050706

USER MANUAL

SERVO TOTAL STATION **GTS-800**

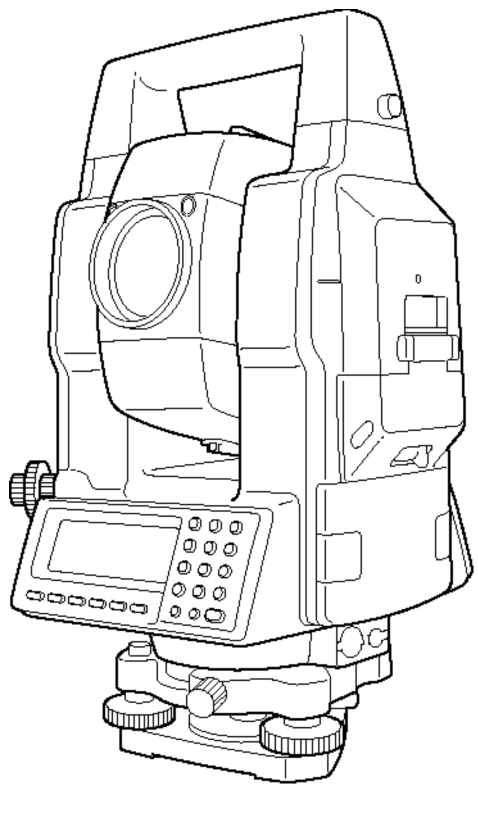
AUTO TRACKING TOTAL STATION **GTS-800A**

AUTO TRACKING PULSE TOTAL STATION **GPT-8000A**

APPLICATION SOFTWARE

STANDARD SURVEY 800

Version 3.5



GTS-800 STANDARD SURVEY 800
User Manual

TOPCON CORPORATION

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Table of Contents

1 Introduction

Main features of Standard Survey Software 800.

<< For GTS-800A users >>

The MONITOR function of GTS-800A is more comprehensive than that of the GTS-800. See chapter 18 for details.

Multiple Job Files

Standard Survey Software 800 uses named jobs with separate files for raw data, coordinates and strings. The jobs are given alpha numeric names with up to eight characters. You may have many jobs on the system. You may create a new job for storing data, or you may open an existing job for data storage. The currently selected job is used for storing observed data. You may also delete job files.

Traverse & Topographic Recording Sequences

Backsight and Foresight observation options allow users to record traverses or sets of multiple observations in any sequence. Multiple observations of foresights and backsights are averaged dynamically. A side shot option allows single key collection for topographic surveys. Traverse and topographic collection may be combined.

Cross Section Surveys

Cross sections may be surveyed with input of chainages and memory of code sequences. Points collected may be downloaded in chainage, offset and level format.

Offsets

A single offset option is activated by a function key and allows manual entry of perpendicular offsets, or calculated offsets, including remote elevation from a second angle reading.

Point Coordinate and String Generation

Coordinates are generated in real-time with optional storage. Stored coordinates are recalled at occupied stations and used for back bearing calculation. Point code defined in the library as a line can be downloaded as lines in DXF format. A point its coordinates with respect to a reference line can be determined.

Horizontal Circle Setting

Backsight bearings may be set on the instrument from calculated coordinates or manual input. Manual bearing input may be either Whole Circle Bearing or Quadrant format.

Control Point Coordinate Library

Separate control point library is accessible by all jobs for storage of frequently used coordinates. Control point file may be entered manually, or uploaded from computer.

Point Code Library

Point codes may be selected from the library file.

Edit Data

Raw data, point coordinates, control point coordinates and codes may be edited within the GTS-800 key panel. If raw data is edited, the previous one is marked as invalidated data in the downloaded file.

Download to Serial Port or Card Drive

Raw data, coordinates and cross sections can be sent to a computer using a serial cable or directly copied to the card drive. The format can be selected from default (GTS-7), GTS-6, FC-5 or MOSS GENIO.

Download DXF Files

Points and lines generated in recorded data may be downloaded in DXF format, with layers defined by point codes.

Printed Reports

Raw data, coordinates and cut/fill reports may be downloaded for printing from serial port or parallel port.

Upload from Serial Port or Card Drive

Coordinates for set out, and control point coordinates may be uploaded from a computer using a serial cable or directly copied to the card drive in default (GTS-7), GTS-6 or MOSS GENIO format.

Upload Point Codes from Serial Port or Card Drive

The point code table may be created by uploading codes from a computer.

Upload Roads design data from Serial Port or Card Drive

Horizontal alignment data, Vertical curve data and Cross section data for Alignment set out may be uploaded in GTS-7 format.

Point Setting Out

The standard setting out program computes bearing and distance, and displays offsets to set out point after each measurement. Coordinates of points as set out may be saved and differences down loaded in the cut/fill report.

Note that the scale factor defined under the SETUP will be used in the calculation of setting out distances. Points with coordinates (North, East) as well as points with coordinates defined with respect to a reference line can be setout.

String Setting Out

Setting out of points by string (point code) allows the setting out of points on a line created in design software.

Road Setting Out

Two options allow the setting out of points by chainage and offset from a road alignment. Complete road designs may be set out from points uploaded in chainage offset and level format referenced to an alignment.

Traverse Adjustment

The Bowditch (compass rule) adjustment method is used to adjust a recorded traverse. The traverse is defined by entering start and end points and the intermediate points are determined from foresight observations.

Resection

Computation of coordinates from known points. The method of calculation is dependent on the data available. Either two points with angles and distances, or three points with angles only are required. Where more than three points and up to a maximum of 16 points are available the least squares method is used. Note that the scale factor defined under the SETUP function will be used in the calculation.

Occupied Point Elevation Computation

Computation of the occupied point elevation by single observation to a known point.

Intersections

Coordinate calculation from two known points, with either bearings and or distances.

Inverse

Computation of bearing and distance between 2 known points.

Area Calculation

Area calculation of a series of points defined by point code or marked point.

Radiation

Coordinate for a point can be computed by entering the Bearing and Distance.

Missing line measurement

The slope distance, horizontal distance and vertical distance between two points can be computed.

Batterboards

A program for setting out on building areas. If two points cannot be setout, a batterboard can be placed in the vicinity. Next the intersection point of the line connecting two setout points and the batterboard can be found.

Tape dimensions

Tape dimensions is a program which integrates surveying using a total station and a measuring tape. This program is especially useful when a quick survey of an object is required.

Monitor

Monitor measurement can be done by using point coordinates with code and string number or by measured points with code and string number.

2 General Information

2.1 Special Keys

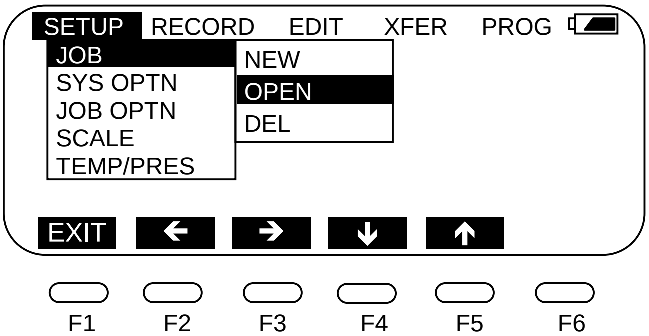
The [ENT] key is the most commonly used key. It is used to record measurements, complete screen input, continue processing after a warning or prompt has been displayed.

The [ESC] key can be used to break out of any function. It will allow you to exit a screen without saving input, exit a menu and return to a higher level menu, or to break a processing loop. Function keys are used to access extended screens when a label is displayed on the bottom row of the screen. When a prompt requiring an [OK] / [CANCL] reply is displayed you can press [OK] or [ENT] key to reply OK, and press [CANCL] or [ESC] key to reply CANCEL.

<GTS-800A only>

The [★] key enables you to aim the prism automatically if the prism is within the predefined area. The extent can be changed which is also included in the [★] key menu.

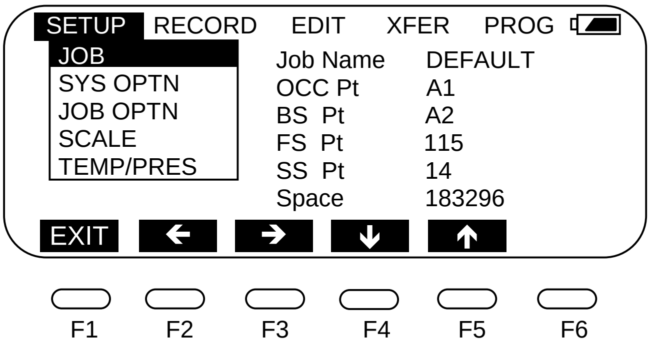
2.2 Menu Selection



The main menu is displayed across the top line of the screen. Sub menus are displayed as pop down menus. Use [←] and [→] keys, as defined on the bottom of the screen, to move between main menu options. Use [↑] and [↓] keys to move the highlight bar on the sub menu. Press [ENT] key to select the highlighted sub menu option.

If the sub menu option has further options they will be displayed to the side. The side menu will be displayed when [ENT] key is pressed. Use [↑] and [↓] keys to move the highlight bar and press [ENT] key to select the option. Press [ESC] key to return to the higher level menu.

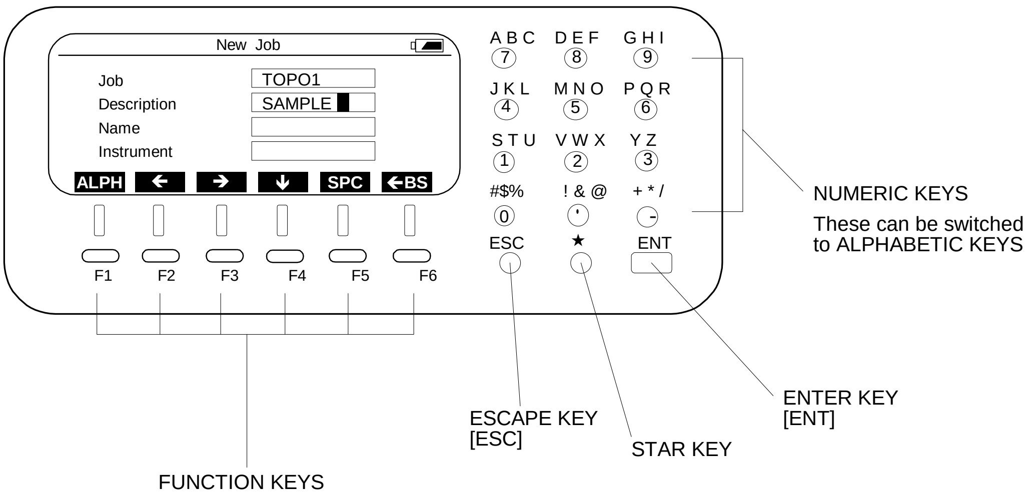
2.3 Job Status Display



The following job status is displayed in the main menu screen.

Job Name	:	The current job name
OCC Pt	:	The last Occupied Station
BS Pt	:	The last backsight point number
FS Pt	:	Previous foresight point number
SS Pt	:	Previous side shot point number
Space	:	Memory space available (in Bytes)

2.4 Key Input



All key input is entered into screens.

Use the cursor keys to move from one field to another.

When in a measure option screen, the measurement can be initiated, and point codes can be accepted as displayed by pressing [ENT] key.

Press [←**BS**] to delete the character to the left of the cursor.

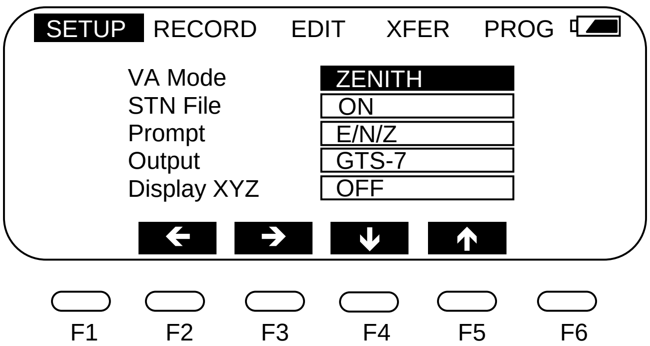
When an input field is larger than the screen, the field scrolls to the left. When the field is full, further input is not accepted.

Some screens will display function key labels. Press the corresponding function key to access the additional screens.

Alpha characters may be entered by first pressing the function key (F1) when labeled [ALPH]. This will make the Alpha character set active on the numeric keypad. In any measure screen or any screen that requires manual input, the (F1) will toggle between [ALPH] (alphabet) mode and [NUM] (number) mode on the keypad.

For example, to enter a single letter 'A', press the [7] key once. To enter a 'B', press the [7] key twice, and 'C' requires three key presses. When entering one character and then wait for about 1 second, the cursor moves to the right automatically. Enter the next letter in the same manner.

2.5 Option Screens



Option screens have fixed input values. To change the options use the [←] and [→] arrow keys to scroll through the values.

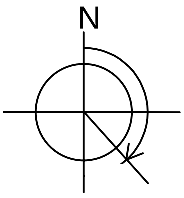
Press [ENT] key to move the highlight bar to the next option.

Press [ENT] key when the highlight bar is on the bottom line of the screen to exit and save the changes. Press [ESC] key to exit the screen without saving the changes.

2.6 Horizontal Angle Input

The horizontal angles can be entered in Whole Circle Bearing or Quadrant Format.

Whole Circle Bearing

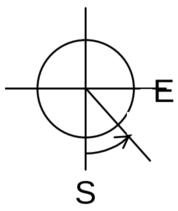


Whole Circle Bearings are entered as follows;

134.0645 (134° 6' 45" in Degree)

or 134.1125 (134g 11c 25cc in Gon)

Quadrant Format



Angles are entered as follows;

S45.5315E (S45° 53' 15" E in Degree)

or S45.8875E (S45g88c75cc E in Gon)

2.7 Recompute Coordinates

Standard Survey Software 800 retains the Raw data file (measured data) and the Coordinate data (which is calculated from the measured data after each measurement) separately. When the raw data is edited the coordinate data may require recomputation.
The coordinate data is automatically recomputed when any output option is executed after editing raw data.

For example the following changes to the raw data will result in the corresponding changes to the coordinate data after recomputation;

(1) Occupied Point No.
The coordinates of points observed from this point will be recomputed using the new Occupied Point data.

(2) Back Sight Point No.
The coordinates of points observed from this station will be recomputed using the new backsight bearing.

(3) Instrument height / (4) Target height
Z coordinates will be recomputed using the new Instrument height or the new Target height.

(5) Offsets
The coordinates of a point will be recomputed using the new offset values.

(6) Point code or String Number
The strings are regenerated for all points.

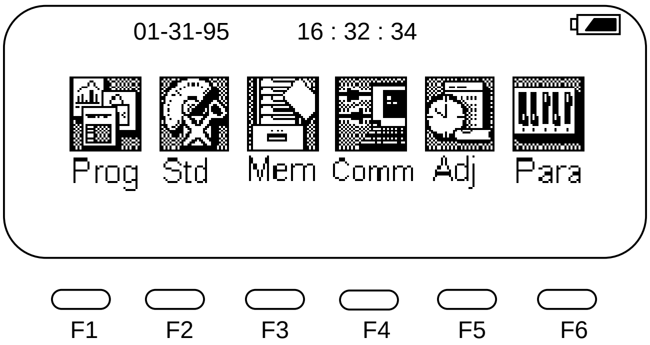
(Remarks)
After editing the Raw Data, the coordinates are not directly recomputed.
The coordinates are recomputed ONLY WHEN an output of coordinate data option is executed.
This is in order to maintain the efficiency during the measuring or editing operation.
(Operation)

XFER → SEND → POINTS or DXF → COM or CARD
XFER → PRINT → POINTS → COM or PRN

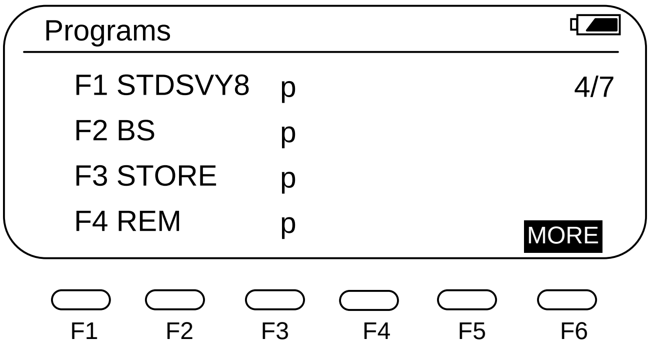
"Re-compute coordinate" is displayed during the recomputation, and when it is completed, "Ready ?" is displayed.

[OK] (F4) → Actual download can be started.
[CANCL] (F5) → Return to menu without download.

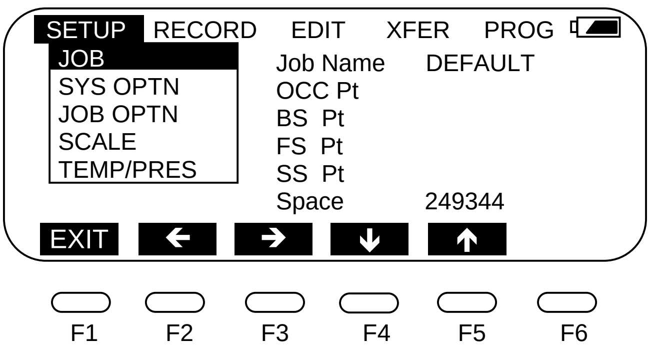
3 Getting Started



Select “Prog” icon [F1] from the GTS-800 start up menu.



The program list is displayed. (The list is not always the same as in the figure.)
Select "STDSVY8" to start the Standard Survey Software 800.



When you start the Standard Survey Software 800 for the first time the current job will be called DEFAULT. You can record into this job, or you can delete it after creating a new job.

Create a new job, by selecting JOB from the SETUP menu, then NEW. Enter the new job name. (A valid job name consists of up to 8 characters alpha/numeric).

Enter the job description, surveyors name, and instrument identification.

Press [ENT] key to move the cursor to the next option. Press [ENT] key when the cursor is on the bottom line of the screen to exit and save the settings. Press [ESC] key to exit the screen without saving the settings.

Select JOB OPTN to set the recording options for the job. Change the options to suit your practice. To change the options use the [🡐] and [➔] arrow keys to scroll through the values. Press [ENT] key to move the highlight bar to the next option. Press [ENT] key when the highlight bar is on the bottom line of the screen to exit and save the changes.

Select RECORD to display the recording options.

From the RECORD menu select OCC PT to enter the occupied point details.

Enter a point number, instrument height and point code, then press [ENT] key to return to the menu. Select BKS PT to enter backsight point details if required.

Select either BS OBS to record the backsight angle, FS OBS to record a foresight point, or SS OBS to record a series side shot or intermediate sight observations.

EXIT Press [EXIT] to quit the software.

NOTE:

Sometimes the software does not start if the data files in internal memory are protected or renamed. If the software fails to open data files, the following messages may be displayed;

Error in Fix Pt File — This message is shown when either the file FIXED.PTS, FIXED.PTN or FIXED.COD is missing or protected.
Delete these 3 files to initialize the fixed point data.

Error in Code Lib — This message is shown when either the file DEFAULT.LIB, DEFAULT.LYR or DEFAULT.SYM is protected or corrupted.
Delete these 3 files to initialize the library.

Job xxxxxxxx CORRUPTED!

If the current job is corrupted or one of the files is missing or protected then the program will prompt for an another job.

Cannot write to Config file!

This message will be shown when the file CONFIG.DAT is protected and you try to change the current job.

The software will not start if any of the files used are corrupted or protected.

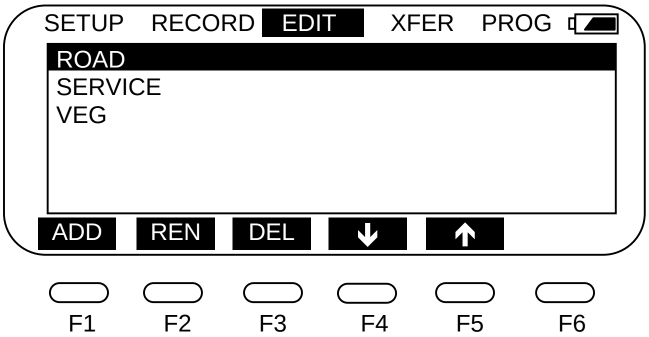
Do not protect any of the files used by the Standard Survey Software 800.

4 Libraries

4.1 Point Code Library (CODE)

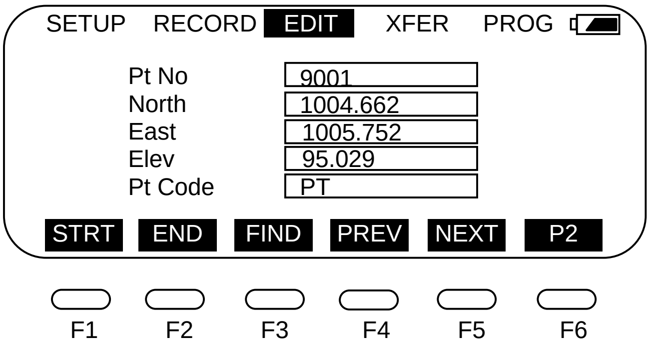
The point code library allows you to store commonly used point codes. Codes are grouped by layer, and can be selected from the library where a code is required in the recording options.

You can create a file in the office using a text editor, or word processor capable of producing text files, and upload it to the internal memory, or you can edit the library file in the internal memory.



See EDIT/CODE (section 10.4) for details on how to create a code library manually.

4.2 Fixed Point Library (PT LIB)



The fixed point library allows you to store coordinates for commonly used points, or control stations. This file is accessed by any job when the STN FILE option is "ON" (see SYS OPTN). When you enter the details for an occupied point, if the job file does not contain coordinates for the point, the fixed point file is searched. If the point is found in the fixed point library those coordinates are used, and written into the raw data as though they were entered manually. If no point is found in the fixed point library then the coordinates must be entered manually. Press [ENT] key to move the cursor to the next option.

Press [ENT] key when the cursor is on the bottom line of the screen to exit and save the settings.

Press [ESC] key to exit the screen without saving the settings.

The fixed point library may be created by uploading points from a computer, similar to uploading job coordinate files, or may be created manually by the edit fixed point option.

5 Job Files & Job Creation

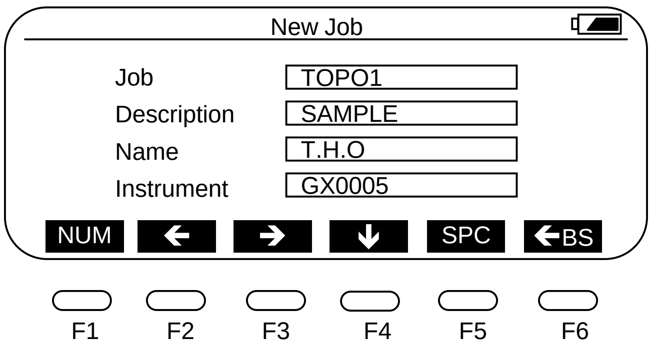
To create a new job, open an existing job, or delete a job, select JOB from the SETUP menu.

SETUP
JOB
SYS OPTN
JOB OPTN
SCALE
TEMP/PRES

5.1 Create a New Job

Select NEW to create a new job.

SETUP
JOB | NEW
SYS OPTN | OPEN
JOB OPTN | DEL
SCALE
TEMP/PRES



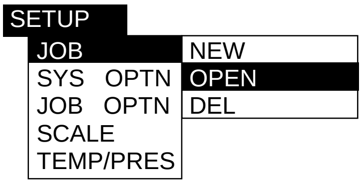
Enter the new job name. A job name has a maximum of 8 characters and should be made up from the letters A-Z, numbers 0-9 and the minus sign (-) only. A job name can not contain a space or any of the special characters. The minus sign cannot be entered as the first character of the job name. Press [ENT] key to move the cursor to the next option. Enter the job details. Press [ENT] key when the cursor is on the bottom line of the screen to exit and save the settings. Press [ESC] key to exit the screen without saving the settings.

The new job will become the current job. If the job name already exists, the message "Job Already Exists" is displayed.
Select OPEN option to see a list of current jobs before creating the new job if you are not sure which jobs currently exist.

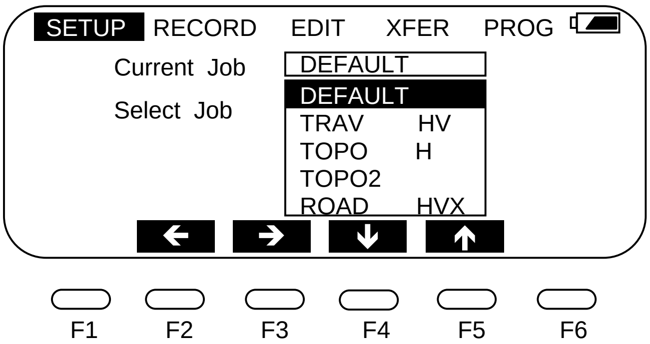
NOTE: The GTS-800 can record a maximum of 304 files in the internal memory. When a JOB is created, the Standard Survey Software 800 creates more than 5 files automatically. When the cross section data, set out data, alignment data and so on is created, more files are added to the job. If more than about 30 JOBs are recorded, you may not be able to create a new JOB. In this case, create a new JOB after deleting a JOB which is not necessary any more.

5.2 Open an Existing Job

Select OPEN from the file menu.



The file display lists all the files stored in the internal memory. The current job is displayed at the top of the screen.



Use [↑] or [↓] keys to move the hi-light bar to select a file to open.

Use [↓] to scroll through additional pages. When the required job is highlighted press [ENT] key to make the job current and return to the menu.

If Alignment data exists in a Job, the job list can display H, V and X behind the job name.

H: Horizontal Alignment data

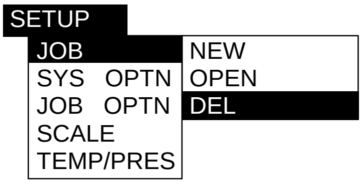
V: Vertical Alignment data

X: Cross section data

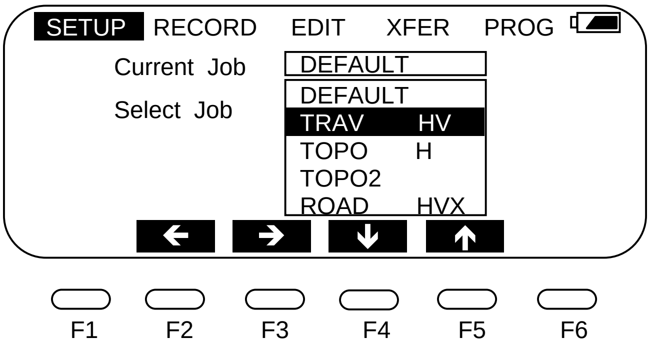
C: Cut / Fill Report data

5.3 Delete a Job

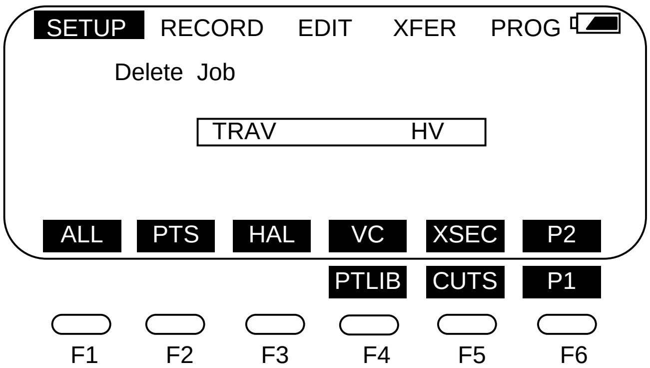
To delete a job from the internal memory select DEL from the file menu.



As with the open file, the display lists all the files stored in the internal memory. The current job is displayed on top of the screen.



To delete a job from the internal memory, move the hi-light bar to the required file and press [ENT] key.



ALL : Delete all files

PTS : Delete Points file

HAL : Delete Horizontal ALignment file

VC : Delete Vertical Curve file

XSEC : Delete Cross section Alignment file

PTLIB : Delete Fixed Point Library (PT LIB)

CUTS : Delete Set out coordinates file

The prompt "Are you sure? " will be displayed. Press [OK] or [ENT] key to delete the file, or [CANCL] or [ESC] key to return to the menu without deleting the file.
The current job cannot be deleted if you select [ALL].

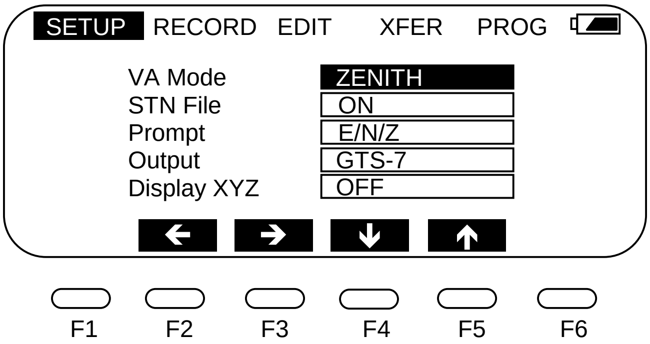
NOTE: If points file data is deleted with some Cut / Fill data remained, the Cut / Fill can not be shown correctly in EDIT-CUTS and PRINT-CUTS.

6 Recording Options

6.1 System Options (SYS OPTN)

To set the system options choose SYS OPTN from the SETUP menu.

SETUP
- JOB
- SYS OPTN
- JOB OPTN
- SCALE
- TEMP/PRES



VA Mode	ZENITH or LEVEL
STN File	ON or OFF
Prompt	N/E/Z or E/N/Z
Output	GTS-7, GTS-6, FC-5 or MOSS
Display XYZ	ON or OFF

> System options apply to all jobs in the internal memory.
> If changes are made they affect all jobs.

To change the options use the [←] and [→] arrow keys to scroll through the values. Press [ENT] key to move the highlight bar to the next option. Press [ENT] key when the highlight bar is on the bottom line of the screen to exit and save the changes. Press [ESC] key to exit the screen without saving the changes.

VA Mode

The vertical angle mode specifies where vertical angles are read from.

Changing this option will set the instrument.

a) ZENITH

The vertical angle is 90 degrees face left to horizontal and decreasing towards Zenith.

b) LEVEL

The vertical angle is 0 degrees face left to horizontal and increases towards Zenith.

Station File (STN File)

The station file (STN FILE) or fixed point library allows coordinates of frequently used control points to be saved and accessed by all jobs. See Library for details on how to create a fixed point file.

a) ON

If the station file option is ON then the fixed point file will be scanned for coordinates of occupied stations and backsight points before prompting for the coordinates, when there is not a coordinate for the point in the current job.

When the same point number is saved both in POINT and PTLIB data base, the data in POINTS is recalled and used for occupied station and backsight point.

b) OFF

If the station file is OFF the fixed point file is not searched for coordinates of occupied stations and backsight points.

Prompts

The order of prompts in the coordinate entry and editing screens may be selected with this option.

a) N/E/Z

Select N/E/Z to display prompts in NORTH, EAST and ELEVATION order.

b) E/N/Z

Select E/N/Z to display prompts in EAST, NORTH and ELEVATION order.

NOTE : The coordinate output format is always E,N,Z except in PRINT POINT when GTS-7 Output is selected.

Output

The Output option controls the format for downloaded and uploaded data, which may be formatted in a number of different formats, providing downward compatibility with other TOPCON data collectors. The default format for the GTS-800 is the Topcon GTS-7 format. If you select GTS-6, then the raw format will be the same as the Topcon GTS-6 instruments.

a) GTS-7

Select GTS-7 (or FC-6). If using TOPCON DRP-1/ DRP2 or Civilcad packages.

b) GTS-6

Select GTS-6 to download data in GTS-6 compatible format.

The downloaded raw data with the SEND option will be unformatted, with the PRINT option it will be formatted.

c) FC-5

Select FC-5 to download data in FC-5 compatible format. The format is the FC-5 SELECT mode. (The function menu [FUNC] [7] of FC-5 will enable you to select the data to record.)

Not all information recorded can be downloaded in FC-5 format.

Raw data downloaded with the SEND option will be unformatted, data downloaded with the PRINT option will be formatted.

d) MOSS

Both MOSS raw data and MOSS GENIO string format files may be downloaded.

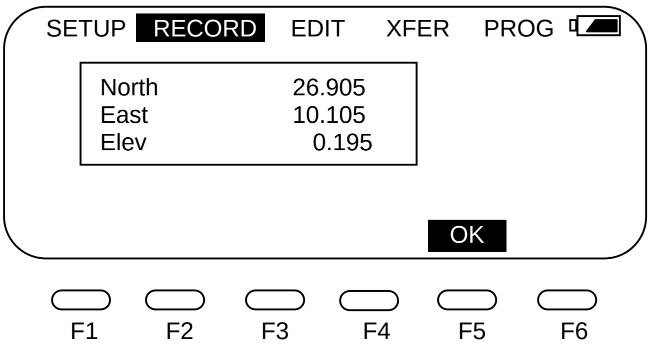
The XYZ download option produces GENIO string files. The string number field and point code are combined to generate strings.

If downloading RAW data in MOSS format the string control fields may be used to enter the MOSS data fields.

NOTE: This option controls the format required when uploading points. (RECEIVE POINTS or PT LIB), but all the others control with GTS-7 format.

Display XYZ

The coordinates are displayed when you record **H/V/SD** or **H/HD/VD** data for FS OBS / SS OBS / X-SECT in case you select **XYZ File** is ON in **JOB OPTN** and **Display XYZ** is ON in **SYS OPTN.**



(Remarks)

It is not possible to cancel the recording of XYZ data in this display, even if you press the [ESC] key.

a) ON

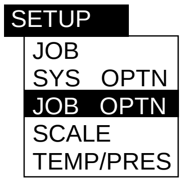
If the Display XYZ is ON the coordinates are displayed.

b) OFF

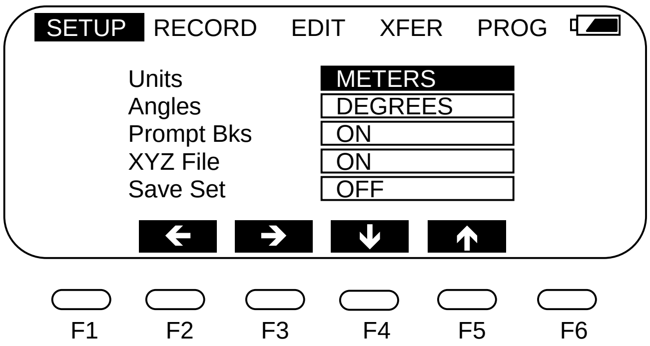
If the Display XYZ is OFF the coordinates are not displayed.

6.2 Job Options (JOB OPTN)

The job options apply to each job, and may be changed from one job to another.



The information is stored as part of the raw data for the job. To set job options select JOB OPTN from the SETUP menu.



Units	METERS or FEET
Angles	GON or DEGREES
Prompt Bks	ON or OFF
XYZ File	ON or OFF
Save Set	ON or OFF

To change the options use the [🡐] and [➔] arrow keys to scroll through the values.
Press [ENT] key to move the highlight bar to the next option. Press [ENT] key when the highlight bar is on the bottom line of the screen to exit and save the changes. Press [ESC] key to exit the screen without saving the changes.
When changing job options only the current job is changed.
When an existing job is opened the options are restored to what they were when the job was last used.

Units

This specifies the unit of distance that will be included in the unit record of the downloaded data, and must correspond to the settings of the instrument.

a) METERS

The unit of distances is meters.

b) FEET

The unit of distances is feet and decimal feet.

Coordinates are stored unitless and calculated from the actual distances measured.

Angles

This specifies the units used to display and download recorded angles.

Angles are stored internally in degrees for calculation purposes, and may be displayed or downloaded in either unit regardless of the units used in measurement.

a) GON

Angles are displayed and downloaded in grads in the format GGG.GGGG.

Manual entry must be entered in this format also.

b) DEGREES

Angles are displayed in degrees minutes and seconds, with the format DDD.MMSS.

Manually entered angles should be entered in this format.

Prompt Bks

If the prompt Bks option is ON the user is forced to enter a backsight point after each new occupied station, before a foresight or side shot can be taken.

XYZ File

Coordinates may be automatically calculated and saved when you measure H/V/SD or H/HD/VD mode. If you intend downloading coordinates, adjusting a traverse, or to use the computed backsight bearing to set the instrument then this option should be ON.

a) ON

Set this option to ON to compute and save coordinates.

b) OFF

If you do not wish to store computed coordinates, set this option to OFF.

If the XYZ option is OFF, coordinates for occupied stations are not required.

Save Setout

Coordinates of points that have been setout may be saved for printing in the CUT/FILL report. This report lists each point setout with the design coordinates and setout coordinates and shows cut or fill height.

NOTE : Road Alignment Setout and X-SECTS data can not print CUT/FILL reports.

a) ON

Set to ON to save coordinates. Coordinates are saved when [ENT] key is pressed in any of the setout options.

b) OFF

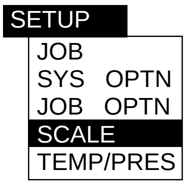
Set to OFF if you do not wish to save the setout coordinates.

6.3 Scale Factor (SCALE)

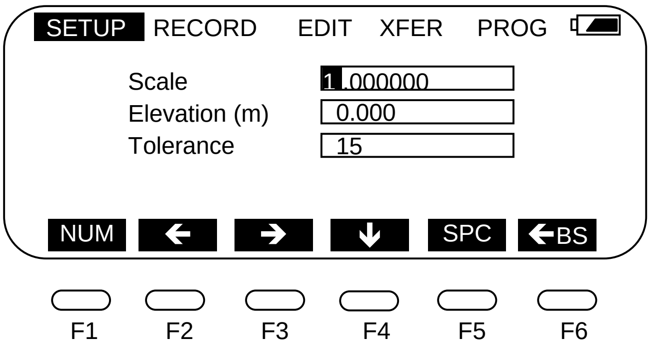
Measured horizontal distances are multiplied by the scale factor in coordinate calculation.

The scale factor to be used may be entered with this option.

The raw data is not altered by the scale factor.



To enter a scale factor select SCALE from the SETUP menu.



Enter the scale factor (Scale) and mean elevation (Elevation) into the screen.

Press [ENT] key to move the cursor to the next option. Press [ENT] key when the cursor is on the bottom line of the screen to exit and save the settings. Press [ESC] key to exit the screen without saving the settings.

The downloaded raw data (in GTS-7 format) will contain a scale factor record.

The following grid factor f ' is used to calculate coordinates.

$$f' = f * R/(R+h)$$

f : Scale

h : Elevation

R : The Radius of the Earth (= 6,372,000m)

When measuring face left and right, the program will calculate the tolerance value. If over the value comparing with manual input value, the warning message will display after calculating while measuring.

The following value “he” is used to comparing with manual input tolerance.

$$he = | h - (h' - 180) |$$

h : angle of face right

h’ : angle of face left

NOTE:

1. Scale can be entered in the following ranges;

   0.900000 — 1.100000

   Scale is rounded to 6 decimal places. The default scale factor is 1.00000.

2. Elevation can be entered in meters only . The ranges are as follows;

   -1000.000 — 10000.000

   Elevation is rounded to 3 decimal places. The default elevation is 0.

3. Tolerance can be entered in the following ranges;

   0 — 300 [sec] (92.59 [mgon])

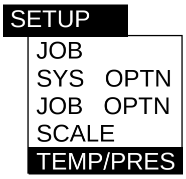
   The default tolerance is 15 [sec] (4.63 [mgon]).

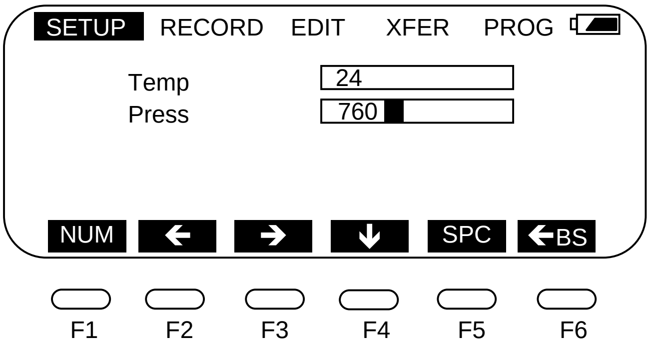
4. Scale is used in the calculation of coordinates and except COGO menu and the calculation of horizontal distance to the Setout point.

5. Calculation of Z coordinate is not influenced even if it is applied to grid factor.

6.4 Temperature and Pressure Input (TEMP/PRES)

To enter temperature and pressure select the TEMP option in the SETUP menu.





The temperature and pressure screen will be displayed.

Enter the temperature value (Temp) and the pressure value (Press).

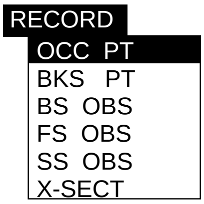
Press [ENT] key to move the cursor to the next option. Press [ENT] key when the cursor is on the bottom line of the screen to exit and save the settings. Press [ESC] key to exit the screen without saving the settings.

NOTE: Temperature and pressure are just stored in the raw data and never affect the GTS-800 parameters nor PPM calculation.

7 Occupied Point Details

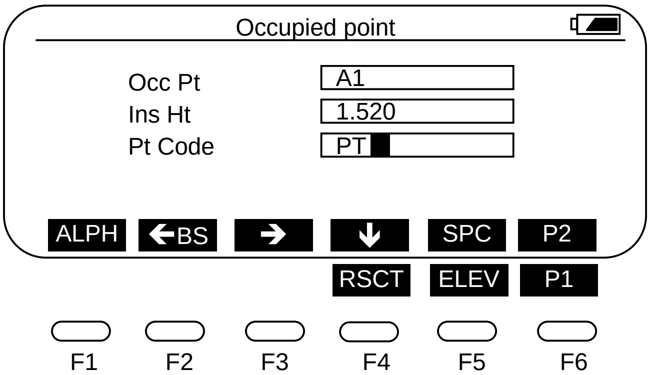
7.1 Occupied Point Input Screen

Occupied point details are entered by selecting OCC PT from the RECORD menu.



The occupied point is normally entered each time the instrument is set up and before you begin observations.

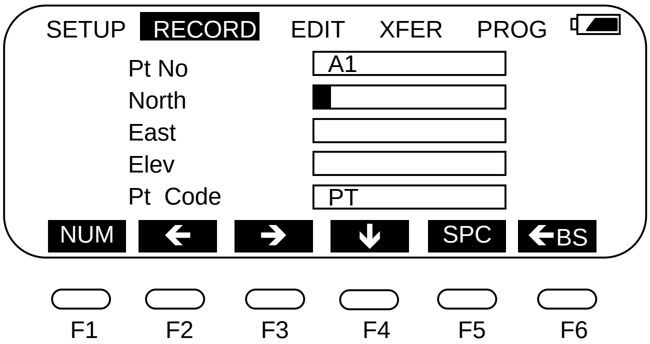
Select OCC PT and the occupied point screen will be displayed.



Enter the point identifier for the occupied point (Occ Pt - maximum 8 characters), the height of instrument (Ins Ht), and the point code (Pt Code).

Press [ENT] key to move the cursor to the next option. Press [ENT] key when the cursor is on the bottom line of the screen to exit and save the settings. Press [ESC] key to exit the screen without saving the settings.

If the XYZ FILE flag is ON and coordinates do not exist in the point file or fixed point file then the coordinate entry screen is displayed.

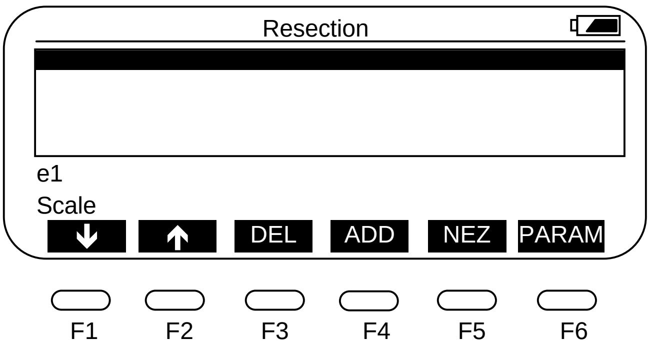


Enter the easting (East) northing (North) and elevation (Elev) of the point.
Press [ENT] key to move the cursor to the next option. Press [ENT] key when the cursor is on the bottom line of the screen to exit and save the settings. Press [ESC] key to exit the screen without saving the settings.
If the point exists both in the point file and fixed point file, then coordinates from the point file will be used.

7.1.1 RSCT (Resection)

If the coordinates of an occupied point are unknown, a resection can be performed to compute these coordinates. A resection involves the measurements from an occupied point to several other points with known coordinates. It is possible to perform a resection by measuring angles and distances or by measuring angles only. The type of measurements influences the minimum number of observations needed to perform a resection. In case of angle as well as distance measurements a minimum of 2 observations are required, by measuring angles only a minimum of 3 observations should be performed.

Select [RSCT] in the Occupied Point screen. The following screen will be displayed:



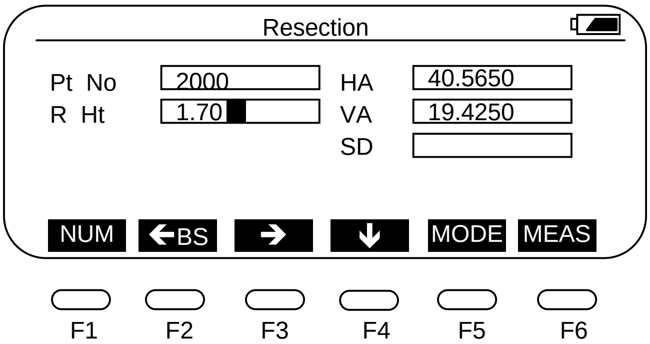
On the lower side of the screen discrepancies (e1) or the standard deviation in N, E and Z direction (sN, sE, sZ) of the occupied point will be displayed. Discrepancies will be shown in case two distance measurements have been performed. They are calculated using the following equations:

$e1 = HD_{12,\ \text{calculated using measurements}} - HD_{12,\ \text{calculated using known coordinates}}$

where: $HD12$ denotes the horizontal distance between the first and second point.

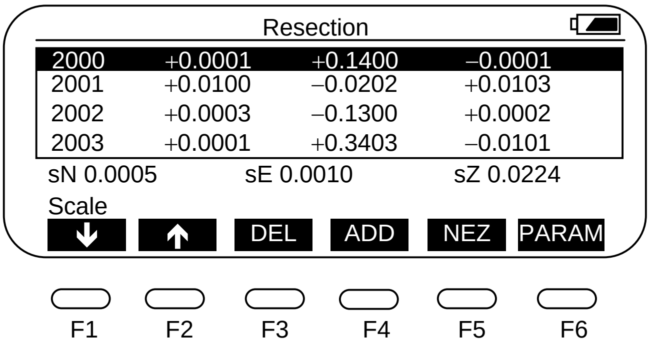
In case 3 or more distance measurements or 4 or more angle measurements have been performed, the standard deviations will be displayed instead of the discrepancies.

On the upper side of the screen a box is shown, which will contain the number of the points to which measurements have been performed and the residuals of these measurements. The box is empty since no measurements have yet been performed. Press [ADD] to add a new measurement to the list of resection measurements. The following screen will be shown.



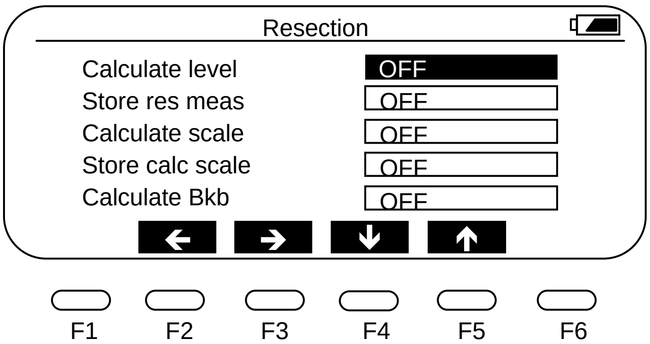
Enter the correct point number. By pressing [MODE] the measuring mode can be changed. By selecting [MEAS] a measurement will be performed, but this measurement will not be saved and will not be used for the resection calculation. In order to perform a measurement which will be added to the list of measurements, select [ENT] key. If the coordinates of this point are still unknown, the user will be asked to enter these coordinates. Again the main resection screen will be shown, but now the point number to which has been measured is shown in the box.

In case 3 angle measurements or 2 angle and distance measurements have been performed, the coordinates of the occupied point can be displayed by pressing [NEZ]. The box on the right will contain point numbers as well as residuals.



The number of residuals shown depends on the parameters selected. Generally, the worst observation will have the largest residual. This observation can be deleted by placing the bar on this observation using the arrow key and then pressing [DEL]. The observation is removed from the list. The coordinates of the occupied point, its standard deviation or discrepancies and the residuals of the remaining observations are automatically recomputed.

By selecting [PARAM], the parameters which are calculated during resection can be selected. The following screen will be shown:



It is possible to select whether the level of the occupied point, a scale factor or the backsight bearing (‘Calculate Bkb’) should be calculated. Furthermore it is possible to select whether the calculated scale or the measurements which have been performed (‘Store res meas’) should be stored. Pressing [ENT] key when the cursor is at the bottom line results in returning to the main resection screen, saving the changes made and (re)calculation of the occupied point, residuals and the required parameters.

Pressing [ENT] key in case the main resection screen is shown will result in leaving this screen and saving of the coordinates of the occupied point. In case 'Store res meas' was turned on in [PARAM], the measurements which have been performed and which are shown in the box will be saved as well.

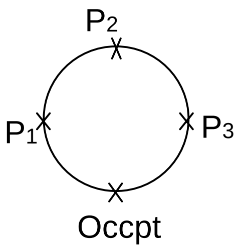
In case 'Calculate Bkb' in [PARAM] was turned on, the backsight bearing will be calculated and set by pressing [ENT] key and leaving the main resection screen. The computation will use all measurements which are shown in the box. In order to calculate a backsight bearing of high quality:

1. **the residuals of the horizontal angle should have low values.**
2. **the user shouldn't change the horizontal angle when leaving the main resection screen.**

NOTE:

1. The measurements can be performed in any order. The point numbers shown in the box in the main resection screen will be sorted by horizontal angle.

2. When 3 points are used for resection using angle measurements only, you must consider the "danger circle".



eg; If P_1, P_2, P_3 and Occpt fall on the circle, the result can not be computed. If the point is near the circle then the result is unstable.

3. Residuals are useful to avoid that observations of low quality will be used for the resection computation. However, in case of a small number of observations or a bad geometrical constellation of the points it is possible that one bad observation influences several residuals.

4. The unit of the residuals is similar to the unit of the measurements performed. However, the residual of the horizontal and vertical angle is always displayed in decimals.

5. In case a point number has more than 6 digits, only the last 6 digits will be shown in the box in the main resection screen. The point number will be stored using the original number of digits.

6. The error message 'Invalid scale' is shown if the calculated scale is not within the range 0.9 – 1.1 and has to be stored.

7. More than one measurement to the same point can be performed during resection. In that case the character '*' is placed behind the point number. The average of the measurements to the same point is used for the calculations.

8. Equations for the calculation of the residuals, the scale and the backsight bearing are explained in appendix E.

9. The following table shows which residuals will be shown (ΔH denotes the residual of the horizontal angle, ΔV the residual of the vertical angle, ΔSD the residual of the slope distance).

	Calc. Level: On	**Calc. Level: Off**
Meas. Mode: H/V/SD	ΔH, ΔV, ΔSD	ΔH
Meas. Mode: H/V	ΔH, ΔV	ΔH

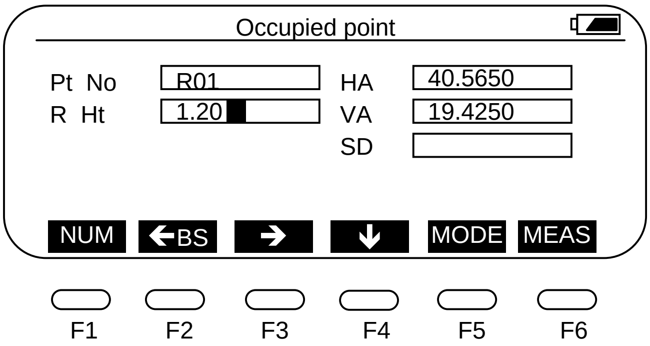
Table 7.1: The residuals which will be displayed depends on the measuring mode and whether level is calculated.

10. When 2 points are used for resection using 2 angles and one distance measurements, you must measure shorter distance. If you measured longer distance, you can not get the correct result. (The residual of SD should have high values.)

7.1.2 ELEV (Station Elevation)

If the elevation of a point to be occupied is not known but a point of known elevation can be observed, then the station elevation can be computed.

To compute the occupied point elevation select [ELEV] from page 2 of the occupied point menu.



Enter the point number for the known point, and the target height. If there is no coordinate for the point the coordinate entry screen will be displayed. Enter the coordinates and press [ENT] key to save the information.

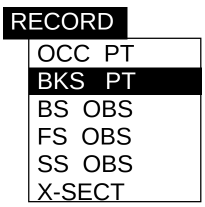
The measure screen will be displayed. Press [ENT] key to record the observation.

The coordinate entry screen will be displayed.

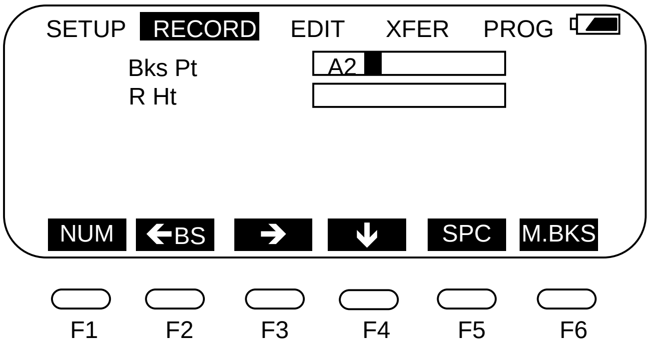
Enter the easting, and northing if required. The computed elevation will be shown.

7.2 Backsight Point Input Screen

After entering the occupied point details, you may want to enter your backsight station details. The backsight point screen is used to set the backsight point, and backsight bearing.



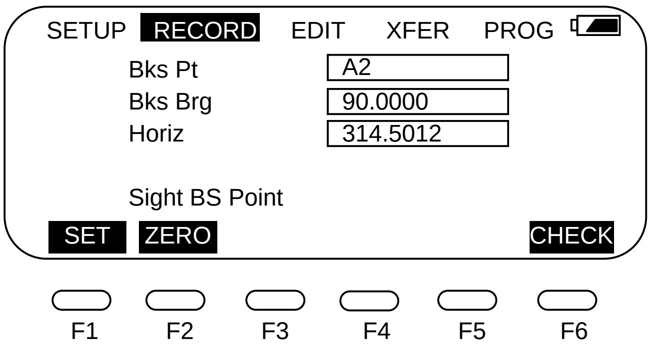
Select BKS PT from the RECORD menu.



In case a backsight orientation using a single target is desired, enter the backsight point number (Bks Pt) in the screen, and press [ENT] key. The backsight orientation using a single point is explained in paragraph 7.2.1. Press [M.BKS] in case you want to perform a backsight orientation using multiple points. The multiple backsight orientation is explained in paragraph 7.2.2.

7.2.1 Single point backsight

If a coordinate for the backsight point is stored then the computed back bearing will be displayed. If the XYZ FILE flag is ON and there is no coordinate for the point the coordinate entry screen will be displayed. Enter the coordinates or press [ESC] key to bypass this screen and enter the bearing manually.



When the back bearing is displayed the screen has two function key options;

SET, and ZERO

These function keys are used to set the horizontal circle of the instrument, and to initialize the internal backsight direction used in coordinate calculations. Sight the backsight point and press one of the function keys.

a) SET

Use the [SET] function to set the back bearing on the instrument.

b) ZERO

Use the [ZERO] key to set zero on the instrument.

c) CHECK

Use the [CHECK] key to check the coordinates of backsight point by measuring the slope distance.

When [ENT] key is pressed the current displayed horizontal angle is recorded as the initial backsight direction along with the computed or manually entered back bearing.

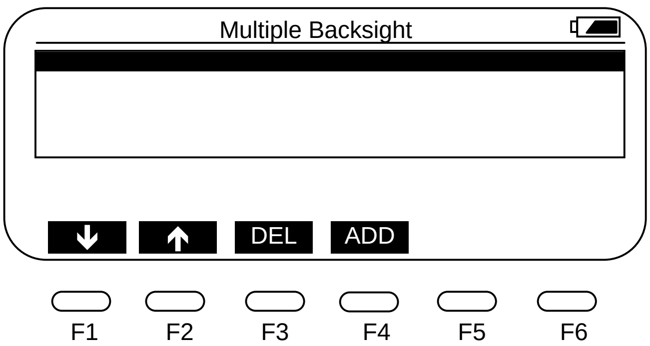
All coordinate calculations are based on the measured angle between backsight and foresight (or side shot). A backsight observation over-rides the initial backsight direction, otherwise the initial value is used in the calculation.

If no backsight point is entered then the backsight bearing, and initial backsight direction are set to zero. This assumes the horizontal circle has been set manually and the recorded observations are bearings.

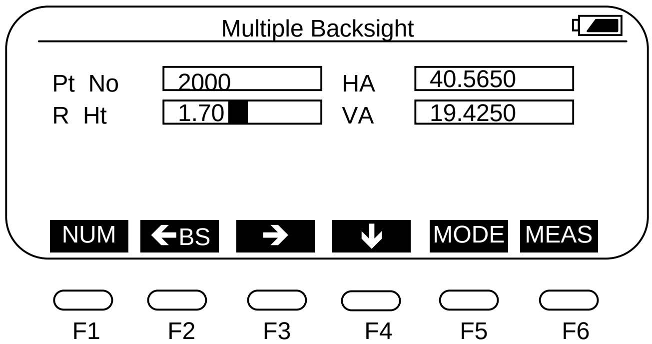
Once you have set the backsight point number and the back bearing, the instrument will be orientated and ready to observe.

7.2.2 Multiple point backsight

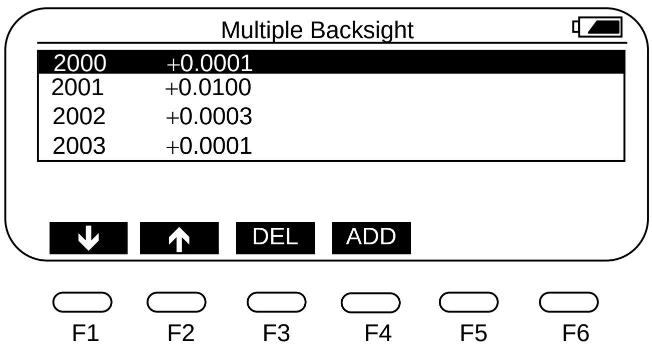
A backsight orientation with a high degree of reliability can be achieved by performing a multiple point backsight. By selecting [M.BKS] in the BKS PT screen, the following screen will be shown.



On the upper side of the screen a box is shown, which will contain the number of the points to which measurements have been performed and the residuals of these measurements. The box is empty since no measurements have yet been performed. Press [ADD] to add a new measurement to the list of multiple point backsight measurements. The following screen will be shown.



Enter the correct point number. By pressing [MODE] the measuring mode can be changed. By selecting [MEAS] a measurement will be performed, but this measurement will not be saved and will not be used for the calculation of the backsight. In order to perform a measurement which will be added to the list of measurements, select [ENT] key. If the coordinates of this point are still unknown, the user will be asked to enter these coordinates. Again the main multiple backsight screen will be shown, but now the point number to which has been measured plus the residual of the horizontal angle is shown in the box.



Generally, the worst observation will have the largest residual. This observation can be deleted by placing the bar on this observation using the arrow key and then pressing [DEL]. The observation is removed from the list. The residuals of the remaining observations are automatically recomputed.

The backsight bearing will be calculated and set by pressing [ENT] key, the display will return to the main menu. The computation of the backsight will use all measurements which are shown in the box. In order to calculate a backsight bearing of high reliability the following points should be noted:

1. the residuals of the horizontal angle should have low values.
2. the user shouldn't change the horizontal angle when leaving the main multiple point backsight screen.

NOTE:

1. The measurements can be performed in any order. The point numbers shown in the box in the multiple backsight screen will be sorted by horizontal angle.

2. Residuals are useful to avoid that observations of low quality will be used for the calculation of the backsight. However, in case of a small number of observations it is possible that one bad observation influences several residuals.

3. In case a point number has more than 6 digits, only the last 6 digits will be shown in the box in the multiple backsight screen. The point number will be stored using the original number of digits.

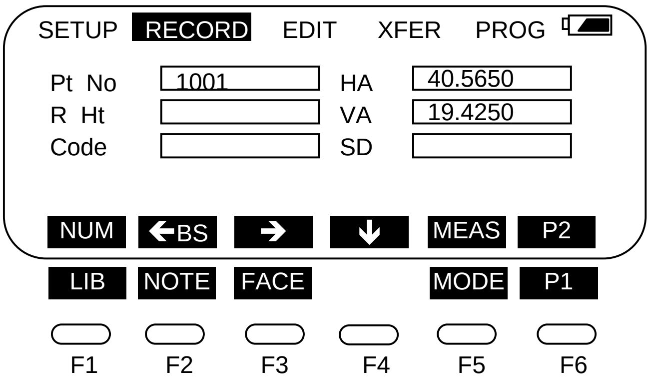
4. More than one measurement to the same point can be performed. In that case the character '*' is placed behind the point number. The average of the measurements to the same point is used for the calculations.

5. Equations for the calculation of the residual of the horizontal angle and the backsight bearing are explained in appendix E.

6. In case a resection is being performed, it is not necessary to perform a multiple point backsight afterwards. By selecting 'Calculate Bkb' = ON, a multiple point backsight will be performed using the resection measurements.

8 Recording Measurements

To record measurements select a measurement type from the **RECORD** menu.
The measurement types available are **BS OBS** (backsight observation), **FS OBS** (foresight observation) and **SS OBS** (sideshot observation).



(Example) FS OBS

These are 2 options for the measurement process:

1. [ENT]

Using [ENT] key allows a recording with single key press, but point number, code and reflector height must be entered before measurement. When [ENT] key is pressed without first taking a measurement, measurement is initiated and the data recorded at the completion of the measurement process.

2. [MEAS] + [ENT]

[MEAS] initiates the measurement process and will display measured data, but the data is NOT YET stored in the job file. The point number, code and reflector height may be entered after the measurement process is completed. Press [ENT] key to save the data.

[GPT-8000A only]

When measuring distance(“<” is moving), [MEAS] key switches prism/non-prism mode.

When distance has been measured using the [MEAS] the instrument can be turned and the HA updated. The new HA will be recorded when the [ENT] key is pressed.
This allows an offset measurement to be recorded without any additional functions.
Press [ESC] key to return to the initial measurement screen.

[MODE]

This allows you to choose the measurement mode, EDM mode and measure repeat mode.

- **Meas Mode (H/V/SD** or **H/V** or **H/HD/VD)**

  The measurement mode determines the type of data recorded.

  H=horizontal angle

  V=vertical angle

  SD=slope distance

  HD=horizontal distance

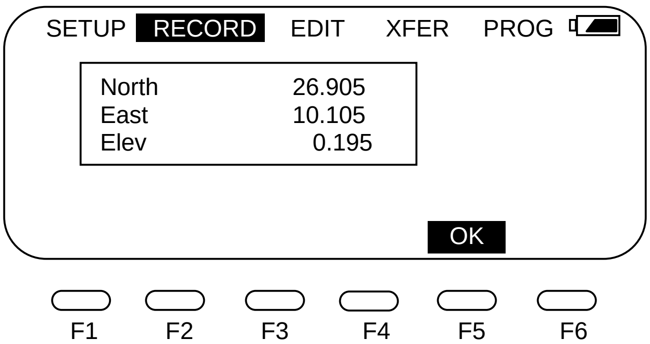
  VD=vertical height difference

  Select H/V/SD or H/HD/VD if you need to record in distance mode.

- **EDM mode (FINE** or **COARSE)**
- **REP mode (SINGLE** or **REPEAT)**

NOTE: **Display XYZ**

The coordinates are displayed when you record **H/V/SD** or **H/HD/VD** data for FS OBS / SS OBS / X-SECT in case you select **XYZ File** is ON in **JOB OPTN** and **Display XYZ** is ON in **SYS OPTN**.



(Remarks)

It is not possible to cancel the recording of XYZ data in this display, even if you press the [ESC] key.

[ALPH] / [NUM] (F1)

[ALPH]/[NUM] (F1) toggles between alpha/numeric modes. When the label shows [ALPH] the mode is alpha and when [NUM] is displayed the mode is numeric.

[P2]

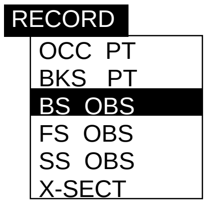
[P2] selects page 2 of the function key menu.

[NOTE]

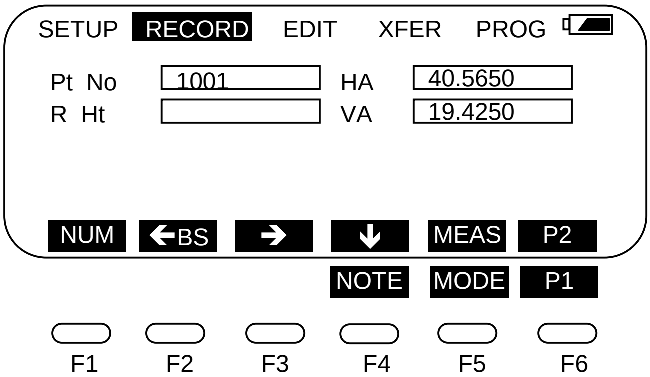
The [NOTE] function allows the addition of a note record. Press [P2] and then [NOTE] to enter a note at any time during recording.

8.1 Back Sight Observations (BS OBS)

The backsight angle is measured with the Prompt BS OBS option. Only a horizontal angle is required for internal coordinate calculations, however the mode may be set to record distances also.



Press [ENT] key, and the displayed horizontal and vertical angles will be recorded.
The previously entered backsight point number is recorded automatically.
No coordinate is computed for the backsight point.



When a backsight angle is recorded, the angle will be used in subsequent coordinate calculations.

8.2 Foresight Observations (FS OBS)

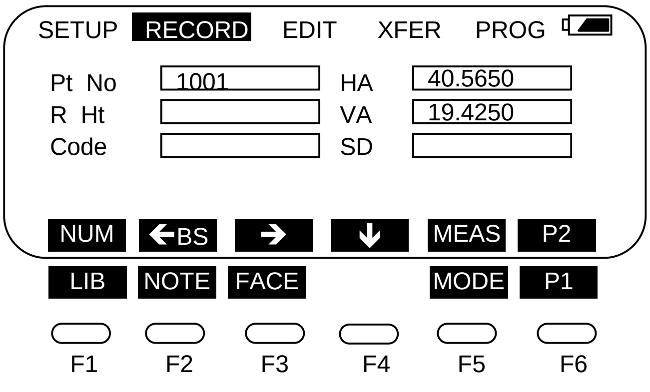
RECORD
OCC PT
BKS PT
BS OBS
FS OBS
SS OBS
X-SECT

The foresight option is used to record observations to the next traverse point, or for collecting a set of foresight points with multiple observations for averaging. An unlimited number of observations can be made to each foresight point, with a maximum of 16 foresight points in a set.

After collecting a set of foresights, the GTS-800 will automatically reverse face and point to each point in the set, in reverse order then return to the backsight point when the FACE option is selected.

Both foresight and backsight observations are averaged, after converting to face left, and coordinates are computed based on the averaged angles.

When collecting multiple foresight points, and the horizontal circle is changed between sets, you must record a complete set of foresight observations and a backsight observation for each change in the horizontal circle, otherwise the average angle calculated will not be correct.



a) LIB

The LIB function allows codes to be selected from the point code library.
Press the function key, and a pick list of layers will be displayed. Pick a layer from the list and the codes for that layer will be displayed.

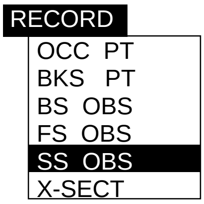
Codes can be selected by pressing the key shown beside the code on the numeric keypad or by using the arrow keys to highlight the required code, followed by pressing [ENT] key. The code will be automatically placed in the point code field.

b)FACE

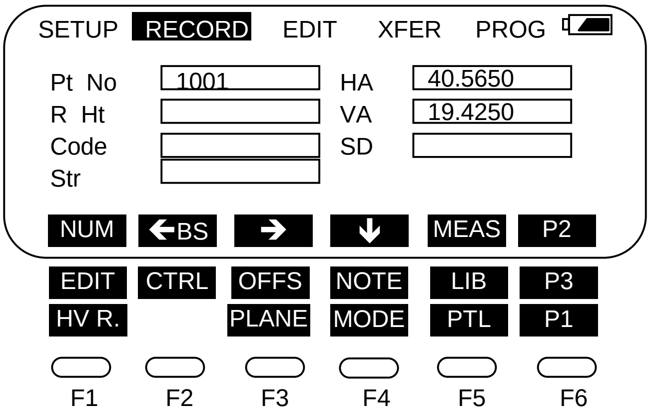
When the Face option is selected the GTS-800 will reverse the face, and after each observation automatically rotate to previous point in the set by using servomotor. When observations have been made to all points in the set it will point to the backsight point.

8.3 Side Shot Observations (SS OBS)

The side shot (intermediate site) option allows recording of points with automatically incrementing point numbers.



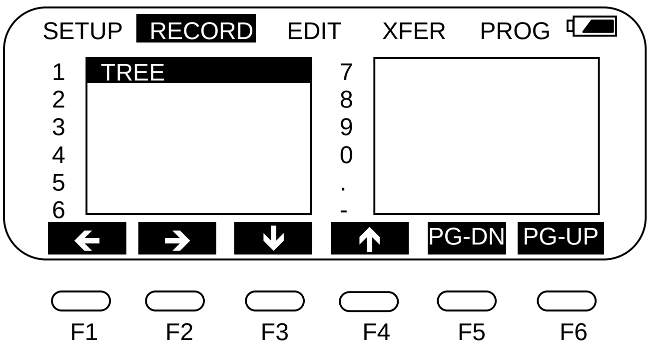
Side shot observations are not averaged and coordinates are computed using the last recorded backsight angle (converted to face left).



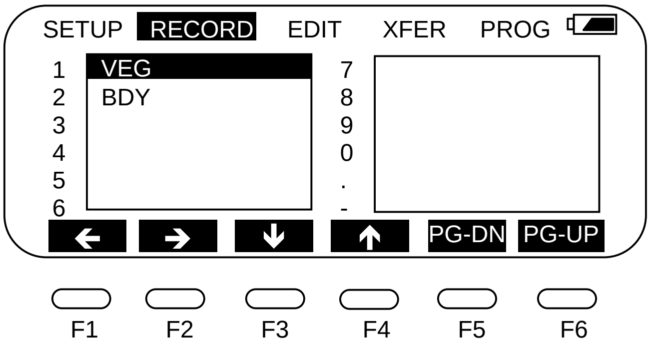
After the observation is stored the measure screen will appear again with the point number incremented and ready for the next observation. Code and reflector height default to the values used for the previous point. This allows single key press operation for measurement and recording, but requires point number, code and reflector height to be entered before measurement.

a) LIB

The [LIB] function allows codes to be selected from the group (or layer). Press the function key labeled [LIB], and select a layer from the list displayed.



Use the arrow keys to choose the required layer. When the layer you wish to use is highlighted, press [ENT] key and move to the screen selecting code.



Then a second list containing codes for that layer are displayed. Select the code from this list. Use the arrow keys to choose the required code. When the code you wish to use is highlighted, press [ENT] key to select the code and return to the measure screen. The code will be automatically placed in the point code field. And string number will be updated with the last string used for that code.

b) EDIT

The [EDIT] function is the same as the RAW of the EDIT menu.
See 10.1 Raw Data.

c) CTRL

This function activates the control screen and allows you to enter a string control or additional code for a point. The control string and additional code relates to your personal computer software package.

d) OFFS

Select [OFFS] to add an offset to the recorded observation. To record an offset observation, first use the [MEAS] to record the target position. (Do not press [ENT] key). Then press [F6] to display the page two menu, and select [OFFS].

When the offset screen is displayed the function key labels [HORZ] and [VERT] are displayed. To compute an offset aim at the offset position and press [HORZ] or [VERT] for the software to compute the offset.

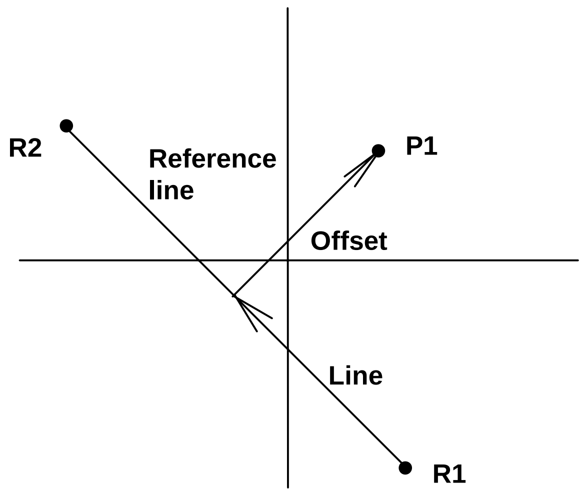
You may manually enter a positive distance away from the measured point, or a negative distance towards the instrument on the line of sight. Press [ENT] key when the offset screen is completed.

In case of measuring in 'PTL mode', the following text will be displayed when [OFFS] is selected: 'Orientation of offsets. Rel to ref or line of sight?'. Two kinds of offsets can be chosen:

1. [REF] (F5): An offset parallel to the reference line, an offset perpendicular to the first offset and an offset in vertical direction. Enter manually the offsets and press [ENT] key.
2. [SIGHT] (F6): An offset in the direction of the line of sight of the total station, an offset perpendicular to the first offset and an offset in vertical direction. This screen is identical to the offset screen when 'PTL mode' is not selected.

e) PTL

A point to line measurement (PTL) will indicate line, offset and elevation of a point.

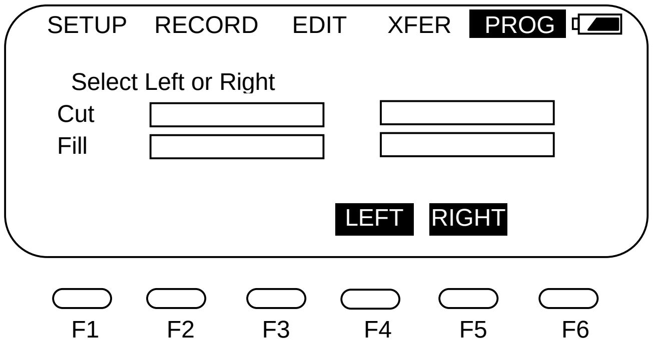


A reference line is defined by the points R1 and R2. The point to line measurement of P1

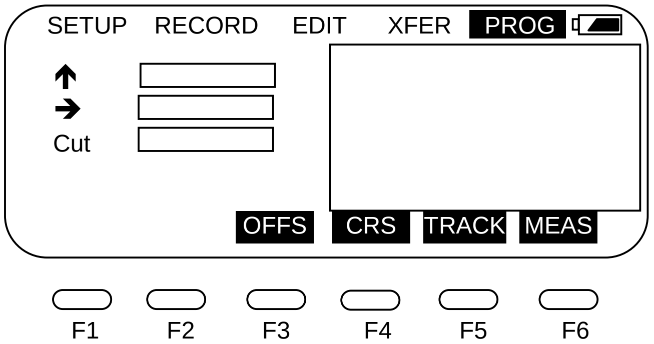
The left and right slopes may be entered for both cut and fill. Enter the required slopes using positive numbers for both cut and fill. The software selects the appropriate slope from the table depending on whether the situation is on the left or right and in cut or fill.

Cut or fill is determined by the estimated level at the offset of the hinge point. If the level is above the level of the hinge then the cut slope is used, otherwise the fill slope is used.

Press [ENT] key to accept this data.

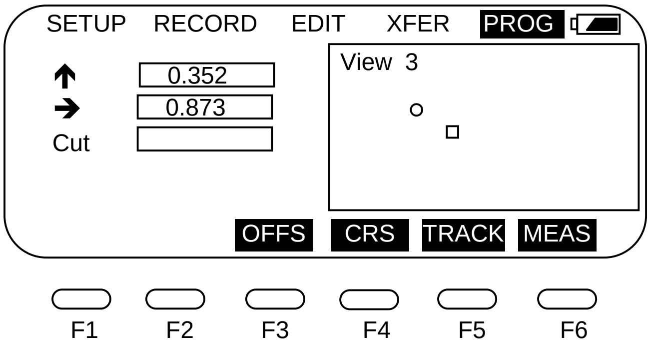


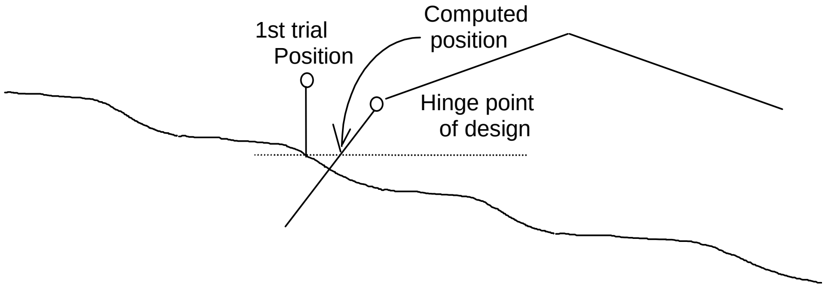
Then select [LEFT] or [RIGHT].



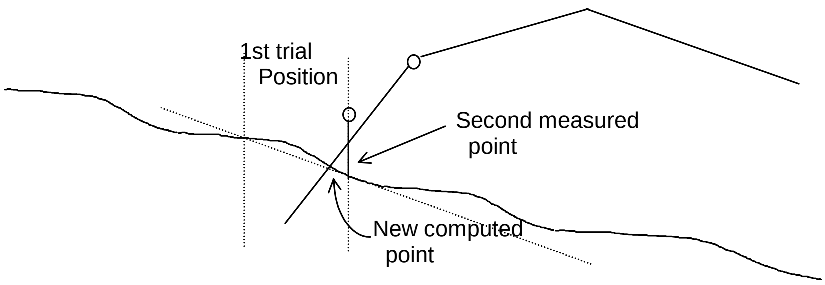
Select [OFFS] and change to offset display. Angle display is not updating when slope setting out. Sight a point near where it is estimated the slope will intercept and press [MEAS] to take the first trial shot. The appropriate slope is selected from the data entered in the preceding step. The first intercept is computed assuming a horizontal surface at the level of the measured point.

The offset from the measured point to the computed point is displayed.





Take a second shot at the computed point. A new point is computed based on the intersection of a line joining the two measured points and the slope. The offset to the newly computed point is displayed.



Further observations will refine the surface approximation and the computed offsets will become close to zero.

NOTE

1. A ground surface cannot be computed if the same point is measured twice
2 An intersection cannot be computed if the ground surface passes through the hinge point.
3. The cut is not displayed because the cut at the computed point is zero.
4. The ANGLE display cannot be used.

13 Traverse Adjustment

To adjust a traverse select TRAV from the program (PROG) menu.

The Bowditch (compass rule) adjustment method is used to adjust a recorded traverse. The traverse is defined by entering start and end points and the intermediate points are determined from foresight observations.

The XYZ file should be ON for the TRAV calculation. (See JOB OPTN.)

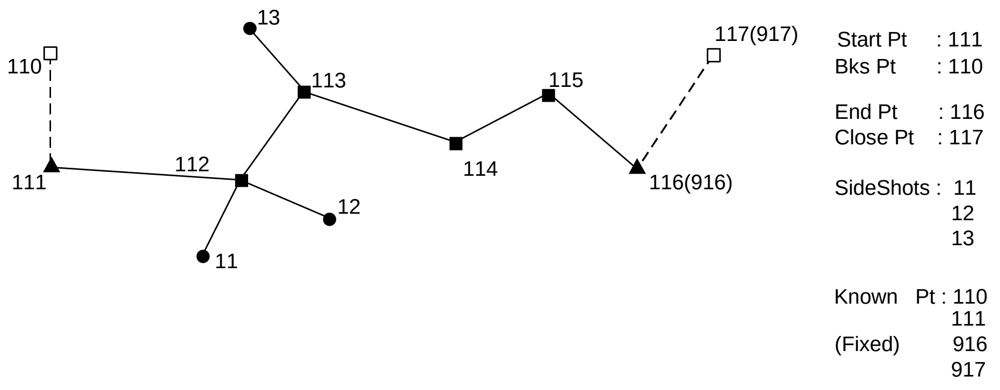
PROG
SET OUT
ROADS
TRAV
COGO
BUILD
MONITOR

The coordinates for the start and end points must be known. If the traverse is a loop traverse then the start point will also be the end point.

If the coordinates of the initial BKS PT are known, the software calculates the bearing from the point data.

The foresight option must be used to record observations to the traverse points and the observed end point must have a different point number to the known point. The known point can be stored in either the fixed point library or the job file.

To adjust angles the end point must be occupied and a known point observed to measure the closing angle. The point number used for this observation must be different from the known point also.

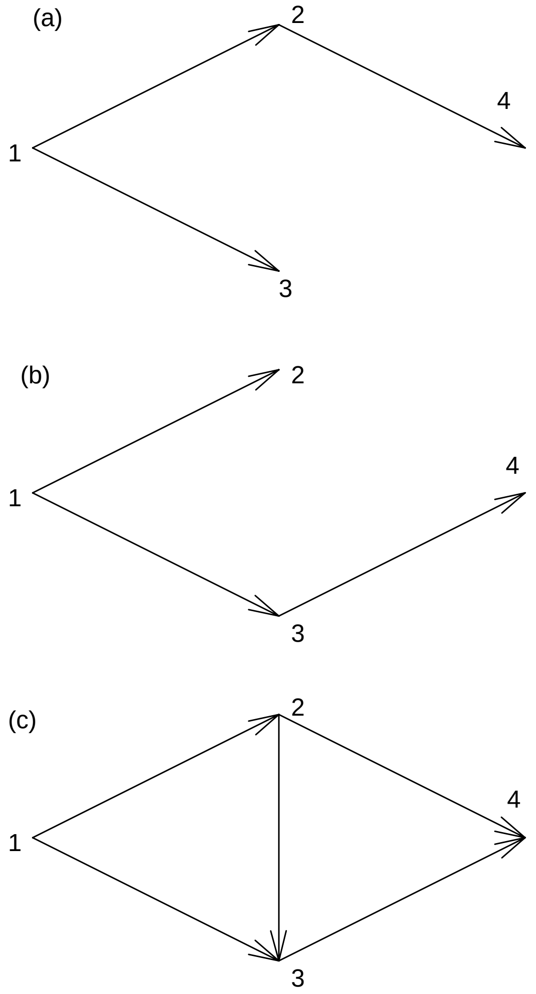


Traverse Sample Data

After entering the start and end points the program searches the data file to determine the traverse path.

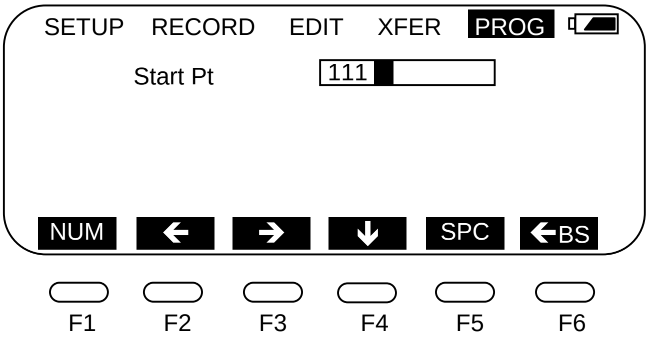
The traverse path is determined by the order of stations occupied. At each traverse point the program searches for a foresight observation to the next occupied station. If one is found this becomes the next traverse point. If none is found the traverse ends.

If more than one foresight point is observed from a station, the next traverse point is the one occupied first.

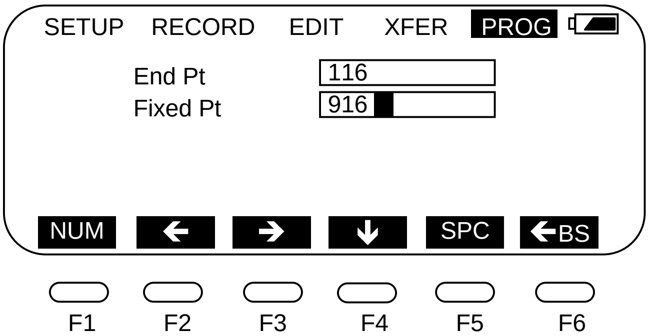


Traverse Route

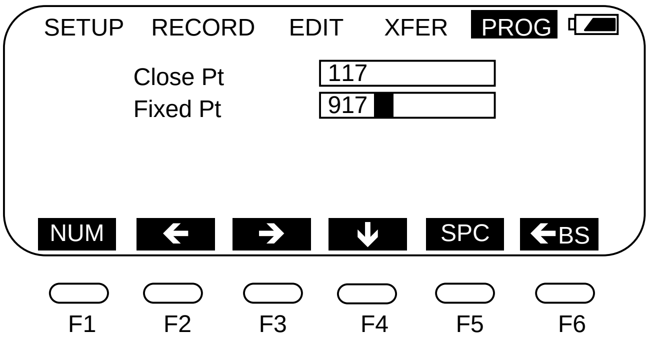
For example if the four points 1, to 4 are occupied in the order of the point numbers shown in the diagram, then for Diagram (a). the path will be 1,2,4.
If the points are occupied as shown in Diagram (b), the traverse will end at point 2, even though there is a link from 3 to 4.
If redundant observations are made as in Diagram (c), the path becomes 1,2,3,4.



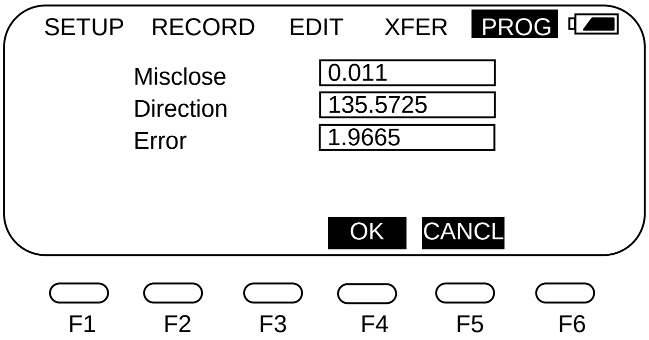
When the traverse adjustment is selected the start point screen will be displayed. Enter the traverse start point.



If the start point is valid the end point screen will be displayed. Press [ENT] key to move the cursor to the next option. Enter the observed point number for the end point of the traverse (End Pt), and a point number with known coordinates for the end point (Fixed Pt). These point numbers must not be the same. Press [ENT] key when the cursor is on the bottom line of the screen to exit and save the settings.

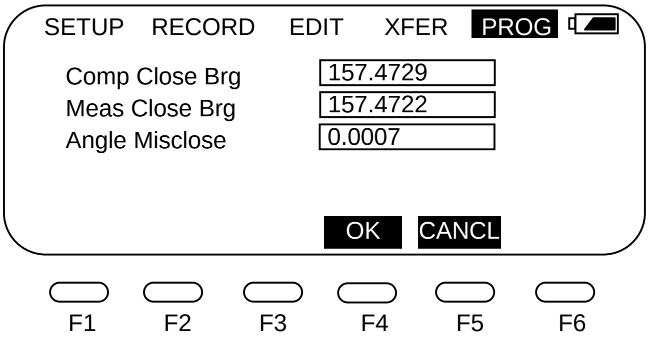


If the end point has been occupied then the closing point screen is displayed. For angles to be adjusted you must enter a point number that has been observed from the end point, and for which there is a known coordinate. Enter the observed point number (Close Pt) and the known point number (Fixed Pt). These point numbers must not be the same.
Press [ESC] key if you do not want to adjust the angles.



The calculated misclose will be displayed.

Select [OK], if the error is acceptable.



If close point is entered, the above screen is displayed.

Press [OK], if you accept the angle misclose.

You may then adjust the coordinates of the traverse points.

Press [ENT] key or [OK] when prompted; "Adjust Angles?" to adjust the angles or press [ESC] key to continue.

Press [ENT] key or [OK] when prompted "Adjust Coord?" to perform the adjustment, or press [ESC] key to return to the menu without further changes.

Press [ENT] key or [OK] when prompted "Adjust Levels?" to adjust the levels or press [ESC] key to return to the menu without making further changes.

Press [ENT] key or [OK] when prompted "Adj Side Shots?" to adjust Side Shots or press [ESC] key to return to the menu without making further changes.

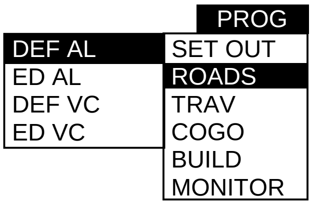
14 Roads

The Road menu contains the alignment design functions.

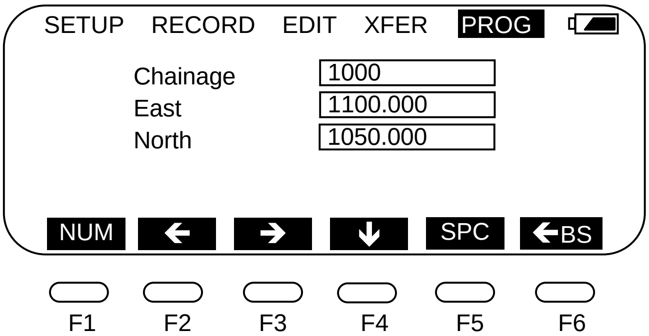
14.1 Define Alignment

To define an alignment select DEF AL from the ROADS menu.

If you want to know how to calculate an alignment, please see Appendix D.

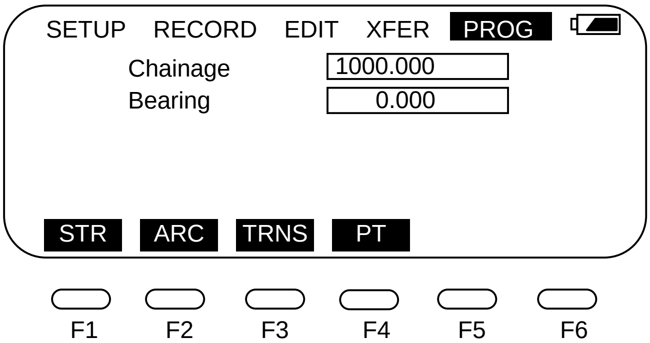


The alignment consists of a set of elements, made up from a start pt, pt, straight, arc or spiral. The define option will prompt for the start details and then continue to the main input routine.



The start element consists of the starting chainage and the easting and northing of the start point. Enter these details in the screen.

Press [ENT] key to move the cursor to the next option. Press [ENT] key when the cursor is on the bottom line of the screen to exit and save the settings. Press [ESC] key to exit the screen without saving the settings.

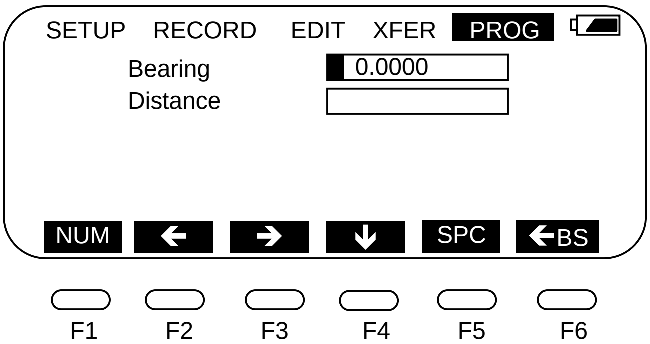


The main input screen will be displayed. It consists of the current chainage and bearing, with function keys to create new elements. Select from [STR] (straight), [ARC] (arc), [TRNS] (spiral transition) and [PT] (point). Select one of the function keys, and enter the details to create each element in the alignment. Press [ENT] key and the program computes the new chainage and bearing and returns to the main alignment screen. Continue entering elements to define the alignment.

Press [ESC] key to exit to the menu. To make changes to a previous element you must go to the edit alignment option.

New elements can only be added to the end of the file.

STR (Straight)



A straight consists of a bearing and distance.

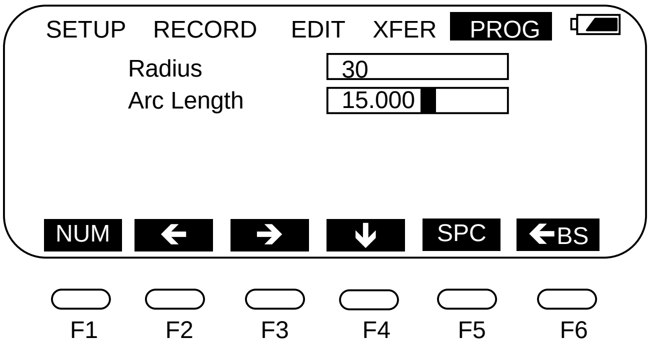
The exit bearing of the previous element is shown as the default bearing.

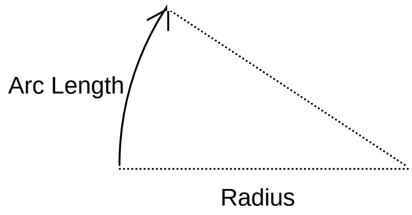
Enter a new bearing if you want to change it.

Enter the distance of the straight line.

Press [ENT] key to move the cursor to the next option. Press [ENT] key when the cursor is on the bottom line of the screen to exit and save the settings. Press [ESC] key to exit the screen without saving the settings.

ARC

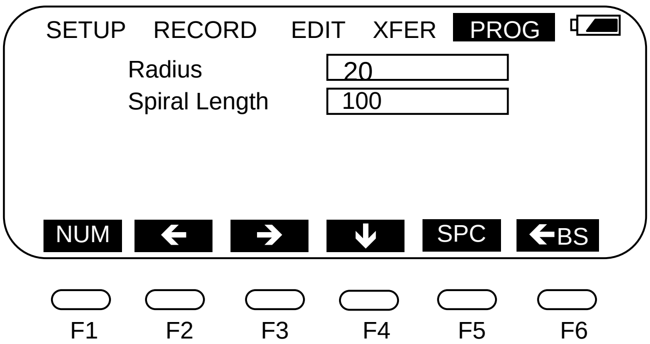


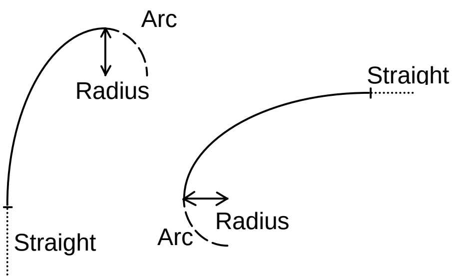


ARC

An arc consists of the radius and arc length. A positive radius is to the right, and a negative radius is to the left. Press [ENT] key to move the cursor to the next option. Press [ENT] key when the cursor is on the bottom line of the screen to exit and save the settings. Press [ESC] key to exit the screen without saving the settings.

TRNS (Transition)

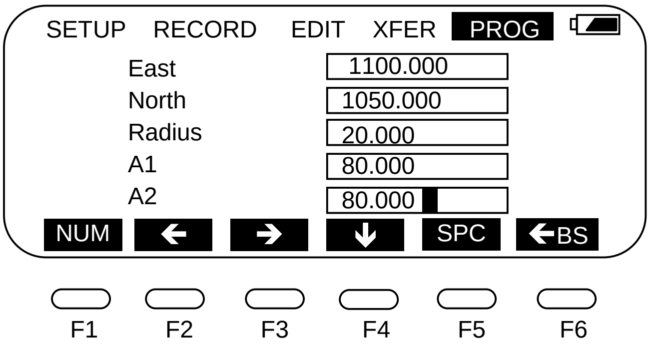


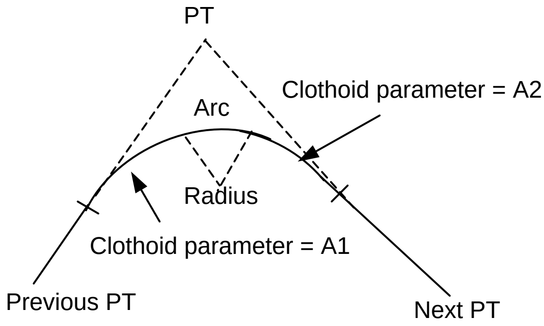


Transition

A transition consists of the spiral length and minimum radius. A positive radius is to the right and a negative radius is to the left. Whether a transition is an entry or exit spiral depends on the previous element. If the spiral follows a straight then it begins tangential to the straight and ends with the minimum radius. If the spiral follows an arc it begins with the minimum radius. If a spiral follows a spiral then the direction is the reverse of the previous spiral. Press [ENT] key to move the cursor to the next option. Press [ENT] key when the cursor is on the bottom line of the screen to exit and save the settings. Press [ESC] key to exit the screen without saving the settings.

PT (Point)





Point

A point element consists of coordinates, radius and clothoid parameter A1,A2.
The bearing and distance from the previous element are calculated.
If radius is entered, an arc is inserted with the specified radius.
If clothoid parameter A1 or A2 is entered, a clothoid is inserted between straight and arc with the specified length. Press [ENT] key to move the cursor to the next option. Press [ENT] key when the cursor is on the bottom line of the screen to exit and save the settings. Press [ESC] key to exit the screen without saving the settings.

NOTE: When you want to enter A1, A2 from clothoid length L1, L2, the following equations are used;

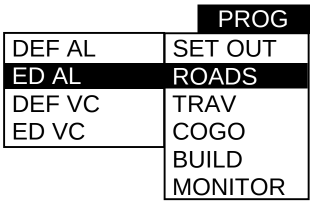
$$A1 = \sqrt{L1 \cdot Radius}$$

$$A2 = \sqrt{L2 \cdot Radius}$$

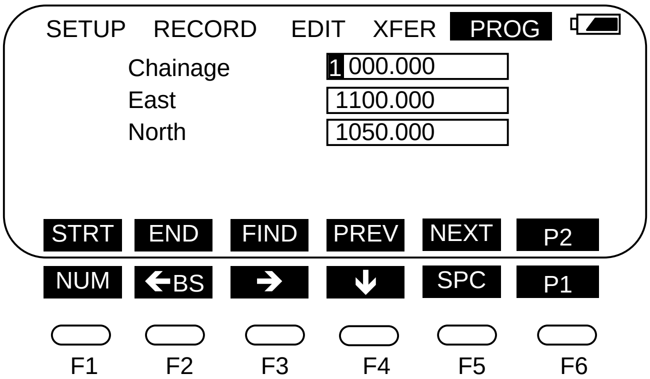
Any changes to the alignment must be done using the edit alignment option.

14.2 Edit Alignment

To edit the alignment select ED AL from the ROADS menu.



The alignment file may be edited by over-typing existing data similar to editing the raw data file.



Use [NEXT] and [PREV] to move between elements.

Use [STRT] and [END] to go to the start or end of the file.

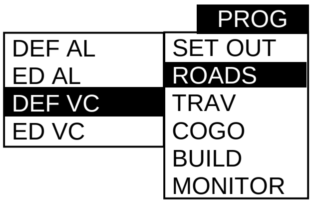
Use [FIND] to locate an element by chainage. Enter the required chainage. The program will search for the element that covers the nominated chainage.

Any of the displayed data may be changed. Press [ENT] key to move the cursor to the next option. Press [ENT] key when the cursor is on the bottom line of the screen to exit and save the settings. Press [ESC] key to exit the screen without saving the settings.

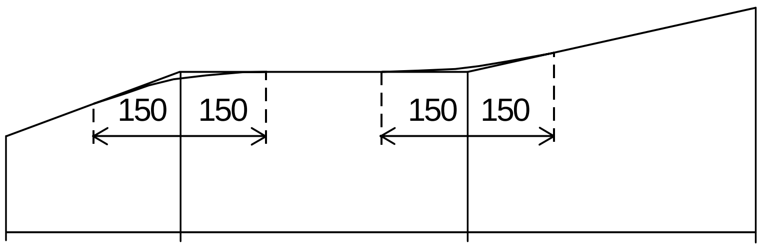
New elements must be added using the DEF AL option.

14.3 Define Vertical Curve

Select DEF VC to define a vertical curve.

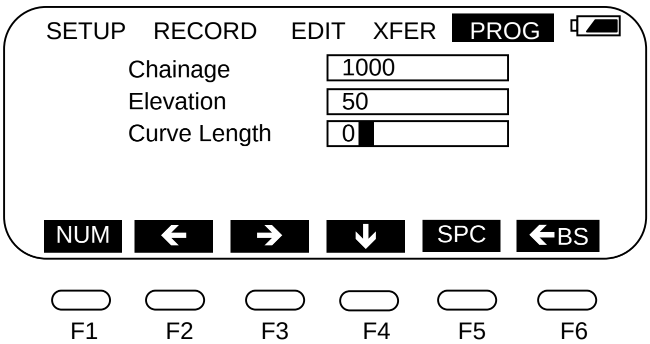


A vertical curve consists of series of IP's (intersection points). The IP element consists of a chainage, level, and curve length. The start and end IP's must have a zero curve length.
An elevation is calculated by symmetric curve length.



Chainage	1000	1300	1800	2300
Elevation	50	70	70	90
Curve Length	0	300	300	0

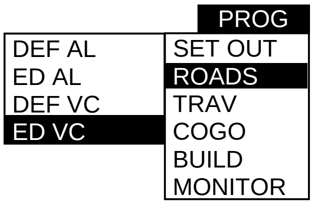
Vertical Curve



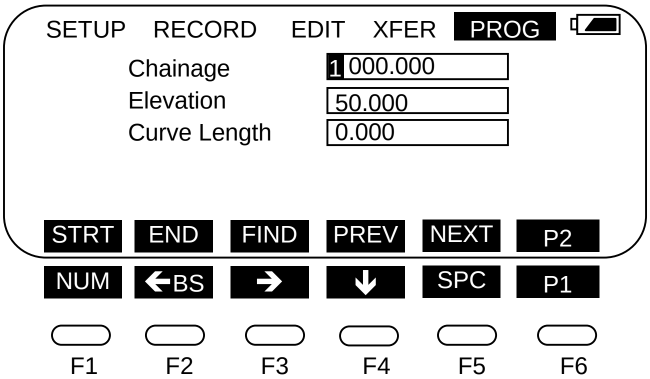
IP's may be entered in any order. To insert an IP into an existing file select DEF VC then add the new IP. It will be inserted into the correct position in the file.
Press [ENT] key to move the cursor to the next option. Press [ENT] key when the cursor is on the bottom line of the screen to exit and save the settings. Press [ESC] key to exit the screen without saving the settings.

14.4 Edit Vertical Curve

To edit a vertical curve file select ED VC from the roads menu.



IP's in an existing vertical curve may be edited by over-typing the displayed data, similar to editing the raw data file.



Use [STRT] and [END] to go to the start or end of the file.

Use [FIND] to locate an IP by chainage. Enter the chainage required.

Press [ENT] key to move the cursor to the next option. Press [ENT] key when the cursor is on the bottom line of the screen to exit and save the settings. Press [ESC] key to exit the screen without saving the settings.

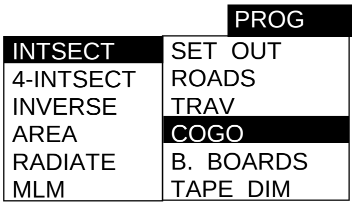
The program will search the file for the element and its position at the IP with that chainage if it exists or the IP after if none exists. New IP's must be added with the DEF VC option.

15 Cogo

The COGO menu contains a number of coordinate geometry functions.

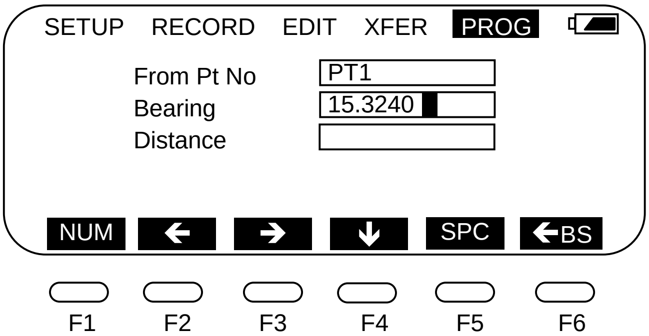
15.1 Intersection

Select INTSECT from the COGO menu.



The coordinate for a point can be computed by the intersection of two known bearings, a bearing and distance or two distances.

When the option is selected the intersection screen will be displayed.



Enter the point number in the From Pt No field and enter a bearing or distance in the appropriate field. Press [ENT] key to move the cursor to the next option. Press [ENT] key when the cursor is on the bottom line of the screen to exit and save the settings.

Enter the same details for the second bearing.

Press [ESC] key to exit the screen without saving the settings.

If there is no intersection point the message “No Intersection” will be displayed.

If an intersection can be computed, the points coordinate screen will be displayed.

Change Pt No or add Elev and Pt code as you like.

Press [ENT] key to save the point in the coordinate file. Press [ESC] key to omit saving.

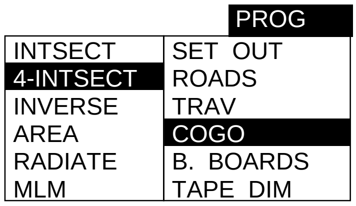
If there are two intersection points, the software shows the message “Two Points” and displays these coordinates sequentially.

NOTE:

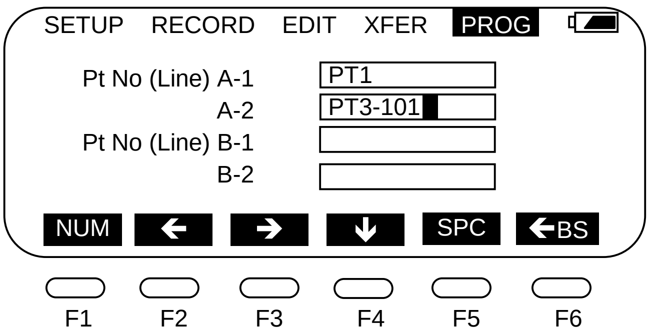
1. If both bearing and distance are entered, the bearing is used to calculate the intersection.
2. If intersection is not in the specified bearing, the software creates the intersection point backward.
3. The intersection point cannot be saved, if the coordinates are not in the range of -9999999.999 to 9999999.999.

15.2 4-points Intersection

Select 4-INTSCT from the COGO menu.



The coordinate for a point can be computed by the intersection of four known points. When the option is selected the intersection screen will be displayed.



Enter the point number in the Pt No field. Press [ENT] key to move the cursor to the next option. Press [ENT] key when the cursor is on the bottom line of the screen to exit and save the settings.

Press [ESC] key to exit the screen without saving the settings.

If there is no intersection point the message “No Intersection” will be displayed.

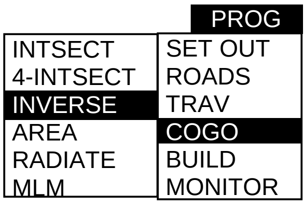
If an intersection can be computed, the points coordinate screen will be displayed.

Change Pt No or add Elev and Pt code as you like.

Press [ENT] key to save the point in the coordinate file. Press [ESC] key to omit saving.

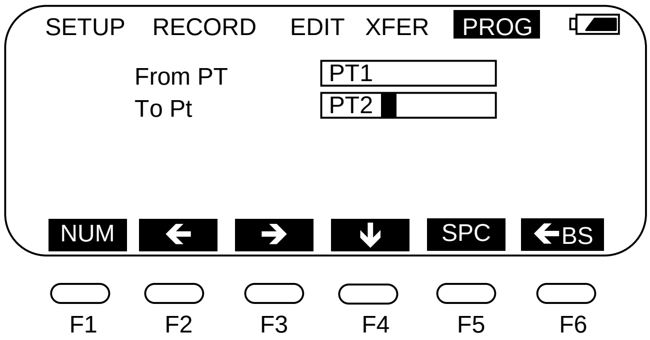
15.3 Inverse

To compute an inverse select INVERSE from the COGO menu.



The inverse option computes bearing and distance between two points.

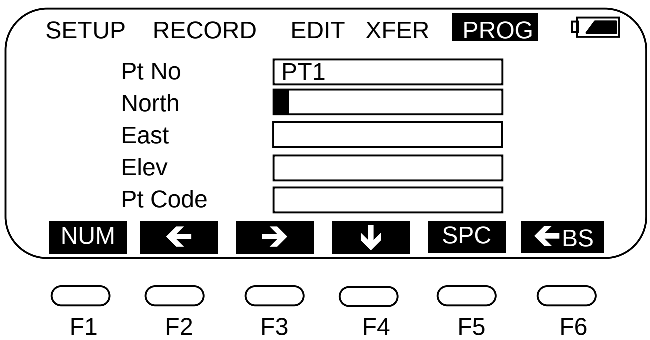
When the option is selected the inverse screen will be displayed.



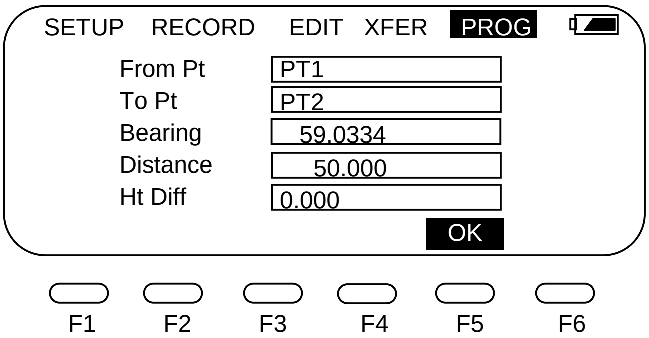
Enter the two points numbers in the From Pt and To Pt fields of the screen.

Press [ENT] key to move the cursor to the next option. Press [ENT] key when the cursor is on the bottom line of the screen to exit and save the settings. Press [ESC] key to exit the screen without saving the settings.

If the coordinates for both points are known then the screen will show the computed bearing and distance. If the coordinates for either point are not known they must be entered manually before the bearing and distance can be computed.



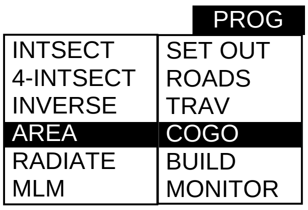
Press [ENT] key to move the cursor to the next option. Press [ENT] key when the cursor is on the bottom line of the screen to exit and save the settings. Press [ESC] key to exit the screen without saving the settings.



If the initial point is occupied, “H Angle” is shown instead of “Bearing” and the scale factor defined under the SETUP function will be used in the calculation of distances.

15.4 Area

Select AREA from the COGO menu.

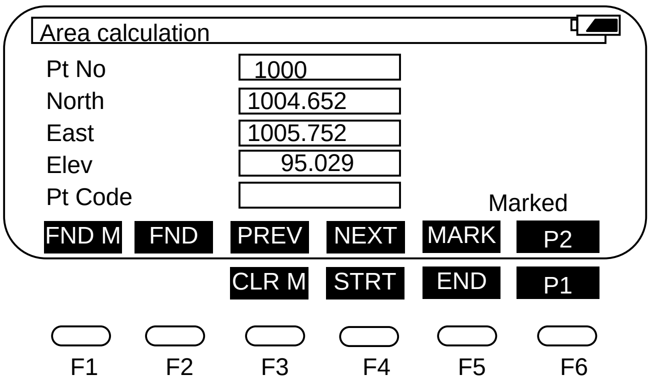


The following question is shown: “ Calculate area using specified points? “.

Press [YES] in case you want to specify which points should be used for the area calculation. Continue with 15.4.1. Press [NO] in case you want to compute the area of a figure enclosed by points with a common coding. Continue with 15.4.2.

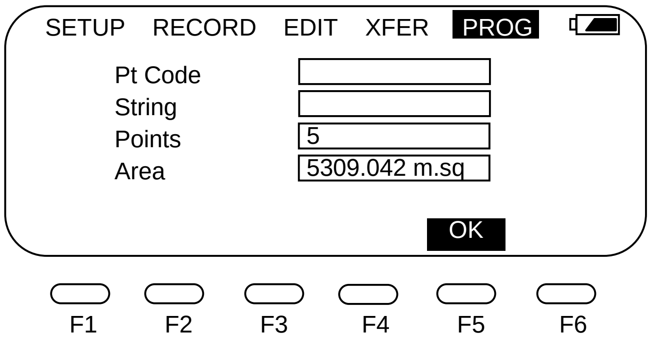
15.4.1 Area using specified points

An area can be calculated by marking at least 3 points. The following screen is shown:



By pressing [MARK], a point can be marked. The text “ Marked “ will appear below right on the screen. Pressing [MARK] again results in unmarking this point (the text “ Marked “ will disappear). [FND M] means find next marked point; a point which has a higher point number and which has been marked will be shown. All the other features are also used in EDIT, POINTS, which has been discussed in paragraph 10.2.
Press [CLR M] to clear all Marks.

After at least 3 points have been marked and an area calculation is required, [ENT] key can be pressed to display this area.



The number of points marked and the enclosed area are displayed. Usually “m.sq”(m^2) or “ft.sq”(ft^2) is used as a unit for the area. If the area is larger than 10000 m.sq then the unit is changed to Ha (hectare). The unit is changed to Ac (acre) if the enclosed area is 43560 ft.sq or more.

NOTE:

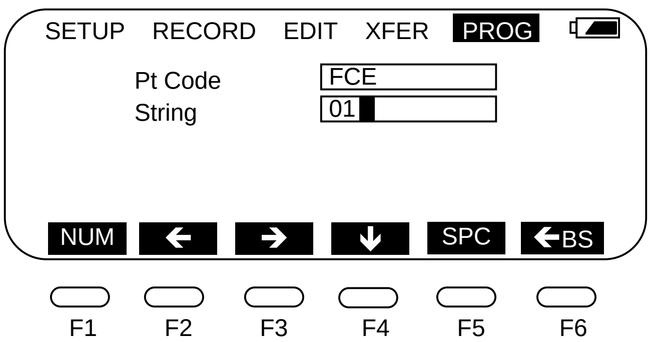
1. Area is not calculated correctly if enclosed lines cross each other.
2. If less than three points are found which have been marked the software will show the message “3 Pts required!”.
3. Point numbers and their coordinates and code are shown on the screen, but they cannot be edited.
4. The function [FND M] will show a point which has a higher point number and which has been marked. So in order to see all marked points, one first has to choose [STRT] and then several times [FND M] until the text “ Pt Not Found “ is shown.

15.4.2 Area using code

The area of a figure enclosed by points with a common coding can be computed. When recording the points observe them in the correct sequence and give each point the same point code (and string number combination).

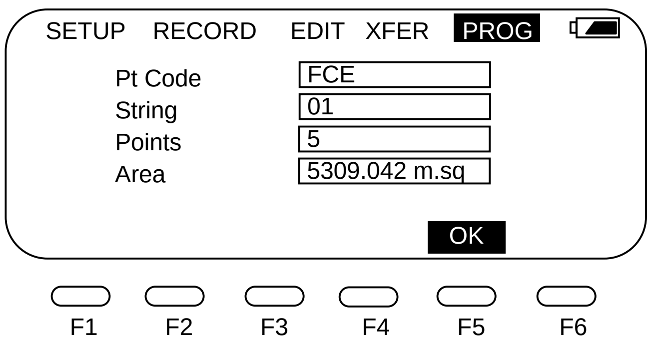
No other points should have this combination, but other points can be observed in between.

When the option has been selected the string code screen will be displayed.



Enter the required point code (and string number). Press [ENT] key to move the cursor to the next option. Press [ENT] key when the cursor is on the bottom line of the screen to exit and save the settings. Press [ESC] key to exit the screen without saving the settings.

The computed area will then be displayed.



The number of points and enclosed area are displayed.

Usually "m.sq"(m^2) or "ft.sq"(ft^2) is used as a unit for the area.

If the area is 10000 m.sq or more then unit is changed to Ha (hectare).

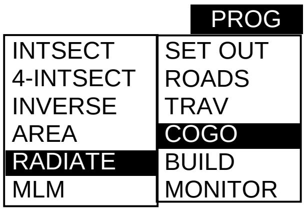
The unit is changed to Ac (acre) if the enclosed area is 43560 ft.sq or more.

NOTE:

1. Area is not calculated correctly if enclosed lines cross each other.
2. If less than three points are found in the raw file with the specified Pt Code and String, the software shows the message "3 Pts required!".

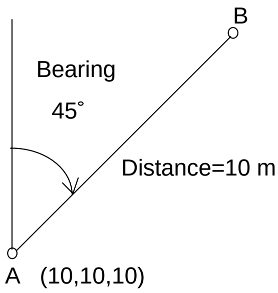
15.5 Radiation

Select RADIATE from the COGO menu.

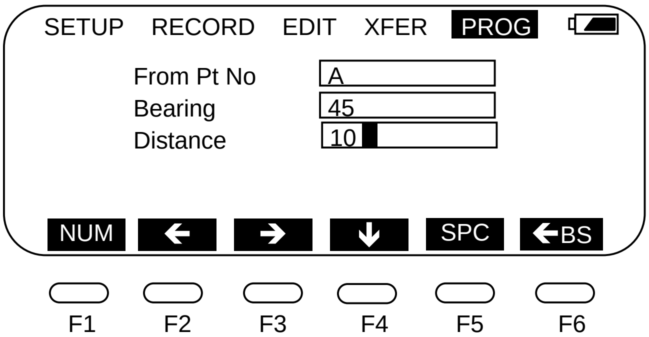


The coordinate for a point can be computed by entering the Bearing and Distance.

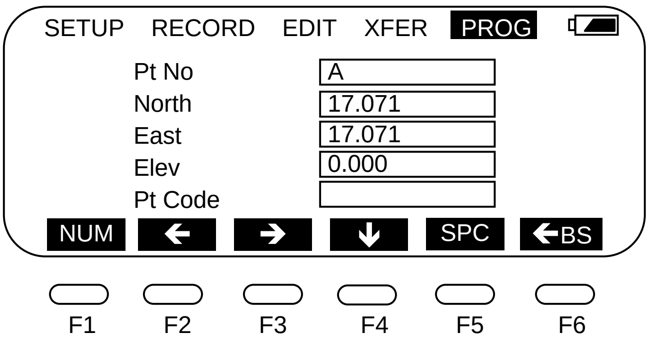
example;



In case of the above, enter as follows;



The result of the calculation;

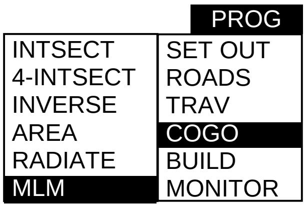


Elevation can not be computed. Enter the elevation manually. The result of the calculation is recorded to the coordinates file (POINTS).

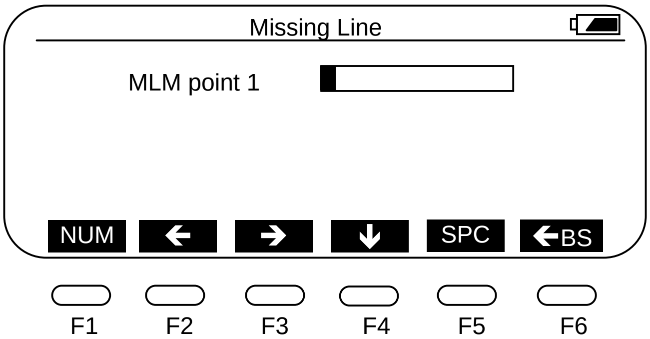
15.6 Missing Line Measurement

This function can be used to calculate the length of a line by measuring the start and end point of this line.

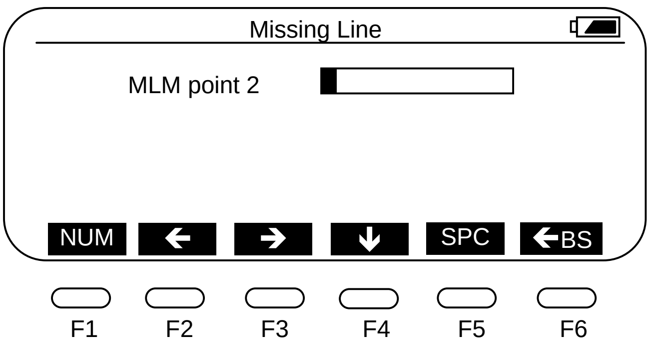
Select MLM from the COGO menu.



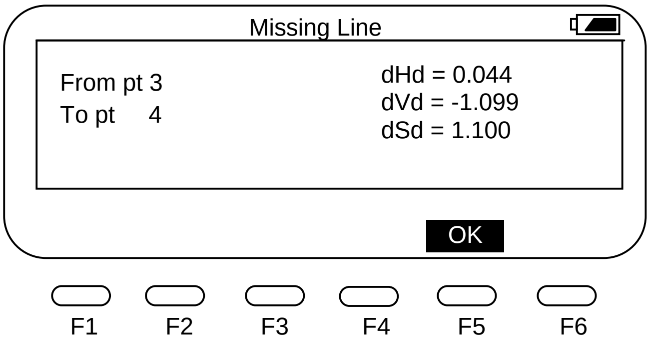
Next the number of the start point of the line should be entered.



Enter this number and press [ENT] key. If this point number does not yet exist, the SS OBS screen will be shown and a measurement must be performed. Next the number of the end point of the line should be entered.



Enter this number and press [ENT] key. Again, if this point number does not yet exist, the SS OBS screen will be shown and a measurement must be performed. In the next screen the results will be displayed. At the left side the two point numbers of the missing line are displayed. At the right sight the horizontal distance (dHd), the vertical distance (dVd) and the slope distance (dSd) are shown.



Press [OK] to return to the menu.

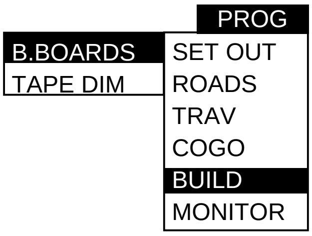
NOTE:

1. dVd is defined as the height of the second point minus the height of the first point. Due to this reason dVd can be negative. dSd is defined as the length of the missing line, dHd is defined as the length of the projected missing line in the horizontal plane. dSd and dHd are always positive.
2. The calculated data is stored in the raw data file.

16 Batterboards

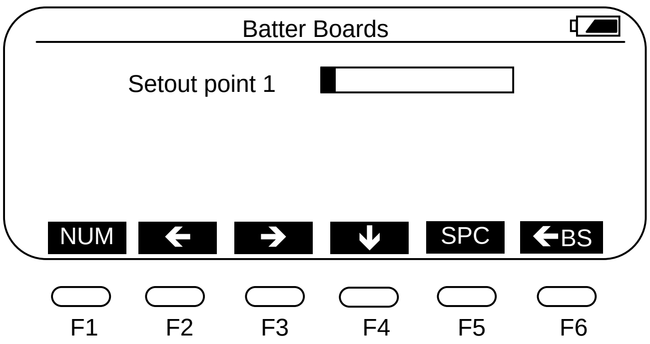
When setting out points, particularly for building plots, it is usually necessary to mark a point with an offset so that the point can be re-established after work has been carried out in the work area. In this case batterboards can be used: the intersection point (of a batterboard and the line that connects two points that have to be set out) can be marked. Later, the intersection points are used by pulling a string line between these points. In this way, the required points can be reconstructed.

Select B. BOARDS from the BUILD menu.



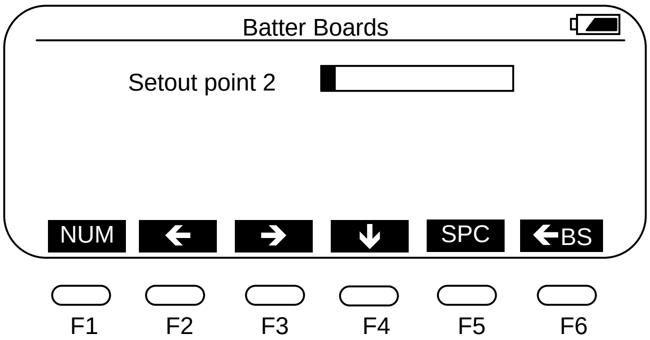
In case the occupied point has not been defined, the program will automatically show the Occupied Point Input screen, which is described in paragraph 7.1. If the backsight point has not been defined, the program will automatically show the Backsight Point Input screen, which is described in paragraph 7.2.

The first setout point is now required. Enter the number of this setout point and press [ENT] key.



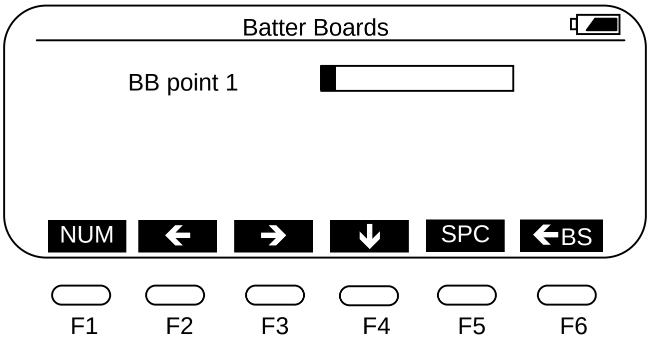
If this point is not known, the program will ask for its coordinates.

Next the second setout point is required. Enter the number of the second setout point and press [ENT] key.

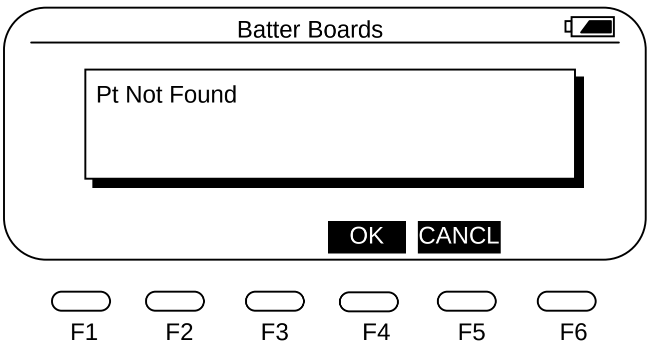


If this point is not known, the program will ask for the coordinates of the second setout point.

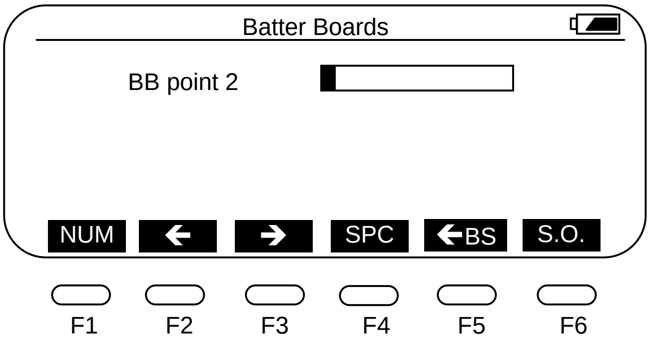
Now one side of the batterboard should be measured (it doesn't matter whether this is the right or the left side of the batterboard). Position the reflector above this side of the batterboard, enter a number for this point (BB point 1) and press [ENT] key.



If this point is not known, the text 'Pt Not Found' is displayed. Press [CANCL] to re-enter the first batterboard point number or [OK].



By pressing [OK] the side shot observation screen is shown, which is explained in paragraph 8.3. Press [ENT] key to measure the first batterboard point. Next the following screen is shown.



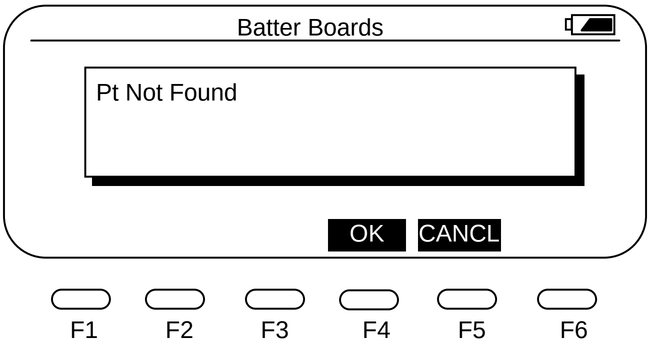
There are two ways to proceed:

1. A method using two sides of the batterboard. The user is advised to use this method in case high accuracy is required, control of the measurements is required or one batterboard is used to mark more than one intersection point. Continue in paragraph 16.1.
2. A method using one side of the batterboard. The user is advised to use this method in case a quick method is required. Continue in paragraph 16.2.

16.1 Batterboards using two sides

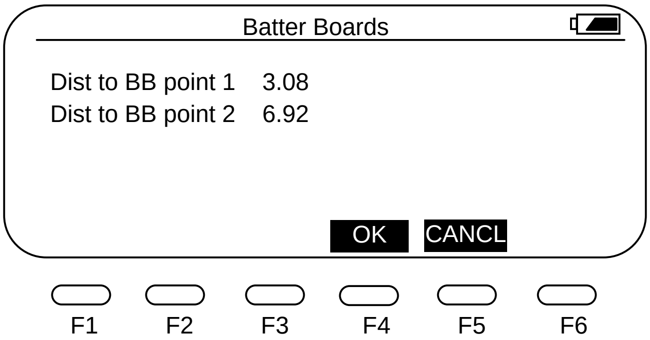
The other side of the batterboard should now be measured. Position the reflector above this side of the batterboard, enter a number for this point (BB point 2) and press [ENT] key.

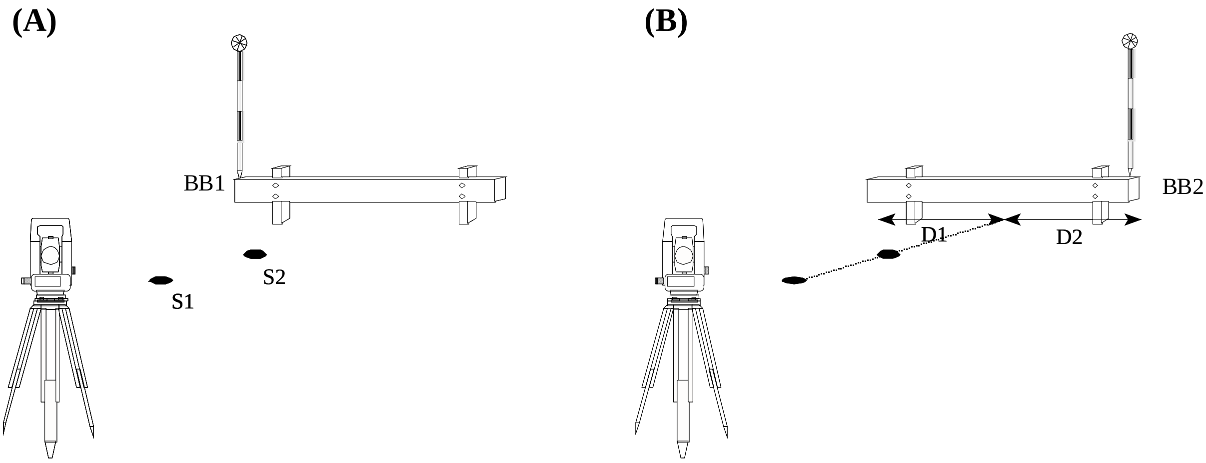
If this point is not known, the text ‘Pt Not Found’ is displayed. Press [CANCL] to re-enter the second batterboard point number or [OK].



By pressing [OK] the side shot observation screen is shown. Press [ENT] key to measure the second batterboard point.

The coordinates of the intersection point (of the batterboard and the line connecting the two setout points) are now calculated. If DISPLAY XYZ is ON, these coordinates are shown and [OK] should be pressed. Next the distance from this intersection point to the first batterboard point and the distance from the intersection point to the second batterboard point are shown.





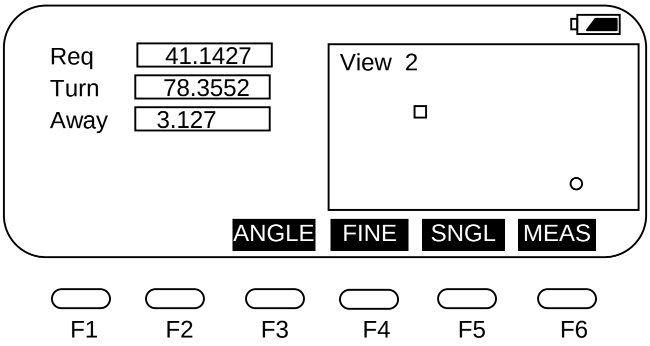
(A) *Two setout points (S1 and S2) are selected and one side of the batterboard is measured (BB1).*

(B) *The other side of the batterboard is measured (BB2). The intersection point of the batterboard and the line connecting S1 and S2 is calculated. Next, the distance (D1) from BB1 to intersection point and the distance (D2) from BB2 to intersection point are calculated.*

Now there are two possibilities:

1. Use a measuring tape to mark the intersection point on the batterboard. Press [CANCL] to leave the batterboard program.
2. Setout the intersection point. Press [OK].

If [OK] is pressed, the intersection point can be setout.



The setout of this intersection point is identical to Point Setout, which is discussed in paragraph 12.2, except for two differences:

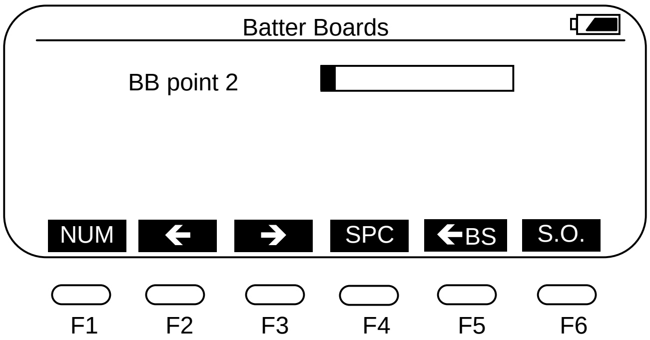
1. Automatically the intersection point is chosen for setting out.
2. CUT is not shown at the screen.

NOTE:

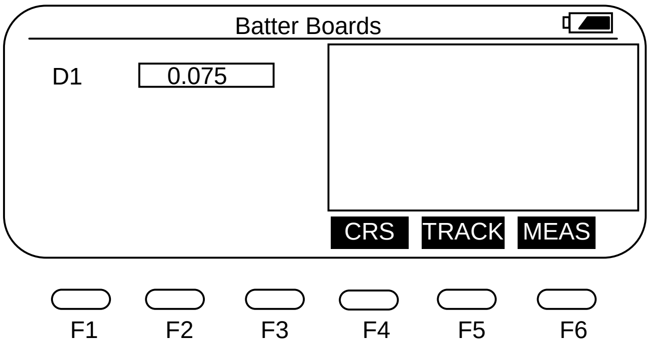
1. If the intersection point is not on the batterboard, the message 'point not on Batter Board!' is shown on the screen.
2. In case a batterboard is used twice and its position hasn't changed, it is not necessary to re-measure the sides of the batterboard. Use the same number for the sides of the batterboard.
3. The error message 'Invalid value' is shown if the batterboard and the line connecting the two setout points are parallel.
4. The coordinates of the calculated intersection point are recorded in the coordinate file. The number of this intersection point is, compared to the highest existing number, incremented by one.

16.2 Batterboards using one side

Press [S.O.] in case you want to measure only one side of the batterboard.



The following screen will be shown:



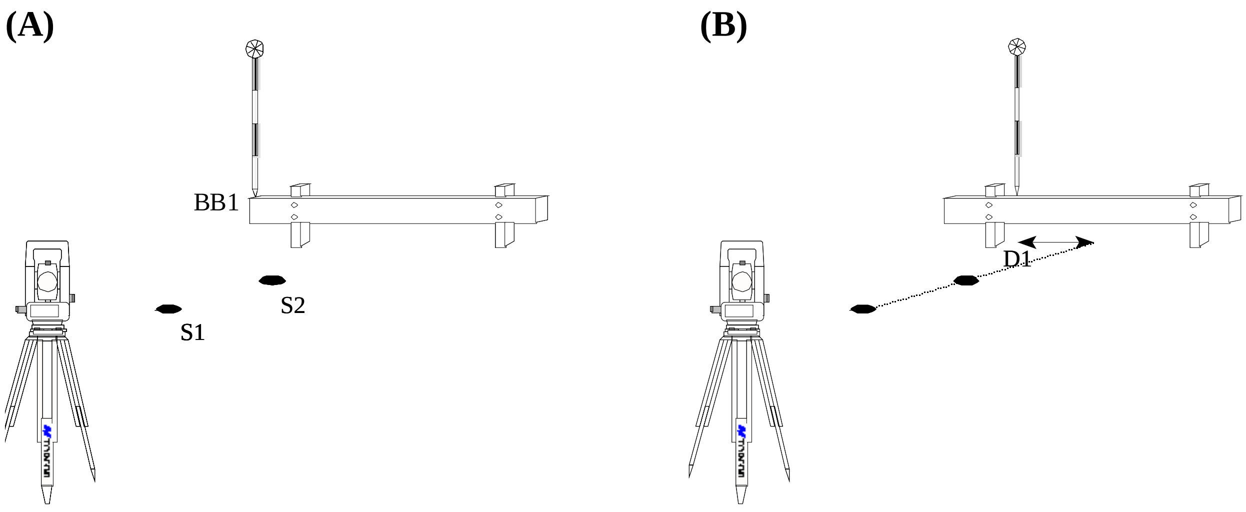
D1 indicates the distance from the pole to the intersection point. This is still an *approximate* distance. Move the pole along the batterboard and press [MEAS]. D1 now indicates a *precise* distance. The intersection point is found when D1 equals zero.

If the function key (F4) is labeled [FINE], a distance will be measured in the fine mode.

The (F4) key will toggle between [FINE] mode and [CRS] mode. [CRS] is a coarse mode.

If the function key (F5) is labeled [TRACK], a distance will be measured in the repeat mode.

The (F5) key will toggle between [TRACK] mode and [SNGL] mode. [SNGL] is single measurement mode.



(A) *Two setout points (S1 and S2) are selected and one side of the batterboard is measured (BB1). An approximate distance D1 is shown.*

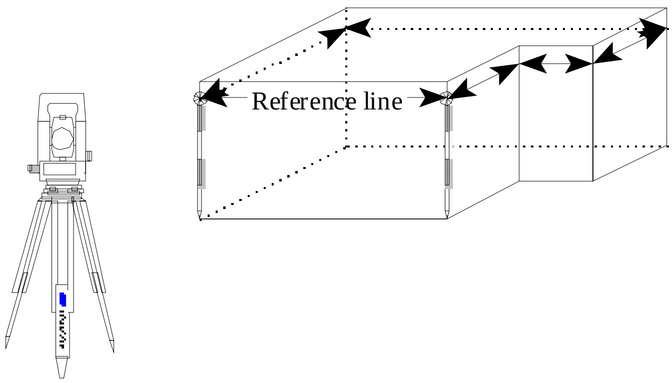
(B) *The position of the pole is changed according to the value of D1 and a measurement is performed. The distance D1 is now precise. This process has to be repeated until D equals zero in order to find the intersection point.*

NOTE:

1. After the first side of the Batterboard has been measured and [S.O.] has been selected, it is assumed that the orientation of the batterboard is perpendicular to the line connecting the two setout points. The distance D1 is calculated using this assumption. Next a second point on the batterboard is measured. From now on the distance D1 will be calculated using the correct orientation of the batterboard. D1 will now be more precise.
2. The error message 'Invalid value' is shown if the batterboard and the line connecting the two setout points are parallel.
3. The coordinates of the calculated intersection point are recorded in the coordinate file. The number of this intersection point is, compared to the highest existing number, incremented by one.

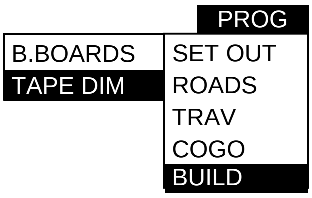
17 Tape dimensions

Tape dimension is a program which integrates surveying using a total station and a measuring tape. This program is especially useful when a quick survey of an object is required. It is assumed that all angles of this object are rectangular.

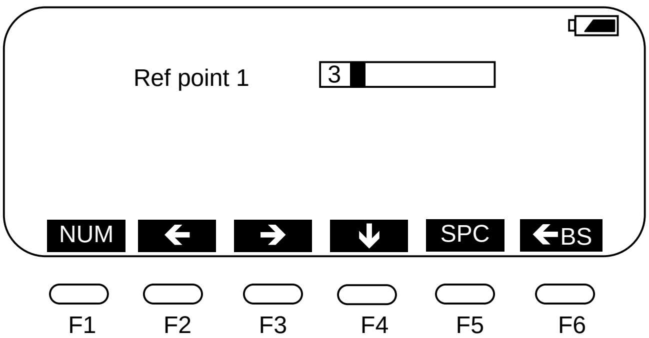


Example of measuring an object using TAPE DIM. Two corners of the object are measured using the total station and a reference line is defined. Next the other sides of the object are measured using a measuring tape. When the last side is measured, the closing error can be shown.

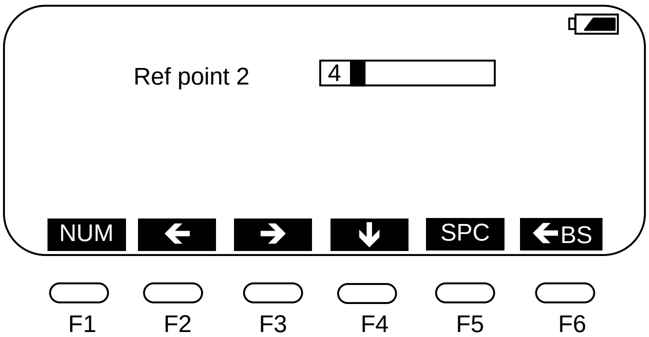
Select TAPE DIM from the BUILD menu.



First a reference line should be defined. Enter the number of the first reference point and press [ENT] key.

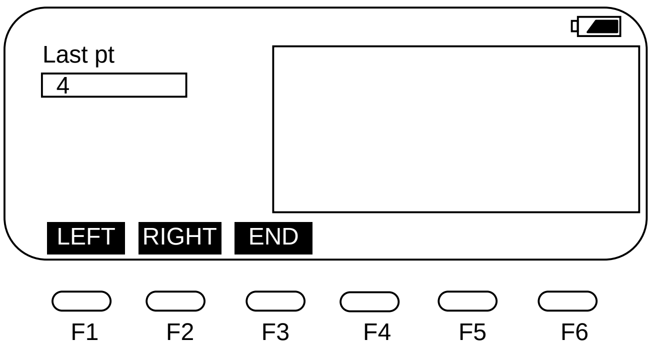


If this point is not known, the SS OBS screen will be shown and the point must be measured. Next, the number of the second reference point should be entered and [ENT] key should be pressed.

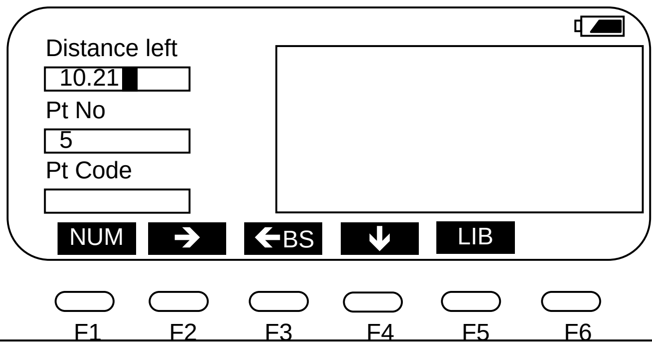


If this point is not known, the SS OBS screen will be shown and the point must be measured. The reference line has now been defined.

Now a line which starts at reference point 2 and *which is perpendicular to the reference line* can be measured using a measurement tape. If this line is at the left hand side of the reference line, press [LEFT]. If this distance is at the right hand site of the reference line, press [RIGHT].



A screen will be shown, in which the distance can be entered (in meters). Also the number of the point that will be created and its code can be defined.



If [ENT] key is pressed, the new line plus the reference line are graphically displayed.
Again [LEFT] or [RIGHT] can be pressed to create another point.

There are two ways to return to the main menu:

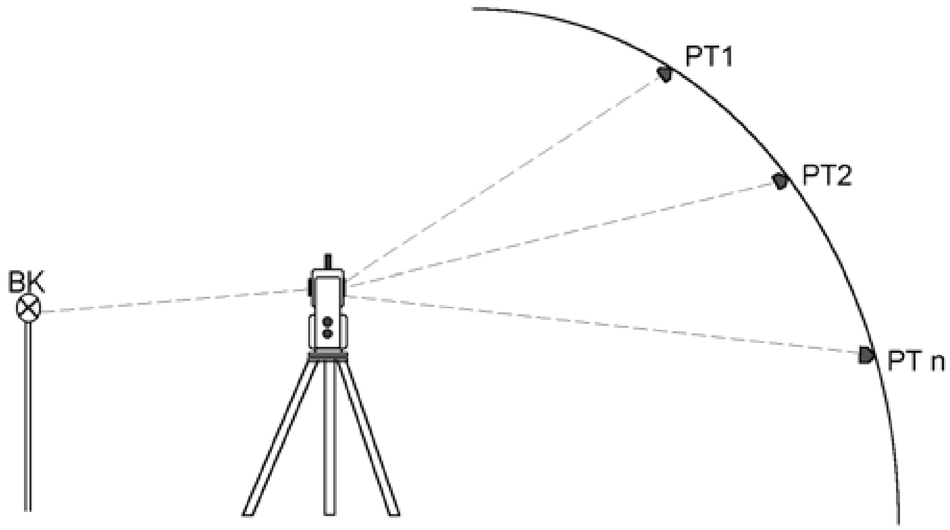
1. Press [ESC] key in case you have measured an open polygon.
   All points defined are automatically stored.
2. Press [END] in case you have measured a closed polygon. The closing error (the distance between the last point and the first reference point) will be displayed. Press [OK] to store all points defined and to return to the main menu. Press [CANCL] in case the closing error is too large. The question 'Delete calculated points?' will be shown. Press [YES] if you want to return to the main menu without storing the coordinates.

NOTE:

1. The reference line and the lines defined by offsets are graphically shown only in case at least one offset has been entered.
2. To use the 'Tape dimension' program, Prompt Bks and XYZ File in JOB OPTN should be turned ON.
3. The coordinates of the points obtained using the 'Tape dimension' program are being computed. Raw data are not being recomputed.

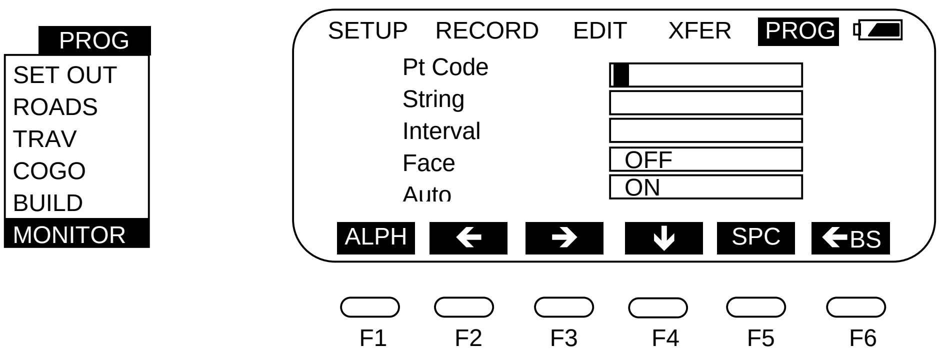
18 Monitor

The monitor program measures more than one prism repeatedly and uses it for the detection of the change of the slope distance. (the Change of the coordinates : GTS-800A)
It automatically aims to a sequence of points which are entered beforehand, measuring and recording in order. The process is repeated at a predetermined time interval. Measured data is recorded in the raw data file.



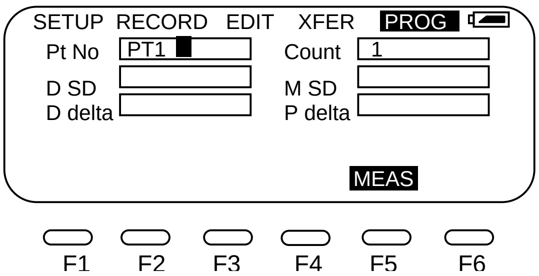
A typical work using Monitor

Points measured in monitor should be entered with the same Pt Code and String. There are two ways to enter points; recording measurements using SS OBS and upload points using RECEIVE POINTS.
Select MONITOR in PROG menu. If either OCC PT or BKS PT has not been entered, the GTS-800 will prompt to enter the point. Then the program shows the following screen;

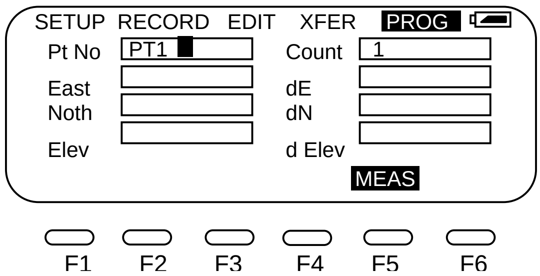


Pt Code, String	Enter point code and string to identity points in monitor measurement.
Interval	Enter the time interval (in minutes) required to repeat measurements.
Face	Select ON to measure with dual faces.
Auto	Select ON to measure in un-manned. If OFF is selected, [ENT] key or [MEAS] is required to be hit before measurements.

The following screen is shown during measurements;



(GTS-800)



(GTS-800A)

Pt No : A current point number, which is selected from series of points specified with Pt Code and String. The points are selected in the order saved in the database.
Then the GTS-800 will turn to the point displayed in the screen.

Count : A current cycle count.

<GTS-800 only>

D SD : Designed slope distance, calculated from two points.

M SD : Measured slope distance.

D delta : A difference between the two slope distances; designed and measured.

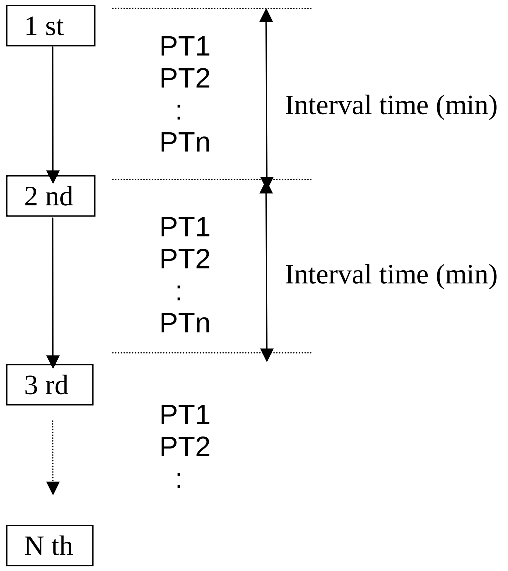
P delta : A difference between the two measurements; previous slope distance and current slope distance.

<GTS-800A only>

East, North, Elev : Coordinates of measured point.

dE, dN, dElev : A difference between the two coordinates; designed and measured.

Processing



If AUTO option is ON, the software displays the point (Ex.PT1) from the specified code and string, and the GTS-800 turns to the point displayed. Then the point is measured and recorded. The GTS-800 turns to the next point when the measurement and recording is completed. This procedure is continued (for the points PT2, PT3, ..., Ptn). The software then restarts measurement from the first point, after the specified time interval..
In the case that no prism is found in the specified direction.

<GTS-800 only>
The GTS-800 will move onto the next point. In this case recording is omitted.

<GTS-800A only>
The GTS-800A will search the prism for 15 sec. If the GTS-800A cannot catch the prism, the GTS-800A will move onto the next point. In this case recording is omitted.

If AUTO option is OFF, the GTS-800 stops after turning to the point direction. [ENT] key or [MEAS] must be pressed to continue measurement and recording.
If the specified interval time is over, the GTS-800 turns to the first point.
You can rename the point number on the screen and record before measurement.

Press [ESC] key to stop the measurement. Press [ESC] key one more time to quit the monitor screen.

Appendix A Interface

A.1 Serial Interface Cable

These cables are used to connect the total station with an IBM PC compatible computer.

F-4 cable (GTS — D-sub 9pins)

(GTS)			(PC)	
GND	(1)	———	(5)	GND
N.C.	(2)			
TD	(3)	→	(2)	TD
RD	(4)	←	(3)	RD
(RTS)	(5)	——┬—	(8)	RTS
N.C.	(6)	└—	(6)	DTR

F-3 cable (GTS — D-sub 25pins)

(GTS)			(PC)	
GND	(1)	——┬—	(1)	FG
N.C.	(2)	└—	(7)	SG
TD	(3)	→	(3)	RD
RD	(4)	←	(2)	TD
(RTS)	(5)	——┬—	(5)	RTS
N.C.	(6)	└—	(6)	DTR

A.2 Parallel Interface Cable

This cable is used to connect the total station with a Centronics printer.

B-2 Cable (GTS Parallel —— Centronics I/F 38pins)

GTS				Printer
STROB	(1)	———	(1)	STROB
BUSY	(2)	———	(11)	INPUT-BUSY
D0	(3)	———	(2)	DATA1
D1	(4)	———	(3)	DATA2
D2	(5)	———	(4)	DATA3
D3	(6)	———	(5)	DATA4
D4	(7)	———	(6)	DATA5
D5	(8)	———	(7)	DATA6
D6	(9)	———	(8)	DATA7
D7	(10)	———	(9)	DATA8
GND	(11)	———	(14)	GND
N.C.	(12)		(16)	GND

A.3 Cable Connections

The GTS-800/GPT-8000A is fitted with a circular RS232 pin connector on the side of the instrument.

A circular parallel connector is under the right side corner of the instrument.(See Fig1.)

Fit the instrument cables to the ports for communication with a computer or printer.

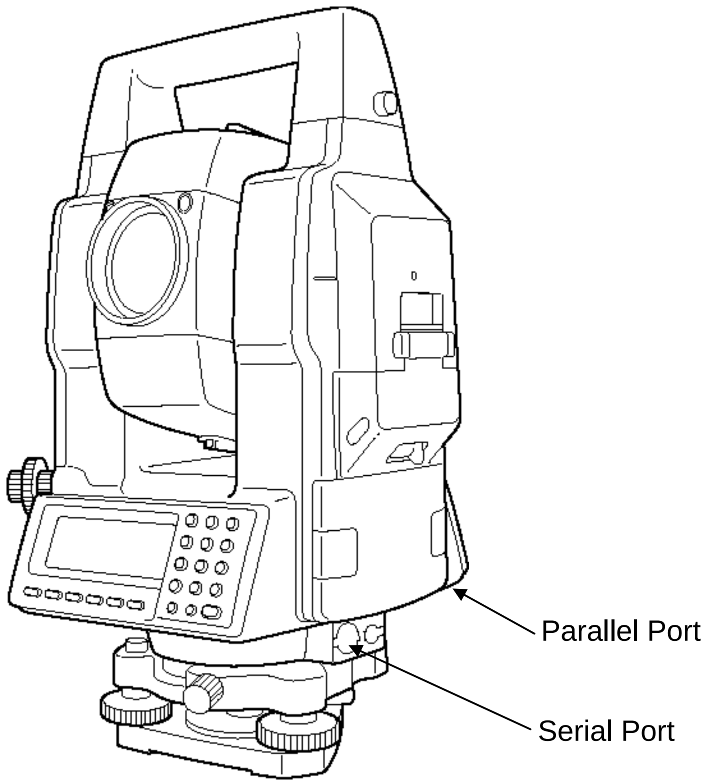


Fig 1 Connectors

A.4 Com Port Status

The following RS-232-C Interface options can be set in the GTS-800/GPT-8000A application program.

```
Baud Rate   : 300/1200/2400/4800/9600/19200 baud
Parity      : NONE / ODD / EVEN
Data Bits   : 7 / 8
Stop Bits   : 0 / 1 / 2
Protocol    : XON-XOFF
              ACK-NAK (Uploading in FC-5 format only)
```

A.5 Data Structure

GTS-7 format

```
|C1|C2|C3|...|Cn|CR|LF|
```

C1~Cn : Please refer Appendix B: Data Format.

The characters CR (0DH) and LF (0AH) add to the end of the data.

GTS-6 and FC-5 format

```
|STX|Data(1)|Data(2)|...|Data(128)|Block No.|B.C.C|ETX|CR|LF|
```

STX (02H) :	Indicates the start of a data block.
Data(1)~Data(128) :	When the length of the data in the last block is less than 128 characters, some SPACE (20H) characters are added as padding so that the data length becomes 128 bytes.
Block No.	‘0’(30H) to ‘9’(39H) is assigned to each block consecutively. The first block is assigned as ‘0’.
B.C.C.(3-digits)	Block check characters which is applied to DATA and block number. Refer to “How to make BCC” in the following chapters.

The characters ETX (03H), CR (0DH) and LF (0AH) add to the end of the data.

A.6 Communication Protocol

Download Data

```
GTS                       Computer
      (DATA)  ⟶
        :
      (DATA)  ⟶
⟵    (X-OFF)

⟵    (X-ON)
      (DATA)  ⟶
        :
      (DATA)  ⟶
      (EOT)   ⟶
```

Select "SEND, RAW" or "SEND, XYZ" in the GTS application menu to start sending data.

If "X-ON, X-OFF" is selected for protocol, GTS stops sending after receiving "X-OFF" characters, and start sending rest of the data after receiving "X-ON" from the PC.

When all the data has been sent, GTS sends EOT (04H) to terminate sending.

Upload Data

(GTS-7 and GTS-6 Format)

```
GTS                       Computer
⟵    (DATA)
        :
⟵    (DATA)
     (X-OFF)  ⟶

     (X-ON)   ⟶
⟵    (DATA)
        :
⟵    (DATA)
⟵    (EOT)
```

Select "RECEIVE, POINTS" or "RECEIVE, PT LIB" in the GTS application menu, and GTS is waiting for the data from the PC.

If "X-ON, X-OFF" is selected for protocol, the PC stops sending after receiving "X-OFF" characters, and start sending rest of the data after receiving "X-ON" from GTS.

When all the data has been sent, The PC sends EOT (04H) to terminate sending.

NOTE: The character X-ON, X-OFF and EOT are sent without CR or LF characters.

Upload Data

(FC-5 Format)

```
   GTS                        Computer
←── (Info Block1)
    (ACK/NAK) ──→
←── (Info Block2)
    (ACK/NAK) ──→
←── (Data Block1)
         :
←── (The last Block)
    (ACK/NAK) ──→
←── (End Block)
```

Select "RECEIVE, POINTS" or "RECEIVE, PT LIB" in the GTS application menu, and GTS is waiting for the data from the PC.

The computer should stop sending until ACK is sent from the GTS. If NAK is sent, the computer should resend the same block again.

When all the data have been sent, GTS sends end block to terminate sending.

(Info. Block 1)

```
|STX|'F'|'0'|'0'|'F'|'0'|'0'|'0'|ETX|CR|LF|
```

STX	(02H)	ETX	(03H)
CR	(0DH)	LF	(0AH)

(Info. Block 2)

```
|STX|PLACE(10)|ELEVATION(5)|SCALE(8)|ACCURACY(4)
|LIMIT(5)|COUNT(4)|'S'||B.C.C.(3)|ETX|CR|LF|
```

EX. "TOPCON   +00001.000000100000-000017S068"

B.C.C : Refer to "How to make a BCC" in the following chapter.

Each information will be set to data collector, if uploading to a FC-5.

But these are ignored and never affect the current job status of the GTS.

(Data Block n)

Total 128 bytes. Refer to Appendix B Data Format.

(End Block)

```
|STX|EOT|ETX|CR|LF|
```

EOT (04H)

A.7 How to Make a BCC

Step 1. Treat each character as 8/7-bit ASCII code.

Step 2. Make bitwise EXCLUSIVE-OR of the BCC (initially which is NULL code -- ASCII 00H) and the first character.

Step 3. Regard the result as the next BCC used.

Step 4. Make bit wise EXCLUSIVE-OR of the BCC and the next character.

Step 5. Repeat step 3 to step 4 until the final character (i.e. Block NO.) is operated.

Step 6. Convert the result 8 / 7 bit code to 3 - digit number.

Example If there is “013468AE”, each character of the data is represented as 8-bit ASCII as follows;

```
“0”    00110000
“1”    00110001
“3”    00110011
“4”    00110100
“6”    00110110
“8”    00111000
“A”    00100001
“E”    00100101
```

Making bitwise EXCLUSIVE-OR of NULL code and the first character “0” results as follows;

```
NULL   00000000
“0”    00110000
--------------------------
       00110000
```

The result is used to make EXCLUSIVE-OR with the next character “1”;

```
       00110000
“1”    00110001
--------------------------
       00000001
```

Repeat the same procedure until reaching to the last character.

```
        00110000
"3"     00110011
--------------------------
        00110010
"4"     00110100
--------------------------
        00000110
"6"     00110110
--------------------------
        00110000
"8"     00111000
--------------------------
        00001000
"A"     01000001
--------------------------
        01001001
"E"     01000101
--------------------------
        00001100
```

The final result "00001100" is converted to decimal "012", thus the BCC in this case is as follows;

B.C.C = "012"

Appendix B Data Format

Standard Survey Software 800 can send and receive a number of different data types. The format of each is determined by the "Output" you select in the SYS OPTN. Refer to the table listed below.

(Function)	(Data)	GTS-7	MOSS	GTS-6	FC-5
SEND	Raw	A	H	K	M
	Points	B	J	L	N
	DXF	C	C	C	C
	X-Sec	D	D	D	D
RECEIVE	Points	P	J	L	L
	Point Library	B	J	L	L
	Code	E	E	E	E
	Alignment	F	F	F	F
	Vertical Curve	G	G	G	G
	Cross Sections	D	D	D	D

A. GTS-7 Raw Data File Format

The format of the GTS-7 data is the same as the Standard Survey Software (GTS-700).
The general format of each record is;

CONTROL WORD   field1 . . . . ,fieldn

Where;

CONTROL WORD is terminated by a space.
Fields 1 to n-1 are terminated by commas.
Field n is terminated by the end-of-line.

Each field may be preceded by a number of space characters which should be ignored but may contain spaces after the first non-space character.

GTS-800 v3.5	
JOB	job name, description
DATE	date, time
NAME	surveyors name
INST	instrument id
UNITS	Meter/Feet, Degree/Gon
SCALE	grid factor, scale factor, elevation
ATMOS	temp, press
STN	ptno, ins ht, stn id
XYZ	X(easting), Y(northing), Z(elevation)
BKB	ptno, backsight bearing, backsight angle
BS	ptno[, target height]
FS	ptno, target height, pt code
SS	ptno, target height, pt code[,string number]
CTL	control code[,pt code 2[,string no 2]](optional)
HV	HA, VA
SD	HA, VA, SD
HD	HA, HD, VD
OFFSET	radial offset, tangential offset, vertical offset
PTL_OFF	offset along ref. line, offset perpendicular to line, vertical offset
NOTE	comments
MLM	from point, to point, delta HD, delta VD, delta SD
RES_OBS	ptno, target height, observation count

XYZ	if present follows the STN record
BKB	if present follows the BKB record or STN record if no BKB.
CTL	if present follows the FS or SS header record.
HV, SD or HD	must follow a BS,FS or SS header and follows the CTL if present.
OFFSET	may follow any SD or HD record.

```
GTS-800 v3.5
JOB      TEST1,TOPO COLLECTION
NAME     FRED
INST     GTS-7
UNITS    M,D
SCALE    1.000000,1.000000,0.0
DATE     24/08/99,09:17:09
STN      1,1.500,STN
SS       1001,1.500,BLDG,01
SD       0.0000,84.4650,9.746
SS       1002,1.500,BLDG,01
HD       0.0000,9.707,0.887
SS       1003,1.500,BLDG,01
SD       0.0000,84.4650,9.747
SS       1004,1.500,BLDG,01
CTL      CL
SD       359.1740,84.4650,9.747
SS       1005,1.500,NS
SD       359.1740,84.4650,9.747
SS       1006,1.500,NS
HD       359.1740,9.707,0.887
```

```
FS       2,1.500,NS
SD       179.1740,84.4650,9.747
STN      2,1.500,STN
SS       1007,1.500,TREE
SD       0.0010,84.4910,9.750
OFFSET   0.000,0.349,0.000
SS       1008,1.500,PATH,01
SD       359.5950,84.4720,9.750
SS       1009,1.500,PATH,01
SD       359.5950,84.4720,9.750
SS       1010,1.500,PATH,01
SD       359.5950,84.4720,9.750
SS       1011,1.500,PATH,01
CTL      ,FENCE,02
SD       359.5950,84.4720,9.750
```

```
GTS-800  v3.5
JOB      TEST2, SET COLLECTION
NAME     FRED
INST     GTS-7
UNITS    M,D
STN      1,1.500,STN
XYZ      1000.000,1000.000,100.000
BKB      2,315.0000,0.0000
BS       2,1.500
HV       344.0620,86.3810
FS       101,1.500,STN
SD       325.3420,88.4750,5.275
FS       102,1.500,STN
SD       7.0610,85.2210,9.914
FS       103,1.500,STN
SD       36.1350,87.3800,9.755
FS       104,1.500,STN
SD       83.4730,84.0410,3.313
FS       104,1.500,STN
SD       263.4820,275.5530,3.313
FS       103,1.500,STN
SD       216.1430,272.2150,9.755
FS       102,1.500,STN
SD       187.0650,274.3730,9.916
FS       101,1.500,STN
SD       145.3520,271.1510,5.275
BS       2,1.500
HV       164.0640,273.2340
```

B. GTS-7 Coordinate Format

The format of downloaded coordinates is as follows:

ptno, X(easting), Y(northing), Z(elevation), pt code

Example:

```
1,1000.0000,1000.0000,100.0000,STN
2,990.0000,1010.0000,100.0000,STN
101,994.8159,1000.9684,100.1130,STN
102,993.9304,1007.7991,100.8000,STN
103,998.5150,1009.6329,100.4026,STN
104,1002.0648,1002.5682,100.3421,STN
1001,1004.7210,997.6496,100.1153,PT
1002,1003.7027,990.8382,100.7989,PT
1003,998.7911,990.3286,100.4033,PT
1004,997.3111,998.0951,100.3421,PT
```

It is also possible to download coordinates which are given with respect to a reference line. This coordinate system is called the point to line system (PTL). More information about this coordinate system can be found in paragraph 8.3. The format of downloaded PTL-coordinates is as follows:

ptno, Line, Offset, Z(elevation), pt code, from reference ptno, to reference ptno

Example:

```
3,29.1456,31.3953,100.9040,PT,1,2
4,128.1436,56.3003,115.7345,PT,1,2
110,29.1456,31.3953,100.9040,PT,101,103
111,49.8290,3.9580,112.8349,PT,101,103
112,394.2840,18.2948,100.9040,PT,101,104
```

C. DXF Format

The occupied point and observed data are sent in DXF.

If the entity and layer is defined in the CODE LIB, the data is sent according to the codes.

(See E. Point Code Format)

e.g.

```
0
SECTION
  2
ENTITIES
  0
LINE
  8
0
```

```
 10
991.237554
 20
1002.760173
 30
1.555728
 11
993.299368
 21
1014.384114
 31
2.350872
POINT
  8
0
 10
1000.000000
 20
1000.000000
 30
0.000000
0
ENDSEC
  0
EOF
  0
ENDSEC
  0
EOF
```

D. Cross Section Format

The format for downloaded and uploaded cross sections is as follows;

chainage, offset, level [,code]

```
0.000,-4.501,18.527
0.000,-3.500,18.553
0.000,0.000,18.658,CL01
0.000,3.500,18.553
0.000,5.501,18.493
12.669,-4.501,18.029
12.669,-3.500,18.059
12.669,-0.000,18.164,CL01
12.669,3.500,18.059
12.669,5.501,17.999
```

E. Point Code Format

Code files for uploading to the point code library, should have a single code per line with optional entity number and layer name. i.e. each entry is terminated by CR LF.

CODE [, ENTITY[, LAYER]]

The entity defined in CODE LIB are

0	Point omitted from DXF
1	Point
2	Line
3	Polyline

The default entity is ‘1’, and the layer is ‘0’, when the code is not defined in CODE LIB.

e.g.

```
TREE,1,VEG
FENCE,2,BDY
CL,2,CL
EP,2,ROAD
GUTTER,2,ROAD
PATH,2,PATH
DRAIN,2,DRAIN
BM,1,CONTROL
MH,1,DRAIN
GAS,1,UTILITY
WATER,2,UTILITY
LP,1,UTILITY
LIGHTS,  1, UTILITY
ROCK,    2, NS
```

F. Alignments (AL)

Alignments are uploaded as elements, and must start with the START definition which includes the starting chainage and a coordinate. The elements are; PT, STRAIGHT, ARC or TRANSITION.

The general format for each record is;

KEYWORD nnnn, nnnn [,nnnn]

where;

START	chainage, easting, northing
STRAIGHT	bearing, distance
ARC	radius, length
SPIRAL	radius, length
PT	easting, northing[, radius[, A1, A2]] (A1, A2 : clothoid length)

Ex. 1

```
START 1000.000, 8.8888, 199.1200
STRAIGHT 25.0000, 48.420
SPIRAL 20.000, 20.000
```

```
ARC 20.000, 23.141
SPIRAL 20.000, 20.000
STRAIGHT 148.3000, 54.678
```

Ex. 2

```
START 1000, 1050, 1100
PT 1750, 1300, 100, 80, 80
PT 1400, 1750, 200
PT 1800, 2000
```

G. Vertical Curves (VC)

Vertical curves are uploaded as IP's and require chainage, level and curve length.

Starting and ending curve lengths should be zero.

The format is;

chainage, level, length

e.g.

1000.000, 100.000, 0.000
1100.000, 125.000, 50.000
1250.000, 100.000, 60.000

H. MOSS Raw Format

e.g.

```
SURVEY  D:\J0119A
017,DMS
190,,,DECR,0900000
180,,,9000,,1000.000,1000.000,0.000
200,9000,9001,SDVA,3595958,,,1.600,,1.000000
201,,,PT01,0103620,14.194,0870623,0.000,,,1001
201,,,PT01,1333115,10.386,0880200,0.000,,,1002
201,,,PT02,2872920,9.187,0901702,0.000,,,1003
201,,,PT02,3350057,15.887,0871812,0.000,,,1004
201,CD2,02,PP01,0103555,14.196,0870649,0.000,,,1005
201,CD2,03,PP01,1333053,10.392,0880209,0.000,,,1006
201,,,P101,2872902,9.187,0901634,0.000,,,1007
201,,,P101,3350118,15.886,0871727,0.000,,,1008
999
FINISH
```

J. MOSS GENIO Format

e.g.

```
GENIO  D:\J0119A
001,FORMAT(3F14.4)
003,ORDR,4=1,1,2,3
080,PT01,7=3
     1002.6092     1013.9337        2.3165
     1007.5266      992.8522        1.9564
        0.0000        0.0000        0.0000
080,PT02,7=3
      991.2378     1002.7609        1.5545
      993.2974     1014.3845        2.3475
        0.0000        0.0000        0.0000
080,CD02,7=3
     1002.6079     1013.9361        2.3148
        0.0000        0.0000        0.0000
080,CD03,7=3
     1007.5318      992.8488        1.9562
        0.0000        0.0000        0.0000
080,OCC,7=3
     1000.0000     1000.0000        0.0000
        0.0000        0.0000        0.0000
080,PT01,7=3
     1002.6079     1013.9361        2.3148
     1007.5318      992.8488        1.9562
      991.2376     1002.7602        1.5557
      993.2994     1014.3841        2.3509
        0.0000        0.0000        0.0000
999
FINISH
```

K. GTS-6 Raw Format

The data is GTS-6 and FC-5 unformatted data.
Refer to the GTS-6 interface manual to confirm details.

```
_!SAMPLE_"SOMEONE_#GX0021_$06/01/95_%24C_&990HP_'X1000_(_)1.20
0_+A001_ ?+00010942m0881003+2755858d+00010936***+**+**054_*NS0
01_,0064

1.200_+A002_ ?+00003366m0952330+3265752d+00003351***+**+**063_
*NS001_,1.200_+A003_ ?+00006913m0894549+0420820d+00006912***+*
*+**1039

055_*NS001_,1.200_
        2037
```

L. GTS-6 Coordinates Format

GTS-6 coordinate input and output is the same format.
Refer to the GTS-6 interface manual to confirm details.
The format of GTS-6 is the same as FC-5 coordinate input.

```
_+A001      _ x+001010876_ y+001001139_ z+000100349_+A002
_  x+001001826_  y+001002809_  z+000099683_+A003            _
x+000995361_0121

 y+001005126_   z+000100028_+X1000              _   x+001000000_
y+001000000_   z+000100000_+X1001              _   x+001000000_
y+001010000_ z+000100000_1071
```

M. FC-5 Raw Data Format

The format is the same as FC-5 selected data format.
Refer to the FC-5 interface manual to confirm details.

```
_!SAMPLE_"SOMEONE_#GX0021_$06/01/95_%24C_&990HP_'X1000_(_)1.20
0_+A001_ a+2755858d_ b0881003d
c+00010942m_*NS001_,1.200_+A002_ a+0006

3265752d_ b0952330d c+00003366m_*NS001_,1.200_+A003_
a+0420820d_ b0894549d c+00006913m_*NS001_,1.200_
1002
```

N. FC-5 Coordinate Format

The format is the same as FC-5 selected data format.

OutPut

```
_+BS_ f+012500000m_ g+011500000m_ h+000050000m_+PJ1_
f+012000000m_ g+011002106m_ h+000049970m_+PJ11_ f+012000000m_
g+011002106m_0063
 h+000049970m_+PJ12_ f+011994478m_ g+011004703m_
h+000050025m_+PJ13_ f+011990588m_ g+011003698m_
h+000049863m_+PJ2_ f+011994476m1051
```

InPut

```
_+BS_ x+012500000m_ y+011500000m_ z+000050000m_+PJ1_
f+012000000m_ g+011002106m_ h+000049970m_+PJ11_ f+012000000m_
g+011002106m_0063
 h+000049970m_+PJ12_ f+011994478m_ g+011004703m_
h+000050025m_+PJ13_ f+011990588m_ g+011003698m_
h+000049863m_+PJ2_ f+011994476m1051
```

NOTE: The format of FC-5 is the same as GTS-6 coordinate input.

NOTE: The format of FC-5 differs from that of GTS-6 in the record of the measurement data. The FC-5 raw data is divided into its elements (i.e. H, V, SD), and each element has an ID.

For example;

When measuring the following data in SD mode, the output is as follows;

SD: 10.942 m
V : 88°10′03″
H : 275°58′58″

- GTS-6 Raw Format
```
_?+00010942m0881003+2755858d+00010936***+**+**063
```
- FC-5 Raw Data Format
```
_a+2755858d_b0881003d_c+00010942m
```

P. GTS-7 Coordinate Format

The format of upload coordinates has the following format.

ptno, X(easting), Y(northing), Z(elevation), pt code, string

```
1,1000.0000,1000.0000,100.0000,STN,001
2,990.0000,1010.0000,100.0000,STN,001
101,994.8159,1000.9684,100.1130,STN,002
102,993.9304,1007.7991,100.8000,STN,001
103,998.5150,1009.6329,100.4026,STN,002
104,1002.0648,1002.5682,100.3421,STN,001
1001,1004.7210,997.6496,100.1153,PT,09
1002,1003.7027,990.8382,100.7989,PT,05
1003,998.7911,990.3286,100.4033,PT,09
1004,997.3111,998.0951,100.3421,PT,05
```

It is also possible to upload coordinates which are given with respect to a reference line. This coordinate system is called the point to line system (PTL). More information about this coordinate system can be found in paragraph 8.3. The format of uploaded PTL-coordinates is as follows:

ptno, Line, Offset, Z(elevation), pt code, string, from reference ptno, to reference ptno

Example:

```
3,29.1456,31.3953,100.9040,PT,001,1,2
4,128.1436,56.3003,115.7345,PT,002,1,2
110,29.1456,31.3953,100.9040,PT,003,101,103
111,49.8290,3.9580,112.8349,PT,004,101,103
112,394.2840,18.2948,100.9040,PT,005,101,104
```

NOTE: Coordinates and distances are rounded to the nearest mm when downloaded in GTS-6 and FC-5 formats, whereas they are rounded to the nearest 0.1 mm when downloaded in the default GTS-7 format.

This results in an apparent inconsistency when a number is rounded up to 0.5 mm in the GTS-7 format but rounded down to the nearest mm in GTS-6/FC-5 format.

e.g.

`11002.2175`	(GTS-7 format)
`+011002217`	(GTS-6, FC-5 format)

Both PT CODE and STRING are optional.

Appendix C Instructions for Recording MOSS

Standard Survey Software 800 MOSS Data Format

The Standard Survey Software 800 can generate MOSS raw data files from the recorded raw data, and MOSS GENIO files from stored coordinates. MOSS genio files can also be uploaded for setting out.

Both traverse and detail raw data formats can be generated.

Code and String

When recording for MOSS output the string code is made by combining the point code and the string number, and the string control screen can be used to enter fields 1 & 2.

By default a 201 minor option record is generated for each observation in a RAW data file, with empty fields for field1 and field2.

To change the minor option, enter the required code into the control field. Fields 1 & 2 will be included when a control field has been entered. Pcode2 is used to enter field1 and String2 to enter field2.

OCC PT and BKS PT

A 180 record is generated for occupied points and backsight points when an XYZ record is present in the raw data. This occurs when the coordinate was entered manually, or was extracted from the fixed point library. This will be for the first occupied point and any unconnected occupied points.

SS OBS

Side shot observations generate 201 records by default. However if 202 is entered into the string control field a 202 record will be generated. Field 1 of a 201 or 202 record can be entered in the pcode2 field of the string control record, and field 2 can be entered in the string2 field.

BS OBS and FS OBS

Backsight and fore sight observations generate traverse records and if used the output will be in traverse format. The occupied point record preceding a backsight or foresight observation record takes the format required for a traverse.

Traverse Survey

MOSS imposes strict procedures on the traverse files and these must be followed when recording the data.

In general the following rules should be followed;

- The first traverse record after the occupied point must be the backsight observation.
- Distances must be measured on backsights observation. (except to the initial backsight point)
- Multiple backsight and foresight observations should follow the pattern BS/FS BS/FS.
- Only one foresight station can be observed from each traverse station.

The first backsight observation can be made as an angle only measurement, in which case the traverse record will contain the horizontal angle and the reference bearing in field 8. (a coordinate for the backsight point is not required in this case)

The recording mode specified in each occupied station record is determined by the following observation, the default is SDVA.

An example of a traverse survey;

```
SURVEY  TEST2
017,DMS
190,,,DECR,0900000
180,,,,0001,,1000.000,1000.000,100.000
200,0001,,SDVA,,,,1.500,,1.000000
201,TRAV,,,0000000,,,,0000000
201,TRAV,,0101,0450000,100.000,0900000,1.500
200,0101,,SDVA,,,,1.500,,1.000000
201,TRAV,,0001,0000000,100.000,0900000
201,TRAV,,0102,2700000,100.000,0900000,1.500
200,0102,,SDVA,,,,1.500,,1.000000
201,TRAV,,0101,0000000,100.000,0900000
201,TRAV,,0103,0900000,100.000,0900000,1.500
999,
FINISH
```

Detail records (SS OBS) can be combined in a traverse survey.

Detail Survey

For detail surveys a backsight observation should not be taken.

When a side shot is the first observation following an occupied point the occupied point record takes the format required for a detail survey. The occupied point record, specifies the backsight point and horizontal angle datum. The horizontal angle datum is the data recorded in the back bearing record.

An example of detail survey;

```
SURVEY  TEST1
017,DMS
190,,DEDR,0900000
180,,,0001,,1000.000,1000.000,100.000
180,,,0002,,1100.000,1100.000,100.000
200,0001,0002,,SDVA,0000000,,,1.500,,1.000000
201,REPS,,A001,0000000,1000.000,0900000,1.500,,,1001
201,REPS,,A001,0450000,1000.000,0900000,1.500,,,1002
201,REPS,,A001,0900000,1000.000,0900000,1.500,,,1003
202,,,B001,0900000,200.000,0900000,1.500,,,1004
202,,,B001,1200000,200.000,0900000,1.500,,,1005
200,0001,0002,,SDVA,0000000,,,1.500,,1.000000
202,,,C001,0900000,141.421,0900000,1.500,,,1006
202,,,C001,1350000,100.000,0900000,1.500,,,1007
202,,,C001,1800000,141.421,0900000,1.500,,,1008
999
FINISH
```

Appendix D How to Calculate Road Alignment

The road alignment set out program can setout the alignment including straight, arc and spiral transition.

NOTE:

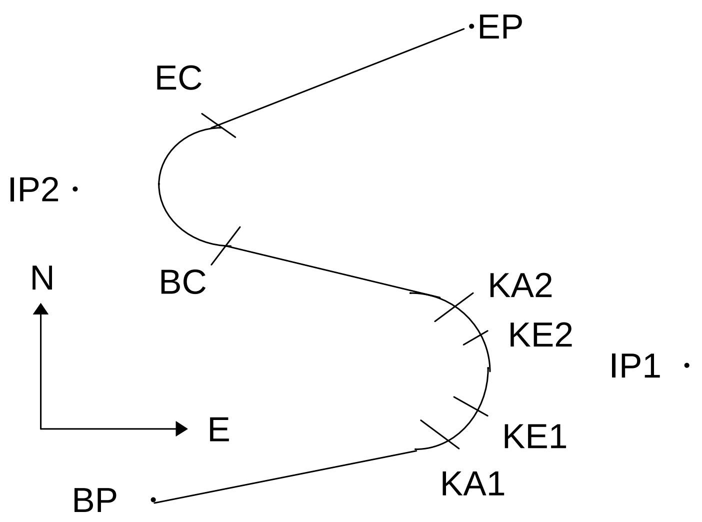
1) Road alignment data can be uploaded from NS-10, PC or can be entered manually
   Cross section elements are uploaded from PC only.
2) Both road alignment and cross section data are managed by chainage.
3) Though SAVE SETOUT is ON, the data can not be printed out and will not be stored.
4) One Job name for one alignment can be registered.
   You may create different job names for many alignments.

1. ROAD Alignment Elements

There are two ways to enter the alignment elements:

1) Upload from NS-10 or another serial communication package.
2) Manually entered on the GTS-800

How to enter the Alignment data is explained below.



point	North (N)	East (E)	Radius	Transparameter A1 (clothoid parameter)	Transparameter A2 (clothoid parameter)
BP	1100.0000	1050.0000			
IP1	1300.0000	1750.0000	100.0000	80.0000	80.0000
IP2	1750.0000	1400.0000	200.0000	0.0000	0.0000
EP	2000.0000	1800.0000			

An Element of Alignment	Parameter
Straight	Bearing, Distance
Transition Curve	Radius, Length of Transition
Arc	Radius, Length of Arc
PT	North, East, Radius, A1, A2

NOTE: When uploading from PC or by entering PT option, you do not have to calculate the Parameter.

example;

To enter the following data select DEF AL of ROADS from PROG menu.

Chainage	0
North	1100
East	1050

Press [ENT] and then the function key [PT]. Enter the following data.

North	1300
East	1750
Radius	100
A1	80
A2	80

Enter the following data in the above way.

North	1750
East	1400
Radius	200
A1	0
A2	0

North	2000
East	1800
Radius	0
A1	0
A2	0

The above example can also be uploaded in the following data format.

START ␣ 0.000 ␣ 1050.000 ␣ 1100.000 CRLF
PT ␣ 1750.000 ␣ 1300.000 ␣ 100.000 ␣ 80.000 ␣ 80.000 CRLF
PT ␣ 1400.000 ␣ 1750.000 ␣ 200.000 ␣ 0.000 ␣ 0.000 CRLF
PT ␣ 1800.000 ␣ 2000.000 CRLF

(1) Calculation of clothoid length

$$L_{1\cdot 2} = \frac{A_{1\cdot 2}{}^{2}}{R}$$

$L_{1\cdot 2}$: Length of clothoid

$A_{1\cdot 2}$: Parameter of clothoid

R : Radius

$$L_1 = \frac{A_1{}^2}{R} = \frac{80^2}{100} = 64\ m \qquad L_2 = \frac{A_2{}^2}{R} = \frac{80^2}{100} = 64\ m$$

(2) Calculation of Spiral Angle

$$\tau = \frac{L^2}{2A^2}$$

$$\tau_1 = \frac{64^2}{2\cdot 80^2} = 0.32rad \;\Rightarrow\; \deg \;\Rightarrow\; 0.32\frac{180}{\pi} = 18^\circ 20' 6''$$

$$\therefore\ \tau_1 = -\tau_2$$

(3) Calculation of transition coordinates

$$N = A\cdot\sqrt{2\tau}\,(1 - \frac{\tau^2}{10} + \frac{\tau^4}{216} - \frac{\tau^6}{9360}\ \cdots)$$

$$E = A\cdot\sqrt{2\tau}\,(\frac{\tau}{3} - \frac{\tau^3}{42} + \frac{\tau^5}{1320} - \frac{\tau^7}{75600}\ \cdots)$$

$$N = 80\cdot\sqrt{2\cdot 0.32}\,(1 - \frac{(0.32)^2}{10} + \frac{(0.32)^4}{216} - \frac{(0.32)^6}{9360}\ \cdots)$$

$$= 64\ (1 - \frac{0.01024}{10} + \frac{0.01048576}{216} - \frac{0.00107341824}{9360}\ )$$

$$= 64\ (1 - 0.01024 + 0.00004855 - 0.00000011)$$

$$= 64\cdot 0.98981$$

$$= 63.348$$

as well as E ;

$$E = 80\cdot\sqrt{2\cdot 0.32}\,(\frac{0.32}{3} - \frac{(0.32)^3}{42} + \frac{(0.32)^5}{1320} - \frac{(0.32)^7}{75600}\cdots)$$

$$= 64\ (0.10666667 - 0.00078019 + 0.0000025 - 0)$$

$$= 6.777$$

This example is symmetry spiral transition $N_1=N_2$, $E_1=E_2$

(4) Calculation of shift value ΔR

$\Delta R = E - R\,(1 - \cos\tau)$

$\Delta R = 6.777 - 100\,(1 - \cos 18°20'6'') = 1.700$

This example is Symmetry spiral transition $\Delta R_1 = \Delta R_2$

(5) Calculation of Spiral Transition coordinate

$Nm = N - R\sin = 63.348 - 100\sin 18°20'6'' = 31.891$

This example is Symmetry spiral transition $Nm_1 = Nm_2$

(6) Calculation of Tangent Distance

$$D_1 = R\tan\left(\frac{IA}{2}\right) + \Delta R_2\ \mathrm{cosec}(IA) - \Delta R_1\ \cot(IA) + Nm_1$$

$$IA = +111°55'47'', \quad \mathrm{cosec} = \frac{1}{\sin}, \quad \cot = \frac{1}{\tan}$$

$$D_1 = 100\cdot\tan\left(\frac{111°55'47''}{2}\right) + 1.7\left(\frac{1}{\sin 111°55'47''}\right)$$

$$- 1.7\left(\frac{1}{\tan 111°55'47''}\right) + 31.891$$

$$= 148.06015 + 1.8326 + 0.6844 + 31.891 = 182.468$$

$D_1 = D_2$

(7) Calculation of the coordinate KA1

$N_{KA1} = N_{IP1} - D_1 . \cos\alpha_1$

$E_{KA1} = E_{IP1} - D_1 . \sin\alpha_1$

Bearing from BP to IP1 $\rightarrow$ $\alpha_1 = 74°03'16.6''$

$N_{KA1} = 1300 - 182.468 \cdot \cos 74°03'16.6'' = 1249.872\text{m}$

$E_{KA1} = 1750 - 182.468 \cdot \sin 74°03'16.6'' = 1574.553\text{m}$

(8) Calculation of Arc Length

$L = R\,(IA - \tau_1 + \tau_2)$

$= R\,(111°55'47'' - 2 \cdot 18°20'6'')$

$= 100\,(75°15'35''\ \frac{\pi}{180°}) = 131.353$ m

(9) Calculation of the coordinate KA2

$N_{KA2} = N_{IP1} - D_2 . \cos \alpha_2$

$E_{KA2} = E_{IP1} - D_2 . \sin \alpha_2$

Bearing from IP1 to IP2 $\rightarrow \alpha_2 =$ 322°07'30.1"

N_{KA2} = 1300 – (– 182.468) ·cos 322°07'30.1" = 1444.032 m

E_{KA2} = 1750 – (– 182.468) ·sin 322°07'30.1" = 1637.976 m

(10) Calculation of coordinates BC, EC which is ARC (IP1,IP2,EP)

Arc length CL = R · IA

IA = 95°52'11" there fore

$$CL = 200 \cdot 95°52'11" \frac{\pi}{180} = 334.648 \text{ m}$$

Tangent Length

$$TL = R \tan\left(\frac{IA}{2}\right) = 200 \tan\left(\frac{95°52'11"}{2}\right) = 221.615 \text{ m}$$

Each coordinates are computed:

N_{BC} = IP2 – TL cos α_1

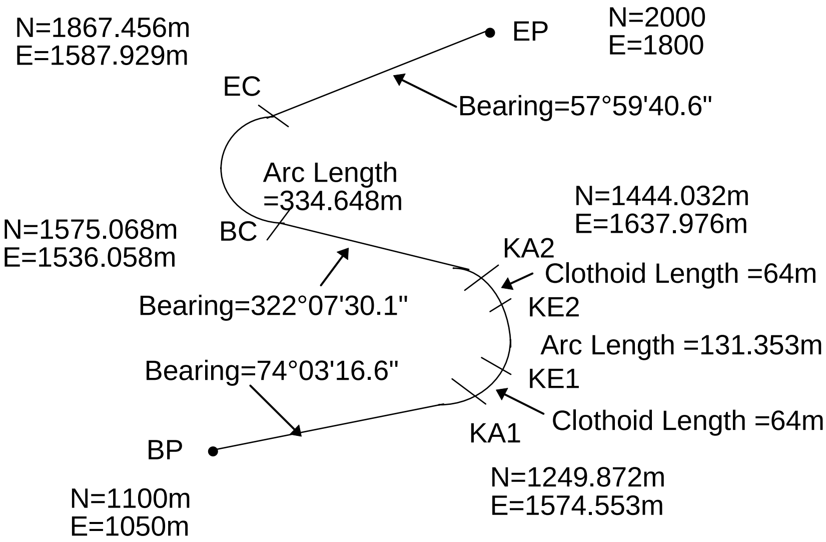
E_{BC} = IP2 – TL sin α_1

N_{EC} = IP2 – TL cos α_2

E_{EC} = IP2 – TL sin α_2

α_1	= bearing from IP1 to IP2	= 322°07'30.1"
α_2	= bearing from IP2 to EP	= 57°59'40.6"
N_{BC}	= 1750 – 221.615 cos 322°07'30.1"	= 1575.068 m
E_{BC}	= 1400 – 221.615 sin 322°07'30.1"	= 1536.058 m
N_{EC}	= 1750 – 221.615 cos 57°59'40.6"	= 1867.456 m
E_{EC}	= 1750 – 221.615 sin 57°59'40.6"	= 1587.929 m

The coordinates and the distances are calculated below:



Compute the length of straight line.

straight line BP・KA1

$$= \sqrt{(1249.872 - 1100.000)^2 + (1574.553 - 1050)^2} = \underline{545.543m}$$

straight line KA2・BC

$$= \sqrt{(1575.068 - 1444.032)^2 + (1536.058 - 1637.976)^2} = \underline{166.005m}$$

straight line EC・EP

$$= \sqrt{(2000 - 1867.456)^2 + (1800 - 1587.929)^2} = \underline{250.084m}$$

start point coordinate (BP)

Northing	1100.000m
Easting	1050.000m

Straight line (between BP and KA1)

Bearing	74° 3’ 17”
Distance	545.543 m

Transition (clothoid) (between KA1 and KE1)

Radius -100 m ("-" sign is turn left curve toward the end point.)

Length 64 m

Arc (between KE1 and KE2)

Radius -100 m (with "-" sign is turn left curve toward the end point)

Length 131.354 m

Transition (between KE2 and KA2)

Radius -100 m (with "-" sign is turn left curve toward the end point)

Length 64 m

Straight line (between KA2 and BC)

Bearing 322° 7’30”

Distance 166.004 m

Arc (between BC and EC)

Radius 200m (without sign is the right toward the end point.)

Distance 334.648 m

Straight line (between EC and EP)

Bearing 57°59’41”

Distance 250.084 m

Above elements are entered manually for the road alignment setout.

If you use TOPCON NS-10 all above elements can be uploaded.

Appendix E Resection calculations

In this appendix the parameters are explained which are used in resection.

E.1 Residuals

Assume that a resection has been performed usingsure meaments to *n* points of which the coordinates are known: (X_1, Y_1, Z_1), (X_2, Y_2, Z_2), … To those points angles and distances have been measured: (H_1, V_1, SD_1), (H_2, V_2, SD_2), … First the coordinates of the occupied point will be calculated (X_0, Y_0, Z_0), next the residuals $(\Delta H_1, \Delta V_1, \Delta SD_1)$, $(\Delta H_2, \Delta V_2, \Delta SD_2)$,… will be calculated using the following equations:

$$h_1 = \tan^{-1}\frac{Y_1 - Y_0}{X_1 - X_0}\ , h_2 = \tan^{-1}\frac{Y_2 - Y_0}{X_2 - X_0}\ , ...$$

$$e = \frac{(h_1 - H_1) + (h_2 - H_2) + ...}{n}$$

$$\nu_1 = \tan^{-1}\frac{Z_1 - Z_0}{\sqrt{(X_1 - X_0)^2 + (Y_1 - Y_0)^2}}\ , \nu_2 = \tan^{-1}\frac{Z_2 - Z_0}{\sqrt{(X_2 - X_0)^2 + (Y_2 - Y_0)^2}}\ , ...$$

$$\Delta H_1 = h_1 - H_1 - e, \Delta H_2 = h_2 - H_2 - e, ...$$

$$\Delta SD_1 = \sqrt{(X_1 - X_0)^2 + (Y_1 - Y_0)^2 + (Z_1 - Z_0)^2} - SD_1, ...$$

$$\Delta V_1 = v_1 - V_1, \Delta V_2 = v_2 - V_2, ...$$

E.2 Scale

The same notation will be used as in paragraph E.1. Scale λ is calculated as follows:

$$HD_1 = SD_1 \sin(V_1), HD_2 = SD_2 \sin(V_2), ...$$

$$\lambda_1 = \frac{\sqrt{(X_1 - X_0)^2 + (Y_1 - Y_0)^2}}{|HD_1|}, \lambda_2 = \frac{\sqrt{(X_2 - X_0)^2 + (Y_2 - Y_0)^2}}{|HD_2|}, ...$$

$$\lambda = \frac{\lambda_1 + \lambda_2 + ...}{n}$$

This scale factor is used to recompute the occupied point coordinates (X_0, Y_0, Z_0).

E.3 Backsight orientation

The same notation will be used as in paragraph E.1. The parameter c is calculated which will be subtracted from the current horizontal angle in order to set the correct angle. This parameter is calculated as follows:

$$h_1 = \tan^{-1}\left(\frac{X_1 - X_0}{Y_1 - Y_0}\right), h_2 = \tan^{-1}\left(\frac{X_2 - X_0}{Y_2 - Y_0}\right), \ldots$$

$$\Delta X_1 = \sqrt{(X_1 - X_0)^2 + (Y_1 - Y_0)^2}\cos(h_1 - H_1), \Delta X_2 = \sqrt{(X_2 - X_0)^2 + (Y_2 - Y_0)^2}\cos(h_2 - H_2), \ldots$$

$$\Delta Y_1 = \sqrt{(X_1 - X_0)^2 + (Y_1 - Y_0)^2}\sin(h_1 - H_1), \Delta Y_2 = \sqrt{(X_2 - X_0)^2 + (Y_2 - Y_0)^2}\sin(h_2 - H_2), \ldots$$

$$ZK = \tan^{-1}\left(\frac{\Delta Y_1 + \Delta Y_2 + \ldots}{\Delta X_1 + \Delta X_2 + \ldots}\right)$$

$$H_1^* = 2h_1 - H_1 - ZK, H_2^* = 2h_2 - H_2 - ZK, \ldots$$

$$c = \frac{(H_1 - H_1^*) + (H_2 - H_2^*) + \ldots}{n}$$

Menu Structure Diagram

SETUP
SetUp

- **JOB**
  Create a New Job
  Open an Existing Job
  Delete a Job
- **SYS OPTN**
  System Options
- **JOB OPTN**
  Job Options
- **SCALE**
  Scale Factor
- **TEMP/PRES**
  Temperature and Pressure Input

RECORD
Record Data

- **OCC PT**
  Occupied Point Input
  Resection
  Station Elevation
- **BKS PT**
  Enter backsight point
  Multiple BS
- **BS OBS**
  Backsight observation
  Multiple BS
- **FS OBS**
  Foresight observation
- **SS OBS**
  Side shot observations
  Record Offset
  PTL
- **X-SECT**
  Record cross section observations

EDIT
Edit Files

- **RAW**
  Edit raw data
- **POINTS**
  Edit coordinate data
- **PT LIB**
  Edit fixed Points
- **CODE**
  Edit code library
- **CUTS**
  Confirm cut / fill data

XFER
File Transfer

- **SEND**
  Download a file to serial port or data card
- **RECEIVE**
  Upload a file from serial port or data card
- **PRINT**
  Print reports to serial or parallel printer or data card
- **PORT**
  Set serial port parameters

PROG
Programs

- **SET OUT**
  Occ Pt and Bks Pt
  Point Setout
  String Setout
  Alignment Setout
  Cross Section Setout
- **ROADS**
  Define Horizontal Alignment
  Edit Horizontal Alignment
  Define Vertical Alignment
  Edit Vertical Alignment
- **TRAV**
  Traverse adjustment
- **COGO**
  Intersection /Inverse
  /Area calculation /Radiation /MLM
- **BUILD**
  Batterboards
  Tape Dimention
- **MONITOR**

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STANDARD SURVEY 800

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