



Surveying with TheoLt

Quick start & Hardware guide:
Tablet PC
(Fujitsu-Siemens ST 5011d/ST5031)
&
Total Station
(Leica TCR405)

About this document

This training manual was prepared to develop survey and CAD skills in Archaeology. The aim is to achieve competence in basic survey procedure and basic CAD operations for survey. 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. The material in this document is copyright and should not be reproduced without the express permission of the Authors or Latimer CAD.

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.

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Cambridge

28.03.08

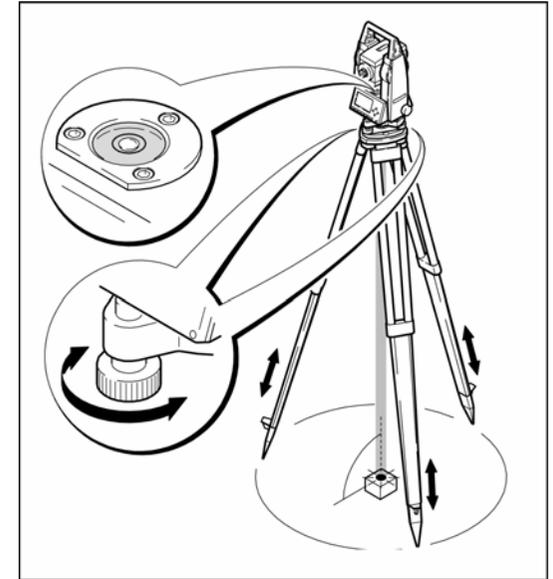
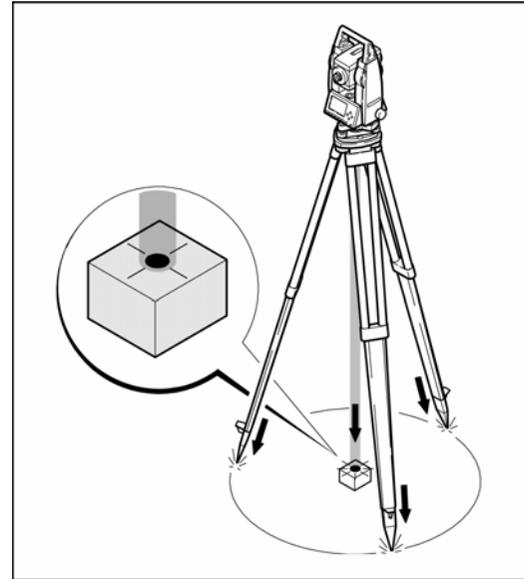
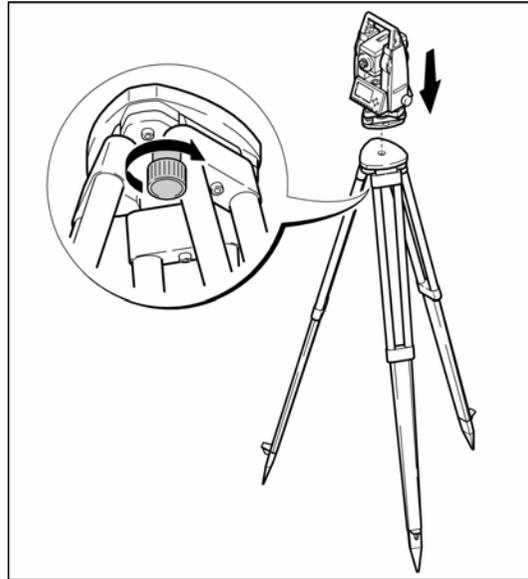
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TCR Accessory list

- 1 **Data cable**
May be USB or Serial type
- 2 **Tribrach:**
laser plummet type, rotate it to fit in the case
- 3 **Charger shoe.**
Check the battery is properly seated in the shoe when charging
- 4 **Adjustment tools**
Do not use these unless you know what you are doing! they are vital for aligning the EDM and should be kept with the instrument
- 5 **Spare battery GEB 111**
The small battery is only good for about an hour of reflector-less 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
- 9 **Lens hood and dust cover**
- 10 **Manual & Basic Software**
- 11 **Mini Prim,**
Can be either Zero or 18mm offset
- 12 **TCR /Total Station /Theodolite.**
Always place in the case battery side up
- 13 **Detail pole.**
In 4 sections. With all 4 sections, tip and prism you have a target height of 1.3m

Centring & levelling up TCR405 Total station



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. Turn 2 of the foot screws by moving 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. Retighten 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, place the tripod over the point by eye first, put your foot over the mark to help.
- ◆ Before you start check the tribrach foot-screws are at the middle of their runs- there is a mark to show this.
- ◆ Centre the tribrach before levelling it. If you run out of travel on the foot-screws reposition the whole tripod and start again
- ◆ 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!
- ◆ 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!
 - 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
 - VERTICALLY CENTERED OVER THE POINT**. If it's not over the mark don't use it!
 - 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 3 1/2 hours each. The smaller 6 cell battery (5) is an emergency spare giving about 2 hours.

Inserting the PCMCIA Serial adaptor 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 (item 8 on p 7) 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.

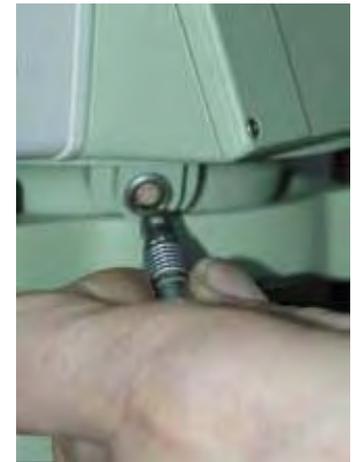


The Lemo connector

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 9pin 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.





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.

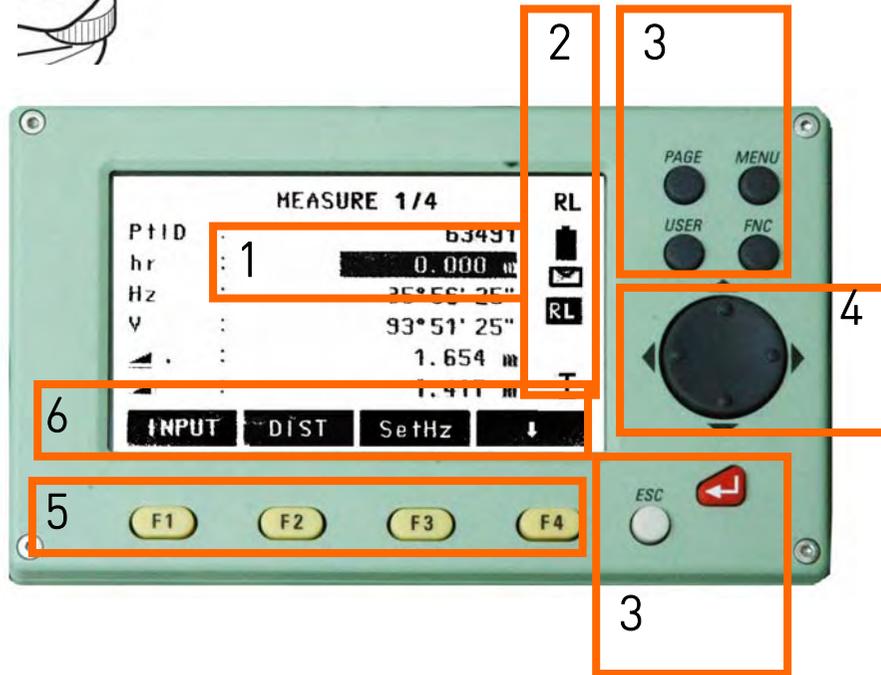
Once the tablet PC is mounted to the tripod and connected to the TCR the instrument should be re-levelled and centred as fitting the tablet often causes a slight dislevelment!



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). Note the banana button may be set to 'off', 'distance only' or 'all' from the settings menu Trigger key option)



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 Menu User Func Enter Esc
		Page Accesses programs and settings Customisable with function from the func menu Quick access to measurement support functions Sets selected option 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

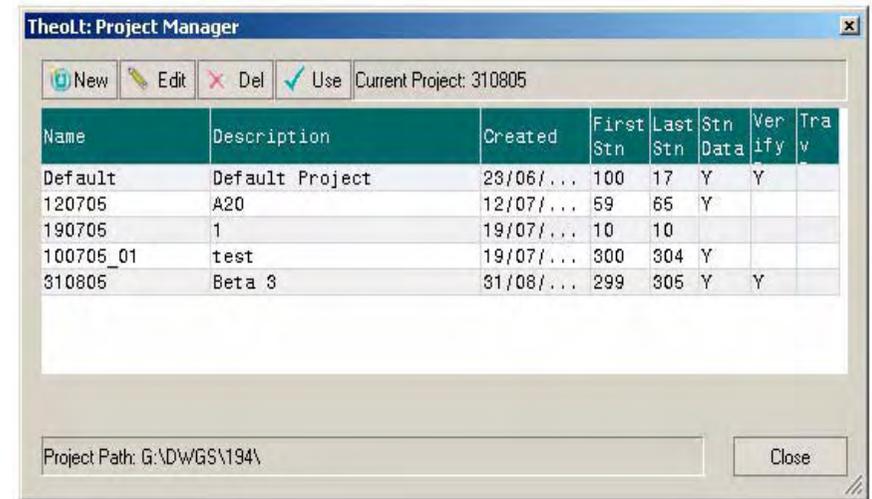
IR and RL modes IR = infra-red and RL = reflector-less. IR mode requires a reflector or prism (Item 11 on p4) to work. RL uses zero (it is set by default when RL is selected) Check that the prism offset (in the instrument EDM settings menu) is set to 18mm or zero when using the mini-prism. This is important 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 dislevelled 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!



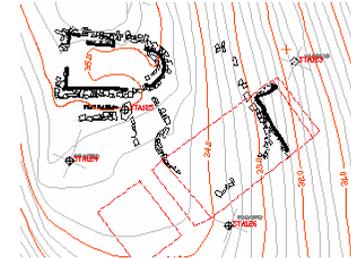
If you start operations by using the project tab you can pick the project in which all the survey data will be written. It is a useful habit to use this as the stations can be picked by number in the orientation dialogues. When you save the AutoCAD drawing if you use *saveas* you can place it in the 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

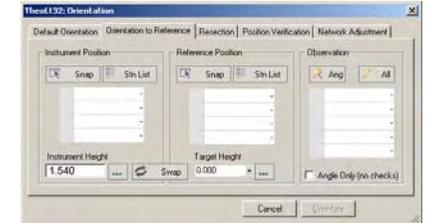
Set up your instrument, centre it and level it. Measure and record the height of instrument from the ground (not the top of the peg) to the instrument centre mark. Connect the tablet to the instrument and check the instrument level again. Make sure the tablet bag and instrument cases are closed after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



3 Orientate

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

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 (orient to reference and resection) 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 incised mark. It is essential the same point can be found and identified WITH 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!

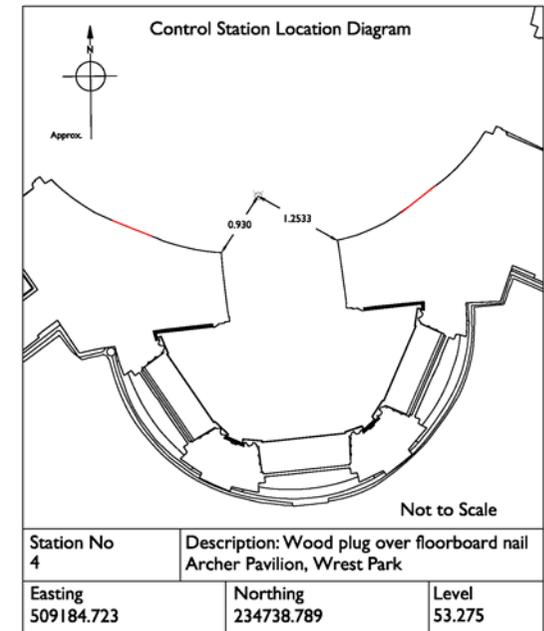
On moving the instrument to a new position there are 2 methods of achieving orientation; both require 2 clearly identifiable marked points. If the 2 points are inter-visible orientation to reference is possible if the 2 points can be seen from a 3rd resection is possible.

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 from it. Always measure and record the height of the instrument once you have levelled it.

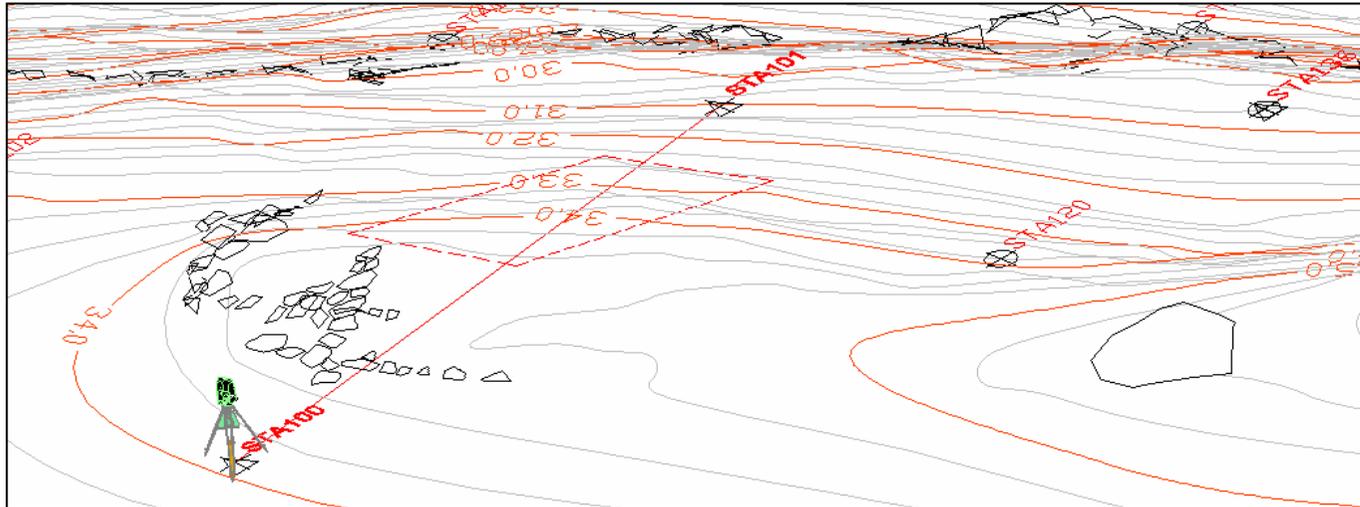
Target heights are crucial. Always check that the height of the target is correct, particularly after orientation when the reference target height can be carried forward and when switching to reflector-less modes when a target height of zero is required.

Levelling and centring the instrument correctly is vital, follow the procedure on p4. Do not take measurements until the instrument is in a fit state to do so!

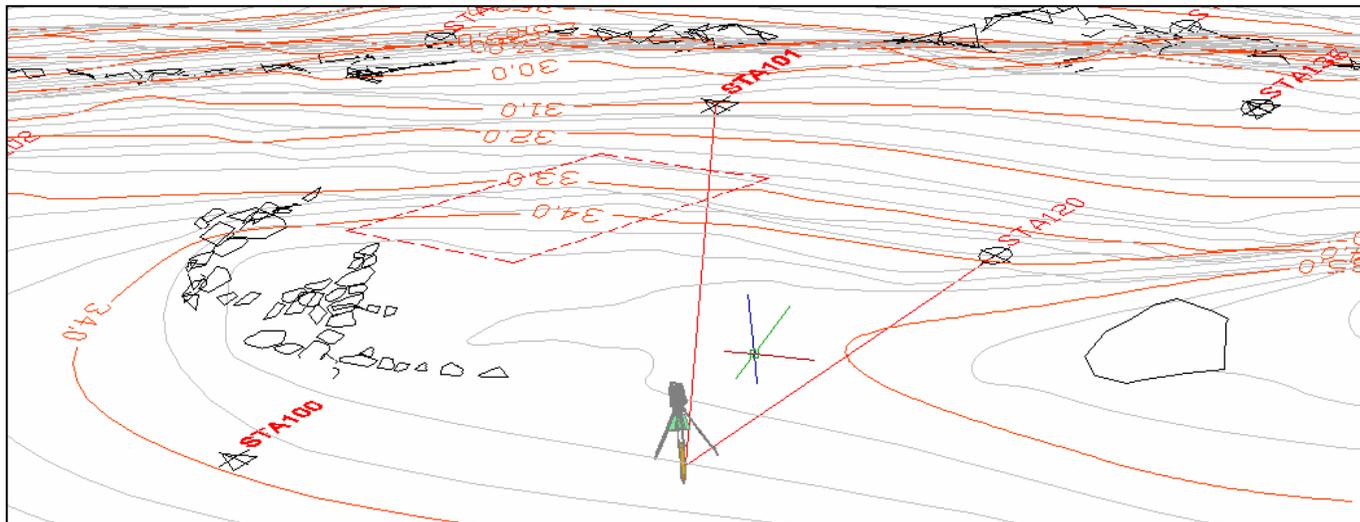


Being positive about station positions is vital, a witnessing diagram like this saves time and error and is well worth the time taken to prepare!

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 the orientation is achieved.



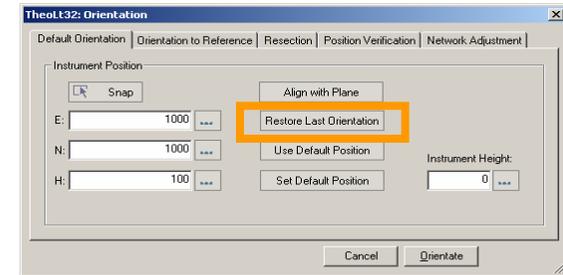
Resection = Occupying an unknown point: To resolve the occupied position measurement to a minimum of 2 identified positions of reference is required. Resection allows you to set out a station where you want to be provided you have lines of sight to 2 other stations or reference positions. If the geometry 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)

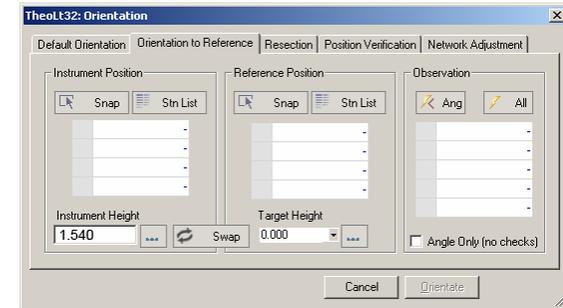


The default orientation is designed for starting a survey job at an arbitrary value for the 1st station; it should not be used once a survey job is underway. The option does include a useful **restore last orientation** function which will restart TheoLt with the last orientation used when resuming survey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



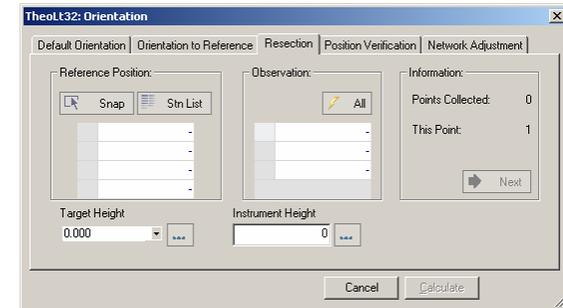
Orientation to reference

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 verify 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 is on track. Don't forget there is a known mismatch between GPS measured points and EDM measurements.

Network Adjustment (available for TheoLt pro licence installs)

Orientation measurements are monitored by the NetAdjust module and can be added by taking rounds with the panel open. The table of observations is used to distribute station location errors by least squares. Opening the NetAdjust panel will load all current project stations into the network.

Position	Report	Observed Position	Recorded Position	dx	dy	dz	Date	Time
2	Current Station							
4	STAS01	STAS02	999.057, 998.875, 101.584	999.057, 998.875, 101.584	0.00006	0.00002	0.00008	01/04/07 20:53
5	STAS01	STAS02	999.057, 998.875, 101.584	999.057, 998.875, 101.584	0.00011	0.00007	0.00013	01/04/07 20:55

Procedure in the field 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.

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 drawing and the project station list.

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.

TheoLt32: Orientation

Default Orientation | Orientation to Reference | Resection | Position Verification | Network Adjustment

Instrument Position | Reference Position | Observation

Snap | Stn List

Instrument Height: 0

TheoLt: Select Station

STA148	4690.724	8078.854	17.736
STA148	4887.881	8088.188	18.104
STA142	4679.409	8092.487	21.078
STA141	4880.180	8088.144	88.486
STA140	4666.184	8086.133	28.394
STA188	4876.725	8088.217	28.858
STA138	4670.126	8096.162	25.107
STA187	4855.802	8088.214	80.781
STA136	4655.902	8098.214	30.761
STA181	4881.581	8108.842	80.174
STA130	4623.666	8114.572	26.033
STA128	4818.850	8116.782	24.828
STA128	4655.398	8058.940	32.614

New | Insert Stn | Insert Ref

TheoLt: New Station Definition

Name: STA

Easting (X): 0

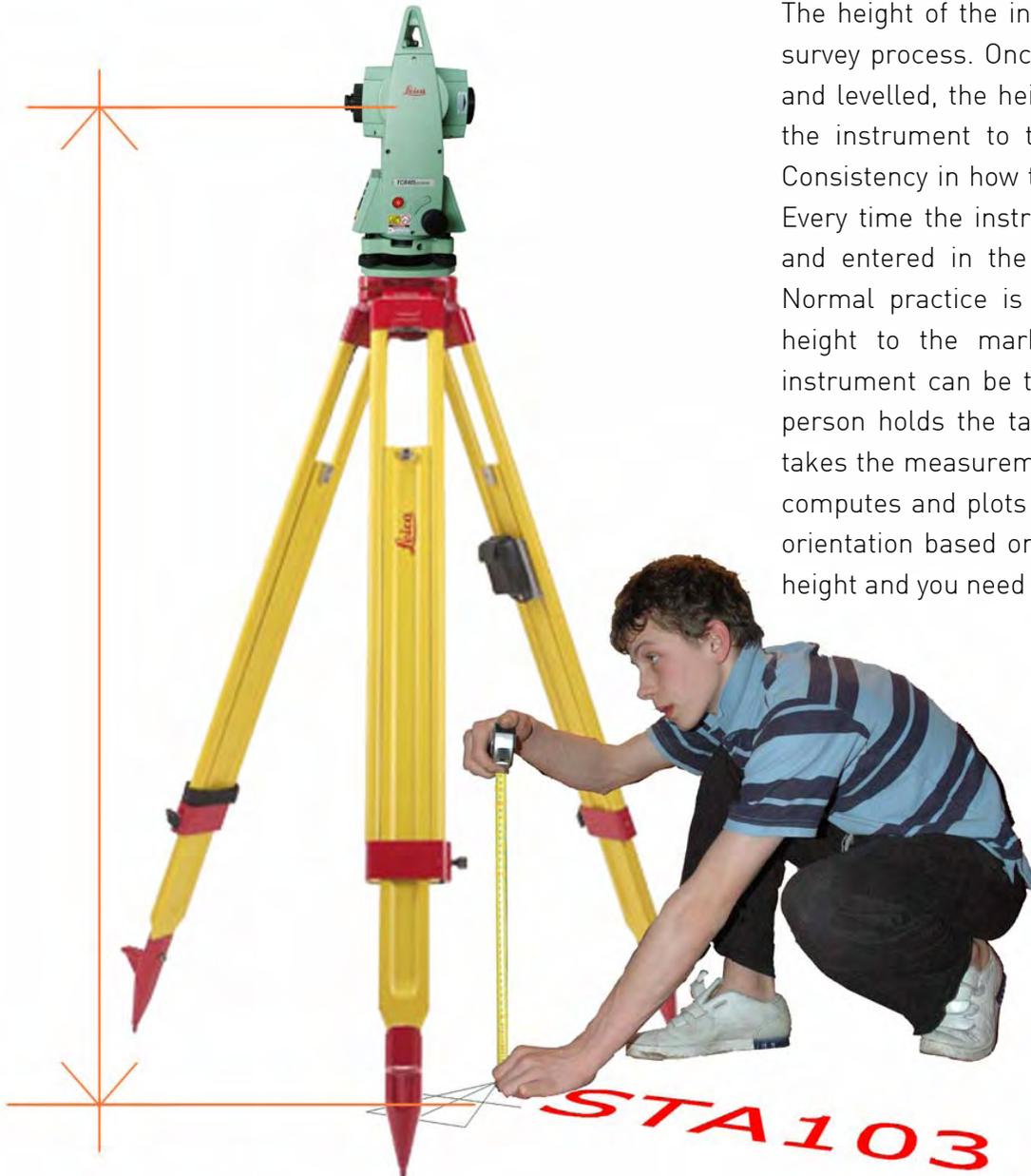
Northing (Y): 0

Height (Z): 0

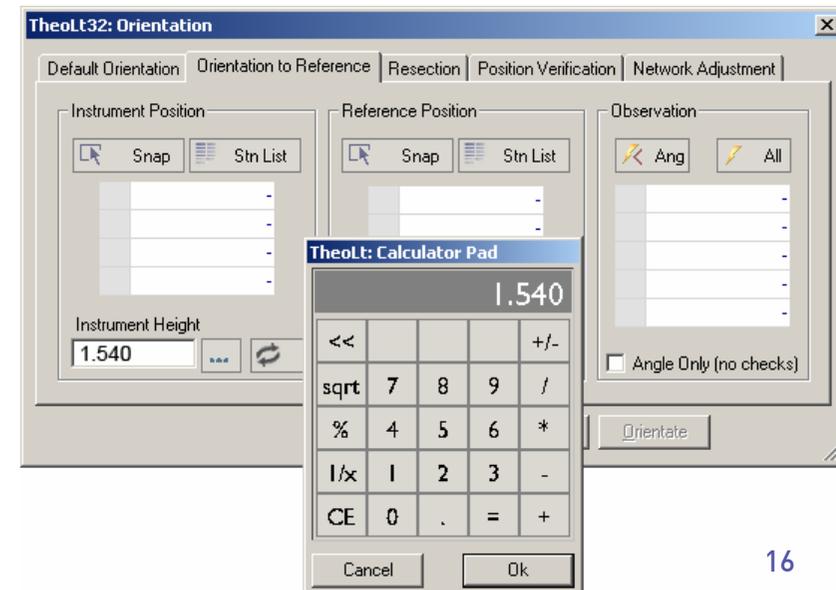
Cancel | OK

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

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 from 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. Normal practice is to centre over the mark and record the height to 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!



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

TheoL t32: Orientation

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

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.

TheoL t32: Orientation

Default Orientation | Orientation to Reference | Resection | Position Verification | Network Adjustment

1	Position	Report							
2	Current Station	Observed Station	Observed Position	Recorded Position	Plan Error	Vertical Error	Total Error	Date	Time
3									
4	STA301	STA302	999.057,998.875,101.384	999.057,998.875,101.384	0.00006	0.00002	0.00006	01/04/07	20:53
5	STA301	STA302	999.057,998.875,101.384	999.057,998.875,101.384	0.00011	0.00007	0.00013	01/04/07	20:53
6									

All Save

Cancel Orientate

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 using the save option if desired.

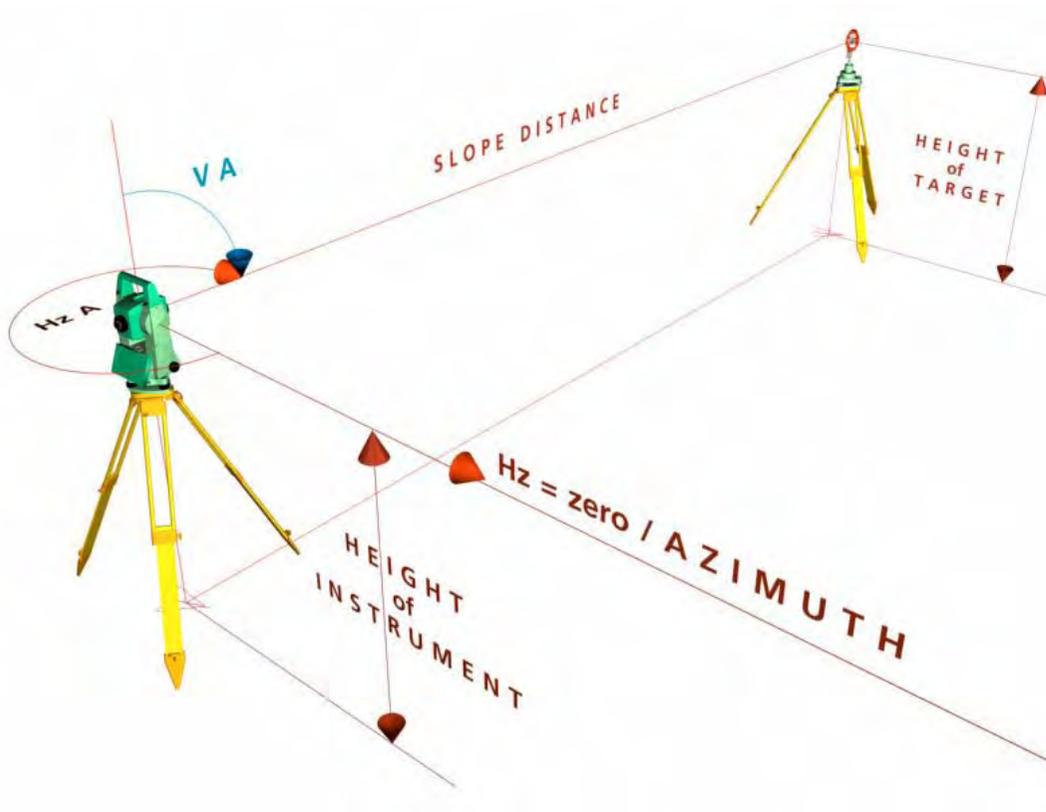
Procedure in the field: Orientation: 4.Set out new stations

Control Tab

If instrument measurements are made with TheoLt in the control tab the *Control Type* dialogue opens to allow a target height to be added and for selection of the station symbol type. To distinguish between occupied stations and reference only stations the circle option is available.

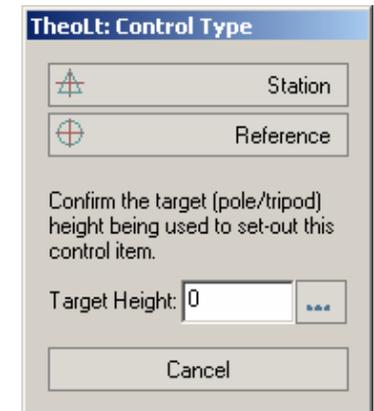


Stations may be inserted as either a foresight shot or resection (some times known as 'free' stations). End over end working means that the occupation of stations is reversed once the station is set out.



Target quality and precision

Ideally, for optimum precision, a prism is set up mounted on a 2nd tribrach over the forward station, the height recorded and the station added to the survey. The precision of station positions is compromised if working with a single tripod as the prism will be hand held or a reflector-less measurement used. It may be wise to set-out a local reference if you are working from stations of good precision to points set-out with a handheld prism to reduce the forward transmission of error.



Target height

On setting out the station there is an opportunity to reset the target height in the *Control Type* dialog, this will override the target height setting in the TheoLt toolbar.

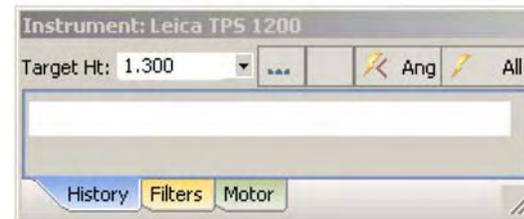
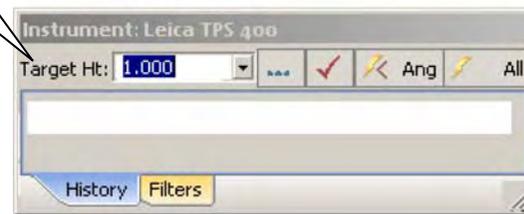
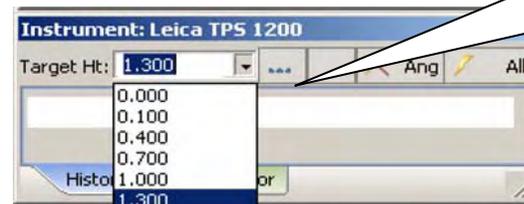
Procedure in the field: measuring with the prism

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

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



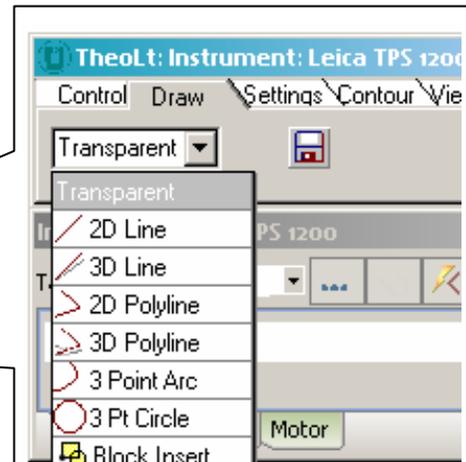
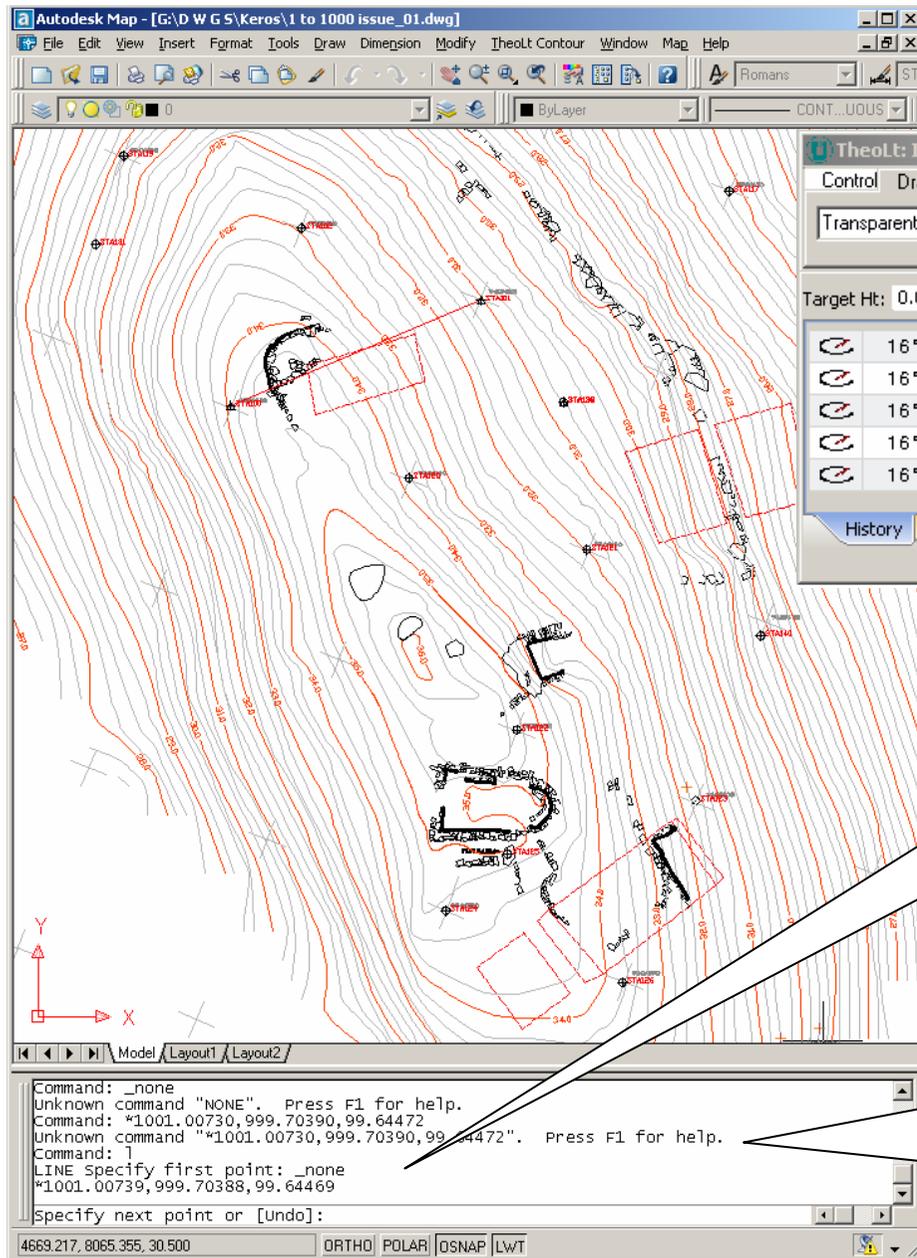
The last used heights are stored for reuse. Zero is always available for RL mode.

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



The target height with the 4 sections fully assembled detail pole is 1.3m

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 are useful you want to plot a circle or arc.in 3D.

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.

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

Tablets PCs for AutoCAD 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 highlighted 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.



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

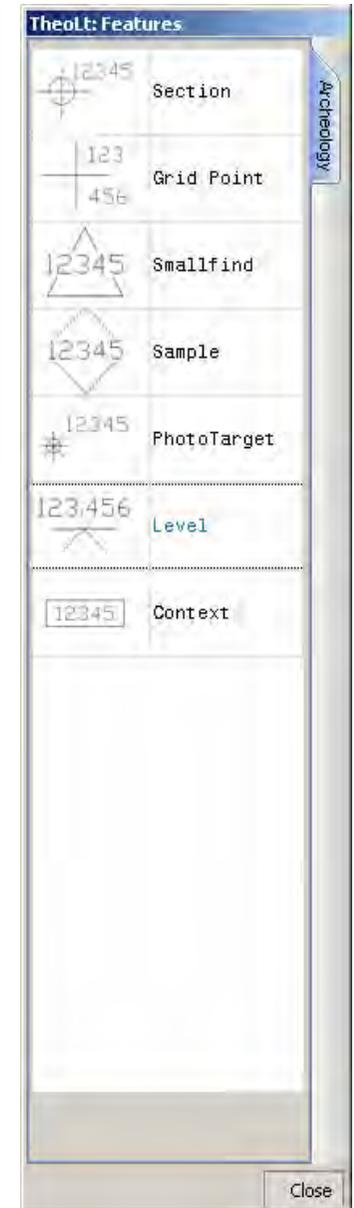
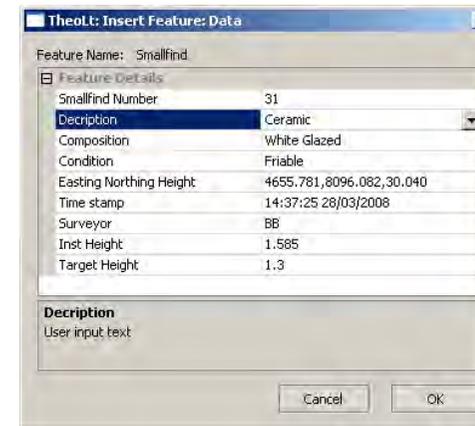
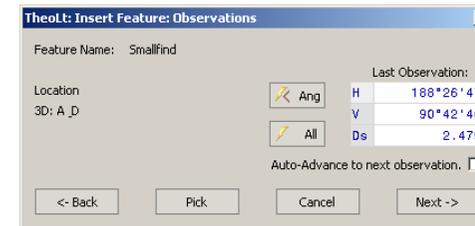
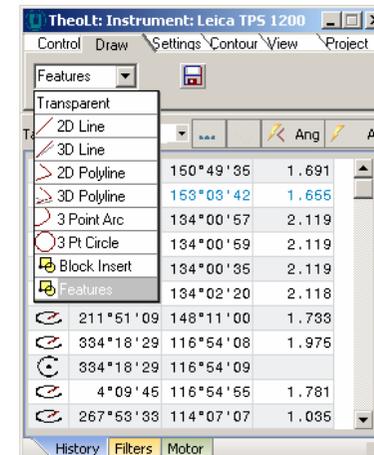
The symbol picked from the palette is inserted into the current drawing at the position of instrument observation. It is tagged with the attributes given to it at capture. Orientation of the symbol is fixed to the current UCS (so use WCS for consistency to the survey grid) . The symbol is inserted into 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

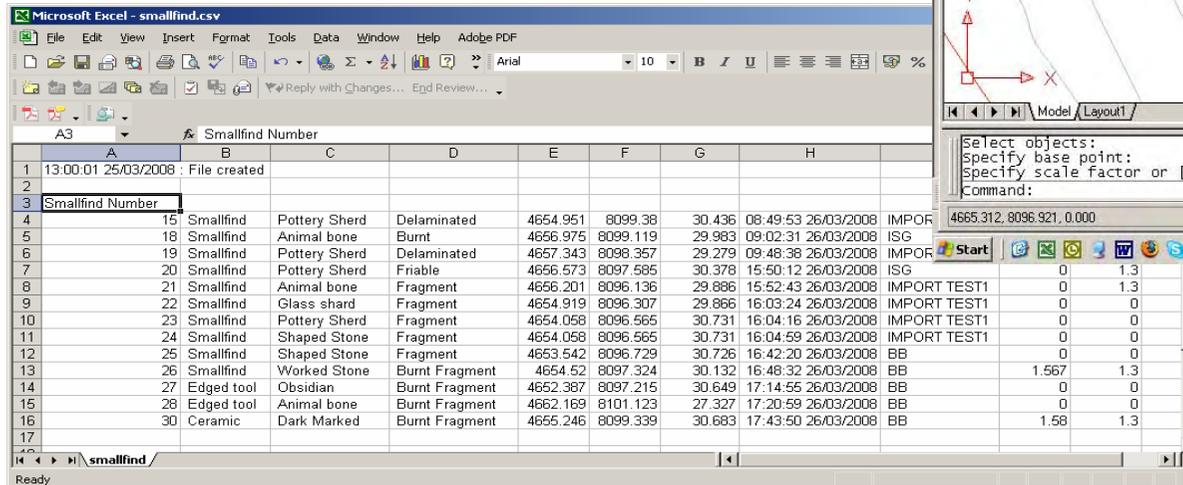
The point symbols on the plan mark the point of capture but also (in the case of surface finds) can be used as nodes for the contour model so careful checking of instrument and target heights is needed to keep the 3D record precise.

The CSV file

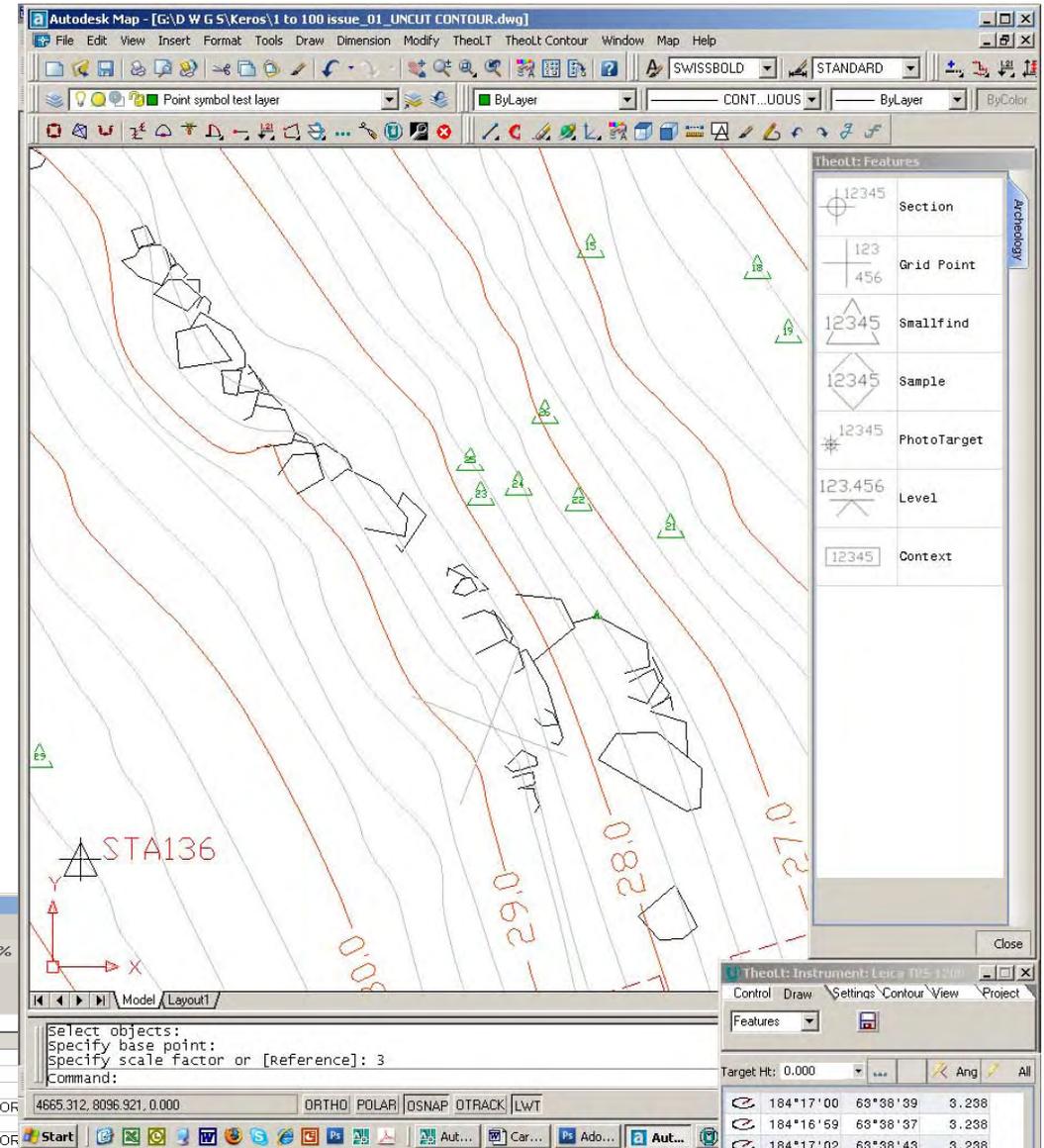
The data is written to a .csv file in the project folder (e.g. *smallfind.csv*) that can be read in Excel. The fields will be tabulated as columns. The first field will determine the row order by default. If a database with fixed fields is needed, a mask can be used to constrain the fields. The mask 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.



	A	B	C	D	E	F	G	H
1	13:00:01	25/03/2008						
2								
3		Smallfind Number						
4	15	Smallfind	Pottery Sherd	Delaminated	4654.951	8099.38	30.436	08:49:53 26/03/2008
5	18	Smallfind	Animal bone	Burnt	4656.975	8099.119	29.983	09:02:31 26/03/2008
6	19	Smallfind	Pottery Sherd	Delaminated	4657.343	8098.357	29.279	09:48:38 26/03/2008
7	20	Smallfind	Pottery Sherd	Friable	4656.573	8097.585	30.378	15:50:12 26/03/2008
8	21	Smallfind	Animal bone	Fragment	4656.201	8096.136	29.886	15:52:43 26/03/2008
9	22	Smallfind	Glass shard	Fragment	4654.919	8096.307	29.866	16:03:24 26/03/2008
10	23	Smallfind	Pottery Sherd	Fragment	4654.058	8096.565	30.731	16:04:16 26/03/2008
11	24	Smallfind	Shaped Stone	Fragment	4654.058	8096.565	30.731	16:04:59 26/03/2008
12	25	Smallfind	Shaped Stone	Fragment	4653.542	8096.729	30.726	16:42:20 26/03/2008
13	26	Smallfind	Worked Stone	Burnt Fragment	4654.52	8097.324	30.132	16:48:32 26/03/2008
14	27	Edged tool	Obsidian	Burnt Fragment	4652.387	8097.215	30.649	17:14:55 26/03/2008
15	28	Edged tool	Animal bone	Burnt Fragment	4662.169	8101.123	27.327	17:20:59 26/03/2008
16	30	Ceramic	Dark Marked	Burnt Fragment	4655.246	8099.339	30.683	17:43:50 26/03/2008



AutoCAD commands you need to know 1: Frequently used commands

Command	Icon	What it does	Command	Icon	What it does
Line		Draws a segmented line through the measured points. "C" closes a line back to its first point. This is the basic mapping tool.	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 Esc		Clears grips	Layer		Don't forget it's 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.
Hard Enter		Repeats last command	List		Displays the properties of the chosen object
Cancel*		Cancel (^c^c) clears the command line but NOT grips: you will need to customise a button for this command.	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.
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.	Filedia*		If AutoCAD fails to display the file list when using open or <i>saveas</i> cancel the command and use the 'f' button to reset it.
Extend		Lengthens a line in its own direction towards another line in the same z plane.	Undo redo		safer than erase for dealing with mistakes
Trim		Lengthens a line in its own direction towards another line in the same z plane.	3D pan, zoom Orbit		Also zoom extents, zoom previous
Plan*		Plan View – this command returns to a flat view from above after a 3D orbiting command			
Copy		Be careful to pick the start point in CAD so TheoLt can send the displacement points to the command line			

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

AutoCAD commands 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, should be separated by placing them 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 text

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

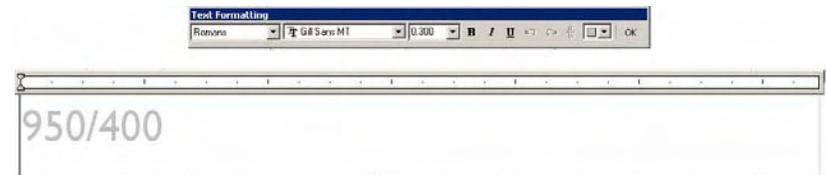
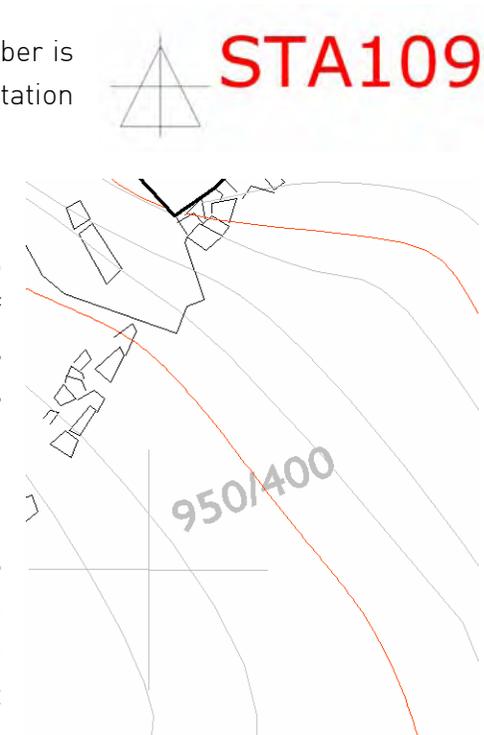
There are 2 methods. Single line and multi-line. Multi-line works in much the same way as adding text to a drawing in Word or drawing packages. The text symbol brings up a text box. This gives the option of font style and size. The text box has to be attached to a point. It is possible to place text 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 (pick a station symbol in the drawing)
Specify second point: Ins of (pick a station symbol in the drawing)
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!

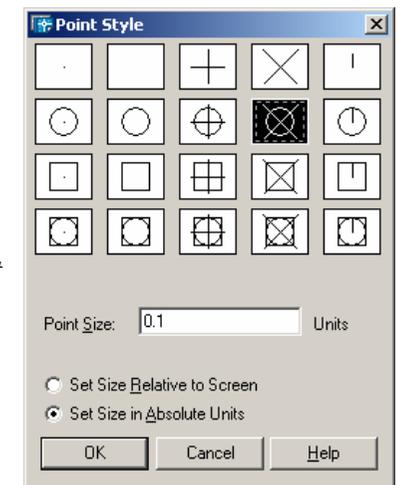
Point



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 for 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 *peedit*. 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.

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.

3. Use TheoLt to set the coms on the tablet to agree with the instrument



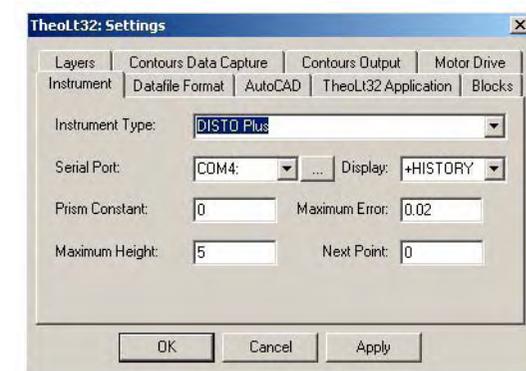
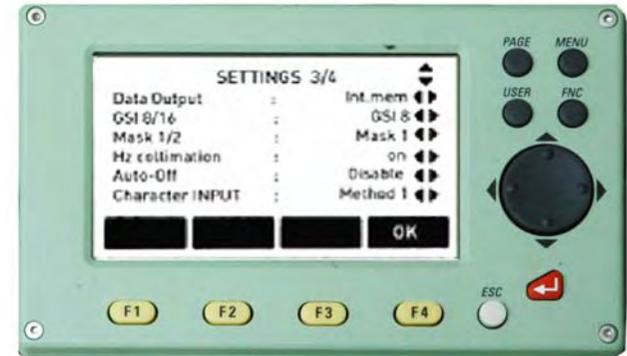
Open TheoLt, Go to the settings tab and click on the spanner icon. Select the instrument tab in the settings panel and then select the instrument and its com port. Using the extended options button to the right of the Serial port

field reveals the settings for the port. Set the port to agree with the instrument. 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

Testing the interface: measuring and recording points

To test the comms the instrument should be set to measure in reflector-less mode, the cable connected and triggered by either the all key indicated at the measure screen on the instrument or the all button on TheoLt. TheoLt will respond with an orientation prompt.



Communications options

'Recording to RS232?' message

After switching on the TCR the first measurement sent from the instrument will prompt confirmation of the interface; accept the request with the indicated 'ok' key.



Note on USB connection

Leica has supplied TCRs with a USB cable [Art No:GEV 189] from late 2004 onward. The cable will ONLY work with specific drivers for it *and* the virtual com port assignment correctly made, USB serial comms can reassign COM port numbers when the cable is plugged into the PC, this can be ok but often the Comport numbers get beyond the permitted range of 1 to 8. If your system has more than one USB port make sure the drivers are loaded for each port by plugging the cable into each one and following the 'new hardware found' prompts.



Note on Bluetooth comms:

It is possible to use Bluetooth to replace the cable connection to the TCR this can be either by using a serial adaptor or by using a BT port on a total station (e.g Leica TCR1200 series). Like USB Bluetooth uses a virtual port mapping method which can reassign the Com port number. Bluetooth serial ports must be in the range 1 to 8. The comms settings for Bluetooth will be set in the same way as for standard coms.



There are a variety of Bluetooth configuration interfaces (e.g Toshiba, Widcom etc) depending on the hardware type present on the system. If possible first time set up should be made using 'custom' settings rather than 'automatic' to allow for Com port assignment.

Note on trigger key (banana button)

The interface may appear to be disabled because of the configuration of the trigger key. The key (the 'banana' button) on the side panel of the instrument should be set to 'measure and record' (the 'all' function in the measure screen). Note the banana button may be set to 'off', 'distance only' or 'all' from the settings menu Trigger key option)

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.

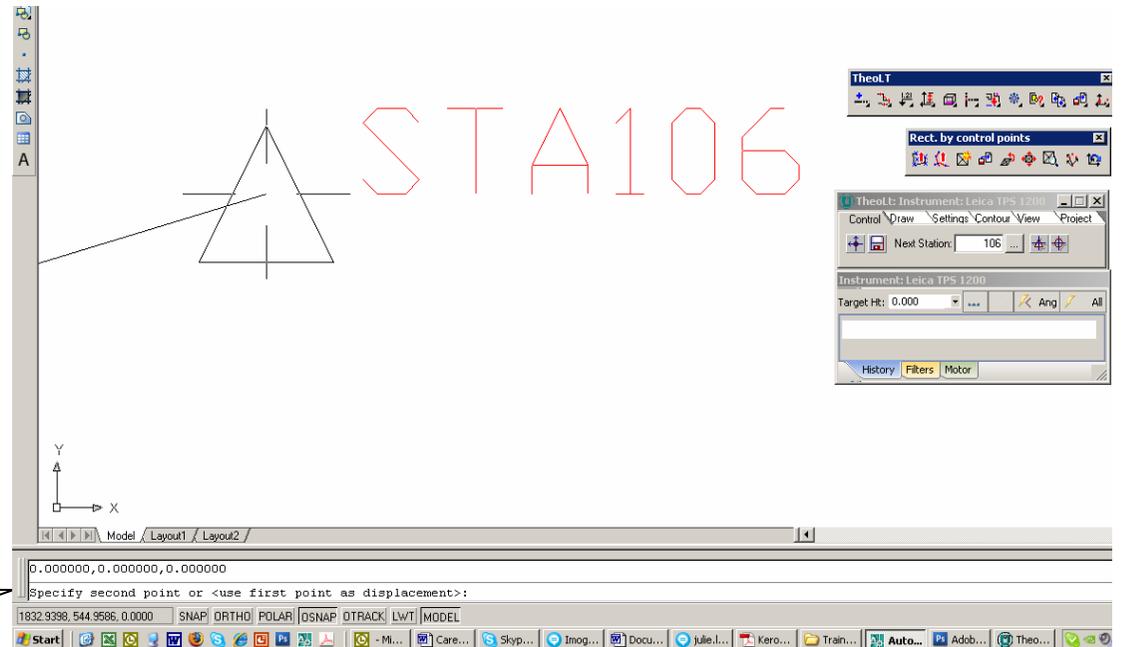
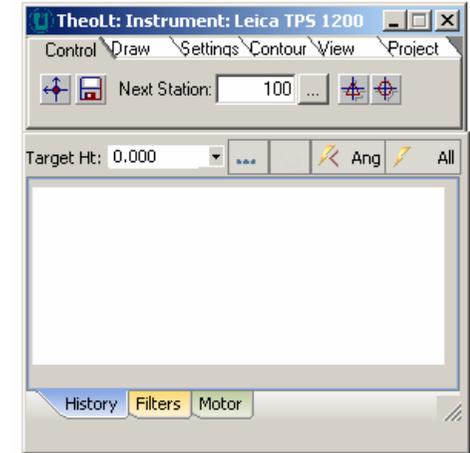
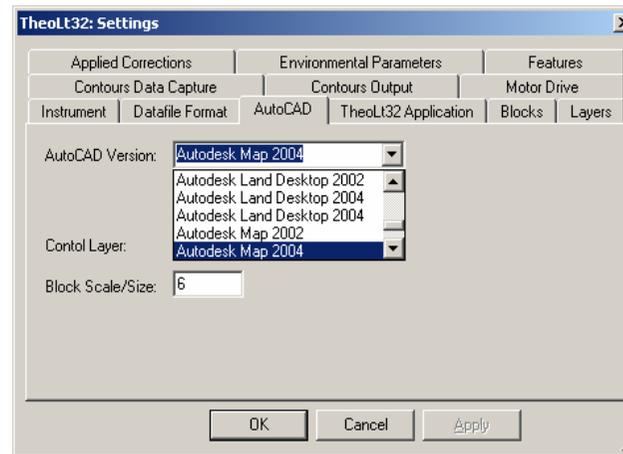
The interface is working when a station block is manually inserted from TheoLt into the current drawing. Close TheoLt. Open AutoCAD, open TheoLt, select control tab, select the insert stn. Button move screen pointer to AutoCAD graphics area and pick a point.

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:

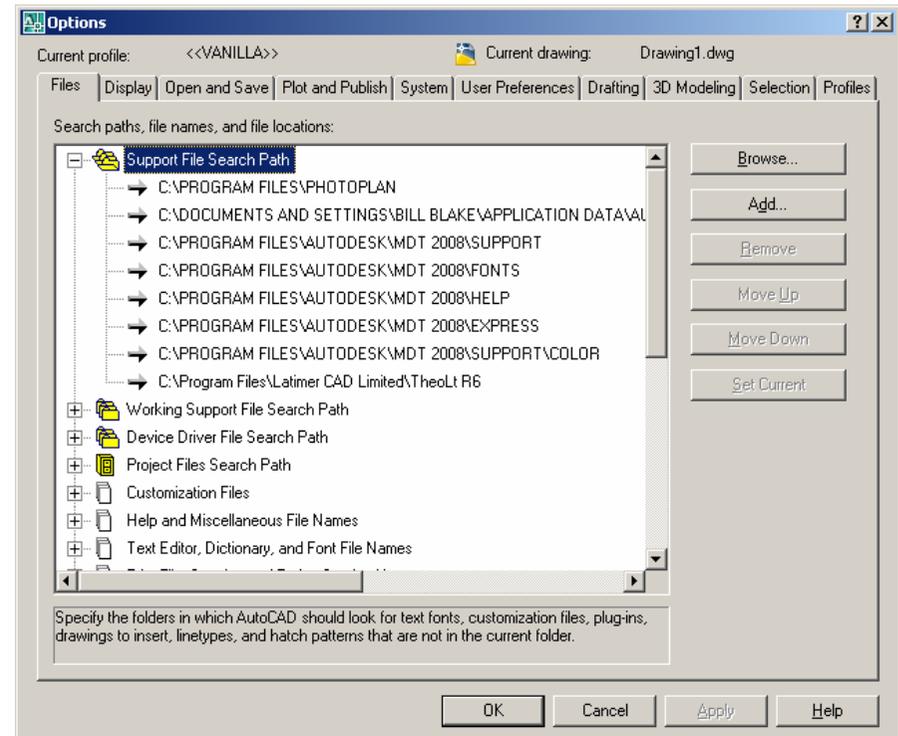
Block path. If the station block is not inserted the command line may report “unknown block name” the AutoCAD support file search path should be edited to add the folder ..C:\.....\theoltblocks in the AutoCAD options panel. (Found under Tools, options, Files, add, browse...).

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 and UCS reset on resection, 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. On completion of the resection the UCS is reset to world, saving the working UCS will enable you to rapidly recover it.



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:

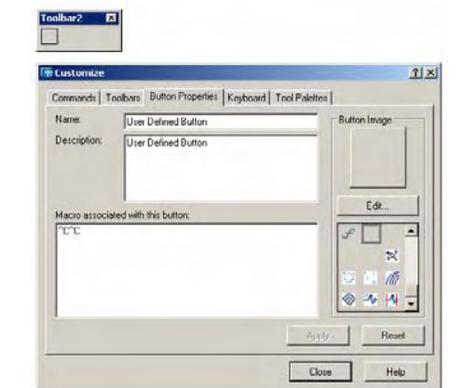
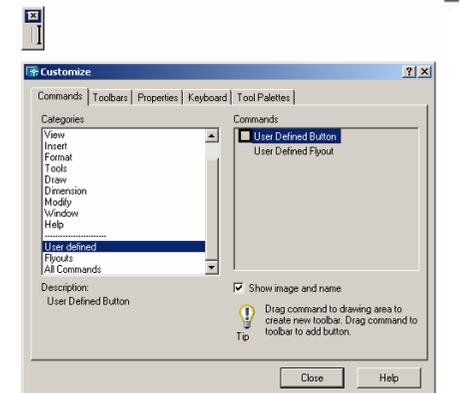
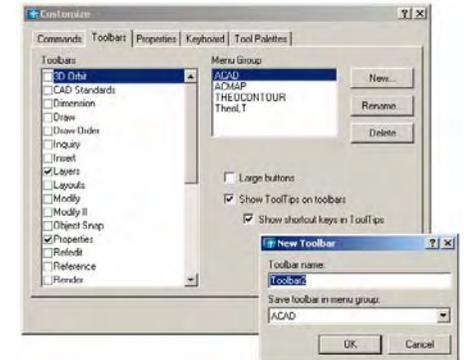
The most important customised toolbar buttons macros are:

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 when used during line command will close the line back to its start point. (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. <i>Polyline is used to draw closed polygons snapped to measured lines, it does not work with measured data itself.</i>

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.

TheoLt: Define Feature: Observations

Feature Details	
Feature Name	Smallfind
Observation Count	1
Allow Distance Mode	False
Distance Count	1
Datafile Name	smallfind.csv
Icon Filename	(Icon)
Observation 1	
Prompt	Location
Observation Type	3D: A & D
Distance Measurement 1	
Prompt	First Measurement for feature

Copy From: [] Cancel Next ->

TheoLt: Define Feature: Data

Feature Details	
Feature Name	Smallfind
Fieldcount	9
Field 1	
Prompt	Smallfind Number
Description	Smallfind Number
Default Value	[Autonumber]
Distance Mode Default Value	
Read Only	False
Mandatory	True
Store Value List	False
Mask	

<- Back Next ->

TheoLt: Define Feature: Block

Block Details	
Feature Name	Smallfind
Block Filename	SMALLFIND.dwg
Layer Name:	
Insert Point Obs	Location
Scale X Obs	[Default]
Scale Y Obs	[Default]
Scale Z Obs	[Default]
Rotation Obs	[Default]
X Insert Offset	[Default]
Y Insert Offset	[Default]
Z Insert Offset	[Default]

<- Back Finish Next Block ->

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

