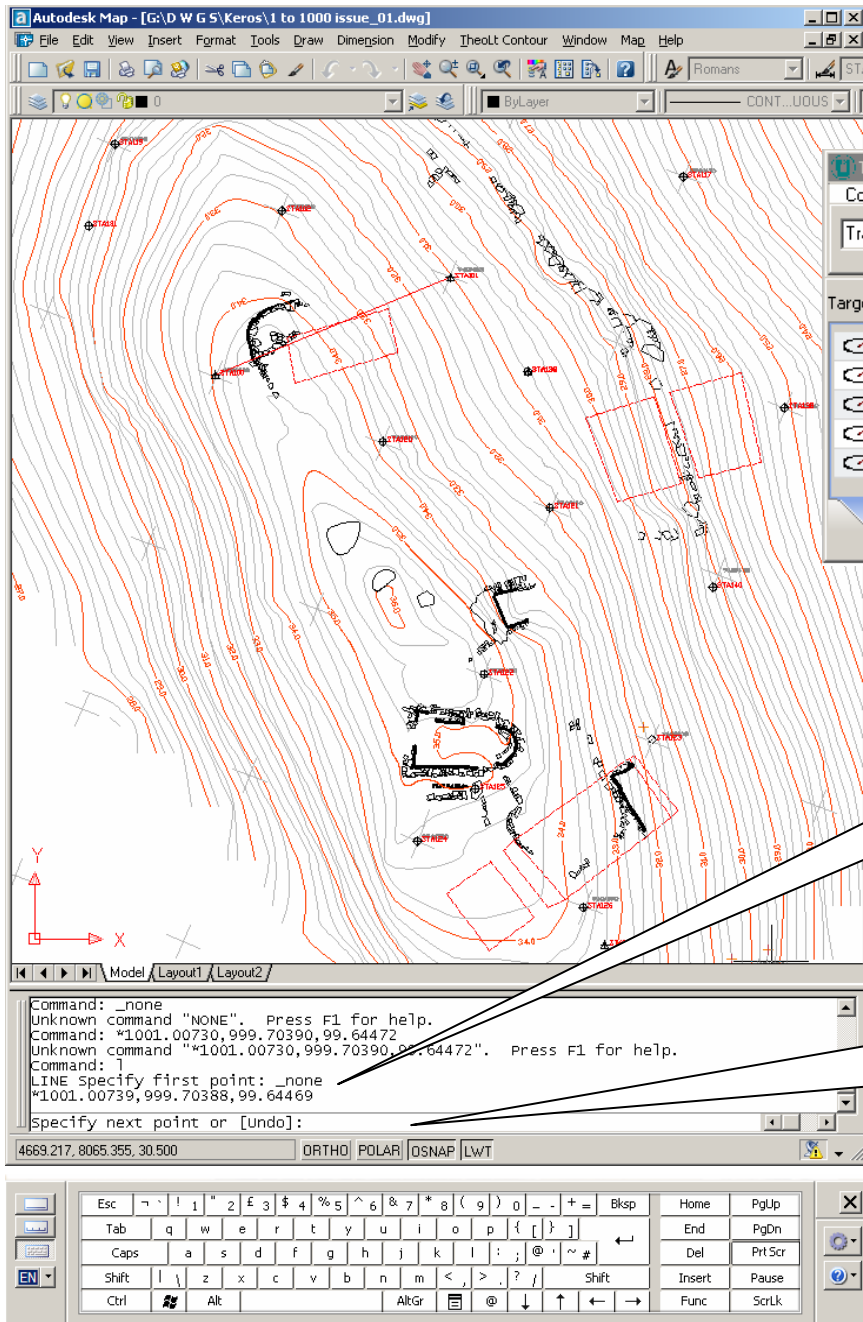
Make sure TheoLt is set to the *draw* tab. Use the transparent setting for AutoCAD commands and select a drawing tool *e.g. line* .

The TheoLt drawing tools should be avoided unless you want to plot a circle or arc.

TheoLt will always plot lines to WCS regardless of the current UCS. You can use any UCS you like to get the view or edits you want.

Watch the command line: the instrument data should appear here as well as the status of any command you are using. Make sure lines are plotted!

The TheoLt history will allow you to go back and redraw lines if you forget to use the line command. Pick on the observation and it is sent to the command line again. The default setting is for the last 10 observations to be stored in the history.

Procedure in the field: Working with the Pen on the Tablet PC

There are 3 methods of entering commands into AutoCAD: The pull-down menu, the toolbar buttons and keyboard entry in the command line. The tablet on-screen keyboard is awkward, not least because of the shift in window focus needed to use it. If the keyboard is docked to the system tray at the bottom of the windows screen it is reasonably predictable. However, it has a tendency to hide or pop up and interrupt command sequences. If you know the keyboard alias for a command (e.g L for line) and you can't find a button for it, the on-screen keyboard gets you there as a last resort! The tablet pc will have a shortcut to the on-screen keyboard fixed on the taskbar,
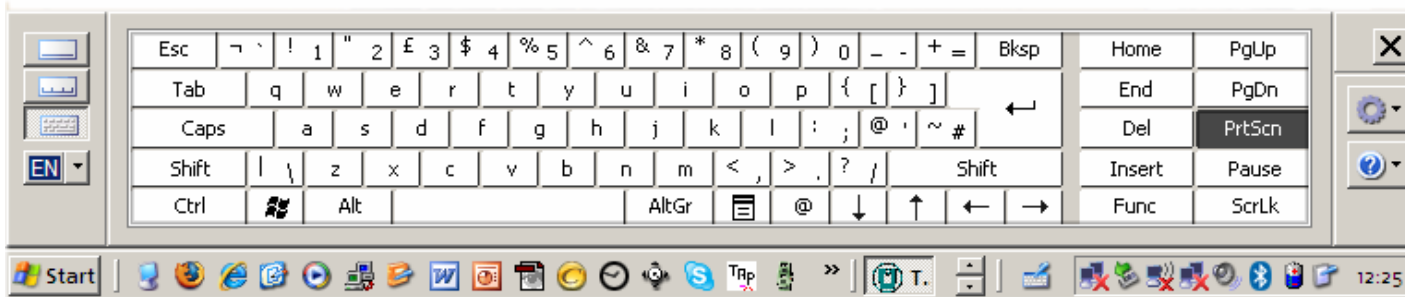
Functions on the pen

The tablets supplied use an active pen. This means the pen is a substitute for a mouse and it can serve all mouse functions other than scroll.

Pick- tap on the item and it will be selected. In the AutoCAD drawing area, selected items will appear 'gripped' or highlit by its snap points.

Right click- squeeze the switch on the side of the pen, tap the pen to the screen and release: this takes some practice!

Double click – it is often better to use a right click and select from a context menu as the double click response on the pen is poor

Enter-double tap, this can be slow so an alternate is the hard enter button on the tablet (see p 18) or enter on the on screen keyboard.

Tool-tips if you 'hover' the pointer over an AutoCAD button its tool-tip should be revealed, indicating its function. (this does not apply to TheoLt).

Pen action in AutoCAD

A tap in the drawing area in AutoCAD while the *line* is running will pick an accidental 'next point' it will be a 2D point with a zero height and useless for the survey. This is to be avoided and repaired immediately. If you draw a line, make sure it is snapped onto objects of the right height! The line command can be stopped and started by using a double right click in the drawing area to act as an 'enter' which repeats the last command in AutoCAD.

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Recording point finds with attributed point symbols

The TheoLt Features command

The features command gives access to point symbols which have attributes logged to an Excel comma space value delimited (csv) data file The command is accessed via the TheoLt tools, when *Features* is selected the *features palette* will open: a double click on an icon in the palette will launch the dialog for symbol insertion. Should the palette not be displayed reselect the *features* option after returning to the *transparent* option.

Point symbol

The symbol picked from the palette is inserted into the current drawing at the position of instrument observation. It is tagged with the attributes given to it at capture. Orientation of the symbol is fixed to the current UCS (so use WCS for consistency to the survey grid) . The symbol is inserted into the current layer, it will be coloured by the current layer colour.   The block size and annotation text style is determined by the prototype block drawing in the folder *c:\theoltblocks* .

Inputting attributes

When the shot to the point is taken the *next* option opens the *Insert feature Data* dialog is prompted to accept the attributes required. Each field is selectable and editable. Data entered into this panel cannot be undone so care should be taken to avoid erroneous entry! The OK button writes the data to the CSV file and inserts the symbol into the drawing. New attribute names can be typed into the pull down last used list.

Context number

A context number defines a specific deposit or feature in archaeological recording. It is important because all finds retrieved from that feature or deposit are located by the context number they are given. The Context symbol may be used to identify a context with a co-ordinated point.
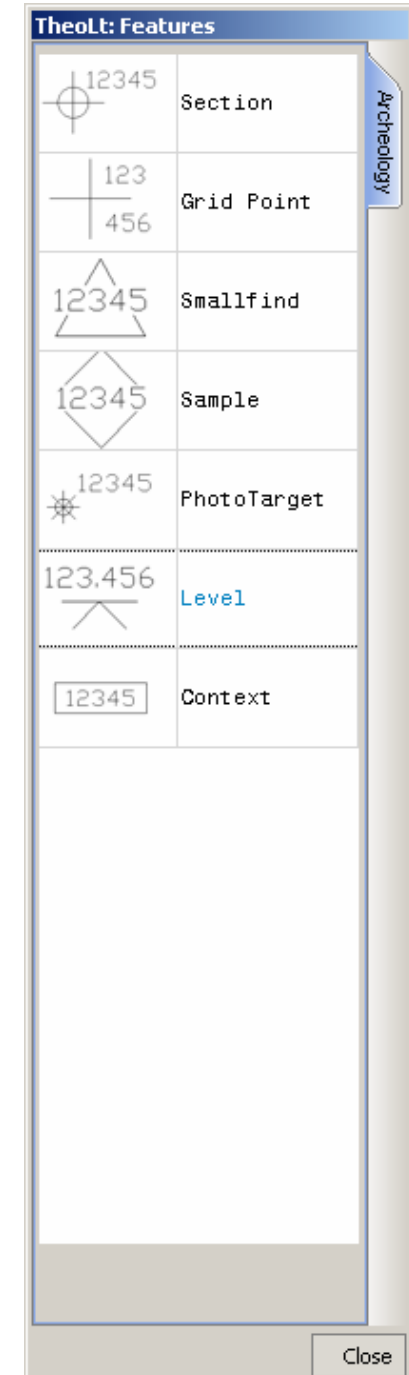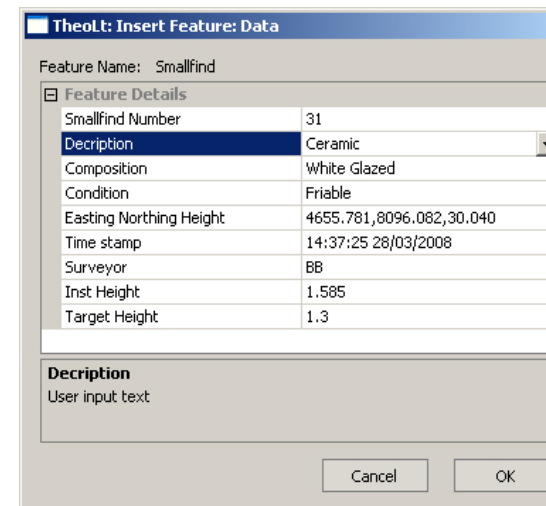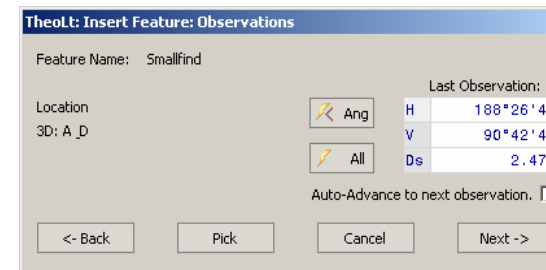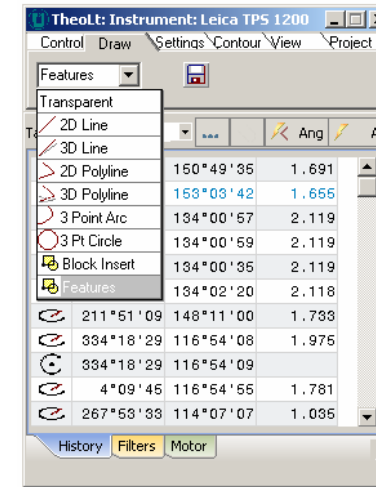
The symbol in the drawing

The point symbols on the plan mark the point of capture but also (in the case of surface finds) can be used as nodes for the contour model so careful checking of instrument and target heights is needed to keep the 3D record precise.
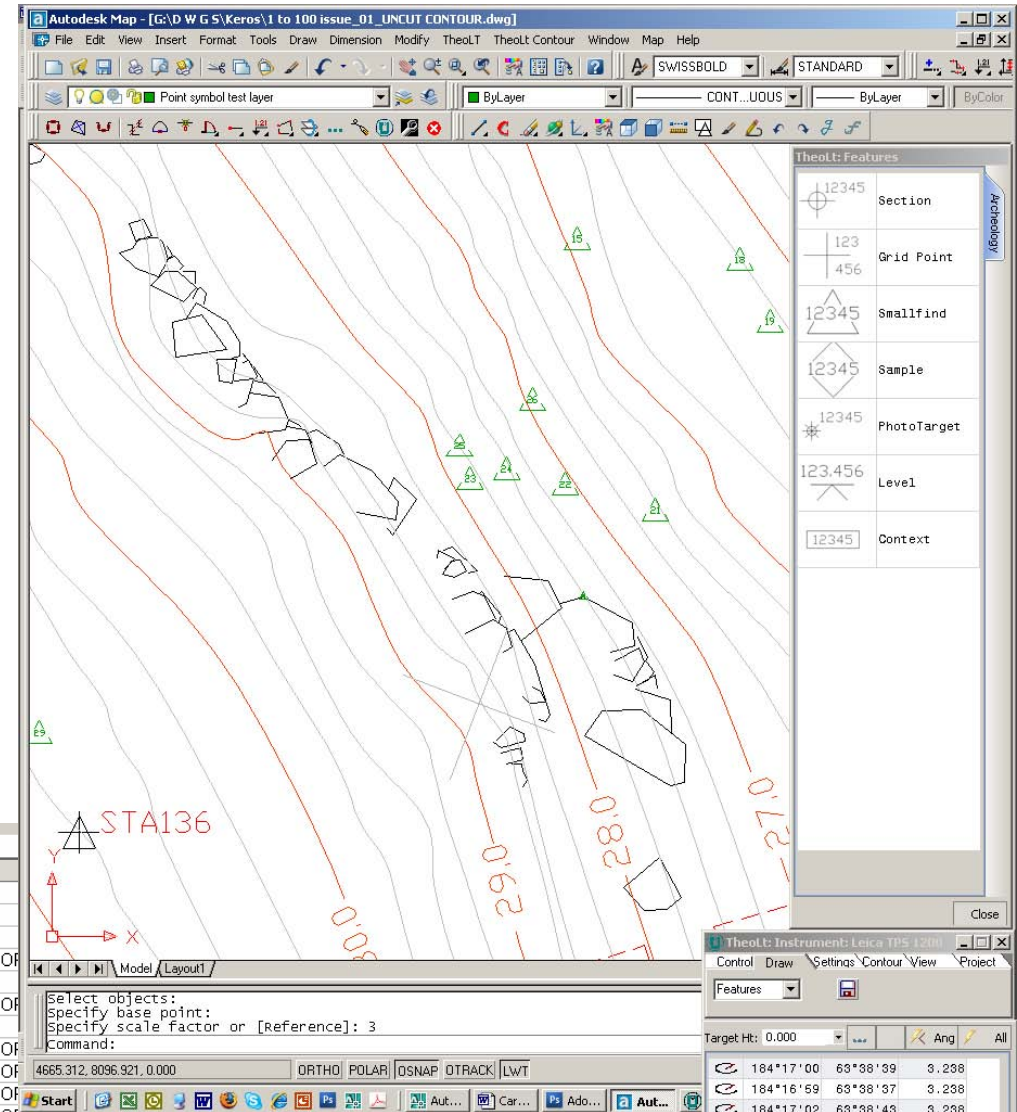
The CSV file

The data is written to a *.csv* file in the project folder e.g. the *smallfind.csv* file can be read in Excel. The fields will be tabulated as columns. The first field will determine the row order by default. If a database with fixed fields is needed, a mask can be used to constrain the fields. The mask table is shown at *Customising the feature attribute table* on p 36. **Note that the file cannot be written to while it is open!**

AutoCAD attribute editor

The AutoCAD attribute editor (double-click on an inserted block) will reveal the attributes attached to the block but not the full attribute list as this is written to the CSV file, it is a useful check on point numbering and confirmation of a successfully inserted block.

AutoCAD commands you need to know 1: Frequently used Commands

Command	Icon	What it does	Command	Icon	What it does
Line		Draws segmented line through measured points, 'C' closes line back to 1st point. This is your basic plot and draw command.	Copy		Be careful to pick the start point in CAD so TheoLt can send the displacement points to the command line
'Hard' Esc		Clears grips	Snap to Insert		The insert point is the true co-ordinate position of a station in WCS, if you want to check a station co-ordinate *list ins of* is one way to do it.
'Hard' Enter		Repeats last command	Layer		Don't forget its easy to change the layer an item is on by picking it and then selecting the required layer from the pull down list in the standard toolbar.
Cancel*		Cancel (^c^c) clears the command line but NOT grips: you will need to customise a button for this command.	List		Displays the properties of the chosen object
Offset		Copies an object at a set distance parallel to it, It works relative to current UCS the 't' option (for through point) will allow a picked point to set the offset distance.	3Dpolyline		If you need to plot a continuous line as a single entity (rather than a series of segments with *line*) Use 3Dpolyline as a standard Polyline will not work with instrument data as it is a 2D command.
Extend		Lengthens a line in its own direction towards another line in the same z plane.	Filedia*		If AutoCAD fails to display the file list when using *open* or *saveas* cancel the command and use the' f' button to reset it.
Trim		Cuts a line with another in the same z plane.	Undo, redo		safer than erase for dealing with mistakes
Plan*		Plan View – this command returns to a flat view from above after a 3D orbiting command	3DPan, 3DZoom, Orbit		Also zoom extents, zoom previous

* These commands do not have preloaded icons in AutoCAD; you will have to customise your toolbar accordingly.

AutoCAD functions you need to know 2: Layers

Current Layer

AutoCAD drawings separate information by layers. The layers in a drawing overlay each other to build up the complete picture. TheoLt plots into the current layer. It automatically sets the working layer (current layer) to a pre-assigned layer when a station is inserted; take care to reset the current layer to the right one for the details you map.

Changing layer assignment

Specific features, like ancient walls, should be placed in an appropriate layer. If you make a mistake, you can always reassign the layer using *match properties* or the property browser.

Distinguishing layers

When more than one is visible, distinguishing different layers is best done by choosing different colours, line weights or line types for each layer. Remember these should be bright colours as pale colours are not easily visible in the harsh light on site. Make them distinctively different from each other, so you don't forget.

Managing layers

The Layer Properties Manager, reached through the 'stack of papers' icon to the far left of the layers bars, governs the layers and their current status. Here you can create layers, select one to be your current layer – ie the one you actively draw in. Here too, you can turn off any or all of the layers to make the screen as easy to work in as possible. The current layer can be assigned by selecting from the pull-down layer list.

Creating a new layer – click on the 'New' button.

Double click on the default name 'Layer 1' and it allows you to rename as you wish.

On – (toggle) – lit light bulb means the layer is visible in the active drawing.

Freeze – (toggle) – means that the layer content will not be visible in the current view port.

Lock – (toggle) - means the layer contents can't be edited.

AutoCAD functions you need to know 3: View

Pan, Zoom and 3D Orbit

These are three of the most used tools. They do not alter the drawing; they alter your view of it.

Use right-click in mid command to switch viewing modes or exit.

Real-time pan, as in pdf files, allows you change the view without changing the apparent scale, Pan allows you to grab the drawing and move in any direction

The Zoom function has several choices of zoom. The most used are:

Real-time Zoom, In and Out – these are familiar to most people from graphics software or print previews in Word, and needs no further explanation

Zoom Extents – this is a valuable zoom, because it takes you out to show the full drawing on screen. If a station input has gone wrong, then this is where you are most likely to spot that something has been inserted far from where it should be.

Zoom Window – allows you to draw a window round the object onto which you wish to zoom, and homes directly in on it.

Zoom Previous – is a shortcut to the last view you had on the screen

3D Orbit allows you to rotate the drawing in 3D, Move the pointer inside the circle and the plane of view rotates, move outside and the view rotates so you can see the terrain on which you are surveying, showing gradient and the vertical relationship between the features or trenches you are recording.

These are all you will ever really need to use, but experiment if you want to, it'll do no harm to learn as you go.

AutoCAD functions you need to know 4: Text

Adding text:

The survey drawing will contain 2 kinds of text.

1 Automated The automatic station numbering used by TheoLt cannot be changed once a station is inserted. The number is set by the counter in the TheoLt instrument panel. Avoid duplication of station numbering as the station database will be corrupted.

2 Inserted text There are 2 methods. *Single line* and *multi-line*. Multi-line works in much the same way as adding text to a drawing in Word or drawing packages. The text symbol brings up a text box. This gives the option of font style and size. The text box has to be attached to a point. It is possible to place text by snapping its insertion point to a measured point (using node snap or endpoint snap). Text associated with a block is fixed unless the block is exploded.

Editing text

A quick method is to copy text, place it and edit it with a double click to open the *Text Formatting* dialogue and editing the text in the formatting window, the revised text will be saved by use of the OK button on the right of the formatting bar. You need this to annotate any new grid pegs laid out in the course of the season, and it must be done immediately to avoid confusion. Each station will have its own TheoLt identity, but the peg identity needs to be marked correctly to be passed on to other users in printed hard copy for use in the field.

Text layer

It is wise to place text on a layer dedicated to it not least because text will not always be legible at the variety of plot scales used, so freezing off the text by layer is a must at the smaller scales.
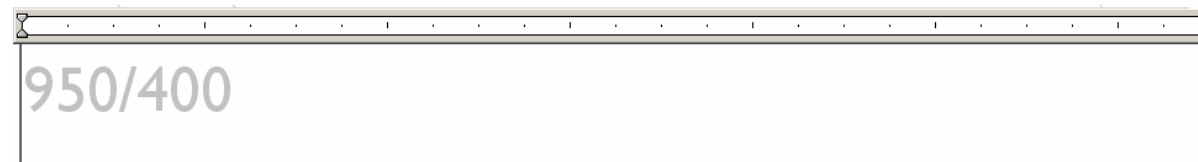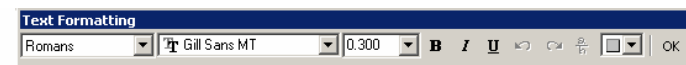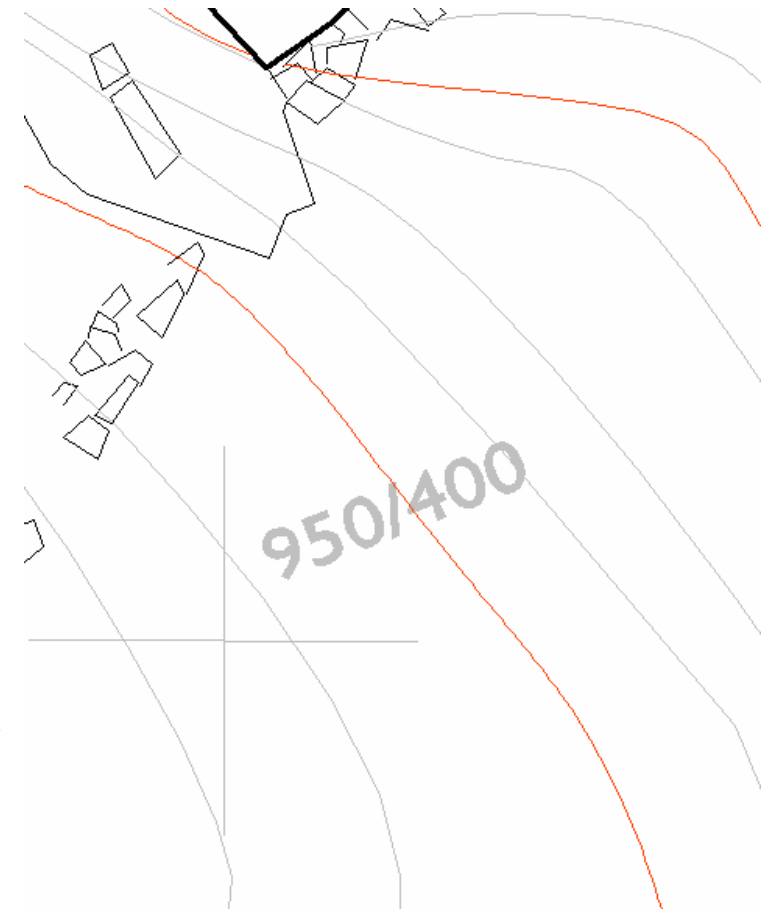
AutoCAD functions you need to know 5: Inquiry

Measuring distance: dist command

This measures the distance between two points, as well as the x,y and z values between them. It gives the angle between the two, and relative to the default AutoCAD WCS angle origin (with zero/360 degrees horizontally to the right). It is a very useful tool for gauging the actual distance between grid pegs or features and the difference in height (z) between the two. The dist command does not report horizontal distances as such but shows the components in the xx yy axes.: Note that the insertion point of a station block is its true position, its easy to snap to a line end point by mistake!

```
Command: dist
Specify first point:
ins of
Specify second point:
Ins of
Distance = 10.735,  Angle in XY Plane = 270,  Angle from XY Plane = 22
Delta X = -0.009,  Delta Y = -9.987,   Delta Z = 3.939
```

Locate Point, or Point ID.

This is very useful for instant 3D coordinates (in the current UCS, set UCS to world for the full site co-ordinates) of any point on the survey. Particularly useful when checking you are using or sighting to the correct station.

List.

This lists all the available details of a selected object: angles, coordinates, layers, line types, weights and colour and all relevant information about that selected object.

Area and Volume:

Neither of these is of any particular use in this. Area is valid from a vertical viewpoint only and gives no indication of the actual surface area of the site, which is considerably greater. Volume is useful only if you want to calculate the volume of earth moved, say, from a particular trench. However, you have to have pre-excavation levels of the ground surface for this to work.

AutoCAD functions you need to know 6: Drawing and editing lines,

Line

The line command is the principal command in surveying with TheoLt. The line command draws from one selected point to another. It has to be selected before measurement, otherwise no data will be recorded to AutoCAD. Confirmation of an active line is the command line comment:

```
LINE Specify first point:
Specify next point or [Undo]:
Specify next point or [Undo]:
Specify next point or [Close/Undo]:
```

This must become as natural as breathing. The selection prior to measurement means the line is automatically drawn onto the screen, allowing you to view the accuracy of the drawing. The command is opened from a button, the *draw* pull-down menu or L in the command line. Line is finished with one of 3 actions. *Close* , which will join the last point to the first one. *End* or Enter, which will close the command and, if repeated, open a new line.

Undo and redo

The undo command will step back and remove the action of the last commands used. Redo will replace them **but not line segments!**

Point

The *point* command plots a single node into the drawing. The *multiple point* command is used for repeated insertion of points for the collection of spot height data for contouring. From the Format pull-down, select *Point Style*, select a point style that will be visible as the default mode is an invisible node.

Keeping the 3D integrity of the data

If you need to freehand draw onto the survey the height of the line must be maintained. The lines must be snapped onto points fixed by survey. A polyline will allow free hand drawing based on snapping the 1st point to a measured one.
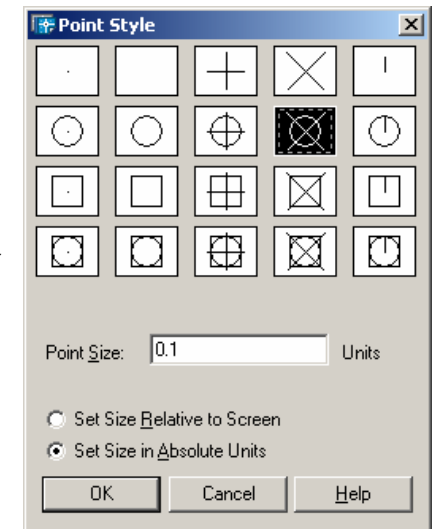
AutoCAD functions you need to know 7: Getting UCS to control views,

Using UCS,

The User Coordinate System (UCS) determines the origin and direction of the x, y & z axes It determines the behaviour of all 2D commands and the z direction of 3d ones. It is a useful tool in controlling the alignment of hand-drawn edits and the controlling views, particularly in 3D. The default co-ordinate system is World (referred to as WCS). In WCS the CAD co-ordinate system is coincident with the GPS survey grid. A UCS is like a piece of graph paper which can be placed on any plane so that it can be drawn on. **TheoLt will always plot in the WCS regardless of the UCS current in the drawing**. A UCS can be set up so that an elevation view can be found quickly (using plan→ C) or so that polylines can be used to trace from a drawing or photograph on to the survey. A UCS can be made by:

- ♦ aligning it to an object (UCS→O),
- ♦ by picking 3 points for the axes (UCS→3p) ,
- ♦ by rotation about one of its 3 axes (e.g. UCS →x→90).
- ♦ or by assigning it to be parallel to a view

Once a UCS is created it can be saved (UCS→s) and re-invoked as required.

Controlling views with UCS

The default view of WCS is as looking down or 'plan view'. if a view is needed of a particular elevation one method is to rotate the UCS about its x axis by 90 deg and then use plan to current UCS (plan→C) to see the view.

Getting an elevation view

A more controlled method is (with the current UCS set to world) to trace a polyline at right angles to the required view (a polyline is used because it will be a level line in 3D). A UCS is aligned to the polyline (UCS→O→pick the polyline). Plan→C will reveal the view. The UCS can then be rotated about the appropriate axis to get the required orientation. Plan C will reveal the effect of each change to the UCS. This method will achieve a true elevation view as it is based on a level line.

Polyline

Polyline is a tool for getting fine continuous lines (such as 1:20 scale line work for 'stone by stone' drawing). It can be smoothed using *pedit*. Polylines are 2d continuous string lines. **Polyline cannot be used to draw with TheoLt because it is a 2D entity and TheoLt works with 3D data.**

Appendix A:

Initial set up of
Instrument communications,
TheoLt interface
&
AutoCAD menus

Procedure for setting up TCR400 Total station comms

There are 3 things you will need to establish to do this:

1 The Com settings used on the instrument

2 The instrument communications are set to the RS232 com port

3 The Serial port number on the tablet

1. Set the instrument comms to the defaults
The comms settings are under the Menu button→ F2 (for settings)→, page to page 2→ select communication parameters: set them to the defaults

The default settings on the instrument are:

Baud-rate	19200
Databit	8
Parity	none
End mark	CR/LF
Stop bit	1

3. Set the coms on the tablet to agree with the instrument
Open TheoLt. Go to the settings tab and click on the spanner icon. Select the instrument tab in the settings panel and then select the instrument and its com port.
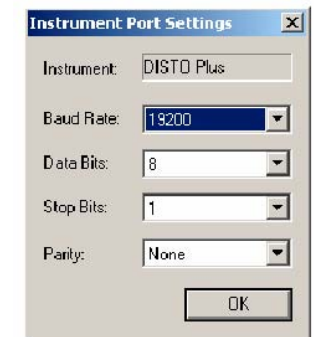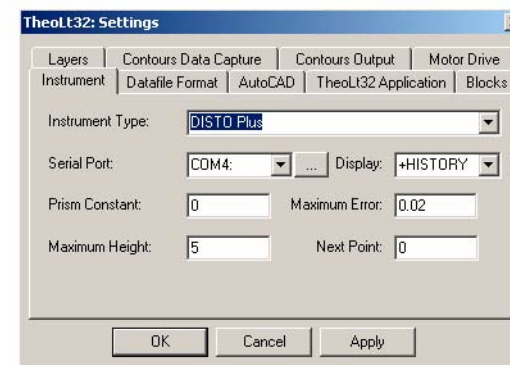
Using the extended options button to the right of the Serial port field reveals the settings for the port. Set the port to agree with the instrument.
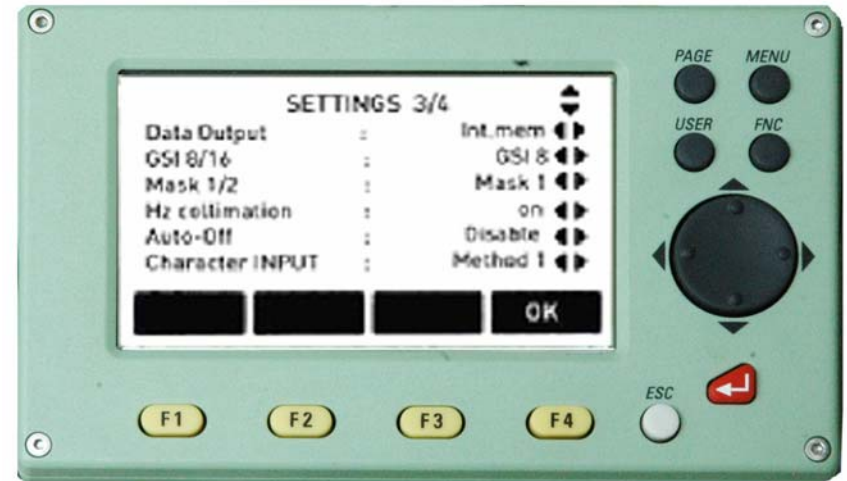
2. Set the TCR to use the data port
Press Menu→ F2 (for settings) →page to page 3 then switch the instrument Data output from *Int.mem* to *RS232* by using the scroll keys.→ Select with the F4 (indicated 'ok') button.

Action the changes in the settings panel using the *apply* button and TheoLt will prompt for a restart to reset the comms.

The serial port number on the Fuji (with the PCMCIA card adapter fitted) is shown in the control panel→ system→hardware→ device manger→ ports, com &LPT

Procedure for setting up TheoLt interface with AutoCAD

TheoLt must be set up to work with your version of AutoCAD. The version list is accessed from the settings panel from the spanner icon on the settings tab. The selection is actioned with the *apply* button.

Testing the interface.

The interface is working when a station block is manually inserted from TheoLt into the current drawing. Close TheoLt. Open AutoCAD, open TheoLt, select *control tab*, select the *insert stn. Button* move screen pointer to AutoCAD graphics area and pick a point. The AutoCAD command line should respond with:

`'second point of displacement or <use first point as displacement>:…'`

A station block is placed on the drawing cursor ready for placement. The station number is incremented from the number indicated in the instrument panel. The option to insert a reference symbol will prompt the same sequence but will insert the circular symbol instead.
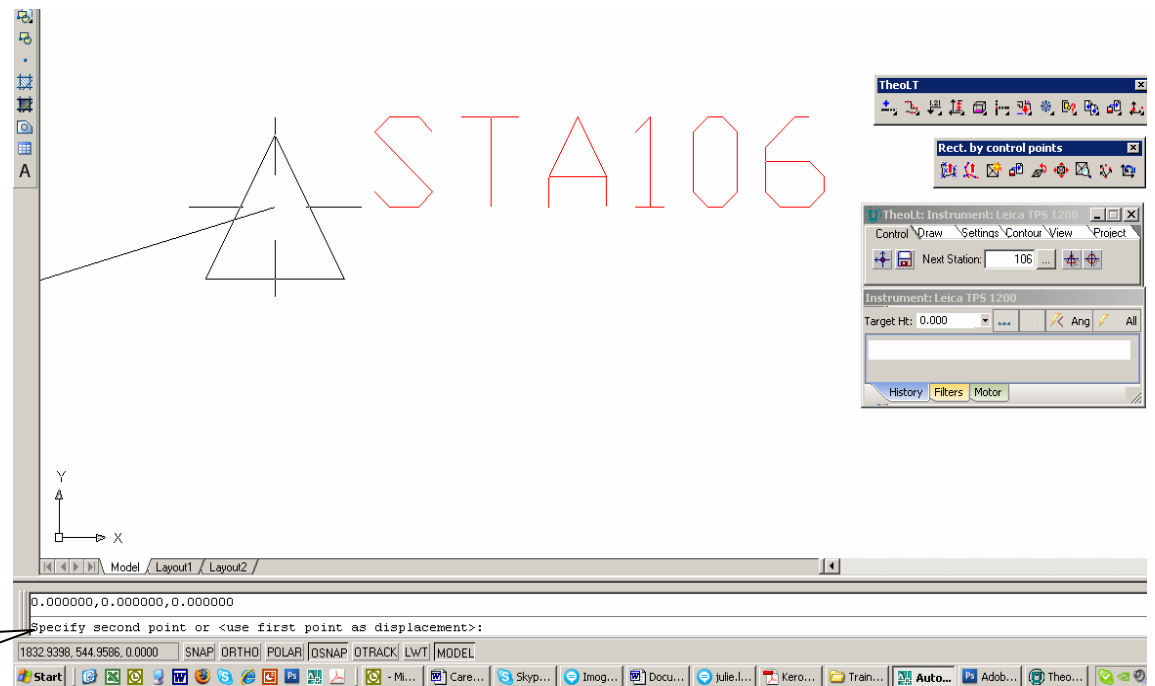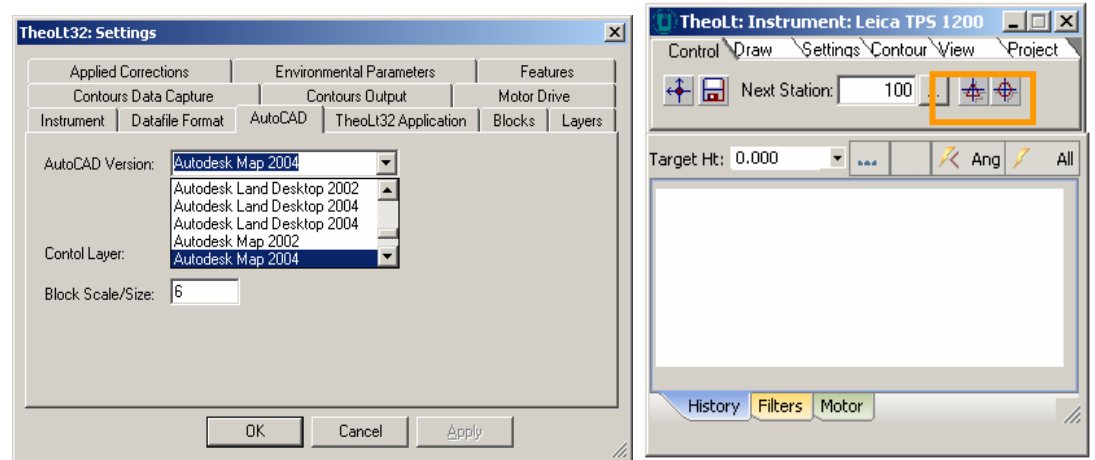
On manual insertion of a station or reference block the command line should respond:
```
....Resuming MOVE command.
Specify base point or displacement: _none
0.000000,0.000000,0.000000
Specify second point of displacement or
<use first point as displacement>:
```

Common interface problems:

Block path. If the station block is not inserted the command line may report "unknown block name" the AutoCAD *support file search path* shout be edited to add the folder *..C:\.....\theoltblocks* in the AutoCAD options panel. (Found under Tools, options, Files, add, browse...).

File path. The AutoCAD file path should include the installed TheoLt folder. In the AutoCAD options panel. (Found under Tools, options, add, browse).

Filedia trips to zero, TheoLt suppresses the file list and browse functions in AutoCAD during block insertion. The resetting of these functions may not occur correctly leading to a condition where the file list is not displayed at *open* or *saveas* .The function is restored by resetting the variable *filedia* (filedialog) to 1 from zero.

Script errors. TheoLt uses a dynamic script called *th.scr* it is written at the root c:\ (unless otherwise set in settings, theolt32 Application, Working Folder) The script is rewritten for each new command used but it can become corrupted in some circumstances. A common cause of failure is a misapplied *snap* function in orientation leading to the current drawing being renamed as *theolt.dxf* . Should this occur, TheoLt cannot continue the drawing should be reamed, TheoLt closed and restarted, In some cases the file *th.scr* may need to be deleted before restarting.

Zoom centre, On completion of a resection TheoLt will prompt a *zoom centre* command in AutoCAD centred on the newly created station. The zoom scale may not be appropriate to the working scale of the survey, a *zoom previous* may be needed to reset the view.
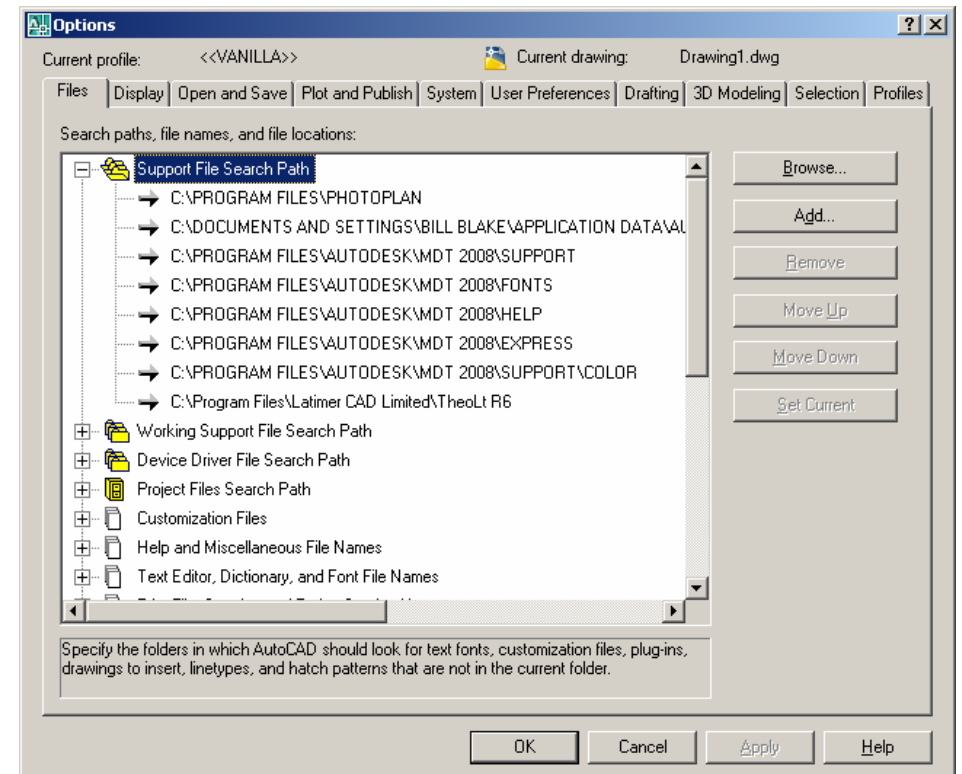
Customising AutoCAD toolbars for surveying with TheoLt:

A number of commands needed to work with survey data on a tablet PC are not on the standard AutoCAD toolbars,

Building a tool bar

Select: *Tools, Customise, toolbars* from the AutoCAD pull-down menu, select the *toolbars* tab, select *new,* add a toolbar name to the ACAD menu group. Switch to the commands tab and pull the slider down to select *user commands.*

From the *command* panel pick 'User Defined Button and drag it onto the unmade toolbar parked in the drawing area. A blank button will appear in the toolbar, Drag 4 buttons into the bar. Pick on one of the new blank buttons and the *properties* panel will be active. Pick on the Button Image and edit to suit. Edit the text to give your Button a name and a tool-tip description. Use a macro as follows:

The most important customised toolbar buttons macros are:

Filedia	^c^c filedia 1	Note the space, it is equivalent to 'enter'
Cancel	^c^c	The default macro starts with the phrase for cancel!
Close	c	Letter c (note that C is the alias for *circle* too)
Plan view (World CS)	^c^c plan w	No space is needed after any macro
Plan view (current UCS)	^c^c plan c	C denotes 'current'
Polyline	^c^c pl	Pl is the keyboard short cut for poly line or the readymade one can be dragged into the toolbar from the 'All commands' list

All modifications to toolbars and button properties need to be actioned with apply before closing the customisation dialogue.

Finding a lost tool bar

A right click on a toolbar panel will bring up the list of loaded toolbars in the current AutoCAD user profile. Select the tool bar you need and it will be displayed. Toolbars can either float or dock to the edges of the graphics area so look carefully after the toolbar is selected.
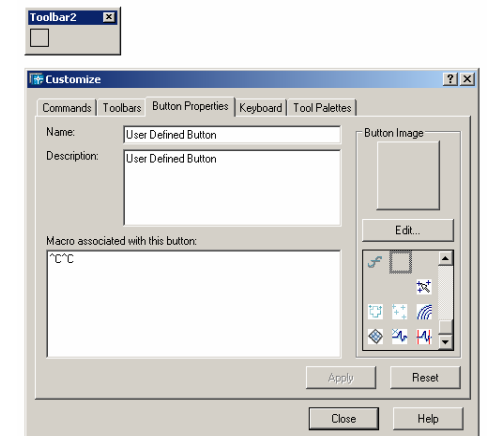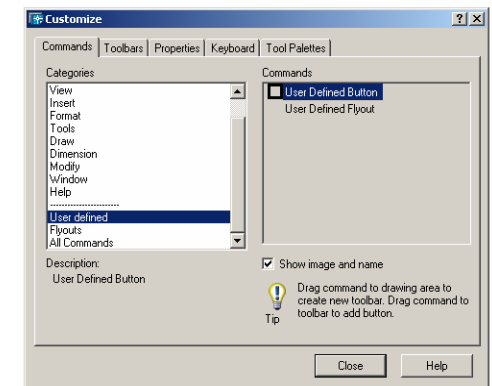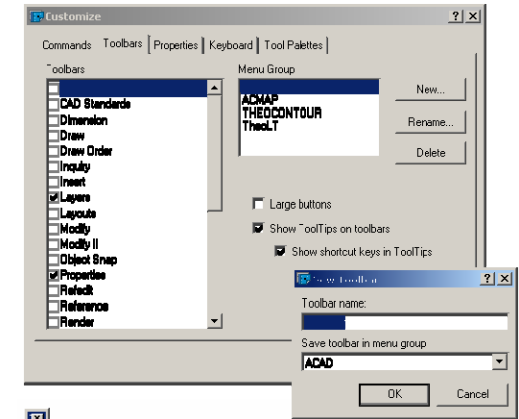
Customising the feature attribute table

The default is for open alpha numeric input, if you wish you can use standard database character formats. The feature tab in TheoLt settings will open an editor for the feature attributes when selected from the folder and then the *Features in Folder* list. It is a 3 panel sequence starting with *Define Feature: Observations* then *Define feature :Data* and *Define Feature Block*. The panels are sequential and the editable fields must be positively selected with the amendments followed by an enter to effect the change. The panels are resizable and pull down preset values are available when a field is selected.

Mask	Character	Description	Typical use
0	Numeric	(0-9)	Point number: mandatory digits
9	Numeric	(0-9) or space (' ')	Point number: open number of digits
#	Numeric	(0-9) or space (' ') or ('+') or ('-')	Relative heights
L	Alpha	(a-Z)	Tag id with no spaces allowed
?	Alpha	(a-Z) or space (' ')	Description
A	Alpha numeric	(0-9 and a-Z)	
a	Alpha numeric	(0-9 and a-Z) or space (' ')	
&	All print character only		
H	Hex digit	(0-9 and A-F)	
X	Hex digit	(0-9 and A-F) and space (' ')	
→	Forces characters to upper case	(A-Z)	Title fields
←	Forces characters to lower case	(a-z)	Attribute data descriptors

Appendix B: Equipment check list and price schedule: TCR Total Station

Leica TCR 400 series :parts list					
Part	Item Replacement cost		Part number	Quantity	Check
Leica Data cable GEV102	£98.00		Leica Art No 563625	1	√
Battery GEB 121	£88.00		Leica Art No 667123	2	√
Battery GEB 111	£48.00		Leica Art No 667318	0	
TCR 405 P	£4,500.00*		Leica Art No	1	√
Mains adapter (UK)	£70.00		Leica Art No	1	√
Battery charger GKL112					
Mini prism GMP 111-0	£188.00		Leica Art No 642534	1	√
Detail pole (4 pieces)				1	√
				1	√
Tribrach, laser plummet type GDF121	£222.00		Leica Art No 667304	1	√
Tripod, adjustable GSTO 5L	£127.00		Leica Art No 563630	1	√
hardware value	**£5.314.00**				
Outfit replacement value	**£4,760.00***		*Unit price for TCR outfit complete: individual parts are replaceable as listed.		

Note: "Leica Geosystems" appears as a vertically spanning label in the Part number column.

Appendix C: Equipment check list and price schedule: Tablet PC

Fujitsu Siemens ST5011D Tablet PC : parts list

Part	Replacement cost		Part number		Quantity	Check
Car charger 12/24 V in 16V out	£74.87			Product No. S26391-F194-L250	1	
Battery 9 cell	£129.00			Product No. FPCBP98	4	√
Battery 6 cell	£119.00			Product No. FPCBP97	2	√
St5011D/St5031 504mb RAM 40gb HDD Intel Pentium M Processor1G Hz 10.4" Indoor /Outdoor screen	£1,400.00		Fujitsu-Siemens	Product No. FPC3511BR sn R4400183 (HDD=Toshiba MK4025GAS UMDA 100 IDE connector. 40gb)	2	√
Off unit dual charger	£154.00			Product No. FPCBC06	2	√
Screen protector	£17.34			Product No. FPCSP04AP	1	X
Bump case	£54.44			Product No. FPCCC24	2	√
Pen (active)	£41.12			Product No. FPCPN07	3	√
Socket serial Card, ruggedised	£95.00		Socket Part No.8510-00073 sn 0304000695		2	√
Leica Data cable	£98.00		Leica Art No 563625		2	√
Bracket	£65.00				2	√
Tablet PC hardware insurance value	£2247.77					