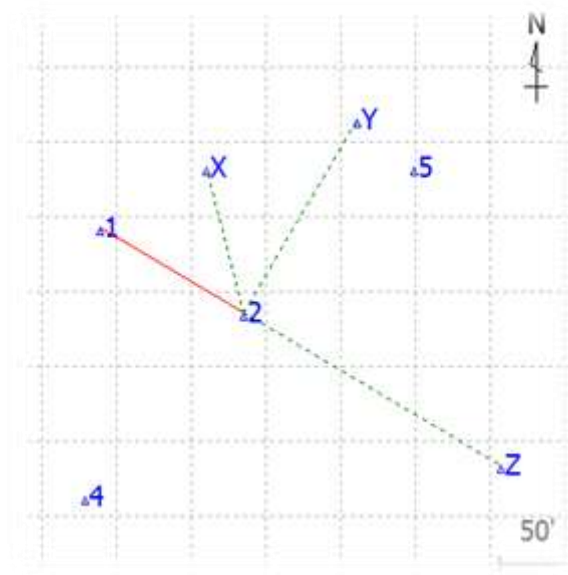


# G-COGO™ v1.0



## GEOMATICS COORDINATE GEOMETRY UTILITY Getting Started Guide

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Gainesville, FL 32605  
Phone: (352) 226-9564  
info@Geomatics.us  
www.geomatics.us

## Definition

G1-LoTUS™ GNSS System is a real-time differential positioning and navigation system utilizing the widely available correction services from Continuously Operating Reference Stations (CORS) across the world to yield cm-level positional accuracy.

## Purpose

This guide covers how to utilize coordinate geometry (COGO) techniques for the **G1-LoTUS™ GNSS System** to precisely survey and stakeout points using GPS

## Audience

This guide is intended for G1-LoTUS™ system users. Basic knowledge of GPS, GIS, and surveying and mapping terminology is presumed.

# 1. G-COGO™ Software

The G-COGO software module can run as stand-alone application or invoked as an embedded module from the G1-LoTUS Field software.

## 1.1 G-COGO™ Interface Structure

The G-COGO software package is a collection of independent modules each of which tackles a specific COGO problem. Each module has its independent tab of the application main dialog.

- ① *all G-COGO modules are connected to each other through the waypoint database file used and displayed in the main dialog title bar. They, however, do not interact directly among themselves.*

**COGO Info for WPTs in: c:\iG\Data\test.wpt** Title Bar

iG Selection WayPoints Main Menu

WayPTS LINEINVERSE POLYGON TWO LINE INT ELEV SHOTS SIDE SHOTS ← Tabs

Line	From	To	Azimuth	Range	Elevation
1	1	2	120° 41' 13.36"	111.610'	0° 29' 45.21"
2	3	4	104° 03' 11.71"	82.508'	5° 19' 21.60"

Input (Bold) → Field → Output (Regular) → Line Inverse Info → Solution

Active Module

XPoint	XAngle	N	E	U
P	16° 38' 1.65" 163° 21' 58.35"	262377.585'	2674920.929'	151.527'

Intersection of Two pre-defined Lines  
 - use the Top Grid to specify id's of the two line end stations.  
 - the Main Grid contains read-only intersection point information.

Instructions

Execution Panel: Enter, SHOW NEW POINTS ON MAP

To use the G-COGO utility, you must load a waypoint database from a “.wpt” file. The waypoint file is a comma-separated-values (csv) text file with the “PNEZD” format for each line as follows:

*“PID, Northing, Easting, Up, Description”.*

Each line represents a single waypoint. In order to comment out a line and exclude the waypoint, precede it with a “#” sign as follows:

#A, 1000.000, 1000.000, 100.000, post.

The main components of the interface are:

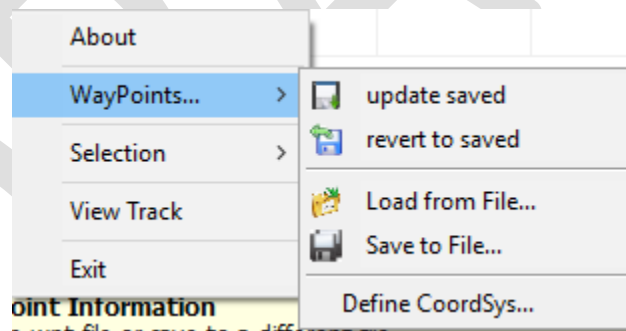
**a. Title Bar**

This shows the file path of the waypoint database.

**b. Main Menu**

This has generic commands applicable to all modules such as to update the waypoint file or to revert to its stored values and so on.

① *the main menu is replicated as a “speed menu” through right-clicking in the main area of the active sheet.*



**c. Tabs**

Except for the first tab that has a tabular view of the waypoint database, each tab is an independent module that tackles on problem. Only one tab can be handled at a time. Bold fields with bold column titles in the active module (sheet) represent input by the user. Light italics column titles represent a by-product or a solution value. Based on the problem at hand, some tabs have limited number of fields for input and/or output, while others may have open-ended series of input/output.

① *the output is only available after the user has entered the input values and then hit the “Enter” button.*

**d. Instructions**

Quick guide on the COGO problem and what it represents.

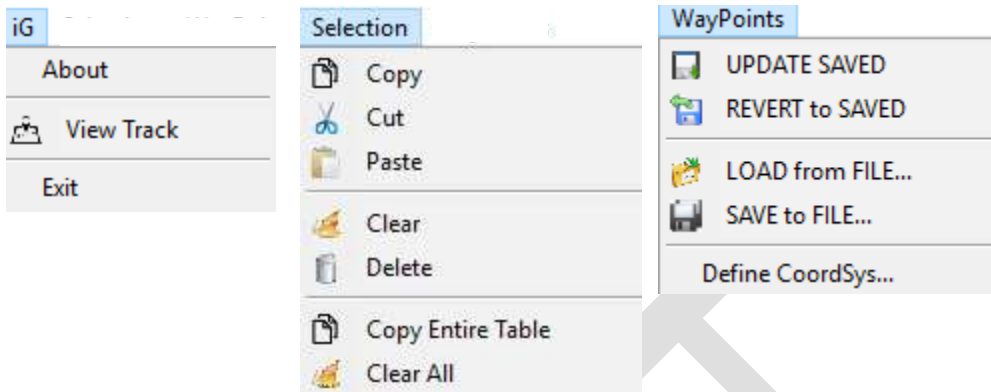
**e. Execution Panel**

Main execution button and track map viewer button.

① *The main dialog and its grids are sizeable.*

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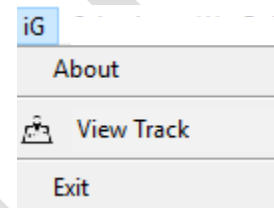
## 1.2 Main Menu



### a. iG Menu

This has the main commands to:

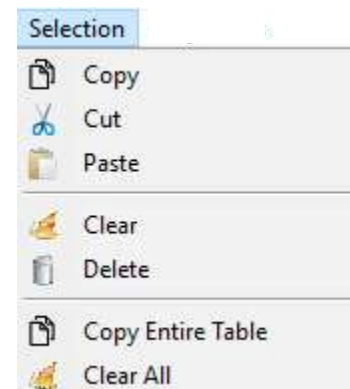
- show the “**About**” dialog
- invoke the “**Track Map**” dialog, a replication of the button in the “execution” panel
- **exit** the application, a replication of clicking the red “x” on the top-right corner of the main dialog



### b. Selection Menu

These commands presume that a selection has been made in the active sheet like the one below. Commands are executed on the selection as follows:

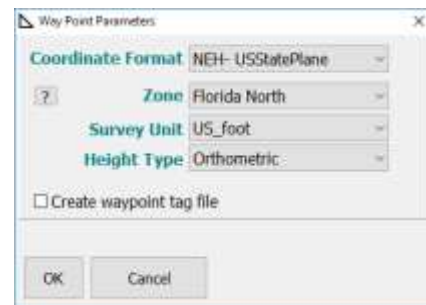
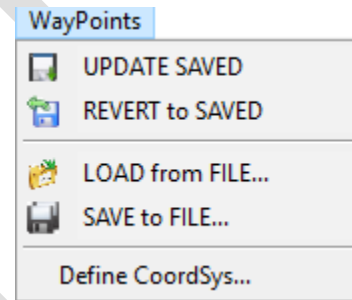
- “**Copy**”: makes a copy of the selection to the clipboard to become available to other Windows applications
- “**Cut**”: similar to “Copy” but with the removal of the selection
- “**Paste**”: replaces the selection with the content of the clipboard
- “**Clear**”: removes the selection content without making a copy in the clipboard
- “**Delete**”: removes the rows containing the selection off the grid
- “**Copy Entire Table**”: similar to “Copy” applied to the whole grid
- “**Clear All**”: clears the contents of the whole grid



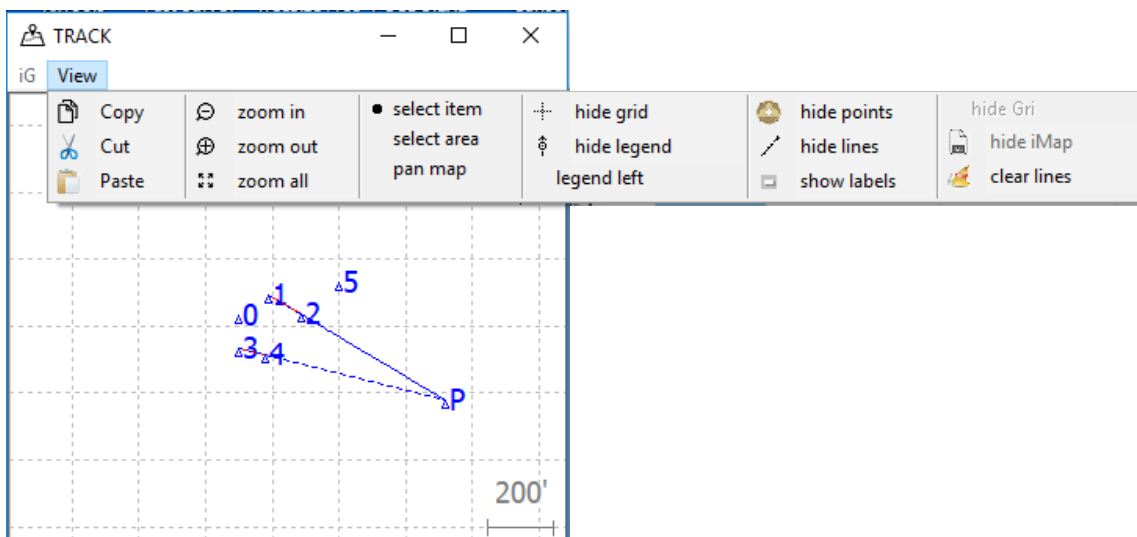
WAYPNTS	LINEINVERSE	POLYGON	TWOLINEINT	ELEVSHOTS	SIDESHOTS	
#	PID	N	E	U		Description
1	0	262633.190	2674299.160	151.230		M
2	1	262693.198	2674389.103	152.301		A
3	2	262636.238	2674485.084	153.267		B
4	3	262533.248	2674299.063	150.268		C
5	4	262513.213	2674379.102	157.955		D
6	5	262733.205	2674599.090	147.950		E
7	P	262377.585	2674920.929	151.527		Work Point

### c. WayPoints Menu

- **Update Saved**: use the current values in the “WayPnts” grid and **overwrite** those in the current “wpt” file
- ① *commented-out lines in the original “wpt” file are not represented in the grid and will be lost if the file is over-written.*
- **Revert to Saved**: opposite of the above; reload what is in the “wpt” file and use their values to **update** the grid
- ① *all unsaved grid changes will be lost when you revert to the saved values*
- **Load from File...**: navigate to a folder on the computer to load a “wpt” file and use its content as the current wpt database; the “WayPnts” grid will also be updated.
- **Save to File...**: navigate to a folder on the computer to save the “WayPnts” grid content to a “wpt” file; the main dialog title bar caption will then report the new name as the current “wpt” database name.
- **Define CoordSys...**: “wpt” files have an auxiliary tag files that has the same name with “.tag” extension. The tag file is necessary for modules that deal with map projection like the “Line Inverse” one. Use the pop-up dialog to specify, and create a file containing, the map parameters of the waypoints database.



## 1.3 Track Map



The track map is a planar graphical representation of the waypoint database points on a non-projected planar ground. It also shows work lines for the module at hand, e.g. the intersection point “P” of lines “1-2” and “3-4” in the example above. The main dialog has the following:

- **Main display** area which contains the waypoint locations and the work lines. The display area can be scaled by zooming in and out. It also can be panned by pressing and holding on the area and move left, right, up, or down. The “*pan map*” must be checked before the area can be panned.
- **Legend** which includes a line scale, a north direction, and a grid. The scale line and the north symbol can move left or right. They can also be shown or hidden. The grid also can be hidden.
- **View Menu** which has the following submenus:
  - a. **Copy Menu**  
Use as described.
  - b. **Zoom Menu**  
Use as described. A double click on the main display area is similar to clicking the “Zoom All” menu item. “Zoom All” brings all waypoints to the main display screen.
  - c. **Select Menu**  
This is a radio group menu; one item can be selected at a time. Use “**select item**” to click on a single waypoint to set focus on it in the waypoint grid. Use “**select area**” to draw a box around a subset of the waypoints to zoom to. Use the “**pan map**” to move the display area by pressing and holding then moving it.



**d. Show/Hide Menu**

Use as described.

**e. Clear Lines Menu**

This forces a *reset* of all work lines to make sure the following operation starts afresh. This is similar to the “revert to saved” from the waypoints menu.

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## 1.4 Waypoints Tab

COGO Info for WPTs in: c:\ig\Data\test.wpt

iG Selection WayPoints

WAYPNTS	LINEINVERSE	POLYGON	TWO LINEINT	ELEVSHOTS	SIDESHOTS
#	PID	N	E	U	Description
1	0	262633.190	2674299.160	151.230	M
2	1	262693.198	2674389.103	152.301	A
3	2	262636.238	2674485.084	153.267	B
4	3	262533.248	2674299.063	150.268	C
5	4	262513.213	2674379.102	157.955	D
6	5	262733.205	2674599.090	147.950	E
7	P	262377.585	2674920.929	151.527	Work Point

**Tabular view of the way point Information**  
- you can *Edit* and update the wpt file or save to a different file.  
- you can also *Revert* to wpt file-saved values.

Enter **SHOW NEW POINTS ON MAP**

This tab is a tabular representation of the waypoint database stored in the file. Each row of the grid represents a row in the file.

- ① ***commented-out lines in the file are not represented in the grid and will be lost if the file is over-written.***
- ① Except for the first row number column, the fields of the grid are editable.
- ① to select a row, click its first column.
- ① clicking the first row of a column selects and sorts the whole table based on the values in the selected column
- ① a blank row is added automatically to the end of the grid when needed.
- ① ***in order for the grid changes to take effect after fields have been modified, the “update saved” menu item must be clicked.***
- ① ***to centre the track map on a waypoint, double click its row in the “WayPnts” grid.***

## 2. G-COGO™ Modules

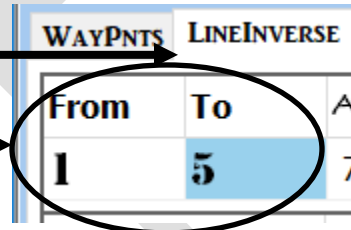
The following is a description of the modules making up the G-COGO package. To execute any of the module, follow the steps:

1. Load the waypoint database from the file

① *When G-COGO is invoked from within the LoTUS Field data collection application, the waypoint database is loaded automatically*

2. Go to the intended module by click on its sheet to make it the **active** one

3. Fill in ALL **bold-titled** fields



WAYPNTS	LINEINVERSE	
<b>From</b>	<b>To</b>	A
<b>1</b>	<b>5</b>	7

① *Waypoint ID Fields are read-only dropdown lists that cannot be edited. Newly generated point fields, however, are editable text fields that require user entering of a new point ID that does not exist in the waypoint database to avoid duplications.*

4. Click the “Enter” button



5. Click the “Track View” button to view the track map, if needed

① *before clicking the “Enter” button, check the “Show New Points on Map” first to view the ID(s) of the newly created point(s) on the map.*

# Line Inverse Information

## INPUT

IDs of two waypoint, e.g. “From” point 1 “To” point 5

## OUTPUT

### - Quick inverse info

Azimuth, Range, and Elevation are ground-based values in the horizontal and vertical planes assuming planimetric trigonometry (no map projection takes effect.)

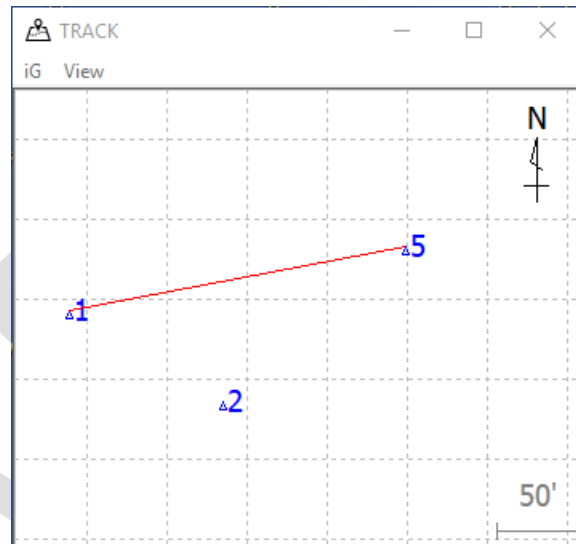
### - Detailed inverse info

Ground-based and grid-based (map-projected) values of the designated line representing changes between the “From” point to the “To” point in:

Northing, Easting, Distance (Horizontal), Azimuth, Bearing, Elevation (Vertical Angle), Grid Convergence of Meridians (Grid North – True Ground North), Point Scale Factor on the map and the combined scale factor after taking height difference into consideration, Height difference, and 3D Spatial (Mark-to-Mark) distance.

① Ground **means reduced to the reference surface, i.e. ellipsoid for geodetic computations or plane for planimetric computations**

① Grid **means projected to a mapping surface, e.g. a cylinder for TM, a cone for LC. Most States use TM and/or LC in their US State Plane Coordinate Systems.**



COGO Info for WPTs in: C:\0\data\Text\wpt

iG Selection WayPoints

From	To	Azimuth	Range	Elevation
1	5	79° 12' 47.55"	213.764'	-1° 09' 57.78"
Coordinate		<b>GROUND</b>	<b>GRID</b>	
Northing		40.007'	40.008'	
Easting		209.987'	209.991'	
Distance		213.764'	213.768'	
Azimuth		79° 12' 47.55"	80° 19' 50.68"	
Bearing		N 79° 12' 47.55" E	N 80° 19' 50.68" E	
Elevation / prnt.Conv		-1° 09' 57.78"	1° 07' 3.13"	
Crnt Factor / prnt.Scale		0.999979 [21ppm]	0.999981 [19ppm]	
Height / Spatial Distance		-4.351'	213.808'	

Single Line Inverse Information  
 - use the Tap dnd to specify line end station id's.  
 - the AGW dnd contains read-only line inverse information.

SHOW NEW POINTS ON MAP

# Polyline Inverse Information

## INPUT

IDs of waypoints forming the polygon rotating clock- or anti-clockwise, e.g. point 0, point 1, point 2, point 4, and point 3

- ① *make sure the polygon lines do not cross one another other than at the vertices*

## OUTPUT

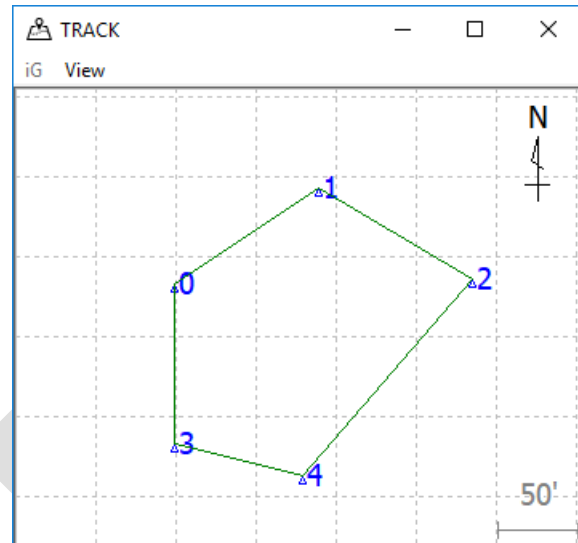
### - Quick inverse info

Azimuth, Range, and Elevation are ground-based values in the horizontal and vertical planes assuming planimetric trigonometry (no map projection takes effect.)

- ① *the “Range” and “Elevation” reported at a point are for the line “From” that point “To” the succeeding point, e.g. the line reported at point 0 is Line 0\_1; the succeeding point for the “Last” point is the “First” point*

### - Shape info

- “Check Sum” of all angles must equal to  $(n-2) \times 180$  degrees, where  $n$  is the number of polygon vertices, 5 in the illustrated example**
- “Perimeter” of the polygon is the sum of all ranges of its sides**
- “Suspended Area” is the area enclosed by the polygon sides**



COGO Info for WPTs in: c:\G\Data\test.vpt

IG Selection: WayPoints

WAYPTS	LINEVERSE	POLYGON	TWOPOINT	ELEVSHOTS	SIDE SHOTS
#	Point	Range	Angle	Elevation	
1	0	108.124'	123° 45' 57.45"	0° 34' 3.06"	
2	1	111.610'	115° 36' 9.38"	0° 29' 45.21"	
3	2	162.380'	79° 56' 35.61"	1° 39' 13.32"	
4	4	82.508'	116° 41' 26.03"	-5° 19' 21.60"	
5	3	99.942'	103° 59' 51.52"	0° 33' 5.36"	

CHECK SUM: [(n-2)\*PI] [540° 00' 0.00"]

PERIMETER 564.564'

SUSPENDED AREA 20717.125<sup>2</sup>

**PolyLine Inverse and Shape Information**  
 - use the Point Column of the Main Grid to specify station #'s of the polygon vertices.  
 - the Angle/Direction/Elevation Column contains read-only line inverse information from that station to the succeeding station, whilst the Lower Grid contains read-only polyline shape information.

and Enter SHOW NEW POINTS ON MAP

# Two-Line Intersection

## INPUT

- IDs of waypoints forming two lines, e.g. point 1 and point 2 for line 1\_2, and point 3 and point 4 for line 3\_4
- ID of the intersection point, e.g. XPoint "p"

① *Lines may be intersecting or crossing*

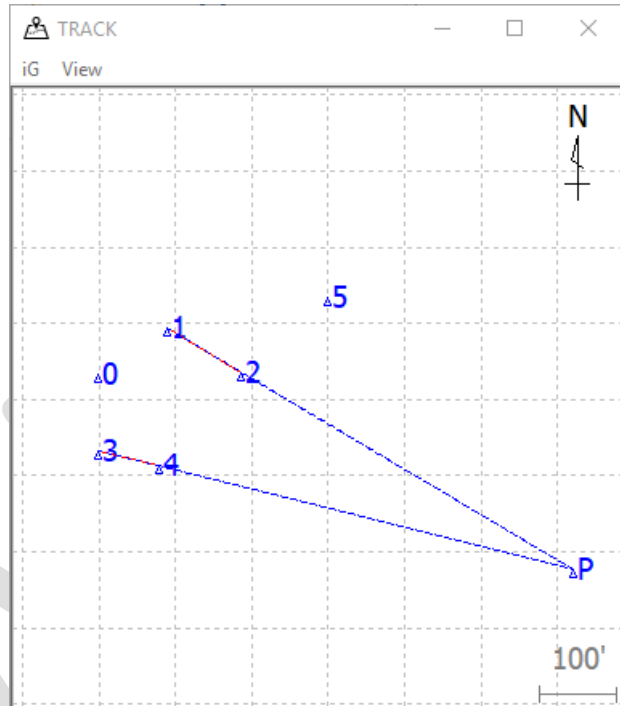
## OUTPUT

- Quick inverse info

Azimuth, Range, and Elevation of the two intersecting lines

- Intersection point info

- **"XAngle"** the angle suspended by the two lines, both acute and obtuse
- **"Northing, Easting, and Up"** coordinates of the intersection point



COGO Info for WPTs in: c:\IG\Data\test1.wpt

ig Selection WayPoints

WayPnts	LineInverse	Polygon	TwoLineInt	ElevShots	SideShots
Line	From	To	Azimuth	Range	Elevation
1	1	2	120° 41' 13.36"	111.610'	0° 29' 45.21"
2	3	4	104° 03' 11.71"	82.508'	5° 19' 21.60"

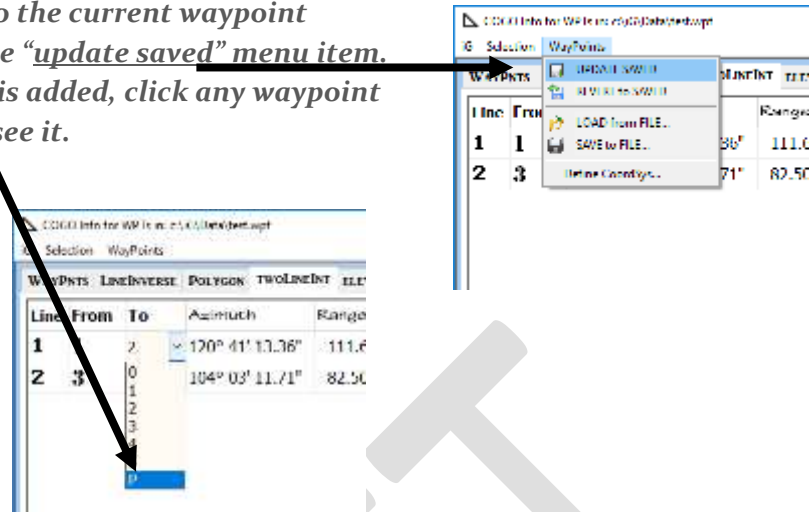
  

XPoint	XAngle	N	E	U
P	16° 38' 1.65" 163° 21' 58.35"	262377.585'	2674920.929'	151.527'

Intersection of two pre-defined Lines  
 - use the Top Grid to specify IDs of the two line end stations  
 - the Main Grid contains read-only intersection point information.

Enter SHOW NEW POINTS ON MAP

① to add point "P" to the current waypoint database, click the "update saved" menu item. To make sure "P" is added, click any waypoint dropdown list to see it.



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# Elevation Shots

## From a single occupation

### INPUT

Spirit Levelling (Type=HGT)

- ID of the Bench Mark (point of known elevation), e.g. point 4
- Instrument height = 0 or leave blank
- Back Sight staff reading on the Bench Mark
- **ID and Height (staff reading)** on each new point

AT	hi	BS Height	U
4		6.45	157.955'

#	Point	ht	Type	Distance& Elev/Height	U
1	G		HGT	3.65	168.055'
2	H		HGT	4.17	168.575'
3	K		HGT	8.22	172.625'
4					

Trigonometric Levelling (Type=ELE)

- ID of the occupied station (point of known elevation), e.g. point 4
- Instrument height, e.g. total station height
- Back Sight height, e.g. zero for vertical circle readings and 90 for zenith angle readings
- **ID, height of target (prism), distance, and elevation angle** in degrees of each new point

AT	hi	BS Height	U
4	6.45		157.955'

#	Point	ht	Type	Distance& Elev/Height	U
1	L	6.56	ELE	100 12.55	180.106'
2	M	6.56	ELE	125 5.40	169.661'
3	N	6.56	ELE	200 -10.38	121.210'
4	Q	6.56	ELE	75 0.00	157.845'

**Single Occupation Vertical/Elevation Shots**

- use the **Top Grid** to specify occupied station id, height of instrument, and zero vertical value, if any.
- use the **Align Grid** to specify prism height and elevation shot to each **New Point**. An **Elev Shot** can be either a **Single Height Value** or a **Distance and an Elev Angle**.

**SHOW NEW POINTS ON MAP**

① *Blank field in a grid is interpreted as zero value*

### OUTPUT

Heights of newly shot targets



# Side (*Directional*) Shots

## From a single occupation

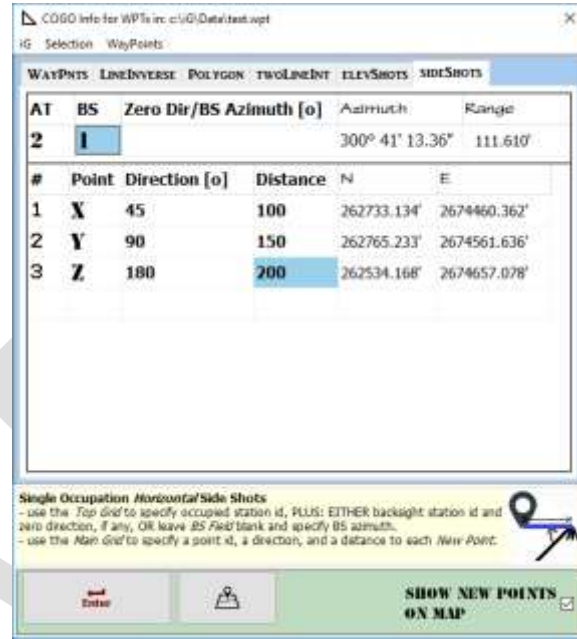
### INPUT

#### Known Back Sight Station

- ID of the occupied station, e.g. point 2
- ID of the back-sight station, e.g. point 1
- Zero Direction Reading for reporting Total Station Horizontal Circle Readings; leave blank if reporting angle right
- **ID, direction, and distance** for each new point

#### Known Back Sight Azimuth

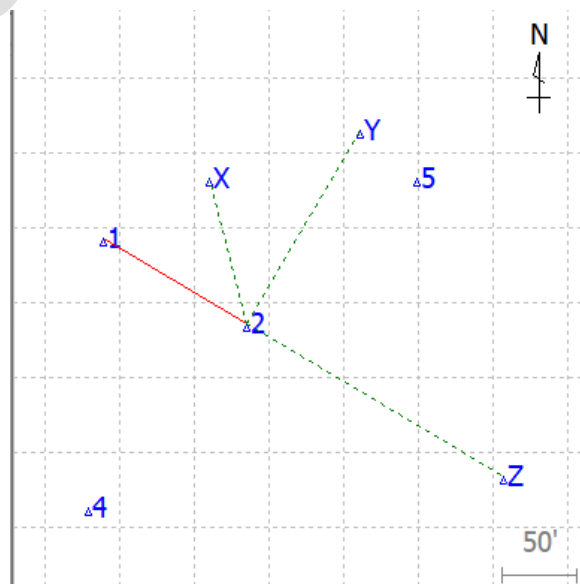
- ID of the occupied station, e.g. point 2
- Leave blank ID of the back-sight station
- Back sight azimuth value, e.g. -89.05
- **ID, direction, and distance** for each new point



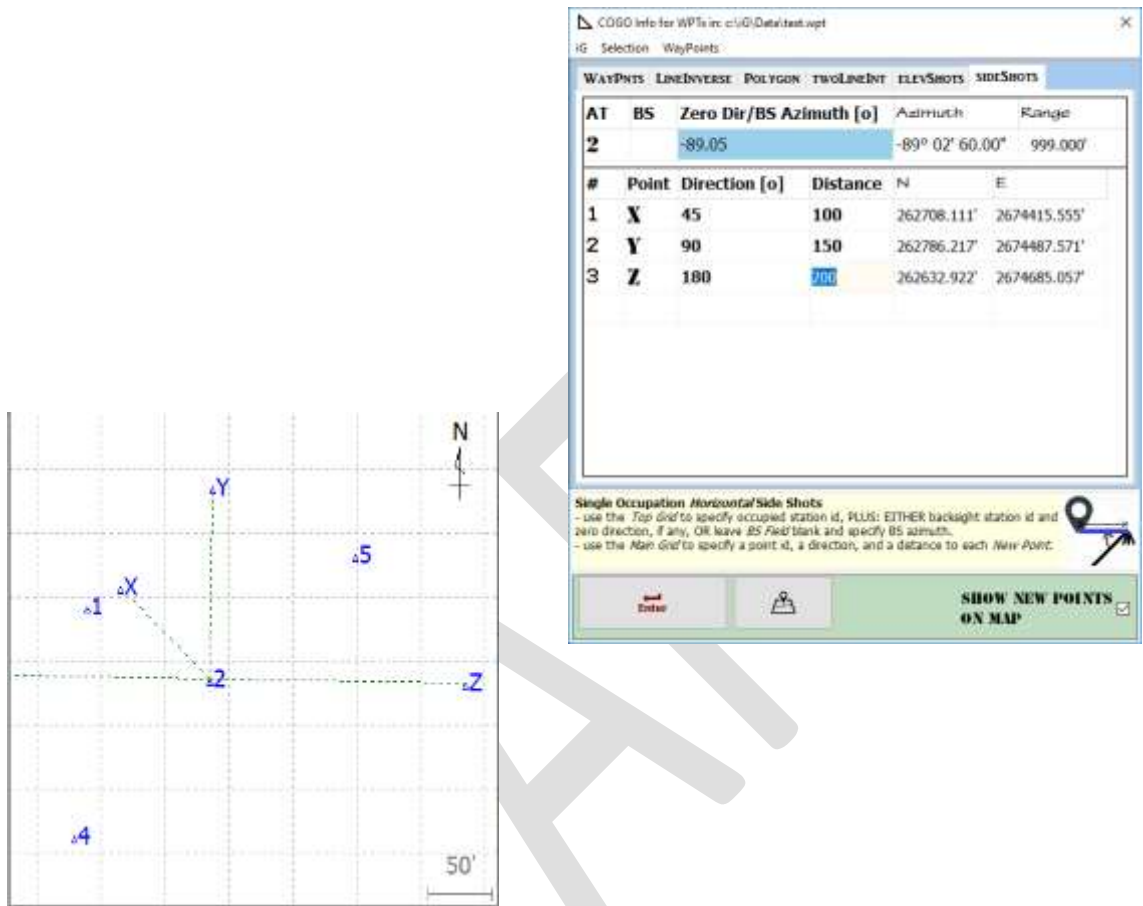
① use the *LineInverse* module to find azimuths of lines, if needed

### OUTPUT

Northing and Easting of newly shot targets



## Known Back Sight Azimuth Case



# Station and Offset Shots

## For a single baseline

### INPUT

#### Known Back Sight Station

- ID of the occupied station, e.g. point 4
- ID of the back-sight station, e.g. point 0
- ***ID, station, and offset*** for each new point

#### Known Back Sight Azimuth

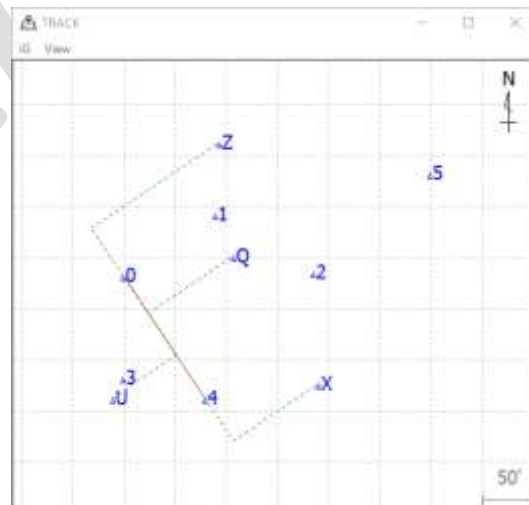
- ID of the occupied station, e.g. point 4
- Leave blank ID of the back-sight station
- Back sight azimuth value
- ***ID, station, and offset*** for each new point

① use the *LineInverse* module to find azimuths of lines, if needed

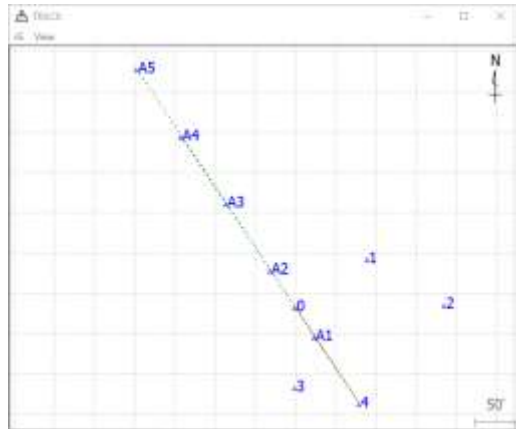


### OUTPUT

Northing and Easting of newly shot targets



① leave offset fields blank to divide a line into stations

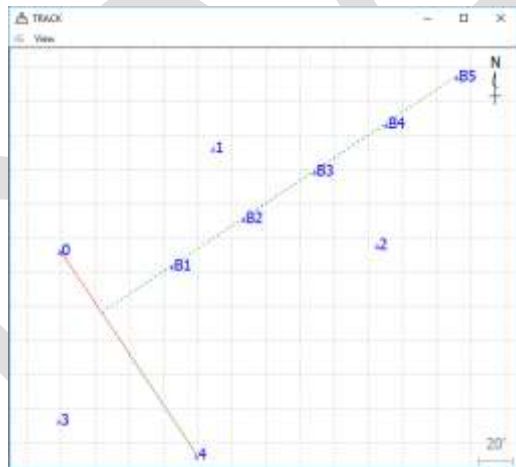


W	L	P	U	S	M
W	L	P	U	S	M
A1	B5	Azimuth [s]	Azimuth	Range	
1	0		326° 19' 20.55"	344.171'	
#	Point	Station	Offset	N	E
1	A1	100		262596.432	2674323.852
2	A2	200		262679.699	2674268.202
3	A3	300		262762.969	2674212.752
4	A4	400		262846.089	2674157.304
5	A5	500		262929.309	2674101.854

Stations and Offsets along a baseline:  
 - set the two points specify adjacent stations (i.e. 1100, 1110) or two baseline points (i.e. 10, 20) specify B1, B2, etc. Then use the 'Offset' field to specify a point (i.e. 1000) and an offset along the baseline to each (i.e. 100).  
 - Dimension station position (rows to B1) / offset position (columns) (single right).

ADD NEW POINTS TO BENCHMARK

① use the same station value with different offsets to divide a perpendicular line



W	L	P	U	S	M
W	L	P	U	S	M
A1	B5	Azimuth [s]	Azimuth	Range	
1	0		326° 19' 20.55"	344.171'	
#	Point	Station	Offset	N	E
1	B1	100	50	262634.190	2674365.252
2	B2	100	100	262651.801	2674406.872
3	B3	100	150	262679.699	2674448.480
4	B4	100	200	262707.331	2674490.088
5	B5	100	250	262735.056	2674531.699

Stations and Offsets along a baseline:  
 - set the two points specify adjacent stations (i.e. 1100, 1110) or two baseline points (i.e. 10, 20) specify B1, B2, etc. Then use the 'Offset' field to specify a point (i.e. 1000) and an offset along the baseline to each (i.e. 100).  
 - Dimension station position (rows to B1) / offset position (columns) (single right).

ADD NEW POINTS TO BENCHMARK