Leica FlexLine plus
User Manual

Version 1.0
English

- when it has to be **right**

Leica Geosystems

Introduction

Purchase

Congratulations on the purchase of a FlexLine plus instrument.

This manual contains important safety directions as well as instructions for setting up the product and operating it. Refer to "13 Safety Directions" for further information. Read carefully through the User Manual before you switch on the product.

Product identification

The model and serial number of your product are indicated on the type plate.
Enter the model and serial number in your manual and always refer to this information when you need to contact your agency or Leica Geosystems authorised service workshop.

Model: _____

Serial No.: _____

Symbols

The symbols used in this manual have the following meanings:

Type	Description
DANGER	Indicates an imminently hazardous situation which, if not avoided, will result in death or serious injury.
WARNING	Indicates a potentially hazardous situation or an unintended use which, if not avoided, could result in death or serious injury.
CAUTION	Indicates a potentially hazardous situation or an unintended use which, if not avoided, may result in minor or moderate injury.
NOTICE	Indicates a potentially hazardous situation or an unintended use which, if not avoided, may result in appreciable material, financial and environmental damage.
☞	Important paragraphs which must be adhered to in practice as they enable the product to be used in a technically correct and efficient manner.

Trademarks

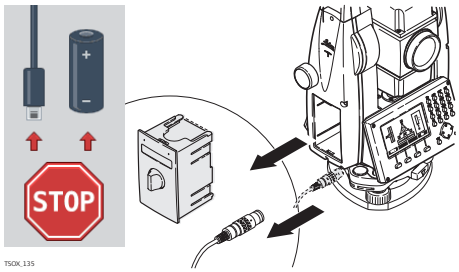
- Windows is a registered trademark of Microsoft Corporation.
- Bluetooth is a registered trademark of Bluetooth SIG, Inc.

All other trademarks are the property of their respective owners.

Validity of this manual

	Description
General	This manual applies to TS06 plus and TS09 plus instruments. Where there are differences between the various instruments they are clearly described.
Telescope	• Measuring with Prism mode: When measuring distances to a reflector with Electronic Distance Measurement (EDM) mode "Prism", the telescope uses a wide visible red laser beam, which emerges coaxially from the telescope's objective. • Measuring with Non-Prism modes: Instruments that are equipped with a reflectorless EDM additionally offer the EDM mode "Non-Prism". When meauring distances with this EDM mode, the telescope uses a narrow visible red laser beam, which emerges coaxially from the telescope's objective.

WARNING



Do NOT remove the battery during operation of the instrument, or during the shut-down procedure.

This can result in a file system error and data loss!

Always switch off the instrument by pressing the On/Off key, and wait until the instrument has shutdown completely before removing the battery.

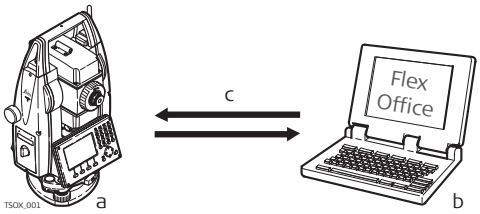
Table of Contents

In this manual

1 Description of the System

1.1 System Components

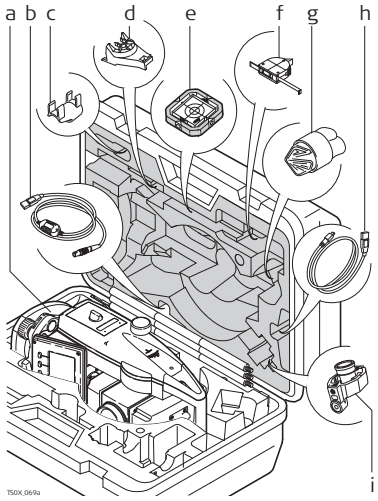
Main components



a) FlexLine plus instrument with FlexField plus firmware
b) Computer with FlexOffice software
c) Data transfer

Component	Description
FlexLine plus instrument	An instrument for measuring, calculating and capturing data. Ideally suited for tasks from simple surveys to complex applications. Equipped with a FlexField plus firmware package to complete these tasks. The various lines have a range of accuracy classes and support different features. All lines can be connected with FlexOffice to view, exchange and manage data.
FlexField plus firmware	The firmware package installed on the instrument. Consists of a standard base operating system with optional additional features.
FlexOffice software	An office software consisting of a suite of standard and extended programs for the viewing, exchanging, managing and post processing of data.
Data transfer	Data can be always transferred between a FlexLine plus instrument and a computer via a data transfer cable. For instruments equipped with a Communication side cover data can also be transferred via USB memory stick, USB cable, or Bluetooth.

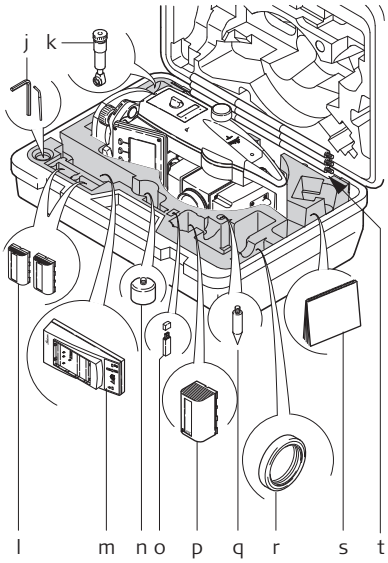
Container contents part 1 of 2



a) Instrument
b) GEV189 data cable (USB-RS232)*
c) GLI115 clip-on bubble*
d) GHT196 holder for height metre*
e) CPR105 flat prism*
f) GHM007 height metre*
g) Protective cover / Lens hood / Cleaning cloth
h) GEV223 data cable (USB-mini USB) - for instruments with a Communication side cover
i) GMP111 mini prism*

* Optional

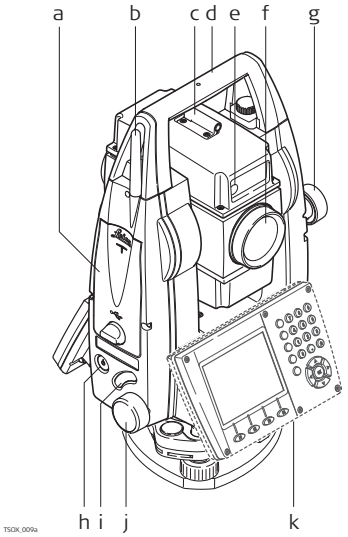
Container contents part 2 of 2



j) Adjustment tools
k) GFZ3 diagonal eyepiece*
l) GEB211/GEB212/GEB221/GEB222 batteries*
m) GKL211 battery charger*
n) GAD105 flat or mini prism adapter*
o) MS1 Leica industrial grade USB memory stick - for instruments with a Communication side cover
p) GEB212/GEB211/GEB221/GEB222 battery*
q) Tip for mini prism pole*
r) Counterweight for diagonal eyepiece*
s) Manuals
t) GLS115 mini prism pole*

* Optional

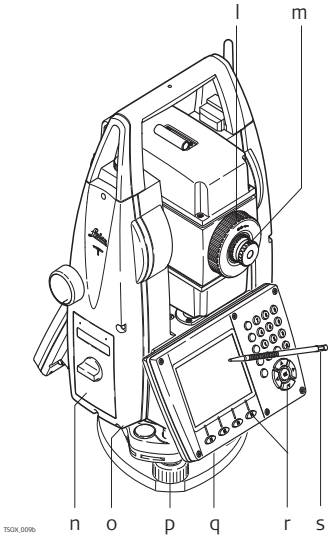
Instrument components part 1 of 2



a) Compartment for USB memory stick and USB cable ports
b) Bluetooth antenna
c) Optical sight
d) Detachable carrying handle with mounting screw
e) Electronic Guide Light (EGL)*
f) Objective with integrated Electronic Distance Measurement (EDM). Exit for EDM laser beam
g) Vertical drive
h) On/Off key
i) Trigger key
j) Horizontal drive
k) Second keyboard**

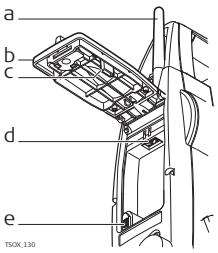
* Optional for TS06 plus
** Optional for TS06 plus/TS09 plus

Instrument components part 2 of 2



l) Focusing telescope image
m) Eyepiece; focusing graticule
n) Battery cover
o) Serial interface RS232
p) Foot screw
q) Display
r) Keyboard, model may vary depending on instrument
s) Stylus

Communication side cover



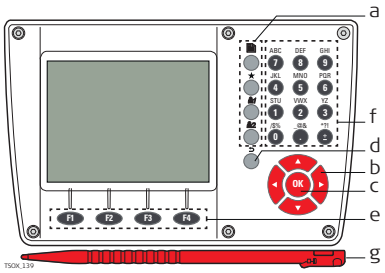
a) Bluetooth antenna
b) Compartment lid
c) USB memory stick cap storage
d) USB host port
e) USB device port

2 User Interface

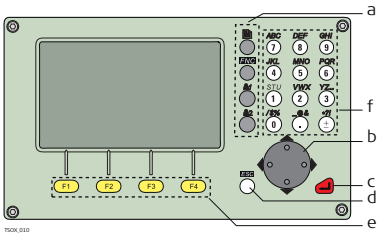
2.1 Keyboard

Keyboard

Color&Touch keyboard



Alphanumeric keyboard



a) Fixed keys
b) Navigation key
c) ENTER key
d) ESC key
e) Function keys F1 to F4
f) Alphanumeric keypad
g) Stylus

Keys

Key B&W	Key C&T	Description
	Tab on screen	Page key. Displays the next screen when several screens are available.
FNC	★	FNC/Favourites key. Quick-access to measurement supporting functions.
		User key 1. Programmable with a function from the **Favourites** menu.
		User key 2. Programmable with a function from the **Favourites** menu.
		Navigation key. Controls the focus bar within the screen and the entry bar within a field.
	OK	ENTER key. Confirms an entry and continues to the next field. When this key is pressed for three seconds, the instrument turns off.
ESC		ESC key. Quits a screen or edit mode without saving changes. Returns to next higher level.
F1, F2, F3, F4	F1, F2, F3, F4	Function keys that are assigned the variable functions displayed at the bottom of the screen.
		Alphanumeric keypad for entry of text and numerical values.

Sidecover keys

Key	Description
	On / Off key. Switches the instrument on or off.
	Trigger key. Quick key programmable with functions **Meas** or **Dist** if desired. The trigger key can be programmed in the **Settings** screen. Refer to "4.1 Work Settings".

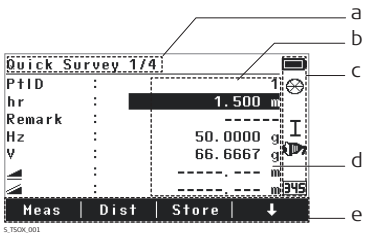
2.2 Screen

Screen

The instrumentsare available with Black&White or with Color&Touch display.

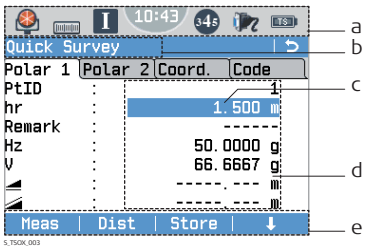
All screens shown in this manual are examples. It is possible that local firmware versions are different to the basic version.

Black&White screen:



a) Title of screen
b) Focus in screen. Active field
c) Status icons
d) Fields
e) Softkeys

Color&Touch screen:



a) Status icons
b) Title of screen
c) Focus in screen. Active field
d) Fields
e) Softkeys

Tap on an icon, field or tab to run a function.

2.3 Status Icons

Description

The icons provide status information related to basic instrument functions. Depending on the firmware version, different icons are displayed.

Icons

Icon		Description
B&W	C&T	
		Non-prism EDM mode for measuring to all targets. For C&T: Tapping the icon opens the **EDM Settings** screen.
		Leica standard prism is selected. For C&T: Tapping the icon opens the **EDM Settings** screen.
		Leica mini prism is selected. For C&T: Tapping the icon opens the **EDM Settings** screen.
		Leica mini 0 prism is selected. For C&T: Tapping the icon opens the **EDM Settings** screen.
		Leica 360° prism is selected. For C&T: Tapping the icon opens the **EDM Settings** screen.

Icon B&W	Icon C&T	Description
		Leica 360° mini prism is selected. For C&T: Tapping the icon opens the **EDM Settings** screen.
		Leica 360° MPR122 prism is selected. For C&T: Tapping the icon opens the **EDM Settings** screen.
		Leica reflector tape is selected. For C&T: Tapping the icons opens the **EDM Settings** screen.
		User defined prism is selected. For C&T: Tapping the icons opens the **EDM Settings** screen.
-		Indicates EDM measurement activity. For C&T: Tapping the icons opens the **EDM Settings** screen.
-		indicates an active laser pointer. For C&T: Tapping the icon opens the **EDM Settings** screen.
I		Indicates telescope position in face I. For C&T: Tapping the icon opens the **Level & Plummet** screen.
II		Indicates telescope position in face II. For C&T: Tapping the icon opens the **Level & Plummet** screen.
		Compensator is on. For C&T: Tapping the icon opens the **Level & Plummet** screen.
		Compensator is off. For C&T: Tapping the icon opens the **Level & Plummet** screen.
		Compensator out of range. For C&T: Tapping the icon opens the **Level & Plummet** screen.
		Keypad is set to numeric mode. Displayed when an editable field is highlighted. For C&T: Tapping the icon switches to alphanumeric mode.
		Keypad is set to alphanumeric mode. Displayed when an editable field is highlighted. For C&T: Tapping the icon switches to numeric mode.
		RS232 communication port is selected. For C&T: Tapping the icon opens the **Interface Settings** screen.
		Bluetooth communication port is selected. If there is a cross beside the icon, the Bluetooth communication port is selected, but the status is inactive. For C&T: Tapping the icon opens the **Interface Settings** screen.
		USB communication port is selected. For C&T: Tapping the icon opens the **Interface Settings** screen.
		Communication is set to auto detect. For C&T: Tapping the icon opens the **Interface Settings** screen.
		The battery symbol indicates the level of the remaining battery capacity, 100% full shown in the example. For C&T: Tapping the icon opens the **Info** screen.
!		Offset is active.
	-	Indicates that horizontal angle is set to left side angle measurement (anticlockwise).

2.4 Softkeys

Description

Softkeys are selected using the relevant F1 to F4 function key. This chapter describes the functionality of the common softkeys used by the system. The more specialised softkeys are described where they appear in the program chapters.

Common softkey functions

Key	Description
Cont	If entry screen: Confirms measured or entered values and continues the process. If message screen: Confirms message and continues with selected action or returns to the previous screen to reselect an option.
Back	To return to the last active screen.
Default	To reset all editable fields to their default values.
Dist	To start distance and angle measurements without saving the measured values.
EDM	To view and change EDM settings. Refer to "4.5 EDM Settings".
ENH	To open the manual coordinate entry screen.
Find	To search for an entered point.
List	To display the list of available points.
Meas	To start distance and angle measurements and save the measured values.
Quit	To exit the screen or program.
Store	To save the displayed values.
View	To display the coordinate and job details of the selected point.
-› ABC	To change the keypad operation to alphanumerical.
-› 345	To change the keypad operation to numerical.
⬇	To display the next softkey level.
⬆	To return to the first softkey level.

2.5 Operating Principles

Turn instrument on/off

- To turn the instrument on or off, use the On/Off key on the side cover of the instrument.
- Alternatively, the instrument can be turned off by pressing the / key for three seconds.

Selection of language

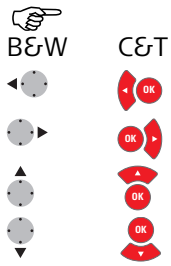
After switching on the instrument the user is able to choose their preferred language. The language choice screen is only shown if multiple languages are loaded onto the instrument and **Lang.Choice**: **On** is set in the instrument settings. Refer to "4.2 Regional Settings".

Alphanumeric keypad

The alphanumerical keypad is used to enter characters directly into editable fields.

- Numeric fields: Can only contain numerical values. By pressing a key of the keypad the number will be displayed.
- Alphanumeric fields: Can contain numbers and letters. By pressing a key of the keypad the first character written above that key will be displayed. By pressing several times you can toggle through the characters. For example: 1-›S-›T-›U-›1-›S....

Edit fields



ESC Deletes any change and restores the previous value.

Moves the cursor to the left

Moves the cursor to the right.

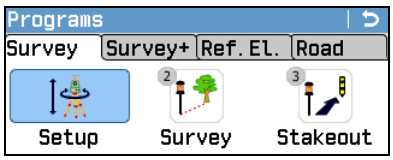
Inserts a character at the cursor position.

Deletes the character at the cursor position.

☞ In edit mode the position of the decimal place cannot be changed. The decimal place is skipped.

Special characters

Character	Description
*	Used as wildcards in search fields for point numbers or codes. Refer to "2.6 Pointsearch".
+/-	In the alphanumeric character set "+" and "-" are treated as normal alphanumeric characters with no mathematical function. ☞ "+" / "-" only appear in front of an entry.



In this example selecting 2 on an alphanumeric keyboard would start the Survey program.

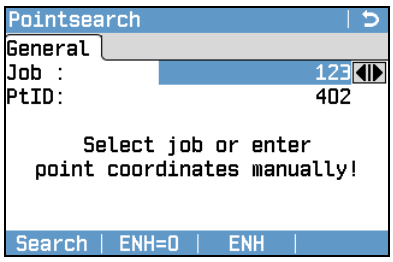
2.6 Pointsearch

Description

Pointsearch is a function used by programs to find measured or fixed points in the memory storage.
It is possible to limit the point search to a particular job or to search the whole storage. The search procedure always finds fixed points before measured points that fulfil the same search criteria. If several points meet the search criteria, then the results are ordered according to the entry date. The instrument finds the most recent fixed point first.

Direct search

By entering an actual point number, for example 402, and pressing **Search**, all points within the selected job and with the corresponding point number are found.



Search
To search for matching points within the selected job.

ENH=0
To set all ENH coordinates for the point ID to 0.

Wildcard search

The wildcard search is indicated by a "*". The asterisk is a place holder for any following sequence of characters. Wildcards should be used if the point number is not fully known, or to search for a batch of points.

Examples of point searches

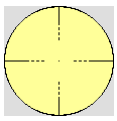
*	All points are found.
A	All points with exactly the point number "A" are found.
A*	All points starting with "A" are found, for example, A9, A15, ABCD, A2A.
*1	All points containing only one "1" are found, for example, 1, A1, AB1.
A*1	All points starting with "A" and containing only one "1" are found, for example, A1, AB1, A51.

2.7 Graphic Symbols

Graphic symbols

In some programs, a graphical display is shown. The graphical display

- provides a guide to find the point to be staked out.
- allows for a better overall understanding of how the data being used and measured relates to each other.

Element	Description
	Point to be staked / known point
/	Instrument
	Current position of prism (measurement with **Dist**)
/	Forward/backwards distance to point
/	Side distance to point
/	Height distance to point
	The stakeout point is the same as the measured point. The difference between stakeout point and measured point is ≤ 0.03 m.
	Circle around the stake out point, supporting the detail view, radius = 0.5 m
	Fixpoint
	Centre point of an arc or circle
	Measured point
	Black squares around the point symbol indicate the plane points.
	New point
	Reference line/arc, straight, curve or spiral from start point to end point
	Extension of reference line/arc, straight, curve or spiral
	Perpendicular distance to the reference line/arc, straight, curve or spiral
	Boundary of an area
	Connection between last measured/selected point and first point of an area
	Boundary of breaklines
	Breaklines of an area

3 Operation

3.1 Instrument Setup

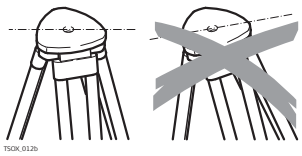
Description

This topic describes an instrument setup over a marked ground point using the laser plummet. It is always possible to set up the instrument without the need for a marked ground point.

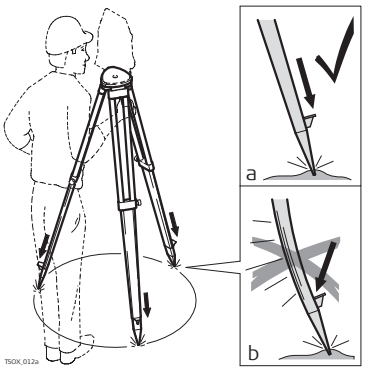
Important features

- It is always recommended to shield the instrument from direct sunlight and avoid uneven temperatures around the instrument.
- The laser plummet described in this topic is built into the vertical axis of the instrument. It projects a red spot onto the ground, making it appreciably easier to centre the instrument.
- The laser plummet cannot be used with a tribrach equipped with an optical plummet.

Tripod

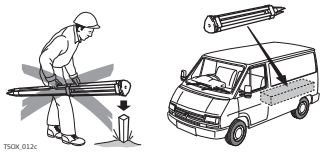


When setting up the tripod pay attention to ensuring a horizontal position of the tripod plate. Slight corrections of inclination can be made with the foot screws of the tribrach. Larger corrections must be done with the tripod legs.



Loosen the clamping screws on the tripod legs, pull out to the required length and tighten the clamps.

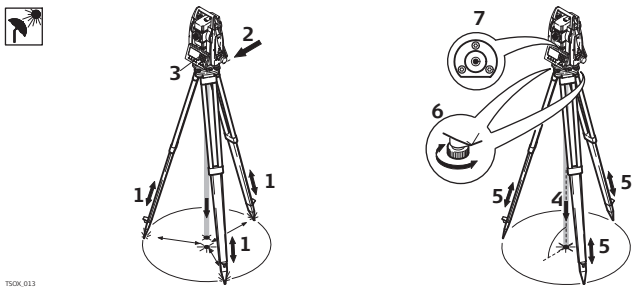
a) In order to guarantee a firm foothold sufficiently press the tripod legs into the ground.
b) When pressing the legs into the ground note that the force must be applied along the legs.



Careful handling of tripod.

- Check all screws and bolts for correct fit.
- During transport, always use the cover supplied.
- Use the tripod only for surveying tasks.

Setup step-by-step



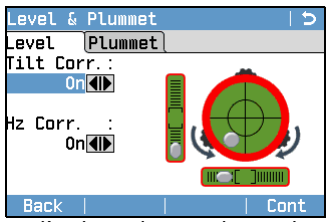
1. Extend the tripod legs to allow for a comfortable working posture. Position the tripod over the marked ground point, centring it as best as possible.
2. Fasten the tribrach and instrument onto the tripod.
3. Turn on the instrument, and, if tilt correction is set to **On**, the laser plummet will be activated automatically, and the **Level & Plummet** screen appears. Otherwise, press the FNC/Favourites key from within any program and select **Level & Plummet**.
4. Move the tripod legs (1) and use the tribrach footscrews (6) to centre the plummet (4) over the ground point.
5. Adjust the tripod legs (5) to level the circular level (7).
6. By using the electronic level, turn the tribrach footscrews (6) to precisely level the instrument. Refer to "Level up with the electronic level step-by-step".
7. Centre the instrument precisely over the ground point by shifting the tribrach on the tripod plate (2).
8. Repeat steps 6. and 7. until the required accuracy is achieved.

Level up with the electronic level step-by-step

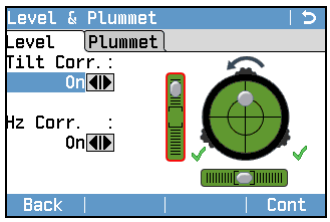
The electronic level can be used to precisely level up the instrument using the footscrews of the tribrach.

1. Turn the instrument until it is parallel to two footscrews.
2. Centre the circular level approximately by turning the footscrews of the tribrach.
3. Turn on the instrument, and, if tilt correction is set to On, the laser plummet will be activated automatically, and the **Level & Plummet** screen appears. Otherwise, press the FNC/Favourites key from within any program and select **Level & Plummet**.

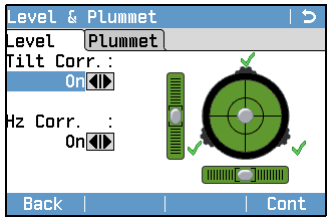
   The bubble of the electronic level and the arrows for the rotating direction of the footscrews only appear if the instrument tilt is inside a certain levelling range.
4. Centre the electronic level of the first axis by turning the two footscrews. Arrows show the direction of rotation required. The first axis is levelled, when the bubble is exactly between the squared brackets [] of the single axis bubble tube.



   When levelled correctly, checkmarks are displayed. For the Color&Touch display only: If the instrument is not levelled to one axis, then the icons for the single axis bubble tube and the circular bubble are framed red, else they are black.
5. Centre the electronic level for the second axis by turning the last footscrew. An arrow shows the direction of rotation required.



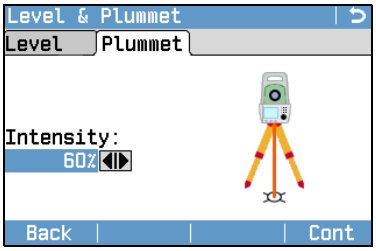
When all three bubbles are centred, the instrument has been perfectly levelled up.



6. Accept with **Cont**.

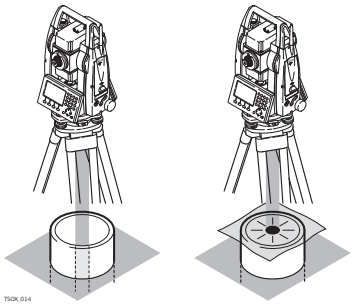
Change the intensity of the laser plummet

External influences and the surface conditions may require the adjustment of the intensity of the laser plummet.



In the **Level & Plummet** screen, adjust the intensity of the laser plummet using the navigation key.
The laser can be adjusted in 20% steps as required.

Position over pipes or holes



Under some circumstances the laser dot is not visible, for example over pipes. In this case, using a transparent plate enables the laser dot to be seen and then easily aligned to the centre of the pipe.

3.2 Working with the Battery

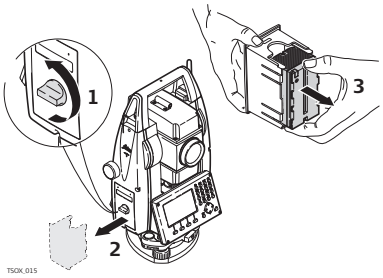
Charging / first-time use

- The battery must be charged prior to using it for the first time because it is delivered with an energy content as low as possible.
- For new batteries or batteries that have been stored for a long time (› three months), it is effectual to make only one charge/discharge cycle.
- The permissible temperature range for charging is between 0°C to +40°C/+32°F to +104°F. For optimal charging we recommend charging the batteries at a low ambient temperature of +10°C to +20°C/+50°F to +68°F if possible.
- It is normal for the battery to become warm during charging. Using the chargers recommended by Leica Geosystems, it is not possible to charge the battery if the temperature is too high.

Operation / discharging

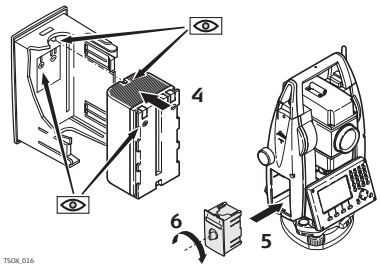
- The batteries can be operated from -20°C to +50°C/-4°F to +122°F.
- Low operating temperatures reduce the capacity that can be drawn; very high operating temperatures reduce the service life of the battery.
- For Li-Ion batteries, we recommend carrying out a single discharging and charging cycle when the battery capacity indicated on the charger or on a Leica Geosystems product deviates significantly form the actual battery capacity available.

Change the battery step-by-step



Open the battery compartment (1) and remove the battery holder (2).

Remove the battery from the battery holder (3).



Insert the new battery into the battery holder (4), ensuring that the contacts are facing outward. The battery should click into position.

Insert the battery holder back into the battery compartment (5) and turn the knob to lock the battery holder in place (6).

☞ The polarity of the battery is displayed inside the battery housing.

3.3 Data Storage

Description

An internal memory is included in all instruments. The FlexField plus firmware stores all data in jobs in a database in the internal memory. Data can then be transferred to a computer or other device for post processing via a LEMO cable connected to the serial interface RS232 port.
For instruments fitted with a Communication side cover, data can also be transferred from the internal memory to a computer or other device via:

- a USB memory stick inserted into the USB host port,
- a USB cable connected to the USB device port, or
- via a Bluetooth connection.

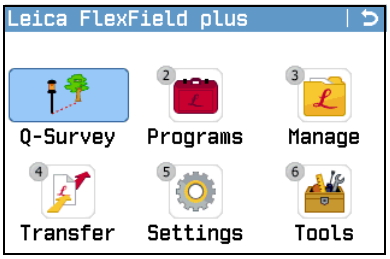
Refer to "10 Data Management" for further information on data management and data transfer.

Description

The Main Menu is the starting place for accessing all functionality of the instrument. It is displayed immediately after the **Level & Plummet** screen, after switching on the instrument.

☞ If desired, the instrument can be configured to start in a user-defined place after the Level/Plummet screen, instead of the Main Menu. Refer to "9.2 Startup Sequence".

Main Menu



Description of the Main Menu functions

Function	Description
Q-Survey	**Quick Survey** program to begin measuring immediately. Refer to "3.5 Q-Survey Program".
Programs	To select and start programs. Refer to "6 Programs".
Manage	To manage jobs, data, codelists, formats, system memory and USB memory stick files. Refer to "10 Data Management".
Transfer	To export and import data. Refer to "10.2 Exporting Data".
Settings	To change EDM configurations, communication parameters and general instrument settings. Refer to "4 Settings".
Tools	To access instrument-related tools such as check and adjust, personal startup settings, PIN code settings, licence keys, system information and firmware upload. Refer to "9 Tools".

3.5 Q-Survey Program

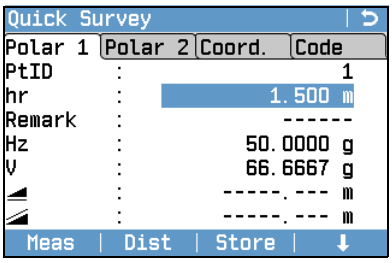
Description

After switching on and setting up correctly, the instrument is immediately ready for measuring.

Access

Select **Q-Survey** from the Main Menu.

Q-Survey



⬇ Station
To enter station data and set the station.

⬇ Set Hz
To set the orientation to a user defined horizontal direction.

⬇ Hz ⬅ / Hz ➡
To set the horizontal angle reading to the left (anticlockwise) or to the right (clockwise).

⬇ Code
To find/enter codes. Refer to "8.1 Coding". Available on page 4/4 or **Code**. Or, on any page, press the FNC/Favourites key and select **Coding**.

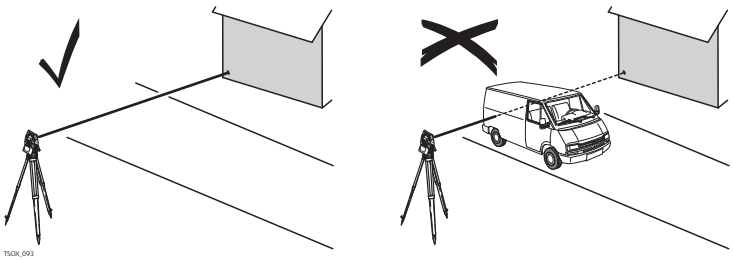
3.6 Distance Measurements - Guidelines for Correct Results

Description

An EDM is incorporated into the FlexLine plus instruments. In all versions, the distance can be determined by using a visible red laser beam which emerges coaxially from the telescope objective. There are two EDM modes:

- Prism measurements
- Non-Prism measurements

Non-Prism measurements



- When a distance measurement is triggered, the EDM measures to the object which is in the beam path at that moment. If a temporary obstruction, for example a passing vehicle, heavy rain, fog or snow is between the instrument and the point to be measured, the EDM may measure to the obstruction.
- Be sure that the laser beam is not reflected by anything close to the line of sight, for example highly reflective objects.
- Avoid interrupting the measuring beam while taking Non-Prism measurements or measurements using reflective foils.
- Do not measure with two instruments to the same target simultaneously.

Prism measurements

- Accurate measurements to prisms should be made in Prism-standard mode.
- Measurements to strongly reflecting targets such as traffic lights in Prism mode without a prism should be avoided. The measured distances may be wrong or inaccurate.
- When a distance measurement is triggered, the EDM measures to the object which is in the beam path at that moment. If for example people, cars, animals, or swaying branches cross the laser beam while a measurement is being taken, a fraction of the laser beam is reflected from these objects and may lead to incorrect distance values.
- Measurements to prisms are only critical if an object crosses the measuring beam at a distance of 0 to 30 m and the distance to be measured is more than 300 m.
- In practice, because the measuring time is very short, the user can always find a way of avoiding unwanted objects from interfering in the beam path.

⚠ WARNING

Due to laser safety regulations and measuring accuracy, using the Long Range Reflectorless EDM is only allowed to prisms that are more than 1000 m (3300 ft) away.

Red laser to prism

- **P-Long (>4.0 km)** mode enables distance measurements of over 4.0 km to standard prisms using the visible red laser beam.

Red laser to reflector tape

- The visible red laser beam can also be used to measure to reflective foils. To guarantee the accuracy the red laser beam must be perpendicular to the reflector tape and it must be well adjusted.
- Make sure the additive constant belongs to the selected target (reflector).

4 Settings

4.1 Work Settings

Access

1. Select **Settings** from the Main Menu.
2. Select **Work** from the **Settings** Menu.

Work Settings

Field	Description	
Trigger Key1 **Trigger Key2**	Trigger Key 1 is the top end of the trigger key. Trigger Key 2 is the lower end of the trigger key.	
	Off	The trigger key is deactivated.
	Meas	Sets the trigger key with the same function as **Meas**.
	Dist	Sets the trigger key with the same function as **Dist**.
USER Key 1 **USER Key 2**	Configures or with a function from the **Favourites** menu. Refer to "7 Favourites".	
Tilt Corr.	**Off**	Tilting compensation deactivated.
	On	2-axis compensation. Vertical angles refer to the plummet line and the horizontal directions are corrected by the standing axis tilt. For corrections depending on the **Hz Corr.** setting, refer to the table "Tilt and horizontal corrections".
☞	If the instrument is used on an unstable base, for example a shaking platform or ship, the compensator should be deactivated. This avoids the compensator drifting out of its measuring range and interrupting the measuring process by indicating an error.	
Hz Corr.	**On**	Horizontal corrections are activated. For normal operation the horizontal correction should remain active. Each measured horizontal angle will be corrected, depending on the vertical angle. For corrections depending on the **Tilt Corr.** setting, refer to the table "Tilt and horizontal corrections".
	Off	Horizontal corrections are deactivated.
Face I Def.	Sets the face I in relation to the position of the vertical drive.	
	V-Left	Sets face I to be when the vertical drive is on the left of the instrument.
	V-Right	Sets face I to be when the vertical drive is on the right of the instrument.

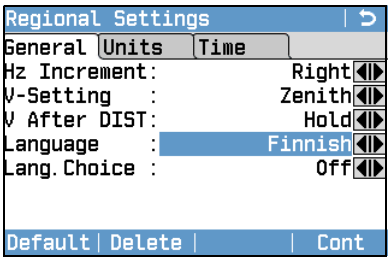
Tilt and horizontal corrections

Setting		Correction			
Tilt correction	**Horizontal correction**	**Incline longitudinal**	**Incline transversal**	**Horizontal collimation**	**Tilting axis**
Off	On	No	No	Yes	Yes
On	On	Yes	Yes	Yes	Yes
Off	Off	No	No	No	No
On	Off	Yes	No	No	No

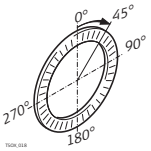
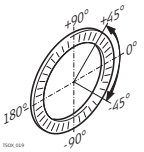
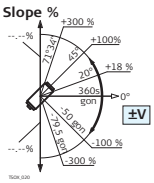
Access

1. Select **Settings** from the Main Menu.
2. Select **Regional** from the **Settings** Menu.
3. Press to scroll through the screens of available settings.

Regional Settings



Delete
To delete an inactive language. Available when the language is highlighted.

Field	Description	
Hz Increment	**Right**	Set horizontal angle to clockwise direction measurement.
	Left	Set horizontal angle to counter-clockwise direction measurement. Counter-clockwise directions are displayed but are saved as clockwise directions.
V-Setting	Sets the vertical angle.	
	Zenith	 Zenith=0°; Horizon=90°.
	Horizon	 Zenith=90°; Horizon=0°. Vertical angles are positive above the horizon and negative below it.
	Slope [%]	 45°=100%; Horizon=0°. Vertical angles are expressed in % with positive above the horizon and negative below it. ☞ The % value increases rapidly. --.--% appears on the display above 300%.

Field	Description	
V After DIST	Sets if the vertical angle value recorded is the value that is displayed when **Dist** or when **Store** is pressed. The vertical angle field in a measurement screen always shows the running angle, regardless of this setting.	
	Hold	The vertical angle value that is recorded is the value that was in the vertical angle field at the time **Dist** was pressed.
	Running	The vertical angle value that is recorded is the value in the vertical angle field at the time **Store** is pressed.
	☞	This setting is not applicable for the program Tie Distance or the favourites Hidden Pointand Height Transfer. For these, the vertical angle is always running and the value recorded is the value when **Store** is pressed.
Language	Sets the chosen language. Several languages can be uploaded onto the instrument. The current loaded language(s) are shown. A selected language can be deleted by pressing **Delete**. This function is available if more than one language is installed, and the selected language is not the chosen operating language.	
Lang.Choice	If multiple languages are loaded, a screen to choose the language can be shown directly after switching on the instrument.	
	On	The language screen is shown as the startup screen.
	Off	The language screen is not shown as the startup screen.
Angle Unit	Sets the units shown for all angular fields.	
	° ' "	Degree sexagesimal. Possible angle values: 0° to 359°59'59''
	dec. deg	Degree decimal. Possible angle values: 0° to 359.999°
	gon	Gon. Possible angle values: 0 to 399.999 gon
	mil	Mil. Possible angle values: 0 to 6399.99 mil.
☞	The setting of the angle units can be changed at any time. The current displayed values are converted according to the selected unit.	
Min. Reading	Sets the number of decimal places shown for all angular fields. This is for data display and does not apply to data export or storage.	
	°'"	(0° 00' 0.1"/0° 00' 01"/0° 00' 05"/ 0° 00' 10")
	dec. deg	(0.0001 / 0.0005 / 0.001)
	gon	(0.0001 / 0.0005 / 0.001)
	mil	(0.01 / 0.05 / 0.1)
Dist. Unit	Sets the units shown for all distance and coordinate related fields.	
	meter	Metres [m].
	US-ft	US feet [ft].
	INT-ft	International feet [fi].
	ft-in/16	US feet-inch-1/16 inch [ft].

Field	Description	
Dist.Decimal	Sets the number of decimal places shown for all distance fields. This is for data display and does not apply to data export or storage.	
	3	Displays distance with three decimals.
	4	Displays distance with four decimals.
Temp. Unit	Sets the units shown for all temperature fields.	
	°C	Degree Celsius.
	°F	Degree Fahrenheit.
Press.Unit	Sets the units shown for all pressure fields.	
	hPa	Hecto Pascal.
	mbar	Millibar.
	mmHg	Millimeter mercury.
	inHg	Inch mercury.
Grade Unit	Sets how the slope gradient is calculated.	
	h:v	Horizontal : Vertical, for example 5 : 1.
	v:h	Vertical : Horizontal, for example 1 : 5.
	%	(v/h x 100), for example 20 %.
Time (24h)	The current time.	
Date	Shows an example of the selected date format.	
Format	**dd.mm.yyyy**, **mm.dd.yyyy** or **yyyy.mm.dd**	How the date is shown in all date-related fields.

Access

1. Select **Settings** from the Main Menu.
2. Select **Data** from the **Settings** Menu.
3. Press to scroll through the screens of available settings.

Data Settings

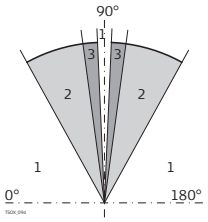
Field	Description	
Double PtID	Sets if multiple points are able to be recorded with the same point ID in the same job.	
	Allowed	Allows multiple points with the same point ID.
	Not Allowed	Does not allow multiple points with the same point ID.
Sort Type	**Time**	Lists are sorted by time of entry.
	PtID	Lists are sorted by Point IDs.
Sort Order	**Descending**	Lists are ordered in descending order of sort type.
	Ascending	Lists are ordered in ascending order of sort type.
Code Record	Sets if the codeblock is saved before or after the measurement. Refer to "8 Coding".	
Code	Sets if the code will be used for one, or many, measurements.	
	Reset after Rec	The set code is cleared from the measurement screen after **Meas** or **Store** is selected.
	Permanent	The set code remains in the measurement screen until manually deleted.
Data Output	Sets the location for data storage.	
	Internal Memory	All data is recorded in the internal memory.
	Interface	Data is recorded via the serial interface, the USB device port or Bluetooth, depending on the port selected in the **Interface Settings** screen. This **Data Output** setting is only required if an external storage device is connected and measurements are started at the instrument with Dist/Store or Meas. This setting is not required if the instrument is totally controlled by a datalogger.
GSI-Format	Sets the GSI output format.	
	GSI 8	81..00+12345678
	GSI 16	81..00+1234567890123456
GSI-Mask	Sets the GSI output mask.	
	Mask 1	PtID, Hz, V, SD, ppm+mm, hr, hi.
	Mask 2	PtID, Hz, V, SD, E, N, H, hr.
	Mask 3	StationID, E, N, H, hi (Station). StationID, Ori, E, N, H, hi (Station Result). PtID, E, N, H (Control). PtID, Hz, V (Set Azimuth). PtID, Hz, V, SD, ppm+mm, hr, E, N, H (Measurement).

Access

1. Select **Settings** from the Main Menu.
2. Select **Screen...** from the **Settings** Menu.
3. Press to scroll through the screens of available settings.

Screen & Audio Settings

Field	Description	
Display Ill.	**Off** to 100%	Sets the display illumination in 20% steps.
Keyb. Ill.	Available for Color&Touch display only.	
	On	The keyboard illumination is activated.
	Off	The keyboard illumination is deactivated.
Reticle Ill.	**Off** to 100%	Sets the reticle illumination in 10% steps.
Touch Screen	Available for Color&Touch display only.	
	On	The touch screen is activated.
	Off	The touch screen is deactivated.
	☞	Press **Calib.** to calibrate the touch screen. Follow the instructions on the screen
Displ.Heater	Available for Black&White display only.	
	On	The display heater is activated.
	Off	The display heater is deactivated.
☞	The display heater is automatically activated when the display illumination is on and the instrument temperature is ≤ 5°C.	
Contrast	0% to 100%	Available for Black&White display only. Sets the display contrast in 10% steps.
Auto-Off	**Enable**	The instrument switches off after 20 minutes without any activity , for example no key pressed or vertical and horizontal angle deviation is ≤ ±3".
	Disable	Automatic switch-off is deactivated.
	☞	Battery discharges quicker.
Screensaver	**after 1 min**, **after 2 min**, **after 5 min**, **after 10 min**	The screensaver is activated and starts after the selected time.
	Off	The screensaver is deactivated.
Beep	The beep is an acoustic signal after each key stroke.	
	Normal	Normal volume.
	Loud	Increased volume.
	Off	Beep is deactivated.

Field	Description	
Sector Beep	**On**	Sector beep sounds at right angles (0°, 90°, 180°, 270° or 0, 100, 200, 300 gon).  1)No beep. 2)Fast beep; from 95.0 to 99.5 gon and 105.0 to 100.5 gon. 3)Permanent beep; from 99.5 to 99.995 gon and from 100.5 to 100.005 gon.
	Off	Sector Beep is deactivated.
Stakeout Beep	**On**	The instrument beeps when the distance from the current position to the point to be staked is ≤ 0.5 m. The closer the prism is to the point to be staked the faster the beeps will be.
	Off	Beep is deactivated.

4.5 EDM Settings

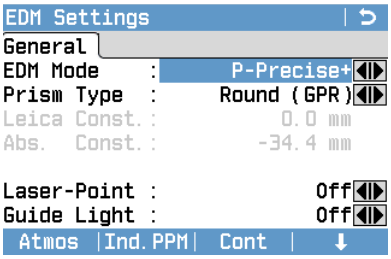
Description

The settings on this screen define the active EDM, Electronic Distance Measurement. Different settings for measurements are available with Non-Prism (NP) and Prism (P) EDM modes.

Access

1. Select **Settings** from the Main Menu.
2. Select **EDM** from the **Settings** Menu.

EDM Settings



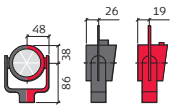
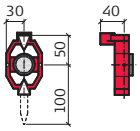
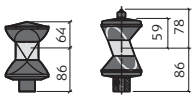
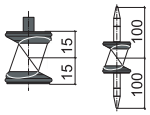
Atmos
To enter atmospheric data ppm.

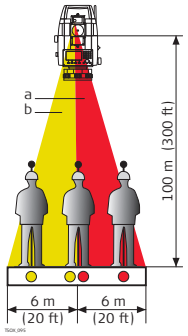
Ind.PPM
To enter an individual ppm value.

⬇ Scale
To enter projection scale details.

⬇ Signal
To view EDM Signal reflection value.

⬇ Freq.
To view the EDM frequency.

Field	Description		
EDM Mode	**P-Precise+**	Fine measuring mode for highest precision measurements with prisms (1.5 mm + 2 ppm).	
	P-Precise & Fast	Quick measuring mode with prisms, with higher measuring speed and high accuracy (2 mm + 2 ppm).	
	P-Tracking	For continuous distance measurements with prisms (3 mm + 2 ppm).	
	Tape	For distance measurements using Retro reflective targets (5 mm + 2 ppm).	
	P-Long (>4.0 km)	For long range distance measurements with prisms (5 mm + 2 ppm).	
	NP-Precise	For distance measurements without prisms (2 mm + 2 ppm; >500 m: 4 mm + 2 ppm).	
	NP-Tracking	For continuous distance measurements without prisms (5 mm + 3 ppm).	
Prism Type	**Round (GPR)**		Standard prism GPR121/GPR111 **Leica Const.**: 0.0 mm
	Mini (GMP) **Mini0 (GMP111-0)**		GMP111 **Leica Const.**: +17.5 mm GMP111-0 **Leica Const.**: 0.0 mm
	Jp Mini (SMP222)	Miniprism	**Leica Const.**: +34.4 mm
	360° (GRZ4)		GRZ4/GRZ122 **Leica Const.**: +23.1 mm
	360°Mini(GRZ101)		GRZ101 **Leica Const.**: +30.0 mm

Field	Description		
	Tape (GZM)		**Leica Const.**: +34.4 mm
	360° (MPR122)		MPR122 **Leica Const.**: +28.1 mm
	None	Without prism	**Leica Const.**: +34.4 mm
	User 1 / **User 2**	For any prism modes, the user can define two of their own prisms. Constants can be entered in mm in either **Leica Const.** or **Abs. Const.**. For example: User prism constant = -30.0 mm **Leica Const.** = +4.4 mm (34.4 + -30 = 4.4) **Abs. Const.** = -30.0 mm	
Leica Const.	This field displays the Leica prism constant for the selected **Prism Type**. Where **Prism Type** is **User 1** or **User 2** this field becomes editable to set a user defined constant. Input can only be made in mm. Limit value: -999.9 mm to +999.9 mm.		
Abs. Const.	This field displays the absolute prism constant for the selected **Prism Type**. Where **Prism Type** is **User 1** or **User 2** this field becomes editable to set a user defined constant. Input can only be made in mm. Limit value: -999.9 mm to +999.9 mm.		
Laser-Point	**Off**	Visible laser beam is deactivated.	
	On	Visible laser beam for visualising the target point is activated.	
Guide Light	**Off**	Guide Light is deactivated.	
	On	Guide Light is activated. The person at the prism can be guided by the flashing lights directly to the line of sight. The light points are visible up to a distance of 150 meters. This is useful when staking out points. Working range: 5 m to 150 m (15 ft to 500 ft). Positioning accuracy: 5 cm at 100 m (1.97" at 330 ft).  a) Flashing red diode b) Flashing yellow diode	

EDM Settings - Enter Atmospheric Data

This screen enables the entry of atmospheric parameters. Distance measurement is influenced directly by the atmospheric conditions of the air in which the measurements are taken. In order to take these influences into consideration distance measurements are corrected using atmospheric correction parameters.
The refraction correction is taken into account in the calculation of the height differences and the horizontal distance. Refer to "14.7 Scale Correction" for the application of the values entered in this screen.

☞ When **PPM=0** is selected, the Leica standard atmosphere of 1013.25 mbar, 12°C, and 60% relative humidity is applied.

EDM Settings - Enter Projection Scale

This screen enables entry of the scale of projection. Coordinates are corrected with the PPM parameter. Refer to "14.7 Scale Correction" for the application of the values entered on this screen.

EDM Settings - Enter Individual PPM

This screen enables the entry of individual scaling factors. Coordinates and distance measurements are corrected with the PPM parameter. Refer to "14.7 Scale Correction" for the application of the values entered on this screen.

EDM Settings - EDM Signal Reflection

This screen tests the EDM signal strength (reflection strength) in steps of 1%. Enables optimal aiming at distant, barely visible, targets. A percentage bar and a beeping sound, indicate the reflection strength. The faster the beep the stronger the reflection.

ppm handling

General handling

Handling of	Geom.ppm	Atmos. ppm	Indiv. ppm
Slope distance	Not applied	Applied	Applied
Horizontal distance	Not applied	Applied	Applied
Coordinates	Applied	Applied	Applied

Exceptions

- Program Stakeout
  Geometric reduction values are applied to calculate and display the horizontal distance difference so that the position of points to be staked is found correctly.
- LandXML Data
  To import and use the measurements into LGO, the distances recorded in LandXML differ from the distances on the instrument.

Handling of	Geom. ppm	Atmos. ppm	Indiv. ppm	ppm tag
Slope distance	Not applied	Applied	Not applied	Available
Horizontal distance	Applied	Applied	Applied	Unavailable
Coordinates	Applied	Applied	Applied	Unavailable

4.6 Interface Settings

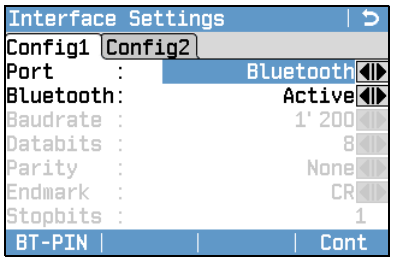
Description

For data transfer the communication parameters of the instrument must be set.

Access

1. Select **Settings** from the Main Menu.
2. Select **Interface** from the **Settings** Menu.

Interface Settings



BT-PIN

To set a PIN code for the Bluetooth connection.

This softkey is only available for instruments with a Communication side cover. The default Bluetooth PIN is '0000'.

Default

To reset the fields to the default Leica standard settings. Available for **RS232**.

Field	Description	
Port :	Instrument port. If a Communication side cover is fitted the options are selectable. If there is no Communication side cover the value is set to **RS232** and is uneditable.	
	RS232	Communication is via the serial interface.
	USB	Communication is via the USB host port.
	Bluetooth	Communication is via Bluetooth.
	Automatically	Communication is set to auto detect.
Bluetooth:	**Active**	Bluetooth sensor is activated.
	Inactive	Bluetooth sensor is deactivated.

The following fields are active only when **Port : RS232** is set.

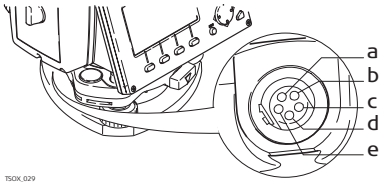
Field	Description	
Baud rate:	Speed of data transfer from receiver to device in bits per second. **1'200**, **2'400**, **4'800**, **9'600**, **14'400**, **19'200**, **38'400**, **57'600**, **115'200**, **Topcon**, **Sokkia**	
Data bits:	Number of bits in a block of digital data.	
	7	Data transfer is realised with 7 databits.
	8	Data transfer is realised with 8 databits.
Parity :	**Even**	Even parity. Available if data bit is set to 7.
	Odd	Odd parity. Available if data bit is set to 7.
	None	No parity. Available if data bit is set to 8.
Endmark :	**CR/LF**	The terminator is a carriage return followed by a line feed.
	CR	The terminator is a carriage return.
Stop bits: 1		Number of bits at the end of a block of digital data.
Acknowlge:	**On**	Acknowledgement expected from other device after data transfer received. An error message will display if no acknowledgement is returned.
	Off	No acknowledgement expected after data transfer.

Leica standard settings

When **Default** is selected the communication parameters are reset to the default Leica standard settings:

- 115200 Baud, 8 Databit, No Parity, CR/LF Endmark, 1 Stopbit.

Interface plug connections



a) External battery
b) Not connected / inactive
c) GND
d) Data reception (TH_RXD)
e) Data transfer (TH_TXD)

5 Programs - Getting Started

5.1 Overview

Description

Programs are predefined programs, that cover a wide spectrum of surveying duties and facilitate daily work in the field. The following programs are available, although program packages for each FlexLine plus instrument may vary from that stated below:

Program	TS06 plus	TS09 plus
Station Setup	✓	✓
Survey	✓	✓
Stakeout	✓	✓
Reference Line	✓	✓
Reference Arc	✓	✓
Reference Plane	✓	✓
Tie Distance	✓	✓
COGO	✓	✓
Area & DTM Volume	✓	✓
Remote Height	✓	✓
Road 2D	✓	✓
Road 3D	Optional	✓
Traverse	Optional	✓

☞ Only softkeys unique to the programs are explained in the program chapters. Refer to "2.4 Softkeys" for descriptions of the common softkeys.

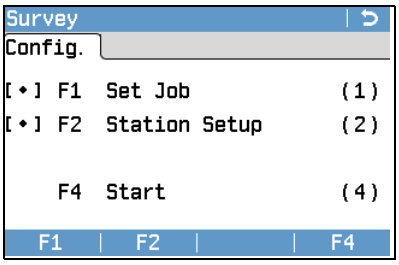
5.2 Starting a Program

Access

1. Select **Programs** from the Main Menu.
2. Press to move through the screens of available programs.
3. Press the number of the program (for Black&White display) or tab on an icon (for Color&Touch display) to select the specified program in the **Programs** Menu.

Pre-settings screens

Pre-settings for Survey is shown as an example. Any additional settings for particular programs are explained within the chapters for those programs.



[•] = Setting has been made.
[ ] = Setting has not been made.

F1-F4
To select menu item.

Field	Description
F1 Set Job	To define the job where data will be saved. Refer to "5.3 Setting the Job".
F2 Station Setup	To determine the station coordinates and station orientation. Refer to "5.4 Station Setup".
F4 Start	Starts the selected program.

5.3 Setting the Job

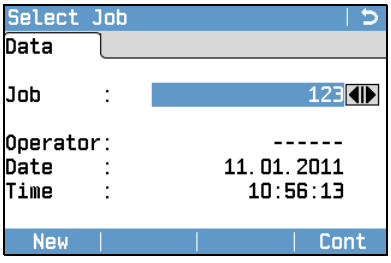
Description

All data is saved in Jobs, like file directories. Jobs contain measurement data of different types, for example measurements, codes, fixed points, or stations. Jobs are individually manageable and can be exported, edited or deleted separately.

Access

Select **F1 Set Job** in **Config.** screen.

Select Job



New
To create a new job.

Field	Description
Job	Name of an existing job to be used.
Operator	Name of operator, if entered.
Date	Date the selected job was created.
Time	Time the selected job was created.

Next step

- Either, press **Cont** to continue with the selected job.
- Or, press **New** to open the **Enter Job Data** screen and create a new job.

Recorded data

Once a job is set up, all subsequent recorded data will be stored in this job.
If no job was defined and a program was started, or if in **Q-Survey** and a measurement was recorded, then the system automatically creates a new job and names it "Default".

Next step

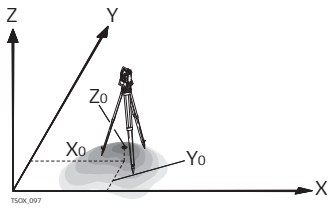
Press **Cont** to confirm the job and return to the **Config.** screen.

5.4 Station Setup

Description

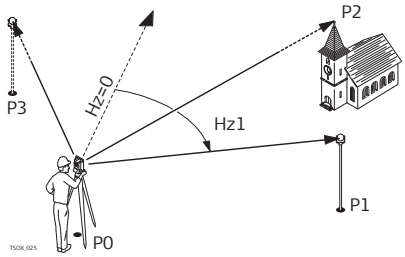
All measurements and coordinate computations are referenced to the set station coordinates and orientation.

Station coordinate calculation



Directions
X Easting
Y Northing
Z Height
Station coordinates
X0 Easting coordinate of station
Y0 Northing coordinate of station
Z0 Height of station

Station orientation calculation



P0 Instrument station
Known coordinates
P1 Target point
P2 Target point
P3 Target point
Calculations
Hz1 Station orientation

Access

Select **F2 Station Setup** in **Config.** screen.

Next step

The Station Setup program begins. Refer to "6.2 Station Setup" for information on the Station Setup process.

If no station was set and a program was started, then the last station is set as the current station and the current horizontal direction is set as the orientation.

6 Programs

6.1 Common Fields

Description of fields

The following table describes common fields that are found within the firmware programs. These fields are described here once and not repeated in the program chapters unless the field has a specific meaning within that program.

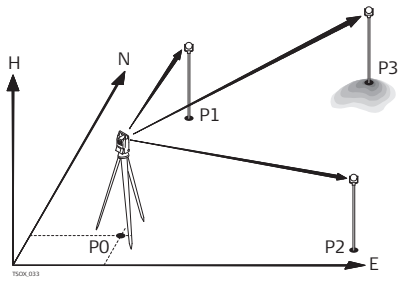
Field	Description
PtID, **Point**, **Point 1**	Point ID of the point.
hr	Height of the reflector.
Remark / **Code**	Remark or Code name depending on the coding method. Three coding methods are available: • Remark coding: This text is stored with the corresponding measurement. The code is not related to a codelist, it is just a simple remark. A codelist on the instrument is not necessary. • Expanded coding with codelist: Press ⬇ **Code**. The code that was entered is searched for within the code list and it is possible to see, change and/or add attributes to the code. If a code is selected the field name will change to **Code**. To toggle through the codelist, change to page *4/4* for Black&White displays or to page **Code** for Color&Touch displays. • Quick coding: Press ⬇ **Q-Code** and enter the shortcut to the code. The code is selected and the measurement starts. The field name will change to **Code**:.
Hz	Horizontal direction to the point.
V	Vertical angle to the point.
◢	Horizontal distance to the point.
◢	Slope distance to the point.
◢	Height to the point.
East	Easting coordinate of the point.
North	Northing coordinate of the point.
Height	Height coordinate of the point.

6.2 Station Setup

6.2.1 Starting Station Setup

Description

Station Setup is a program used when setting up a station, to determine the station coordinates and station orientation. A maximum number of 10 known points can be used to determine the position and orientation.



P0 Instrument station
P1 Known point
P2 Known point
P3 Known point

Setup methods

The following setup methods are available:

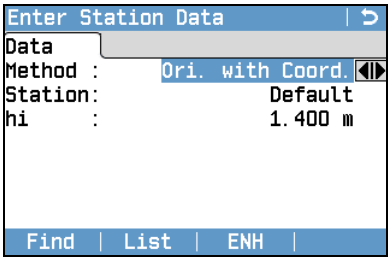
Setup method	Description
Orientation with Angle	The station is known. Aim at a target to set the orientation.
Orientation with Coordinates	The station and target coordinates are known. Aim at a target to set the orientation.
Height Transfer	The station is known, a new station height must be computed. Measure to one or more known targets to compute new height for the station.
Resection	The station is unknown. Measure to two or more target points to compute station coordinates and orientation. Scale setting is configurable.
Helmert Resection	The station is unknown. Measure to two or more target points to compute station coordinates and orientation. The measured angles and distances are adjusted, based on coordinates of a local and global system. A 2D Helmert transformation is used, with four (shift x, shift y, rotation and scale) or three (shift x, shift y, rotation) parameters, depending on the scale setting in the configuration. Points can be defined as 1D, 2D or 3D.
Local Resection	The station is unknown. Measure distances to two points: • To the origin (E = 0, N = 0, H = 0) of the coordinate system • To a point the North or East direction of the coordinate system Scale and standard deviation are not calculated.

Each setup method requires different input data and a different number of target points.

Access

1. Select **Programs** from the Main Menu.
2. Select **Station Setup** from the **Programs** Menu.
3. Select a job. Refer to "5.3 Setting the Job".
4. Select **F2 Settings**:
   - Set the standard deviation limits for the position, height, Hz orientation, and the Face I-II difference. For Local Resection, define the positive North or positive East axis. For Resection Helmert, set the distance weighting that is used in the calculation of the station height in the Resection.
     Set **Calc.new Scale**: **Yes** to calculate the scale for the setup methods Resection and Resection Helmert. The scale can then be set at the end of the Resection calculation. Measured distances are always reduced with the scale set on the instrument. To get a correct result from the scale calculation in Resection, the **Scale PPM** in the **EDM Settings** screen must be set to 0.
   - Press **Cont** to save the limits and return to the **Stn.Setup** screen.
5. Select **F4 Start** to begin the program.

Enter Station Data



1. Select the desired setup method.
2. Enter the station number or press **Find** or **List** to select an existing point. If the entered station number can not be found in the current job, then the **Point Search** screen appears. Select a different job to search or press **ENH** to enter the coordinates manually. **ENH** is only available for the methods Ori. with Angle, Ori. with Coord. and H-Trans.
3. For all methods except Ori. with Angle and Local Resection, press **Cont** to continue to the **Enter Target Point** screen.
   For the Ori. with Angle method, **Cont** continues to the **Manual Angle Setting** screen. Refer to "6.2.2 Measuring the target points", "Sight target point".
   For the Local Resection method, **Cont** continues to the **Meas. Pt1: Origin (0/0/0)** screen. The first point measured is the origin of the coordinate system. The second point measured is, depending on the setting, either the North or East direction of the coordinate system.
4. **Enter Target Point**: Enter the PtID of the target. Press **Cont** to search for the point in the current job. Select the desired point or enter new coordinates and continue to the **Sight target point!** screen. Refer to "6.2.2 Measuring the target points", "Sight target point".

Manual Angle Setting

Available for **Method**: **Ori. with Angle** only.
Enter the PtID and height of the target. Measure the Hz angle and repeat the measurement in the ohter face by pressing ⬇ **Face**. Press **Set** to set the new orientation. The station setup is complete.

Sight target point

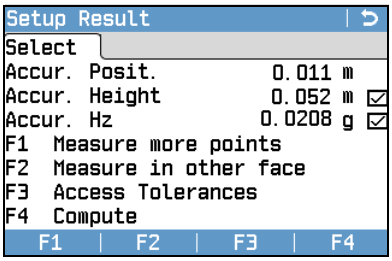
The remaining screens are available for all methods except Ori. with Angle and Local Resection.
In the **Sight target point!** screen:

2 / I: Indicates that the second point was measured in face I.

2 / I II: Indicates that the second point was measured in faces I and II.

Sight the target point and select **Meas**, or **Dist** and **Store** to measure to the target point.

Station Setup Result



F1 Measure more points
To return to the **Enter Target Point** screen to measure more points.

F2 Measure in other face
To measure the same target point in another face.

F3 Access Tolerances
To change the accuracy limit values.

F4 Compute
To calculate and display the station coordinates.

Description of symbols

Field	Description
✓	Standard deviation/value within the defined limit
x	Standard deviation/value exceeds the defined limit
---	No value calculated

Description of fields

Field	Description
Accur. Posit.	If the standard deviation for position in **East** and **North** is calculated, a checkbox is displayed. The checkbox is checked if the calculated position is within the standard deviation limits or crossed if it is not.
Accur. Height	If the standard deviation for **Height** is calculated, a checkbox is displayed. The checkbox is checked if the calculated **Height** is within the standard deviation limits or crossed if it is not.
Accur. Hz	If the standard deviation for the Hz Orientation angle is calculated, a checkbox is displayed. The checkbox is checked if the calculated Hz Orientation is within the standard deviation limits or crossed if it is not.

Computation procedure

The computation of the station position is done via the **Method** selected in **Enter Station Data**.
If more than the minimum required measurements are performed, the procedure uses a least squares adjustment to determine the 3D position and averages orientation and height measurements.

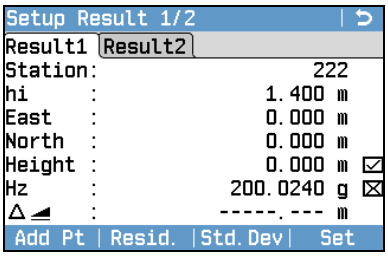
- The original averaged face I and face II measurements are used for the computation process.
- All measurements are treated with the same accuracy, whether these are measured in single or dual face.
- Easting and Northing are determined by the least squares method, which includes standard deviation and improvements for horizontal direction and horizontal distances.
- The final height (**H**) is computed from averaged height differences based on the original measurements. For the methods **Ori. with Coord.** and **H-Trans** the height can be selected from old, average and new.
- The horizontal direction is computed with the original averaged face I and face II measurements and the final computed plan position.

Access

Press **F4 Compute** in the **Station Setup Result** screen.

Station Setup Result

This screen displays calculated station coordinates. The final computed results depend on the **Method** selected in **Enter Station Data**.
Standard deviations and residuals for accuracy assessments are provided.



Add Pt
To return to the **Enter Target Point** screen to enter the next point.

Resid.
To display residuals and to define the use of points as 1D, 2D or 3D. Refer to "Target Residuals".

Std.Dev
To display the standard deviation of the station coordinates and orientation.

Set
To set the station coordinates and/or orientation.

☞ If the instrument height was set to 0.000 in the setup screen, then the station height refers to the height of the tilting axis.

Description of fields

Field	Description
Station	Current station ID.
hi	Current instrument height.
East	Calculated Easting coordinate of the station.
North	Calculated Northing coordinate of the station.
Height	Calculated Height coordinate of the station.
Hz	Current Hz angle with the new orientation.
Δ	Available for **Method**: **H-Trans** or **Ori. with Coord.** with only 1 target point. Difference between the calculated and measured horizontal distance from the station to the design target.

Field	Description
Scale	Available for **Method**: **Resection** and **Method**: **Res.Helm.**. The calculated scale, if available.
Apply Scale	**Yes** or **No**. Select **Yes** to use the calculated scale as the system PPM scale. This overwrites any PPM scale previously set in the EDM Settings screens. Select **No** to keep the existing PPM value in the system and not apply the calculated scale.

Target Residuals

The **Target Residuals** screen displays the computed residuals for the horizontal and vertical distances and the horizontal direction. Residual = Calculated value - Measured value.

Use indicates if and how a target point is used in the station calculation. Choices are **3D**, **2D**, **1D** and **Off**.

Description of fields

Field	Description
3D	Easting, Northing and Height coordinates are used for the calculation.
2D	Easting and Northing coordinates are used for the calculation.
1D	Only the height of the point is used for the calculation.
Off	The point is not used for the calculation.

Messages

The following are important messages or warnings that may appear.

Messages	Description
Selected point has invalid data! Check data and try again!	This message occurs if the selected target point has no Easting or Northing coordinate.
Max. 10 points supported!	10 points have already been measured and another point is selected. The system supports a maximum of 10 points.
No position computeddue to bad data!	The measurements may not allow final station coordinates (Eastings, Northings) to be computed.
No height computed due to bad data!	Either the target height is invalid or insufficient measurements are available to compute a final station height.
Face I/II mismatch!	This error occurs if a point was measured in one face and the measurement in the other face differs by more than the specified accuracy limit for the horizontal or vertical angle.
No data measured!Measure point again!	There is insufficient data measured to be able to compute a position or height. Either there are not enough points used or no distance measured.

Next step

Press **Set** to set the station coordinates and/or orientation and return to the **Programs** Menu.

☞

- If a target point is measured several times in the same face, only the last valid measurement is used for computation.
- For **Method**: **Resection**:
  - The prism used for face I and face II measurements must be the same.
  - If different codes for face I and II are used, then the code of face I is used. If only face II is measured with a code, then the code of face II is assigned to the point.

- XML output does not allow a change of the ppm value during Stn.Setup measurements.
- If the scale is calculated, then the standard deviation of the position with two targets is 0.0000. With flexible scale, the resection is fitted perfectly into the geometry without redundancy. Therefore the standard deviation is 0.000.

6.3 Surveying

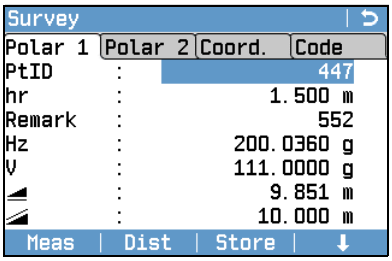
Description

Survey is a program used for the measurement of an unlimited number of points. It is comparable to **Q-Survey** from the Main Menu, but includes pre-settings for the job, station and orientation prior to beginning a survey.

Access

1. Select **Programs** from the Main Menu.
2. Select **Survey** from the **Programs** Menu.
3. Complete program pre-settings. Refer to "5 Programs - Getting Started".

Survey



⬇ Q-Code
To activate quick coding. Refer to "8.2 Quick Coding".

⬇ IndivPt
To switch between individual and current point numbers.

⬇ Manage
To view measurement data.

Description

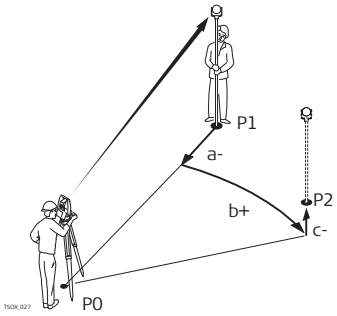
Stakeout is a program used to place marks in the field at predetermined points. These predetermined points are the points to be staked. The points to be staked may already exist in a job on the instrument, or be manually entered.

The program can continuously display differences, between current position and desired stake out position.

Stakeout modes

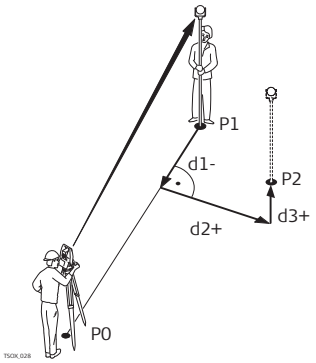
Points can be staked using different modes: Polar mode, Orthogonal to station mode and Cartesian mode.

Polar Stakeout mode



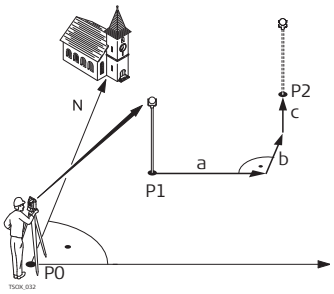
P0 Instrument station
P1 Current position
P2 Point to be staked
a- Δ: Difference in horizontal distance
b+ ΔHz: Difference in direction
c+ Δ: Difference in height

Orthogonal to Station Stakeout mode



P0 Instrument station
P1 Current position
P2 Point to be staked
d1- ΔLength: Difference in longitudinal distance
d2+ ΔTrav.: Difference in perpendicular distance
d3+ ΔHeight: Difference in height

Cartesian Stakeout mode



P0 Instrument station
P1 Current position
P2 Point to be staked
a ΔEast: Difference in Easting coordinate
b ΔNorth: Difference in Northing coordinate
c ΔHeight: Difference in height

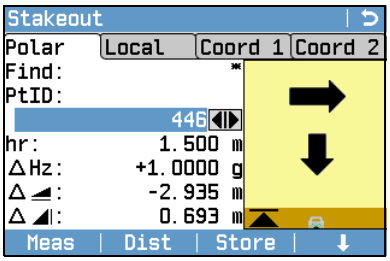
Access

1. Select **Programs** from the Main Menu.
2. Select **Stakeout** from the **Programs** Menu.
3. Complete program pre-settings. Refer to "5 Programs - Getting Started".

Stakeout Settings

Field	Description	
Pre-/Suffix	☞	Only used for the Stakeout program.
	Prefix	Adds the character entered for **Identifier** in front of the original point number of the point to be staked.
	Suffix	Adds the character entered for **Identifier** at the end of the original point number of the point to be staked.
	Off	The staked point is stored with the same point number as the point to be staked.
Identifier	☞	Only used for the Stakeout program.
	The identifier can be up to four characters and is added at the start, or end, of a point number of a point to be staked.	
Stakeout Beep	**On**	The instrument beeps when the distance from the current position to the point to be staked is ≤ 0.5 m. The closer the prism is to the point to be staked the faster the beeps will be.
	Off	Beep is deactivated.

Stakeout



⬇ B&Dist
To enter the direction and horizontal distance to a stake out point.

⬇ Manual
To manually enter coordinates of a point.

⬇ Survey
To switch to the Survey program. Press ESC to return to the **Stakeout** screen..

☞ Refer to "2.7 Graphic Symbols" for a description of the graphic elements.

Field	Description
Find	Value for Point ID search. After entry, the firmware searches for matching points, and displays these in **PtID**: If a matching point doesn't exist the pointsearch screen opens.
Pt Type/ID:	Displays the type of point selected. • **Fixpt.**, or • **Meas.**
ΔHz	Angle offset: Positive if stake out point is to the right of the measured point.
Δ	Horizontal offset: Positive if stake out point is further away than the measured point.
Δ	Height offset: Positive if stake out point is higher than the measured point.
ΔL	Longitudinal offset: Positive if stake out point is further away than the measured point.
ΔT	Perpendicular offset: Positive if stake out point is to the right of the measured point.
ΔH	Height offset: Positive if stake out point is higher than the measured point.
ΔE	Easting offset: Positive if stake out point is to the right of the measured point.
ΔN	Northing offset: Positive if stake out point is further away than the measured point

6.5 Reference Line

6.5.1 Overview

Description

Reference Line is a program that facilitates the easy stake out or checking of lines, for example, for buildings, sections of road, or simple excavations. It allows the user to define a reference line and then complete the following tasks with respect to that line:

- Line & offset
- Stake out points
- Grid stake out
- Line segmentation stake out

Access

1. Select **Programs** from the Main Menu.
2. Select **Ref.Line** from the **Programs** Menu.
3. Complete program pre-settings. Refer to "5 Programs - Getting Started".

Next step

Define the base line for the reference line.

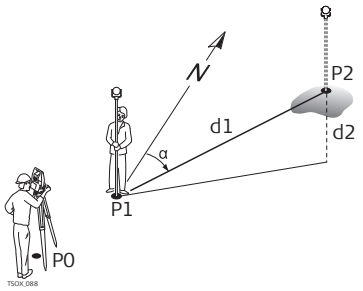
6.5.2 Defining the Base Line

Description

A reference line can be defined by referencing a known base line. The reference line can be offset either longitudinally, in parallel or vertically to the base line, or be rotated around the first base point as required. Furthermore the reference height can be selected as the first point, second point or interpolated along the reference line.

Define the base line

The base line is fixed by two base points. All points can be either measured, manually entered, or selected from the memory.



Base line
P0 Instrument station
P1 Start point
P2 End point
d1 Known distance
d2 Difference in height
α Azimuth

Define the base line by measuring or selecting the start and end points of the line.

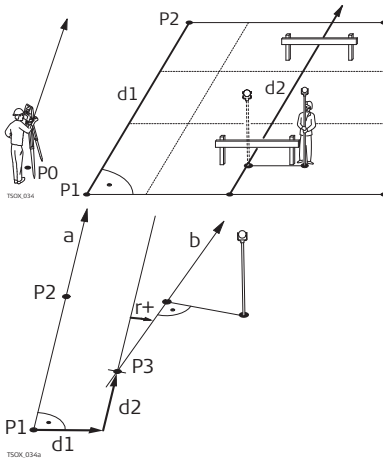
Next step

After defining the base line the **Reference Line** - **Info** screen will appear for defining the reference line.

6.5.3 Defining the Reference Line

Description

The base line can be offset from, either longitudinally, in parallel or vertically, or be rotated around the first base point. This new line created from the offsets is called the reference line. All measured data refers to the reference line.

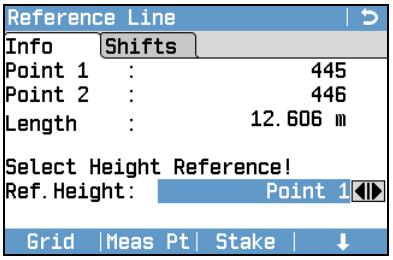


P0	Instrument station
P1	Start point
P2	End point
d1	Base line
d2	Reference line
P1	Base point
P2	Base point
a	Base line
d1	Parallel offset
d2	Longitudinal offset
P3	Reference point
r+	Rotation parameter
b	Reference line

Access

After completing the measurements required for defining the base line, the **Reference Line** - **Info** screen will appear.

Reference Line - Info



Grid
To stake out a grid relative to the reference line.

Meas Pt
To measure Line & Offset.

Stake
To stake out points orthogonal to the reference line.

⬇ NewBL
To define a new base line.

⬇ Shift=0
To reset all offset values to 0.

⬇ Segment
To subdivide a reference line into a definable number of segments and stake out the new points on the reference line.

Field	Description	
Length	Length of the base line.	
Ref. Height	**Point 1**	Height differences are computed relative to the height of the first reference point.
	Point 2	Height differences are computed relative to the height of the second reference point.
	Interpolated	Height differences are computed along the reference line.
	No Height	Height differences are not computed or shown.
Offset	Parallel offset of the reference line relative to the base line (P1-P2). Available on page 2/2 for Black&White display or on page **Shifts** for Color&Touch display. Positive values are to the right of the base line.	

Field	Description
Line	Longitudinal offset of the start point, reference point (P3), of the reference line in the direction of base point 2. Available on page 2/2 for Black&White display or on page **Shifts** for Color&Touch display. Positive values are towards base point 2.
Height	Height offset of the reference line to the selected reference height. Available on page 2/2 for Black&White display or on page **Shifts** for Color&Touch display. Positive values are higher than the selected reference height.
Rotate	Rotation of the reference line clockwise around the reference point (P3). Available on page 2/2 for Black&White display or on page **Shifts** for Color&Touch display.

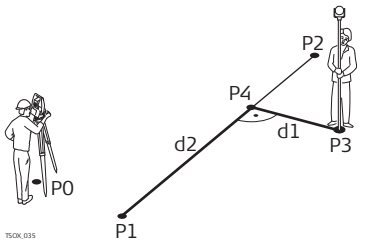
Next step

Select a softkey option, **Meas Pt**, **Stake**, **Grid** or ⬇ **Segment**, to proceed to a subprogram.

6.5.4 Measure Line & Offset

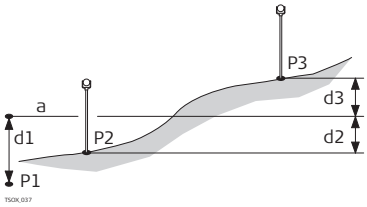
Description

The Measure Line & Offset subprogram calculates from measurements or coordinates, longitudinal offsets, parallel offsets and height differences of the target point relative to the reference line.



P0 Instrument station
P1 Start point
P2 End point
P3 Measured point
P4 Reference point
d1 Δ Offset
d2 Δ Line

Example of height difference relative to first reference point



P1 Start point
P2 Target point
P3 Target point
a Reference height
d1 Height difference between start point and the reference height
d2 Height difference between P2 and the reference height
d3 Height difference between P3 and the reference height

Access

Press **Meas** in the **Reference Line** - **Info** screen.

Measure line & offset

Field	Description
ΔL	Calculated distance longitudinal to the reference line.
ΔO	Calculated distance perpendicular from the reference line.
ΔH	Calculated height difference relative to the defined reference height.

Next step

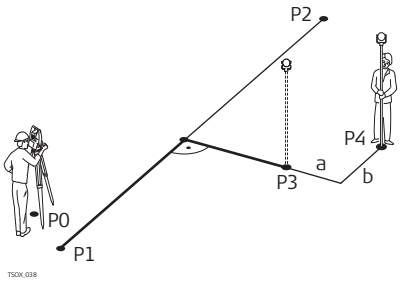
- Either, press **Meas** to measure and record.
- Or, press ⬇ **Back** to return to the **Reference Line** - **Info** screen.

6.5.5 Stakeout

Description

The stakeout subprogram calculates the difference between a measured point and the calculated point. The orthogonal (**ΔL**, **ΔO**, **ΔH**) and polar (**ΔHz**, Δ ◢, Δ ◢|) differences are displayed.

Example orthogonal stakeout



P0 Instrument station
P1 Start point
P2 End point
P3 Stake out point
P4 Measured point
a Δ Parallel offset
b Δ Longitudinal offset

Access

Press **Stake** from the **Reference Line** - **Info** screen.

Orthogonal stakeout

Enter the stake out elements for the target points to be staked out relative to the reference line.

Field	Description
Line	Longitudinal offset: Positive if stake out point is further away from the reference line.
Offs	Perpendicular offset: Positive if stake out point is to the right of the reference line.
Height	Height offset: Positive if stake out point is higher than the reference line.

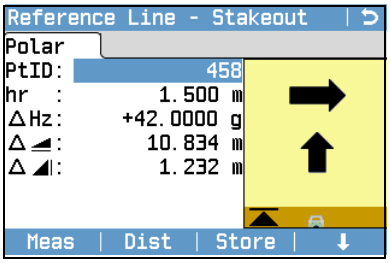
Next step

Press **Cont** to proceed to measurement mode.

Reference Line - Stakeout

The signs for the distance and angle differences are correction values (required minus actual). The arrows indicate the direction to move to get to the stake out point.

To allow a better visibility, for example if the line is very long and the target close to the line, the scale for x and y can be different in the graphic. If the instrument is far off the line, the instrument in the graphic is placed in the corner and marked red/grey.



Next Pt
To add the next point to be staked out.

Field	Description
ΔHz	Horizontal direction from the measured point to the stake out point. Positive if the telescope must be turned clockwise to the stake out point.
Δ ◢	Horizontal distance from the measured point to the stake out point. Positive if the stake out point is further away than the measured point.
Δ ◢|	Height difference from the measured point to the stake out point. Positive if the stake out point is higher than the measured point.

Next step

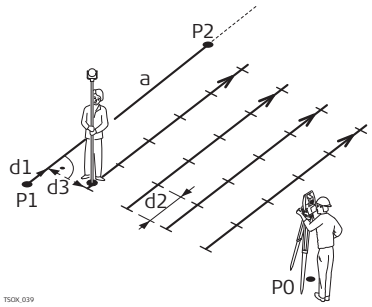
- Either, press **Meas** to measure and record.
- Or, press ⬇ **Back** to return to the **Reference Line** - **Info** screen.

6.5.6 Grid Stakeout

Description

The Grid subprogram calculates and displays the stake out elements for the points on the grid, orthogonal (**ΔL**, **ΔO**, **ΔH**) and polar (**ΔHz**, Δ ◢, Δ ◢‖). The grid is defined without boundaries. It can be extended over the first and second base points of the reference line.

Example Grid Stakeout



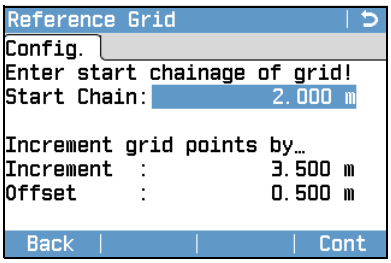
a	Reference line
P0	Instrument station
P1	Start point
P2	End point
d1	Start distance
d2	Increment
d3	Line offset

Access

Press **Grid** from the **Reference Line** - **Info** screen.

Grid definition

Enter the chainage and the increment of grid points in length and cross direction of the reference line.



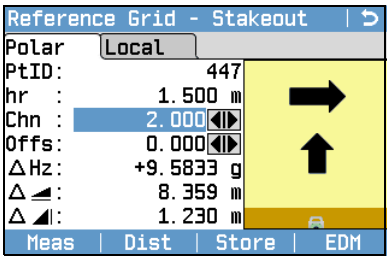
Field	Description
Start Chain	Distance from the reference line start point to the beginning grid start point.
Increment	Length of incrementation.
Offset	Offset distance from the reference line.

Next step

Press **Cont** to proceed to the **Reference Grid - Stakeout** screen.

Reference Grid - Stakeout

The signs for the distance and angle differences are correction values (required minus actual). The arrows indicate the direction to move to get to the stake out point.



Field	Description
Chn	The chainage of the grid stakeout point.
Offs	Offset increment values. The stake out point is to the right of the reference line.
ΔHz	Horizontal direction from the measured point to stake out point. Positive if the telescope must be turned clockwise to the stake out point.
Δ	Horizontal distance from the measured point to stake out point. Positive if the stake out point is further away than the measured point.
Δ	Height difference from the measured point to the stake out point. Positive if the stake out point is higher than the measured point.
Line	Grid increment values. The stake out point is in the direction from the first to the second reference point.
ΔL	Longitudinal distance from the measured point to the stake out point. Positive if stake out point is further away than the measured point.
ΔO	Perpendicular distance from the measured point to the stake out point. Positive if stake out point is to the right of the measured point.

Next step

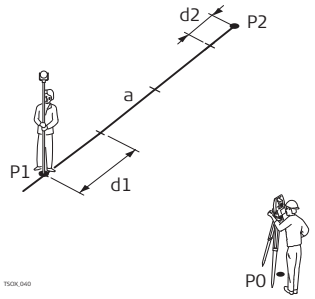
- Either, press **Meas** to measure and record.
- Or, press ESC to return to the **Enter start chainage of grid!** screen and from there, press **Back** to return to the **Reference Line** - **Info** screen.

6.5.7 Line Segmentation

Description

The line segmentation subprogram calculates and displays the stake out elements for the points along the line, orthogonal (**ΔL**, **ΔO**, **ΔH**) and polar (**ΔHz**, Δ ◢, Δ ◢). Line Segmentation is limited to the reference line, between the defined start and end points of the line.

Example Line Segmentation Stakeout



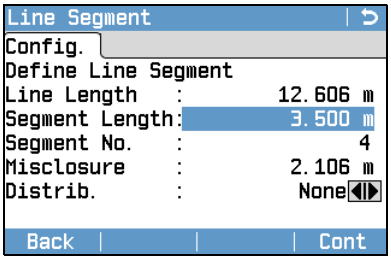
P0 Instrument station
P1 First reference point
P2 Second reference point
a Reference line
d1 Segment length
d2 Misclosure

Access

Press ⬇ **Segment** from the **Reference Line** - **Info** screen.

Segment Definition

Enter either the number of segments, or the length of segments and define how the remaining line length is treated. This misclosure can be placed at the start, at the end, at the start and the end or distributed evenly along the line.



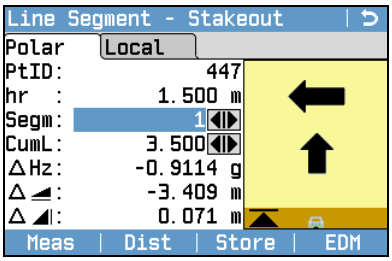
Field	Description	
Line Length	Calculated length of the defined reference line.	
Segment Length	Length of each segment. Updated automatically if the number of segments is entered.	
Segment No.	Number of segments. Updated automatically if the segment length is entered.	
Misclosure	Any remaining line length after segment length has been entered.	
Distrib.	Method of misclosure distribution.	
	None	All of the misclosure will be placed after the last segment.
	At start	All of the misclosure will be placed before the first segment.
	Equal	The misclosure will be equally distributed between all segments.
	StartEnd	The misclosure is equally distributed at the start and at the end of the segment line.

Next step

Press **Cont** to proceed to the **Line Segment - Stakeout** screen.

Line Segment - Stakeout

The signs for the distance and angle differences are correction values (required minus actual). The arrows indicate the direction to move to get to the stake out point.



Field	Description
Segm	Segment number. Includes the misclosure segment, if applicable.
CumL	Cumulation of the segment lengths. Changes with the current number of segments. Includes the misclosure segment length if applicable.
ΔHz	Horizontal direction from the measured point to the stake out point. Positive if the telescope must be turned clockwise to the stake out point.
Δ	Horizontal distance from the measured point to the stake out point. Positive if the stake out point is further away than the measured point.
Δ	Height difference from the measured point to the stake out point. Positive if the stake out point is higher than the measured point.
ΔL	Longitudinal distance from the measured point to the stake out point. Positive if stake out point is further away than the measured point.
ΔL	Perpendicular distance from the measured point to the stake out point. Positive if stake out point is to the right of the measured point.

Messages

The following are important messages or warnings that may appear.

Messages	Description
Baseline too short!	Base line is shorter than 1 cm. Choose base points such that the horizontal separation of both points is at least 1 cm.
Coordinates invalid!	No coordinates or invalid coordinates for a point. Ensure that points used have at least Easting and Northing coordinates.
Recording to interface!	**Data Output** is set to **Interface** in the **Data Settings** Menu. To be able to successfully start reference line, **Data Output** must be set to **Internal Memory**.

Next step

- Either, press **Meas** to measure and record.
- Or, press ESC to return to the **Define Line Segment** screen and from there, press **Back** to return to the **Reference Line** screen.
- Or, continue selecting ESC to exit the program.

6.6 Reference Arc

6.6.1 Overview

Description

The Reference Arc program allows the user to define a reference arc and then complete the following tasks with respect to the arc:

- Line & offset
- Stakeout (Point, Arc, Chord, Angle)

Access

1. Select **Programs** from the Main Menu.
2. Select **Ref.Arc** from the **Programs** Menu.
3. Complete program pre-settings. Refer to "5 Programs - Getting Started".

Next step

Define the reference arc.

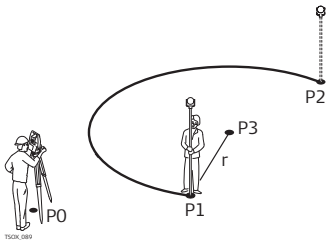
6.6.2 Defining the Reference Arc

Description

The reference arc can be defined by;

- a center point and start point,
- a start point, end point, and radius, or
- by three points.

All points can be either measured, manually entered, or selected from the memory.



Reference arc
P0 Instrument station
P1 Start point
P2 End point
P3 Center point
r Radius of arc

All arcs are defined in a clockwise direction and all calculations are made in two dimensions.

Access

Select **Ref.Arc** and then the method to define the arc by:

- **F1 Centre,Start Point**
- **F2 Start & End Pt,Radius**
- **F3 3 Points**

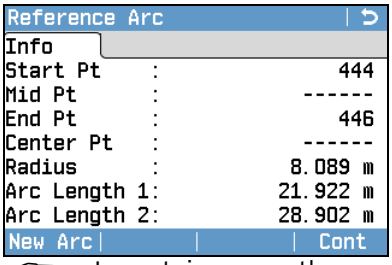
Reference Arc - Measure to start point

Field	Description
Start Pt	Point ID of the start point.
Centre Pt	Point ID of the center point.
Mid Pt	Point ID of the mid point.
End Pt	Point ID of the end point.
Radius	Radius of the arc.

Next step

After defining the reference arc the **Reference Arc** - **Info** screen will appear.

Reference Arc - Info



In certain cases, there are two mathematical solutions, as shown in the screen-shot. In the subprograms Measure and Stakeout, the appropriate solution can be selected.

Next step

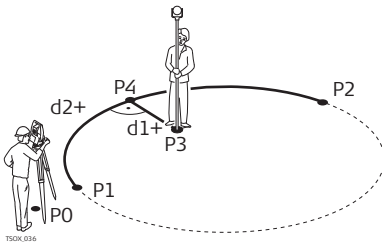
Select **Cont** and then **Meas Pt** or **Stake** to proceed to a subprogram.

6.6.3 Measure Line & Offset

Description

The Measure Line & Offset subprogram calculates from measurements or coordinates, longitudinal and orthogonal offsets and height differences of the target point relative to the reference arc.

Example reference arc - measure line & offset



P0 Instrument station
P1 Start point
P2 End point
P3 Measured point
P4 Reference point
d1+ Δ Offset
d2+ Δ Line

Access

Press **Meas** from the **Reference Arc** - **Info** screen.

Measure Line & Offset

Field	Description
ΔL	Calculated distance longitudinal to the reference arc.
ΔO	Calculated distance perpendicular from the reference arc.
ΔH	Calculated height difference relative to the start point of reference arc.

Next step

- Either, press **Meas** to measure and record.
- Or, press ⬇ **Back** to return to the **Reference Arc** - **Info** screen.

6.6.4 Stakeout

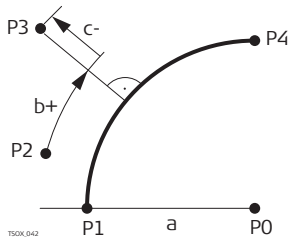
Description

The Stakeout subapplication calculates the difference between a measured point and the calculated point. The Reference Arc program supports four ways to stake out:

- Stake out point
- Stake out arc
- Stake out chord
- Stake out angle

Stake out point

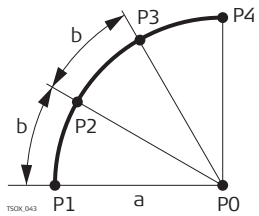
To stake out a point by entering a line and an offset value.



P0 Center point of arc
P1 Start point of arc
P2 Measured point
P3 Stake out point
P4 End point of arc
a Radius of arc
b+ Line offset
c- Perpendicular offset

Stake out arc

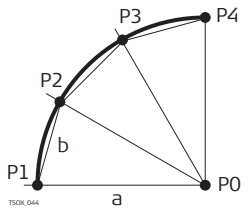
To stake out a series of equidistant points along the arc.



P0 Center point of arc
P1 Start point of arc
P2 Stake out point
P3 Stake out point
P4 End point of arc
a Radius of arc
b Arc length

Stake out chord

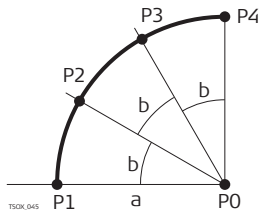
To stake out a series of equidistant chords along the arc.



P0 Center point of arc
P1 Start point of arc
P2 Stake out point
P3 Stake out point
P4 End point of arc
a Radius of arc
b Chord length

Stake out angle

To stake out a series of points along the arc defined by the angle segments from the center point of the arc.



P0 Center point of arc
P1 Start point of arc
P2 Stake out point
P3 Stake out point
P4 End point of arc
a Radius of arc
b Angle

Access

1) Press **Stake** from the **Reference Arc** - **Info** screen.
2) Select one of the four methods of stake out available.

Stake out point, arc, chord or angle

Enter the stake out values. Press **CentreP** to stake the arc centre point.

Field	Description
Line	For stake out arc, chord and angle: Longitudinal offset from the reference arc. This is calculated by the arc length, chord length or angle and the selected misclosure distribution. For stake out point: Longitudinal offset from the reference arc.
Offset	Perpendicular offset from the reference arc.
Distrib.	For stakeout arc: Method of misclosure distribution. If the entered arc length is not an integer of the whole arc, there will be a misclosure. **None** All of the misclosure will be added to the last arc-section. **Equal** The misclosure will be equally distributed between all sections. **Start Arc** All of the misclosure will be added to the first arc-section. **Start & End** The misclosure will be added half to the first arc-section and half to the last arc-section.
Arc Length	For stakeout arc: The length of the arc-segment to stake out.
Chord Length	For stakeout chord: The length of the chord to stake out.
Angle	For stake out angle: The angle around the center point of the arc, of the points to be staked out.

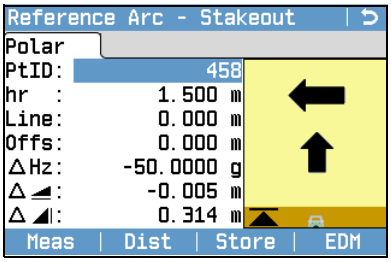
Next step

Press **Cont** to proceed to measurement mode.

Reference Arc - Stakeout

The signs for the distance and angle differences are correction values (required minus actual). The arrows indicate the direction to move to get to the stake out point.

To allow a better visibility, for example if the arc is very long and the target close to the line, the scale for x and y can be different in the graphic. If the instrument is far off the arc, the instrument in the graphic is placed in the corner and marked red/grey.



To define the next point to be staked out, type in a point ID, the reflector height, the distance along the arc and an offset.

Field	Description
ΔHz	Horizontal direction from the measured point to the stake out point. Positive if the telescope must be turned clockwise to the stake out point.
Δ◢	Horizontal distance from the measured point to the stake out point. Positive if the stake out point is further away than the measured point.
Δ◢|	Height difference from the measured point to the stake out point. Positive if the stake out point is higher than the measured point.

Next step

- Either, press ⬇ **Meas** to measure and record.
- Or, press ⬇ **Back** to return to the **Reference Arc** - **Info** screen.
- Or, continue selecting ESC to exit the program.

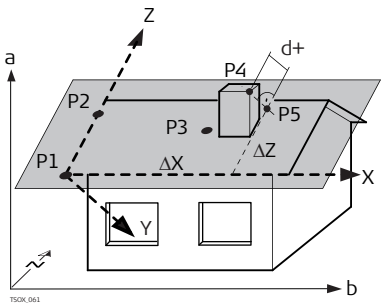
Description

Reference Plane is a program used to measure points relative to a reference plane. It can be used for the following tasks:

- Measuring a point to calculate and store the perpendicular offset to the plane.
- Calculating the perpendicular distance from the intersection point to the local X- and Z-axis. The intersection point is the footprint point of the perpendicular vector from the measured point through the defined plane.
- Viewing, storing and staking out the coordinates of the intersection point.

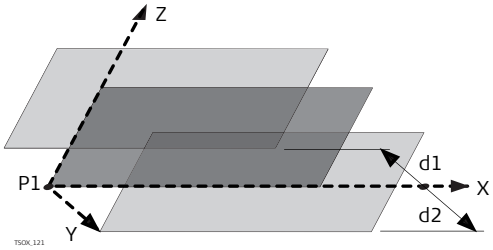
A reference plane is created by measuring three points on a plane. These three points define a local coordinate system:

- The first point is the origin of a local coordinate system.
- The second point defines the direction of the local Z-axis.
- The third point defines the plane.



X X-axis of local coordinate system.
Y Y-axis of local coordinate system.
Z Z-axis of local coordinate system.
P1 First point, origin of local coordinate system.
P2 Second point
P3 Third point
P4 Measured point. This point is probably not located on the plane.
P5 Intersection point of the perpendicular vector from P4 to the defined plane. This point is definitely located on the defined plane.
d+ Perpendicular distance from P4 to the plane.
ΔX Perpendicular distance from P5 to the local Z-axis.
ΔZ Perpendicular distance from P5 to the local X-axis.

The perpendicular distance to the plane can be positive or negative.



P1 Origin of plane
X X-axis of plane
Y Y-axis of plane
Z Z-axis of plane
d1 Positive offset
d2 Negative offset

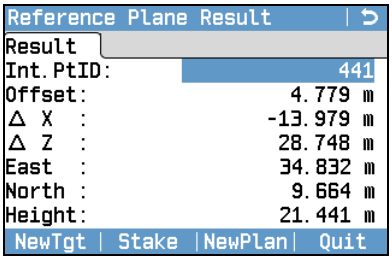
Access

1. Select **Programs** from the Main Menu.
2. Select **Ref.Plane** from the **Programs** Menu.
3. Complete program pre-settings. Refer to "5 Programs - Getting Started".

Measure plane and target points

1. Once the plane has been defined by three points, the **Measure target point!** screen appears.
2. Measure and record the target point. The results are displayed in the **Reference Plane Result** screen.

Reference Plane Result



NewTgt
To record and save the intersection point and to proceed to measure a new target point.

Stake
To display stake out values and a graphic for the intersection point. Refer to "2.7 Graphic Symbols" for an explanation of the graphic symbols.

NewPlan
To define a new reference plane.

Field	Description
Int.PtID	Point ID of the intersection point, the perpendicular projection of the target point on the plane.
Offset	Calculated perpendicular distance between target point and plane (intersection point).
Δ X	Perpendicular distance from the intersection point to the local Z-axis.
Δ Z	Perpendicular distance from the intersection point to the local X-axis.
East	Easting coordinate of the intersection point.
North	Northing coordinate of the intersection point.
Height	Height of the intersection point.

6.8 Tie Distance

Description

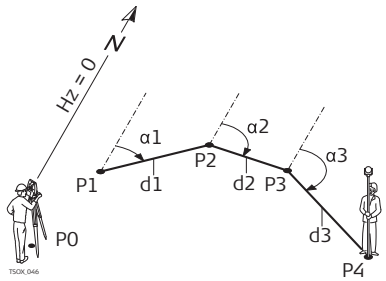
Tie Distance is a program used to compute slope distance, horizontal distance, height difference and azimuth of two target points which are either measured, selected from the memory, or entered using the keypad.

Tie distance methods

The user can choose between two different methods:

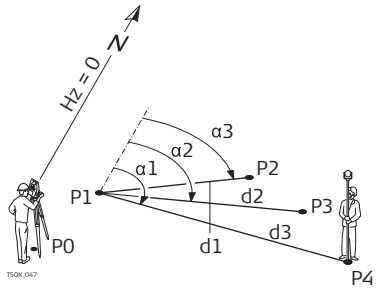
- **F1 Polygonal**: P1-P2, P2-P3, P3-P4.
- **F2 Radial**: P1-P2, P1-P3, P1-P4.

Polygonal method



P0 Instrument station
P1-P4 Target points
d1 Distance from P1-P2
d2 Distance from P2-P3
d3 Distance from P3-P4
α1 Azimuth from P1-P2
α2 Azimuth from P2-P3
α3 Azimuth from P3-P4

Radial method



P0 Instrument station
P1-P4 Target points
d1 Distance from P1-P2
d2 Distance from P1-P3
d3 Distance from P1-P4
α1 Azimuth from P1-P4
α2 Azimuth from P1-P3
α3 Azimuth from P1-P2

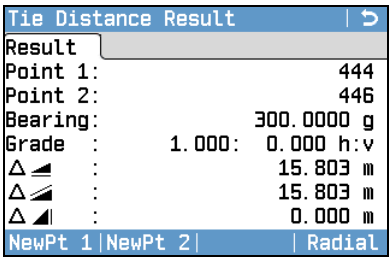
Access

1. Select **Programs** from the Main Menu.
2. Select **Tie Dist.** from the **Programs** Menu.
3. Complete program pre-settings. Refer to "5 Programs - Getting Started".
4. Select **F1 Polygonal** or **F2 Radial**.

Tie distance measurements

After completing the measurements required, the **Tie Distance Result** screen will appear.

Tie Distance Result - Polygonal method



NewPt 1
To calculate an additional line. The program starts again at point 1.

NewPt 2
To set point 2 as the starting point of a new line. A new point 2 must be measured.

Radial
To switch to radial method.

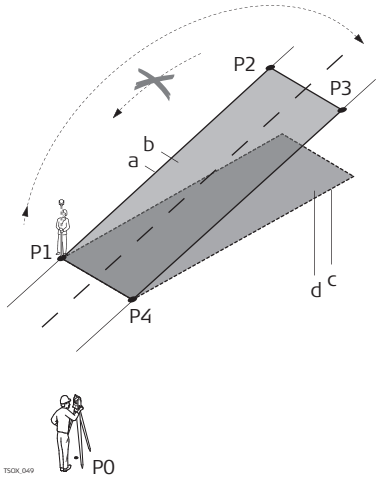
Field	Description
Bearing	Azimuth between point 1 and point 2.
Grade	Grade between point 1 and point 2.
Δ	Slope distance between point 1 and point 2.
Δ	Horizontal distance between point 1 and point 2.
Δ	Height difference between point 1 and point 2.

Next step

Press ESC to exit the program.

Description

Area & DTM Volume is a program used to compute online areas to a maximum of 50 points connected by straights. The target points have to be measured, selected from memory, or entered via the keypad in a clockwise direction. The calculated area is projected onto the horizontal plane (2D) or projected onto the sloped reference plane defined by three points (3D). Furthermore a volume can be computed by automatically creating a digital terrain model (DTM).



- P0 Instrument station
- P1 Target point which defines the sloped reference plane
- P2 Target point which defines the sloped reference plane
- P3 Target point which defines the sloped reference plane
- P4 Target point
- a Perimeter (3D), polygonal length from the start point to the current measured point of the area (3D)
- b Area (3D), projected onto the sloped reference plane
- c Perimeter (2D), polygonal length from the start point to the current measured point of the area (2D)
- d Area (2D), projected onto the horizontal plane

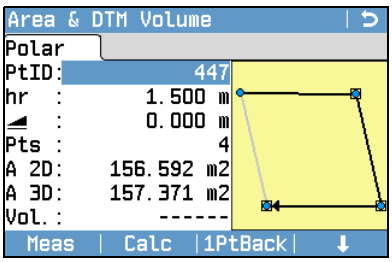
Access

1. Select **Programs** from the Main Menu.
2. Select **Area&Vol.** from the **Programs** Menu.
3. Complete program pre-settings. Refer to "5 Programs - Getting Started".

Area & DTM Volume

The graphic always shows the area projected onto the reference plane. The points used for defining the reference plane are indicated by:

- ◦ for measured points.
- ▲ for manually entered points.
- □ for points defining the reference plane.



Calc
To display and record additional results (perimeter, volume).

1PtBack
To undo measurement or selection of the previous point.

⬇ Volume
To measure or select points on the breakline. These points are then used to calculate a volume.

⬇ Def. 3D
To manually define the sloped reference plane by selecting or measuring three points.

☞ The breakline points must be located within the boundary of the defined area.

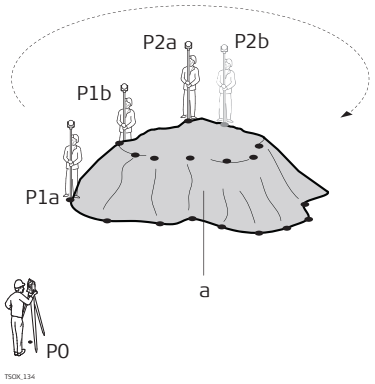
Area calculation

The 2D and 3D areas are calculated automatically and displayed once three points have been measured or selected. The 3D area is calculated automatically based on the following;

- The system will use the three points which cover the largest area.
- If there are two or more equal largest areas, the system will use the area with the shortest perimeter.
- If the largest areas have equal perimeters, the system will use the area with the last measured point.

A reference plane for the 3D area calculation can be manually defined by selecting **Def. 3D**.

Graphical representation

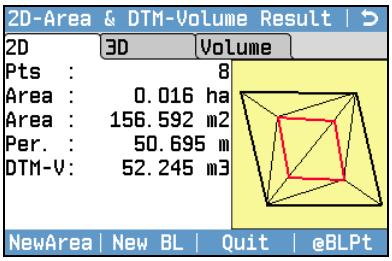


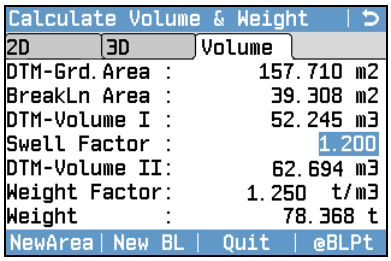
P0	Instrument station
P1a..	Boundary point
P2a..	Breakline point
a	Volume as calculated by the triangulated irregular network (TIN)

Next step

Press **Calc** to calculate area and volume and proceed to the **2D-Area & DTM-Volume Result** / **3D-Area & DTM-Volume Result** screens.

2D-Area & DTM-Volume Result





Field	Description
Area (2D)	Area calculated by projection onto a horizontal plane.
Area (3D)	Area calculated by projection onto an automatically or manually defined reference plane.
DTM-Grd.Area	Area defined by ground points, calculated by triangulated irregular network (TIN).
BreakLn Area	Area defined by breakline points, calculated by TIN.
DTM-Volume I	Volume as calculated by TIN.
Swell Factor	Factor that gives the relationship between the volume of a material as found in nature, to the volume of the same material after excavation. Refer to the table "Swell Factor" for more information on swell factors.
DTM-Volume II	Volume of the material after excavation from its original location. **DTM-Volume II** = **DTM-Volume I** x **Swell Factor**.
Weight Factor	Weight in tons per m^3 of material. Editable field.
Weight	Total weight of material after being excavated. **Weight** = **DTM-Volume II** x **Weight Factor**.

Swell Factor

According to DIN18300, the following soil classes have the given swell factors.

Soil class	Description	Swell Factor
1	Topsoil containing unorganic material, as well as humus or organic animals.	1.10 - 1.37
2	Fluent soil types of fluid to semi-fluid consistency.	n/a
3	Easily degradable soil types. Cohesionless to hardly cohesive sands.	1.06 - 1.32
4	Moderately degradable soil types. Mixture of sand, silt and clay.	1.05 - 1.45
5	Hard to degrade soil types. Same soil types as classes 3 and 4, but with a greater ratio of stones bigger than 63mm and between 0.01 m^3 to 0.1 m^3 in volume.	1.19 - 1.59
6	Rock types that have an inner mineral cohesiveness, however are fragmented, slaty, soft or weathered.	1.25 - 1.75
7	Hard to degrade rock types with a strong inner mineral cohesiveness and minimal fragmenting or weathering.	1.30 - 2.00

Swell factor examples: The values given are approximate only. Values may be different depending on various soil factors.

Soil type	Swell factor	Weight per cubic metre
Silt	1.15 - 1.25	2.1 t
Sand	1.20 - 1.40	1.5 - 1.8 t
Clay	1.20 - 1.50	2.1 t
Topsoil, humus	1.25	1.5 - 1.7 t
Sandstone	1.35 - 1.60	2.6 t
Granite	1.35 - 1.60	2.8 t

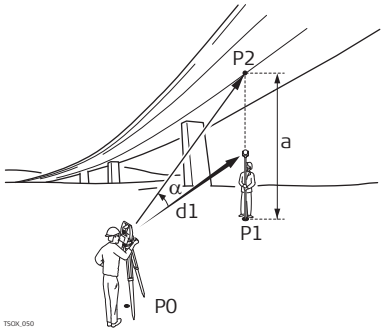
Next step

- Press **NewArea** to define a new area.
- Press **New BL** to define a new breakline area and calculate a new volume.
- Press **@BLPt** to add a new point to the existing breakline area and calculate a new volume.
- Or, press **Quit** to exit the program.

6.10 Remote Height

Description

Remote Height is a program used to compute points directly above the base prism without a prism at the target point.



P0 Instrument station
P1 Base point
P2 Remote point
d1 Slope distance
a Height difference from P1 to P2
α Vertical angle between base point and remote point

Access

1. Select **Programs** from the Main Menu.
2. Select **Remote Ht** from the **Programs** Menu.
3. Complete program pre-settings. Refer to "5 Programs - Getting Started".

Remote height measurement

Measure to the base point or press **hr=?** to determine an unknown target height.

Next step

After measuring, the **Aim at remote point!** screen appears.

Remote Height - Result - Aim at remote point!

Aim the instrument at the inaccessible remote point.

Field	Description
Δ ◢	Height difference between the base point and the remote point.
Height	Height of the remote point.
East	Calculated Easting coordinate for the remote point.
North	Calculated Northing coordinate for the remote point.
ΔEast	Calculated difference in Easting coordinate between the base point and the remote point.
ΔNorth	Calculated difference in Northing coordinate between the base point and the remote point.
ΔHeight	Calculated difference in Height between the base point and the remote point.

Next step

- Either, press **Cont** to save the measurement and record the calculated coordinates of the remote point.
- Or, press **Base** to enter and measure a new base point.
- Or, press ESC to exit the program.

6.11 COGO

6.11.1 Starting COGO

Description

COGO is a program used to perform coordinate geometry calculations such as, coordinates of points, bearings between points and distances between points. The COGO calculation methods are:

- Inverse and Traverse
- Intersections
- Offset
- Extension

Access

1. Select **Programs** from the Main Menu.
2. Select **COGO** from the **Programs** Menu.
3. Complete program pre-settings. Refer to "5 Programs - Getting Started".
4. Select a COGO subprogram from the **COGO** Main Menu.

Graphics

In the Results screen, press **Stake** to access the Stakeout graphic.
Or, in the Results screen, change to the second page for a simple graphic. Refer to "2.7 Graphic Symbols" for a description of the graphic symbols.

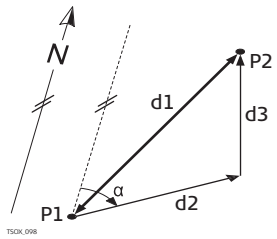
6.11.2 Inverse and Traverse

Access

Select **Inverse** or **Traverse** from the **COGO** Main Menu.

Inverse

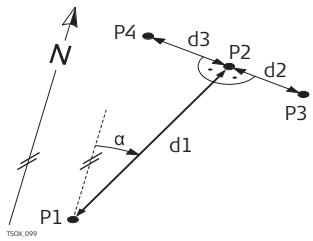
Use the **Inverse** subprogram to calculate the distance, direction, height difference and grade between two known points.



Known
P1 First known point
P2 Second known point
Unknown
α Direction from P1 to P2
d1 Slope distance between P1 and P2
d2 Horizontal distance between P1 and P2
d3 Height difference between P1 and P2

Traverse

Use the **Traverse** subprogram to calculate the position of a new point using the bearing and the distance from a known point. Offset optional.



Known
P1 Known point
α Direction from P1 to P2
d1 Distance between P1 and P2
d2 Positive offset to the right
d3 Negative offset to the left
Unknown
P2 COGO point without offset
P3 COGO point with positive offset
P4 COGO point with negative offset

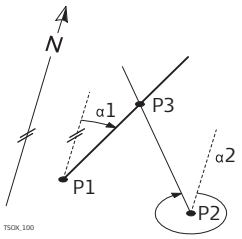
Access

Select the desired COGO subapplication from the **COGO** Main Menu:

- **Brg-Brg**
- **Brg-Dst**
- **Dst-Dst**
- **4 Point**

Bearing - Bearing

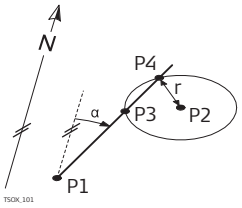
Use the Bearing - Bearing subprogram to calculate the intersection point of two lines. A line is defined by a point and a direction.



Known
P1 First known point
P2 Second known point
α1 Direction from P1 to P3
α2 Direction from P2 to P3
Unknown
P3 COGO point

Bearing - Bearing

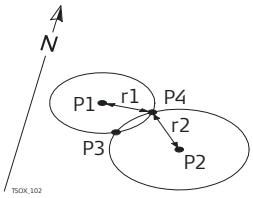
Use the **Bearing - Bearing** subprogram to calculate the intersection point of a line and a circle. The line is defined by a point and a direction. The circle is defined by the center point and the radius.



Known
P1 First known point
P2 Second known point
α Direction from P1 to P3 and P4
r Radius, as the distance from P2 to P4 or P3
Unknown
P3 First COGO point
P4 Second COGO point

Distance - Distance

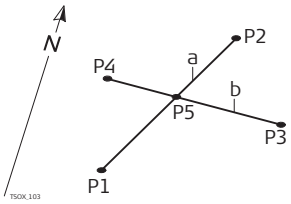
Use the **Distance - Distance** subprogram to calculate the intersection point of two circles. The circles are defined by the known point as the center point and the distance from the known point to the COGO point as the radius.



Known
P1 First known point
P2 Second known point
r1 Radius, as the distance from P1 to P3 or P4
r2 Radius, as the distance from P2 to P3 or P4
Unknown
P3 First COGO point
P4 Second COGO point

4 Point

Use the **4 Point** subprogram to calculate the intersection point of two lines. A line is defined by two points.
To add a shift for the lines, change to page 2/2 for Black&White display or page **Shifts** for Color&Touch display. + indicates a shift to the right. - indicates a shift to the left.



Known
P1 First known point
P2 Second known point
P3 Third known point
P4 Fourth known point
a Line from P1 to P2
b Line from P3 to P4
Unknown
P5 COGO point

6.11.4 Offsets

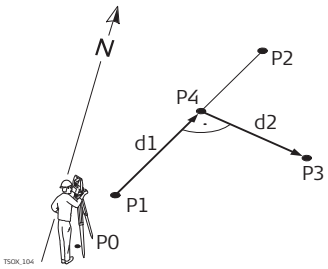
Access

Select the desired COGO subapplication from the **COGO** Main Menu:

- **DistOff**
- **Set Pt**
- **Plane**

Distance Offset

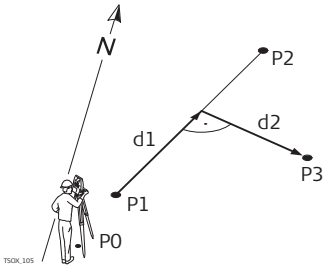
Use the **Distance Offset** subprogram to calculate the distance and offset of a known point, with the basepoint in relation to a line.



Known
P0 Instrument station
P1 Start point
P2 End point
P3 Offset point
Unknown
d1 Δ Line
d2 Δ Offset
P4 COGO (base) point

Set Point by Distance Offset

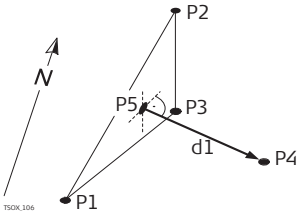
Use the **Set Point by Distance Offset** subprogram to calculate the coordinates of a new point in relation to a line from known longitudinal and offset distances.



Known
P0 Instrument station
P1 Start point
P2 End point
d1 Δ Line
d2 Δ Offset
Unknown
P3 COGO point

Plane Offset

Use the **Plane Offset** subprogram to calculate the coordinates of a new point and its height and offset, in relation to a known plane and offset point.



Known
P1 Point 1 which defines plane
P2 Point 2 which defines plane
P3 Point 3 which defines plane
P4 Offset point
Unknown
P5 COGO (intersection) point
d1 Offset

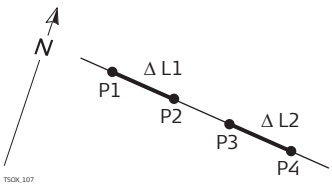
6.11.5 Line - Extension

Access

Select **Line - Extension** from the **COGO** Main Menu.

Line - Extension

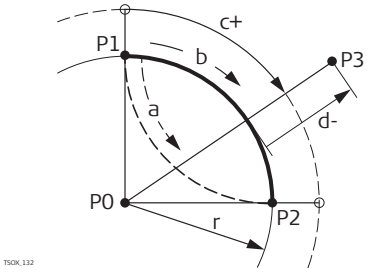
Use the **Line - Extension** subprogram to calculate the extended point from a known base line.



Known
P1 Baseline start point
P3 Baseline end point
ΔL1, ΔL2Distance
Unknown
P2, P4 Extended COGO points

Description

Road 2D is a program used to measure or stake out points relative to a defined element. The element can be a line, curve or spiral. Chainage, incremental stake outs and offsets (left and right) are supported.

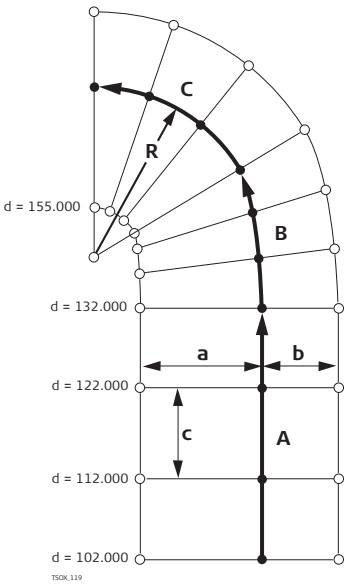


P0 Center point
P1 Start point of arc
P2 End point of arc
P3 Point to stake
a Anti-clockwise
b Clockwise
c+ Distance from start of arc, following curve
d- Perpendicular offset from arc
r Radius of arc

Access

1. Select **Programs** from the Main Menu.
2. Select **Road 2D** from the **Programs** Menu.
3. Complete program pre-settings. Refer to "5 Programs - Getting Started".
4. Select the element type:
   - Straight
   - Curve
   - Spiral

Elements

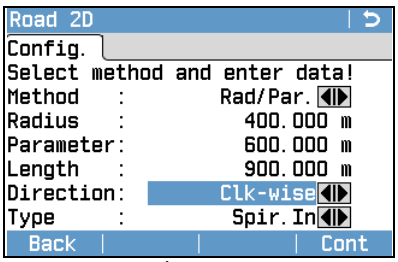


A Straight
B Spiral
C Curve
R Radius

a Perpendicular offset left
b Perpendicular offset right
c Increment
d Chainage

Define the element step-by-step

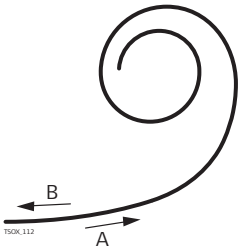
1. Enter, measure or select from memory the start and end points.
2. For curve and spiral elements the **Road 2D** screen for defining the element appears.



3. For a curve element:
   - Enter the radius and curve direction.
   - Press **Cont**.

   For a spiral element:
   - Select the method to be used, **Rad/Par.** or **Rad/Len.**.

- Enter the radius and parameter, or radius and length, depending on the method chosen.
- Select the type and direction of the spiral.
- Press **Cont**.



Spiral type
A Spiral in
B Spiral out

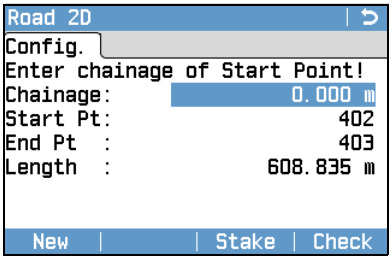
4. When the element has been defined the **Road 2D** - **Config.** appears.

Chainage and method

Enter the chainage values and press:

- **Stake**: to select the point and offset (center, left or right), to stake out and start the measurement. The correction from actual point to stake out point is shown on the display.
- **Check**: to measure, or select points from memory, to calculate the chainage, line and offset from the defined element.

Enter stakeout values



Next step

- If in stakeout mode, press **Cont** to begin staking out.
- Or, if in measurement mode, press **Meas** to measure and record.

6.13 Road 3D

6.13.1 Starting Road 3D

Description

Road 3D is a program used to stake out points or for as-built checks relative to a road alignment, including slopes. It supports the following features:

- Horizontal alignments with the elements straight, curve, and spiral (entry and exit as well as partial).
- Vertical alignments with the elements straight, curve and quadratic parabola.
- Upload of horizontal and vertical alignments which are in gsi data format of FlexOffice Road Line Editor.
- Creation, view and deletion of alignments onboard.
- Use of design height of vertical alignments or manually entered heights.
- Log file via Format manager of FlexOffice.

Road 3D methods

Road 3D has the following subprograms:

- Subprogram Check
- Subprogram Stake
- Subprogram Check Slope
- Subprogram Stake Slope

The program can be trialled 15 times. After 15 trials, it is necessary to enter the licence code.

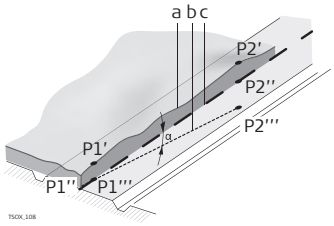
Road 3D step-by-step

1. Create or upload road alignments.
2. Select horizontal and/or vertical alignment files.
3. Define stake/check/slope parameter.
4. Select one of the Road 3D subprograms.

- The alignment file data has to be in the same data structure as FlexOffice Road Line Editor. These gsi files have unique identifiers for each element which are used by the program.
- The alignments must be continuous because geometrical gaps and chainage equations are not supported.
- The file name for the horizontal alignment file must have the prefix ALN, for example, ALN_HZ_Axis_01.gsi. The file name for the vertical alignment files must have the prefix PRF, for example PRF_VT_Axis_01.gsi. File names can be 16 characters long.
- The uploaded or created road alignments are permanent and stored even if the program is closed.
- Road alignments can be deleted onboard or via FlexOffice Data Exchange Manager.
- Road alignments cannot be edited onboard. This needs to be done via FlexOffice Road Line Editor.

Elements of a road project

Road projects consist, in general, of a horizontal and a vertical alignment.



Any project point P1 has E, N and H coordinates in a determined coordinate system and has three positions.

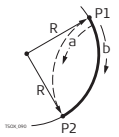
- P1' Position on natural surface
- P1'' Position on vertical alignment
- P1''' Position on horizontal alignment

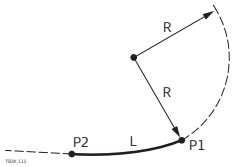
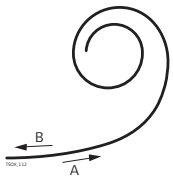
With a second point P2 the alignment is defined.

- P1' P2'
  Projection of the alignment onto the natural surface.
- P1'' P2''
  Vertical alignment
- P1''' P2'''
  Horizontal alignment
- α Grade angle between the vertical and horizontal alignment.
- a Natural surface
- b Horizontal alignment
- c Vertical alignment

Horizontal geometry elements

For onboard input Road 3D supports the following elements for horizontal alignments.

Element	Description
Straight	A straight has to be defined by: • Start point (P1) and end point (P2) with known Easting and Northing coordinates.  P1 Start point P2 End point
Curve	A circular curve has to be defined by: • Start point (P1) and end point (P2) with known Easting and Northing coordinates. • Radius (R). • Direction: Clockwise (b) or Anticlockwise (a).  P1 Start point P2 End point R Radius a Anticlockwise direction b Clockwise direction
Spiral / Clothoid	A spiral is a transition curve whose radius changes along its length. A spiral has to be defined by: • Start point (P1) and end point (P2) with known Easting and Northing coordinates. • Radius at the start of the spiral (R). • Spiral parameter ($A = \sqrt{L \cdot R}$) or length (L) of the spiral. • Direction: Clockwise or Anticlockwise. • Spiral type: Spiral in or Spiral out.

Element	Description
	 P1 Start point P2 End point R Radius L Length
Spiral types	• Entry spiral (Spiral in = A): Spiral with a radius of infinity at the start and a given radius at the end. • Exit spiral (Spiral out = B): Spiral with a given radius at the start and radius of infinity at the end. • Partial/Ovoid spiral: A spiral with a given radius at the start and another given radius at the end.  A Entry spiral B Exit spiral